REPORT

CALENDAR YEAR 2012 OF ACTIVITIES UNDER THE ANADROMOUS FISH AGREEMENT AND HABITAT CONSERVATION PLAN

ROCKY REACH HYDROELECTRIC PROJECT

FERC LICENSE NO. 2145

Prepared for

Federal Energy Regulatory Commission

888 First Street N.E.

Washington, D.C. 20426

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TABLE OF CONTENTS

List of Tables

List of Appendices

1 INTRODUCTION

On June 21, 2004, the Federal Energy Regulatory Commission (FERC) approved an Anadromous Fish Agreement and Habitat Conservation Plan (HCP) for the Rocky Reach Hydroelectric Project (Rocky Reach – FERC License No. 2145) on the Columbia River in Washington State, operated by Public Utility District No. 1 of Chelan County (Chelan PUD). The HCP provides a comprehensive and long-term adaptive management plan for species addressed in the plan (Plan Species) and their habitat. This document fulfills Article 10 of Appendix B and Section 9.8 of Appendix E of the new FERC License issued February 19 2009[1], and Section 4.8 of the HCP, which requires an annual report of progress toward achieving the No Net Impact (NNI) goal, as described in Section 3 of the HCP and in common understandings based upon completed studies, including those conducted as research and development for NNI progress or those not considered valid due to extenuating circumstances (Section 5.2.3 of the HCP).

The signatories of the Mid-Columbia HCPs (HCPs for the Wells, Rocky Reach, and Rock Island hydroelectric projects) meet as combined Coordinating Committees, Hatchery Committees, and Tributary Committees to expedite the process of overseeing and guiding HCP implementation. Minutes from the monthly meetings are compiled in Appendices A (Coordinating Committees), B (Hatchery Committees), and C (Tributary Committees); Appendix D lists members of the Rocky Reach committees. In addition, there is a Policy Committee whose function is to provide dispute resolution if issues arise in the Coordinating, Hatchery, or Tributary Committees. The Policy Committee did not meet in 2012. The Coordinating Committee for the Rocky Reach HCP oversaw the preparation of this ninth Annual Report for calendar year 2012, which covers the period from January 1 to December 31, 2012. (The first eight Annual Reports covered January 1 to December 31, 2004 through 2011, respectively.)

[1] 126 FERC, paragraph 61,138 (2009)

2 PROGRESS TOWARD MEETING NO NET IMPACT

The Rocky Reach HCP requires preparation of an Annual Report that describes progress toward achieving the performance standard of NNI for each Plan Species. The NNI standard consists of three elements: 1) project passage survival; 2) hatchery production; and 3) tributary restoration. Survival standards and measures established in the HCP must be achieved no later than March 2013. These survival standards and measures are: 1) 91 percent combined adult and juvenile project survival, as achieved by project improvement measures implemented within the geographic area of the project; and 2) up to 9 percent compensation for unavoidable project mortality provided through hatchery and tributary programs, with up to 7 percent compensation provided through hatchery programs and 2 percent through tributary programs (Section 3.1 of the HCP).

In 2012, Chelan PUD has met or exceeded all requirements for NNI under the Rocky Reach HCP for spring migrant HCP Plan Species (spring Chinook, steelhead, and sockeye). Project survival standards have been exceeded for steelhead, yearling Chinook, and sockeye. Yearling Chinook, sockeye, and steelhead are currently designated Phase III (Standards Achieved). For summer Chinook (a summer migrant and a non-Endangered Species Act [ESA]-listed Plan Species), considerable life history variability and limited technology constrain the ability to meaningfully estimate project survival; as a result, summer Chinook subyearlings are designated as Phase III (Additional Juvenile Studies) and compensated through the Tributary Conservation and Hatchery Compensation Plans at levels consistent with direction provided in the HCP. As established in Section 3.1 of the HCP, the inability to estimate survival due to limitations of technology shall not be construed as a success or a failure to achieve NNI. Coho salmon also are currently classified as Phase III (Additional Juvenile Studies[2]) and are compensated at levels indicated by the HCP to achieve NNI through Tributary Conservation and Hatchery Compensation Plans as the species is being reintroduced to the Upper Columbia River (UCR).

Hatchery Compensation commitments for initial production have been implemented and will continue through 2013; recalculated NNI production levels were agreed upon in 2011, and implementation will begin with the 2014 release year and continue for the next ten

[2] The current phase designation will be re-evaluated in 2017.

years (2014 through 2023). Chelan PUD has funded the Tributary Conservation Plan at the level agreed to in the HCP ($229,800 in 1998 dollars) and will continue to do so for the duration of the HCP (see Section 2.3) (Table 1).

Table 1
Rock Island HCP NNI Progress for Plan Species, 2012

HCP Plan Species (ESA Status)	Survival Standard Met?	Hatchery Compensation Provided?	Tributary Conservation Plan Funded?	NNI?
Spring Chinook Yearlings (ESA-Listed)	Yes-Combined Adult and Juvenile	Yes	Yes	Yes
Steelhead (ESA-Listed)	Yes- Combined Adult and Juvenile	Yes	Yes	Yes
Sockeye (Not Listed)	Yes- Combined Adult and Juvenile	Yes	Yes	Yes
Summer/Fall Chinook (Not Listed)	Phase III (Additional Studies)	Yes	Yes	Yes- compensation provided but additional studies required
Coho (Not Listed)	TBD	Yes	Yes	Yes

Note:
TBD = To be determined

In December 2012, Chelan PUD distributed their revised draft 2013 Comprehensive NNI Progress Report for review. The final 2013 Comprehensive NNI Progress Report is expected to be finalized and approved by the Coordinating Committees by March 2013.

The remainder of this section of the report summarizes decisions and agreements reached by the Rocky Reach Coordinating, Hatchery, and Tributary Committees in 2012 in support of achieving and maintaining NNI. This summary is followed by individual sections that summarize achievements, actions, and activities in 2012 that are specific to the areas of project survival and dam operations, hatchery compensation, and funding of tributary habitat protection and restoration projects.

Throughout 2012, the HCP Coordinating, Hatchery, and Tributary Committees reached agreement on numerous issues during meetings, all of which were documented in the meeting minutes, with many described in stand-alone Statements of Agreement (SOAs). These agreements, along with approvals for funding of habitat projects by the Rocky Reach Tributary Committee, are summarized in Table 2 and are discussed in the remainder of this report.

Table 2
Summary of 2012 Decisions for Rocky Reach HCP

Meeting Date	Agreement	HCP Committee	Reference
January 12, 2012	Approved revisions to the Policies and Procedures for Funding Projects document	Tributary	Appendix C
January 19, 2012	Approved the Chelan PUD Spring Chinook Compensation SOA – Release Year 2014, as revised	Hatchery	Appendix B and Appendix F
February 9, 2012	Agreed to increase the maximum contract allowance for small projects proposals from $75,000 to $100,000	Tributary	Appendix C
February 15, 2012	Approved in principal the Spring Chinook Size-at-Release Target SOA, as revised	Hatchery	Appendix B
March 8, 2012	Approved revisions to Section VII, Full Disclosure, in the Tributary Committee Operating Procedures document	Tributary	Appendix C
March 27, 2012	Approved the 2012 Rocky Reach and Rock Island Fish Spill Plan with revisions	Coordinating	Appendix A
March 27, 2012	Approved the 2012 Rocky Reach Fish Bypass Operations Plan with revisions	Coordinating	Appendix A
March 27, 2012	Finalized the 2012 Rocky Reach and Rock Island HCP Action Plan	Coordinating	Appendix A
March 28, 2012	Approved the Chiwawa Spring Chinook Size-at-Release Target SOA	Hatchery	Appendix B and Appendix F
March 28, 2012	Agreed to defer assigning the task of developing recommendations for multi-species acclimation to the Hatchery Evaluation Technical Team (HETT) at this time	Hatchery	Appendix B
March 28, 2012	Agreed that the Yakama Nation (YN) could use actively migrating coho and steelhead smolts from Rolfing Pond to test smolt trap efficiency	Hatchery	Appendix B

Meeting Date	Agreement	HCP Committee	Reference
April 18, 2012	Agreed to begin discussions on updating the Hatchery Program Monitoring and Evaluation (M&E) Plans and communicating with National Marine Fisheries Service (NMFS) on the pending Section 10 permits	Hatchery	Appendix B
May 17, 2012	Agreed, along with NMFS and U.S. Fish and Wildlife Service (USFWS), on Tumwater Dam operations for 2012	Hatchery	Appendix B
May 17, 2012	Agreed to continue discussions on updating the Hatchery Programs M&E Plans at the June 20, 2012 Hatchery Committees meeting	Hatchery	Appendix B
June 20, 2012	Agreed to the Request Authorization for Four (4) Additional Hatchery-Origin Wenatchee Spring Chinook for the Continuation of the Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study	Hatchery	Appendix B
July 18, 2012	Chelan PUD agreed to meet with fisheries and hatcheries staff to discuss the best approach to: 1) engage Washington State Department of Ecology (Ecology) to explain the Committees' efforts to meet the upcoming Wenatchee River phosphorus total maximum daily load (TMDL) at the Dryden Rearing Facility; and 2) share applicable baseline water quality data. Chelan PUD also agreed to join with the Joint Fisheries Parties (JFP) to meet with Ecology if cleared by Chelan PUD management	Hatchery	Appendix B
August 15, 2012	Agreed that Chelan PUD and Washington Department of Fish and Wildlife (WDFW) should implement their plan, titled "Chelan River Brood Collection 2012 Pilot Study," to test methods for capturing returning adults to use as broodstock for the Chelan Falls summer/fall Chinook program	Hatchery	Appendix B
August 15, 2012	Agreed that Chelan PUD could proceed with their proposal, "Mid-Columbia Chinook Salmon Precocity Studies," but requested a more detailed study plan and monthly updates as the study progresses	Hatchery	Appendix B
August 15, 2012	Agreed to continue the existing Hatchery M&E programs with minor revisions in 2013, and to implement the updated M&E program for 2014 and beyond	Hatchery	Appendix B
September 25, 2012	Accepted the 2012 Rocky Reach and Rock Island Fish Spill Report as final	Coordinating	Appendix A

Meeting Date	Agreement	HCP Committee	Reference
October 23, 2012	Agreed to Chelan PUD's proposal to extend the Rocky Reach Dam maintenance work outage two weeks from a beginning date of January 2, 2013, to a beginning date of December 17, 2012, to allow more time to complete needed work	Coordinating	Appendix A
November 14, 2012	Agreed to a Chelan PUD request for 3,000 summer/fall Chinook salmon eggs from the Eastbank Hatchery for use in an intra-gravel dissolved oxygen (DO) study at Chelan Falls	Hatchery	Appendix B
December 11, 2012	Agreed to Chelan PUD's request for a Turbine Unit 2 (C2) outage at Rocky Reach Dam during the last week of August 2013 for mandatory rotor crack repair. It was also agreed to employ the same alternative Rocky Reach Surface Collector Operation as approved for the Turbine Unit 1 (C1) outage in April 2013	Coordinating	Appendix A
December 12, 2012	Agreed that Chelan PUD and Douglas PUD will provide their respective draft M&E Implementation Plans to the Hatchery Committees for review no later than July 1 of the preceding year	Hatchery	Appendix B

2.1 Project Survival and Dam Operations

2.1.1 Status of Phase Designations for Current Plan Species

A major feature of the Rocky Reach HCP is what is termed "a phased implementation of measures to achieve the survival standards." Briefly, Phase I consists of a 3-year period in which studies are conducted to determine annual survival rates for each of the Plan Species. Following the completion of 3 years of valid studies, the Rocky Reach HCP Coordinating Committee will determine whether the survival standard has been achieved. Depending on the results of this determination, Chelan PUD will proceed to either Phase II or Phase III. Under Phase II, the Rocky Reach HCP Coordinating Committee would have determined that the standards were not met, and that Chelan PUD would be responsible for evaluating additional tools to improve survival. Under Phase III, the Rocky Reach HCP Coordinating Committee would have determined that the survival standards have been achieved, and that Chelan PUD would be required to re-evaluate survival every 10 years.

Current phase designations for all Rocky Reach HCP Plan Species are summarized in Table 3.

Table 3
Current Phase Designations for Rocky Reach HCP

Plan Species	Project Survival (percent)	Phase Designation	SOA Date
UCR steelhead	95.79[1]	Phase III (Standards Achieved)	October 24, 2006
UCR yearling Chinook	92.28[2]	Phase III (Standards Achieved)	August 30, 2011
UCR subyearling summer/fall Chinook	TBD	Phase III (Additional Juvenile Studies)	June 24, 2008
Okanogan River sockeye	93.59[1]	Phase III (Standards Achieved)	December 17, 2010
Coho	NA	Phase III (Standards Achieved – Interim Value)	June 20, 2007

Notes:
1. Juvenile project survival achieved (HCP standard is 93 percent)
2. Combined adult and juvenile survival achieved (HCP standard is 91 percent)

TBD = To be determined
NA = Not applicable

In 2010, the Coordinating Committees approved a Chelan PUD request to restart passage survival testing of UCR yearling Chinook salmon at the Rocky Reach Project, starting with the year 2011. In 2011, the estimated juvenile yearling Chinook project survival was 92.94 percent. In 2011, Chelan PUD presented to the Coordinating Committees passive integrated transponder (PIT) tag data in support of an empirically based estimate of adult spring Chinook project passage survival for the Rocky Reach Project. As described in Section 2.1.2 of this report, Section 5.2 of the Rocky Reach HCP states that a combined adult and juvenile project survival of 91 percent shall be achieved and maintained. Only due to an inability to differentiate hydro-related mortality from natural adult losses and straying rates, when the HCP was developed, 93 percent juvenile project survival and 95 percent juvenile dam passage survival standards were used as alternative measures of initial compliance. Using PIT tag data, the 3-year (2009 to 2011) average adult spring Chinook passage survival rate at Rocky Reach was estimated to be 99.90 percent. Combined with a 4-year average (2004, 2005, 2010, and 2011) Rocky Reach Project yearling spring Chinook passage survival estimate of 92.37 percent, the combined adult and juvenile survival was estimated to be 92.28 percent, which exceeds the HCP combined survival standard of 91 percent. On August 30, 2011, a

Phase III (Standards Achieved) designation for UCR spring Chinook for the Rocky Reach Project was approved by the Rocky Reach Coordinating Committee.

No new or additional project survival studies were conducted in 2012 for the Rocky Reach Project.

2.1.2 Assessment of Project Survival

The HCP requires that Chelan PUD shall work toward 91 percent combined adult and juvenile project survival at Rocky Reach Dam, achieved by project improvement measures implemented within the geographic area of the project. Progress toward this objective is described in the following sections.

2.1.2.1 Adult Passage Monitoring

2.1.2.1.1 Rocky Reach Project

When the HCP was signed in 2002, it was acknowledged that there is no scientifically rigorous method for the Rocky Reach HCP Coordinating Committee to assess adult project survival for Plan Species. Existing methods did not differentiate between mortality caused by the project and other sources of mortality (such as mortality from natural causes, injuries and delayed mortality resulting from passage at downstream projects and marine mammal predation, harvest, or other types of non-project-specific mortality). Section 5.2 of the HCP states that given the inability to differentiate between the sources of adult mortality, initial compliance with the combined adult and juvenile survival standard would be based on the measurement of 93 percent juvenile project survival or 95 percent juvenile dam passage survival, and an adult survival estimate of 98 to 100 percent.

In December 2012, Chelan PUD was able to evaluate adult passage survival through the Rocky Reach Project (dam and reservoir) for steelhead and sockeye, even though unknown harvest mortality remained in the survival estimates. PIT tag detections from the PITAGIS database were used to evaluate adult fish migrating upstream in 2010, 2011, and 2012 to estimate project conversion rates. For steelhead, adult fish destined for the Methow and Okanogan River systems were used for the survival evaluation. For sockeye, adults returning to the Okanogan River Basin were evaluated. The three-year arithmetic mean survival rates at Rocky Reach Project for adult steelhead and sockeye were 98.93 percent and 98.92 percent, respectively (Table 4). A year prior in 2011, Chelan PUD estimated the three-year mean survival rates for adult spring Chinook migrating through the Rocky Reach Project. This survival estimate was 99.90 percent for migration years 2009 through 2011.

Table 4 details HCP juvenile, adult, and combined survival rates at the Rock Island and Rocky Reach projects. Adult conversion rates were calculated from adult passage data for the years 2010 through 2012 (Buchanan and Skalski, University of Washington, 2012).

Table 4
HCP Juvenile, Adult, and Combined Survival Rates at Rock Island and Rocky Reach

Project	Species	Juvenile Survival	Adult Survival	Combined [5]
Rock Island	Steelhead	96.75%	99.31% [2]	96.08%
	Spring Chinook	93.75% [1]	99.89% [3]	93.65%
	Sockeye	93.27%	98.37% [2]	91.75%
Rocky Reach	Steelhead	95.79%	98.93% [2]	94.77%
	Spring Chinook	92.37% [1]	99.90% [3]	92.28%
	Sockeye	93.59%	98.92% [4]	92.58%

1. Spring-migrating yearling Chinook.
2. Estimate does not account for fish losses due to recreational harvest in any years
3. No recreational harvest occurred.
4. Estimate adjusted for fish losses from recreational harvest in 2010 and 2011, but not for harvest losses in 2012.
5. Combined survival is the product of juvenile and adult survival estimates (e.g., 98% × 93% = 91%).

The HCP combined adult and juvenile project survival standard is 91 percent. The HCP combined adult and juvenile project survival estimates apply to fish actively migrating through the Rock Island and Rocky Reach projects in the mainstem Columbia River and do not include mortality occurring in other locations (i.e., they do not include ocean or tributary mortality).

2.1.2.1.2 Tumwater Dam

In January 2011, an evaluation of adult fish passage conditions at Tumwater Dam using real-time monitoring of PIT tag data from spring Chinook and sockeye indicated significant delays and obstructions in adult passage under trapping operations. In March 2011, the HCP

Hatchery Committees began working on operating protocols for the Tumwater Dam fish trapping facility to address trapping delays at Tumwater Dam for implementation in 2011. In May 2011, a Tumwater Dam Trap Operation Plan (TWD Operation Plan) was submitted to NMFS and USFWS for a check on consistency with Chelan PUD's Incidental Take Statements. The TWD Operation Plan included: timing and scheduling of fish trap operations; protocols for processing fish in the fish trap during broodstock collection; plans for moving broodstock collection efforts to other fish collection facilities; protocols for fish handling activities at the fish trap in addition to broodstock collection efforts (i.e., steelhead and spring Chinook reproductive success studies); and plans for monitoring adult fish passage to allow for the identification of adult passage delay problems during trap operations. The monitoring of adult passage timing at Tumwater Dam in 2011, during the peak salmon and steelhead adult migration, indicated that adult passage delays at Tumwater Dam were reduced by implementing the trap operation protocols. In 2012, the Rocky Reach and Rock Island Hatchery Committees agreed, along with NMFS and USFWS, to implement the same Tumwater Dam operations for 2012 as were implemented in 2011 (Appendix B).

2.1.2.2 2012 Survival Studies

2.1.2.2.1 Yearling Chinook Salmon

In 2011, Chelan PUD conducted a yearling Chinook survival study at Rocky Reach. This study was originally intended to be the first year of the restart of up to 3 years of testing of yearling Chinook project passage survival at Rocky Reach Project. The 2011 project survival estimate was 92.94 percent. Although only three survival estimates are required, if averaged with yearling Chinook survivals from 2004, 2005, and 2010, the estimated survival was 92.37 percent. When the 4-year survival estimate was combined with the adult spring Chinook conversion rate from Rocky Reach Dam to Wells dam (99.90 percent), the combined adult and juvenile survival for Rocky Reach Project equals 92.28, exceeding the HCP combined standard of 91 percent survival. On August 30, 2011, with 1 year of additional testing, Phase III Standards Achieved was approved for yearling Chinook using the combined adult and juvenile spring Chinook survival at Rocky Reach Project. In February 2012, the 2011 Rocky Reach Yearling Chinook Survival Study report (Appendix G) was finalized and distributed to the Coordinating Committees.

2.1.2.2.2 Subyearling Chinook Salmon

In 2010, Chelan PUD began compiling information on PIT tag detections of subyearling Chinook at Rocky Reach Dam to further the understanding of subyearling life histories in the mainstem Columbia River upstream of Rocky Reach Dam. By June 2011, however, the number of detections was less than 50 fish, limiting the ability to conduct a useful analysis. Chelan PUD discontinued the PIT tag analysis pending Douglas PUD's 2011 assessment of available, taggable subyearling Chinook and capture success in the Wells Reservoir. In 2011 and 2012 Douglas PUD significantly increased the numbers of PIT tagged subyearling Chinook salmon migrating from the UCR, and Chelan PUD, along with Douglas PUD, is once again compiling data on migration behavior and survival of UCR subyearling migrant Chinook salmon. In addition, Chelan PUD is developing a series of briefing reports on the status of subyearling Chinook survival studies in the entire Columbia River Basin, and will be using these reports to propose a path forward for similar studies at the Rocky Reach and Rock Island projects in 2013.

2.1.2.3 2013 Planned Survival Studies

There are no planned Rocky Reach juvenile salmonid project survival studies for 2013. Chelan PUD has achieved a Phase III (Standards Achieved) designation for yearling Chinook, sockeye, and steelhead at the Rocky Reach Project (Section 2.1.1). However, subyearling Chinook survival status is pending development of suitable methods, and is currently designated Phase III (Additional Juvenile Studies). These designations will be re-evaluated at 10-year intervals, as required.

2.1.3 Project Operations and Improvements

This section summarizes project operations and progress toward achieving the juvenile project survival standard at Rocky Reach Dam in 2012. Actions in 2012 were guided by the 2012 Chelan PUD HCP Action Plan (Appendix I), as approved by the Coordinating Committees (Appendix A).

2.1.3.1 Operations

2.1.3.1.1 Juvenile Bypass and Fish Spill Operations[3]

In March 2012, the Coordinating Committees approved the 2012 Rocky Reach Fish Bypass Operations Plan (Appendix J), and the 2012 Rocky Reach and Rock Island Fish Spill Plan (Appendix K). The juvenile bypass system operated from April 1, 2012, through August 31, 2012, during the outmigration of juvenile salmon and steelhead at Rocky Reach. The target level for summer spill was 9 percent of the daily average river flow. Spill for summer-migrating subyearling Chinook at Rocky Reach Dam began on May 26, 2012, at 0001 hours, and continued through midnight on August 9, 2012. Following completion of the bypass operations on August 31, 2012, it was estimated that spill was provided for 97.42 percent of the subyearling Chinook outmigration. Spill volume for the 76-day summer period averaged 31.86 percent of the total river flow, and was composed of 9 percent fish spill and an additional 22.86 percent unavoidable hydraulic spill. The Columbia River flows past Rocky Reach Dam during the spill period averaged 233,370 cubic feet per second (cfs) and the daily average spill rate was 74,355 cfs. Complete Rocky Reach Dam 2012 fish spill operations results are summarized in the 2012 Rocky Reach and Rock Island Fish Spill Report as attached to the Coordinating Committees September 25, 2012 meeting minutes (Appendix A).

2.1.3.1.2 Pikeminnow Predator Control

In 2012, northern pikeminnow predator control work continued with Columbia Research long-line angling during the pre-migration period to target large pikeminnow staging in deep reservoir areas that are difficult to capture with other gear types; the contract was extended to overlap with the 2012 USDA effort. The USDA hook-and-line angling program commenced during the peak of juvenile salmonid migration. The total combined harvest of pikeminnow in 2012 from Rocky Reach and Rock Island reservoirs was 70,470 fish. Harvest numbers from the various control efforts in 2012 were as follows: USDA hook-and-line angling—36,118 fish; Columbia Research long-line angling —30,227 fish; East Wenatchee Rotary Club pikeminnow derby—2,894 fish; angling by Chelan PUD Fish and Wildlife personnel—1,231 fish. Chelan PUD once again provided contract funding for the annual

[3] 129 FERC ¶ 62,183 (issued December 8, 2009). Order Modifying and Approving Operations Plan Pursuant To License Article 402.

East Wenatchee Rotary Club Pikeminnow Derby in 2012. A report summarizing results of the 2012 removal effort is expected sometime in early 2013.

2.1.3.1.3 Total Dissolved Gas Testing at Rocky Reach Dam

Under the Clean Water Act 401 Water Quality Certification of the Rocky Reach FERC License, Chelan PUD is required to implement alternative spillway operations to determine whether total dissolved gas (TDG) levels can be reduced. In 2011, Chelan PUD conducted an informal test of spillway operations not previously tested under the high-flow conditions to evaluate the effectiveness of alternative operations using gates 2 through 12, to determine whether TDG levels could be reduced without adverse effects on fish passage. In June 2012, the same four spill configurations that were tested at Rocky Reach in 2011 were tested again to collect additional data on how tailrace TDG levels respond to different spill gate patterns. Testing was conducted 24 hours a day, every day, from June 18, 2012, until July 30, 2012. During this time, fish passage counts were monitored daily, using PIT tag data, to see if passage trends showed any obvious time differences for the three test patterns compared with the "normal spill" pattern. Results from the 2011 testing will be combined with 2012 data to determine if there is a statistical difference in the gate patterns. These results are expected sometime in 2013.

2.1.3.2 Improvements and Maintenance

Facility improvements and maintenance at the Rocky Reach Project in 2012 that had the potential to affect Plan Species are described in this section.

Late winter 2011/early winter 2012 annual maintenance of the Rocky Reach fishways was completed and the ladders were fully operational before the March 1, 2012 deadline. The Coordinating Committees approved an earlier-than-usual start time for the 2012/2013 annual maintenance to allow more time to complete needed work. Dewatering of the Rocky Reach fishway began on December 17, 2012.

In October 2012, FERC requested a mandatory inspection of the Rocky Reach spillway apron and dragons teeth, which required intermittent closure of the middle spillway entrance to the Rocky Reach Fishway from October 15, 2012, to October 18, 2012. Outages were required in order to install barriers to inspect the entire spillway apron. Data on upstream passage of adult salmon were analyzed and analyses did not indicate any significant statistical differences among passage numbers or rates before, during, or after the outages; therefore, it was concluded that the outages had minimal effects.

Turbine Unit 1 (C1) at Rocky Reach Dam will be taken offline during the 2012/2013 maintenance period for mandatory rotor crack repair, and will be placed back online by May 1, 2013. While C1 is offline, the Rocky Reach Juvenile Fish Bypass (RRJFB) Surface Collector (SC) will use additional SC pumps to increase attraction flow, and Turbine Unit 2 (C2) flow will be increased. This alternative operation will be tested during the normal pre-season (the last week of March) to insure there are no effects on fish condition or passage.

Other Rocky Reach fishway maintenance work scheduled for the 2012/2013 maintenance period includes a full juvenile bypass inspection and evaluation, annual fish ladder maintenance, and replacement of a half-duplex PIT tag antenna in the right powerhouse entrance to the adult fishway.

2.2 Hatchery Compensation

Section 8.1 of the Rocky Reach HCP describes a Hatchery Compensation Plan with two primary objectives: 1) to provide compensation for Plan Species; and 2) to implement specific elements of the hatchery program consistent with the overall objectives of rebuilding natural populations and achieving NNI. In 2012, Chelan PUD continued funding and providing capacity for hatchery production consistent with NNI, and will continue to do so through 2013. Recalculated hatchery production necessary to meet NNI for the next ten years (2014 through 2023) was approved by the Rocky Reach Hatchery Committee on December 14, 2011 and represents "Chelan PUD's No Net Impact and Inundation obligations for release years 2014-2023." Hatchery compensation for Rocky Reach Project in 2012 included the release of 1,752,021 juvenile salmonids, consisting of 914,221 fish from smolt production and 837,800 sockeye fry from Shuswap River Hatchery (combined Rocky Reach and Rock Island hatchery compensation—see Table 5).

To improve coordination, a representative from Grant PUD is invited to the monthly Hatchery Committees meetings. In addition, the Grant PUD representative and the Priest Rapids Coordinating Committees (PRCC) Hatchery Subcommittee facilitator receive meeting announcements, draft agendas, and meeting minutes. This practice benefits the Hatchery Committees through increased coordination and sharing of expertise. The Grant PUD representative has no voting authority.

2.2.1 Hatchery Production Summary

Table 5 summarizes and compares HCP hatchery production objectives and actual 2012 smolt releases.

Table 5
2012 Production Level Objectives and Smolt Releases for Rocky Reach HCP Hatchery Programs

Species	Program	Final Rearing Site	Rocky Reach Production Level Objectives (2004 to 2013)	Total Smolt Releases for Rocky Reach in 2011 (Number of fish)	Total Smolt Releases from Final Rearing Site
Spring Chinook	Methow	Methow Hatchery	144,000	144,000	874,908
Summer Chinook	Chelan Falls Yearlings	Chelan Falls	600,000	563,824	563,824
Steelhead[1]	Wenatchee	Chiwawa Hatchery	247,300	206,397	206,397
Sockeye	Okanogan	Shuswap Hatchery	291,040[2]	837,800[3]	837,800

Notes:
1. Steelhead production at Chiwawa includes both Rock Island and Rocky Reach obligations.
2. Combined with the Rocky Reach HCP, the Okanogan sockeye production requirement totals 591,040 fish (production is allocated between the two HCPs). By agreement of the HCP Hatchery Committee, this production requirement is satisfied for Okanogan sockeye by funding of the Okanogan Skaha Lake sockeye reintroduction program until otherwise determined by the HCP Hatchery Committees.
3. The total number of fry released by the Skaha Lake Program was 837,800 in 2012 (including Grant PUD's production).

2.2.2 Hatchery Planning

The following sections detail 2012 actions that are relevant to planning for hatchery operations that support the HCP.

2.2.2.1 2012 Broodstock Collection Protocols

The Hatchery Committees began reviewing the draft 2012 Broodstock Collection Protocols in March and April 2012 (for Chinook and coho salmon, and steelhead). The protocols were finalized in April 2012 and implemented at program hatcheries (Appendix L); in-season revisions were made as needed in coordination with the Hatchery Committees. As recommended by the Hatchery Committees, a prioritized broodstock collection list was added to the 2012 protocols. Coho broodstock collection protocols were provided by the YN and subsequently incorporated into the 2012 Broodstock Collection Protocols. The 2012 Broodstock Collection Protocols were intended to guide the collection of salmon and steelhead broodstock in the Methow River, Wenatchee River, and Columbia River basins. The protocols are consistent with previously defined program objectives such as program operational intent (i.e., conservation and/or harvest augmentation) and mitigation production levels (HCPs, Priest Rapids Dam 2008 Biological Opinion), and they comply with ESA permit provisions.

2.2.2.2 2014 to 2023 NNI Production Levels

Section 8.4.3 of the Rocky Reach HCP specifies that hatchery production levels, except for original inundation mitigation, will be adjusted in 2013 and every ten years thereafter to achieve and maintain NNI. In September 2010, the process to recalculate hatchery production was initiated by the HCP Hatchery Committees. Recalculated hatchery production levels are scheduled for release beginning in 2014, which required adjustments to broodstock collection as early as 2012. After approving a method for recalculating hatchery production on July 20, 2011, and approving as final a database containing the numeric inputs for use in the recalculation efforts on August 17, 2011, the Hatchery Committees approved recalculated hatchery production for Chelan PUD's NNI supplementation programs for 2014 through 2023 on December 14, 2011.

2.2.2.3 Five-Year Hatchery M&E Report

During 2011, as required by the HCP (Sections 8.5.1 and 8.7), Chelan PUD conducted an analysis of available salmon and steelhead survival and productivity data for use in evaluating the performance of Chelan PUD's salmon and steelhead hatchery supplementation programs during the 5-year period from 2006 to 2010. This 5-Year Hatchery M&E Report was the first 5-year report required by the HCP. In May 2012, after a 60-day Hatchery Committees review period, the Chelan PUD Final 5-Year Hatchery M&E Report (Appendix M) was approved.

2.2.2.4 Adjustment of 2012 Steelhead NNI Production Levels

In 2006 and 2010, respectively, Chelan PUD completed the survival studies at the Rocky Reach and Rock Island projects, which are the basis for adjusting hatchery NNI compensation levels for steelhead. During the development of the HCP, Chelan PUD had agreed to an initial hatchery compensation level of up to, and often greater than, 14 percent. In February 2011, Chelan PUD introduced an SOA requesting Hatchery Committees' concurrence to reduce Wenatchee steelhead production consistent with the completed juvenile project survival estimates. Adjusted program levels allowed for the rearing and acclimation of 100 percent of Chelan PUD steelhead hatchery production within the Wenatchee Basin. It was anticipated that in-basin rearing would improve homing fidelity and improve the contribution of the program to rebuilding UCR steelhead. On March 16, 2011, the Hatchery Committees approved adjustment of Wenatchee steelhead hatchery production levels for brood years 2011 to 2012, commensurate with NNI for the Rocky Reach and Rock Island projects and reflecting available capacity at the Chiwawa Acclimation Facility in the Wenatchee Basin.

2.2.2.5 2012 Wenatchee Steelhead Acclimation and Release Plan

In late-August 2011, Chelan PUD, the YN, and WDFW produced a 2012 Wenatchee Steelhead Stocking and PIT Tag Distribution Plan that was approved by the Hatchery Committees. This document is revised and approved annually based on analysis of M&E data for the Wenatchee hatchery steelhead program from previous years.

In November 2012, Chelan PUD presented analyses of post-release survival rates of Wenatchee steelhead. Results indicated unprecedentedly low post-release survival rates of steelhead smolts migrating from the Chiwawa River, Nason Creek, and Wenatchee River in 2012, based on PIT tag detections at McNary Dam. Potential causes for these low survival rates included: overwinter acclimation; brood origin; size at release; timing; volitional release; and release number, or number of fish in each release group. Based on these data that indicate new release approaches implemented in 2012 significantly compromised survival of juvenile steelhead, Chelan PUD recommended reverting back to release techniques with proven success before implementing unproven changes in 2013.

Discussion of a formal Wenatchee Steelhead Acclimation and Release Plan for 2013 is planned for February 2013.

2.2.2.6 M&E Plan Implementation

In 2012, Chelan PUD continued to implement M&E activities to meet goals and objectives of the *Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Hatchery Programs* (2005). Implementation of this M&E Plan began in 2006 and continues in accordance with two refining documents: the *Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs*, prepared in 2006 (and updated in 2007), which identifies the analytical strategies and methods for the M&E Program; and the *Chelan County PUD Hatchery Monitoring and Evaluation Work Plan 2012* (M&E Work Plan), which is prepared annually and describes the M&E activities for the next calendar year, and which anticipates that adaptive modification of the plan may be necessary in future years. In August 2012, the Hatchery Committees agreed to defer implementation of the fully revised Hatchery M&E Program until 2014; in 2013, they agreed to implement the existing M&E programs with minor updates. This revised schedule will align new Section 10 permits with the proposed date for the new M&E programs, and also allows more time for a thorough review of the existing programs to inform any modifications to the revised Hatchery M&E Program. In January 2013, the Chelan PUD M&E Work Plan for 2013 (Appendix N) was finalized after a 30-day Hatchery Committees review period. As in previous years, Chelan PUD provided an M&E Annual Report documenting M&E activities in 2011, titled

Monitoring and Evaluation of the Chelan County PUD Hatchery Programs (Appendix O). A similar report will be prepared in 2013 for 2012 hatchery evaluation.

2.2.2.7 Okanogan Sockeye Mitigation

In 2012, Chelan PUD provided a seventh year of funding for a portion of the Skaha Lake Sockeye Salmon Reintroduction Program (current Rocky Reach obligation for Okanogan sockeye salmon mitigation is 591,040 smolts for both Rocky Reach and Rock Island HCPs combined). The Shuswap River Hatchery compensation included the release of 837,800 sockeye fry from the Hatchery. Funding in 2012 also included the continued design of the new fish hatchery in Penticton, British Columbia.

2.2.2.8 Hatchery Production Management Plan

In 2011, WDFW, in coordination with the HCP Hatchery Committees, drafted a Hatchery Production Management Plan to document criteria, measures, and actions that contribute to better meeting hatchery production targets, and minimize overproduction. Although not finalized in 2011, WDFW began implementing those actions identified in the draft 2011 Hatchery Production Management Plan for which there was support among the fishery co-managers. In 2012, the Hatchery Production Management Plan was finalized and approved and included as an appendix to the Final 2012 Broodstock Collection Protocols that was submitted to NMFS in April 2012.

2.2.2.9 HGMPs for Chiwawa Spring Chinook and Wenatchee Steelhead

In October 2009, Chelan PUD submitted Chiwawa Spring Chinook and Wenatchee Steelhead HGMPs to NMFS. In 2012, NMFS continued their review of the Chiwawa spring Chinook program HGMP and began their review of the Wenatchee steelhead hatchery program HGMP. Draft Terms and Conditions were developed in late 2012, and NMFS is anticipating completion of consultation and issuance of new permits in spring 2013.

2.2.2.10 Objective 10 of the Hatchery M&E Plan—Non-target Taxa of Concern

In 2012, the HETT began preliminary runs of the risk assessment model (developed in 2009) using the recalculated production numbers. Due to the unexpected amount of time needed to complete the NTTOC risk assessment, the HETT limited modeling of NTTOC/hatchery program interactions to a subset of all possible interactions, including only hatchery programs that are representative of certain types of interactions that may occur and that were necessary to model for the analysis to remain robust. In August 2012, the HETT agreed to compile the results of model runs completed to date into a database for analysis, which would then be used to assess Delphi panel results in comparison with the model results. The HETT also agreed that the Delphi panel will initially consist of a smaller group of local scientists and that the HETT will produce a report on the NTTOC modeling and Delphi results for the Hatchery Committees; and then later, the HETT will potentially engage a broader Delphi panel and ultimately develop a more robust manuscript.

2.2.2.11 Steelhead Reproductive Success Study

Section 8.5.3 of the Rock Island HCP requires that Chelan PUD fund and implement a steelhead reproductive success study (RSS). The RSS began in 2008 and incorporates four brood years (2008, 2009, 2010, and 2011). WDFW and NMFS issued a revised report in February 2012 that presented preliminary ecological and demographic results, an overview of genetic analysis methods, and preliminary results and conclusions to the Hatchery Committees. In future years, the report will be available in September or October.

2.2.2.12 Wenatchee Steelhead Hatchery, Wild Spawn Timing, and Spawner Distribution Activities

In 2010 Chelan PUD funded a study on the distribution and spawn-timing of hatchery and wild steelhead in the Wenatchee and Methow Subbasins; WDFW is conducting the study. All steelhead trapped at Priest Rapids Dam were PIT tagged, with females also receiving Floy tags. During subsequent spawning ground surveys, the numbers of redds, redd locations, and tagged fish were recorded. Results of the study in 2010 indicated that both Wenatchee and Methow Basin hatchery and wild steelhead spawned in the same general locations. In 2011, WDFW continued the study, with improved tagging methods as indicated by the 2010 results; the frequency of the surveys was increased to twice per week. The 2012 draft report summarizing 2011 results will be available in early 2013.

2.2.2.13 Parental Based Tagging Pilot Study

A genetic analysis of spring Chinook began in 2010 with the collection of tissue samples from spring Chinook sampled at Priest Rapids Dam. The sampled adults were PIT tagged and released to continue migration. PIT tag detections of sampled fish were monitored at upstream PIT tag detector arrays and tissue samples were analyzed to establish fish origin. Initial analyses of the 2011 samples suggested low assignment probability, with only about 10 percent of the adults sampled at the Priest Rapids Dam identifiable to a tributary-of-origin. Preliminary results indicated, however, that the assignment probabilities were much higher than originally thought; and in February 2012, WDFW presented a re-analysis of the 2010 and 2011 parental based tagging (PBT) study results that concluded that parental analysis could be used to successfully identify Wenatchee-origin spring Chinook. However, parental analysis would require a sampling rate at Priest Rapids Dam that exceeds the average annual return of Wenatchee-origin spring Chinook, as well as 100 percent handling of all spring Chinook (both wild- and hatchery-origin fish) at Tumwater Dam. Results indicated that a likelihood of detection (LOD) greater than 10 and a two-parent assignment should result in 90 to 100 percent correct assignment; however, due to the requirement to handle 100 percent of all spring Chinook encountered at Tumwater Dam, the Hatchery Committees agreed that implementation of PBT at this location was infeasible. Results of the analysis were summarized in two reports: *Priest Rapids Dam – Wenatchee River Spring Chinook Salmon Parentage-based Tagging Project: Two-year Summary of Testing Accuracy of Parentage Assignments*; and *2010 and 2011 Parental-Based Tagging Project at Priest Rapids Dam*, as attached to the Hatchery Committees February 2012 meeting minutes (Appendix B).

2.2.2.14 Spring Chinook Size-at-Release Targets

In December 2011, Chelan PUD presented an analysis of the relationship between the size of juvenile hatchery spring Chinook versus the size of juvenile wild spring Chinook, along with performance, as reflected in age-at-maturity and survival, using PIT tag data from more than 65,000 spring Chinook between 2006 and 2009. The analysis indicated that hatchery smolts released from the Chiwawa Acclimation Facility survived to McNary Dam at a higher rate than wild fish, but that adult returns, based on PIT tag data, showed that wild fish had a higher adult return rate in comparison with hatchery fish. The results further demonstrated that larger hatchery smolts resulted in significantly more mini-jacks and jacks, whereas smaller smolts contributed to more 3-salt adults. Based on the analysis, Chelan PUD proposed reducing the release size targets for hatchery-origin Chiwawa spring Chinook. The intentions of the program adjustment are to: 1) more closely mimic wild-origin smolt populations; 2) replicate the unique length-weight relationship of Chiwawa spring Chinook; and 3) increase age at maturity for hatchery-origin adults. Further, a reduction in size at release was supported by the Hatchery M&E results and in documentation by NOAA scientists. In January 2012, a complete report of results was released: *Use of Monitoring and Evaluation Data to Identify Appropriate Size at Release Targets for Hatchery-origin Chiwawa River Spring-run Chinook Salmon Oncorhynchus Tshawytscha*, (Appendix B); and in February 2012, the Hatchery Committees conditionally approved an SOA (Appendix F) to adjust the size at release target for the Chiwawa Spring Chinook program from 12 fish-per-pound to 18 fish-per-pound beginning with the 2012 brood year (the SOA was officially approved in March 2012 [Appendix F]).

2.2.2.15 Chelan PUD Spring Chinook Compensation 2014 Release Year

In January 2012, in response to a JFP request to increase Chiwawa spring Chinook production starting with the 2014 release year, the Hatchery Committees approved Chelan PUD meeting its 2014 spring Chinook mitigation obligation through production of 204,542 smolts at the Chiwawa Acclimation Ponds in lieu of production requirements in the Methow River, contingent on the Methow River production of 60,516 smolts being produced by another entity (Appendix F).

2.2.2.16 Dryden Overwintering Feasibility Study/Wenatchee River TMDL

In January 2012, Chelan PUD began evaluating the feasibility of converting the Dryden and/or Carlton facility to a permanent overwintering facility for the purpose of accommodating Grant County PUD's production obligations, which require overwinter acclimation. Overwintering was proposed by the JFP as an alternative acclimation method to improve smolt-to-adult returns (SARs) and to reduce straying for Grant PUD's summer Chinook programs. In 2012, Chelan PUD worked with Grant PUD to develop a mutually beneficial agreement for the shared use of these facilities. Work will be ongoing in 2013.

In conjunction with these discussions, Chelan PUD has been evaluating ways to meet Ecology's addendum to the Wenatchee River TMDL, which establishes a modified phosphorus target not to exceed 743 micrograms per liter for the entire Wenatchee River and also a point discharge limit for the Dryden Facility. Facilities must be compliant with the TMDL in 2018.

After discussions and presentation of data to the Hatchery Committees in July 2012, Chelan PUD proposed a path forward to ensure that summer Chinook production and infrastructure at the Dryden facility would comply with the Wenatchee River TMDL for phosphorus. This proposed path forward would result in a decision by 2015 on how to meet the 2018 phosphorus TMDL.

2.2.2.17 Rohlfing Pond Steelhead Trap

In March 2012, the Hatchery Committees agreed to the YN's proposal to use actively migrating coho and steelhead from Rohlfing Pond for smolt-trap efficiency trials for the Nason Creek steelhead smolt trap (Appendix B). Steelhead were scanned for PIT tags and all fish captured coming out of Rohlfing Pond were PIT tagged (standard Wenatchee and Methow subbasins PIT tagging protocols were applied). The release site for the efficiency trials was approximately 1 mile upstream from the trap.

2.2.2.18 Residualism

In April 2012, WDFW initiated a discussion of the management of non-migrating juvenile hatchery steelhead because the ESA Section 10 permit under which the hatcheries operate limits the release of non-migrating fish. Hatchery managers have been employing volitional release at Wells Hatchery, with varying numbers of non-migrants ultimately being forced out. In May 2012, Chelan PUD presented findings on Wenatchee steelhead residuals and predation. Avian predation was measured by recovering PIT tags from Island 18, Foundation Island, Badger Island, and Crescent Island. A logistic regression on hatchery releases from April 15, 2012, through May 25, 2012, showed a significant correlation between later release and a higher likelihood of recovering a PIT tag on one of the islands.

2.2.2.19 Summer Chinook Growth Modulation Experiment

In July 2012, Chelan PUD and NMFS Science Center staff presented a conceptual draft Mid-Columbia Chinook Salmon Precocity Studies design outlining potential approaches to develop biologically-based growth regimes and size targets (via altering lipid levels and rearing strategies) for Mid-Columbia River hatchery yearling Chinook salmon. Results of this study would contribute information that could maximize performance of hatchery-origin fish and could also help Chelan PUD meet the phosphorus TMDL targets at the Dryden facility. In August 2012, the Hatchery Committees agreed to proceed with the study, contingent upon receiving a more complete study plan that includes: 1) fish size targets and estimated pond timing; and 2) a section on sample sizes and proposed statistical methods for analyzing and interpreting results.

2.2.2.20 Chelan PUD Spring Chinook Production

In July 2012, Chelan PUD terminated their Methow Hatchery Sharing Agreement with Douglas PUD. As a result, the last release of Chelan PUD spring Chinook from the Methow Hatchery will be in 2013. Alternative program options were investigated to meet Chelan PUD spring Chinook salmon mitigation in the UCR, including two options for broodstock collection involving: 1) trapping at Rocky Reach Dam and holding at Eastbank Hatchery while Genetic Stock Identification (GSI) is used to determine genetic identity PBT; and 2) trapping at Priest Rapids, PIT tagging, genetic analyses (GSI via micro-satellite or single nucleotide polymorphism) to determine origin, and then recapture at Rocky Reach. Adult holding and rearing was considered at Eastbank Fish Hatchery; and two options for acclimation were considered including: 1) spring acclimation at Carlton with early imprinting; and 2) Carlton overwintering plus YN upper basin acclimation.

In December 2012, the JFP presented a draft strategy to meet Chelan PUD Methow production goals. The Hatchery Committees discussed the JFP recommendation and ultimately decided that for brood year 2013, Chelan PUD will coordinate with NMFS to determine permit coverage that authorizes collection of Methow spring Chinook broodstock using a modified PBT approach at the Rocky Reach trap, and out-of-basin rearing facilities. For adult holding and rearing, Chelan PUD's proposed option to hold and spawn 2013 broodstock at Eastbank Fish Hatchery was agreed to by the Hatchery Committees; and for acclimation, Chelan PUD and the YN agreed to discuss the potential use of upper Methow Basin acclimation sites. USFWS also agreed to discuss the potential to collect, spawn, incubate, and early rear Chelan PUD's Methow spring Chinook at Winthrop National Fish Hatchery in 2013, as an alternative to collecting broodstock at the Rocky Reach trap and holding and rearing at Eastbank Hatchery. USFWS, Chelan PUD, and WDFW agreed to meet in early 2013 to discuss a plan forward for the 2013 broodstock.

2.2.2.21 Chelan Falls Brood Collection

From August to October 2012, Chelan PUD and WDFW conducted a Chelan Falls summer Chinook salmon pilot broodstock collection study (Appendix P) designed to investigate the potential to collect returning Chelan River summer/fall Chinook to use as brood for Chelan Falls Hatchery production. The study's purposes were: 1) to determine if adult summer Chinook salmon could be captured in the vicinity of the Chelan River; 2) to determine which stocks are returning to the area; and 3) to determine the best methods for capture. Sampling the Eastbank Hatchery outfall (EBO) resulted in the highest number of fish captures. Fish collected from the EBO were predominantly male and the coded wire tags (CWTs) indicated that most fish were 4-year-olds from Turtle Rock. Based on these results, recommendations included: 1) discontinuing testing collection methods in the vicinity of the Chelan River; and 2) utilizing the EBO as a trap location for the Chelan Falls program beginning July 2013. The Hatchery Committees also recommended that in 2013, sampling activities be conducted earlier to have the opportunity to intercept females.

2.2.3 Maintenance and Improvements

Maintenance or improvement activities implemented in 2012, in support of hatchery production under the Rocky Reach HCP, are described in this section.

Capacity and reliability improvements were completed at Eastbank Hatchery, including additional testing of the new chiller and installation of the new Motor Control Center.

The inlet structure at Blackbird Pond was modified for increased predator control.

A new anchoring system was installed for the relocated Lower Wenatchee smolt trap (supports M&E activities).

2.3 Tributary Committees and Plan Species Accounts

As outlined in the Rocky Reach HCP, the signatory parties designated one member each to serve on the Tributary Committee. The Rock Island, Rocky Reach, and Wells Tributary Committees meet on a regularly-scheduled basis as a collective group to enhance coordination and minimize meeting dates and schedules. Subject items requiring decisions are voted on in accordance with the terms outlined in the specific HCPs. During 2012, the Tributary Committees met on eight different occasions.

An initial task of the Tributary Committees in 2012 was to review and update their operating procedures that provide a mechanism for decision making; these procedures were initially developed in 2005 and were included in the 2005 annual report (Anchor 2006)[4]. The Tributary Committees also developed Policies and Procedures for soliciting, reviewing, and approving project proposals (Anchor 2005)[5]; this document was last reviewed and updated in April 2012. The Policies and Procedures provide formal guidance to project sponsors on the submission of proposals for projects to protect and restore the habitat of Plan Species within the geographic scope of the HCP. The Committees established two complementary funding programs, the General Salmon Habitat Program and the Small Projects Program.

In 2012, the Tributary Committees revised language to Section VII, Full Disclosure, in the Operating Procedures document. The last sentence in Section VII was changed from, "Committee members should recuse themselves from voting on a particular project if they represent an entity that may benefit from that project" to, "Committee members who represent an entity that submitted a project proposal will not vote on that particular project." Under Section 3.8 in the Policies and Procedures document, the Committees added the

[4] Anchor Environmental, L.L.C., 2006. Annual Report, Calendar Year 2005, of Activities Under the Anadromous Fish Agreement and Habitat Conservation Plan. Wells Hydroelectric Project, FERC license no. 2149. Prepared for FERC by Anchor Environmental LLC. and Public Utility District No. 1 of Douglas County. April 2006.

[5] Anchor Environmental, L.L.C., 2005. *The Tributary Fund Policies and Procedures for Funding Projects.* Prepared for Public Utility District No. 1 of Douglas County and Chelan County Public Utility District. March 2005.

following language, "The Tributary Committees reserve the right to require public access on conservation easements or lands acquired with Plan Species Account funds." The addition of this statement does not require public access on all easements or acquisitions. However, if the Committees believe that a given protection project should have public access, they will make it a requirement for that specific project. Thus, the Committees will evaluate public access on a case-by-case basis. Finally, after examining the appraisal process used by project sponsors, the Committees decided to hire their own appraisers. The Committees hired Larry Rees as their primary appraiser and Michael Gentry, Peter Shorett, and Fred Strickland as reviewers. These appraisers will conduct all appraisals and reviews on conservation easements and acquisitions funded by the Tributary Committees.

2.3.1 Regional Coordination

Similar to the Hatchery Committees and to improve coordination, a representative from Grant PUD and the facilitator of the PRCC Habitat Subcommittee were invited to the Tributary Committees monthly meetings. In addition, they received meeting announcements, draft agendas, and meeting minutes. This benefits the Tributary Committees through increased coordination and sharing of expertise. The Grant PUD representative and PRCC Habitat Subcommittee facilitator have no voting authority. The Tributary Committees, through the Coordinating Committees, also invited American Rivers and the Confederated Tribes of the Umatilla Indian Reservation to participate in Committees meetings. Both parties contributed to the development of the HCP, yet elected not to sign the document. Neither of these parties participated in the deliberations of the Tributary Committees in 2012.

The Tributary Committees also coordinate with the Upper Columbia Salmon Recovery Board (UCSRB). Coordination is typically between the chairperson of the Tributary Committees and the Executive Director or Associate Director of the UCSRB. The Tributary Committees also invite representatives from the UCSRB to at least one meeting per year to update the Committees on activities proposed by the Board. In addition, some members of the Committees typically attend the UCSRB meetings to foster coordination in developing and selecting projects for funding. Some members of the Committees are also members of the UCSRB's Regional Technical Team (RTT), which increases coordination in selecting projects for funding. Many of the policies and procedures of the Salmon Recovery Funding Board (SRFB) and Tributary Committees are complementary, and annual funding rounds by these funding entities have been coordinated over the last several years.

The Tributary Committees held a funding coordination meeting with the Bonneville Power Administration in July 2012. The purpose of the meeting, according to Section 2 of the Tributary Fund Policies and Procedures for Funding Projects, was to collaborate with regional, local, state, tribal, and national organizations that fund salmon habitat projects. The meeting resulted in identification of cost-shares for suitable habitat restoration projects.

2.3.2 Fiscal Management of Plan Species Accounts

The Tributary Committees set up methods for the long-term management of the Plan Species accounts for each HCP. The Rocky Reach Tributary Committee appointed the accounting firm Clifton Larson Allen to perform the necessary tasks for fiscal management of the Rocky Reach Plan Species Account. These tasks include, but are not limited to, the following: (1) develop a long-term approach to maintain the funds and to carry out tax calculations and reporting; (2) conduct the daily management of activities (such as processing of invoices); and (3) provide technical expertise on financial matters to the committees. The beginning balance of the Rocky Reach Plan Species Account on January 1, 2012, was $1,905,051.85; Chelan PUD's annual Rocky Reach contribution was $318,959; interest accrued during 2012 was $4,617.04; funds disbursed for projects in 2012 totaled $180,479.47; and $5,055.91 was paid to Clifton Larson Allen and Chelan PUD for account administration during 2012, resulting in an ending balance of $2,063,006.53 on December 31, 2012. The 2012 Annual Financial Report for this Plan Species Account is provided in Appendix J.

The Rocky Reach Tributary Committee delegated signatory authority to the Tributary Committees Chairperson for processing of payments for invoices approved by the Committee, with the Coordinating Committee Chairperson serving as the alternate. Chelan PUD recognizes the uniqueness of the Tributary Committee decision-making process, and the delegation of signatory authority to the Tributary Committees Chairperson, and subsequently has provided the funding necessary to assign reasonable liability insurance to the Tributary Chairperson.

2.3.3 General Salmon Habitat Program

The Tributary Committees established the General Salmon Habitat Program as the principle mechanism for funding projects. The goal of the program is to fund projects for the protection and restoration of Plan Species habitat. An important aspect of this program is to assist project sponsors in developing practical and effective applications for relatively large projects. Many habitat projects are increasingly complex in nature and require extensive design, permitting, and public participation to be feasible. Often, a reach-level project involves many authorities and addresses more than one habitat factor. Because of this trend, the General Salmon Habitat Program was designed to fund relatively long-term projects. There is no maximum financial request in the General Salmon Habitat Program; the minimum request is $50,000, although the Tributary Committees may provide lesser amounts during a phased project.

In an effort to coordinate with ongoing funding and implementation programs within the region, the Tributary Committees used the previously established technical framework and review process for this geographic area, and worked with the other funding programs to identify cost-sharing procedures (see Section 1.1.1).

2.3.3.1 2012 General Salmon Habitat Projects

The Tributary Committees announced their 2012 funding cycle in March 2012, with pre-proposal applications due on May 7, 2012 and full proposals due on June 29, 2012. The Tributary Committees received and reviewed 27 pre-proposal applications. The Tributary Committees identified 14 projects that they believed warranted full proposals and dismissed 13 projects because they did not have strong technical merit.

In June, the Tributary Committees received 16 full proposals to the General Salmon Habitat Program. All but one were "cost-shares" with the SRFB or other funding entities. The Tributary Committees approved funding for five projects. Table 6 identifies the projects, sponsors, total cost of each project, amount requested from Tributary Funds, and, if funded, which Plan Species Account supported the project.

Table 6

General Salmon Habitat Program Projects Reviewed by the Tributary Committees in 2012

Project Name	Sponsor[1]	Total Cost	Request from TC[2]	Plan Species Account[3]
Lower Wenatchee Sleepy Hollow Easement	CDLT	$545,000	$136,250	Not funded
Lower White Floodplain Rehabilitation	CCFEG	$125,000	$25,000	Not funded
Nason Creek RM 3.7-4.7 Restoration	CCNRD	$398,233	$60,000	Not funded
Skinney Creek Floodplain Restoration Design	CCNRD	$60,000	$4,000	Not funded
Wenatchee and Entiat Beaver Reintroduction	TU-WWP	$199,000	$70,000	Not funded
Entiat PUD Canal System Conversion	CCD	$240,000	$36,000	Not funded
YN Lower Entiat RM 2.6-3.5 Habitat	YN	$98,000	$98,000	Not funded
Cottonwood Flats Phase 1 Acquisition	CCNRD	$402,000	$60,300	Not funded
Methow Riparian Planting	CCFEG	$95,000	$15,000	Not funded
Twisp River Elbow Coulee Phase II Restoration	MSRF	$77,000	$14,580	Not funded
Twisp River-Poorman Wetland Habitat Acq.	MSRF	$423,000	$63,450	W: $63,450
Upper Beaver Creek Habitat Improvement	MSRF	$674,300	$205,225	W/RR: $205,225
Lower Chewuch Beaver Restoration	MC	$231,000	$27,000	W: $27,000
Big Valley Riparian Protection	WDFW	$404,000	$200,000	Not funded
Fish Passage at Shingle Creek Dam	ONA/CCT	$180,950	$118,450	W/RR: $118,450
Lower Foster Creek Habitat Enhancement	FCCD	$85,500	$57,500	W: $57,500

Notes:

1. CCNRD = Chelan County Natural Resource Department; CCD = Cascadia Conservation District; FCCD = Foster Creek Conservation District; MC = Methow Conservancy; ONA/CCT = Okanagan Nation Alliance and Colville Confederated Tribes; MSRF = Methow Salmon Recovery Foundation; WDFW = Washington Department of Fish and Wildlife; CCFEG = Cascade Columbia Fisheries Enhancement Group; TU-WWP = Trout Unlimited – Washington Water Project; YN = Yakama Nation; CDLT = Chelan-Douglas Land Trust.
2. TC = Tributary Committees
3. RI = Rock Island Plan Species Account; RR = Rocky Reach Plan Species Account; W = Wells Plan Species Account.

In 2012, the Rocky Reach Tributary Committee agreed to fund the following General Salmon Habitat Program projects:

- Upper Beaver Habitat Improvement Channel Restoration Project for the amount of $102,612.50 (with cost share the total cost of the project was $674,300). This project will increase habitat complexity that will support rearing, spawning, and migration of steelhead in Beaver Creek. This project will be accomplished by reconnecting 600 feet of historic channel and by constructing 1,700 feet of new meandering stream to replace a 1,160-foot long straightened channel. In addition, the project will reconnect the stream with the floodplain and add large woody debris to create complexity. Finally, the Batie diversion will be replaced with a diversion that meets all state and federal criteria.

- Fish Passage at Shingle Creek Irrigation Dam Project for the amount of $59,225 (with cost share the total cost of the project was $180,950). This project will provide fish passage at an irrigation dam, which prevents access to 22 miles of spawning and rearing habitat in Shingle Creek and Shatford Creek. The dam will be modified and/or replaced with a series of riffles that will maintain the stability of the streambed while allowing access to upstream habitat.

2.3.3.2 Modifications to General Salmon Habitat Program Contracts

In November 2012, Trout Unlimited—Washington Water Project asked the Rocky Reach Tributary Committees for a budget amendment to the Chewuch River Instream Flow Project. The reason for the modification is that it has taken longer than planned to secure permits and the costs to complete those permits were higher than anticipated. Therefore, they asked to move money from salaries/benefits and excavation/heavy equipment work to contract labor and permitting. The Rocky Reach Tributary Committees approved the budget modification with the understanding that the total budget amount will not change as a result of the request.

2.3.4 Small Projects Program

The Small Projects Program has an application and review process that increases the likelihood of participation by private stakeholders that typically do not have the resources or expertise to go through an extensive application process. The Tributary Committees encourage small-scale projects by community groups, in cooperation with landowners, to support salmon recovery on private property. Project sponsors may apply for funding at any time, and in most cases, will receive a funding decision within three months. In 2012, the Tributary Committees increased the maximum contract allowed under the Small Projects Program to $100,000.

2.3.4.1 2012 Small Projects

In 2012, the Tributary Committees received seven requests for funding under the Small Projects Program. The Tributary Committees approved funding for three projects. The Committees were unable to make a funding decision on one project because of a lack of information in the proposal. The Committees have asked the project sponsor to provide additional information. Table 7 identifies the projects, sponsors, total cost of the projects, amount requested from Tributary Funds, and, if funded, which Plan Species Accounts supported the projects.

Table 7
Projects Reviewed by the Tributary Committees under the Small Projects Program in 2012

Project Name	Sponsor[1]	Total Cost	Request from TC[2]	Plan Species Account[3]
Mission Creek Fish Passage	CCD	$50,000	$50,000	RI: $50,000
Wenatchee Levee Removal and Riparian Restoration	CCNRD	$67,450	$56,700	RI: $56,700
Wenatchee River RM 20 to 23 Riparian Restoration	CCD	$95,424	$80,424	Not funded
Peshastin Creek Riparian Restoration	CCD	$76,257	$51,257	Not funded
Entiat 1G/2A Reach Riparian Restoration	CCD	$100,000	$85,000	Not funded
Twisp River Well Conversion	TU-WWP	$87,739	$43,550	W: $43,550
Beaver Creek Late Season Well Test	TU-WWP	$1,500	$1,500	No Decision[4]

Notes:
1. CCNRD = Chelan County Natural Resource Department; CCD = Cascadia Conservation District; TU-WWP = Trout Unlimited – Washington Water Project.
2. TC = Tributary Committees
3. RR = Rocky Reach Plan Species Account; W = Wells Plan Species Account.
4. The Committees were unable to make a funding decision based on the information presented in the proposal. The Committees asked the sponsor for additional information.

The Rocky Reach Tributary Committee funded no Small Projects in 2012.

2.3.4.2 Modifications to Small Project Contracts

The Rocky Reach Tributary Committee received no requests from sponsors in 2012 asking for modifications to Small Projects funded by the Committee.

2.3.5 Tributary Assessment Program

In 2012, the Rocky Reach Tributary Committee did not receive or solicit any proposals to monitor the effectiveness of habitat restoration actions.

3 HCP ADMINISTRATION

3.1 Mid-Columbia HCP Forums

In 2005 and 2006, Mid-Columbia Forums (Forums) were held as a means of communicating and coordinating with the non-signatories and other interested parties on the implementation of the HCPs. Non-signatory parties at the time of the 2006 meeting included the Confederated Tribes of the Umatilla Reservation and American Rivers. As in 2007 through 2011, these parties were invited by letter in 2012 to attend a Forum, in conformity with the 2005 FERC Order on Rehearing 109 FERC 61208 and in accordance with the offer to non-signatory parties of non-voting membership in HCP Tributary and Hatchery Committee processes. The non-signatory parties again indicated no interest in attending a Forum in 2012, and thus a Forum was not held in 2012.

APPENDICES

APPENDIX A
HABITAT CONSERVATION PLAN COORDINATING COMMITTEES 2012 MEETING MINUTES AND CONFERENCE CALL MINUTES

Note: The Coordinating Committees did not meet in November 2012.

ANCHOR QEA

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	February 29, 2012
From:	Michael Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the January 20, 2012, HCP Coordinating Committees' Conference Call		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met by conference call on Friday, January 20, 2012, from 9:30 am to 12:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Steve Hemstrom will forward a copy of his email correspondence with Bryan Nordlund reporting steelhead mortalities during dewatering of the Rocky Reach fishway for maintenance on December 8, 2011 (Item II-A).
- Lance Keller will email the Draft 2011 Chelan PUD Predator Control Report to Carmen Andonaegui for distribution to the Coordinating Committees for review (Item II-C).
- Tom Kahler will provide a demonstration of Douglas PUD's Document Management Tool (DMT) for the February 28, 2012, Coordinating Committees' meeting (Item V-B).

DECISION SUMMARY

- There were no decisions made at today's meeting.

REVIEW ITEMS

- The Draft 2011 Rocky Reach Yearling Chinook Survival Study report is out for an extended review period. Comments are now due by <u>January 27, 2012</u>.
- The Draft 2012 Wells HCP Action Plan is out for a 30-day review. Comments are due

to Tom Kahler by February 20, 2012.

- The Draft 2011 Rocky Reach Juvenile Fish Bypass System Report is out for a 60-day review. Comments are due to Lance Keller by March 20, 2012.

REPORTS FINALIZED

- There are no reports to finalize at this time.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees' members and asked for any additions or changes to the agenda. He said that the November 15, 2011, Director Level meeting summary would also be up for approval at today's meeting. The following item was added to the agenda:

- Tom Kahler: Discussion of the draft Wells 2012 HCP Action Plan and an update on the status of Half-Duplex (HD) Passive Integrated Transponder (PIT) tag detector installations in the Wells Dam fishways.

The Committees reviewed the draft November 15, 2011, meeting minutes and the draft November 15, 2011, Director Level meeting summary. The November 15, 2011, meeting minutes and the November 15, 2011, Director Level meeting summary were approved as revised. Carmen Andonaegui will finalize the meeting minutes and distribute them to the Committees.

II. Chelan PUD

A. Rocky Reach Fishway Maintenance (Steve Hemstrom)

Steve Hemstrom gave an update on fishway maintenance activities at Rocky Reach Dam. On December 9, 2011, Hemstrom said that he sent an email to Bryan Nordlund reporting five Endangered Species Act (ESA)-listed steelhead (two adults and three juveniles) mortalities and a number of non-ESA-listed fish mortalities during dewatering of the fish ladder for maintenance on December 8, 2011. He said that this is the first time that fish mortalities have occurred during fishway maintenance at Rocky Reach Dam. Hemstrom reported that Chelan PUD had gone through an extensive review to determine the cause of the mortalities and to identify procedures necessary to prevent future fish mortalities. He said that human error resulted in the total dewatering of the fishway prior to proper safety measures being in place to allow entry by personnel to perform normal, live-fish removal operations; as a result, fish trapped in the fishway died. Hemstrom said that Chelan PUD has prepared documents describing very strict standard procedures that must be followed during future fishway dewatering activities. Hemstrom said that the ESA-listed steelhead mortalities were covered under Chelan PUD's Incidental Take Permit; however, Chelan PUD's goal is to avoid any take during operation of the Rocky Reach Project. Lance Keller said that the recovered steelhead were checked for PIT tags but none were discovered. He said the snout was taken from the one recovered hatchery steelhead and it will be checked for a coded-wire tag.

B. 2011 Rocky Reach and Rock Island Annual Reports Update (Steve Hemstrom)

Steve Hemstrom said that the 2011 updates to the Rocky Reach and Rock Island HCP annual reports have started. He said that Chelan PUD intends to add a section to the reports describing the achievement of all HCP No Net Impact (NNI) standards for Chinook, steelhead, and sockeye. Carmen Andonaegui said that the Rocky Reach and the Rock Island HCP annual reports will be available for a 60-day review by the Coordinating Committees starting February 23, 2012; the Wells HCP annual report will be available February 10, 2012, for a 60-day review. Mike Schiewe said that the HCP annual reports have been produced for the past ten years and provide a summary of all activities accomplished under the HCP by all the HCP committees.

C. Draft 2011 Rocky Reach Juvenile Fish Bypass System Report and Draft 2011 Chelan PUD Predator Control Report (Steve Hemstrom)

Steve Hemstrom said that it was Chelan PUD's intent to have both the draft 2011 Rocky Reach Juvenile Fish Bypass System Report and the draft 2011 Chelan PUD Predator Control Report to the Coordinating Committees for review by today's meeting; however, due to workload constraints, they only just sent the draft 2011 Juvenile Fish Bypass System Report to Carmen Andonaegui January 19, 2012, for distribution to the Committees. He said that Lance Keller will email the draft 2011 Predator Control Report to Andonaegui for distribution to the Committees by the end of day, January 20, 2012. Both of the reports will be available for a 60-day review; comments should be sent to Lance Keller.

D. 2011 Rocky Reach Yearling Chinook Survival Study Results (John Skalski/Columbia Basin Research)

Dr. John Skalski summarized results of the 2011 Rocky Reach Yearling Chinook Survival Study (Attachment B). He reviewed the study purpose, study goals, study design, and assumptions tested. The study design incorporated both a day/night paired-release and a daytime-only triple-release into the bypass system; all releases occurred between April 25 and May 27, 2011. Assumptions tested included: tagger effects, tag lot effects, tag life corrections, and downstream mixing of release groups; no tag lot or tagger effects were detected, and the probability of tag life ending before fish arrived at downstream detection points was less than one percent, and there was good downstream mixing of release groups.

The study design allowed for estimates of project passage survival and route-specific survival (RSS). All study fish were tagged with acoustic tags and 3-D detection was available. Results included an estimate of absolute survival through the surface collector and bypass system, and relative survivals through all other passage routes. Analyses included a comparison of 2011 survival estimates to past years' survival estimates.

Estimated project passage survival was 92.89 percent for daytime releases and 92.99 percent for nighttime releases, with no significant differences between day and night survivals. Pooled project survival was estimated at 92.94 percent. The 2011 water discharge early in the study period was very typical of past years, but very high during the latter part of the study period. To provide a look at the effects of high flows and unintended spill on project survival, early- and late-season survival estimates were calculated (spill was required after May 15, 2011). Estimated early season survival was 91.61 percent with an increase in survival to 95.60 percent during the late-half of the study period. Removal of the 41 detected spillway passage study fish resulted in a decrease in late-season survival (94.74 percent) and a decrease in pooled project survival from 92.94 percent to 92.55 percent, indicating that spilled fish survival was high. Detection at all passage routes was greater than 99 percent.

Analyses of diel project passage data indicated that, regardless of release time, a higher percentage of study fish passed during the daytime compared to nighttime, and that study fish passed at a higher percent than run-of-the-river (ROR) fish during the daytime. ROR fish passed Rocky Reach Dam at a higher percent than study fish, during the night. Passage was highest through units 3 to 11 (47.77 percent) during both day and night. Spillway passage made up a very small proportion of fish passing the dam day or night (4.25 percent and 6.00 percent, respectively). Survival of fish that passed through the surface collector relative to all other passage routes was higher for both daytime and nighttime (1.017 percent and 1.013 percent, respectively); lowest survival was through turbine routes. There were no significant differences between absolute route-specific-survival (RSSs) and no significant differences between day and night absolute survivals for specific routes. The daytime dam passage survival estimate was 97.15 percent and the nighttime survival estimate was 96.14 percent. Overall estimated dam passage survival was 96.21 percent for non-spill routes and 96.42 overall. Estimated pool passage survival was 96.39 percent.

Comparing survival estimates from 2011 with past years' (2004, 2005, and 2010) survival estimates (all using acoustic tagged ROR yearling Chinook and Waterview operations), the lowest estimated survival was 2005 (91.09 percent) and the highest in 2011 (92.94 percent). The four-year average project passage survival was 92.37 percent. A table showing project survival for sockeye, steelhead, and yearling Chinook for all survival study years for each species was provided.

Bill Tweit asked Skalski about river flows during the study years. Skalski said that 2011 was a high-flow year. Steve Hemstrom said that 2004 and 2005 were low-flow years. He said that average flows in 2004 were so low that 2004 did not qualify as a valid study based on HCP minimum flow criteria; however, after evaluating the results, the Coordinating Committees approved the study. Tweit commented on the diel passage route proportions relative to the surface collector and asked for thoughts on why so many fish that did not go through the surface collector would pass through units 3 to 11. The Committees discussed the potential effects of turbine operations on surface collector efficiency, and discussed survivals through the various turbine units. Hemstrom said that the surface collector operated the same during daylight hours in 2011, but that later during the year the powerhouse was fully loaded to handle high flows. He said in 2010, operations were almost the complete opposite. Lance Keller said there are data showing approach tracks in 3-D from the boat restriction zone (BRZ). He said that dam approach tracks of study fish could be viewed under the different flow characteristics. Hemstrom said that data on avoidance versus rejection behavior are available and that these data could be reviewed to see if fish are just not detecting the surface collector attraction flows before being attracted to the powerhouse. Skalski drew Committees' members' attention to the relatively high standard errors (SE) for the absolute survival estimates. Hemstrom asked that anyone with questions please email him and reminded Committees' members that comments were due January 27, 2012, after which time the report will be finalized.

III. Douglas PUD

A. Draft 2012 Wells HCP Action Plan (Tom Kahler)

Tom Kahler reported that the draft 2012 Wells HCP Action Plan (Action Plan) was emailed to Coordinating Committees' members on January 18, 2012. He drew Committees' members' attention to Item 2 of the Coordinating Committees' section, *2013 NNI Progress Report*, in the draft Action Plan. Kahler said that section 6.9 of the Wells HCP describes a 10-Year check-in report describing progress towards achieving NNI by 2013 with a deadline of March 2012 for the report; therefore, the Action Plan includes a date of no later than March 2013 for delivery of a draft 2013 NNI Progress Report (Progress Report) to the Committees. He said that section 6.9 of the HCP also requires the development of an analysis to determine whether each Plan Species is rebuilding. Kahler said that the Action Plan assumes coordination with and participation by the Committees no later than March 2012, in the development of the outline for the Progress Report, then Committees' input on the status update due no later than May 2012. Kahler said that Douglas PUD anticipates relying on the analyses in existing documents for a determination of whether Plan Species are rebuilding. He said Douglas PUD has submitted this draft Action Plan for consideration by each of the HCP Committees and will be asking for approval of the Action Plan at the February 28, 2012, Committees' meeting. Kahler said the draft Action Plan was presented to the Hatchery Committees January 19, 2012, and to the Tributary Committees the week prior for review of their respective sections. Mike Schiewe said that the Coordinating Committees will be asked to approve the items, steps, and timelines in the Action Plan. Kahler said he would like feedback on whether the Committees' members feel all HCP-required tasks for 2012 are reflected in the draft Action Plan and that the actions as presented are accurate according to the HCP.

Bill Tweit asked if there are similar requirements in Chelan PUD's HCPs regarding an analysis of whether Plan Species are rebuilding. Joe Miller said that under section 4.8 in both the Rocky Reach and Rock Island HCPs there is a requirement that Chelan PUD work with the HCP committees to prepare an overall progress report by 2013 describing progress towards achieving NNI; the progress report is to include the status of each Plan Species. Tweit said the question of whether Plan Species are rebuilding is a regional question and should be a requirement for both Chelan and Douglas PUDs' HCPs, as well as in the Grant PUD Priest Rapids Salmon and Steelhead Settlement Agreement. He suggested that the three mid-Columbia PUDs think of this question as a regional issue.

Kahler said that National Marine Fisheries Service (NMFS), as recently as 2011, completed an updated status of ESA-listed Plan Species, and that Douglas PUD planned to rely on these NMFS documents for an analysis of whether ESA-listed species were rebuilding. He also referred to the recently completed draft 5-Year Hatchery Monitoring and Evaluation (M&E) reports for both Douglas and Chelan PUDs' hatchery programs. Kahler said that these analyses provided perhaps the best evaluation of the extent to which Plan Species populations are rebuilding. He said that Douglas PUD was not looking to do a more extensive review of the Plan Species than what is already available. Mike Schiewe said that relying on the NMFS status reviews and the PUDs' 5-year M&E reports does seem reasonable for ESA-listed Plan Species. Schiewe said that Action Plans are provided early in the year by the PUDs and that they are intended to show the Committees all HCP-required actions that can be expect from the PUDs during the coming year.

Tweit reiterated that the HCPs were intended to be similar. He urged Chelan and Douglas PUDs to have joint discussions so that whatever approach is taken regarding analyzing the status of Plan Species that the same approach would be taken by both PUDS. Schiewe said that the draft Action Plan asks only for an NNI progress report outline by March 2012, and then by May 2012 for the Committees to provide Douglas PUD more detailed direction for a status update of Plan Species. The report itself is not due to the Committees for review until 2013 as a draft. Tweit said he wanted to flag Item #2 in the Coordinating Committees section of the draft Action Plan as something that may require more effort and coordination than the other activities in the draft Action Plan. Kahler said that the Action Plans do not create a binding timeline, that timeline dates may be adjusted at the discretion of the Committees as the work progresses.

B. HD PIT tag detection installation Update (Tom Kahler)

Tom Kahler said that at the November 15, 2011, Coordinating Committees' meeting, Douglas PUD said that it planned to install HD PIT tag detection arrays in the Wells Dam west adult fish ladder during annual maintenance in December 2011. He said, however, that the installation of HD PIT tag detectors in the west ladder did not occur due to the contractor's failure to deliver essential components of the system in a timely manner. As a result, Douglas PUD was unable to conduct necessary tests for possible interference between the prototype HD and existing full-duplex (FD) systems. Kahler said that Douglas PUD had now focused on installation of HD PIT tag detector arrays in the east fish ladder at Wells Dam, during the longer, biannual maintenance period in 2012. In early January 2012, Douglas PUD contractors began working on design and installation approaches and in-ladder testing and "noise listening" (identifying electromagnetic-field [EMF] interference) related to ensuring that the installation of the HD detectors in the east ladder would not diminish function of the existing FD detectors and vice versa. Kahler explained that there is a problem with the operation of the HD detectors interfering with FD PIT tag readings and with EMF from the FD system overwhelming the HD system. He said that Douglas PUD and the contractors are still discussing options.

IV. Tributary and Hatchery Committees Update (Mike Schiewe)

Mike Schiewe reported that the Tributary Committees met on December 14, 2011 and on January 17, 2012, and discussed the following items. He said that the majority of items discussed at the last two Tributary Committees' meetings were in the category of house-keeping with requests for amendments to projects or adjustment to funding:

- The Mission Creek Passage Structures project was sent back to the project sponsors for application to the General Salmon Habitat Program after the cost of the project rose from $45,000 to over $90,000. Tom Kahler said that the project concept was for the design and placement of permanent log weir structures to be constructed for three irrigators in place of the annual use of push-up dams. A U.S. Bureau of Reclamation (Reclamation) design brought the project cost to about $90,000, exceeding the Small Projects Program fund grant allowance and was rejected. Subsequently, the Natural Resources Conservation Service (NRCS) provided a design with a total cost of under $50,000, which was approved.
- The maximum contract allowance for projects funded by the Small Projects Program fund was raised from $50,000 to $75,000.
- The 2012 schedule for General Salmon Habitat Program funding proposals came out and will be much the same as in past years with final funding coordinated with other

funding entities for approval in November or December.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the most recent Hatchery Committees' meeting on January 19, 2012, by conference call:

- The Hatchery Committees approved a production swap to move Chelan PUD's 60,000 Methow spring Chinook production to the Wenatchee Basin in 2014. This approval was coupled with a Priest Rapids Coordinating Committee (PRCC) agreement that required Grant PUD picked up the production of 60,000 spring Chinook in Methow Basin.
- The Hatchery Committees discussed an analysis of size-at-release for Wenatchee spring Chinook. There is emerging evidence that a reduced size-at-release reduces the number of minijack returns, increases the age-at-return, and reduces straying. The Hatchery Committees asked Chelan PUD for a proposal for adjusting size-of-release and size-at-transfer targets. Chelan PUD's 5-Year M&E Report, which presents this analysis, will be released by February 3, 2012, for a 60-day review by the Coordinating Committees.
- Allyson Purcell, NMFS, gave an update to the Hatchery Committees on the "Mitchell Act EIS" now referred to as the Federal Hatcheries EIS. NMFS plans to have the draft EIS available early in 2012, but more likely it will be available by the summer. NMFS said that to the extent that Hatchery and Genetic Management Plan (HGMP) Biological Opinions could tier off the Federal Hatcheries EIS, NMFS will use the Federal Hatcheries EIS. Craig Busack, NMFS, said that HGMP Biological Opinions would not be delayed by the timing of the release of the final EIS.
- The Hatchery Committees discussed the Hatchery Committees section of the draft 2012 Wells Action Plan.
- The Hatchery Committees discussed the Washington Department of Fish and Wildlife (WDFW) Parental-Based Tagging (PBT) Pilot Study results which sampled fish at Priest Rapids Dam and re-sampled fish at Tumwater Dam for identification of tributary-of-origin. Preliminary analyses suggested poor parental identification; however, additional analyses have suggested an alternate conclusion. The more definitive analysis and conclusions will be presented by Ken Warheit (WDFW) at the February 15, 2012, Hatchery Committees' meeting.
- The Hatcheries Committees completed and approved the 2013 NNI recalculation for

HCP Plan Species, and SOAs were approved in December 2011 for both Douglas and Chelan PUDs' HCP hatchery programs.

V. HCP Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees' meetings are February 28, 2012, March 27, 2012, and April 24, 2012, all in SeaTac, Washington.

B. Document Management Tools (Tom Kahler/Carmen Andonaegui)

Tom Kahler described Douglas PUD's software for managing documents, the Document Management Tool (DMT). He said that the DMT was developed by a Wells relicensing contractor, and adapted to Douglas PUD's needs, to manage all the Wells Project relicensing documents. Kahler described the DMT as a web-based document-management system and repository that could be accessed from anywhere without the need for the user to have the repository software. He said that the DMT worked not only as a document repository, but also allowed for collaborative editing of documents so that multiple persons could work on the same document at the same time. A document could also be set up so that only one document can be checked out and edited at a time. He said that the DMT worked very well and was being used all over the country. Kahler said that he had experience using SharePoint, but that it could not be used for document collaboration, only for document management. He said that he found the search engine in SharePoint to be cumbersome and of very limited use because of the lack of file structure. He said that SharePoint is not designed to allow browsing through file folders; instead, the user must rely on search results that may not return the desired result or may provide so many results as to render the search fruitless. Kahler said that access to files can be controlled and customized with DMT. He provided an annual cost estimate to maintain a new DMT for all HCP committees (Attachment C). He said there would be initial setup costs associated with DMT which are not reflected in the cost estimate but that the setup costs are likely not much. The DMT can be housed at Douglas PUD on servers or at any preferred location.

Carmen Andonaegui described the SharePoint document management tool. She said that there would be a $400 per month cost, covering up to 3.0 GB of storage, for Anchor QEA to manage a SharePoint site for the combined HCP committees. Andonaegui said the HCP ftp site currently stores 1.9 GB of storage. She said that SharePoint allows for multiple logins, document use restrictions, document management, and document storage, but does not allow for document collaboration. It is a reliable, web-based tool, requiring little maintenance other than managing storage space. SharePoint has a document search function and can be set up to provide user alerts when documents are uploaded or edited. Chelan PUD said it uses SharePoint and had no complaints. Bill Tweit said WDFW uses SharePoint, but his experience using it is very limited. Anchor QEA uses SharePoint. Mike Schiewe said that a decision does not need to be made today and asked Kahler if he would prepare a demonstration of DMT for next meeting. Kahler agreed to provide a DMT demonstration at the February 28, 2012, Committees' meeting.

List of Attachments

Attachment A – List of Attendees
Attachment B – Skalski 2011 Rocky Reach Yearling Chinook Survival Study Presentation
Attachment C – Estimated DMT Server Costs

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Steve Hemstrom *	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Joe Miller	Chelan PUD
Jerry Marco*	Colville Confederated Tribes
Bill Tweit*	WDFW
John Skalski	Chelan PUD Consultant
Bob Rose*	Yakama Nation
Jim Craig*	USFWS

* Denotes Coordinating Committees member or alternate

Attachment B

SURVIVAL AND MIGRATION DYNAMICS OF YEARLING CHINOOK SALMON SMOLTS AT ROCKY REACH DAM IN 2011

J. R. Skalski
R. L. Townsend
University of Washington

T. W. Steig
P. A. Nealson
Hydroacoustic Technology, Inc.

PURPOSE

- Present 2011 yearling Chinook salmon results at the Rocky Reach Project
- Compare survival results over years

GOALS OF STUDY

- Estimate project passage survival at Rocky Reach for yearling Chinook salmon smolts
- Perform evaluation under “waterview” operating conditions with no voluntary spill
- Partition project passage survival into dam and pool components
- Compare diel passage patterns

RELEASE-RECAPTURE DESIGN

STUDY DESIGN: PAIRED RELEASE

Release dates

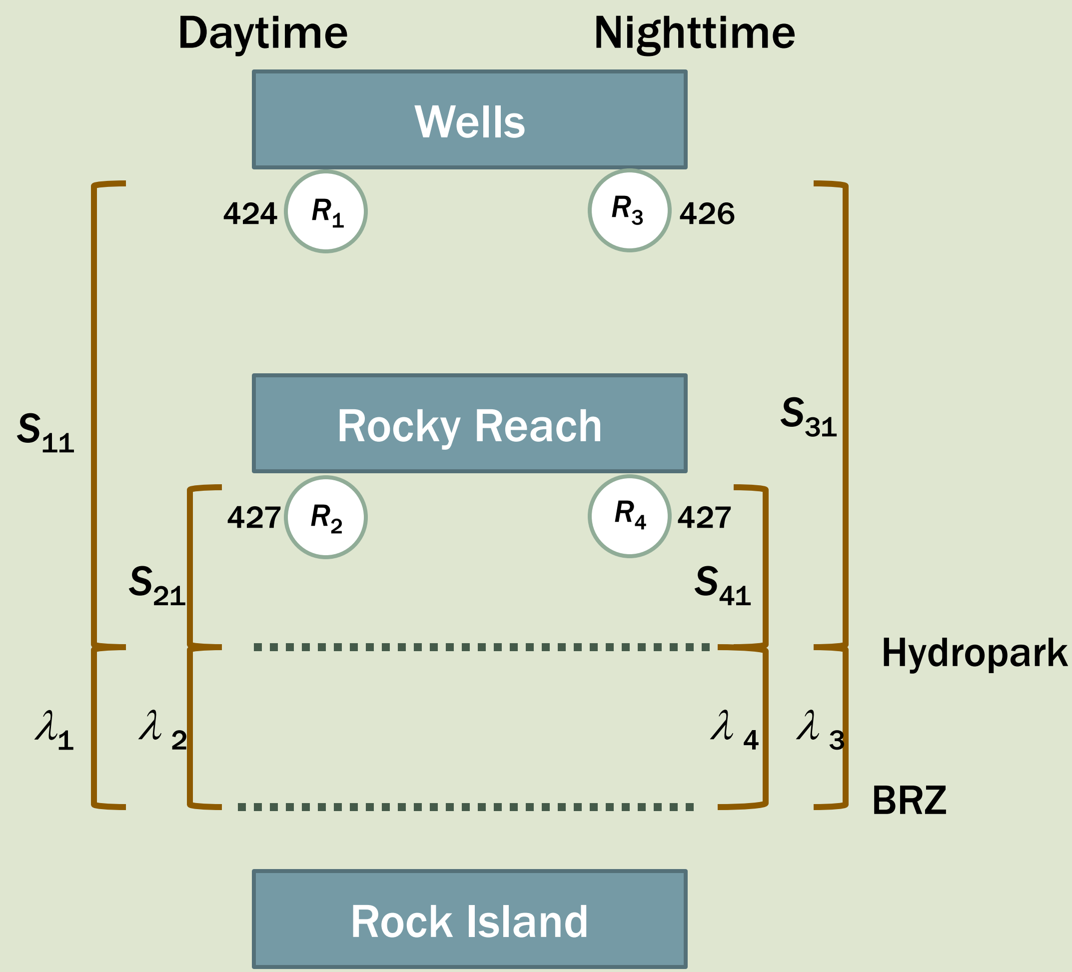
- 25 April - 27 May 2011

Release times

- 1 pm or midnight
- 15 day/15 nighttime

Pool data

- Day or night
- Season-wide

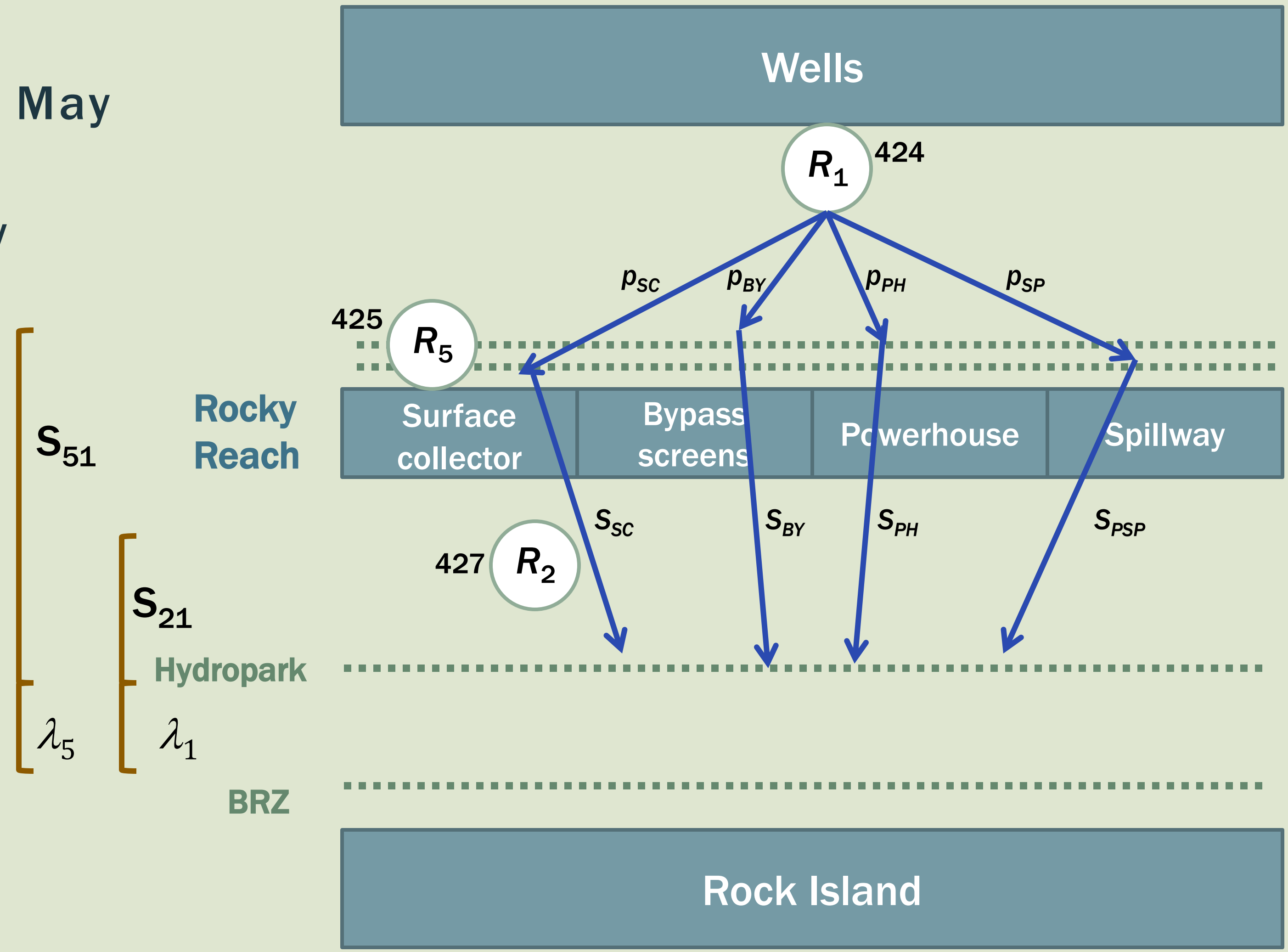


Attachment B

STUDY DESIGN: TRIPLE RELEASE

Release dates

- 28 April - 26 May 2011
- Daytime only



TRIPLE RELEASE

Triple release used to estimate dam passage survival

- Surface collector survival using releases R_2 and R_5

$$\hat{S}_{SC} = \frac{\left(\frac{r_5}{R_5}\right)}{\left(\frac{r_2}{R_2}\right)}$$

- Relative survival compared to surface collector

$$RS_{BY:SC} = \frac{\left(\frac{n_{BY}}{N_{BY}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)};\ RS_{PH:SC} = \frac{\left(\frac{n_{PH}}{N_{PH}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)};\ RS_{SP:SC} = \frac{\left(\frac{n_{SP}}{N_{SP}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)}$$

Attachment B

ESTIMATES OF SURVIVAL

- Dam passage survival

$$\hat{S}_{\text{Dam}} = \hat{P}_{SC}\hat{S}_{SC} + \hat{P}_{BY}\left(\hat{S}_{SC} \cdot RS_{BY:SC}\right) + \hat{P}_{PH}\left(\hat{S}_{SC} \cdot RS_{PH:SC}\right) + \hat{P}_{SP}\left(\hat{S}_{SC} \cdot RS_{SP:SC}\right)$$

- Pool passage survival

$$\hat{S}_{\text{Pool}} = \frac{\hat{S}_{\text{Project}}}{\hat{S}_{\text{Dam}}}$$

TESTS OF ASSUMPTIONS

Attachment B

TEST FOR TAGGER EFFECTS

- Test for homogeneous survivals
- 0/9 tests of homogeneity significant at $\alpha = 0.10$
- **CONCLUDE:** Use all fish from all taggers

Release site	Release	Tagger	CJS Survival: Release to Beebe Bridge	CJS Survival: Beebe Bridge to RR Boat R. Zone	CJS Survival: RR Boat R. Zone to RI Hydropark
Wells tailrace	Day	#1	0.9825 (0.0123)	0.9643 (0.0175)	0.9630 (0.0182)
		#2	0.9825 (0.0123)	1.0000 (< 0.0001)	0.9732 (0.0153)
		#3	0.9912 (0.0088)	0.9732 (0.0153)	0.9450 (0.0218)
		#4	0.9639 (0.0205)	0.9875 (0.0124)	0.9494 (0.0247)
		P(F-test)	*0.5755*	*0.2327*	*0.7511*
	Night	#1	0.9912 (0.0087)	0.9735 (0.0151)	0.9545 (0.0199)
		#2	1.0000 (< 0.0001)	0.9741 (0.0147)	0.9204 (0.0255)
		#3	0.9911 (0.0089)	0.9820 (0.0126)	0.9541 (0.0200)
		#4	1.0000 (< 0.0001)	0.9881 (0.0118)	0.9639 (0.0205)
		P(F-test)	*0.5677*	*0.8534*	*0.5041*
Rocky Reach SC	Day	#1			1.0000 (< 0.0001)
		#2			1.0000 (< 0.0001)
		#3			0.9821 (0.0125)
		#4			0.9884 (0.0116)
		P(F-test)			*0.3525*
Rocky Reach tailrace	Day	#1			1.0000 (< 0.0001)
		#2			1.0000 (< 0.0001)
		#3			0.9821 (0.0125)
		#4			1.0000 (< 0.0001)
		P(F-test)			*0.1045*
	Night	#1			1.0000 (< 0.0001)
		#2			0.9912 (0.0087)
		#3			1.0000 (< 0.0001)
		#4			0.9884 (0.0116)
		P(F-test)			*0.5613*

TEST FOR TAGGER EFFECTS

- Test for homogeneous tagger effort

Release location	Tagger			
	#1	#2	#3	#4
Wells tailrace (day)	114	114	113	83
RR tailrace (day)	116	115	112	84
			$P\left(\chi_3^2 \geq 0.0216\right) = 0.9992$	
Wells tailrace (night)	114	116	112	84
RR tailrace (night)	115	114	112	86
			$P\left(\chi_3^2 \geq 0.0444\right) = 0.9976$	

TEST FOR TAG-LOT EFFECTS

- Tests for homogeneous survivals

Tag lot	Survival: Release to Rocky Island Hydropark			
	Wells tailrace (day)	Wells tailrace (night)	RR tailrace (day)	RR tailrace (night)
11204	0.9571 (0.0159)	0.9451 (0.0178)	0.9939 (0.0060)	0.9939 (0.0060)
11205	0.8929 (0.0239)	0.9048 (0.0226)	0.9941 (0.0059)	0.9940 (0.0059)
11206	0.9140 (0.0291)	0.9149 (0.0288)	1.0000 (<0.0001)	1.0000 (<0.0001)
11204	0.9571 (0.0159)	0.9451 (0.0178)	0.9939 (0.0060)	0.9939 (0.0060)
P(F-test)	***0.1235***	***0.4958***	***0.6821***	***0.6705***

- 0/4 tests of homogeneity significant at $\alpha = 0.10$
- **CONCLUDE:** Use all tag lots in survival estimation

TEST FOR TAG-LOT EFFECTS

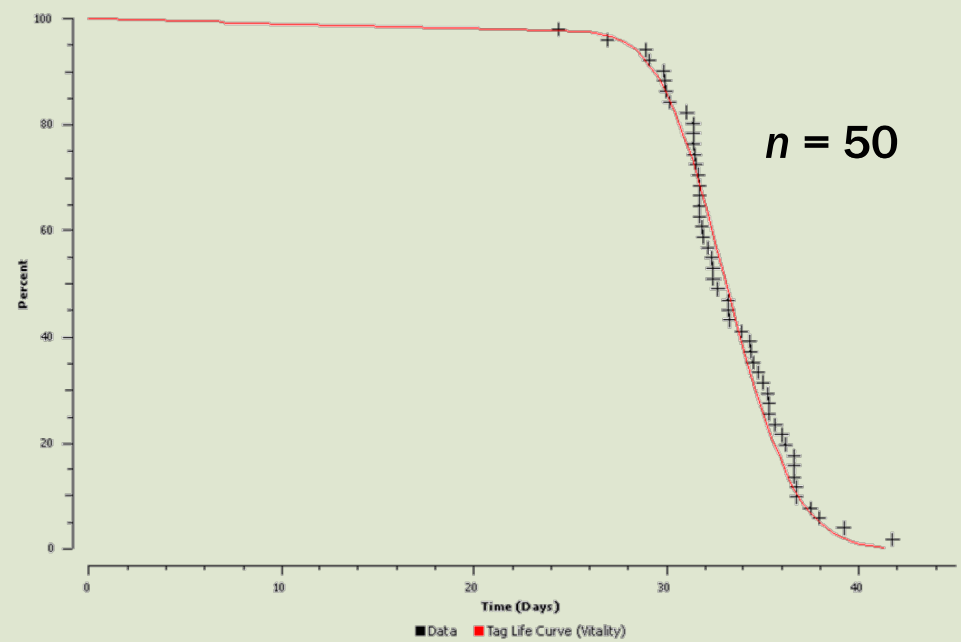
- Test for homogeneous tag-lot usage

Release	Manufacturing lot number		
	11204	11205	11206
Wells tailrace (day)	163	168	93
Wells tailrace (night)	164	168	94
Rocky Reach tailrace (day)	164	170	93
Rocky Reach tailrace (night)	165	168	94
		$P\left(\chi_6^2 \geq 0.0266\right) = 0.9999$	

Attachment B

TAG-LIFE CORRECTIONS

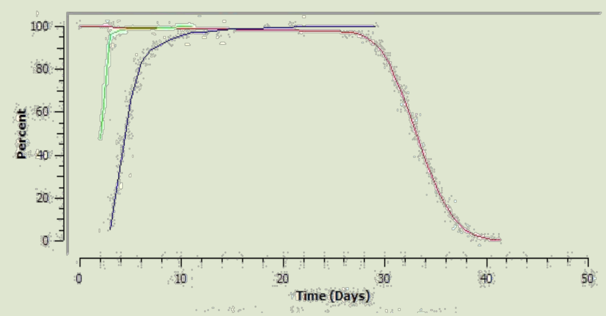
- HTI *Model 795Lm* micro acoustic tags
  - 0.65 g in air
- Vitality curve (Li and Anderson 2009)
- $\bar{t}$ = 32.7 days



TAG-LIFE CORRECTIONS

- Arrival distributions vs. tag life

Example:
Rock Island BRZ
Daytime releases



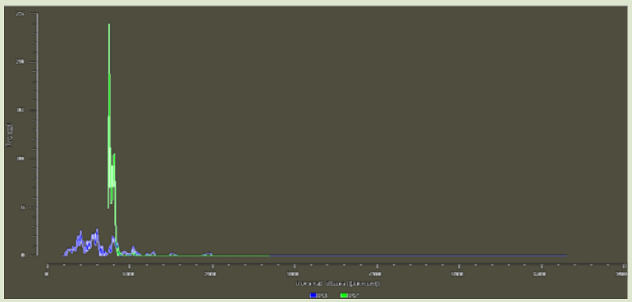
- Probabilities of tags being active

Release time	Release site	Detection site	
		Rock Island Hydropark	Rock Island BRZ
Daytime	Wells tailrace	0.9946 (0.0046)	0.9946 (0.0047)
	Rocky Reach tailrace	0.9972 (0.0024)	0.9970 (0.0027)
Nighttime	Wells tailrace	0.9938 (0.0034)	0.9935 (0.0035)
	Rocky Reach tailrace	0.9970 (0.0018)	0.9965 (0.0021)

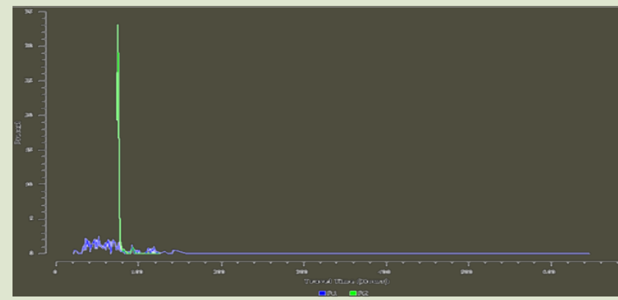
Attachment B

DOWNSTREAM MIXING OF RELEASE GROUPS

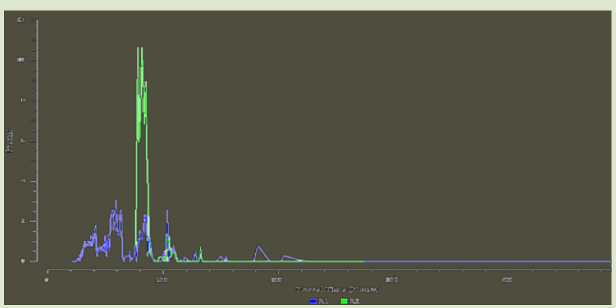
a. Rock Island Hydropark – Daytime releases



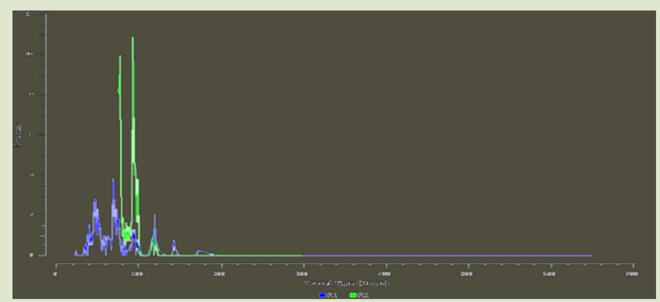
b. Rock Island Hydropark – Nighttime releases



c. Rock Island BRZ – Daytime releases



d. Rock Island BRZ – Nighttime releases



Good mixing achieved

Attachment B

ESTIMATION OF PROJECT PASSAGE SURVIVAL

ESTIMATES OF PROJECT PASSAGE SURVIVAL

- Yearling Chinook Salmon – Study Wide

Daytime releases	$\hat{S}_{RR-\text{Day}} = 0.9289*\left(\widehat{\text{SE}} = 0.0135\right)$
Nighttime releases	$\hat{S}_{RR-\text{Night}} = 0.9299*\left(\widehat{\text{SE}} = 0.0135\right)$
Pooled	$\hat{S}_{RR} = 0.9294\left(\widehat{\text{SE}} = 0.0097\right)$

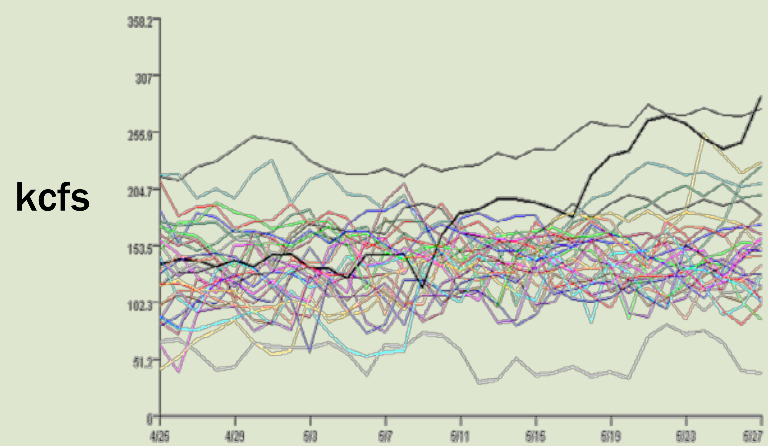
***No significant difference**

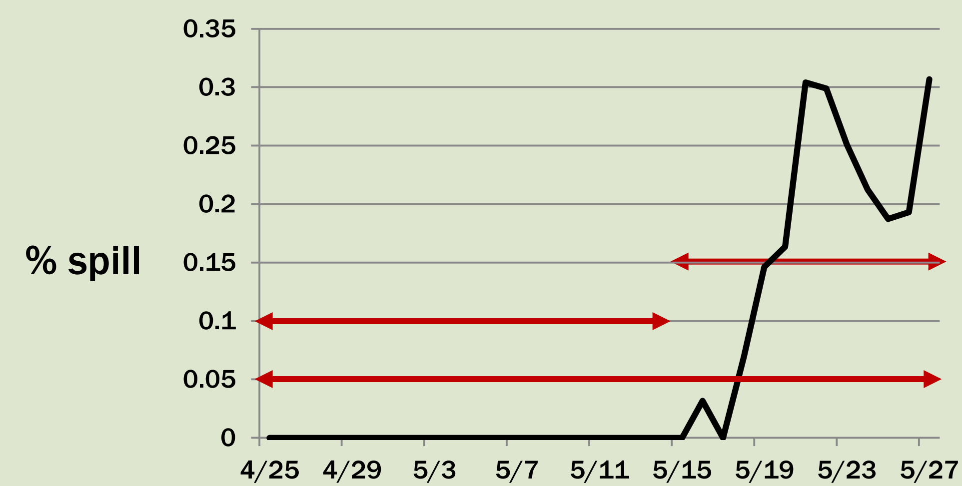
$$P\left(\left|Z\right| \geq 0.0524\right) = 0.9582$$

Attachment B

FLOW AND SPILL CONDITIONS AT ROCKY REACH DAM – SPRING 2011

Total discharge





SUMMARY OVER DIFFERENT TIME PERIODS

Day and Night Releases Pooled

Period	All fish $(\hat{S})$
Early	0.9161 (0.0125)
Late	0.9560 (0.0143)
Study wide	0.9294 (0.0097)

SUMMARY OVER DIFFERENT TIME PERIODS

Day and Night Releases Pooled

Period	All fish $(\hat{S})$	Spillway detected fish removed	
		#	
Early	0.9161 (0.0125)	0	0.9161 (0.0125)
Late	0.9560 (0.0143)	41	0.9474 (0.0162)
Study wide	0.9294 (0.0097)	41	0.9255 (0.0101)

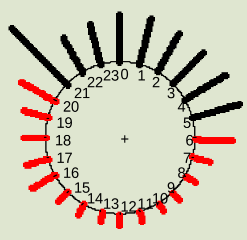
DIEL PASSAGE

Attachment B

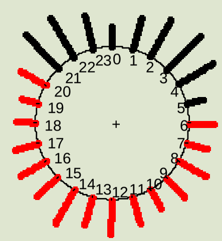
COMPARISON OF 2011 DIEL DISTRIBUTION

Diel Distributions

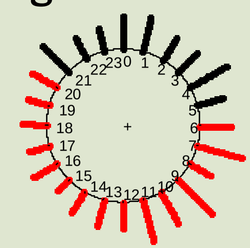
a. Juvenile sampling facility



b. Day releases



c. Night releases



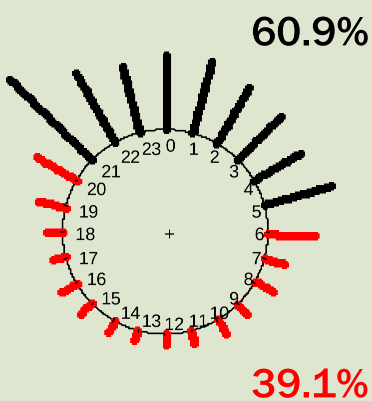
Diel Proportions

Wells tailrace releases	Proportion of Rocky Reach yearling Chinook salmon passage	
	Day	Night
Day releases	0.5368	0.4632
Night releases	0.6145	0.3855
ROR at Juvenile Sampling Facility	0.4092	0.5908

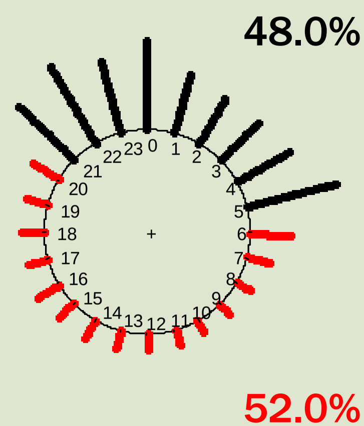
Attachment B

DIEL PASSAGE DISTRIBUTION AT ROCKY REACH DAM

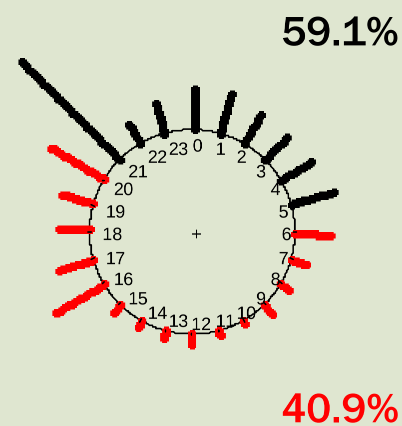
ROR 2009



ROR 2010



ROR 2011



DAM PASSAGE SURVIVAL

Attachment B

DIEL PASSAGE PROPORTIONS AT ROCKY REACH, SPRING 2011

Route	Diel passage proportions		*P*-value (2-tailed)
	Day	Night	
Surface collector	0.3800 (0.0224)	0.2229 (0.0222)	<0.0001
Bypass screens	0.0510 (0.0101)	0.0657 (0.0132)	0.3765
Units 1–2	0.0488 (0.0099)	0.0657 (0.0132)	0.3057
Units 3–11	0.4777 (0.0230)	0.5857 (0.0263)	0.0020
Spillway	0.0425 (0.0093)	0.0600 (0.0127)	0.2662
Total	1.00	1.00	

RELATIVE SURVIVALS (RS)

- Relative survivals (RS) compared to yearling Chinook salmon survival through the surface collector at Rocky Reach Dam

Parameter	Relative survival through the surface collector		*P*-value (2-tailed)
	Day	Night	
$S_{Bypass\ screens}$	1.0170 (0.0099)	1.0130 (0.0131)	0.8075
$S_{Units\ 1\text{-}2}$	0.9286 (0.0604)	0.8809 (0.0720)	0.6118
$S_{Units3\text{-}11}$	0.9492 (0.0193)	0.9487 (0.0211)	0.9860
$S_{Spillway}$	1.0170 (0.0099)	1.0130 (0.0131)	0.8075

Attachment B

ROUTE-SPECIFIC SURVIVAL ESTIMATES

- Route-specific survival estimates during daytime and nighttime passage at Rocky Reach Dam, 2011

Parameter	Absolute survival		*P*-value (2-tailed)
	Day	Night	
$S_{Surface\ collector}$	0.9976 (0.0053)		
$S_{Bypass\ screens}$	1.0146 (0.0113)	1.0106 (0.0141)	0.8248
$S_{Units\ 1\text{-}2}$	0.9264 (0.0605)	0.8788 (0.0720)	0.6128
$S_{Units3\text{-}11}$	0.9469 (0.0199)	0.9464 (0.0216)	0.9864
$S_{Spillway}$	1.0146 (0.0113)	1.0106 (0.0141)	0.8248

DAM PASSAGE SURVIVAL ESTIMATE

Time	$\hat{S}$	$\widehat{SE}$
Daytime	0.9715	0.0103
Nighttime	0.9614	0.0137
Overall (0.4092/0.5908)	0.9642	0.0091
	*0.9621 (0.0097) for non-spill routes	

Pool Passage Survival

$$\hat{S}_{\text{Pool}} = \frac{\hat{S}_{\text{Project}}}{\hat{S}_{\text{Dam}}} = \frac{0.9294}{0.9642} = 0.9639(0.0135)$$

SUMMARY

Attachment B

CROSS-YEAR SUMMARY

Yearling Chinook Salmon – Rocky Reach Project

Year	Technique	Fish source	Dam operations	$\hat{S}$	$\widehat{SE}$
2004	Acoustic tag	Run-of-river	Waterview	0.9293	0.0196
2005	Acoustic tag	Run-of-river	Waterview	0.9109	0.0179
2010	Acoustic tag	Run-of-river	Waterview	0.9250	0.0142
2011	Acoustic tag	Run-of-river	Waterview	0.9294	0.0097
			Average	0.9237	

Attachment B

THREE-SPECIES SUMMARY
ROCKY REACH PROJECT

Species	Year	Technique	Fish source	Dam operations	$\hat{S}$	$\widehat{SE}$
Sockeye	2006	Acoustic tag	Run-of-river	Waterview	0.9331	0.0121
	2008	Acoustic tag	Run-of-river	Waterview	0.9202	0.0212
	2009	Acoustic tag	Run-of-river	Waterview	0.9545	0.0118
				Average	0.9359	
Steelhead	2004	Acoustic tag	Run-of-river	Waterview	0.9833	0.0184
	2005	Acoustic tag	Run-of-river	Waterview	0.9303	0.0134
	2006	Acoustic tag	Run-of-river	Waterview	0.9598	0.0100
				Average	0.9578	
Yearling Chinook	2004	Acoustic tag	Run-of-river	Waterview	0.9293	0.0196
	2005	Acoustic tag	Run-of-river	Waterview	0.9109	0.0179
	2010	Acoustic tag	Run-of-river	Waterview	0.9250	0.0142
	2011	Acoustic tag	Run-of-river	Waterview	0.9294	0.0097
				Average	0.9237	

Attachment C

Estimated Yearly Cost for DMT Server

*** Does not include initial setup costs from Natoma and DCPUD personnel**

Item	Original Cost Per Unit	Num Units Involved	Original Total	Lifespan (yrs)	Original Yearly Cost	Yearly Maint Fee	Total Yearly Cost	Percentage for single server	Yearly Cost For Single Server
Server Hardware	$ 7,500.00	2.00	$ 15,000.00	5.00	$ 3,000.00	$ -	$ 3,000.00	8.50%	$255.00
Storage Hardware	$ 22,700.00	2.00	$ 45,400.00	8.00	$ 5,675.00	$ 1,320.00	$ 8,315.00	1.50%	$124.73
Backup Hardware	$ 41,500.00	2.00	$ 83,000.00	8.00	$ 10,375.00	$ 5,750.00	$ 21,875.00	1.50%	$328.13
Vmware Licenses	$ 4,100.00	2.00	$ 8,200.00	10.00	$ 820.00	$ 1,450.00	$ 3,720.00	8.50%	$316.20
Virtual Center Licenses	$ 3,600.00	1.00	$ 3,600.00	10.00	$ 360.00	$ 1,250.00	$ 1,610.00	1.50%	$24.15
Switches	$ 2,600.00	4.00	$ 10,400.00	10.00	$ 1,040.00	$ 402.00	$ 2,648.00	1.50%	$39.72
Certificate	$ 360.00	1.00	$ 360.00	4.00	$ 90.00	$ -	$ 90.00	100.00%	$90.00
Domain Name	$ 150.00	1.00	$ 150.00	10.00	$ 15.00	$ -	$ 15.00	100.00%	$15.00
RedHat Support	$ -	1.00	$ -	1.00	$ -	$ 675.00	$ 675.00	100.00%	$675.00
In house maintenance	$ 50.00	24.00	$ 1,200.00	1.00	$ 1,200.00	$ -	$ 1,200.00	100.00%	$1,200.00
								Server Costs Per Year	**$720.08**
								Backup Costs Per Year	**$328.13**
								Server Software Costs Per Year	**$780.00**
								Labor Costs Per Year	**$1,200.00**
								Total Costs Per Year	**$3,028.20**

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	April 5, 2012
From:	Michael Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the February 28, 2012, HCP Coordinating Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met in SeaTac, Washington, on Tuesday, February 28, 2012, from 9:30 am to 12:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Tom Kahler will email the Wells 2011 Gas Bubble Trauma (GBT) Study Report to Carmen Andonaegui for distribution to the Coordinating Committees (Item II-A).
- Tom Kahler will email a photo of the Half-Duplex (HD) Passive Integrated Transponder (PIT) detector installed in the Wells Dam west fish ladder to Jerry Marco (Item II-C).
- Steve Hemstrom will advise the Coordinating Committees whether Chelan PUD supports the use of Douglas PUD's Document Management Tool (DMT) as a document library from where the Committees' members can access HCP documents (Item II-D).
- Lance Keller will email the list of fish recovered during normal maintenance of the Rock Island Dam right fish ladder to Carmen Andonaegui for distribution to the Coordinating Committees (Item III-A).
- Steve Hemstrom will incorporate the 2013 10-Year No Net Impact (NNI) Progress Report into the Rocky Reach and Rock Island HCP Action Plan, including timelines (Item III-D).
- Steve Hemstrom will look into updating Peven et al. 2004 (Item III-E).

DECISION SUMMARY

- The Coordinating Committees approved the 2012 Wells HCP Action Plan (2012 Action Plan) as revised (Item II-B).

REVIEW ITEMS

- The Draft Rock Island and Rocky Reach 2012 HCP Action Plan is out for a 30-day expedited review. Comments are due to Steve Hemstrom by March 1, 2012.
- The Draft 2012 Rocky Reach Fish Bypass Evaluation Study Plan is out for a 30-day expedited review. Comments are due to Lance Keller by March 9, 2012.
- The Draft 2011 Chelan PUD Predator Control Report is out for a 60-day review. Comments are due to Lance Keller by March 24, 2012.
- The Draft 2011 Rocky Reach Juvenile Fish Bypass System Report is out for a 60-day review. Comments are due to Lance Keller by March 26, 2012.
- The Draft 2012 Wells Bypass Operations Plan is out for a 30-day expedited review. Comments are due to Tom Kahler prior to the next Coordinating Committees' meeting on March 27, 2012.

REPORTS FINALIZED

- Tom Kahler will finalize the 2012 Action Plan and email it to Carmen Andonaegui for distribution to the Coordinating Committees (Attachment B).
- The 2011 Rocky Reach Yearling Chinook Survival Study report was finalized on February 17, 2012, and emailed to the Coordinating Committees on February 29, 2012.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees' members and asked for any additions or changes to the agenda. Steve Hemstrom added to the agenda a briefing on the Fish Passage Center's (FPC's) Public Records Request to Chelan PUD, and a discussion of the Draft 2012 Rocky Reach and Rock Island HCP Action Plan.

The Committees reviewed the revised draft January 20, 2012, meeting minutes. Tom Kahler provided editorial comments to item II-A of the meeting minutes, which he will email to Carmen Andonaegui to include in the minutes. The draft January 20, 2012, meeting minutes were approved as revised. Andonaegui will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Draft 2012 Wells Dam Bypass Operations Plan (Tom Kahler)

Tom Kahler said that the Draft 2012 Wells Dam Bypass Operations Plan (Wells Bypass Operations Plan) was similar to the 2011 Wells Bypass Operations Plan with only minor changes. The changes included the adjusted start and end dates for bypass operations previously approved by the Coordinating Committees and changes to the last paragraph of the Wells Bypass Operations Plan to reflect changes in criteria for bypass barriers removal for total dissolved gas (TDG) compliance. Bryan Nordlund noted that the U.S. Army Corps of Engineers (USACE) had indicated that it plans to test spill at Chief Joseph Dam in 2012. Steve Hemstrom said that Chelan PUD was working to schedule a meeting with USACE and other involved parties for the end of March 2012 to discuss the issue. Jerry Marco asked if Douglas PUD used juvenile sampling results from the Rocky Reach Dam juvenile fish bypass to evaluate GBT occurrences for Wells Dam. Steve Hemstrom confirmed that this was the case. Marco referred to the elevated TDG levels coming out of Grand Coulee Dam in 2011 (144 percent). He said that there needs to be a discussion about how to reduce TDG levels in the Wells forebay given the 10-year turbine maintenance schedule at Grand Coulee Dam. Kahler said that he would email a copy of the Wells 2011 GBT Study Report to Carmen Andonaegui for distribution to the Coordinating Committees. He said that the new bypass operation dates will be implemented in 2012 as approved by the Committees on November 15, 2011. Wells Project 2012 bypass operations will commence on April 9, 2012, instead of April 12 as in 2011, and be discontinued August 19, 2012, instead of August 26 as in 2011. Kahler said that he would request approval of the Draft 2012 Wells Bypass Operations Plan at the March 27, 2012, Committees' meeting and said that comments could be provided to him up until the March meeting date.

B. 2012 Wells HCP Action Plan Approval (Tom Kahler)

Tom Kahler said that changes recommended by the Hatchery Committees had been made to the revised draft 2012 Action Plan emailed to the Coordinating Committees on February 10,

2012. He asked for Coordinating Committees' approval of the 2012 Action Plan as revised. The Committees approved the 2012 Action Plan as revised. Kahler will finalize the 2012 Action Plan and email it to Carmen Andonaegui for distribution to the Committees.

C. West Ladder HD-PIT Detection System Installation (Tom Kahler)

Tom Kahler said that Douglas PUD had intended to install the HD detection system in the east fish ladder at the Wells Project during the early December 2011 normal maintenance outage; however, the contractor, Biomark, was moving its manufacturing facility during that period and was not able to build the detection array antennae as required. Kahler said Douglas PUD also was not able to get the 2020 HD detection receiver, which is required to operate the system. In the west fish ladder, an HD detector array was installed in pool 19 during January 2012. Pool 19 is above the maximum tailrace elevation ensuring that migrating adult lamprey will be forced to pass through the detection array (because they are averse to passing via the overflow weirs). Additional detection arrays will be installed in west ladder in December 2012 and HD detection will be installed in the east ladder in January 2013. Kahler will email to Jerry Marco the photograph of the HD detector installed in pool 19 of the west ladder that was provided to Coordinating Committees' members at today's meeting.

D. Document Management Tool Demonstration and Discussion (Tom Kahler)

Tom Kahler said that Douglas PUD intends to use the DMT to create a repository for its HCP-related documents for its internal use. He said that Douglas PUD was willing to make this repository available to the Coordinating Committees for the Committees' use as well. Kahler asked if this would also meet Chelan PUD's needs, making it a single location where all Coordinating Committees members could access all HCP documents. Steve Hemstrom asked whether all files contained in the DMT would be open to a public records request. Kahler replied that he did not know the answer. He gave a brief demonstration of the DMT file structure saying it could function as a library only but that it also allowed for collaborative document revision. Mike Schiewe summarized that the objective for the Committees was to find an alternative to the existing HCP file transfer protocol (ftp) site for storage and management of HCP documents. At the January 20, 2012, Committees' meeting, SharePoint was presented along with the DMT as possible alternatives.

The Committees discussed which documents created within the HCP committees would be available to the public. Schiewe said that only final documents (such as final meeting minutes, study reports, Statements of Agreement [SOAs], and agendas) should be made available to the public and that working versions of documents should be located in a place not accessible to the public. Hemstrom said that Chelan PUD would want a backup of all documents, not just a repository for final documents. Teresa Scott said that she would like a filing system that clearly indicated which documents were subject to discussion for a given meeting. Bryan Nordlund said that he would like a site that provided a consistent filing structure. Kahler said that SharePoint would not meet Douglas PUD's needs and that they will set up a DMT repository for its HCP-related documents. Schiewe asked if Chelan PUD would be supportive of using the DMT as a library for the Committees. The site would be available through the Internet and accessible only by password. Schiewe said that filing structure could allow for some flexibility among HCP committees. Nordlund said that Grant PUD has recently developed a new filing structure for organizing and storing the Priest Rapids Coordinating Committee (PRCC) documents. He suggested that the Committees could hyperlink documents in the HCP library to references in HCP annual reports. The Committees discussed the possibility of including email correspondences in the HCP repository and which categories of emails may or may not be appropriate to archive. Schiewe said that a formal agreement would be necessary in regards to storing emails or email content. Hemstrom said that he would inquire into whether Chelan PUD would be willing to use the DMT as its library for HCP documents. Schiewe said that after a new file storage alternative is selected, the next step would be to discuss document filing structures.

III. Chelan PUD

A. Rocky Reach and Rock Island Fishways Dewatering and Fish Recovery Summary (Lance Keller)

Lance Keller said that at the January 20, 2012, Coordinating Committees' meeting, Steve Hemstrom reported the incidence of fish stranding and mortalities during routine fishway dewatering and maintenance activities at the Rocky Reach Project. He said that the HD PIT-tag detection arrays had been installed as planned in the Rocky Reach fishways along with other scheduled modifications. Keller said that Rocky Reach was being re-watered and would be fully watered by the March 1, 2012, deadline. He reported that Chelan PUD began dewatering the Rock Island left fish ladder on January 5, 2012; two wild steelhead were recovered during dewatering. Staff was able to do required maintenance, and the left fish ladder was re-watered February 3, 2012. Keller said that the center fish ladder at Rock Island was dewatered beginning January 12, 2012, with the right fish ladder remaining open to allow adult fish passage. He said that the center fish ladder was the fishway receiving the major overhaul for 2012. One wild juvenile steelhead was rescued from the center fish ladder. The outage for the center ladder used the entire outage period through February 2012 to ensure that all routine work was performed, and work to procure and replace a unique set of butterfly valves in the Rock Island center ladder auxiliary water supply system. The center fishway will be re-watered February 29, 2012, before the March 1, 2012 deadline. The upper end of the right fish ladder was dewatered on February 8, 2012, and the lower end on February 10, 2012. Keller said that the right fish ladder was the ladder that receives the most use. He provided the list of species recovered during dewatering and maintenance of the right fish ladder and will email a copy of the list to Carmen Andonaegui for distribution to the Committees (Attachment C). Keller said that the right fish ladder would be re-watered by Thursday, February 23, 2012.

B. Draft 2012 Rocky Reach Fish Bypass Evaluation Study Plan (Lance Keller)

Lance Keller said that the draft 2012 Rocky Reach Fish Bypass Evaluation Study Plan included tasks to be accomplished by Chelan PUD in 2012 during the operation of the juvenile bypass. He said that no survival studies were required in 2012, but that routine index sampling of juvenile fish would start April 1, 2012. Keller briefly described the routine indexing procedures. He said that all fish would be interrogated for PIT tags. Bob Rose indicated that the Yakamas might want to take tissue samples for genetic analysis from lamprey captured in the fish bypass. Keller said that there were no changes to the operations of the fish bypass other than that there would be no 24-hour sampling in 2012. Comments on the draft 2012 Rocky Reach Fish Bypass Evaluation Study Plan are due to Keller by March 9, 2012.

C. Pacific Lamprey Fishway Passage Improvements and Half-duplex PIT Antenna Installation (Steve Hemstrom)

Steve Hemstrom said that HD detectors have been installed at Rocky Reach dam as planned. He said that the Rocky Reach Fish Forum toured both dams last week. HD detectors are installed in both the fish ladder exists and in additional locations in Rocky Reach Dam. Hemstrom offered an open invitation to Coordinating Committees' members to tour Rocky

Reach Dam. He reported that the planned improvements to the fish ladders for lamprey were progressing well.

D. Draft 2012 Rock Island and Rocky Reach HCP Action Plan (Steve Hemstrom)

Steve Hemstrom said that the draft 2012 Rock Island and Rocky Reach HCP Action Plan described activities for all the HCP committees. He said that planned activities for 2012 were the same as for 2011, with the exception that no survival studies are planned for 2012. Hemstrom said Coordinating Committees' activities totaled 14. Predator control programs are planned for 2012 with the option for extending long-line fishing later into the year. Lance Keller said that predator control activities will start in February 2012 and extend through October 2012. Mike Schiewe asked if Chelan PUD was required to complete an HCP Plan Species status report similar to that required of Douglas PUD, and if so, he said it should be included in Chelan PUD's 2012 HCP Action Plan. Hemstrom agreed to incorporate the required 2013 10-Year NNI Progress Report into the Rocky Reach and Rock Island HCP Action Plan, including timelines. Tom Kahler said that for the Wells Project, Douglas PUD would be referencing the August 2011 federal agencies' Endangered Species Act (ESA)-listed species status updates, with additional information from the 5-Year Monitoring and Evaluation (M&E) analyses.

Jim Craig asked if Chelan PUD saw an increase in pikeminnow migration in the fall after fish ladder trapping operations are halted in August. Hemstrom said that July is typically the busiest month for adult pikeminnow migration, with the right ladder at Rock Island seeing the heaviest use for both salmon and pikeminnow. Keller said that pikeminnow trapping normally shuts down in September so that staff can turn its attention to spawning ground surveys, but in 2012 trapping did not occur at all due to the large adult sockeye return that overlapped with the pikeminnow migration

Teresa Scott said that she thought the FPC's comprehensive survival study (CSS) intersected with the PUDs' HCP 10-Year Plan Species status check-in. But, she also thought that the CSS was independent from the National Marine Fisheries Service (NMFS) Fish Science Center's species status reviews, which evaluate all viable salmonid population (VSP) parameters and include an evaluation of hatchery survival. Bob Rose said that the FPC wants to evaluate whether survival of juvenile salmonids detected migrating out of the Upper Columbia are "adequate" based on the numbers of returning adults. Scott said that the next

FPC CSS meeting is scheduled for April 12, 2012, for a discussion of study results and conclusions. Rose said that the Committees might want to review the CSS analysis to determine whether it should be incorporated into the HCP 10-Year Plan Species status update. Scott asked how the CSS was similar or different from what was required of the PUDs by their HCPs. Mike Schiewe said that when the CSS began in the late-1990s, the FPC was initially focused on evaluating reach survivals of hatchery releases. Scott said that Michelle DeHart, manager of the FPC, was willing to present a summary of CSS results to the Committees. Scott encouraged Committees' representatives to attend the April 12, 2012, CSS meeting and then to consider inviting DeHart to present the CSS results and answer questions at a future Committees' meeting.

E. Fish Passage Center Public Records Request (Steve Hemstrom)

Steve Hemstrom said that on February 20, 2012, Michelle DeHart requested copies of all Chelan PUD's survival study reports. Hemstrom said he sent DeHart a compact disk containing 31 Adobe Acrobat files of 26 survival study reports conducted from 2003 through 2011. He said that Dehart had said that the FPC was looking at what she called a disparity between the PUDs' survival estimates and survival estimates based on analysis of PIT tag data. She said the focus was mostly on the Rock Island Project since most juvenile spring Chinook, steelhead, and sockeye were PIT-tagged at Rock Island. DeHart said that she was also looking at all PIT-tagged hatchery fish. He said that DeHart was looking into whether there was a positive bias for survival using acoustic-tagged fish. Josh Murauskas and Hemstrom said that they will be attending the FPC's April 12, 2012, CSS meeting.

Bryan Nordlund noted that the FPC tended to favor the use of PIT tags over acoustic tags to estimate survival of run-of-the-river fish. He said that the CSS looked at smolt-to-adult returns (SARs) using PIT tag data; whereas, the PUDs focused on evaluating Project survival and therefore used acoustic tags. Schiewe suggested Committees' members look at the FPC webpage for copies of recent CSS reports. Hemstrom mentioned an unpublished 2007 U.S. Geological Services (USGS) study comparing the performance of acoustic tags versus PIT tags for use in survival studies, which can probably be located on the Internet. The Committees discussed the available literature comparing the use of acoustic- versus PIT-tagged juvenile salmonids for survival studies. Nordlund noted that within the next couple of years, Chelan PUD should think about updating Peven et al. 2004, to include information on the design of acoustic tag survival studies used by the Chelan and Douglas PUDs. Hemstrom agreed and said he would look into what it would take to accomplish the update. Schiewe said that the Committees would be well represented at the CSS April 12, 2012, meeting and that after the meeting they should reconsider if there are outstanding issues to discuss and if they would like to invite DeHart to attend a future Committees' meeting.

IV. Tributary and Hatchery Committees Update (Mike Schiewe)

Mike Schiewe reported that the Tributary Committees met on February 9, 2012, and discussed the following items:

- The 2012 HCP Tributary Account funding levels are $673,000 for Rock Island, almost $319,000 for Rocky Reach, and $244,500 for the Wells Project.
- The Tributary Committees raised the maximum funding limit for Small Projects Programs from $75,000 in 2011 to $100,000 for 2012. The Small Projects Program grants were originally set at a maximum funding level of $25,000, but were increased to $50,000 in 2007 and to $75,000 in 2011.
- The Wells and Rocky Reach Tributary Committees approved $250,000 in funding for a project to protect acreage on the Methow River downstream of Twisp.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the most recent Hatchery Committees' meeting on February 15, 2012, at Chelan PUD's headquarters building:

- Chelan PUD's 5-Year M&E Report is out to the Coordinating Committees for a 60-day review; the Douglas PUD 5-Year M&E Report is almost ready for review. Based on results of the 5-Year M&E Reports, the Hatchery Committees are already considering changes to hatchery programs, such as changing the size-of-release targets for Chiwawa spring Chinook.
- The Wells 2012 HCP Action Plan was approved by the Hatchery Committees at the February meeting. The Hatchery Committees added the modernization of the Wells Hatchery and Hatchery Committees' recommended check-ins to allow for periodic input on the progress of the modernization.
- Ken Warheit, Washington Department of Fish and Wildlife (WDFW), gave a presentation to the Hatchery Committees on parental assignment as a tool for managing spring Chinook in the upper Wenatchee Basin. The results as first presented were not encouraging; however, Warheit's interpretation of the results

showed that parental assignment works, but that the problem may be in getting a large enough sample size collected at Priest Rapids Dam to allow use of the tool. No decisions were made by the Hatchery Committees at this time as to whether to continue with using parental assignment to help with broodstock selection for upper Wenatchee stocks, but it does not look like enough fish can be sampled at Priest Rapids to make this tool effective. The alternative to collecting fish at Priest Rapids Dam is to sample adults at Tumwater Dam (TWD) and hold the sampled adults onsite until the samples can be analyzed and the results returned. The Hatchery Committees will look into the feasibility of using this option. Both Teresa Scott and Bryan Nordlund mentioned the possible negative effect of multiple trapping of returning adults during the migration.

- Maureen Hess, Columbia River Intertribal Fisheries Commission (CRITFC), gave a presentation to the Hatchery Committees on the Snake River parental-based tagging (PBT) program. Hess said CRITFC hoped to expand the collection of genetic samples to the upper Columbia as part of a regional PBT program. She said that the program goal was to collect tissue samples for all Columbia River hatchery steelhead and spring Chinook and asked for the participation of upper Columbia River hatchery operators by collecting and archiving samples. The Hatchery Committees were generally receptive to the program, saying that they were mostly already collecting genetic samples from broodstock and archiving them. Jim Craig said that the U.S. Fish and Wildlife Service (USFWS) did not routinely collect genetic samples at their hatcheries.
- The Yakama Nation introduced the idea of using the Hatchery Evaluation Technical Team (HETT), a subgroup of the Hatchery Committees, to develop a strategy for the use of distributed acclimation for salmon and steelhead hatchery fish in the upper Columbia. The Yakama Nation has pioneered the use of distributed acclimation using coho; since those initial efforts, the Hatchery Committees approved the use of Blackbird Pond for acclimating steelhead and approved co-acclimating coho and steelhead at Rohfling Pond and steelhead and spring Chinook at Twisp Pond. The Yakama Nation would like the Hatchery Committees to develop a long–term approach to distributed acclimation rather than continue with annual approvals. Bob Rose said that he hoped acclimation sites considered would be located in areas with suitable quantities and quality of spawning and rearing habitat. He asked about available information on returns from remote acclimation sites. Schiewe said that the

Yakama Nation was leading the use of remote acclimation and that it is still early for conclusive results. Rose said that a connection should be made to the Tributary Committees funding of habitat restoration and protection projects. Schiewe said that Keely Murdoch had drafted a proposal for the Hatchery Committees to consider assigning to the HETT, requesting their consideration of the role of remote acclimation in improving fish returns. Tom Kahler said that questions to evaluate when considering expanding spawning distribution included targets for ratios of wild-to-hatchery fish on the spawning grounds, and whether it is desirable to extend hatchery fish spawning beyond where they are currently spawning and into strongholds of wild spawners. Hemstrom said that it would be useful to look at other hatchery programs, like in the Clearwater drainage where a goal is to get as many hatchery fish returning to the Lochsa River as possible by planting hatchery fish.

- Craig Busack, National Oceanic and Atmospheric Administration (NOAA), updated the Hatchery Committees on permitting of Hatchery Genetic Management Plans (HGMPs) for Upper Columbia River hatchery programs. NOAA is now reviewing the USFWS and Douglas PUD Methow Basin HGMPs.
- The 2012 Rocky Reach and Rock Island HCP Action Plans are out for a 30-day review with comments to Chelan PUD by March 1, 2012, for approval at the next Hatchery Committees meeting on March 28, 2012.
- The Hatchery Committees discussed Chiwawa spring Chinook size-at-release targets. The draft Chelan PUD 5-Year M&E report suggests that the 12 fish-per-pound (fpp) target was producing more mini-jacks and more straying without increasing the number of returning adults. Hatchery managers will need to look at size-of-transfer to get to a release size of the proposed 18 fpp size-at-release target. The Hatchery Committees are mostly supportive of the proposed change in targets; additional information on feeding rates and other factors related to changing size-at-release will be provided at the next Hatchery Committees' meeting on March 28, 2012.
- The Hatchery Committees discussed the HETT's progress in addressing Objective 10 of the PUD Hatchery M&E programs: Non-target Taxa of Concern (NTTOC), one of three regional M&E program objectives. Objective 10 requires the PUDs to look at interactions between hatchery fish and native fish species. The evaluation has become very involved and the HETT has reported that it will likely be another year before the process is completed. It is expected that the information from the NTTOC evaluation will allow for managing supplementation programs to avoid or minimize

impacts on NTTOC. Schiewe said that the Hatchery Committees will be careful to include timelines in future requests to the HETT to develop a strategy for long-term distributed acclimation of hatchery program fish in the Upper Columbia.

- The HETT has completed the reference stream selection methods analysis assigned to it by the Hatchery Committees. The reference stream selection methods write up has been included as an appendix to both the Chelan and Douglas PUDs' 5-Year M&E reports.
- USFWS announced that all upper Columbia hatchery spring Chinook would be externally marked beginning with the 2012 release. The agreement was reached working through the *U.S. v OR* forum.

V. HCP Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees' meetings are March 27, 2012, April 24, 2012, and May 22, 2012, all in SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees
Attachment B – Final Wells 2012 HCP Action Plan
Attachment C – 2012 Rock Island Adult Fish Ladder Rescue Summary

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Jerry Marco*†	Colville Confederated Tribes
Teresa Scott*	WDFW
Bryan Nordlund*	NMFS
Bob Rose*	Yakama Nation
Jim Craig*	USFWS

*Denotes Coordinating Committees member or alternate
†called in to the meeting

2012 ACTION PLAN
WELLS HCP

WELLS HCP COORDINATING COMMITTEE

1. **Bypass Operating Plan**
   a. Draft to Coordinating Committee (CC): .... February 2012
   b. Approval deadline: .... March 2012
   c. Period of implementation: .... April 9 to August 19, 2012
   d. Report deadline: .... October 2012

2. **2013 NNI Progress Report (per Wells HCP §6.9)**
   a. Douglas/CC develop report outline .... March 2012
   b. CC provides direction on status update for Plan Species .... May 2012
   c. Douglas submits Draft NNI Progress Report to the CC .... March 2013

3. **Predator Control Programs**
   a. Pikeminnow removal – Wells Project: .... March – August 2012
   b. Draft 2011 pikeminnow report to DCPUD: .... January 2012
   c. 2011 pikeminnow report internal review and submission to CC: .... February 2012
   d. Avian predator hazing at Wells: .... October 2011 – May 2012

4. **Sub-yearling Chinook Life-history Study**
   a. Draft 2011 report to CC: .... February 2012
   b. Final 2011 report: .... April 2012
   c. Update study plan: .... January-April 2012
   d. Tag and release study fish: .... June-July 2012
   e. Monitor study fish: .... through life cycle
   f. Draft 2012 report to CC: .... February 2013
   g. Final 2012 report: .... April 2013

5. **Annual Monitoring of Juvenile Migration Run Timing**
   a. Skalski analysis of index data from RR: .... September 2012
   b. Draft of Skalski's report to DCPUD: .... September 2012
   c. Final report presented to CC: .... October 2012

6. **Installation of HDX PIT-tag Detection System at Wells Dam**
   a. Contractor noise testing and site analysis .... January 2012
   b. Fabrication and installation of partial system in the west ladder .... January/February 2012
   c. Complete installation in the west ladder .... December 2012
   d. Complete installation in the east ladder .... January/February 2013

7. **Lamprey Entrance Efficiency Study**
   a. Study plan .... June 2012
   b. Conduct velocity test and efficiency study .... July – August 2012
   c. Draft report .... November 2012
   d. Final report .... February 2013

WELLS HCP HATCHERY COMMITTEE

1. **Implement 5-year Hatchery Monitoring and Evaluation (M&E) Plan**
   a. Ongoing implementation: ....January – December 2012
   b. Draft annual report for 2011 to Douglas PUD:.. June 2012
   c. Draft annual report to Hatchery Committee (HC): ....July 2012
   d. Final annual report to HC: ....October 2012
   e. Draft 5-year synthesis/analysis report to HC: .... February 2012
   f. Final 5-year synthesis/analysis report:.. April 2012
   g. Draft 2013 implementation plan to HC: ....October 2012

2. **Review and Update 5-year M&E Plan (per Wells HCP §8.5.1 and 8.8)**
   a. Draft to HC: ....July 2012
   b. Final to HC:..October 2012

3. **2013 Hatchery Program Review (per Wells HCP §8.8)**
   a. Data and analyses for the Hatchery Program Review are contained within several existing documents or documents scheduled for completion in 2012:
      1. Douglas 5-Year M&E Report (to HC in 2012) addresses all aspects of the Hatchery Program Review for Methow Hatchery spring Chinook and Wells Hatchery steelhead and summer Chinook.
      2. Chelan 5-Year M&E Report (to HC in 2012) addresses all aspects of the Hatchery Program Review for Carlton Pond summer Chinook.
      3. Hatchery M&E annual reports (2003-2011) provide detailed data necessary for the Hatchery Program Review.
      4. Methow Spring Chinook HGMP (2010) included thorough review of the program and redesigned the program based on the review.
      5. Wells Complex Summer Steelhead HGMP (2011) included thorough review of the program and redesigned the program based on the review.
      6. Adjustment of hatchery compensation (2011) conducted review and assessment of SARs, adults returns, hatchery and natural smolt production.
      7. Fish-Water Management Tool (FWMT) Progress Report (Hyatt et al. in prep) provides an analysis of the multi-year data set to determine the contribution of FWMT implementation to average production of Okanagan sockeye.
   b. HC directs the development of summary report:.................................June – August 2012
   c. HC reviews draft summary report: ....September – October 2012
   d. Final summary report to HC: ....December 2012
   e. Final summary report from HC to CC:.. January 2013

4. **2012 Broodstock Collection Protocol**
   a. Draft to HC: .... March 2012
   b. Approval deadline:.. April 2012
   c. Implementation: ....May 2012 to April 2013

5. **Annual Implementation Report - Sockeye Fish/Water Management Tools**
   a. Period covered: ....Water Year 2011-2012 (October – September)
   b. Draft to HC: ....*to be determined*

c. Presentation to HC: ....August or September 2012
d. Draft 2013 FWMT progress report to Douglas PUD: .... August 2012
e. Draft 2013 FWMT progress report to HC: ....October 2012
f. Final 2013 FWMT progress report to HC: .... December 2012
g. HC delivers final 2013 FWMT progress report to CC: .... January 2013

6. HGMP – Methow Spring Chinook

a. Draft Spring Chinook HGMP to HC: .... Complete November 2009
b. Final Spring Chinook HGMP to NMFS: ....Completed March 2010
c. NMFS approval of Spring Chinook HGMP: ....*to be determined*

7. HGMP – Wells Steelhead

a. Draft Steelhead HGMP to HC: ....Completed February 2011
b. Final Steelhead HGMP to NMFS: ....Completed March 2011
c. NMFS approval of Steelhead HGMP: ....*to be determined*

8. Methow Steelhead Relative Reproductive Success Study

a. Implementation: .... March 2010 - December 2021
b. Interim reports:... September 2012
c. Final report:.. 2021/2022

9. Wells Hatchery Modernization

a. Update on rearing criteria and Master Plan: .... December 2012
b. Provide updates to the HC ....Monthly
c. Provide opportunities for HC input.. Periodically

WELLS HCP TRIBUTARY COMMITTEE

1. **Plan Species Account Annual Contribution**
   a. $176,178 in 1998 dollars.. January 2012

2. **Annual Report - Plan Species Account Status**
   a. Draft to Tributary Committee (TC): .... February 2012
   b. Approval Deadline:.. March 2012
   c. Period Covered: ....January to December 2011

3. **2012 Funding-round – General Salmon Habitat Program**
   a. Request for project pre-proposals:........................... *To be determined* (typically in March)
   b. Pre-proposals to TC: .... *To be determined* (typically in early May)
   c. Tours of proposed projects: ....*To be determined* (typically in late May)
   d. Project sponsor presentations to TC: .... *To be determined* (typically in early June)
   e. Final project proposals to TC:............................*To be determined* (typically in early July)
   f. RTT project rating decisions:......................................*To be determined* (typically in July)
   g. Supplemental sponsor presentations ....*To be determined*
   h. TC final funding decisions:......................... *To be determined* (typically before December)

4. **Small Project Program**
   a. Project review and funding decision.................................. Applications accepted any time

5. **Tributary Assessment Program**
   a. Proposal to TC for year-5 of 5 for ORRI monitoring ....July 2012
   b. Develop monitoring plan for remaining funds... March 2012
   c. Implement monitoring plan..*To be determined* (2012)
   d. Monitoring plan final product... December 2012
   e. TC delivers final product to CC... January 2013

2012 Rock Island Adult Fish Ladder Rescue Summary:

Left Ladder

Ladder De-Watered: January 5th, 2012
Fish Rescued: 2 wild juvenile steelhead/rainbows
Ladder Back in Operation: February 3rd, 2012

Center Ladder

Ladder De-Watered: January 12th, 2012
Fish Rescued: 1 wild juvenile steelhead/rainbow
Ladder Back in Operation: March 1, 2012

Right Ladder

Ladder De-Watered: February 8th, 2012 (upper portion), February 10th, 2012 (lower portion)
Fish Rescued:

- Clipped Adult Steelhead: 1
- Ad-Present Adult Steelhead: 4
- Ad-Present Steelhead 12-18”: 5
- Ad-Present Juvenile Chinook: 2
- Ad-Present Steelhead Parr: 1
- Whitefish: 5
- Burbot: 1
- Sculpin: 1
- Lamprey Macrophthalmia: 5
- Lamprey Macrophthalmia (mortalities): 2

Ladder Back in Operation: February 23rd, 2012

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	April 24, 2012
From:	Michael Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the March 27, 2012, HCP Coordinating Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met in SeaTac, Washington, on Tuesday, March 27, 2012, from 9:30 am to 12:00 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Bryan Nordlund will review Peven et al., 2005, and prepare a list of how the juvenile survival study protocols used in the 2011 Chelan PUD survival study differed from the survival study protocols in Peven et al. (2005) (Item I-B).
- Steve Hemstrom will set up a conference call with Douglas PUD to discuss the shared use of Douglas PUD's data management tool (DMT) for use by the Coordinating Committees (Item I-B).
- Tom Kahler will finalize and email to Carmen Andonaegui the 2012 Wells Juvenile Bypass Operating Plan for distribution to the Coordinating Committees (Item II-A).
- Tom Kahler will prepare a detailed outline of the Douglas PUD 2013 No Net Impact (NNI) Progress Report (Progress Report) for distribution to the Coordinating Committees prior to the April 24, 2012, meeting (Item II-B).
- Steve Hemstrom will prepare a detailed outline of the Chelan PUD 2013 NNI Progress Report for distribution to the Coordinating Committees prior to the April 24, 2012, meeting (Item III-A).
- Lance Keller will finalize and email to Carmen Andonaegui the 2012 Rocky Reach Fish Bypass Operations Plan for distribution to the Coordinating Committees (Item III-C).
- Teresa Scott will report to the Coordinating Committees on Washington Department of Fish and Wildlife's (WDFW's) review of the Schaffer Joint-Use Dock and Trail

Proposal (III-E).

- Steve Hemstrom will finalize the Rocky Reach and Rock Island 2012 Fish Spill Plan per comments and as approved at today's Coordinating Committees' meeting and email it to Carmen Andonaegui for distribution to the Coordinating Committees (Item III-B).
- Steve Hemstrom will email Chelan PUD's comment letter regarding the Douglas County Schaffer Joint-Use Dock and Trail Proposal to Carmen Andonaegui for distribution to the Coordinating Committees, (Item III-E).

DECISION SUMMARY

- The Coordinating Committees approved the Wells 2012 Juvenile Bypass Operating Plan (Item II-A).
- The Coordinating Committees approved the 2012 Rocky Reach and Rock Island Fish Spill Plan with revisions (Item III-B).
- The Coordinating Committees approved the 2012 Rocky Reach Fish Bypass Operations Plan with revisions (Item III-C).
- The Coordinating Committees finalized the 2012 Rocky Reach and Rock Island HCP Action Plan (2012 Action Plan) (Item III-D).

REVIEW ITEMS

- Carmen Andonaegui sent an email notification to the Coordinating Committees on March 5, 2012, that the Draft 2011 Rocky Reach HCP Annual Report and the Draft 2011 Rock Island Annual Report were out for a 30-day review with comments due to Andonaegui by April 4, 2012.

REPORTS FINALIZED

- Lance Keller will finalize the 2011 Chelan PUD Predator Control Report and email it to Carmen Andonaegui for distribution to the Coordinating Committees.
- Lance Keller will finalize the 2011 Rocky Reach Juvenile Fish Bypass System Biological Evaluation Report and email it to Carmen Andonaegui for distribution to

the Coordinating Committees.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees' members and asked for any additions or changes to the agenda. The following items were added to the agenda:

- Steve Hemstrom asked if Teresa Scott could provide additional information about the comparative survival study meeting on April 12, 2012.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft February 28, 2012, meeting minutes. Lance Keller raised a variety of editorial corrections, which will be incorporated into the meeting minutes. The draft February 28, 2012 meeting minutes were approved as revised. Carmen Andonaegui will finalize the meeting minutes and distribute them to the Committees.

B. Action Item Review (Mike Schiewe)

Mike Schiewe asked Steve Hemstrom about an Action Item from the February 28, 2012, meeting regarding updating the Chelan PUD Technical Report, *Guidelines and Recommended Protocols for Conducting, Analyzing, and Reporting Juvenile Salmonid Survival Studies in the Columbia River Basin* by Peven et al. (2005). Hemstrom said that although the simplest approach might be to update the existing document that was not realistic, because the document involved multiple authors, some of whom were in different positions. He said that Chelan PUD could potentially draft a new stand-alone protocols document but that he was open to other ideas. Schiewe suggested that writing a stand-alone document might be the best approach. Bryan Nordlund suggested that another approach might be to document changes to the Peven et al. protocols employed in the 2011 survival study as a way to guide the 10-year survival study check-in. As a starting place, Nordlund said that he planned to review the Peven et al. (2005) protocols and prepare a list of how the 2011 juvenile survival study differed from the protocols in Peven et al. (2005). He said he would then submit that list to the Coordinating Committees for review and consideration. The Committees could then discuss the best approach to capture the changes to the 2011 survival study protocols.

With regard to another Chelan PUD Action Item, Schiewe asked Hemstrom whether Chelan PUD staff had further considered using Douglas PUD's DMT as a library for HCP documents. Hemstrom stated that he had discussed this option with Joe Miller, Chelan PUD, and that there were concerns regarding whether the items stored using DMT would be subject to public release. Also, Hemstrom said that Chelan PUD would need to budget funds to cover the cost of using the Douglas PUD DMT and that this was not included in the 2012 budget. Hemstrom said that he and Miller had discussed a number of benefits of using the DMT at Douglas PUD; however, he said that Chelan PUD needed to consider the option further to ensure they understood all the possible implications. Tom Kahler stated that Douglas PUD's new Clean Water Act (CWA) 401 Water Quality Certification (401 Certification) has the requirement that nearly everything associated with implementing the 401 Certification be made available to the public, on a web site, and that Douglas PUD was still sorting out exactly what implementing this requirement will entail. Kahler said that Douglas PUD's funding for using the DMT was in their 2012-2013 budget, which starts in September 2012. He suggested a phone call between Douglas PUD and Chelan PUD staff to talk about some of the issues surrounding shared use of the DMT. Schiewe stated that the FTP site currently used by the group is working for now, but at some point, it will make sense to move the record storage away from an outside consulting company (i.e., Anchor QEA). Schiewe concurred with the need to set up a meeting between Douglas PUD (Kahler and Shane Bickford) and Chelan PUD (Hemstrom and Miller). He said that it would be important to develop rules so that only HCP Committees' member had full access to drafts and working versions of documents. Kahler clarified that the DMT would not be available to the public. He said that there would be logins set up with specific permissions so that access to documents could be managed. Hemstrom said that he will set up a conference call with Douglas PUD to discuss the shared use of Douglas PUD's DMT.

II. Douglas PUD

A. Draft Wells 2012 Juvenile Bypass Operating Plan (Tom Kahler)

Tom Kahler said that Douglas PUD received no comments on this document and asked if there were any comments people wanted to raise today at the meeting. No comments were noted, and the plan was approved. Kahler will finalize the 2012 Wells Juvenile Bypass

Operating Plan and email it to Carmen Andonaegui for distribution to the Coordinating Committees.

B. Douglas PUD 2013 NNI Progress Report Outline (Tom Kahler)

Tom Kahler explained that he has begun working on an outline for the 2013 Progress Report but that it was not ready for review by the Coordinating Committees. He said that the Wells HCP stated that the Hatchery Committees and Tributary Committees would develop an initial progress report for the Coordinating Committees, and then the Coordinating Committees would prepare a "comprehensive" progress report. Kahler said that he envisioned that the Tributary Committees would document the distribution of tributary funds, including the types of projects funded and the amounts distributed, and perhaps some discussion of the implementation of the Tributary Assessment Program. However, Kahler said that because the Tributary Assessment Program is not explicitly tied to NNI this information may not be appropriate to include. He said that the Hatchery Committees' contribution to the Progress Report would probably include a discussion of what has been accomplished during the past 10 years, as compared to what had been identified in the HCPs, including a discussion of additional programs that had been developed since the HCP signing. There would also be a discussion of the 5-Year Monitoring and Evaluation (M&E) Report. The Coordinating Committee's contribution to the Progress Report would be a summary of Wells Project passage survival and a discussion of what has been accomplished and what was planned to continue meeting the HCP survival standards.

Mike Schiewe suggested that the Progress Report be kept as brief as possible. Bryan Nordlund stated that he would like to see the Progress Report include a very general summary of how NNI had been achieved over the past 10 years. He suggested describing habitat improvements, hatchery production, and fish survival rates achieved over the past 10 years. Steve Hemstrom agreed with this approach. Kahler will prepare a more detailed outline for distribution to the Coordinating Committees prior to the next meeting on April 24, 2012.

III. Chelan PUD

A. Chelan PUD 2013 NNI Progress Report (Steve Hemstrom)

Steve Hemstrom said that he had added a line item for the Chelan PUD's 2013 Progress Report to the Chelan PUD 2012 Action Plan. He said that he would provide a detailed draft outline of the Progress Report for distribution to the Coordinating Committees prior to the April 24, 2012 meeting. Bryan Nordlund asked about the target audience for the NNI reports. Tom Kahler responded that the Wells HCP says the Progress Report will be filed "for the Parties," so there is no plan to submit it formally with the Federal Energy Regulatory Commission (FERC). The Committees agreed that, once it is finalized, the report could be distributed to other audiences. Teresa Scott said that the Progress Report should be written with a larger, more general audience in mind. Hemstrom said that Chelan PUD's report will be very straightforward and factual. Mike Schiewe asked that the Committees' members keep in mind that the document is meant to be produced by the HCP Committees for the HCP Signatories (Washington Department of Fish and Wildlife [WDFW], the Yakama Nation, the Colville Confederated Tribes, Douglas and Chelan PUDs, U.S. Fish and Wildlife Service [USFWS], and National Marine Fisheries Service [NMFS]).

B. Rocky Reach and Rock Island 2012 Fish Spill Plan (Steve Hemstrom)

Steve Hemstrom said that the 2012 Fish Spill Plan was sent out for a 30-day review late in February 2012. Hemstrom asked if there were any comments or questions on the document. Jim Craig noted that Table 5 is not included in the text but there is a reference to such a table in the 2012 Fish Spill Plan; Hemstrom agreed to fix this to reference Table 2 or 3, which also includes the same information (on spill levels). Teresa Scott pointed out that 2011 needs to be changed to 2012 in a header on page 7. Hemstrom will make these revisions today (March 27, 2012) and will email the revised 2012 Fish Spill Plan to Carmen Andonaegui for distribution to the Coordinating Committees. The Coordinating Committees approved the document with these revisions.

C. 2012 Rocky Reach Juvenile Bypass Operations Plan (Lance Keller)

Lance Keller provided a summary of the draft 2012 Juvenile Bypass Operating Plan (Bypass Operating Plan). Steve Hemstrom said that this plan had previously been referred to as the, "Annual Bypass Evaluation Plan;" however, Chelan PUD was proposing changing the title to

"Bypass Operating Plan." He said that they believe this would be a more descriptive title because, after 9 years of operation, the plan is about operations and not evaluation. The Committees agreed to the title change. Keller said that comments on the 2012 Bypass Operating Plan were received from Jim Craig and his revisions had been incorporated into the document. Teresa Scott noted that there are some places in the documents (in a heading and in a table title) where the year 2011 needed to be changed to the year 2012. There were no other comments on the document. Keller will incorporate revisions as discussed at today's meeting and email the Final Bypass Operating Plan to Carmen Andonaegui for distribution to the Committees. The Committees approved the Bypass Operating Plan as revised.

D. Draft 2012 Rocky Island and Rocky Reach HCP Action Plan (Lance Keller and Steve Hemstrom)

Steve Hemstrom said that the 2013 Progress Report has been added as an activity to the 2012 HCP Action Plan. Mike Schiewe recommended that, if there were no further concerns or questions, the Coordinating Committees consider approving the 2012 HCP Action Plan today rather than delay until the April 24, 2012, meeting. The Committees approved the 2012 HCP Action Plan.

E. Douglas County Schaffer Joint-Use Dock and Trail Proposal (Steve Hemstrom)

Steve Hemstrom said that Douglas County had asked for comments on a proposed joint use dock and small trail on the Rock Island Reservoir. He said that Chelan PUD sent a comment letter to Douglas County on March 8, 2012. Hemstrom pointed out that Chelan PUD does not own the Shorelines adjacent to the Rock Island Reservoir and so has no authority over land use along the reservoir; they can only provide comments to Douglas County on the proposal. Hemstrom will send Chelan PUD's comment letter to Carmen Andonaegui for distribution to the Coordinating Committees. Hemstrom said that the proposed dock would not be for public access but for use only by several property owners in the vicinity of the dock. Bryan Nordlund and Hemstrom clarified that there are several permits that would still need approval for the proposed project to move forward. Hemstrom said that the proposed project was brought to the Coordinating Committees for their information only and that Chelan PUD was not asking for any action from the Committees at this point. Teresa Scott agreed to report to the Committees on WDFW's considerations after staff reviews of the proposed project.

F. Comparative Survival Study Annual Meeting (Steve Hemstrom)

Steve Hemstrom opened discussion by asking who was planning to attend the Comparative Survival Study (CSS) Annual Meeting. Douglas PUD staff, Hemstrom and Josh Murauskas from Chelan PUD, and Teresa Scott said that they were planning to attend. Mike Schiewe asked if the meeting would be on WebEx; Scott said that she would find out and report back by email. She said that the agenda for the meeting was not available yet, but that the format for the meeting would be a series of very interactive presentations and discussions.

IV. Tributary and Hatchery Committees Update (Mike Schiewe)

Mike Schiewe said that the Hatchery Committees meeting was delayed this month and will be held tomorrow, March 28, 2012, so there would be no Hatchery Committees' update this month. Schiewe reported that the primary item for discussion at the Hatchery Committees' meeting March 28, 2012, would be the 2012 broodstock collection protocols.

Schiewe reported that the Tributary Committees met on March 8, 2012, and discussed the following items:

- Regarding Conflict of Interest in Selection of Projects: The Tributary Committees added to their operating protocols that Tributary Committees' members who represent a project proponent would not be allowed to vote on that proposal.
- Regarding Public Access to Tributary Funded Projects: The Tributary Committees agreed that it is not a requirement for Tributary Program funding, but that it is an option for the Tributary Committees to require public access on a project-by-project or site-by-site basis.
- Regarding Photo Documentation: Photo documentation and monitoring of structures during construction will be included as a requirement on some funded projects.
- Regarding Nutrient Enhancement Design Subcontract Agreement: the Cascade Columbia Fish Enhancement Group (CCFEG) asked the Rock Island Tributary Committee to review and approve their subcontract agreement with Water Quality Engineering. CCFEG asked Water Quality Engineers to assist them with the Nutrient

Enhancement Design Project. The Rock Island Tributary Committee reviewed and approved the subcontract agreement.

- Regarding Evaluation of Appraisals/Values of Conservation Easements: With the escalating value of real estate, the Tributary Committees will be contracting with an economist at a local university, if possible, to research if there are other options for appraising conservation easements. Tom Kahler stated that there appears to be a lot of subjectivity in the appraisals. He said that it seemed prices were being paid to protect property from development that was far in excess of the property's value, especially when it did not appear the property owner intended to develop the property in the first place. Kahler said that Tracy Hillman, BioAnalysts, and Becky Gallaher, Chelan PUD, were directed by the Tributary Committees to begin investigating this issue. Teresa Scott said that the lead at WDFW working on real estate appraisals is Dan Budd; Kahler will pass this information on to Hillman and Gallaher.
- General Salmon Habitat Program Schedule: The Tributary Committees have established their calendar for processing the 2012 Salmon Habitat general fund. It is similar to previous years, although a slightly shorter time frame, and is expected to be finished by the end of August 2012. Pre-proposals are due May 7, 2012; project tours will be May 21 through May 24, 2012; the pre-proposal presentation workshop is scheduled for June 13, 2012; Tributary Committees' review will occur June 14, 2012; final proposals are due June 29, 2012; and final evaluations of proposals will occur by July 12, 2012, with project funding awards announced by August 31, 2012.
- River Safety Signs: The Tributary Committees have been asked whether they would fund the posting of signs at boater-access locations in the Wenatchee and Methow basins, to warn rafters, kayakers, and other boaters of hazards posed by habitat-restoration structures. The Tributary Committees decided against providing funding for the signage, believing that it would be better that the State of Washington provide such signage.

Jim Craig asked whether there was a requirement that projects funded by the Tributary Committees be monitored and then maintained at some functioning level over time following project completion. Kahler stated that this would be a very difficult requirement to include, primarily because it requires funding of presently undefined future actions. He said that the most the Tributary Committees have required of project sponsors to date was that the project be implemented as designed. He said that the program is self-policing at this point, because contractors implementing the projects want to be able to get future projects funded, so it is in their interest to install projects that are designed well and last into the future. Kahler clarified that the Tributary Committees and Regional Technical Team (RTT) have toured completed projects at least once, and annually tour proposed projects, and that in 2012 they are planning to extend the scheduled tours of proposed projects to review some completed projects as well.

V. HCP Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meeting is April 24, 2012 (conference call only). Subject to arranging for site visits, the May 22 meeting may be moved to the Wenatchee area. The June 26 meeting is planned for SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Virginia See	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Jerry Marco*†	Colville Confederated Tribes
Teresa Scott*†	WDFW
Jim Craig*	USFWS
Bryan Nordlund*	NMFS

*Denotes Coordinating Committees member or alternate
†joined by phone

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	May 24, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the April 24, 2012, HCP Coordinating Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met by conference call on Tuesday, April 24, 2012, from 9:30 am to 11:00 am. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Mike Schiewe will coordinate with Steve Hemstrom to confirm a meeting room at Rocky Reach Dam for next month's Coordinating Committees meeting on May 22, 2012, beginning at 10:00 am (Item I-A).
- Teresa Scott will add Jim Craig to her Fish Passage Center Weekly Report distribution list (Item II-B).
- Tom Kahler will send the revised draft 2013 Douglas PUD HCP NNI Progress Report Outline with recent additions tracked to Kristi Geris for distribution to the Coordinating Committees (Item III-B).

DECISION SUMMARY

There were no decisions made at today's meeting.

REVIEW ITEMS

There were no new review items distributed at today's meeting.

REPORTS FINALIZED

There are no reports to finalize at this time.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and introduced Kristi Geris as new Anchor QEA support staff to the Committees. Schiewe reviewed the agenda and asked for any additions or changes to the agenda. No additions or changes were requested.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft March 27, 2012, meeting minutes. Mike Schiewe reported that Carmen Andonaegui incorporated all comments and revisions received by the Coordinating Committees and there were no outstanding items remaining to be discussed. The draft March 27, 2012, meeting minutes were approved as revised. Kristi Geris will finalize the meeting minutes and distribute them to the Committees.

Schiewe suggested holding the May 22, 2012, Coordinating Committees meeting in Eastern Washington or by conference call. The Priest Rapids Coordinating Committee will be meeting in Eastern Washington on May 23, 2012, and hence, this will simplify travel for agency staff serving on both committees. Chelan PUD offered to host the meeting if convened in Eastern Washington. Schiewe suggested the meeting be held at Rocky Reach Dam as a way to familiarize members with the facility. Steve Hemstrom said he will confirm a meeting room at the dam for the meeting. The Coordinating Committees agreed to the new location for the May meeting. Jim Craig indicated he will not attend the May meeting due to other obligations.

II. Chelan PUD

A. 2013 Chelan PUD HCP NNI Progress Report Outline (Steve Hemstrom/Lance Keller)

Steve Hemstrom reported that the draft 2013 Chelan PUD HCP NNI Progress Report Outline was sent to the Committees per an action item from the March 27, 2012, Coordinating Committees meeting. Hemstrom noted the goal of the HCP NNI Progress Report is to produce a report describing what has been accomplished over the past 10 years in such a way that is not “too heavy” on the reader. The HCP NNI Progress Report includes three key pieces: (1) a Passage Survival Plan; (2) a Hatchery Compensation Plan; and (3) a Tributary

Conservation Plan. Hemstrom said the report will document what the HCPs have accomplished in the first 10 years of their implementation.

He added that the report, as required by the HCPs, is due in March 2013, and will be available to the Coordinating Committees and HCP Signatories. Hemstrom stated this will be an ongoing topic with plenty of opportunities for discussion. Mike Schiewe asked the Coordinating Committees to share any initial comments with Hemstrom. Tom Kahler said Douglas PUD and Chelan PUD have met on this topic and both PUDs are striving to use a similar format and include similar content. Jerry Marco said he reviewed both Douglas PUD and Chelan PUD draft outlines and thought both looked good. Marco pointed out, however, that the Chelan PUD outline proposes to address only juvenile survival; whereas, the Douglas PUD outline indicates incorporating information on adult survival as well. Hemstrom confirmed with Marco that Chelan's 2013 Check-in report would address adult passage because the Rocky Reach Project has achieved the HCP Combined Adult and Juvenile Survival Standard for Spring-run Chinook and so it would be important for Chelan to include the relevant adult survival information as well.

Schiewe wrapped up the discussion by reminding the Committees that this is an ongoing effort and both PUDs will provide updates to Coordinating Committees as the draft reports are developed.

B. 2012 Fish Spill and Juvenile Bypass Operations (Steve Hemstrom/Lance Keller)

Steve Hemstrom informed the Coordinating Committees that the fish spill at Rock Island Dam was started on April 17, 2012. Hemstrom also updated the Coordinating Committees about recent spills at Grand Coulee Dam.

Teresa Scott mentioned to the Committees that the Fish Passage Center (FPC) Weekly Reports provide a good summary of water supply and river operations affecting the migration of juvenile and adult salmon and steelhead. These reports include daily average flow and spill reports, reservoir elevations and outflows, and water supply forecast reports. Scott asked the Committees if they would like to be added to her FPC Weekly Report distribution list. Most Committees' members indicated they already received similar information. Jim Craig requested to be added to Scott's list.

Lance Keller updated the Coordinating Committees on recent juvenile bypass operations at Rocky Reach Dam. Keller reported that the bypass system was fully operational on April 1, 2012, with no major problems to report to date; to this, Keller applauded the diligent offseason maintenance of the system. Keller reported there was a recent increase in yearling Chinook passage. The University of Washington RealTime Model currently indicates approximately 14 percent of the yearling Chinook and 2 percent of the steelhead expected this season have passed Rocky Reach Dam. Coho are also showing up in larger numbers. Keller reported that only one injured steelhead had been found in the routine bypass system samples and that there have been no mortalities. Keller concluded that the system is performing as it should.

III. Douglas PUD

A. Re-analysis of Wells Project Salmonid Passage Data During the 2009 and 2010 Lamprey Studies (Tom Kahler)

Tom Kahler reviewed with the Coordinating Committees the final report from Dr. John Skalski evaluating the effects of reduced head differentials at the Wells Dam fishway entrances on salmonid passage. Kahler explained that a study of the reduced entrance velocities had been requested by the Aquatic Settlement Work Group (ASWG) to determine whether a reduction in entrance velocity could potentially enhance lamprey passage. Douglas PUD retained LGL Limited to conduct the study using DIDSON technology to record lamprey passage events at the fishway entrances. The Wells Coordinating Committee conditionally approved the study, provided that the study include an analysis of salmonid-passage data.

During two years of testing (2009 and 2010), three different operating levels were tested: low (0.5-foot), medium (1.0-foot), and high (1.5-foot) head differentials. A 1.5-foot head differential is the standard operating condition. All three levels were tested in 2009; whereas, only the 1.0-and 1.5-foot levels were tested in 2010. Similar to LGL Limited's findings, results of Skalski' s analyses indicated no significant differences in passage of Chinook salmon at any of the three head differentials tested; however, significantly fewer steelhead passed at the 0.5-foot level in 2009.

Kahler noted that the lamprey study report that included analysis of salmonid passage was originally distributed about a year ago; however, based on a request from Bryan Nordlund, Douglas PUD asked Skalski to conduct an independent statistical analysis of the salmonid-passage data. The Coordinating Committees decided to continue review of the report and defer approval to next month's meeting when Nordlund returns. Mike Schiewe noted that the ASWG will probably request a similar "lamprey operation" in 2012 to that approved by the Coordinating Committees in 2011. The 2011 lamprey operation included an evening reduction of fishway entrance velocity (a 1.0-foot head differential) from August 19 through September 30, 2011.

B. 2013 Douglas PUD HCP NNI Progress Report Outline (Tom Kahler)

Tom Kahler indicated that a proposed outline of the 2013 Douglas PUD HCP NNI Progress Report had now been internally reviewed, and would be distributed to the Coordinating Committees. Kahler said that Douglas PUD envisioned a very focused document. Changes to the outline that was previously distributed to the Committees included the following:

- Differentiated between juvenile and adult survival (e.g., changed name of plan and moved description).
- Added a summary to the end of the Passage Survival Plan section.
- Added a section on the Tributary Assessment Plan.
- Added an Inundation Compensation Plan section that summarizes the production of inundation compensation fish (this has no NNI implications; just information purposes).

Kahler said he will send the revised draft 2013 Douglas PUD HCP NNI Progress Report Outline with these recent additions tracked to Kristi Geris for distribution to the Coordinating Committees. Kahler welcomed feedback and said if no comments are received, Douglas PUD will move forward as described in the draft outline. Mike Schiewe reminded the Coordinating Committees that the deadline for the final report was March 2013.

Lastly, Kahler added that bypass operation at Wells Dam started April 9, 2012, as expected, and everything was going well. Kahler also reported on involuntary spill at Wells Dam, and the strategy of Mid-Columbia Hourly Coordination to maximize generation at Wells Dam and transferring spill to Priest Rapids Dam as a means of minimizing total dissolved gas (TDG) in the mid-Columbia. Wells involuntary spill over the last week has exceeded bypass spill by 12,000 to 30,000 cubic feet per second (cfs), with an average of 17,000 cfs. Schiewe asked Lance Keller if there is monitoring for Gas Bubble Trauma (GBT) at Rocky Reach, and Keller said monitoring was occurring; however, they have not seen any signs of GBT.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the Tributary Committees has not reconvened since March 8, 2012, as already discussed at the March 27, 2012, Coordinating Committees meeting; therefore, there would be no Tributary Committee's update this month.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last two Hatchery Committees' meetings on March 28, 2012, and April 18, 2012, both held at the Douglas PUD's headquarters building:

- *Columbia River Inter-Tribal Fish Commission (CRITFC) Proposal for Participation in the Collection of Hatchery Steelhead and Chinook Genetic Samples*: CRITFC approached the Hatchery Committees two months ago with a proposal asking them to endorse collecting tissue samples from all hatchery broodstock; the samples would be genetically analyzed and these data used to determine parentage of offspring. Hatchery Committees members raised a number of questions about the proposal, including the need for detailed collection and analytical protocols, how the information will be used, who has access to the information, etc. Because of these unresolved issues, the Hatchery Committees deferred consideration of a Statement of Agreement until these issues were satisfactorily addressed by individual agency genetics staff. No schedule was set for revisiting this topic until CRITFC biologists and applicable agencies are satisfied that planning for this endeavor was complete.
- *Facility Modifications Proposed for Dryden and Overwintering Feasibility*: The Hatchery Committees discussed changing/improving the water supply for the Dryden Facility. The current Dryden Facility is served by irrigation canal water, and the Joint Fisheries Parties (JFP) have proposed developing a Wenatchee River surface water supply to open the possibility of overwinter acclimation at Dryden. Currently, only

Chelan PUD summer Chinook are spring acclimated at the Dryden Facility. Beginning in 2013, under a proposed sharing agreement with Chelan PUD, Grant PUD will be also be producing summer Chinook; the JFP, working with the Priest Rapids Coordinating Committee Hatchery Subcommittee are proposing a transition to overwinter acclimation for the Grant PUD program, which would also affect the existing Chelan PUD program. This issue is complicated because planning and decision-making started in the Priest Rapids Coordinating Committee, not with the Hatchery Committees; development of overwintering at Dryden had not yet been fully vetted in the Hatchery Committees, and there are mixed opinions on the topic. One issue for Chelan PUD is compliance with a Washington State Department of Ecology addendum to the Wenatchee total maximum daily load, which establishes a phosphorus discharge limit not to exceed 743 micrograms per liter for the entire Wenatchee River by 2018 (includes the Dryden and Chiwawa facilities, plus waste water discharge facilities). Further, because the goal of transitioning to overwinter acclimation at Dryden is to improve smolt-to-adult returns (SARs) and reduce straying, a necessary step is to consider alternative approaches to achieve these same goals. Accordingly, Chelan PUD agreed to convene a subgroup of the Committees to develop a conceptual approach to investigating Dryden Facility improvement needs for the Committees' review and further development. Joe Miller emphasized that Chelan PUD has not ruled out overwinter acclimation, but wants to make sure that alternatives have been considered and that a final decision is technically supported.

- *Draft 2011 Hatchery M&E Annual Report Out for Review*: Chelan PUD released its annual M&E report available for review by the Committees.
- *Residual Steelhead Associated With Juvenile Hatchery Steelhead Releases*: There was considerable discussion on the management of non-migrating juvenile hatchery steelhead. Currently, there are several programs that employ volitional release, with varying numbers of non-migrants ultimately being forced out. There is concern that this practice could result in a large number of residual steelhead remaining in freshwater near the point of release that (1) prey on juvenile Chinook salmon; and (2) ecologically compete for rearing space. Different approaches to managing non-migrants were discussed, including planting non-migrants in lakes for recreation fisheries. The Washington Department of Fish and Wildlife acknowledged that the National Marine Fisheries Service would need to approve this approach because of the

Endangered Species Act listing of steelhead. The JFP plans to further discuss management of non-migrant steelhead at their next meeting.

- *Fish Water Management Tool (Dr. Kim Hyatt and Margo Stockwell, Fisheries and Oceans, Canada):* Dr. Kim Hyatt gave a presentation on implementation of the Fish and Water Management Tool (FWMT). The FWMT is a water management decision model that guides water management in the Okanogan River basin. The FWMT is used by water managers and fisheries managers to minimize flooding, limit desiccation and scouring of salmon redds, and minimize the spatial extent of low oxygen levels in Osoyoos Lake. Hyatt's team recently received an award for their collaborative efforts to enhance sockeye production in the Canadian Okanagan Basin.

Mike Schiewe suggested that the Coordinating Committees might want to hear the presentation on the FWMT, as it has applications beyond what was accomplished in the Okanogan. Joe Miller suggested that the Coordinating Committees might also benefit from hearing what Chelan PUD is doing to enhance sockeye production in Skaha Lake. The results of the FWMT may support this effort as well.

V. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meeting is May 22, 2012, at Rocky Reach Dam at 10:00 am (instead of 9:30 am). The June 26, 2012, and July 24, 2012, meetings are planned for SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Joe Miller	Chelan PUD
Jerry Marco*	Colville Confederated Tribes
Teresa Scott*	WDFW
Jim Craig*	USFWS

* Denotes Coordinating Committees member or alternate

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	June 26, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the May 22, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met at Rocky Reach Dam in Wenatchee, Washington, on Tuesday, May 22, 2012, from 10:00 am to 2:30 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Teresa Scott will contact Bill Tweit to arrange a presentation for the Committees on the technical modeling being conducted to support decisions relating to CRT re-negotiations (Item II-D).
- Tom Kahler will respond to Columbia River Inter-Tribal Fish Commission's (CRITFC's) request to collect and tag sockeye at Wells Dam indicating conditional approval, with the requirements that tagged adults are released upstream of Wells Dam rather than into the ladders, that Dr. Jeff Fryer (the study's Principal Investigator) provides the Committees with a study plan with future request, and that the Committees receive annual reports of study results prior to receiving future requests and that the submittal of future requests be in time to be included in the March meeting agenda (Item III-A).
- Douglas and Chelan PUDs agreed to have their draft HCP NNI Progress Reports ready for review by the Committees by the October 2012 HCP-CC meeting. It was also agreed that the draft reports should be approximately 15 pages in length (Item III-C).

DECISION SUMMARY

- There were no Statements of Agreement (SOAs) approved at today's meeting.

AGREEMENTS

- The Coordinating Committees approved the annual request from CRITFC to collect and tag sockeye at Wells Dam with the conditions listed in the Action Item Summary (Item III-A).
- The Coordinating Committees approved Dr. John Skalski's re-analysis of the effects of reduced fishway entrance velocities on the passage of adult salmonids (Item III-B).

REVIEW ITEMS

- There were no review items at today's meeting.

REPORTS FINALIZED

- There are no reports to finalize at this time.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and thanked Steve Hemstrom, Lance Keller, and the folks at Rocky Reach Dam for hosting the Coordinating Committees meeting at the dam and providing a tour of the facilities. Schiewe reviewed the agenda and asked for any additions or changes to the agenda. No additions or changes were requested.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft April 24, 2012, meeting minutes. Kristi Geris reported that all comments and revisions received from the Coordinating Committees members were incorporated in the revised minutes and there were no outstanding items remaining to be discussed. The draft April 24, 2012, meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Chelan PUD

A. Follow-up Questions on Rocky Reach Fish Facilities/Operations (Steve Hemstrom/Lance Keller)

Steve Hemstrom invited questions and comments from the Committees regarding Rocky Reach fish operations and facilities, and how these work in the context of the HCP. Hemstrom said to feel free to email him at any time.

B. Update: 2012 River Flow Forecasts/Rock Island Spill (Steve Hemstrom/Lance Keller)

Steve Hemstrom informed the Coordinating Committees that from April 1 to May 20, 2012, flows at Rock Island Dam were at approximately 200,000 cubic feet per second (cfs), and high flows are anticipated to continue in the coming weeks. Hemstrom also reported that fish spill started at Rock Island Dam on April 17, 2012; to date the total dissolved gas (TDG) cap has not been exceeded. The spring target for Rock Island Dam is 10 percent, and Hemstrom said the dam is currently at 16.1 percent. Hemstrom said a peak in flows is expected sometime in June.

Hemstrom also reported "unavoidable spill" at Rocky Reach Dam from May 1 to May 22, 2012. The total spill volume for this period was 20.47 percent of the average river flow; day-average spill for this period was approximately 45,000 cfs. Flow was greater than powerhouse capacity on 19 of the 22 days, with a maximum day-average river flow of 246,000 cfs.

Jerry Marco told the Coordinating Committees that last month the U.S. Army Corps of Engineers shutdown spill at two bays for a couple of days on the right bank at Chief Joseph Dam. This action was taken to facilitate installation of the foundation for the new Chief Joseph Hatchery fish ladder. Marco said that during the shutdown hourly TDG concentrations increased about 2 to 5 percent.

C. Update: Pikeminnow Programs and Catch Rates (Steve Hemstrom/Lance Keller)

Lance Keller said the Pikeminnow Program has already passed the 20,000 fish catch mark this year, averaging approximately 270 to 300 fish per day. The U.S. Department of Agriculture (USDA) has two fishermen on site at Rock Island Dam, three fishermen at Rocky

Reach Dam, and two roaming boats between the two dams. Keller said Columbia Research is also contributing to the removal program. Keller said this year the size distribution of fish caught by both USDA and Columbia Research has been smaller. Last year, both USDA deck crews' combined catch was less than 1,000 fish all year; this year the crews have already caught approximately 600 fish. Keller said the Rotary Club Community Derby will be held this year on Father's Day weekend. Last year, the event attracted approximately 120 to 150 participants, and Keller said the event expects a similar turnout this year. Steve Hemstrom added that pikeminnow passage counts have shown a decreasing trend over the past few years, which is suggestive of lower pikeminnow abundance.

D. Update: Chelan PUD's General Manager and Commissioners' Recent Trip to Washington D.C. visiting Congressional Representatives, Federal Energy Regulatory Commission Staff, Agency Directors, the U.S. Department of Energy, and the U.S. Department of the Interior (Steve Hemstrom/Lance Keller)

Keith Truscott presented an overview of Chelan PUD's General Manager and Commissioners' recent trip to Washington D.C. The trip presented an opportunity to inform members of the Northwest Congressional Delegation about the HCP and its accomplishments. Truscott said the HCP and its accomplishments were well-received, and several people were already well-informed about what had been achieved. Truscott shared with the Committees the fact sheets on the HCP that were distributed during the trip (Attachments B and C). Regarding Congressional hydropower bills, Truscott said there was discussion of several non-hydropower projects (approximately 2,000) that have the potential to include hydropower without significant environmental impacts. Wind integration, Truscott said, was another high interest topic, and cyber security was also discussed.

Jerry Marco asked if Truscott thought staff in Washington D.C. were well-versed in the Columbia River Treaty (CRT)? Truscott indicated that they were aware of the issue, but not necessarily well-versed regarding details. Steve Hemstrom said Chelan PUD participates in a CRT evaluation team. Truscott said the primary purpose of the treaty was flood control, and that current discussions are primarily about whether changes are needed in 2024, when changes can first be made. Mike Schiewe asked the Committees if they thought potential changes to the CRT might affect implementation of the HCPs, and whether it may be beneficial to invite someone to speak to the Committees regarding this issue. Hemstrom said a minor re-regulation would not significantly change flows. Teresa Scott volunteered to contact Bill Tweit, who is the lead for the Washington Department of Fish and Wildlife (WDFW) on CRT, to arrange a presentation for the Committees on the technical modeling being conducted to support decisions relating to CRT re-negotiations.

III. Douglas PUD

A. DECISION: Approval of Annual Request from CRITFC to Collect and Tag Sockeye at Wells Dam (Tom Kahler)

Tom Kahler reviewed with the Committees CRITFC's annual request to collect and tag sockeye at Wells Dam (Attachment D). The Committees raised several questions about the ultimate objective of collecting these data, and if there were any annual reports summarizing past data? Josh Murauskas said some of Dr. Jeff Fryer's data are available on the CRITFC website. Kahler added that Fryer has presented his findings to various groups and agencies; however, Kahler remains uncertain of the ultimate objective of the study. Kahler and other members of the Committees expressed concerns regarding the proposed release of tagged fish back into the fish ladder. Kahler said Douglas PUD had recommended to CRITFC that they release tagged fish into the forebay of Wells Dam as in past years, but no changes had been made to the study proposal. Murauskas said he is also interested in Fryer's use of different fish anesthetics and whether he has observed any differences in recovery.

Kahler said Fryer's plan is to begin tagging the last week of June. Mike Schiewe asked whether anyone has reasons to not approve the study this year. Committees members agreed to approve Fryer's request, but conditioned the approval on release of tagged fish upstream of Wells Dam, and receiving a study plan and annual reports of study results prior to receiving future requests to approve collection and tagging of sockeye at Wells Dam. Bryan Nordlund said he would prefer to have the Committees' questions answered this year; however, timing wise, he acknowledged that would not be feasible. Kahler agreed to respond to CRITFC's request to collect and tag sockeye at Wells Dam indicating conditional approval, with the requirements that: (1) tagged adults are released upstream of Wells Dam rather than back to the ladder; (2) that Fryer provides the Committees with a study plan along with future requests for approval of collection and tagging at Wells Dam, and that future requests be submitted to the Committees in time to be included on the March meeting agenda; and (3) the Committees receive annual reports of study results prior to submittal of annual requests for trapping/tagging.

B. Re-analysis of Wells Project Salmonid Passage Data During the 2009 and 2010 Lamprey Studies (Bryan Nordlund blessing; Tom Kahler)

Tom Kahler briefly reviewed for Bryan Nordlund the final report from Dr. John Skalski evaluating the effects of reduced water velocity at the Wells Dam fishway entrances on salmonid passage. The report had been reviewed and discussed by the Committees at the April meeting when Nordlund had been unable to attend. Kahler asked Nordlund if his earlier questions had been answered. Nordlund said they had, and the Committees gave their final approval of the report.

C. Discussion: 2013 Douglas PUD HCP NNI Progress Report Outline (Bryan Nordlund recent comments; Tom Kahler)

Tom Kahler reviewed Bryan Nordlund's recent comments on the revised 2013 Douglas PUD HCP NNI Progress Report outline. The revised outline was emailed to the Committees by Kristi Geris on April 24, 2012, and Nordlund's comments to the revised outline were forwarded to the Committees by Geris on May 3, 2012. Kahler noted the following:

- Comment #3 – Nordlund asked for clarification of how inundation compensation fits within the HCP. Kahler pointed out the new section on Inundation Compensation Production in the revised outline was added to cover this topic.
- Comment #2 – Nordlund asked whether Douglas PUD has data to estimate smolt-to-adult returns (SARs) for the HCP species. Kahler said they do and will.
- Comment #1 – Nordlund asked Douglas PUD to include a discussion of how Wells HCP and achievement of NNI is contributing to recovery of spring Chinook and steelhead, and if adult counts have increased for the non-listed HCP species. Kahler said Douglas PUD had not intended to include that information in the NNI progress report because the purpose of that report was not to demonstrate whether or not HCP implementation had contributed to recovery. The Wells HCP describes a second analysis (in addition to the NNI progress report) for which the Committee was responsible that would determine whether Plan Species were rebuilding. In previous

discussions on this topic the Committee agreed that the PUDs should not make the determination of species status, as that was not their purview. Nordlund explained that including information on species performance could potentially demonstrate that these long-term agreements were beneficial. He said the overarching purpose of the HCPs is to keep listed and non-listed species healthy.

Josh Murauskas said that the focus of the HCP NNI Progress Reports should be on evaluating the three components of the HCP, and describe accomplishments. Steve Hemstrom noted that no net impact (NNI) and recovery are not the same thing. Hemstrom said the PUDs are not accountable for recovery of listed fish in the upper Columbia, but are required to contribute to recovery. Teresa Scott added that there will likely be people who want to make the connection between the HCPs and recovery, so it is important to be as robust as possible. Murauskas said the HCPs are also about harvest opportunities, and Murauskas said there has been great success there. Jerry Marco added that the fisheries managers also need to be included in this discussion because high harvest numbers do not necessarily equal a lot of fish; NNI may be the best way to express successes.

Mike Schiewe reminded the Committees that the HCP NNI Progress Reports are due in March 2013. Hemstrom added that in order to write a useful report with enough detail, and conversely, to avoid too much unnecessary detail, it important to identify the audience. Schiewe clarified that the audience for the HCP NNI Progress Reports is the signatories. Douglas and Chelan PUDs agreed to develop a succinct, draft HCP NNI Progress Report, approximately 15 pages in length, ready for review by the Committees by the October 2012 HCP-CC meeting.

D. Update: Bypass Operations and TDG at Wells Dam (Tom Kahler)

Tom Kahler shared with the Committees that in accordance with Douglas PUD's 2012 Bypass Operating Plan (BOP), the bypass barriers were removed from Bypass Bay #6 at Wells Dam to minimize TDG, as described in an email Kristi Geris distributed to the Coordinating Committees on May 2, 2012.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that Tracy Hillman had distributed the HCP Tributary Committees Meeting Progress Report, and discussed the following items:

- *General Salmon Habitat Program Pre-Proposals:* The Tributary Committees received 27 General Salmon Habitat Program pre-proposals, and selected nine projects they would like to visit in the field. Schiewe clarified the nine projects selected were ones the Tributary Committees wanted to visit, and not necessarily the only projects considered for funding. The Tributary Committees will conduct their evaluation of pre-proposals on June 14.
- *Okanogan River Restoration Initiative Monitoring:* Continued funding for the Okanogan River was authorized in the amount of approximately $20,000.
- *Methow River River Mile 48.9 (Peters) Conservation Easement:* The Tributary Committees elected not to fund the Methow River Peters Conservation Easement proposal, because they believed the potential benefits of the acquisition did not justify the cost.
- *Evaluation of Appraisals:* The Tributary Committees have been discussing the use of outside appraisals when reviewing proposals that involve purchase of conservation easements or properties. Dan Budd and Shawn Kyes from WDFW's Real Estate group recommended that the Tributary Committees contract directly to have their own appraisals done, use an outside firm to obtain a second evaluation, or both.
- *WDFW Alternate on the Tributary Committees:* WDFW reported that Carmen Andonaegui will serve as alternate representative on the Tributary Committees.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Hatchery Committees meeting on May 17, 2012, held at the Douglas PUD headquarters:

- *National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) Approval of Tumwater Dam Operations for 2012:* The Rock Island Hatchery Committee, including NMFS and USFWS, approved the Tumwater Dam operations for 2012.
- *Hatchery Monitoring and Evaluation (M&E) Programs (Adaptive Management):* The Hatchery Committees started discussion on the 5-year review and revision of the

Hatchery M&E Programs. It is expected that results from the first Five-Year M&E Reports will inform potential changes. The Committees agreed that Douglas and Chelan PUDs will initiate development of potential paths forward for this effort. The Committees need to finalize changes to the plans by September for the PUDs to have time to award new contracts.

- *Draft SOA Entiat National Fish Hatchery (NFH) Summer Chinook Brood Stock Collection:* The Hatchery Committees discussed approval (and will consider an SOA in June) for collection of summer Chinook at Wells Dam for broodstock for the Entiat NFH program.
- *Coho Restoration:* The Yakama Nation (YN) asked Chelan and Douglas PUDs to consider potential rearing space for coho salmon for their coho salmon reintroduction project. The YN may lose access to their existing space at Willard NFH, which is being considered for reprogramming for John Day mitigation.
- *Dryden Feasibility Study:* Chelan PUD is evaluating a Priest Rapids Coordinating Committee Hatchery Subcommittee proposal to construct a new surface water supply at the Dryden facility; this would open the possibility of implementing over-winter acclimation. Because the potential benefits expected from over-winter acclimation would be improved SARs and reduced straying, Chelan PUD asked whether alternative approaches to achieving these goals were considered. Because they had not, Chelan PUD has asked the Committees to consider investigating other options. A Washington State Department of Ecology Total Maximum Daily Load (TMDL) for phosphorus is anticipated to be in place in 2018 and may limit hatchery activities in the Wenatchee Basin in the future.

V. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meeting is June 26, 2012 (conference call only). The July 24, 2012, and August 28, 2012, meetings are planned for SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees
Attachment B – HCP Washington D.C. Update May 2012

Attachment C – Focused on a Sustainable Future

Attachment D – 2012 CRITFC Sockeye Tagging at Wells Dam

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Josh Murauskas	Chelan PUD
Keith Truscott†	Chelan PUD
Tom Kahler*	Douglas PUD
Jerry Marco*	Colville Confederated Tribes
Teresa Scott*	WDFW
Bryan Nordlund*	NMFS

* Denotes Coordinating Committees member or alternate
† Joined for the discussion of Chelan PUD's General Manager and Commissioners' recent trip to Washington D.C.

Attachment B

Chelan County PUD

Habitat Conservation Plans (HCPs) Status Sheet • May 2012

CHELAN COUNTY POWER

Chelan PUD's Habitat Conservation Plans: A success story in the making

Chelan's Habitat Conservation Plans (HCPs) commit us to operate our dams so there is no net impact on Upper-Columbia salmon and steelhead by using a combination of fish bypass and spill to help move at least 93 percent of juveniles safely past the dams plus hatchery programs and habitat restoration in tributaries. By March 2013, Chelan must provide a report assessing the status of achieving no net impact. This report will focus on survival, hatchery programs and tributary program funding.

Young salmon and steelhead survival

Under the HCPs, Chelan PUD must meet minimum targets for either combined juvenile and adult survival (91%), or for juvenile survival only (93%) for fish traveling through our reservoirs and past our dams. Chelan has met or exceeded those levels for all spring migrating salmon and steelhead species at both Rocky Reach and Rock Island hydro projects*.

Spring Species	3-year average project passage survival (targets)	
	Rock Island Dam	Rocky Reach Dam
Sockeye	Target met	Target met
Spring Chinook	Target met	Target met**
Steelhead	Target met	Target met

Once technology becomes available, Chelan PUD will address survival levels for the smaller subyearling Chinook which migrate in the summer. At this point there is no technology to measure survival for these fish.

***Combined adult and juvenile measurement.*

Fish Spill* Levels (% of daily river flow)

Moving fish safely through the reservoirs and past the dams is a primary objective of the HCPs. To help move fish past the dams, Chelan PUD uses fish spill at Rock Island Dam and a fish bypass system with supplemental spill at Rocky Reach Dam.

	Spring	Summer
Rocky Reach	0%	9%
Rock Island	10%	20%

**Sending water and fish through spill gates during the juvenile fish migration season.*

Hatchery production - Targets met

Chelan PUD funds hatchery production as part of the no-net-impact requirement of the HCPs. These production targets will be adjusted in 2013 based on project survival and other factors.

Species	Location	Current production targets (fish)
Spring Chinook	Chiwawa River	298,000
	Methow River	288,000
Summer Chinook	Wenatchee River	864,000
	Similkameen River	576,000
	Methow River	400,000
	Chelan Falls	600,000
Sockeye	Lake Wenatchee	280,000
	Skaha Lake, BC	591,000
Steelhead	Wenatchee River	243,000

Tributary projects - Targets met

Chelan PUD funds two accounts for habitat projects as part of compensating for fish that do not survive migration through our reservoirs and past our dams. The funds are used by a committee to award money to projects that members decide will have the best biological outcome. These funds leverage other sources to make up Total Project costs.

HCP Habitat Account	No. of projects since 2005	Funding provided to date*
Rocky Reach	19	$1,291,308
Rock Island	27	$2,774,767
Total	46	$4,066,075
Total project costs		$19,396,064

**as of Dec. 1, 2011*

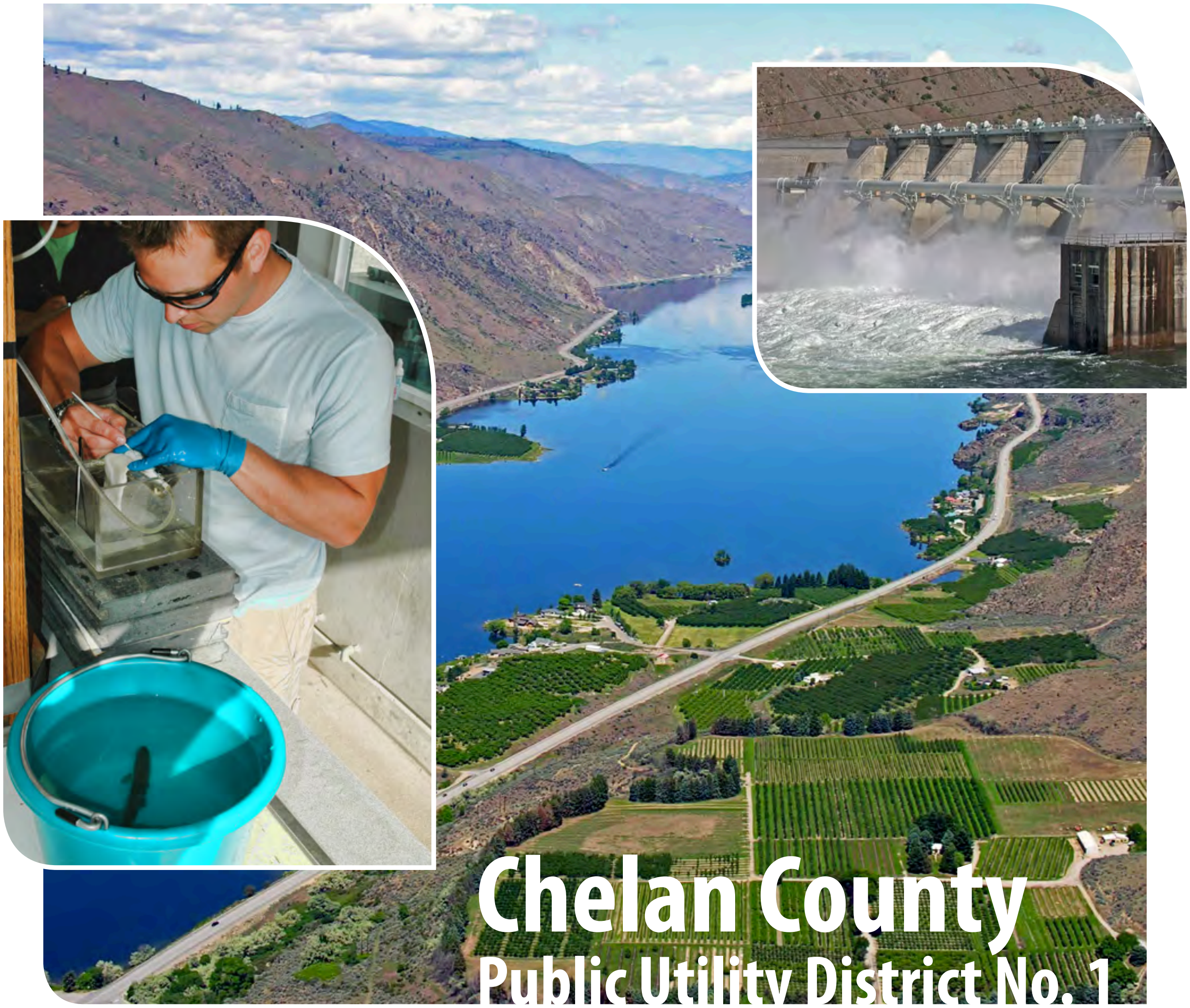
Managing the HCPs toward success

The HCPs are managed by three operating committees: Coordinating, Hatchery and Tributary. Each committee is facilitated by a chair chosen by its members and each committee has a representative from the agencies and tribes that signed the agreements. All decisions are based on unanimous agreement. The signators are:

- Chelan County PUD
- Colville Confederated Tribes
- NOAA Fisheries Service
- US Fish and Wildlife Service
- Washington Department of Fish and Wildlife
- Yakama Nation

Contact: Keith Truscott - Natural Resources Director
(509) 661-4831 • keith.truscott@chelanpud.org

Attachment C



Chelan County Public Utility District No. 1

Focused on a sustainable future

- *About Chelan PUD*
- *Deciding the future of the Columbia River Treaty*
- *Successes of our Habitat Conservation Plans*
- *Integrating wind energy into the regional transmission system*
- *Concerns with proposed tax exempt financing changes*
- *Chelan PUD's view of cyber security for the transmission grid*
- *Congressional hydropower bills show promise*

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About Chelan PUD

Chelan County Public Utility District No. 1

May 2012

Chelan County Public Utility District (Chelan PUD) was formed in 1936 by local voters who wanted affordable power for rural as well as urban residents. The PUD delivered its first electricity 11 years later to a small group of customers near Lake Chelan. Today, the PUD operates three hydro projects that deliver clean, renewable, low-cost energy to 48,000 local customers and to other utilities that serve businesses and residents throughout the Pacific Northwest.

The District is directed by a five-member Board of Commissioners elected by the voters of Chelan County. These commissioners oversee a utility system that now includes local water, wastewater and wholesale fiber-optic services in addition to electricity.

Chelan County PUD relies on the mighty Columbia River for much of its hydropower generation. We recognize this great river as a multi-use system and we're proud to take a leadership role in environmental stewardship. Each year the District dedicates millions of dollars and thousands of work hours to protect and enhance fish, wildlife and plant ecosystems. As part of the hydropower operations, the PUD also built 14 parks that serve more than three million visitors each year.

Under the guidance of its elected commissioners, the PUD continues to deliver affordable, dependable utilities to rural and urban areas alike while also emphasizing careful management of our natural habitats. The belief that local people are the best stewards of resources has guided District actions for 75 years. Our ties to the river, local residents and the region are long and strong.

Deciding the future of the Columbia River Treaty

Electric customers should not be required to pay for power benefits that aren't received.

The Columbia River Treaty, which governs river operations between the U.S. and Canada, can be terminated in 2024 if notice is given by either party by 2014. If the Treaty continues without modification post-2024, U.S. power utilities would remain obligated to deliver Canadian Entitlement, a continuous power and energy delivery to the Canadian government paid for by the Northwest electricity customers. Over time, the value of the Canadian Entitlement has remained significant, while the actual benefit realized by U.S. hydro generators has decreased.

Currently, the Bonneville Power Administration (BPA) and the U.S. Army Corps of Engineers (Army Corps) are meeting with states and tribes to review the Treaty. A Columbia River Treaty Power Group has also formed to represent power interests. Members of the Power Group, including Chelan PUD, want to ensure a fair and equitable outcome for the estimated 6.4 million Pacific Northwest electric customers they serve. Further studies are needed to analyze Treaty costs and benefits for Canadian and U.S. operations, and determine impacts of post-2024 flood control on downstream power generation and fish. The Power Group is participating in modeling work with BPA and the Army Corps to consider post-Treaty operational scenarios.

Successes of our Habitat Conservation Plans

We've made a 50-year commitment to ensure our hydro projects have no net impact on mid-Columbia River salmon and steelhead.

Chelan PUD's two Columbia River dams, Rocky Reach and Rock Island, operate under "Habitat Conservation Plans" (HCPs) for migrating salmon and steelhead that commit the utility to a 100% "no net impact" standard, to be met 91% through survival (93% survival standard for juvenile fish); 7% through hatcheries; and 2% through habitat mitigation. Continued success of the HCP is key to Chelan PUD's ability to operate the projects.

Before the HCPs were established, regulatory agencies were contemplating a requirement of 40% river spill for the projects. Under the agreements, Chelan PUD was allowed to test and implement measures which worked better for fish and reduced the need for spill, such as the $107 million juvenile fish bypass system at Rocky Reach and effective predator control in the reservoirs. The HCPs provided for three operating committees through which the signatory parties (fish agencies, tribes and Chelan PUD) have identified issues and made decisions. The process has proved to be collaborative and effective.

At Rock Island, the 93% juvenile fish survival standard has been met, which allows Chelan PUD to reduce spill from 20% to 10% of river flow (with summer spill at 20%) for the next 10 years. At Rocky Reach, fish survival standards have been met for spring species, and the project may be operated with zero spill in the spring and 9% spill in the summer for the next 10 years. Chelan PUD is still verifying the standard for the final species, sub-yearling Chinook, which are difficult to study.

The debate over integrating wind energy into the regional transmission system

We support regional efforts to improve wind integration.

Chelan PUD is less directly affected by BPA's environmental redispatch policy because we do not purchase power from BPA, but we have an interest in a fair and functioning market. Lawmakers should consider reforming incentives that impede voluntary actions to reduce generation during times of oversupply. Chelan PUD understands BPA's need to act consistently with statutory obligations, and the PUD shares concerns about fish protection and elevated total dissolved gas - but also supports reform of BPA's policy to treat all generators fairly.

Chelan PUD sees merit in BPA's recent temporary oversupply cost-allocation proposal as addressing the comparability issues raised by FERC, but the PUD recognizes that longer-term solutions are still needed. Chelan PUD supports regional efforts to improve wind integration through dynamic scheduling and 30-minute intra-hour scheduling. Chelan PUD believes a cost/benefits study of a voluntary energy imbalance market, with both an energy and capacity component, would be appropriate.

Concerns with proposed tax exempt financing changes

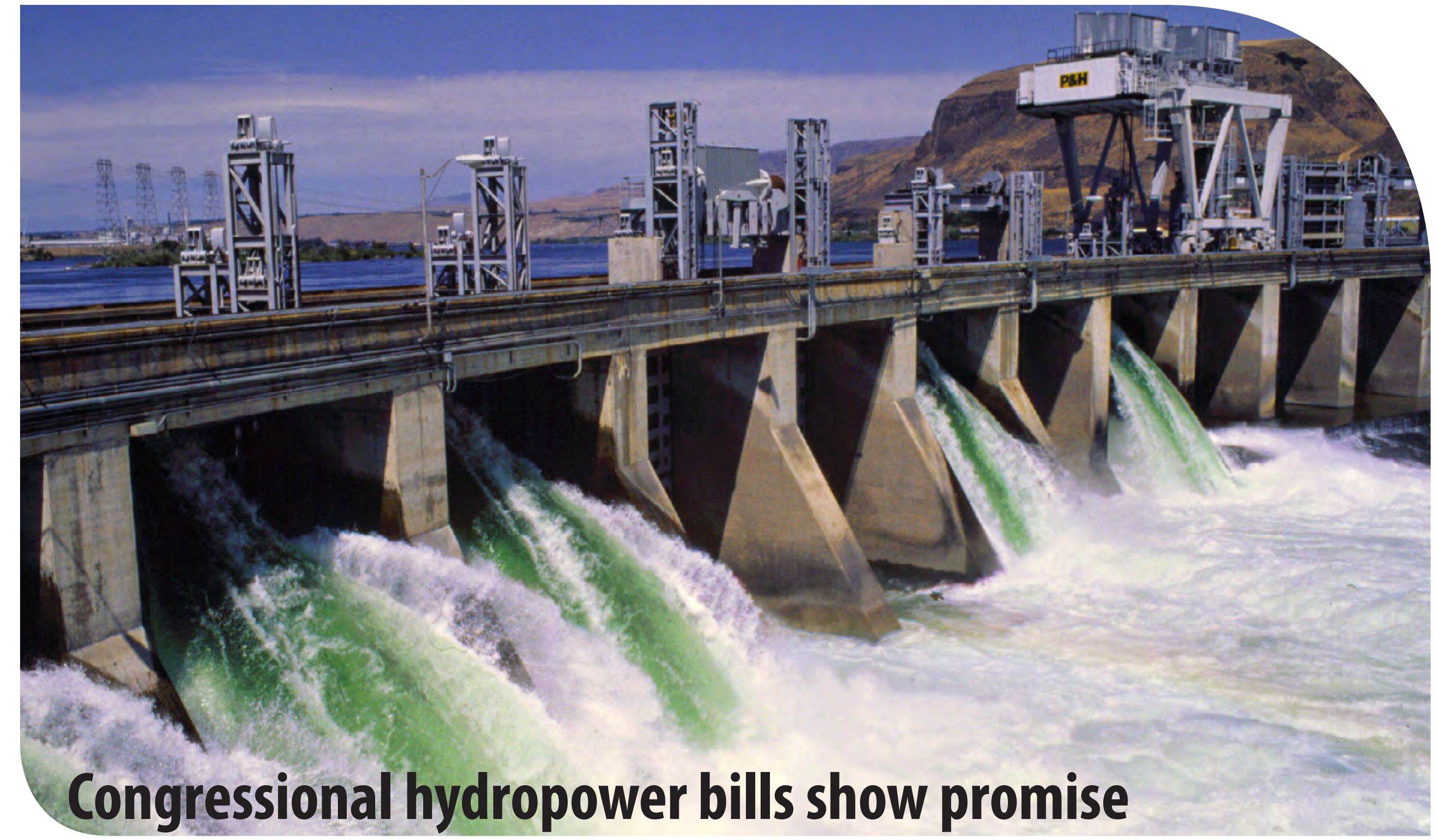
Electric ratepayers would pay higher bills if the municipal bond interest exemption is capped.

Tax-exempt financing is an essential tool for financing public power's capital intensive infrastructure. The president's 2013 budget proposal would have capped the municipal bond interest exemption at 28% for high income earners. If this proposal were enacted into law, investors would likely demand higher interest rates for municipal bonds. This approach would be expected to increase financing costs for PUDs and essentially result in a tax increase on ratepayers.

Chelan PUD's view of cyber security for the transmission grid

We urge caution in adopting cyber security legislation for transmission.

Any cyber security legislation should 1) maintain the relationship between the FERC and the North American Electric Reliability Corporation (NERC) and not give FERC new authority over cyber security vulnerabilities or facilities that are not part of the bulk electric system; 2) enhance information sharing between utilities and the federal government; and 3) delineate the framework under which the government responds to an imminent cyber emergency.



Congressional hydropower bills show promise

Hydropower is one of our country's great resources.

Chelan PUD supports hydropower bills sponsored by Representative McMorris Rodgers and Senator Murkowski that facilitate small hydropower and conduit hydropower development and that direct the Federal Energy Regulatory Commission (FERC) to investigate the feasibility of an expedited two-year licensing process for closed-loop pumped storage and hydro installations at non-hydro dams. Chelan PUD also supports several other hydropower bills pending in Congress.

For more information

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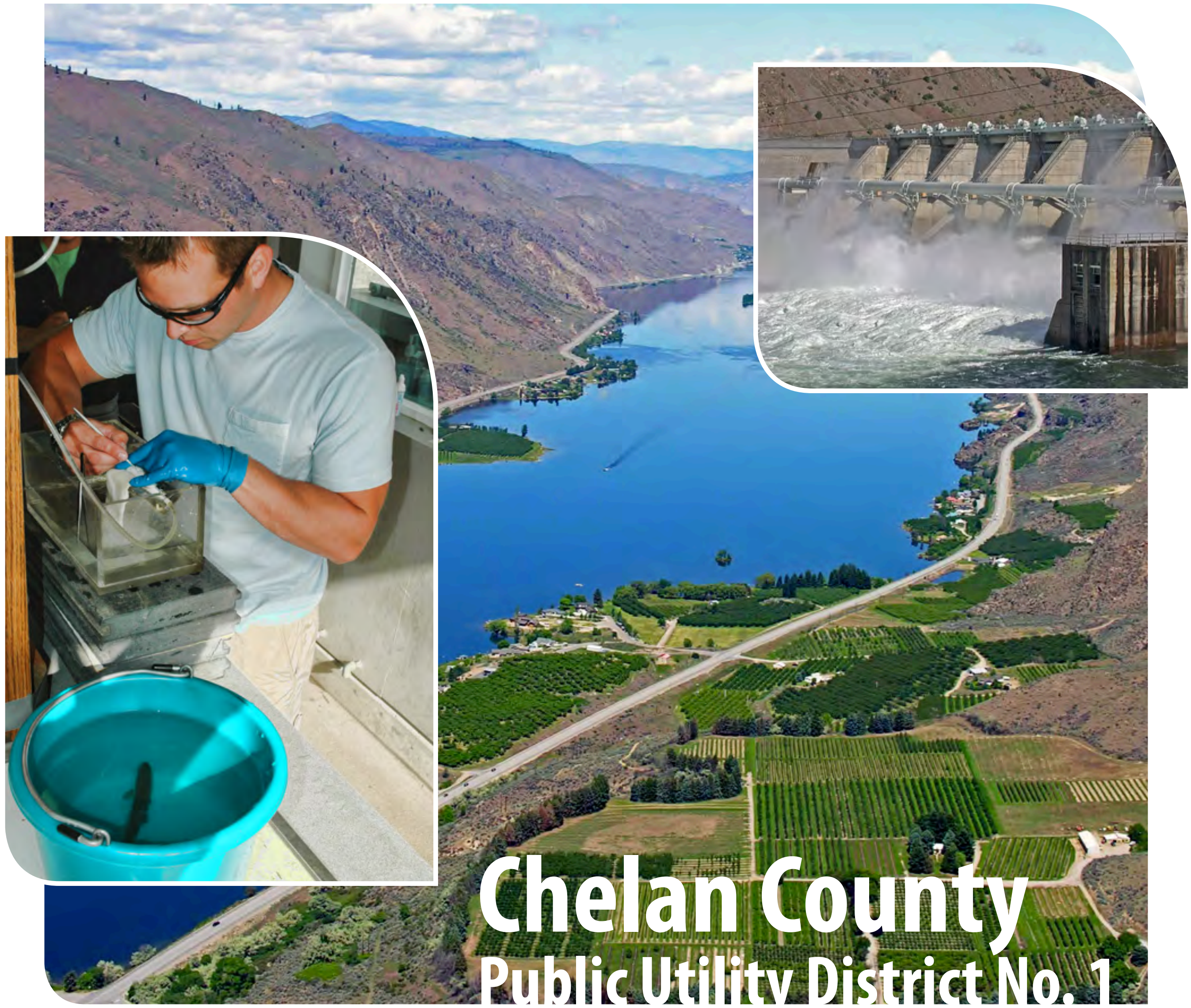
Attachment C



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Attachment D

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 NE Oregon, Suite 200, Portland, Oregon 97232
Telephone 503 238 0667
Fax 503 235 4228

April 26, 2012

Shane Bickford
Natural Resources Supervisor
Public Utility District Number 1 of Douglas County
1151 Valley Mall Parkway
East Wenatchee, Washington 98801

Dear Mr. Bickford:

1200 max

In 2012, CRITFC is planning to once again sample sockeye salmon at Wells Dam. We hope to collect scale samples from up to 600 sockeye, all of which we will PIT tag if they have not already been tagged. In addition, we will acoustic tag up to 70 sockeye salmon and affix temperature tags on up to 200 sockeye salmon. We anticipate sampling from late June through late July. We will coordinate sampling activities with Wells Hatchery brood stock collection programs. Sampling personnel may include Ryan Branstetter and Jeff Fryer of CRITFC, Greg Robison, Kraig Mott, Tim Jeffris, and Barry Hodges of the Yakama Nation, and Jennifer Panther of the Colville Tribe.

One interesting result from last year was that approximately 15% of the Wells tagged fish passed the opposite fish ladder from which they were tagged. We would like to deploy additional acoustic receivers to investigate sockeye behavior after tagging. We hope to deploy some of these receivers in the ladders, as well as immediately upstream and downstream from the ladders. Jennifer Panther will be coordinating with Tom Kahler on possible sites and procedures for this potential deployment.

Please contact me or Dr. Jeff Fryer if you have any questions. Thank you for your cooperation with this study.

Sincerely,

Babtist Paul Lumley
Executive Director

Cc: Jayson Wahls, Wells Hatchery Complex Manager, WDFW
Chris Moran, Fish Management Division, WDFW
Mike Tonseth, Fish Biologist, WDFW
Tom Kahler, Fisheries Biologist, Douglas County PUD

NOTED
APR 30 2012
MEM

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	July 24, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the June 26, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met by conference call on Tuesday, June 26, 2012, from 9:30 am to 11:00 am. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Kristi Geris will redistribute to the Coordinating Committees fact sheets on HCP implementation that were presented during Chelan PUD's General Manager and Commissioners' recent trip to Washington D.C., and that were distributed to the Committees by Keith Truscott at the May 22, 2012 Coordinating Committees meeting (Item I-A).
- Mike Schiewe will request that Tom Kahler provide to the Coordinating Committees an overview of Douglas PUD's agenda items from today's meeting (Item II-A).
- Steve Hemstrom will distribute to the Coordinating Committees a study plan and details on the four spill configurations being tested during Chelan PUD's spill gate pattern test at Rocky Reach Dam (Item III-A).
- Steve Hemstrom will contact Chelan County (or the Chelan County Weed Board) to obtain further information on Chelan County's proposal to apply aquatic herbicide to control Eurasian milfoil in the Columbia River at Entiat Park (Item III-B).
- Bryan Nordlund will inquire internally within National Marine Fisheries Service (NMFS) to obtain information on the application of aquatic herbicide to control Eurasian milfoil in the Columbia River (Item III-B).
- Tom Kahler will report back to the Coordinating Committees on how Douglas PUD and Douglas County coordinate on issues of aquatic weed control (Item III-B).

- Kristi Geris will distribute to the Coordinating Committees the HCP Tributary Committees June Progress Report (Item IV).
- Steve Hemstrom will ask Steve Hays to provide a brief overview of the requirements and stipulations (including criteria) for receiving HCP Tributary Funds (Item IV).
- Mike Schiewe will contact Josh Murauskas to be sure he is aware of the Interagency Avian Workgroup, and to suggest that he contact the group regarding his analysis of the putative impact of avian predation on late migrating steelhead smolts (Item IV).

DECISION SUMMARY

- There were no Statements of Agreements (SOAs) approved at today's meeting.

AGREEMENTS

- There were no agreements discussed at today's meeting.

REVIEW ITEMS

- There are currently no items out for review.

REPORTS FINALIZED

- There are no reports that have been recently finalized.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or changes to the agenda. No additions or changes were requested.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft May 22, 2012 meeting minutes. Kristi Geris reported that all comments and revisions received from the Coordinating Committees members were incorporated in the revised minutes and that there were no outstanding items remaining to be discussed. A request was made that Geris redistribute to the Coordinating Committees the fact sheets on HCP implementation that were presented during Chelan PUD's General Manager and Commissioners' recent trip to Washington D.C., and that were distributed to the Committees by Keith Truscott at the May 22, 2012 Coordinating Committees meeting. The draft May 22, 2012 meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Update: Projects in Process at Wells Dam (Tom Kahler)

Tom Kahler was unavailable to present Douglas PUD's agenda items at today's conference call. Mike Schiewe requested that Kahler provide to the Coordinating Committees an overview of Douglas PUD's agenda items from today's meeting.

III. Chelan PUD

A. Rocky Reach Spill Gate Pattern Test – Total Dissolved Gas Evaluation (Steve Hemstrom/Lance Keller)

Steve Hemstrom said that on June 18, 2012, Chelan PUD will begin spill gate pattern testing at Rocky Reach Dam to determine if total dissolved gas (TDG) levels can be reduced downstream by using different spill gate patterns at the dam, as described in an email Hemstrom distributed to the Coordinating Committees on June 8, 2012.

Hemstrom said spill gate pattern testing at Rocky Reach Dam was first conducted in 2011. He said this second year of testing is being conducted to collect additional data on how tailrace TDG levels respond to different spill gate patterns. The testing will use the same four spill configurations that were used in 2011: TDG, Shallow Arc, Flattened, and Fish Spill patterns. Hemstrom said 24-hour testing will be conducted each day from June 18, 2012, until July 30, 2012. Data from the 2011 testing will be combined with this year's data to determine if there is a statistical difference in the gate patterns. Hemstrom said he will distribute to the Committees a study plan and additional details on the four spill configurations being tested.

Bryan Nordlund asked Hemstrom what the path forward would be if the gate patterns do not show a statistical difference. Hemstrom said that Chelan PUD hopes that with this second year of testing there will be sufficient data to indicate some differences; whether they are statistically significant or not, Hemstrom believes these differences will be useful. Hemstrom also said that Chelan PUD will likely have Dr. John Skalski analyze the combined data from both years.

Nordlund commented that it is also important to remember that spill patterns are designed to facilitate fish passage at the dams. He said it is important to be sure this testing does not affect, for example, the attraction of adults to the ladders, migration through the ladders, and egress out of the tailrace. Mike Schiewe asked Hemstrom if the spill patterns affect the collection efficiency of the bypass, and Hemstrom replied that the spill patterns are designed to increase both bypass efficiency and spill efficiency. Hemstrom added that during 2011 testing, the migration times for passive integrated transponder (PIT)-tagged adult spring Chinook did not show visible delays, and all adults detected at Rock Island during the various spill gate test scenarios successfully passed upstream of Rocky Reach.

Teresa Scott asked at what discharge level do we start experiencing TDG. Hemstrom said that if a spill gate pattern is identified through this study that reduces incoming and project-related TDG levels downstream, then potentially that spill pattern could be used when river flow and incoming TDG are high. Hemstrom added that the river flow and TDG level at which such a pattern would be implemented has not been decided. Scott said that it is important to manage each project to achieve a regional outcome (e.g., achieve a reduction in TDG through the entire Mid-Columbia system). Hemstrom responded that TDG from all Mid-Columbia projects is managed by the Mid-Columbia Hourly Coordination staff by distributing spill and generation levels among the five Mid-Columbia PUDs. Hemstrom concluded by saying Chelan PUD is only collecting data at this point with the spill gate pattern testing and that there will be substantive discussion with the Committees before any changes are considered at Rocky Reach Dam.

B. Chelan County's (Weed Board) Proposal to Apply Aquatic Herbicide to Control Eurasian Milfoil in the Columbia River at Entiat Park (Steve Hemstrom/Lance Keller)

Steve Hemstrom alerted the Coordinating Committees that Chelan PUD had received notification from the Chelan County Weed Board of their intent to apply aquatic herbicide to control Eurasian milfoil in the Columbia River at Entiat Park. Hemstrom said he currently had little information about this proposal but thought it should be brought to the attention of the Coordinating Committees. Bryan Nordlund said there are mechanical methods for removing milfoil, but Mike Schiewe said mechanical methods have the potential to spread milfoil when the milfoil is cut up. Bob Rose suggested that Chelan County be contacted to provide the Committees with details on this proposal; Hemstrom said he will contact Chelan County to obtain further information. Nordlund agreed to inquire internally within NMFS to obtain information on the application of aquatic herbicide to control Eurasian milfoil in the Columbia River. Schiewe said he will ask Tom Kahler how Douglas PUD and Douglas County coordinate on issues of aquatic weed control and report back to the Coordinating Committees. Hemstrom added that if Chelan County engages in any activity within the Rocky Reach Project boundary, they are required to work with Chelan PUD per their Federal Energy Regulatory Commission (FERC) license.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the HCP Tributary Committees last met on June 14, 2012. Kristi Geris said she will distribute to the Coordinating Committees the HCP Tributary Committees June Progress Report. The following items were discussed:

- *General Salmon Habitat Program Pre-proposals*: The Tributary Committees received 27 pre-proposals for the 2012 round of the General Salmon Habitat Program. Thirteen projects were found to be either inconsistent with the intent of the Tributary Fund or did not have strong technical merit; and so the Committees solicited full proposals from the remaining 14 projects, which are due on June 29, 2012. The proposed projects are located in the Okanogan, Foster, Methow, Entiat, and Wenatchee basins. Teresa Scott asked about the criteria that are used to evaluate the proposals. Steve Hemstrom said that the Tributary Committees use both technical and biological criteria that were established by the Upper Columbia Regional Technical Team (RTT). Hemstrom added that HCP Tributary Funds are used to match funds for large projects that also include funds from the Salmon Recovery Funding Board and Bonneville Power Administration. Hemstrom said he will ask Steve Hays to provide a brief overview of the requirements and stipulations (including criteria) for receiving HCP Tributary Funds.

- *Small Projects Program Application*: The Rock Island Tributary Committee approved funding for the Wenatchee Levee Removal and Riparian Restoration Project. The project, located at river mile 13.5 on the Wenatchee River, will remove 300 feet of levee, restore the riparian zone, and eliminate a surface-water irrigation diversion. Approved HCP Tributary Funds will cover $56,700 of the $67,450 total cost of the project.
- *Evaluation of Appraisals*: The Tributary Committees have been discussing how they can better evaluate appraisals. Washington Department of Fish and Wildlife (WDFW) Real Estate Services advised the Tributary Committees to hire a firm to conduct appraisals, or hire a firm to review the appraisals. The Committees decided to do both (i.e., hire both the appraiser and the reviewer).
- *Next Steps*: The next Tributary Committees meeting will be July 12, 2012. The Tributary Committees plan to evaluate General Salmon Habitat Program proposals, discuss a policy for stewardship plans and public access on protected properties, and continue their discussions on appraisals and the appraisal process.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Hatchery Committees meeting on June 20, 2012, held at the Chelan PUD headquarters:

- *Collection of Entiat National Fish Hatchery (NFH) Summer Chinook Broodstock at Wells Hatchery SOA*: The Wells Hatchery Committee approved the Collection of Entiat NFH Summer Chinook Broodstock at Wells Hatchery SOA. The SOA approves the collection of up to 270 hatchery origin summer Chinook adults to support the Entiat summer Chinook program.
- *5-Year Update of the Monitoring and Evaluation (M&E) Plan*: The Hatchery Committees are reviewing and updating the Chelan PUD and Douglas PUD Hatchery M&E Programs following the completion of the first 5-year summary reports. Josh Murauskas and Greg Mackey presented ideas for initial approaches for reviewing and revising the Hatchery M&E Programs. The Hatchery Committees agreed to convene a smaller workgroup to further discuss recommendations for revisions. A timeline for this process has not yet been developed; however, the goal is to complete the revisions by the end of 2012.

- *Methow Broodstock Collection Update*: WDFW asked the Hatchery Committees for a recommendation for dealing with 27 spring Chinook collected at Wells Dam for Methow broodstock that appear to be of Carson lineage. The Hatchery Committees recommended that the fish not be retained for broodstock, but agreed to their release in the Methow River.
- *Steelhead Residualism and Predation*: Josh Murauskas presented an analysis suggesting a relationship between release data of hatchery steelhead and rates of avian predation. Avian predation was measured by recovering PIT tags from bird colonies on local islands. The analysis shows a significant correlation between later release and a higher likelihood of recovering a PIT tag on one of the islands. Bryan Nordlund said the Priest Rapids Coordinating Committee has also been discussing this issue and suggested that Murauskas consider sharing his findings with that group. Teresa Scott said the U.S. Army Corps of Engineers has convened an Interagency Avian Predation Workgroup (IAPWG) that addresses avian predation. Schiewe said he will contact Murauskas to be sure he is aware of the IAPWG, and will suggest that he contact the group regarding his analysis of the putative impact of avian predation on later migrating steelhead smolts. Scott added that she would like to see broader involvement of all parties in decision-making regarding controlling avian predation. She said that this is a regional issue that is not location specific.
- *Presentation: Dryden Phosphorus Total Maximum Daily Load (TMDL)*: Chelan PUD's Sam Dilly gave a presentation on the Wenatchee River phosphorus TMDL that will be implemented by the Washington State Department of Ecology beginning in 2018. The TMDL may affect rearing at the Dryden Facility. Current background levels of phosphorus are already higher than the TMDL. The Hatchery Committees discussed the potential for using low phosphorus feed and automated feeders, and for rearing summer Chinook to smaller size at release to manage the phosphorus concentration in discharge water. Chelan PUD and Grant PUD agreed to develop a detailed timeline, including milestones, for evaluating options for addressing compliance with the proposed TMDL at the Dryden Rearing Facility.
- *HGMP Update*: Craig Busack reported that NMFS is currently working on the Snake River fall Chinook and Chiwawa spring Chinook Biological Opinions. He said that for the Methow, NMFS is in discussions with WDFW, Douglas PUD, and the affected

tribes regarding reduced production of spring Chinook and steelhead, targeting a proportion hatchery origin spawners (pHOS) of 25 to 30 percent for spring Chinook. Busack also mentioned that NMFS is taking a second look at the White River Project, and is considering alternatives because of local land use permitting issues. Lastly, Busack said it was clear that there are significant differences of opinion regarding the effects of trapping at Tumwater Dam, and NMFS is planning to further investigate the basis for these differences.

V. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meetings are July 24, 2012, August 28, 2012, and September 25, 2012, planned for the Radisson Hotel at SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Bob Rose	Yakama Nation
Tom Kahler*	Douglas PUD
Jerry Marco*	Colville Confederated Tribes
Jim Craig*	USFWS
Teresa Scott*	WDFW
Bryan Nordlund*	NMFS

* Denotes Coordinating Committees member or alternate

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	August 29, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the July 24, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met at the Radisson Gateway Hotel in SeaTac, Washington, on Tuesday, July 24, 2012, from 9:30 am to 12:00 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Steve Hemstrom will update the Coordinating Committees on Chelan PUD's progress on installing a bar system on the outside of the left bank fishway overflow protection gate to prevent fish from entering the space between the fishway and the left bank shore. The bar system will be installed during the Rock Island left bank fishway maintenance period (late winter 2012/2013) (Item III-A).
- Steve Hemstrom will distribute photos of the area between the left bank and left bank fishway at Rock Island Dam where the sockeye and summer Chinook were unintentionally trapped (Item III-A).
- Mike Schiewe will contact Bill Tweit to confirm a presentation for the August 28, 2012 Coordinating Committees meeting covering potential renegotiation of the Columbia River Treaty (Item V-A).

DECISION SUMMARY

- The Coordinating Committees approved the Statement of Agreement (SOA) to implement a 1.0-foot fishway-entrance head-differential for lamprey from 17:00 to 00:59 daily during the 2012 lamprey migration period at Wells Dam (Item II-A).

AGREEMENTS

- There were no agreements discussed at today's meeting.

REVIEW ITEMS

- Kristi Geris sent an email notification to the Coordinating Committees on July 23, 2012, stating that the Draft 2011 Douglas PUD Pikeminnow Program Annual Report is out for a 60-day review period with comments due to Tom Kahler by September 21, 2012.

REPORTS FINALIZED

- There are no reports that have been recently finalized.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or changes to the agenda. Tom Kahler added an update on the 2011 Douglas PUD Pikeminnow Program Annual Report.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft June 26, 2012 meeting minutes. Kristi Geris said there was one outstanding comment remaining to be discussed regarding something that was said by Steve Hemstrom during the Rocky Reach Spill Gate Pattern Test discussion; Hemstrom clarified what he had said. Teresa Scott also clarified a question she asked during that same discussion. Geris said that all other comments and revisions received from the Coordinating Committees members were incorporated in the revised minutes. The draft June 26, 2012 meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. DECISION: Implementation of Modified Fishway Operations at Wells in 2012 During the Lamprey Migration (Tom Kahler)

Tom Kahler introduced an SOA to implement a 1.0-foot fishway-entrance head-differential for lamprey from 17:00 to 00:59 daily during the 2012 lamprey migration at Wells Dam (Attachment B). The draft SOA was distributed to the Coordinating Committees by Kristi Geris on July 17, 2012. Kahler said this SOA requests the same lamprey operation that was approved by the Committees in 2011. Kahler said that last year the modified fishway operations at Wells began on August 19, 2011; this year, Kahler said, one lamprey had already passed Rocky Reach on July 18, 2012. Kahler said no lamprey have passed at Wells.

Mike Schiewe said that the Aquatic Settlement Workgroup is in the process of developing a Lamprey Study Plan, combining the installation of infrared (IR) cameras in the Wells fishway and the active tagging of translocated adult lamprey, to assess lamprey passage and enumeration at Wells Dam. The study plan is intended to improve the accuracy of fish counts at Wells Dam, and to detect lamprey that may be passing through the picketed lead and bypassing the counting window. Bob Rose added that a more robust lamprey evaluation is anticipated over the next few years, with the tagging of translocated lamprey a component of the plan. The Coordinating Committees approved the SOA to implement a 1.0-foot fishway-entrance head-differential for lamprey from 17:00 to 00:59 daily during the 2012 lamprey migration period at Wells Dam.

B. Update: 2012 Subyearling Life History Studies (Tom Kahler)

Tom Kahler said approximately 20,000-plus subyearling summer/fall Chinook salmon were tagged during the seining efforts from June 25, 2012, to July 12, 2012. Kahler said most fish were collected near the mouth of the Okanogan. However, as the recapture rate increased at that location, seining was moved to an area located approximately one mile above Wells Dam, which Kahler said likely included Methow-origin fish. Kahler said fish were also collected and tagged upstream of the Okanogan near Washburn Island. To date, there has been approximately 700 detections at all locations, including approximately 300 detections at Rocky Reach and others at John Day, McNary, and Bonneville dams. Kahler added that fish bypass system efficiency (and hence tag detection efficiency) at dams will likely be affected by the high flows and involuntary spill this year.

Kahler said that Douglas PUD staff revisited the sampling site above Wells Dam on July 20, 2012, to determine if juvenile Chinook salmon were still present. He said their seining caught a mix of previously tagged and untagged fish ranging in length from 55 millimeters (mm) to 80 mm. Kahler said the 2011 Subyearling Study Report is expected to be released by the end of this summer.

Jerry Marco asked how sampling compared between the 2011 and 2012 studies. Kahler replied that in 2011, their sampling started slowly as they were learning where to fish. Kahler said that as a result of last year's research, this year they were able to go directly to the areas where they knew there were fish, and conversely, skip the areas where there were few fish in 2011. Further, Kahler said that in the areas where many fish were sampled in 2011, even more fish were sampled in 2012. Kahler added that sampling was conducted using a 100-foot-long seine, and on occasion, up to 800 to 1,000 fish were sampled per haul. Kahler said that he has not compared the numbers; however, sampling efforts seemed more productive this year than in 2011.

Jim Craig asked which species were numerically dominant in the bycatch; Kahler said that bycatch was minimal in most seine sets and in some locations rare; but in a few locations there were large numbers of stickleback, juvenile suckers, and shiners. Kahler said they did not routinely examine stomach contents of large predatory species caught; however, in 2011, a bass was caught that had the tail of a subyearling Chinook protruding from its mouth. Bryan Nordlund asked if any hatchery fish were observed, and Kahler replied that no adipose-clipped fish were observed.

C. Update: 2011 Douglas PUD Pikeminnow Program Annual Report (Tom Kahler)

Tom Kahler noted that the Draft 2011 Douglas PUD Pikeminnow Program Annual Report is out for a 60-day review period; Kristi Geris notified the Coordinating Committees of its availability by email on July 23, 2012. Comments are due to Kahler by September 21, 2012.

Kahler noted that the January date on the draft report reflects the date the report was distributed to Douglas PUD staff for internal review.

III. Chelan PUD

A. Chelan County's Rock Island Left-Bank Fish Recovery – Review of Events (Steve Hemstrom)

Steve Hemstrom updated the Coordinating Committees on the status of the fish recovery in the area adjacent to the Rock Island left bank fishway. He said the recovery effort is managed by Lance Keller, and has been described in emails distributed to the Coordinating Committees by Kristi Geris on July 12, 2012; July 13, 2012; and July 22, 2012. Hemstrom said that an area between the riprapped shoreline and the left bank fishway wall, and approximately 45 feet deep, receives overflow water from the left-bank fishway through slots in the fishway wall as a hydraulic/structural protection measure for the fishway itself. Extra water from the fishway flowed into the space, and then exited into the tailrace through a hydraulic relief gate which opened under increased hydraulic pressure. Hemstrom said that when the hydraulic relief gate opened to let the overflow water out of the space, sockeye and summer Chinook salmon entered the space from the tailrace. Hemstrom described the gate as approximately 8 feet by 8 feet and partially submerged, opening and closing automatically to reduce fishway flow. Hemstrom said the gate opened on July 11, 2012, and an estimated 200 to 250 fish entered the space from the fishway; it is unknown how long the gate was open. He said Chelan PUD staff decided to not reopen the gate and run the risk of more fish entering the space than going out. Teresa Scott asked how long this gate system has been in operation at Rock Island; Hemstrom said since the 1960s. Keller added that the gate opened and a similar incident occurred in the 1980s.

Keller said an early visual estimate of the fish trapped in the space was approximately 150 sockeye salmon and 125 summer Chinook salmon. He said Chelan PUD seasonal employees used hook and line on July 13, 2012, to remove 13 sockeye. Hook and line attempts continued on July 16, 2012, and additional fish were caught and released. Keller said a seine net was not as successful due to a natural basalt outcrop in a section of the shoreline where trapped fish were able to avoid the multiple seine attempts. Stainless steel fish traps originally made for capturing pikeminnow, were modified to provide attraction flow through the trap and were submerged in the space. The traps have caught up to 20 fish per day.

Keller said that a Denil and trap with pumped attraction entering a floating box frame and net pen is currently under design for testing. Tangle nets, 15 feet in length with 5-inch mesh, were deployed, and six sockeye were captured, but this method caused two mortalities; therefore, the tangle nets were abandoned. Another method that was rejected involved modifying the panel in the fishway itself; this method posed significant structural concern and ran the risk of more fish entering the space from the fishway itself. Keller said installing a slide gate was also considered; however, this option was determined to be infeasible.

Keller said that 136 sockeye salmon and one summer Chinook salmon have been removed to date, including five sockeye mortalities. Keller said that all other fish have been in good shape when released. Hemstrom and Keller invited the Coordinating Committees to offer suggestions and ideas on how to recover the remaining fish. Keller added that a dedicated crew is working every day on this recovery effort. He also noted that some options are unavailable because BNSF Railway owns a portion of the shoreline adjacent to the space. Hemstrom said that in December 2012, Chelan PUD engineers plan to design and construct a bar system to cover the tailrace side of the relief-gate preventing fish from entering the space again if the relief gate is opened. Hemstrom said he will keep the Coordinating Committees updated on the progress of this Rock Island left-bank fishway maintenance period.

Keller concluded that the current plan is to continue hook and line, and test the steep-pass Denil option. Hemstrom said he will distribute photos to the Committees of the area between the left bank and left bank fishway at Rock Island Dam where the sockeye and summer Chinook salmon are trapped.

B. Update: Pioneer Water District Irrigation Water Withdrawal (Steve Hemstrom)

Steve Hemstrom updated the Coordinating Committees on Pioneer Water District's plans to install a pipeline in the lower Wenatchee River near the confluence with the Columbia River. The pipeline will cross a portion of the Rocky Reach Project Boundary, and will therefore require approval from the Federal Energy Regulatory Commission (FERC). A Hydraulic Project Approval (HPA) permit from the State must also be acquired by the Pioneer Water District before work begins. Hemstrom said the project details are being developed by Pioneer Water District and Trout Unlimited; however, these details are not yet finalized. Hemstrom said the project should be beneficial for fish, and that he will keep the Committees updated as plans progress. Teresa Scott added that most funding for this project is from Washington State Department of Ecology (Ecology).

C. 2012 Adult Passage Counts at Rock Island and Rocky Reach (Steve Hemstrom)

Steve Hemstrom said adult passage fish counts look great. He said that Rock Island is three days behind on posting counts due to so many fish passing on July 19, 2012, and July 20, 2012. The passage count at Rock Island was 354,877, averaging a rate of 10,000 fish per day, which leads to an estimated total count of 394,000 over Rock Island. The passage count at Rocky Reach is 350,000 and Wells is a few behind Rocky Reach.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the HCP Tributary Committees last met on July 23, 2012, and that Kristi Geris distributed the HCP Tributary Committees July Progress Report to the Coordinating Committees on July 23, 2012. The following items were discussed:

- *2012 General Salmon Habitat Program Proposals*: The Tributary Committees selected six projects to receive Tributary Funds out of the 16 full proposals received for consideration under the General Salmon Habitat Program. The largest Tributary funds contributions went towards the Upper Beaver Creek Habitat Improvement ($205,225), and to Fish Passage at Shingle Creek Dam ($118,450). Kahler said that Shingle Creek in the Canadian Okanagan is among the best tributary spawning areas on the Okanagan.

  Regarding the summary table of 2012 General Salmon Habitat Program Projects listed in the HCP Tributary Committees July 2012 Meeting Progress Report, Teresa Scott asked for clarification on the footnote for the Twisp River Elbow Coulee Phase II Restoration. Kahler said the footnote was intended to indicate that if BPA elects to fund the entire project, the Wells Committee will not need to contribute any matching funds.

  Scott asked Kahler about the criteria used to evaluate the proposals. Kahler explained that there are no explicit rating criteria to determine fundability of a project. Scott said if there are different purposes for what the Upper Columbia Regional Technical Team (RTT) funds and what the Tributary Committees fund; she said she is interested in any difference. Kahler explained that the RTT does not have funds to distribute, but rates projects according to established criteria for the annual funding rounds of the Salmon Recovery Funding Board (SRFB), which has a set amount of funds to disburse each year that they are required to spend. The Tributary Committees do have dedicated funds to distribute but are not obligated in any given year to fund projects if they do not have consensus.

- *Small Projects Program Applications*: The Tributary Committees received three Small Projects Program Applications, all of which the Tributary Committees elected not to fund because the applications lacked detailed information needed to comprehensively evaluate the potential success of the proposed actions.
- *Acquisitions*: The HCPs include a provision that the PUDs can hold titles to acquired properties; however, the PUDs are uncertain that they want to exercise this option because of the associated liability and other potential implications. Therefore, the PUDs are discussing internally how to address this situation.
- *Methow Conservancy Questions:* The Tributary Committees responded to questions from the Methow Conservancy confirming the requirement for granting public access on conservation easements and acquisitions funded by the Tributary Committees.
- *Next Steps*: There will be no Tributary Committees meeting in August. The next Tributary Committees meeting will be held on September 13, 2012.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Hatchery Committees meeting on July 18, 2012, held at the Douglas PUD:

- *Summer Chinook Growth Modulation Experiment*: Josh Murauskas has been working with Brian Beckman and Don Larson (National Marine Fisheries Service [NMFS] Northwest Fisheries Science Center) to develop a plan to evaluate fish size at release at summer/fall Chinook acclimation facilities, including the Dryden Facility. Because a reduced size at release would reduce feeding and hence phosphorus in waste water discharge, the results of the study could contribute to meeting the proposed Wenatchee River phosphorus Total Maximum Daily Load (TMDL). Chelan PUD is developing a full proposal to present to the Hatchery Committees. If approved the study would begin in fall 2012.

- *Dryden Acclimation Ponds*: Alene Underwood presented a description of actions developed by Chelan PUD to ensure summer Chinook production and infrastructure complies with the Wenatchee River TMDL for phosphorus. Detailed study plans are still under development. There was also further discussion regarding the Dryden water source issue. The Joint Fisheries Parties (JFP) would like to see Chelan PUD take advantage of Grant PUD's offer to install a dedicated surface water intake at the Dryden Facility. The JFP are anxious for Chelan PUD to complete their due diligence, including reconciling water rights issues and conducting chemical analyses in the irrigation canal (which is scheduled for 2013). Tom Scribner recommended that the fisheries parties collectively meet with Ecology regarding the TMDL issue. Underwood explained that Chelan PUD has multiple interests in the TMDL, particularly because Chelan PUD deals with wastewater. Therefore, Underwood said that Chelan PUD will need to be careful that communication with Ecology is first internally vetted.
- *Douglas PUD and Chelan PUD Hatchery M&E Updates*: Douglas PUD and Chelan PUD laid out schedules for their respective 5-year review and updating of the Hatchery Monitoring and Evaluation (M&E) Programs. Both PUDs said their updated programs may be ready for implementation in 2013. A Hatchery M&E Programs working group has been set up to review and recommend revisions to the Hatchery M&E Plans.
- *Methow Sharing Agreement*: The sharing agreement for Chelan PUD to produce spring Chinook at Methow Hatchery has expired. Chelan PUD is working with Douglas PUD on a new agreement but is uncertain if a new agreement will be worked out. There are several issues and entities affected by these sharing arrangements, including the Colville Confederated Tribes' plans at Chief Joseph.
- *Yakama Nation Coho Restoration Program Update*: The Yakama Nation (YN) has been working with Douglas PUD regarding the potential to rear coho salmon at Wells Hatchery. The YN is also looking for potential coho acclimation sites in the Chewuch River.

- *HETT Update*: The Non Target Taxa of Concern (NTTOC) risk modeling exercise is approaching a point where most model runs are complete. In an effort to evaluate how much further to go, the Hatchery Committees are asking the Hatchery Evaluation Technical Team (HETT) to develop a consensus report based on the modeling results, opposed to moving forward with the Delphi route. Early modeling results suggest there is minimal impact of the supplemented populations on non-target taxa.

V. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meetings are August 28, 2012; September 25, 2012; and October 23, 2012, all planned for the Radisson Hotel at SeaTac, Washington.

Dr. Kim Hyatt, Fisheries and Oceans Canada, will attend the August 28, 2012 Coordinating Committees meeting and provide an update on implementation of the Fish and Water Management Tool (FWMT) in the Canadian Okanagan. Mike Schiewe said he will also contact Bill Tweit to confirm a presentation for the August meeting covering potential renegotiation of the Columbia River Treaty.

List of Attachments

Attachment A – List of Attendees
Attachment B – SOA to implement a 1.0-foot fishway-entrance head-differential for lamprey from 17:00 to 00:59 daily during the 2012 lamprey migration period at Wells Dam

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Bob Rose†	Yakama Nation
Tom Kahler*	Douglas PUD
Jerry Marco*†	Colville Confederated Tribes
Jim Craig*	USFWS
Teresa Scott*	WDFW
Bryan Nordlund*†	NMFS

Notes
* Denotes Coordinating Committees member or alternate
† Joined by phone

Wells HCP Coordinating Committee
Statement of Agreement to implement 1.0' Fishway-entrance Head-differential for Lamprey from 17:00 to 00:59 daily during the 2012 Lamprey Migration at Wells Dam

Date of Approval:

Statement

The Wells HCP Coordinating Committee (CC) approves the request of the Wells Aquatic Settlement Work Group (ASWG) for operating the Wells fishway collection galleries at a 1.0' head differential from 17:00 to 00:59 daily during the 2012 lamprey migration. The requested operations will commence three days after the day on which the cumulative passage of lamprey at Rocky Reach Dam equals five lamprey, and terminate on September 30.

Background

Douglas PUD and the Aquatic Settlement Work Group are evaluating ways to improve the ladder-entrance efficiency for adult lamprey attempting to pass Wells Dam. Radio-telemetry studies and passive monitoring indicate that normal operating conditions may present a velocity impediment to lamprey passage through the fishway entrances. The Wells HCP CC approved studies in 2009 and 2010 at Wells Dam that used Dual Frequency Identification Sonar (DIDSON) technology to observe the behavior of lamprey attempting to pass the fishway entrances under different operating conditions.

At the request of the Wells HCP CC, the studies also included observations of salmonid behavior in response to changes in operating conditions. The results of those studies indicate that lamprey entrance efficiency may be enhanced by reducing the collection-gallery-to-tailwater head differential from 1.5' to 1.0' between 17:00 and 0:59 hours during the peak of the lamprey migration. Post-hoc analyses indicate this is the eight-hour block with the lowest diel salmonid passage activity and highest diel lamprey activity. Analysis of data on the passage of salmonids during the DIDSON studies indicated no significant difference in passage rates of steelhead or sockeye, Chinook, or coho salmon with either a 1'0 or 1.5' head differential.

Conclusions regarding lamprey performance under different flow velocities were drawn from DIDSON observations of only a few lamprey. As a best-management practice and until operational changes can be tested in 2013 with an active-tag study, Douglas PUD and the ASWG propose to operate the Wells Dam fishway entrances with a 1-foot differential at night as a means of enhancing adult lamprey passage.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	September 25, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the August 28, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met at the Radisson Gateway Hotel in SeaTac, Washington, on Tuesday, August 28, 2012, from 9:30 am to 1:30 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Steve Hemstrom will finalize Chelan PUD's Spill Programs Report, after Rocky Reach and Rock Island bypass operations are complete on August 31, 2012. The final report will include bypass index counts, and corrections to the dates reported in the draft document for Rock Island's 2012 summer spill start and stop dates. Hemstrom will provide the finalized report to Kristi Geris for distribution to the Coordinating Committees (Item IV-A).

DECISION SUMMARY

- There were no decisions at today's meeting.

AGREEMENTS

- There were no agreements at today's meeting.

REVIEW ITEMS

- Kristi Geris sent an email notification to the Coordinating Committees on July 23, 2012, stating that the Draft 2011 Douglas PUD Pikeminnow Program Annual Report is out for a 60-day review period with comments due to Tom Kahler by September 21, 2012.

REPORTS FINALIZED

- There are no reports that have been recently finalized.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or changes to the agenda. No additions or changes were requested.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft July 24, 2012 meeting minutes. Kristi Geris said all comments and revisions received from Committees' members were incorporated in the revised minutes, and there were no outstanding edits or questions to discuss. The draft July 24, 2012 meeting minutes were approved as revised. Bryan Nordlund approved the July meeting minutes by email as distributed to the Coordinating Committees on August 13, 2012. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Update: Rebuild of Wells Hatchery (Shane Bickford)

Shane Bickford said that Douglas PUD is currently in Phase I of modernizing Wells Hatchery. He said Phase I includes a facility assessment, a groundwater well field assessment, and bio-programming. Bickford said Phase II will address configurations for the facility in terms of water needs for Wells Hatchery operations. He said that Douglas PUD plans to use only a portion of allotted water for rearing at the Wells Hatchery facility, and it is yet to be determined how or if the remaining allotted water will be used. Bickford said Douglas PUD has discussed potential options with several agencies, including the Yakama Nation's (YN's) Upper Columbia Coho Reintroduction Program and Twisp River Steelhead Kelt Reconditioning Program; Grant PUD's Steelhead Program; and various Colville Confederated Tribes (CCT) programs. Bickford said Phase II of the Wells Hatchery rebuild will also address steelhead and Chinook management, including various rearing strategies. He said Douglas PUD anticipates completing Phase II by November 2012; completing Phase III by January 2013; and commencing construction by 2014. Bickford said there are a lot of stakeholders that are interested in the bio-programming at Wells Hatchery, and that Douglas PUD wants to be sure people are well-informed on the rebuild process. Bickford added that the Hatchery Committees have been informed of the rebuild.

B. Update: 2012 Bypass Operations (Tom Kahler)

Tom Kahler said that in accordance with the Douglas PUD 2012 Bypass Operating Plan (BOP), bypass operations at Wells Dam started April 12, 2012, and ended August 19, 2012. Kahler said that a maximum of three bypass barriers were removed at one time to manage high flows. He said that the three barriers were removed by June 26, 2012, and all barriers were reinstalled by August 2, 2012. Kahler said Wells Dam operated under a regular configuration from August 2, 2012, through August 19, 2012, when bypass operations ended for 2012.

C. Update: Total Dissolved Gas (Shane Bickford)

Shane Bickford said that the 2012 spill season was a challenging flow year, characterized by high total dissolved gas (TDG) levels. He said that last week, TDG levels were in the 122 percent range for four days, and that TDG concentrations exceeded the 120 percent limit for five days. Bickford said that August 26, 2012, was the first day of the current fish passage season that Chief Joseph Dam discharged water in compliance with the TDG standard (below 110 percent).

Bickford said there were 12 instances during the current fish passage season when gas bubble trauma (GBT) monitoring was triggered at Rocky Reach Dam, based on hourly TDG concentrations of 125 percent or greater in the Wells Tailrace. He said that signs of GBT were observed on two of the 12 days; these signs were observed in less than 1 percent of the fish sampled. He said that, from a biological standpoint, TDG concentrations have not posed many problems.

D. Presentation by Dr. Kim Hyatt, Fisheries and Oceans Canada, on implementation of the Fish and Water Management Tool in the Canadian Okanagan (Dr. Kim Hyatt)

Dr. Kim Hyatt, Fisheries and Oceans Canada, introduced the Fish and Water Management Tool (FWMT; Attachment B), and provided an overview of the authors and contributors to FWMT development. Hyatt provided information on the Okanagan Lake/River (OLR) System, including geography, water management control points, and hydrology. He described factors that drive water management decisions in the OLR-System, and issues that affect water management decisions. Hyatt summarized the history of compliance with fishery flows prior to 1997; and he noted that reduced compliance was often the result of competing rules and objectives.

Hyatt said that he was asked to develop a model that could be used to guide a water release strategy quickly enough to inform water managers required to make daily water release decisions. He described the development of the FWMT, starting with the development of a program to model flow versus water needs during critical sockeye salmon life stages. Hyatt explained that available spawning habitat was modeled as a function of flow, and he described how the quantity of habitat could be controlled by flow and how water-release practices affect the survival of sockeye eggs and alevins in that habitat. With the FWMT, water managers can avoid dewatering of redds and flood-scour events, that have historically resulted in substantial density-independent mortality. Hyatt presented the results of an evaluation of risks, by life stage, to the Osoyoos Lake sockeye population as a result of a temperature-oxygen "squeeze," a density-independent rearing limitation in Osoyoos Lake. He said that flows into and out of Okanagan Lake were monitored on a real-time basis, allowing water managers to monitor potential effects on fish in Osoyoos Lake, and to make informed decisions on water use for fish. Hyatt said that this year, in spite of it being a good water year, the upper basin has begun to experience conditions that will result in a temperature-oxygen "squeeze." Hyatt said an option to use pulse discharge to avoid losses to juvenile and adult sockeye is being considered. He said the FWMT will help inform managers of current conditions in terms of thresholds. Hyatt said that in the north basin, sockeye like to hold at 9 to 12 degrees Celsius, 15 to 20 meters below the surface, with at least 5 parts per million (ppm) oxygen.

Hyatt reviewed examples of predicted versus actual flows to demonstrate how the FWMT has been used to inform conditions at several locations. He also reviewed examples of how FWMT predictions for sockeye fry emergence have been used by water managers to manage water storage and release strategies to minimize density-independent mortality associated with scour events. He showed an example of a range of water storage or release options the FWMT produced for three locations in August 2009. He said the FWMT calculated the best options for both domestic and agricultural purposes, and it also calculated what was in the best interest of fish.

Hyatt recapped that the FWMT is a coupled set of biophysical models of key relationships used to predict the consequences of water management decisions for fish and other water users, allowing water managers to avoid or minimize impacts to fish and other users. He said the FWMT may be used to explore the impacts of water management decision in an operational mode employing real-time data, in a prospective mode, or in a retrospective mode. Hyatt said that following the implementation of the FWMT in the OLR System, there has been a five- to ten-fold increase in sockeye smolt production and adult escapement. Furthermore, the FWMT has reduced density-dependent losses.

E. Update: Lamprey Operations at Wells (Tom Kahler)

Tom Kahler said that lamprey operations at Wells Dam for the 2012 lamprey migration commenced August 6, 2012. Kahler said that, to date, no lamprey have passed Wells Dam, and 125 have passed Rocky Reach Dam.

F. Update: 2012 Subyearling Life History Studies (Tom Kahler)

Tom Kahler said Douglas PUD collected more than 30,000 subyearling summer/fall Chinook salmon during their sampling effort. He said that more than 20,000 fish were tagged, and there were approximately 273 mortalities. Kahler said that, to date, there have been nearly 2,700 detections; most of these have been at the Rocky Reach Bypass. Kahler added that three jacks from the 2011 outmigration have also been detected. Kahler said that Andrew Gingerich is developing a detailed report on the 2011 study, and these results will be shared with the Coordinating Committees this fall.

III. WDFW

A. Potential Renegotiation of the Columbia River Treaty (Bill Tweit)

Bill Tweit presented an overview of the Columbia River Treaty (CRT) and modeling results from Iteration 1 (Attachment C), which Kristi Geris distributed to the Coordinating Committees by email on August 27, 2012. Tweit said that all of his presentation materials are public information and can also be found online.

Tweit said that potentially affected parties in the Pacific Northwest have approached review of the CRT using a regional consultation process, called the "Sovereign Process." He said there are two teams: a Columbia River Sovereign Review Team and a Sovereign Technical Team. He noted that the U.S. Department of State will ultimately make all final decisions regarding the U.S. positions in their negotiations with Canada. Tweit said that the Pacific Salmon Treaty also uses a similar approach to seek regional consensus. He said that the purpose of this CRT review process is to determine what to negotiate with Canada in 2014. He said that the United States (U.S.) has three options: 1) keep the status quo of the CRT with no changes; 2) give Canada the required 10-year notice of termination of the treaty; or 3) alert Canada that the U.S. would like to renegotiate the treaty.

Tweit said that Iteration 1 has just been completed, and objectives and details for Iteration 2 are being developed. He said that Iteration 1 modeled two flood control trigger flows: 1) 450,000 cubic feet per second (450 kcfs), which is the status quo; and 2) 600 kcfs, which was primarily advanced by tribal and some state fish and wildlife managers because it allows for decreased fluctuation in water storage reservoirs and higher spring flows. The purpose of the model runs was to investigate costs associated with a change from the status quo to 600 kcfs. Tweit emphasized that assumptions drive model outputs, and that key assumptions in Iteration 1 included assumptions about Canadian Operations post-2024 without the CRT, and assumptions about flood risk management strategies, "effective use," and "called upon."

Tweit discussed that Iteration 1 modeling results indicated almost no difference in the annual hydrograph between the 450 kcfs and 600 kcfs scenarios if the status quo were maintained. However, results suggested a change to a relatively constant outflow across the year without the treaty.

Tweit explained that “effective use” is U.S. use of U.S. flood control. He said that under “effective use,” most U.S. reservoirs are drawn down to lower water levels more frequently; the more frequently “effective use” occurs, the more negative impacts there are for the U.S. Tweit said that with 600 kcfs, models indicate “effective use” would only be needed one time in 70 years, peak river flows would increase, and some U.S. reservoirs would on average, have decreased draw down levels and increased refill probabilities. Tweit said that the flood risk management strategy, “called upon,” is viewed by Canada as highly disruptive, and that the U.S. has not exercised this option in the history of the treaty. He added that “called upon” has significant financial impacts, and that further modeling of this option is planned for Iteration 2.

Tweit introduced the concept of “ecosystem-based functions,” which is a new element being considered in the context of the CRT. “Ecosystem-based functions” address reservoir elevations and river flows, and the potential impacts on anadromous and resident fish, wildlife and the estuary. Other objectives include cultural resources, recreation, and irrigation. He said that, currently, the geographic focus starts in Montana and runs down through the mainstem Columbia River. He added that the Snake River is also being considered, to a lesser degree. Tweit said that the Bonneville Power Administration (BPA) and the U.S. Army Corp of Engineers are assisting in the analysis of the hydropower element of the CRT.

Tweit also presented a summary analysis of ecosystem-based function modeling runs (Attachment D), which Kristi Geris distributed to the Coordinating Committees by email on August 27, 2012. Tweit summarized model runs of five alternatives for these five areas: Kootenai River Basin; Flathead River Basin; Pend Oreille River Basin; Spokane River Basin; the Columbia River border to Grand Coulee Dam; Grand Coulee Dam to the confluence with the Snake River; Snake River Basin; and the Columbia River at the Snake River confluence to its estuary. Tweit said that climate change models will be addressed in Iteration 2.

IV. Chelan PUD

A. Update: Rocky Reach and Rock Island Summer Spill (Steve Hemstrom)

Steve Hemstrom distributed to the Coordinating Committees the Rocky Reach and Rock Island HCPs' 2012 Draft Fish Spill Program Results (Attachment E). Kristi Geris also distributed the draft document to the Coordinating Committees by email on August 27, 2012. Hemstrom said that while spill ended earlier in the month at both Projects, the 2012 Fish bypass operations at both Rocky Reach Dam and Rock Island Dam will end on August 31, 2012. He said that, at that time, Chelan PUD will finalize the draft spill program results and provide a final report to Kristi Geris for distribution to the Coordinating Committees.

Hemstrom reviewed the draft Fish Spill Program results as described in Attachment E and asked the Coordinating Committees to contact him with any questions or comments. Hemstrom received Coordinating Committees representatives' concurrence by email to end spill at Rocky Reach Dam and Rock Island Dam for the 2012 spill season. Hemstrom received concurrence on August 9, 2012, from Scott Carlon on behalf of Bryan Nordlund, and Joe Peone on behalf of Jerry Marco, to end summer spill at Rocky Reach Dam.

B. Final Results of Fish Rescue from Rock Island Left-Bank Overflow Space (Steve Hemstrom/ Lance Keller)

Lance Keller reported that August 17, 2012, was the last day of rescue efforts to recover fish from the area adjacent to the Rock Island left bank fishway. Keller said that as of August 17, 2012, a total of 213 live fish were rescued from the space, including 198 sockeye and 15 summer Chinook salmon. Keller said there were a total of 24 mortalities, including 18 sockeye and 6 summer Chinook salmon. He added that approximately 12 fish have been observed that are remaining in the space. Keller said the design drawing is complete for the bar system that will be installed on the outside of the overflow protection gate for the left bank fishway, in order to prevent fish from entering the space between the fishway and the left bank shore. He said the bar system will be installed during the left bank fishway maintenance period at Rock Island this winter. Steve Hemstrom said the entire rescue effort lasted more than a month; and Keller added that more than $50,000 was billed to this effort.

V. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the HCP Tributary Committees did not meet in August; therefore, there is no Tributary Committees' update this month.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Hatchery Committees meeting on August 15, 2012, held at the Chelan PUD:

- *SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook*: Douglas PUD introduced a draft SOA that permanently adjusts the release date for Wells Hatchery subyearling summer/fall Chinook salmon from mid-June to mid-May. The results of a study conducted over a series of years indicated better smolt to adult returns (SARs) in subyearlings released in May rather than June. Josh Murauskas agreed to check with the fish monitoring staff at Rock Island Dam about shifting the start date of subyearling Chinook monitoring to begin in May in future years. Teresa Scott said she will also check with fish monitoring staff at Rock Island Dam about shifting the start date.
- *Hatchery Monitoring and Evaluation (M&E) Update*: Douglas PUD and Chelan PUD have been discussing the review of their Hatchery M&E Plans. The goal is to use results from the first 5-year M&E report to inform changes to the Hatchery M&E programs. The initial plan was to implement a fully revised Hatchery M&E Program in 2013. However, the Hatchery Committees agreed to delay full implementation of a new program to 2014; during 2013, the Hatchery Committees will implement the existing M&E programs with minor changes.
- *Wells Hatchery Modernization Update*: Greg Mackey provided to the Hatchery Committees the same update Shane Bickford provided to the Coordinating Committees on the Wells Hatchery modernization process. Keely Murdoch also provided an update on the YN Kelt Reconditioning Program. Murdoch said the YN is also still investigating options for the YN Upper Columbia Coho Reintroduction Program.
- *CCT's Chief Joseph Hatchery Programs and M&E Plans*: Kirk Truscott provided an overview of Chief Joseph Hatchery Programs and M&E Plans. Truscott promised a more detailed presentation on the CCT's Chief Joseph Hatchery Programs at a future

Hatchery Committees meeting. Truscott said the CCT's Hatchery M&E Program will be complementary to the PUDs' Hatchery M&E Programs although the language will be slightly different to comply with submittal requirements for BPA's PISCES program. Key components of the CCT Hatchery M&E Program include: 1) in-hatchery monitoring by life stage; 2) tagging plans; 3) deployment of two smolt traps to increase monitoring on the Okanogan River; and 4) fall carcass recovery and redd counts. CCT will begin their production this coming year, sourcing fish from Winthrop National Fish Hatchery. CCT is anticipating 60 percent of capacity production in 2012. CCT also plans to operate overwinter acclimation ponds this winter to investigate if groundwater prevents the ponds from freezing.

- *Methow Update*: Chelan PUD is discussing with Douglas PUD options for continuing spring Chinook production at the Methow facility. Chelan PUD terminated the previous sharing agreement.
- *Chelan Falls Brood Collection*: Chelan PUD and Washington Department of Fish and Wildlife (WDFW) are investigating the potential to collect returning Chelan River summer/fall Chinook salmon to use as brood for Chelan Falls Hatchery production. WDFW and Chelan PUD will investigate various methods for capturing returning fish.
- *Summer Chinook Salmon Size Targets*: Chelan PUD presented a proposal for a study to investigate the effect of size-at-release of summer/fall Chinook salmon on fish performance at Chelan Falls and Dryden. This proposal has both performance and Total Maximum Daily Load (TMDL) implications. Chelan PUD, in coordination with National Marine Fisheries Service, plans to refine the proposal and provide the revised study plan to the Hatchery Committees.
- *Dryden Update as it Pertains to the Wenatchee River Phosphorus TMDL*: The Hatchery Committees continued discussing a plan to engage Washington State Department of Ecology in the Hatchery Committees' efforts to meet the Wenatchee River phosphorus TMDL.

VI. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The next scheduled Coordinating Committees meeting is September 25, 2012 (conference call). The October 23, 2012, and November 27, 2012, meetings are planned for the Radisson Hotel at SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees
Attachment B – FWMT Presentation by Dr. Kim Hyatt, BC Fisheries and Oceans
Attachment C – Columbia River Treaty and modeling results from Iteration 1
Attachment D – Ecosystem-Based Function Presentation
Attachment E – Rocky Reach & Rock Island HCPs 2012 Draft Fish Spill Program Results

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Shane Bickford*	Douglas PUD
Bob Rose*†	Yakama Nation
Jim Craig*	USFWS
Teresa Scott*	WDFW
Bill Tweit*	WDFW
Dr. Kim Hyatt	BC Fisheries and Oceans

Notes
* Denotes Coordinating Committees member or alternate
† Joined by phone

Attachment B

Okanagan Fish-and-Water Management Tools (Ok-FWMT): A Decision Support System to Balance Water Objectives in Real-time.

HCP Presentation, Aug. 28, 2012, Seattle.

Douglas County Public Utility District

Fisheries and Oceans Canada / Pêches et Océans Canada

Department of Fisheries and Oceans Canada

British Columbia

BC Ministry of Water Land and Air Protection

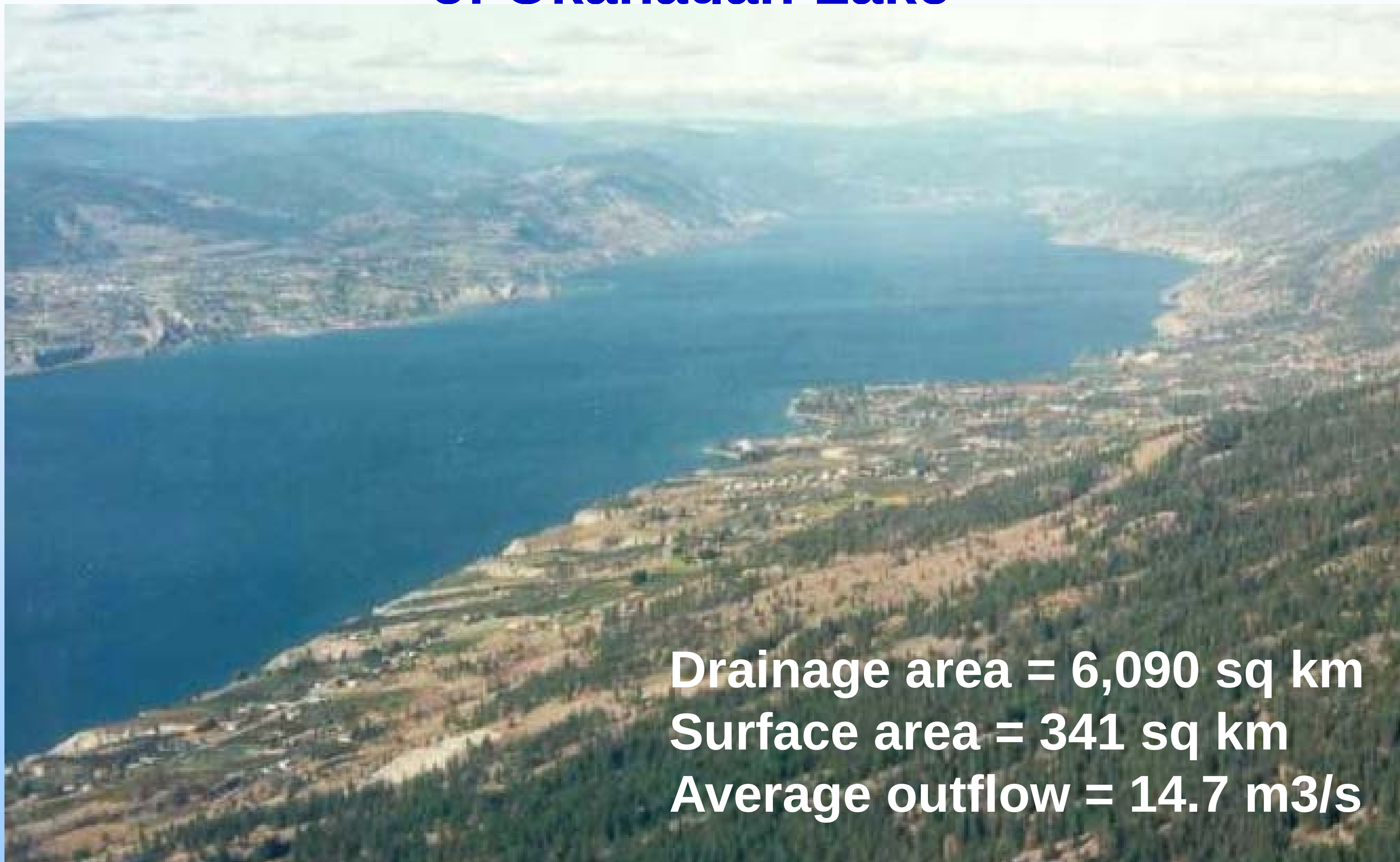
Okanagan Nation Alliance

Kim Hyatt*, Brian Symonds, Clint Alexander, Margot Stockwell, Chris Bull, Steve Matthews, Deana Machin, Andrew Wilson, Paul Rankin, Howie Wright, Colin Daniel, Calvin Peters, Brent Philips, Brian Guy, Harvey Andrusak

Outline for This Talk

- Identify context, process and objectives for managing water supplies in the OLRS.
- Comment on “audit” for water management compliance with fisheries requirements under the Okanagan Basin Agreement (OBA).
- Describe creation of Fish-and-Water Management Tools (FWMT) system to support “fish friendly” water management.
- Review experience with FWMT as an efficient information exchange, decision support utility.

OLR-System Management Begins in the Headwaters of Okanagan Lake



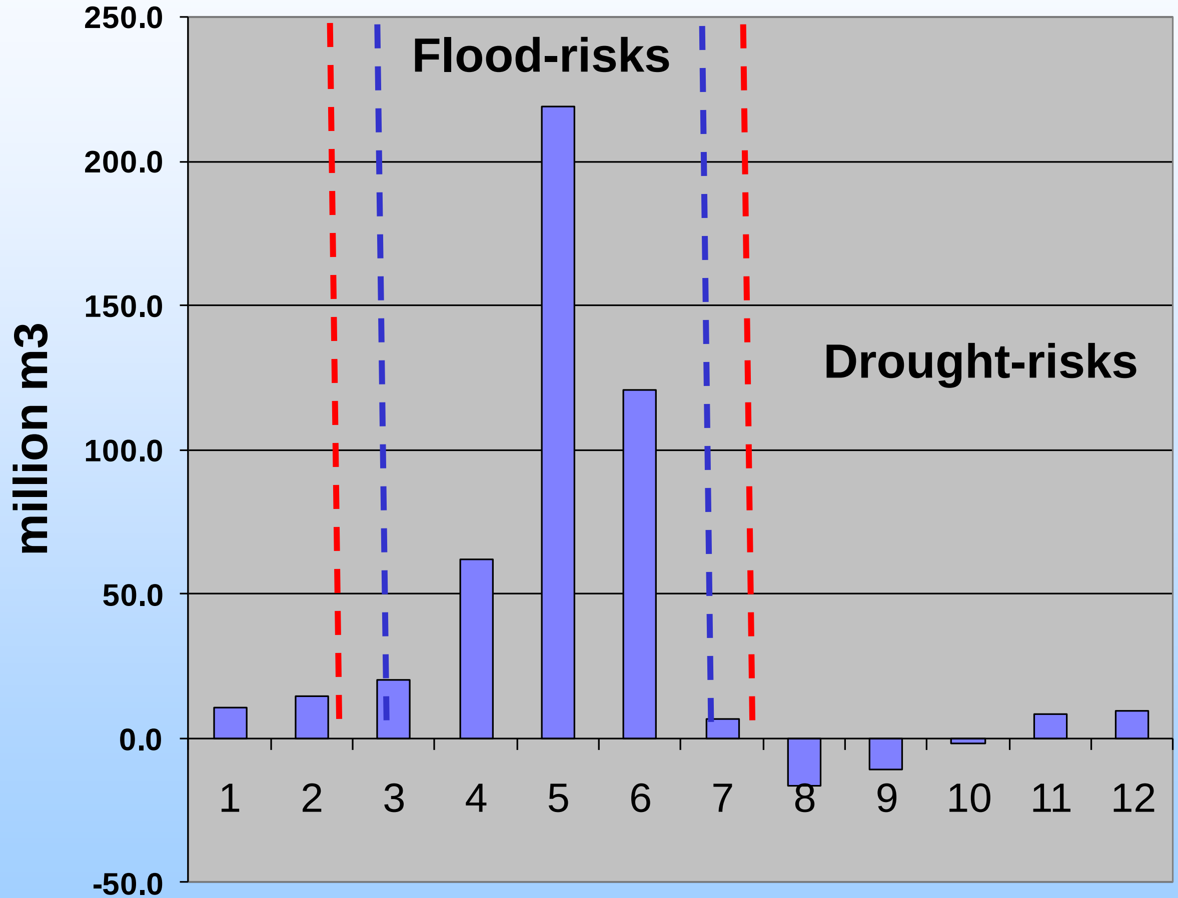
Attachment B

Okanagan Lake Dam at Penticton is the major control point in the system

OKANAGAN LAKE HYDROLOGY

- Annual inflow hydrograph dominated by snowmelt runoff
- Large range of annual inflows:
  - 78 million to 1.4 billion m^3
  - 0.23 m to 4.12 m stage change

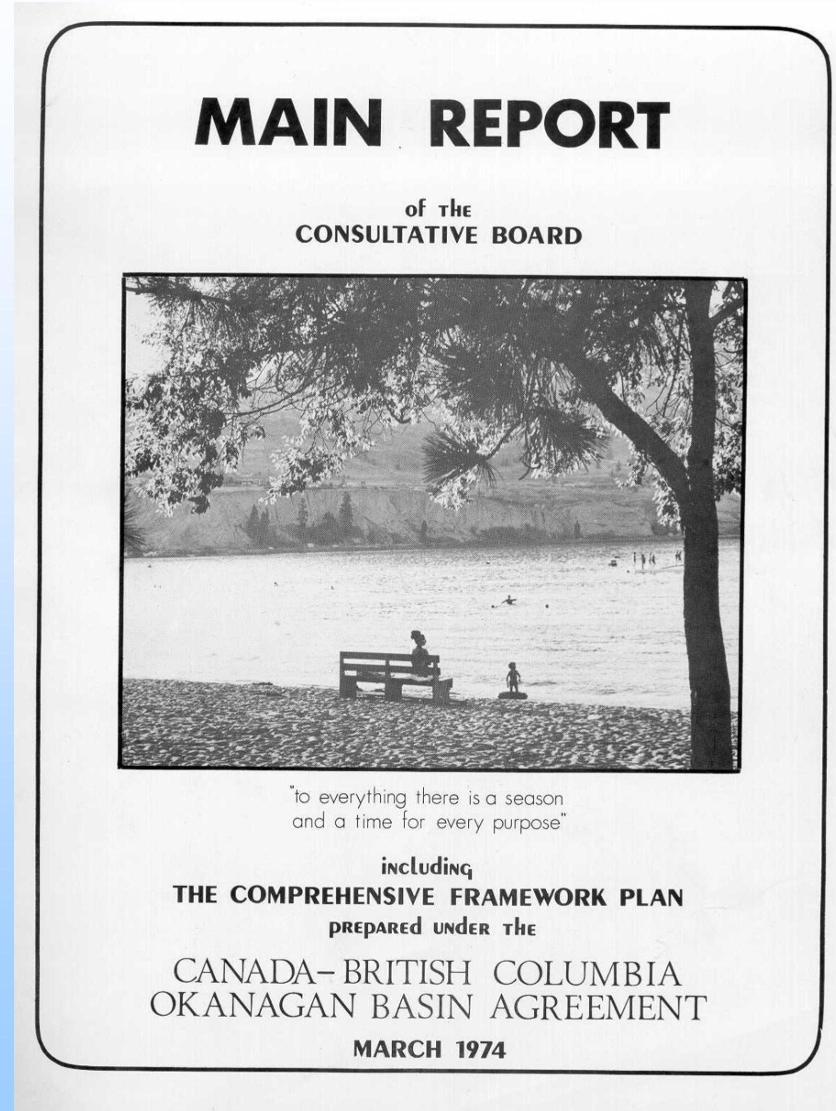
Mean monthly inflows to Okanagan L. (85 % of inflow from Apr-Jun)



How are Release Patterns Determined?

Okanagan Basin Agreement of 1974

"The Comprehensive Framework Plan" provides general rules for operating the OLRS.


MAIN REPORT

of the
CONSULTATIVE BOARD

"to everything there is a season
and a time for every purpose"

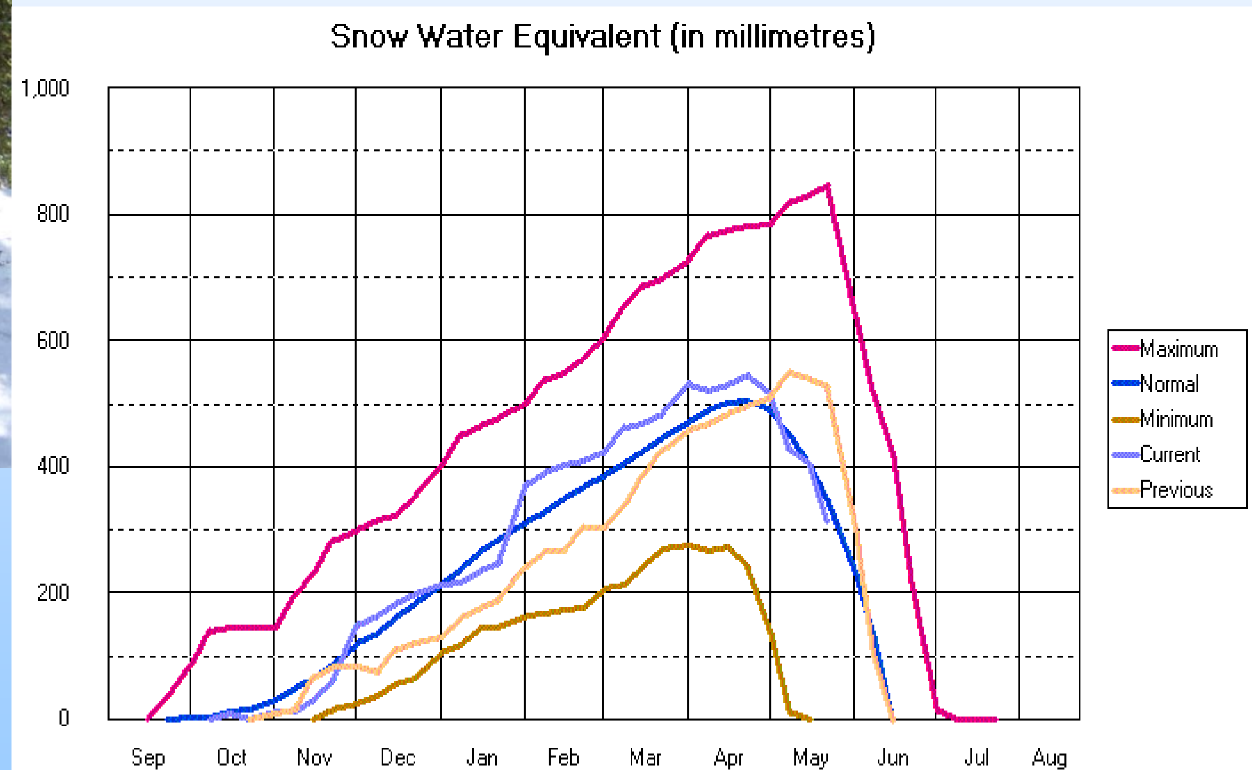
including
THE COMPREHENSIVE FRAMEWORK PLAN
prepared under the
CANADA–BRITISH COLUMBIA
OKANAGAN BASIN AGREEMENT
MARCH 1974

Attachment B

Inflow Forecasts and Discharge Observations Drive Management Decisions

Inflow forecasts based on seasonal precipitation, snow packs & tributary inflow data.

2003-04 Mission Ck. Snow Pillow @2F05P



OLRS OPERATIONS

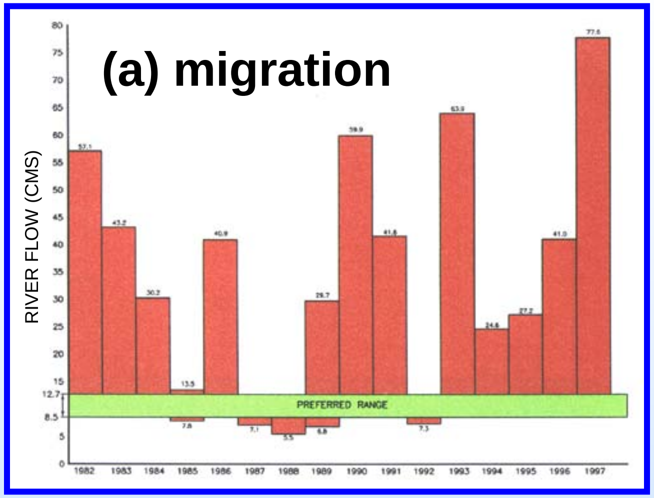
- OBA rules specify seasonal lake levels and flows.
- Operating plans/decisions reflect inflow forecasts.
- Decisions address competing objectives to satisfy: flood control, fisheries values, water storage/extraction, navigation, tourism, international agreements, etc.

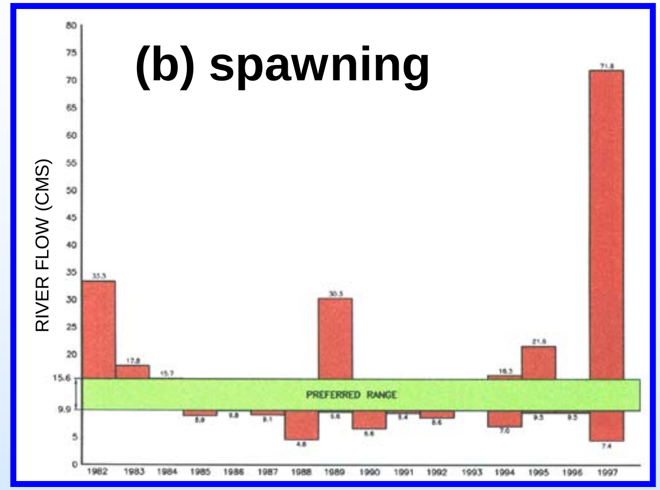
OPERATOR CHALLENGES

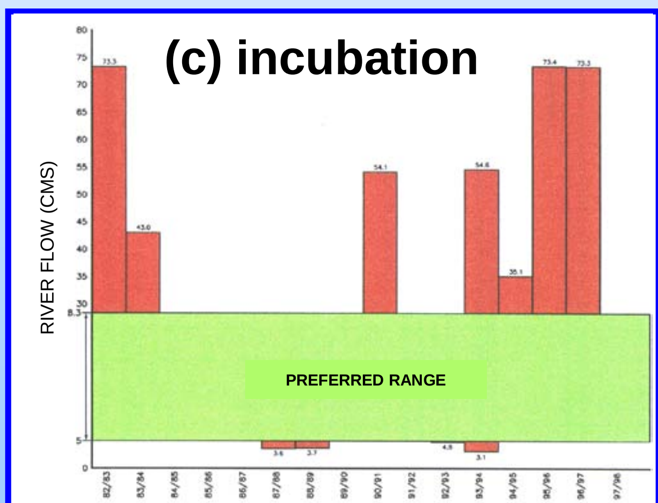
- Forecast uncertainty re: freshet inflow volumes and capacity to match lake spill or storage to spring inflows ("bathtub" analogy).
- Effects of environmental variability (water levels, flow, temp.) on risk assessments given competing economic, social & environmental demands of multiple "parties" & authorities.
- **OLRS decisions re: water storage or release based on rules of thumb, past experience & incomplete information.**

Attachment B

Compliance with OBA Fishery Flows was low prior to 1997.







OBA preferred flow range

Observed flow range

From 1982-1997 river discharge exceeded OBA fishery flows in:

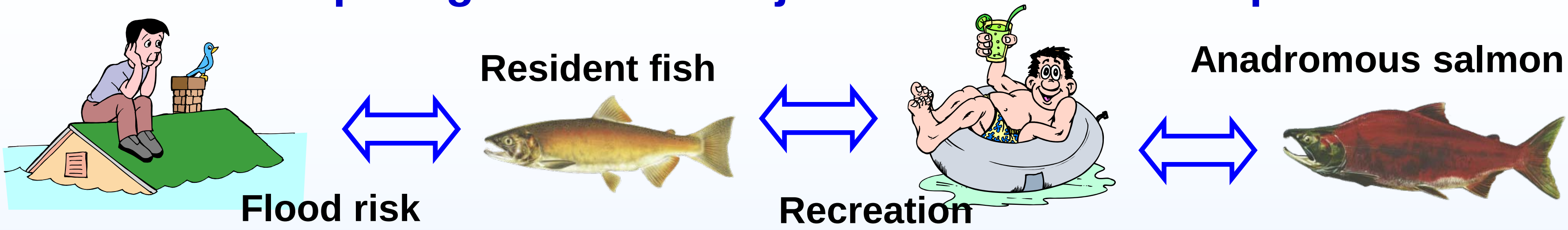
(a) 13 of 16 yrs for adult migration

(b) 7 of 16 yrs for spawning and

(c) 7 of 16 yrs for egg incubation & fry migration

Attachment B

Competing “Rules”& Objectives Reduce Compliance



Rule 1: Don’t fill Okanagan Lake above 342.56 meters (i.e. 10 cm rise above 342.56 incurs $5-$10 million in “property” losses !)

Rule 2: Try to avoid drafting to lake levels below 341.50 meters. (i.e. problems with docks, water intakes & vessel navigation become severe).

Rule 3: Minimize draw-down of Okanagan L. between the time of kokanee spawning and 100% fry emergence (i.e. minimize dewatering kokanee eggs & fry but don’t risk violatin of “rules” 1 or 6,7,8, & 9)

Rule 4: Minimize the number of buildings flooded at Penticton

Rule 5: Provide summer flows for recreation if possible

Rule 6: Sox. Migration – maintain flows (@ Oliver) between 8.5 & 12.7 cms during Aug 1 to Sept 15 to allow “easy” passage of VDS.

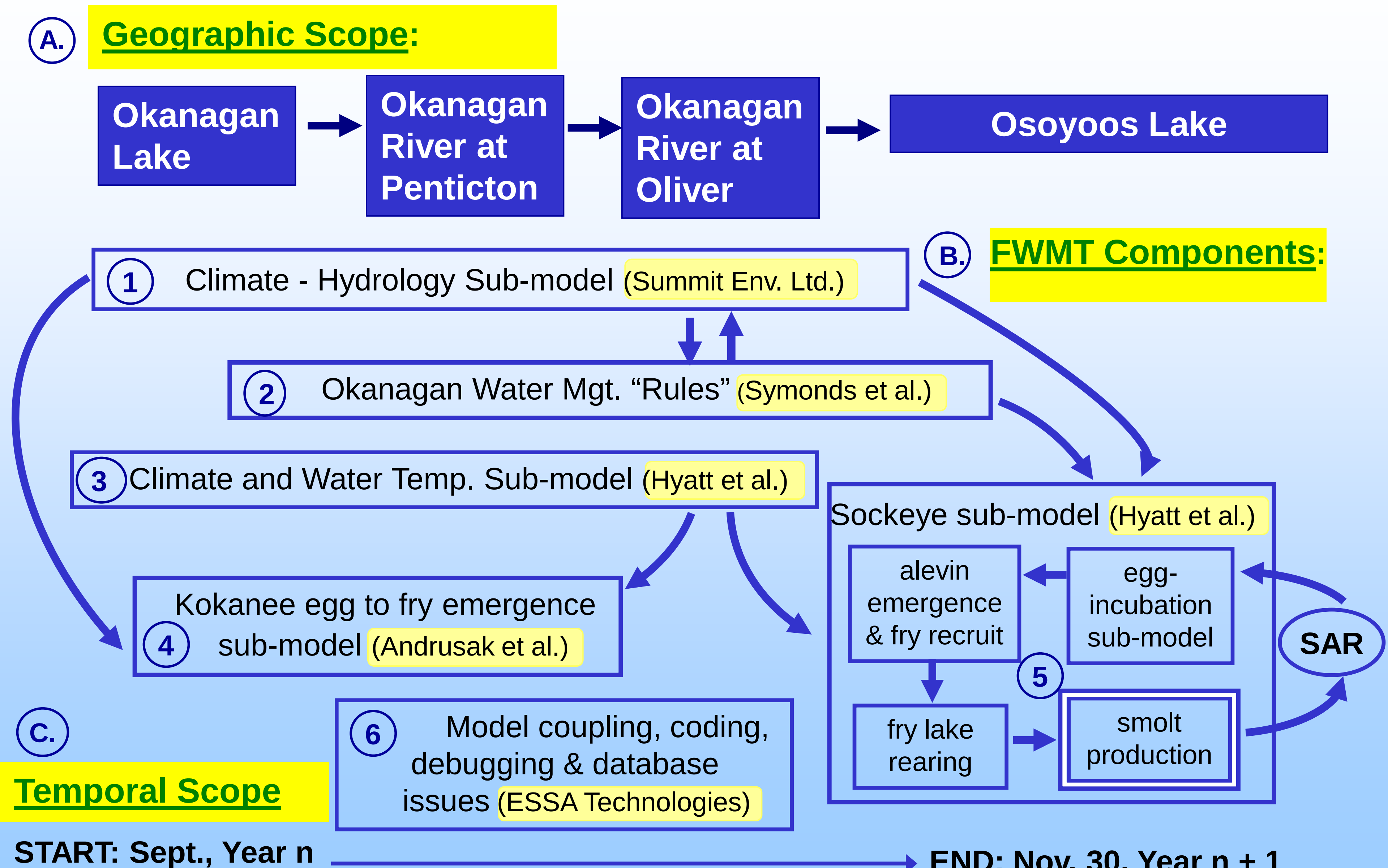
Rule 7: Sox. Spawning – maintain flows between 9.9- 15.6 cms during Sept 16- Oct 31 to maximize “good” spawning habitat.

Rule 8: Sox Incubation- flows at 5.0- 28.3 cms during Nov 1- Feb 15 i.e. egg incubation flows greater than or equal to 50 % of spawning flows & must not exceed 28.3 cms to avoid redd desiccation & scouring.

Rule 9: Sox. Fry emergence-migration- flows during Feb16- Apr 30 at 5.0- 28.3 cms.

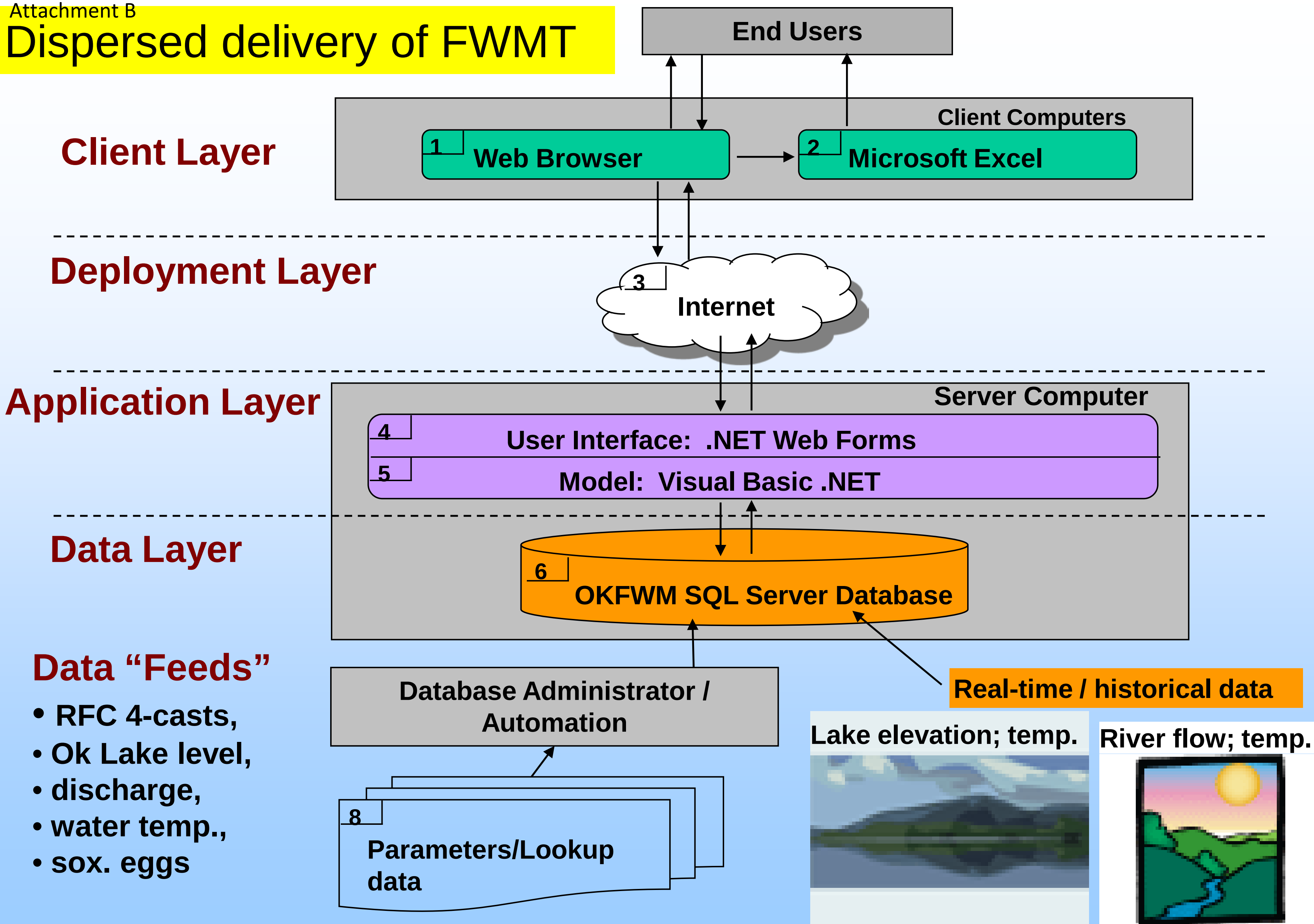
Attachment B

Structure & Science Foundations of the FWMT Decision Support System

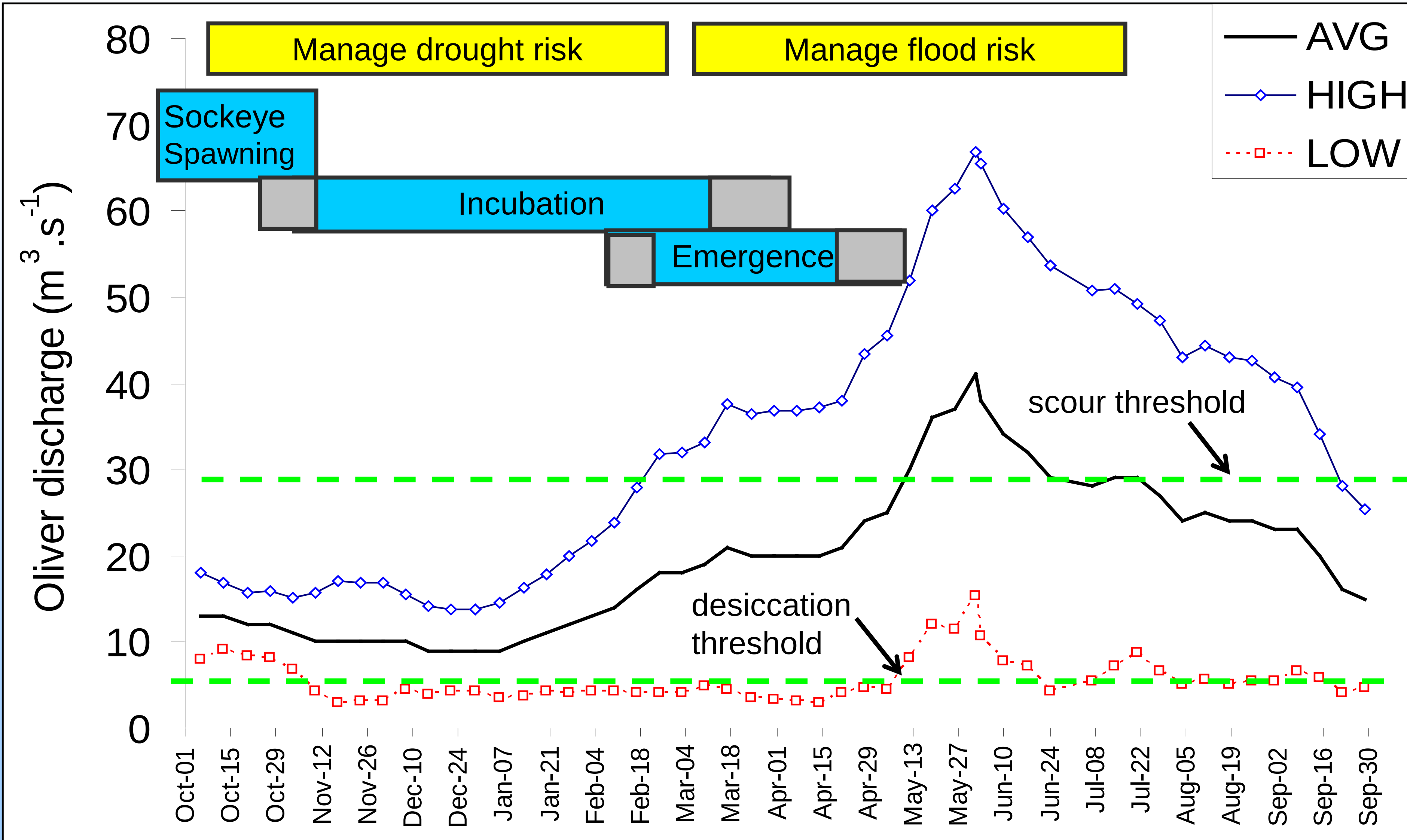


Attachment B

Dispersed delivery of FWMT



Event timing & natural variations determine whether fish-and-water managers satisfy OBA rules & competing objectives



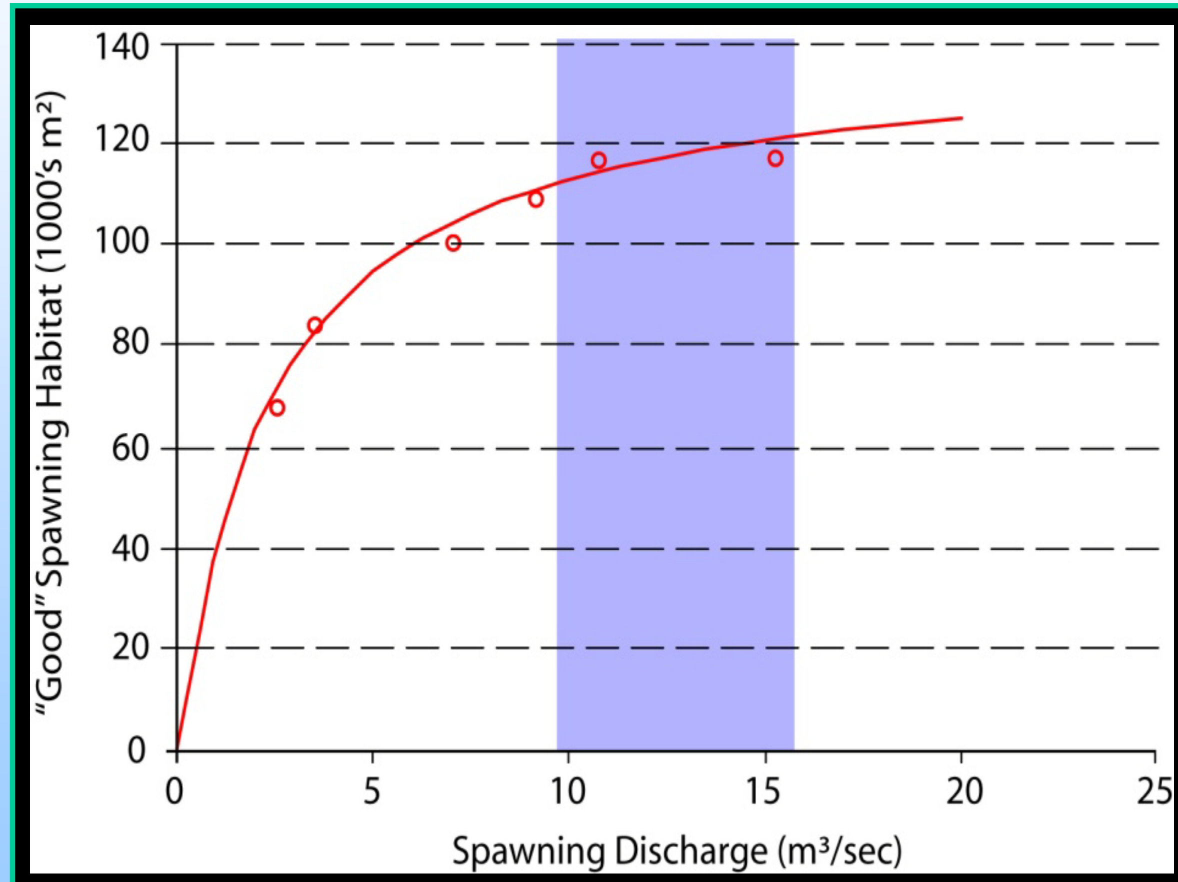
Attachment B

Available Spawning Habitat is Controlled by Flow

Paul Rankin photo

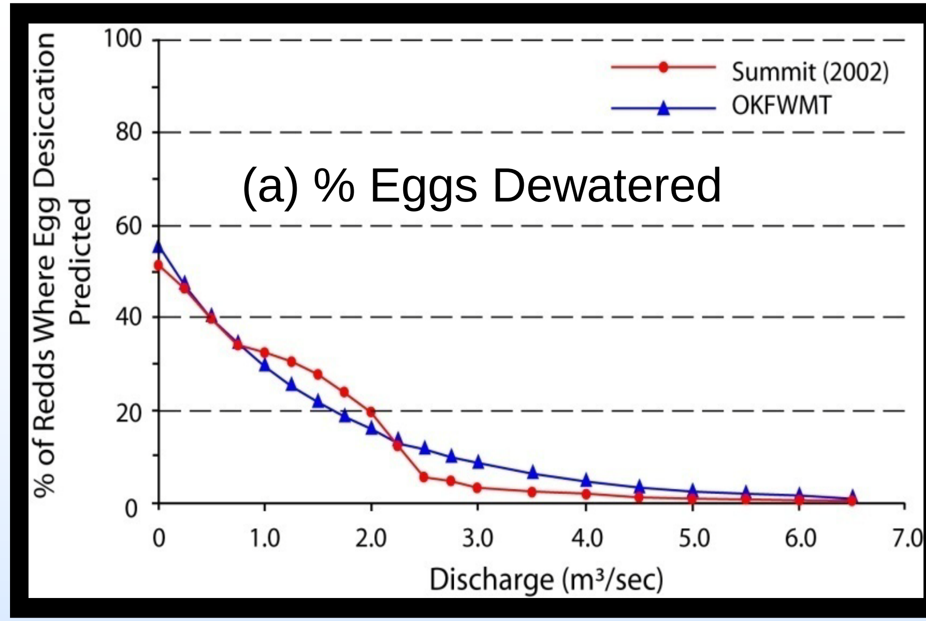
Okanagan Nation Alliance photo

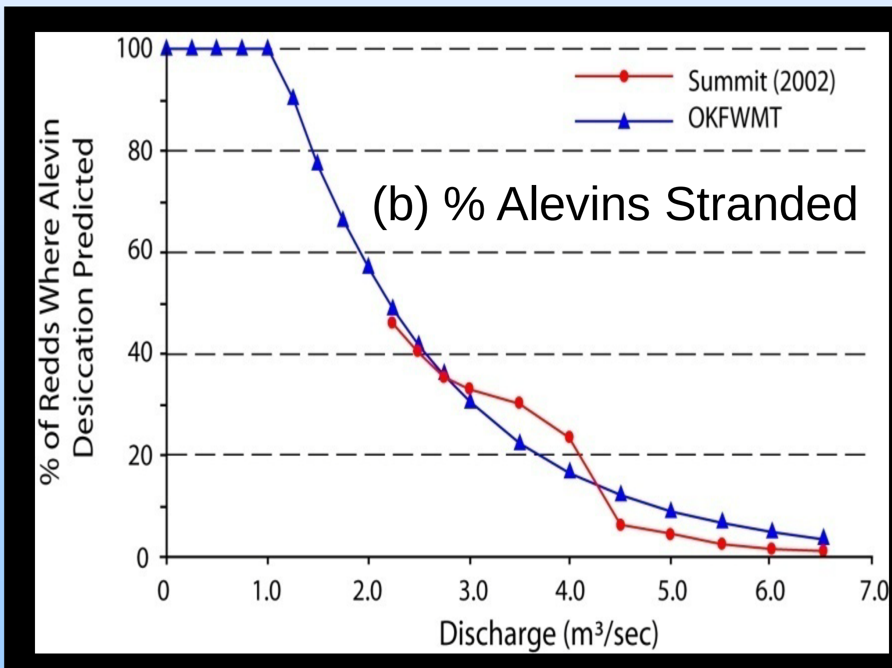
Recommended flows for Okanagan sockeye spawning are: **9.9 m³/sec to 15.6 m³/sec**

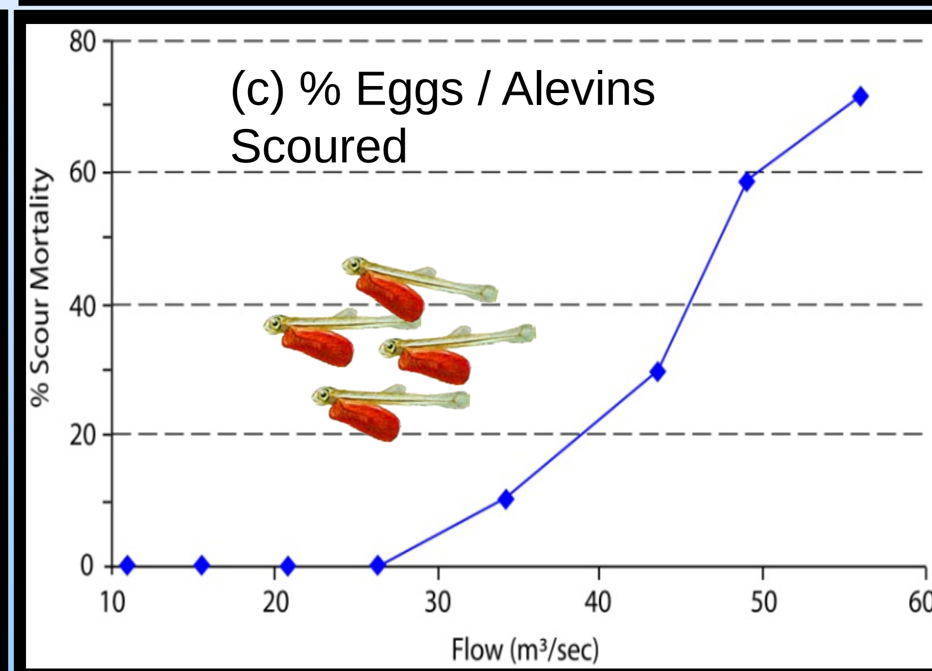


Discharge & Okanagan Sockeye Incubation

Dewatering/desiccation or flood-and-scour processes control incubation and emergence success of sockeye eggs and alevins.



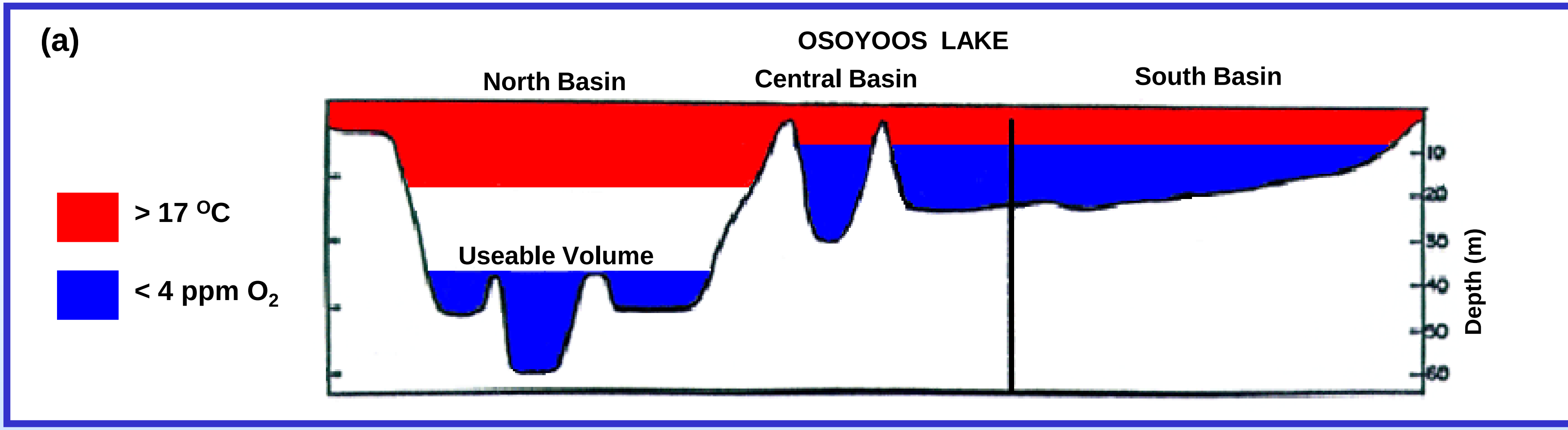




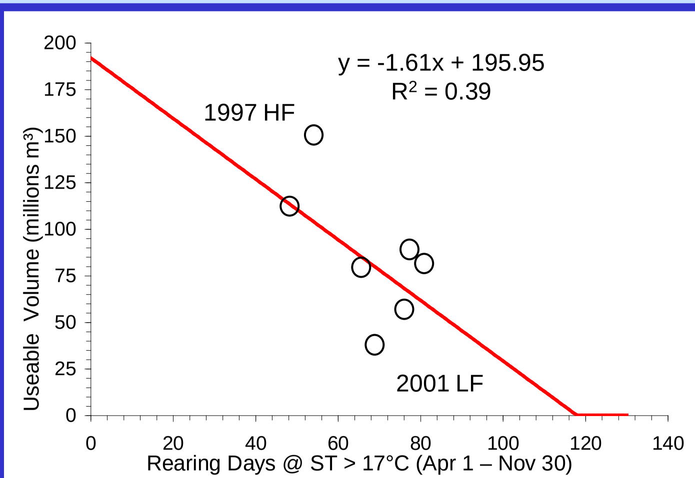
Attachment B

Temperature-Oxygen Effects on Useable Rearing Volume (URV) in Osoyoos L.

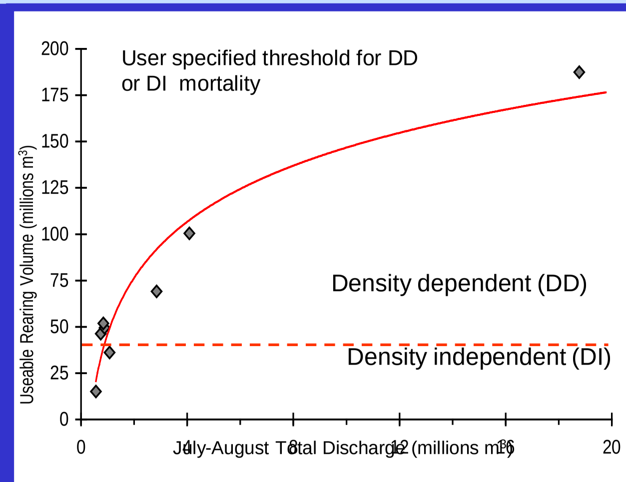
Seasonal temperature and oxygen extremes restrict the useable rearing volume of Osoyoos Lake which can induce density-independent mortality processes.



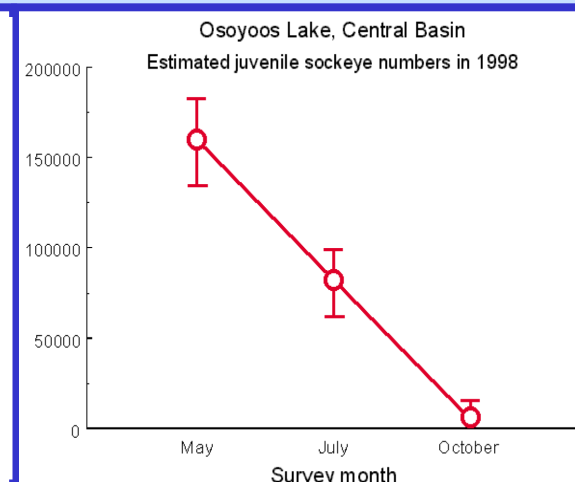
(b) URV vs days > 17oC



(c) URV vs July-Aug discharge

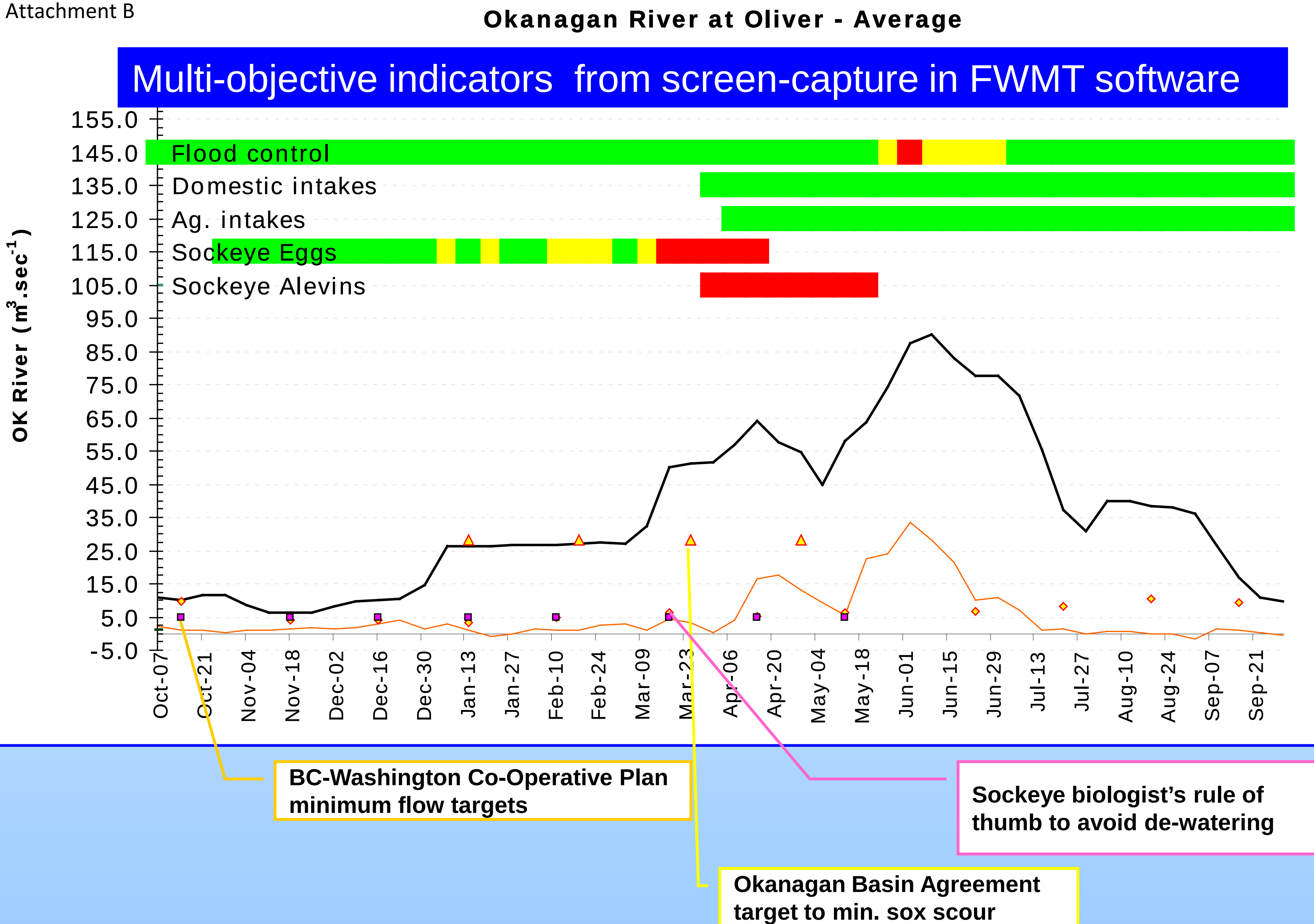


(d) Fry #s vs URV days at 0



Attachment B

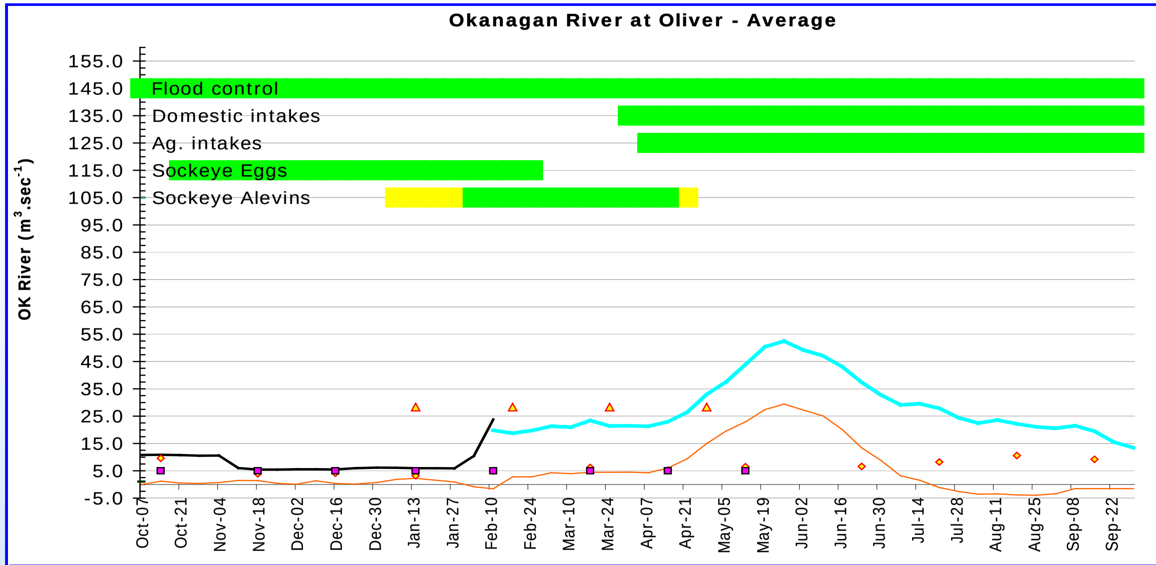
Multi-objective indicators from screen-capture in FWMT software



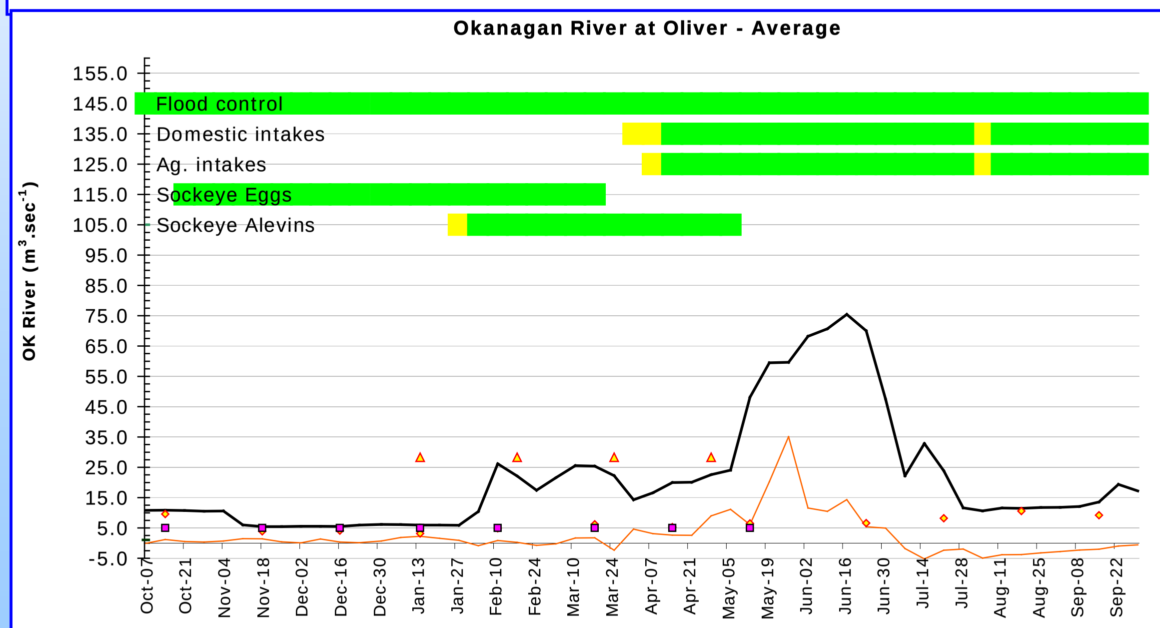
Attachment B

OKANAGAN FWMT 2005-2006 WATER MANAGEMENT YEAR

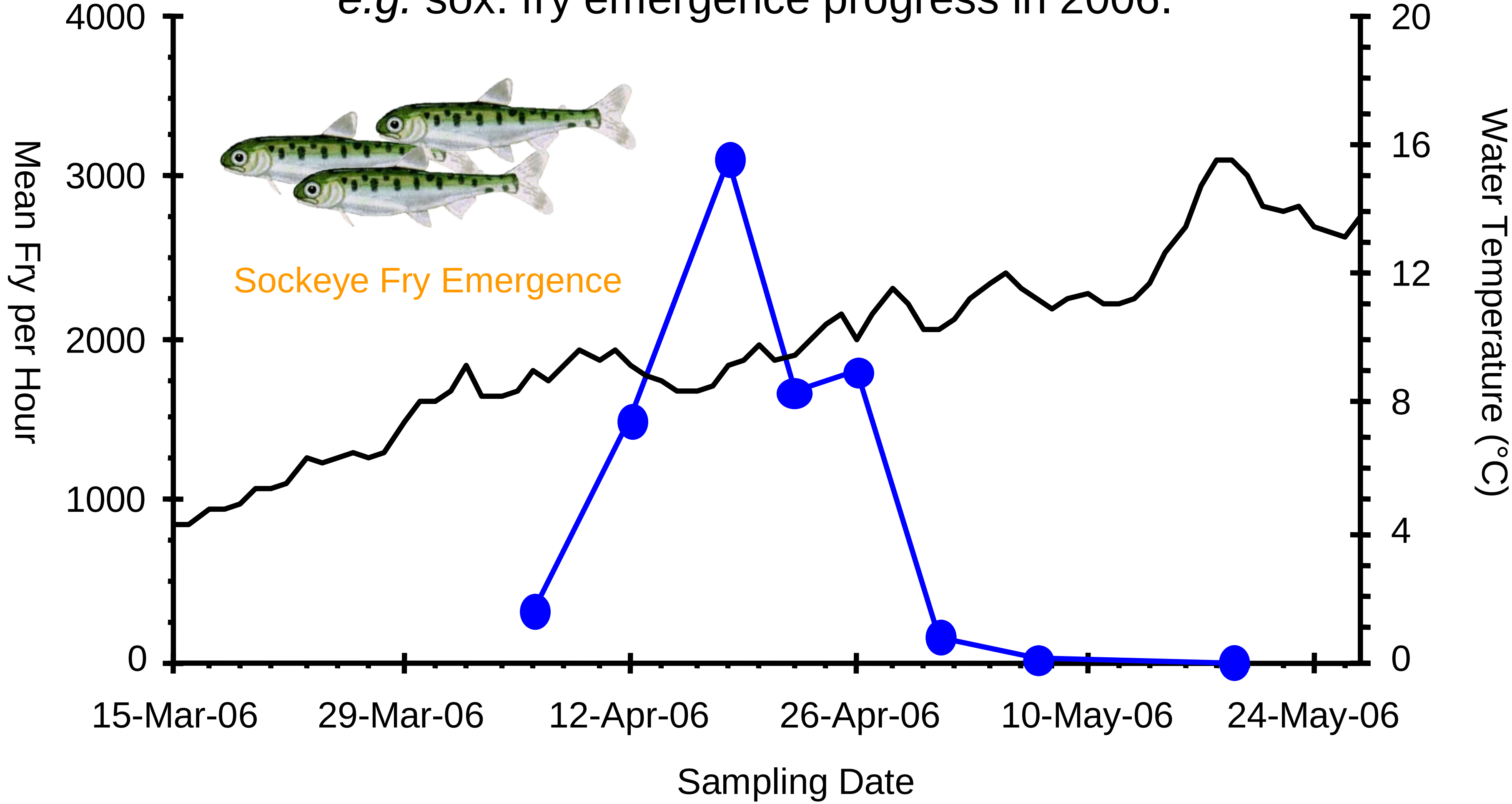
(A) Actual and predicted flows at Oliver (sockeye spawning grounds) 9-Feb-06



(B) Final outcome at Oliver (sockeye spawning grounds) 30-Sep-06

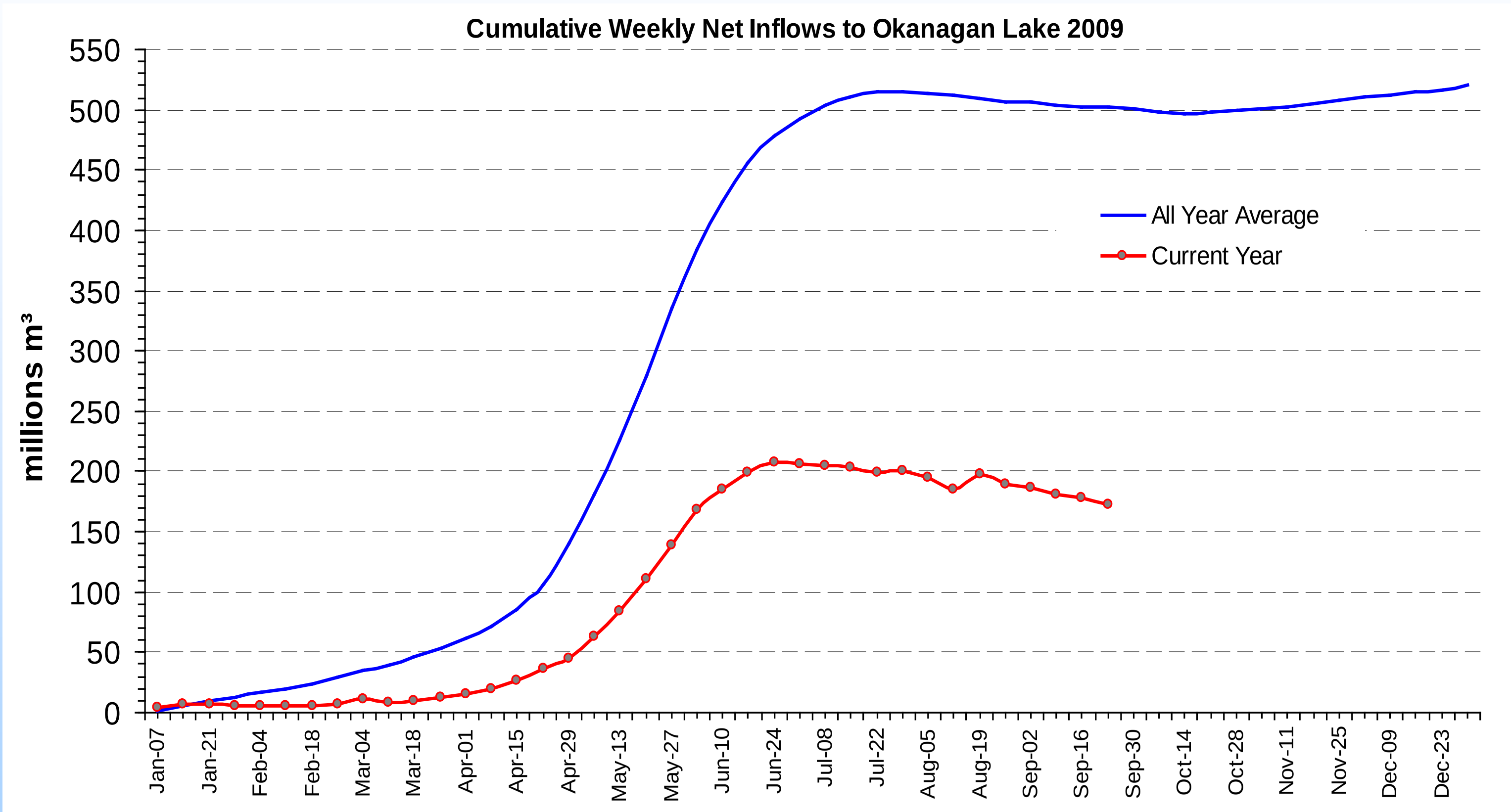


Field observations verify FWMT predictions *e.g.* sox. fry emergence progress in 2006.



Attachment B

FWMT WATER YEAR 2008 - 2009



Attachment B

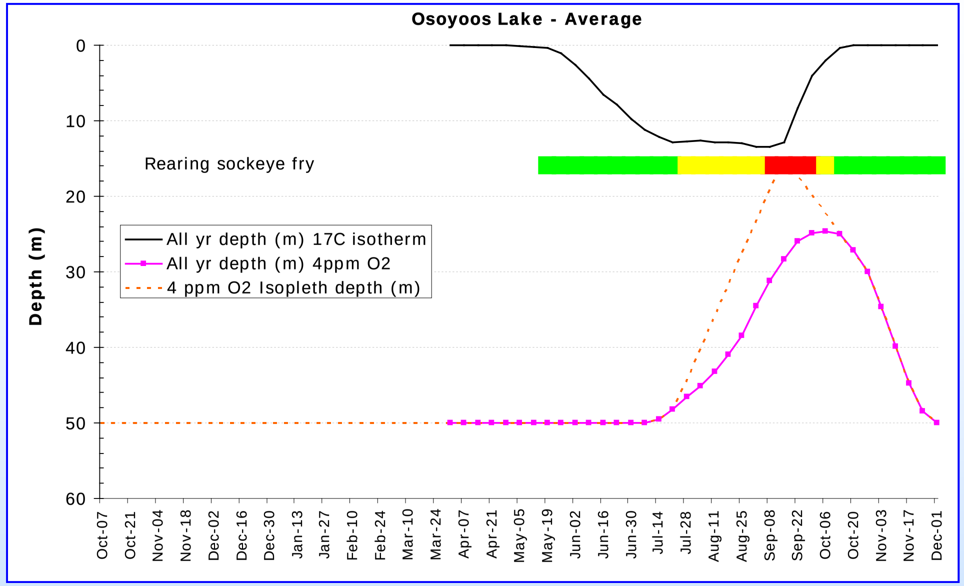
Table 1. A summary by location & issue of consequences associated with adoption of three alternate flow scenarios (FWMT-569, 561,568) during Aug-Sept, 2009.

August 2009 FWMT Scenario Options

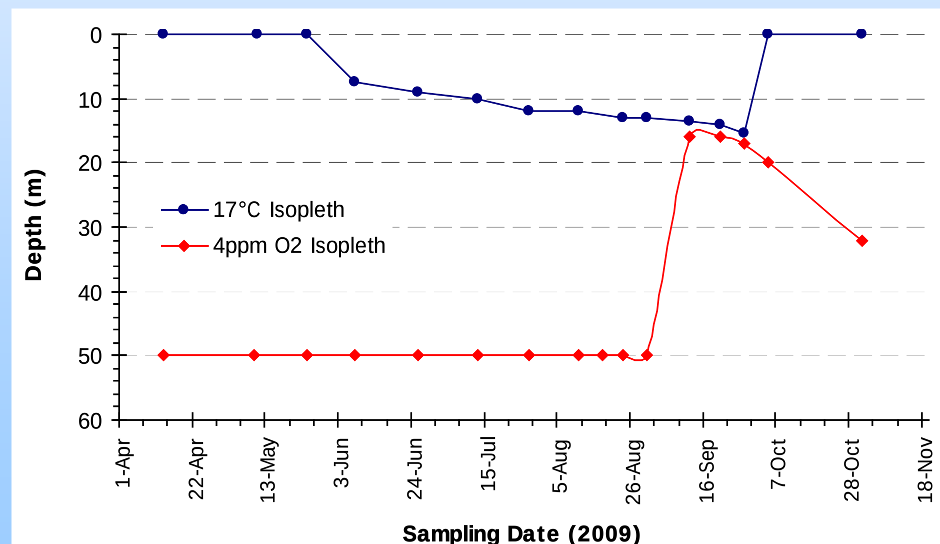
	FWMT-569	FWMT-561	FWMT-568
Location/Issue [1]	Current (10.7 cms)	OBA max (12.7 cms)	Mitigate squeeze (18.3 cms)
Ok Lk levels predicted (Sept 30, 2009) [2]	341.76	341.72	341.69
Domestic intakes [3]			
Agricultural intakes [3]			
Navigation boats [4]			
Navigation docks [4]			
Kokanee spawn/survival [5]			
Ok Lk levels expected by Oct 14, 2009 [5]	341.72	341.66	341.64
Okanagan River			
Recreation at Penticton [6]			
Domestic intakes-Oliver [7]			
Agricultural intakes-Oliver [8]			
Osoyoos Lake			
Juvenile sockeye rearing [9]			
Adult sockeye holding [9]			
Ok Lk levels expected by April 1, 2010 [10]	341.48	341.42	341.40

FWMT Fish-and-Water YEAR 2008 - 2009

Predicted Temp-O2 "Squeeze"

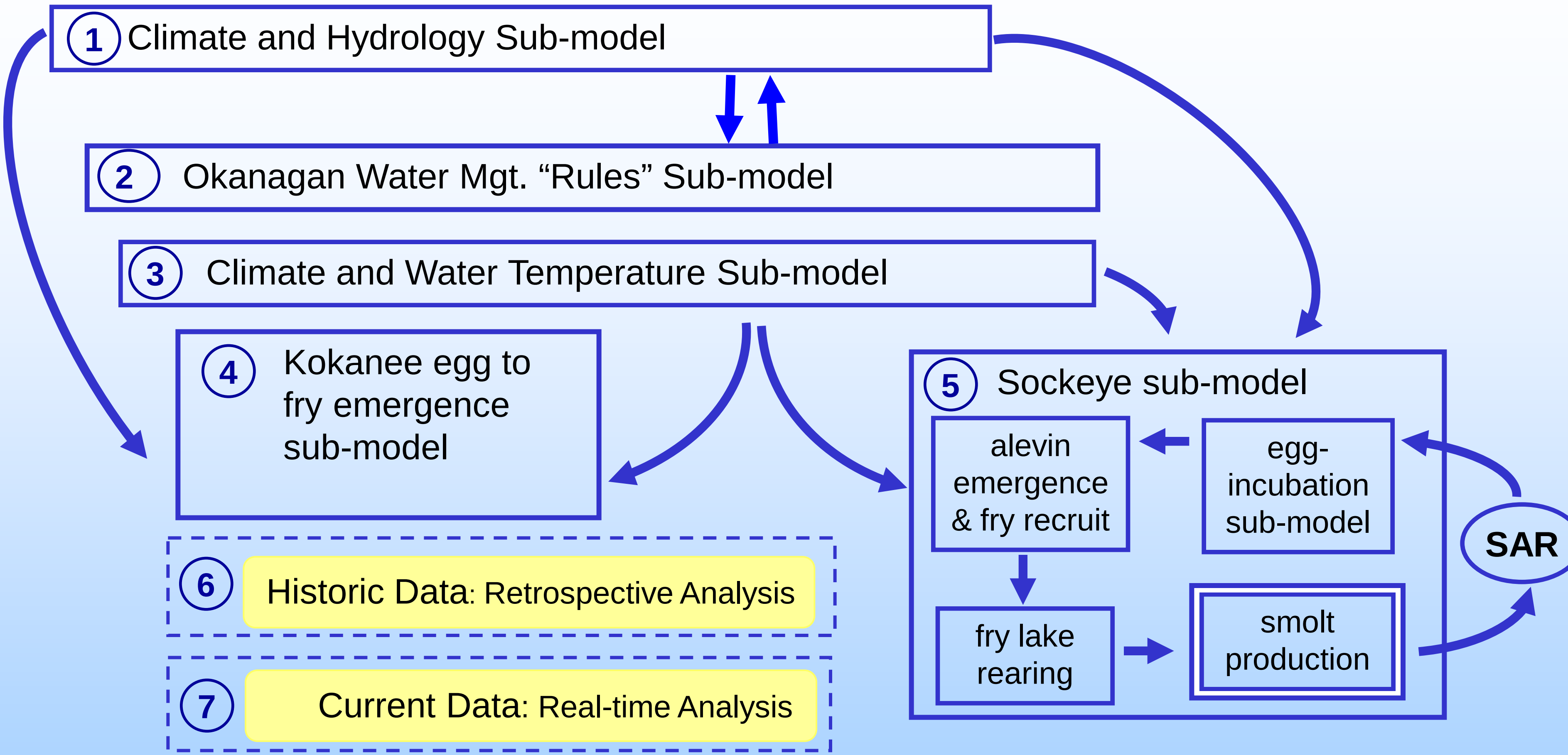


Observed Temp-O2 "Squeeze"



Attachment B

FWMT Decision Support System



The FWMT System is a coupled set of biophysical models of key relationships (among climate, water, fish & property) used to predict the consequences of water mgt. decisions for fish & other water users.

FWMT may be used to explore water management decision impacts in an operational mode employing real-time data, a prospective-mode going forward or in a retrospective-mode looking back on historic water supply, climate & fish years.

FWMT-DSS vs Jodie's Check List

- [X] Spatially explicit to represent multiple scales,
- [X] Species and life stage specific (sockeye and kokanee),
- [X] Identifies and explores limiting conditions (stage, flow, temperature),
- [X] Provides predictions & observed events to validate model results,
- [X] Model uncertainties & sensitivities identified.
- [X] Models have transparent and flexible structure.
- [X] FWMT-DSS is effective in communicating with fish-and-water mgrs.

FWMT User Experience to Date

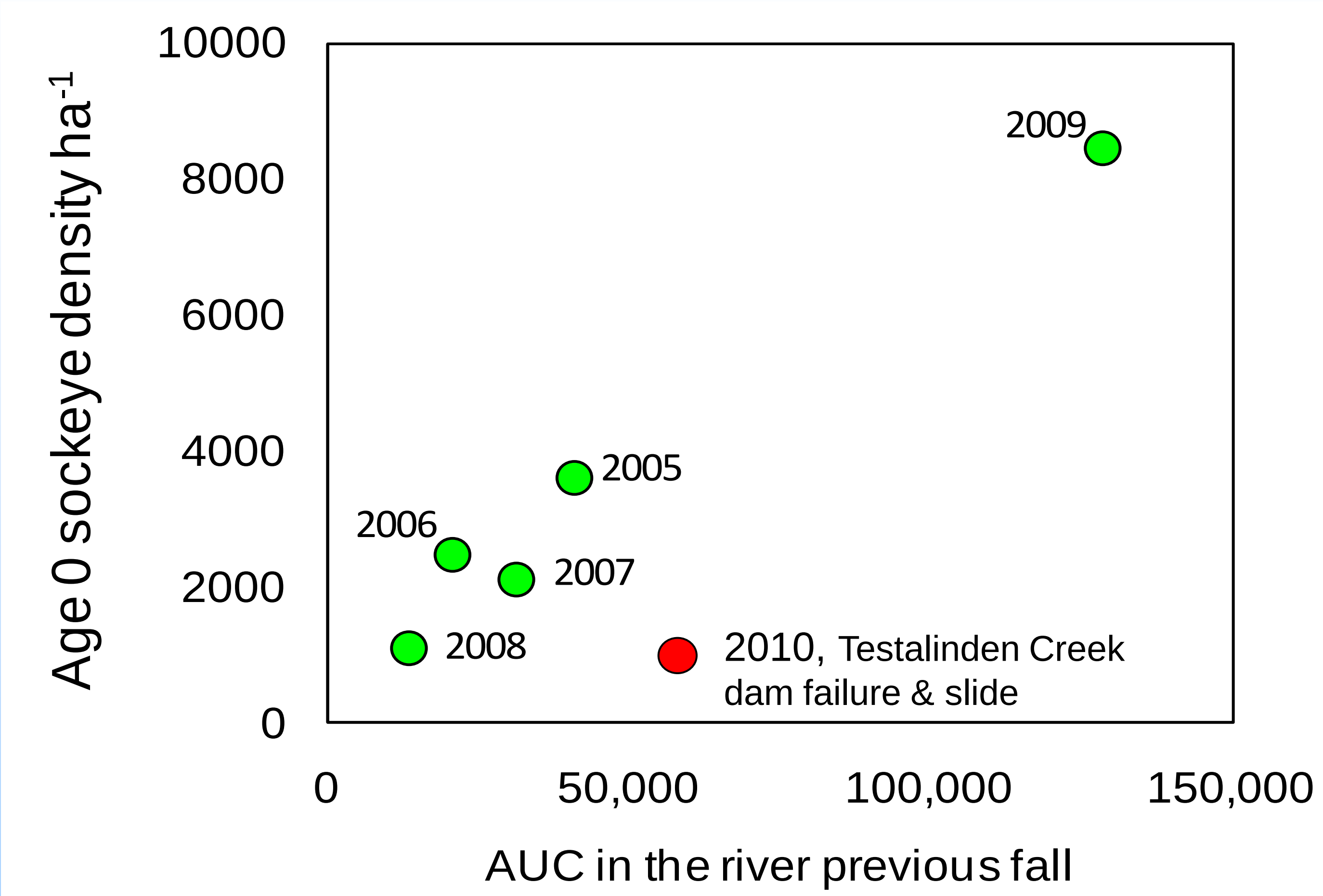
- balances consideration of multiple objectives (*i.e.* social, economic, cultural, ecological)
- recognizes inflow forecast uncertainties,
- uses “rich” information sources refreshed in real-time (*i.e.* annual to daily imports of biophysical data),
- facilitates effective input from limited pool of expertise,
- accelerates training & access to diagnostics,
- provides common, “transparent” framework for “team” collaboration, synthesis & decisions,
- allows managers to “measure twice” & “cut once”,
- provides record of annual strategy & outcomes to assess performance against multiple objectives.

OLRS-Operational Outcomes

Since deployment in fall of 2005, we have avoided (a) major drought and desiccation or flood and scour losses of salmon egg or fry production Okanagan Lake (kokanee) and river (sockeye) and (b) most temp-O2 induced losses of sockeye fry rearing in Osoyoos Lake

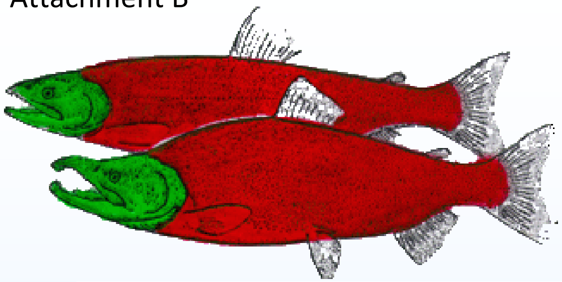
In theory, FWMT use should have reduced density-independent losses of fry & smolt production.

Where do all the sockeye come from ?



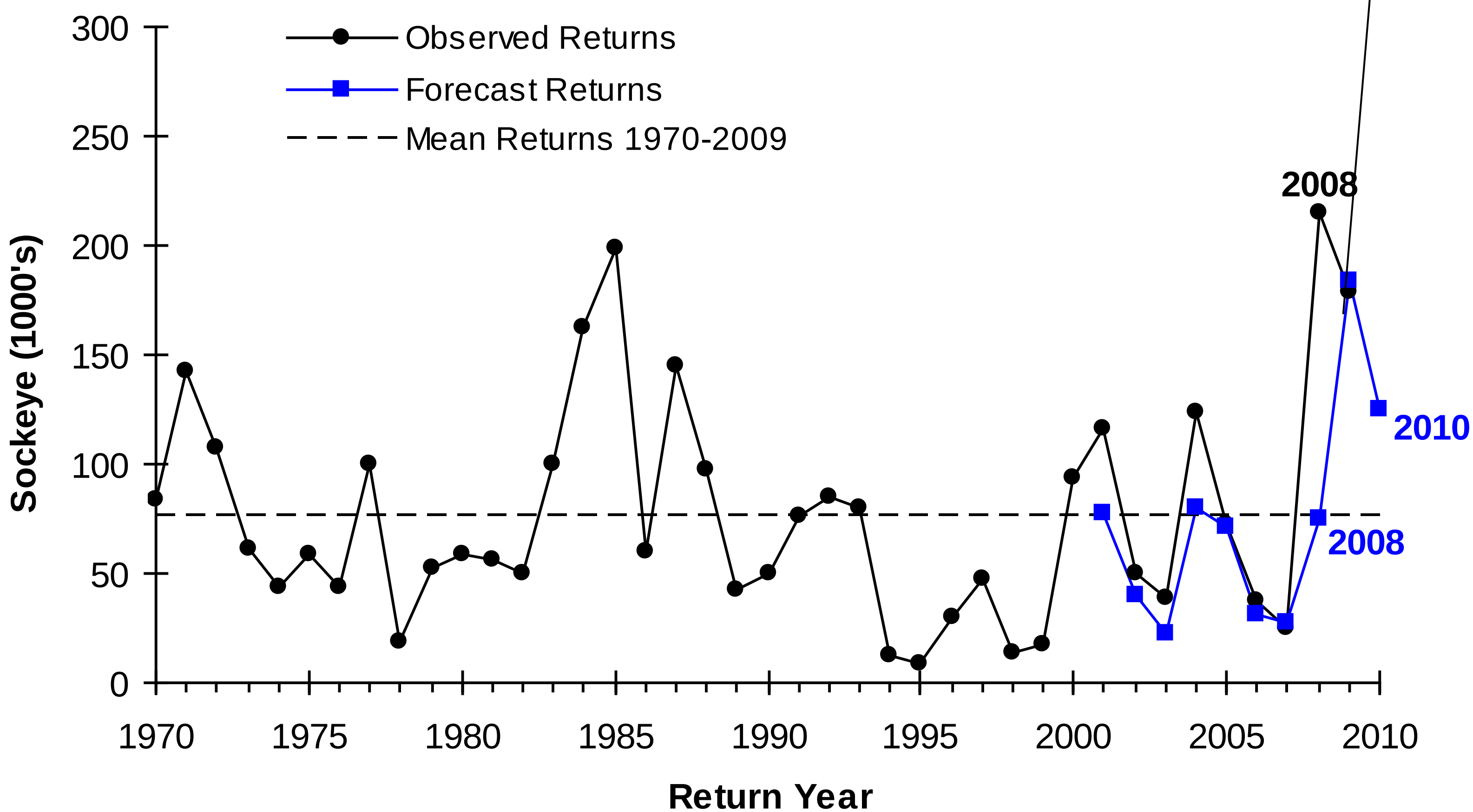
Post FWMT deployment, more adult spawners clearly lead to more smolt production as per Hyatt & Rankin (1996) analysis of carrying capacity of river and lake habitats. However, density independent losses of eggs/fry do still occur e.g. spring 2010.

Attachment B



Columbia R. Sockeye Returns 1970-2010.

Okanagan = 75-80% of all Columbia R. Sockeye after 1980



Questions ?

Fisheries and Oceans Canada   Pêches et Océans Canada

Canada

Modeling Results: Iteration One

COLUMBIA RIVER TREATY 2014/2024 REVIEW

CRPAG

July 26, 2012

Overview of Today's Presentation

- Basics of Treaty Review
- Key Terms and Definitions
- Iteration 1 Alternatives
- Iteration 1 Modeling Results
- Next Steps for Treaty Review

Basics of Treaty Review

1. Understand
   - Start by understanding regional needs and priorities.
2. Determine
   - Can the current Treaty meet those needs?
   - Does the Treaty need to be changed?
   - Are the changes so significant that we have to start over with a new Treaty?
3. Arrive at that determination by:
   - Collecting information
   - Evaluating the results
   - Assessing impacts on various river interests

Basics, cont.

1. Evaluation takes place over three "iterations."
2. Each iteration tests a number of scenarios or "alternatives."
3. Information from each iteration used to refine approach and build alternatives for the next iteration.

Basics, cont.

- Iteration One has just been completed.
  - Current Condition (only for comparison)
  - Alternatives post 2024:
    - 450 kcfs – Treaty Continues and Treaty Terminates
      - Uses current storage reservation diagrams
    - 600 kcfs – Treaty Continues and Treaty Terminates
      - Uses relaxed storage reservation diagrams

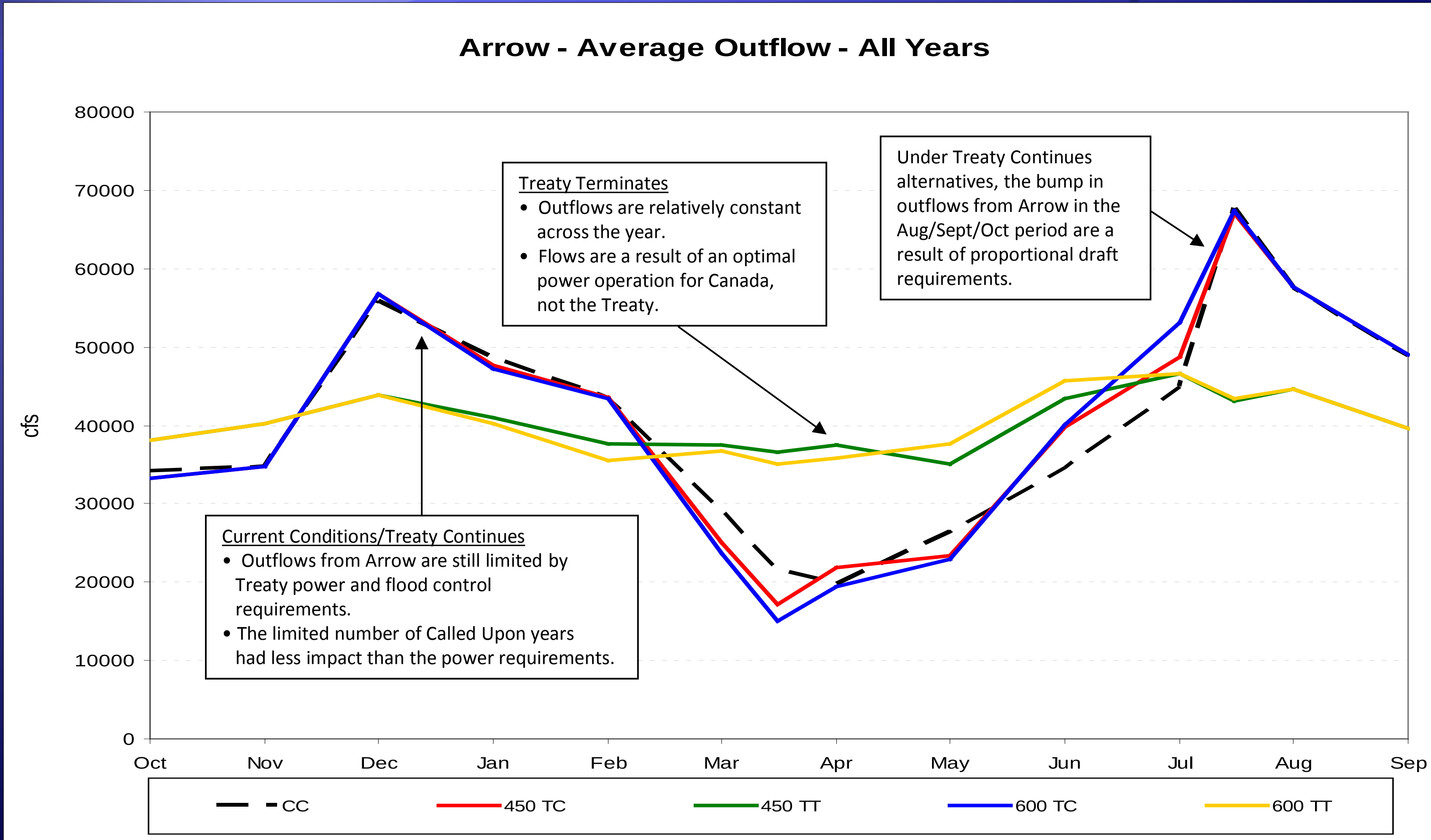
Key Terms and Definitions

- Canadian Entitlement
- Effective Use
- Called Upon Flood Control
- Flood Flow Objective
- Storage Reservation Diagrams
- Peak Flows

Key Assumptions in Iteration 1

- Assumptions about Canadian Operations Post-2024 without the Treaty.
- Flood Risk Management: Effective Use and Called Upon
- Both assumptions affected outcomes across all scenarios.

Canadian Operations:
With (TC) and without (TT) the Treaty



Iteration 1 Results
Flood Risk Management

Effective Use
Called Upon
Peak Flows

Flood Risk Management Effective Use at 450kcfs…

Treaty Continues

- Effective use in 18 out of 70 Years

Treaty Terminates

- Effective use in 23 out of 70 Years

Why is this important?

Under effective use most U.S. reservoirs are drawn down to lower water levels more frequently. This could:

- Limit a reservoir's ability to refill.
- Hinder the ability to meet needs such as irrigation, summer fish flows, recreation and protection of cultural resources.

Flood Risk Management Effective Use at 600 kcfs…

Effective use 1 time in 70 Years, Treaty Continues or Terminates

Increases fish flows during the spring and keeps some U.S. reservoirs fuller.

May increase flood risk. Increases peak river flows

Average: 17-21 kcfs higher
In 10 wettest years: 28-49 kcfs higher
(more analysis in iteration 2)

Flood Risk Management How often do we "Call Upon" Canada for more storage?

At 450 kcfs…

- Treaty Continues – 4 times in 70 Years
- Treaty Terminates – 6 times in 70 Years

At 600 kcfs…

- 0 times in 70 Years

Why is this important?

Called Upon has financial impacts to U.S. – $4-$34 million per request (based on power cost to Canada).

For Iteration 2…
Analysis of the annual average payment required for Called Upon.

Iteration 1 Results
Ecosystem-Based Function

Reservoir Levels

River Flows

Ecosystem-Based Function

Reservoir Elevations

- Effective use resulted in deeper draw downs and less frequent refill for some reservoirs. Could have an impact on resident fish, cultural resources, recreation, and irrigation.
- In several tributary sub-basins, Treaty operations had little or no effect on reservoir elevations and outflows.

Ecosystem-Based Function

River Flows

- In the Lower Columbia Basin, Treaty Terminates alternatives resulted in:
  - Lower winter flows
  - Higher spring flows
  - Lower late summer flows

- 600 kcfs alternatives increased peak river flows in the spring –Treaty or no Treaty.

Why is this important?

- Lower summer flows could affect ability to meet summer fish flow objectives.
- Reduction in winter flows could affect salmon protection flow objectives.
- Higher spring flows could benefit juvenile salmon migration.

For Iteration 2…
We will continue to examine these preliminary results.

Iteration 1 Results Hydropower

Canadian Entitlement

Hydropower Generation

Canadian Entitlement

If the Treaty continues, U. S. payment of Canadian Entitlement also continues:

- Energy -- 442aMW Capacity -- 1331 MW

Estimated value of Canadian Entitlement in 2024:

- Energy -- $113-$219 million
- Capacity -- $115 million
- Combined -- $229-$335 million per year

Hydropower Generation

Net effect of terminating the Treaty on total power and power costs (including the entitlement) for each country:

	Average Annual Hydropower Generation (aaMW)
Canada	410 loss (-$220 to -$320 million)
United States	325 – 350 gain (+$180 to $280 million)

Next Steps for Treaty Review

- End of 2012: Iteration 2 Completed
- Winter 2013: Stakeholder Listening Sessions on Iteration 2
- Website: http://www.crt2014-2024review.gov/

Attachment D

COLUMBIA RIVER TREATY REVIEW

Summary Analysis of Revised Iteration #1

Ecosystem-Based Function

Sovereign Review Team Meeting
June 14, 2012

Attachment 9

Locations Analyzed for Ecosystem-Based Functions

KOOTENAI RIVER BASIN

- Lake Koocanusa above Libby Dam
- Kootenai River below Libby Dam

FLATHEAD RIVER BASIN

- Hungry Horse Reservoir
- South Fork Flathead River below Hungry Horse Dam
- Flathead River at Columbia Falls
- Flathead Lake above Kerr Dam
- Flathead River below Kerr Dam

PEND OREILLE RIVER BASIN

- Clark Fork River at Cabinet Gorge Dam (inflow to Lake Pend Oreille)
- Lake Pend Oreille above Albeni Falls Dam
- Pend Oreille River below Albeni Falls Dam

SPOKANE RIVER BASIN

- Lake Coeur d'Alene above Post Falls Dam
- Spokane River below Post Falls Dam

COLUMBIA RIVER BORDER to GRAND COULEE DAM

- Columbia River at Border (flowing into USA)
- Lake Roosevelt above Grand Coulee Dam
- Columbia River below Grand Coulee Dam

Locations Analyzed for Ecosystem-Based Functions

GRAND COULEE DAM to SNAKE RIVER CONFLUENCE

- Columbia River at Priest Rapids Dam
- Columbia River at Vernita Bar

SNAKE RIVER BASIN

- Snake River at Brownlee Dam
- Hells Canyon Complex
- North Fork Clearwater River at Dworshak Dam
- Lower Snake River at Lower Granite Dam

COLUMBIA RIVER at SNAKE RIVER CONFLUENCE to ESTUARY

- Columbia River at McNary Dam
- Columbia River at The Dalles Dam
- Columbia River at Bonneville Dam (Estuary)

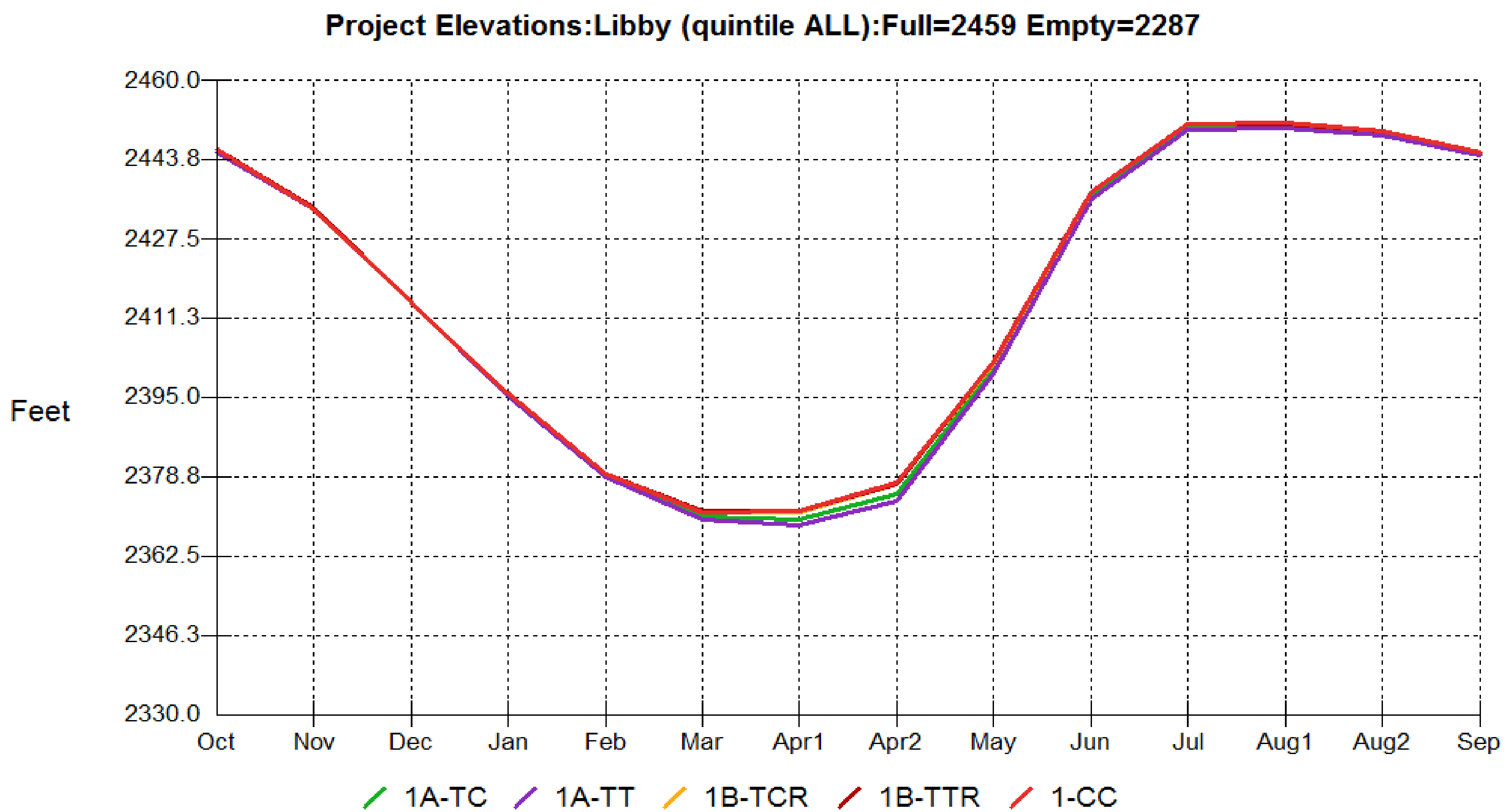
KOOTENAI RIVER BASIN

- Lake Koocanusa above Libby Dam
- Kootenai River below Libby Dam

Attachment D

LAKE KOOCANUSA – Elevations

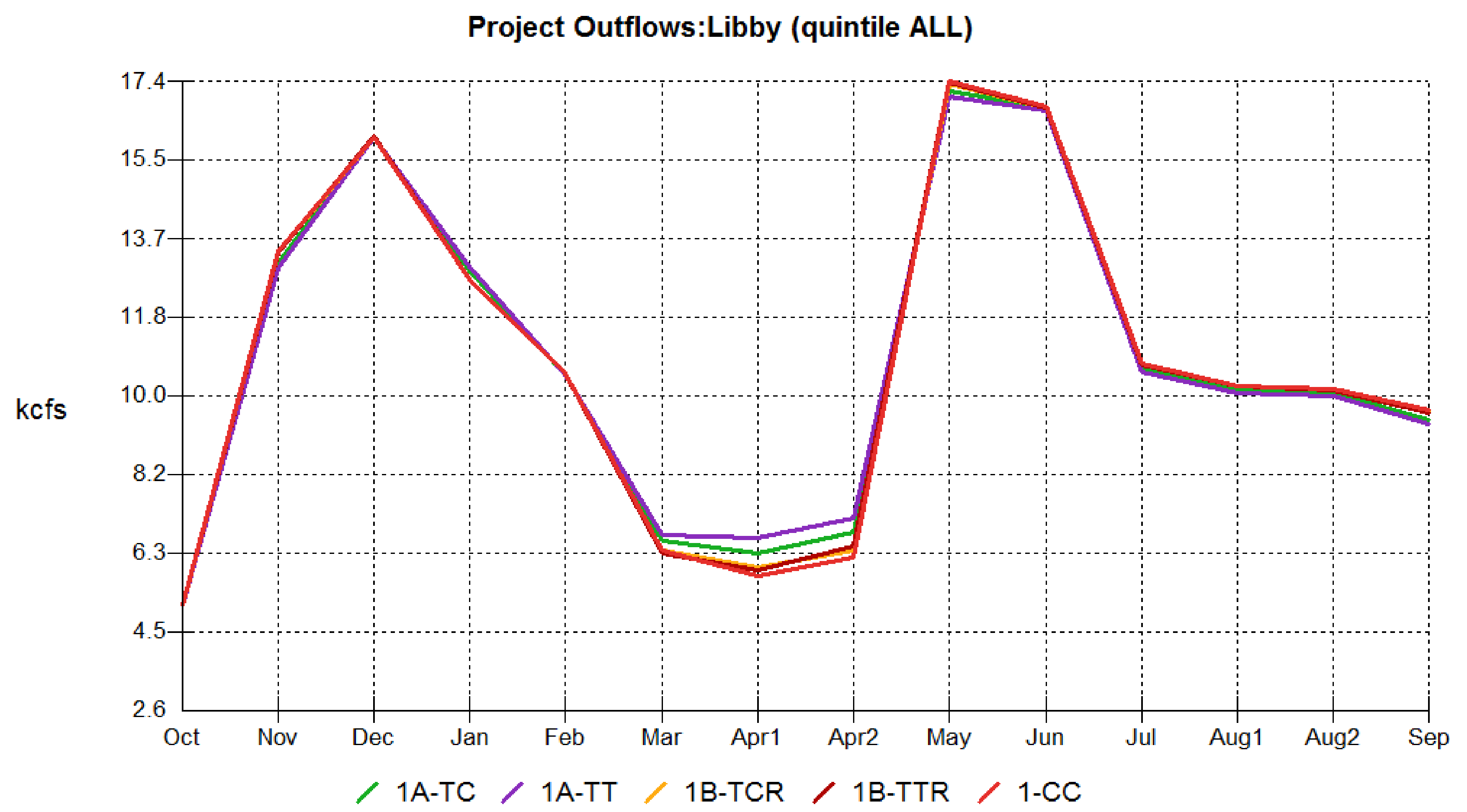
5 Alternatives – 70 Water Years



•With 600 alternatives, Lake is 2’-4’ higher in April and 1’ higher in summer than 450 alternatives, but 1’ lower in April and the same in summer as Current Condition.

•In higher water years, Lake is 5’-12’ higher in April and 3’-4’ higher in summer with 600 alternatives compared to 450 alternatives ; 600 alternatives draft 2’ more than Current Condition, but have same summer elevations.

Kootenai River
5 Alternatives – 70 Water Years



- 450 alternatives have < 1 kcfs greater flows in April compared to 600 alternatives and Current Condition.
- In lower water years, flows are very similar for all alternatives.
- In higher water years, 450 alternatives have flows ~2-3 kcfs more in April; ~ 1 kcfs less in Sept. compared to 600 alternatives and Current Condition.

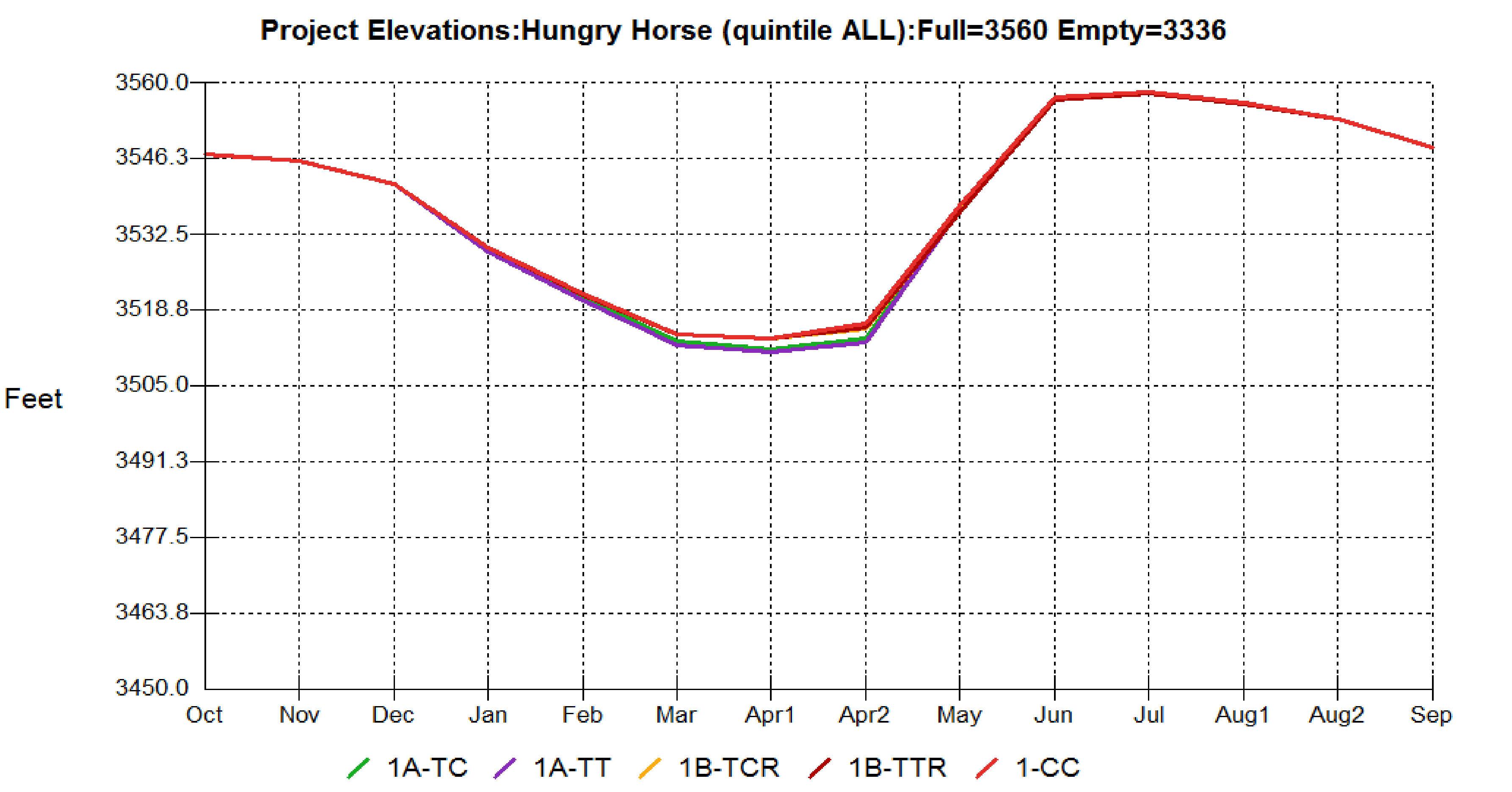
FLATHEAD RIVER BASIN

- Hungry Horse Reservoir above Dam
- South Fork Flathead River below Hungry Horse Dam
- Flathead River at Columbia Falls
- Flathead Lake above Kerr Dam
- Flathead River below Kerr Dam

Attachment D

Hungry Horse Reservoir Elevation

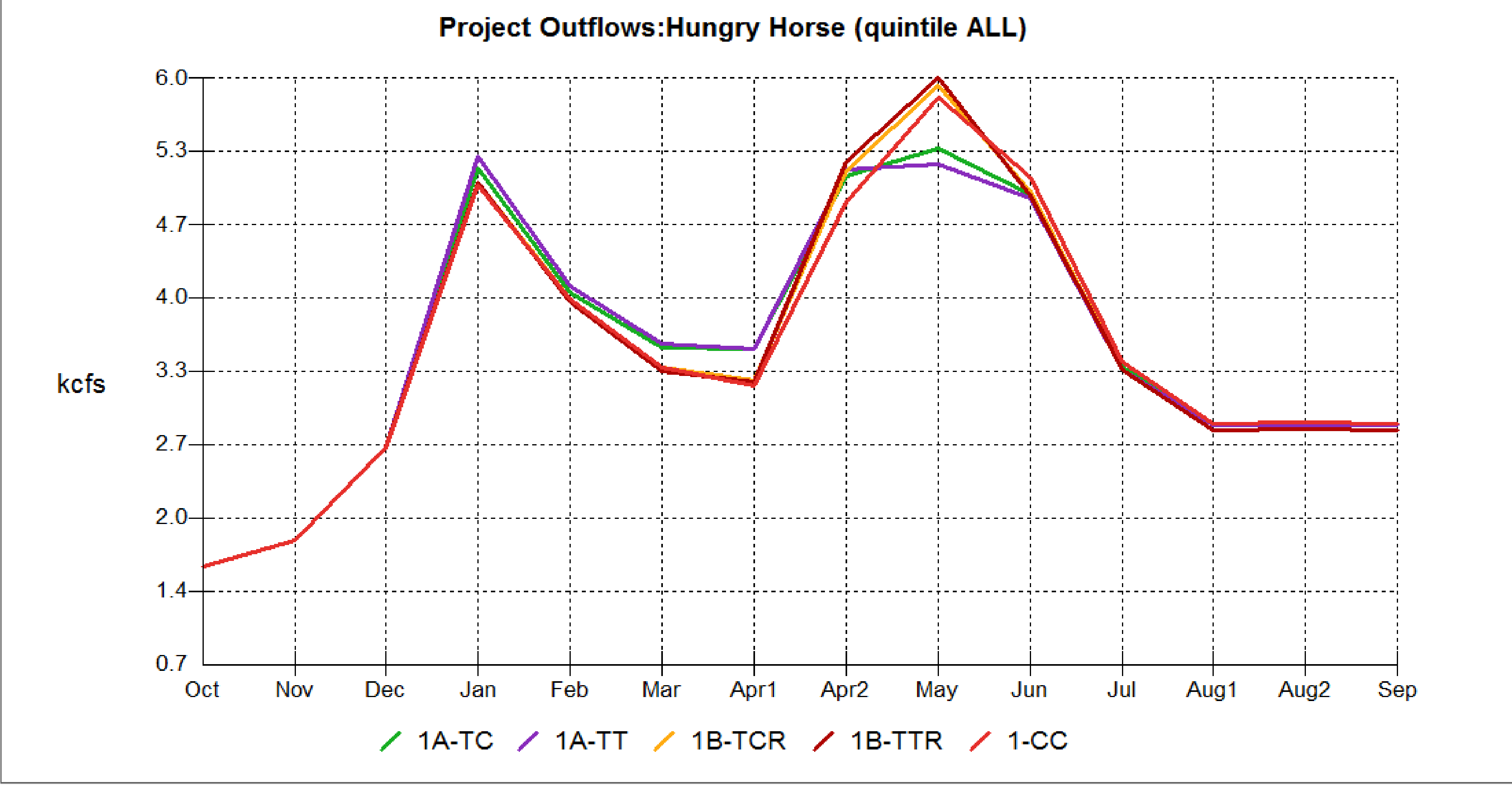
5 Alternatives – 70 Water Years



- 600 alternatives draft the reservoir 2’-3’ less in the spring compared to 450 alternatives, but 1’ more than Current Condition.
- 600 alternatives draft 8’-9’ less than 450 alternatives and about 4’ more than Current Condition in April.
- Refill is similar for all alternatives.

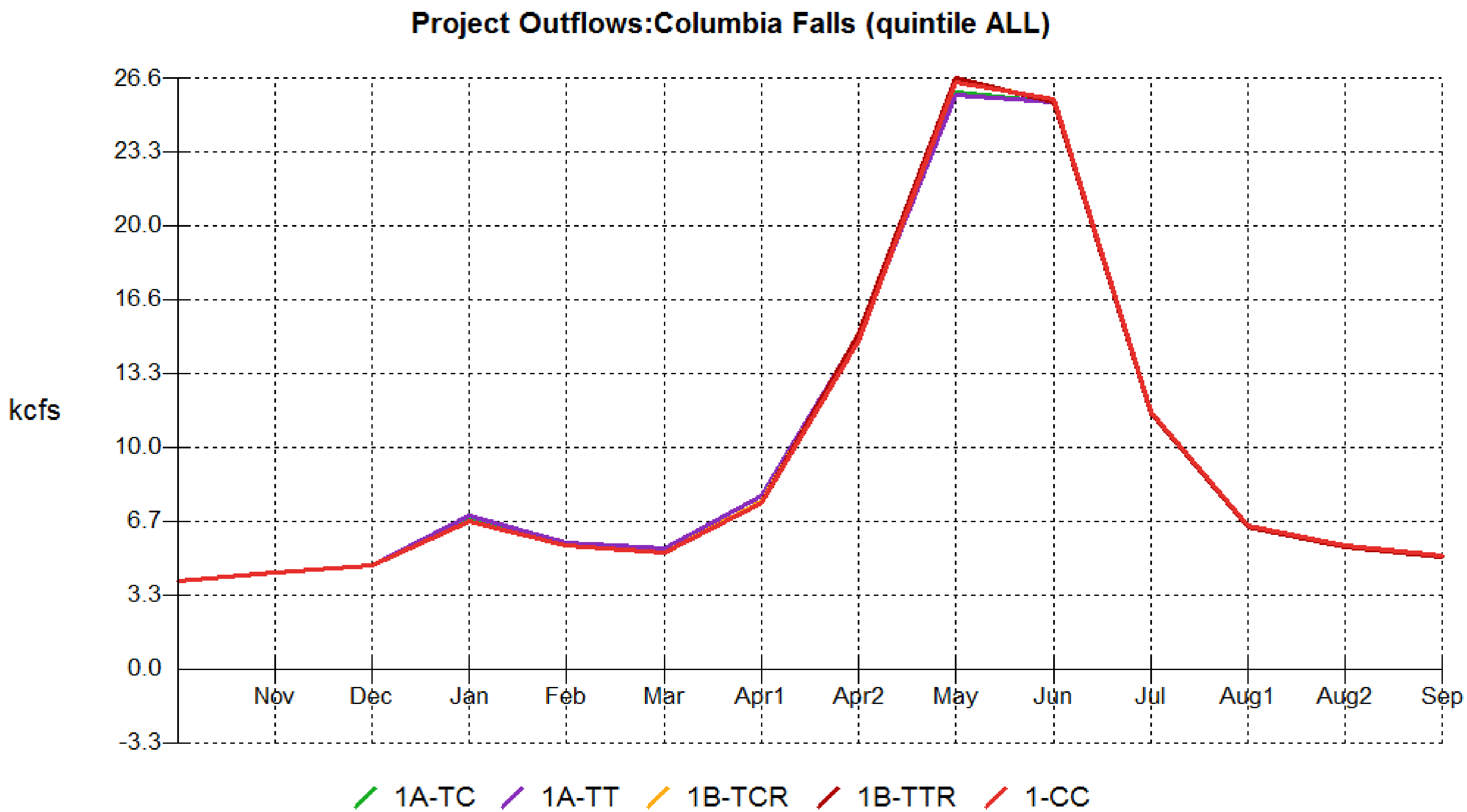
S.F. Flathead below Hungry Horse Dam

5 Alternatives – 70 Water Years



- •450 alternatives show ~ 0.3 kcfs higher flows in early spring and ~ 0.7 kcfs lower flows in May compared to the 600 alternatives and Current Condition.
- •In higher water years, 450 alternatives show ~ 1 kcfs greater flow in the early spring and ~ 2 kcfs less flow in May compared to the 600 alternatives and Current Condition.

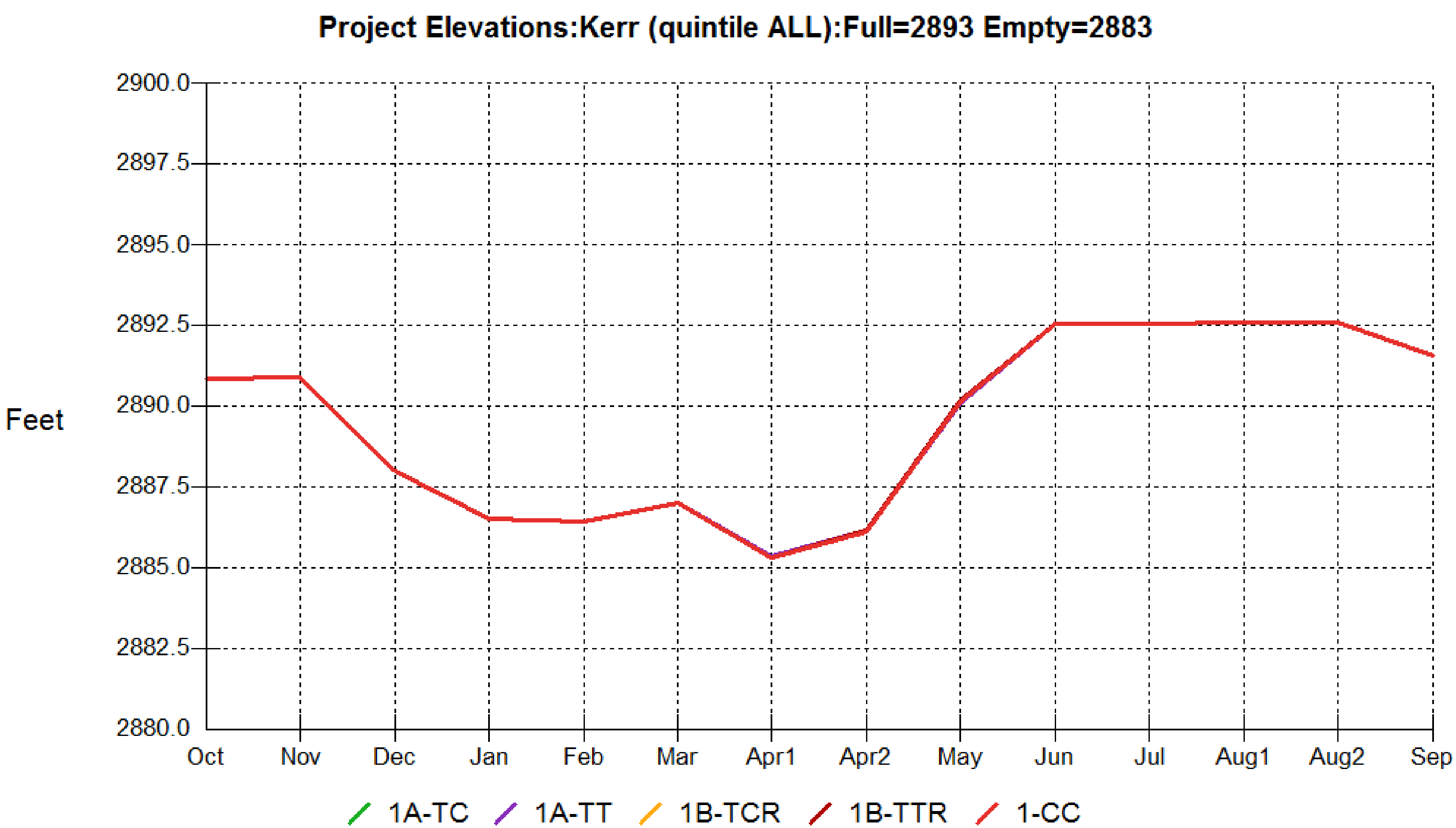
Flathead River @ Columbia Falls
5 Alternatives – 70 Water Years



- Little differences in flows between alternatives.
- 450 alternatives' flows are ~1 kcfs higher in early spring and ~ 2 kcfs lower in May compared to the 600 alternatives and Current Condition.

Attachment D

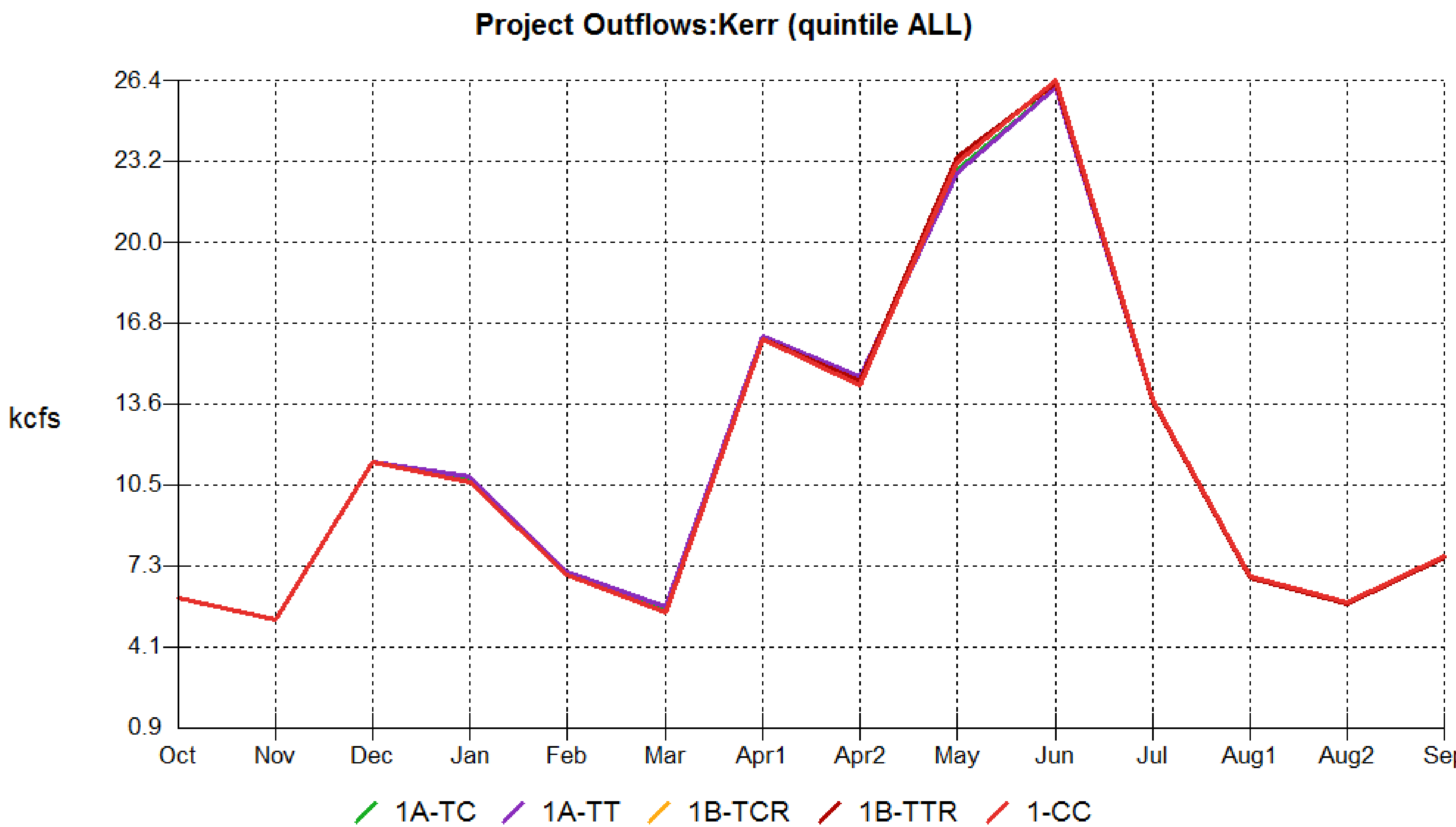
Flathead Lake – Elevations
5 Alternatives – 70 Water Years



- No effects of alternatives on Flathead Lake elevations; same for lowest and highest water years.

Kerr Dam Outflows

5 Alternatives – 70 Water Years



- Little, if any, differences in flows between alternatives; same for lowest and highest water years.

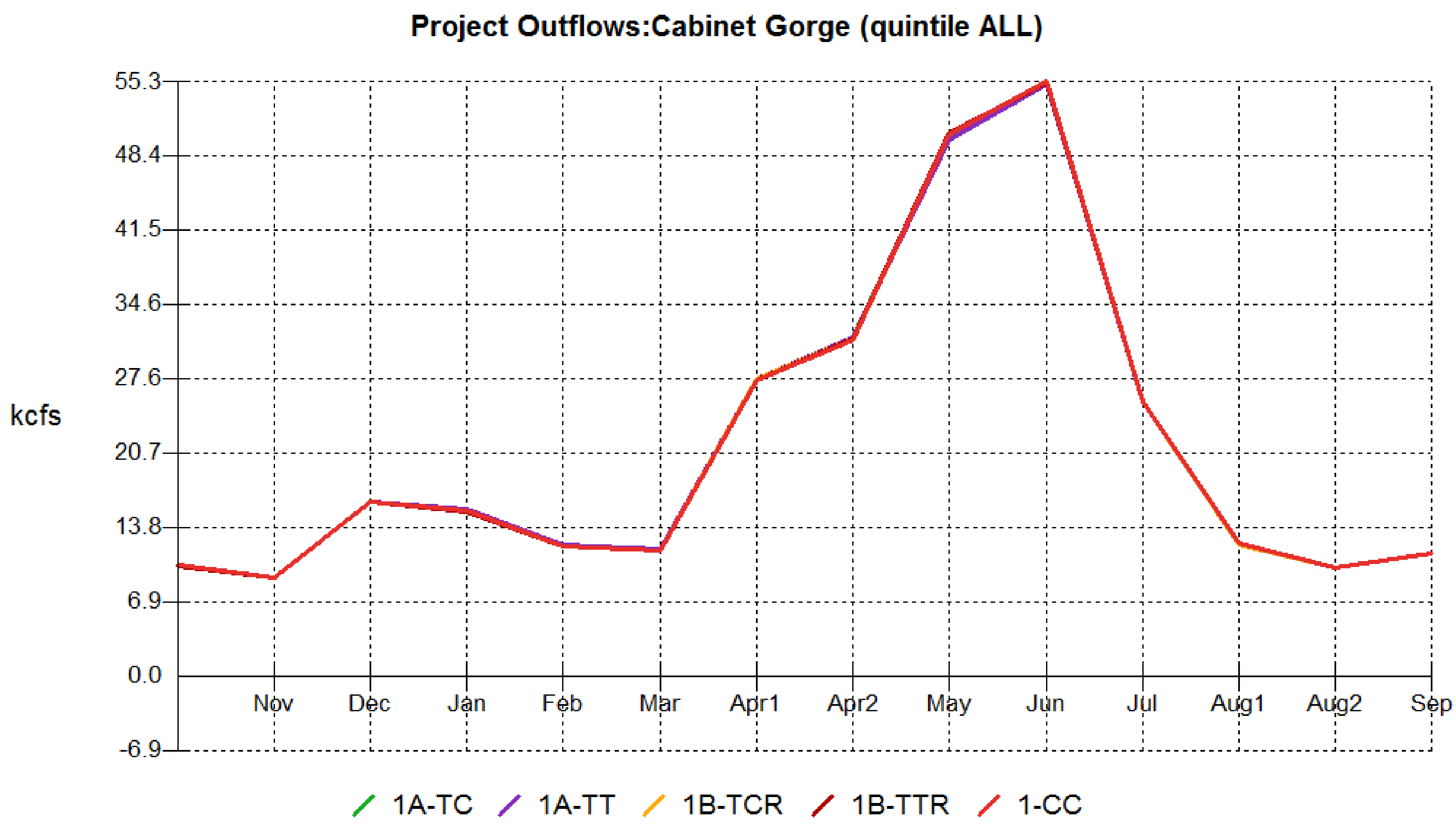
Attachment D

PEND OREILLE RIVER BASIN

- Clark Fork River at Cabinet Gorge Dam
- Lake Pend Oreille above Albeni Falls Dam
- Pend Oreille River below Albeni Falls Dam

Clark Fork River at Cabinet Gorge Dam

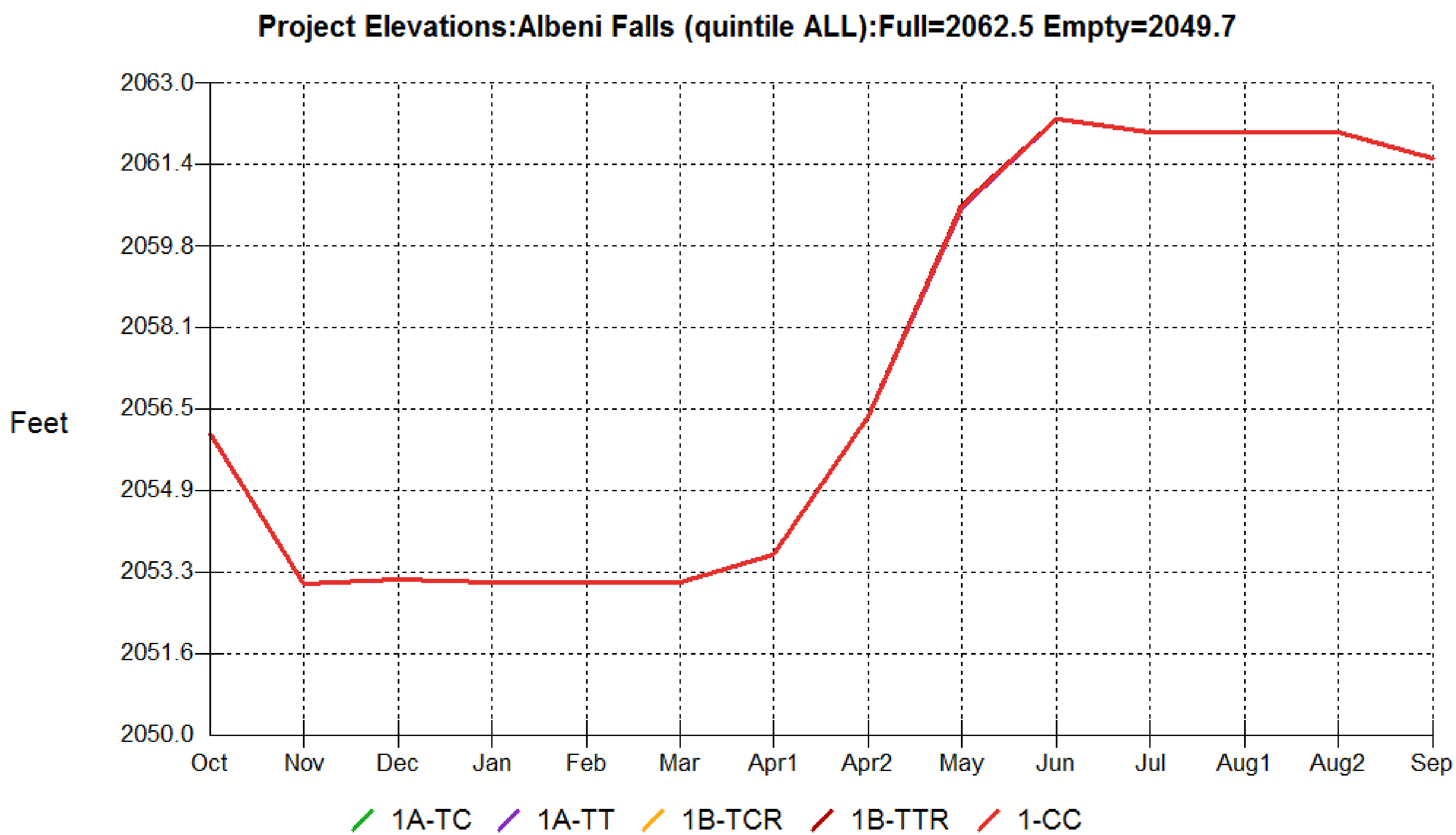
5 Alternatives – 70 Water Years



•Effects of Treaty alternatives is limited to 0 – 0.4 kcfs; similar effects in the lowest and highest water years.

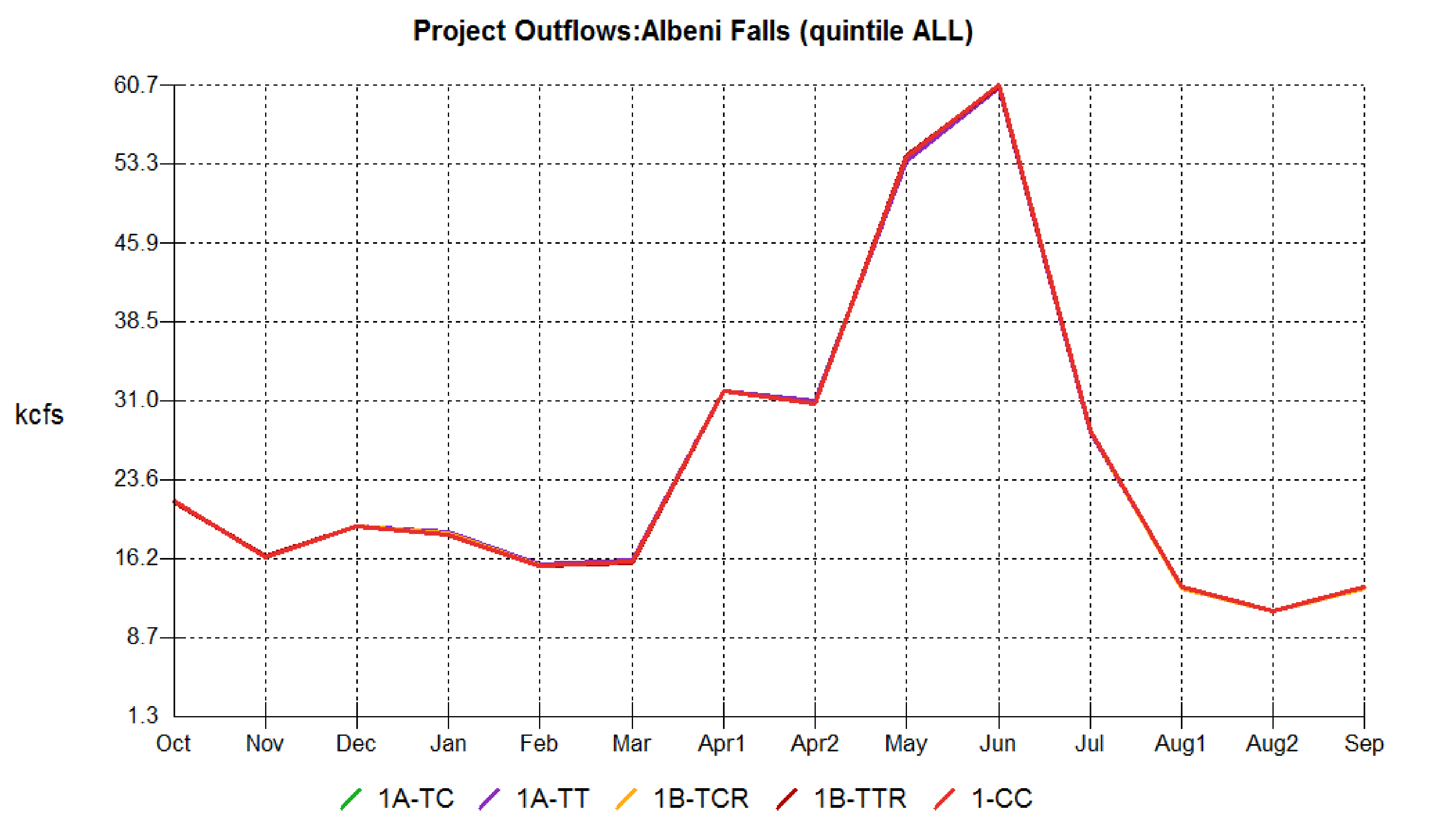
Lake Pend Oreille Elevations

5 Alternatives – 70 Water Years



- No effects of Treaty alternatives on Lake elevations in all water conditions.

Albeni Falls Dam – Outflows
5 Alternatives – 70 Water Years



- Flow effects of Treaty alternatives are limited to no more than ~ 0.2 kcfs in all water conditions.

Attachment D

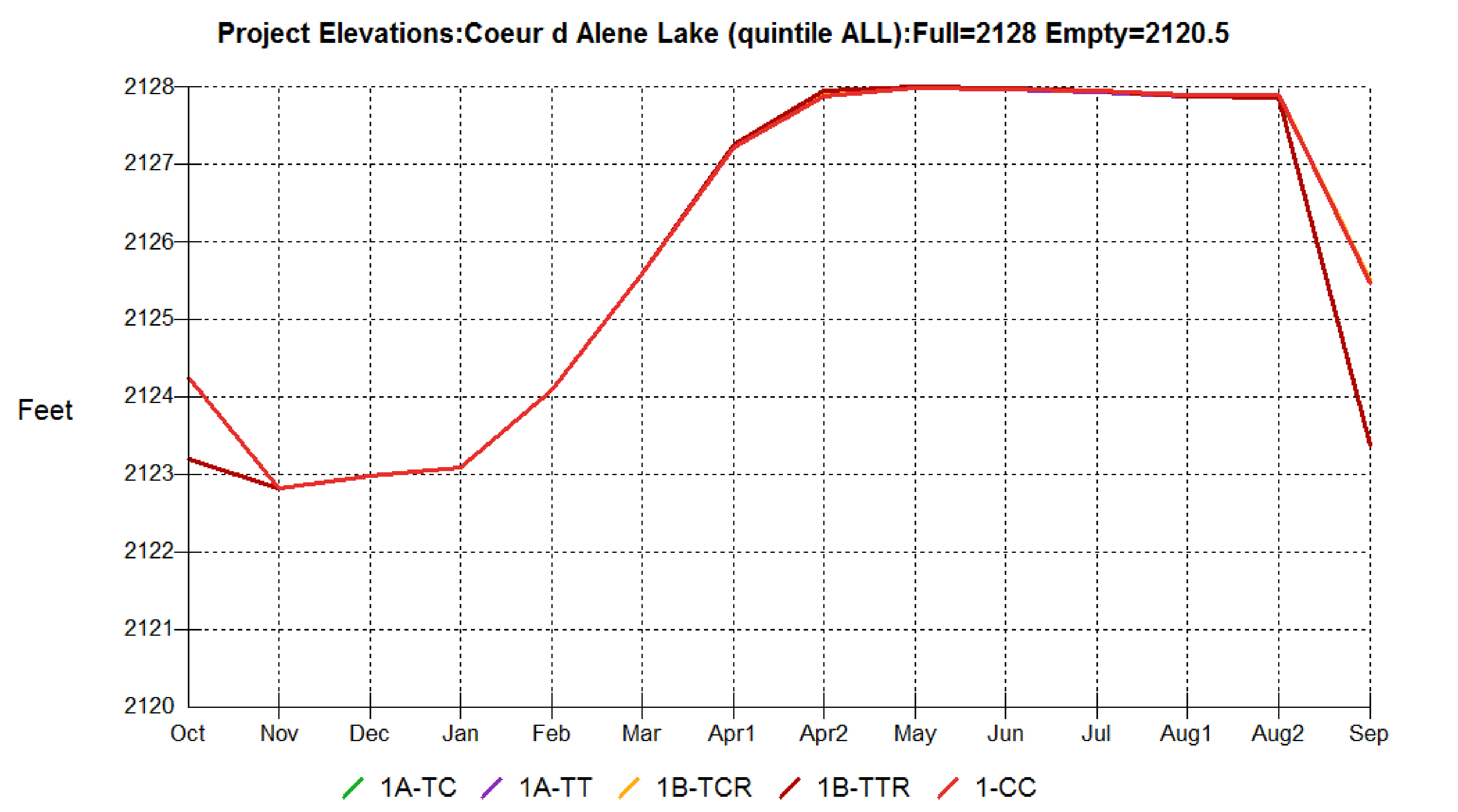
SPOKANE RIVER BASIN

- Lake Coeur d’Alene
- Spokane River below Post Falls Dam

Attachment D

Coeur d’ Alene Lake Elevations

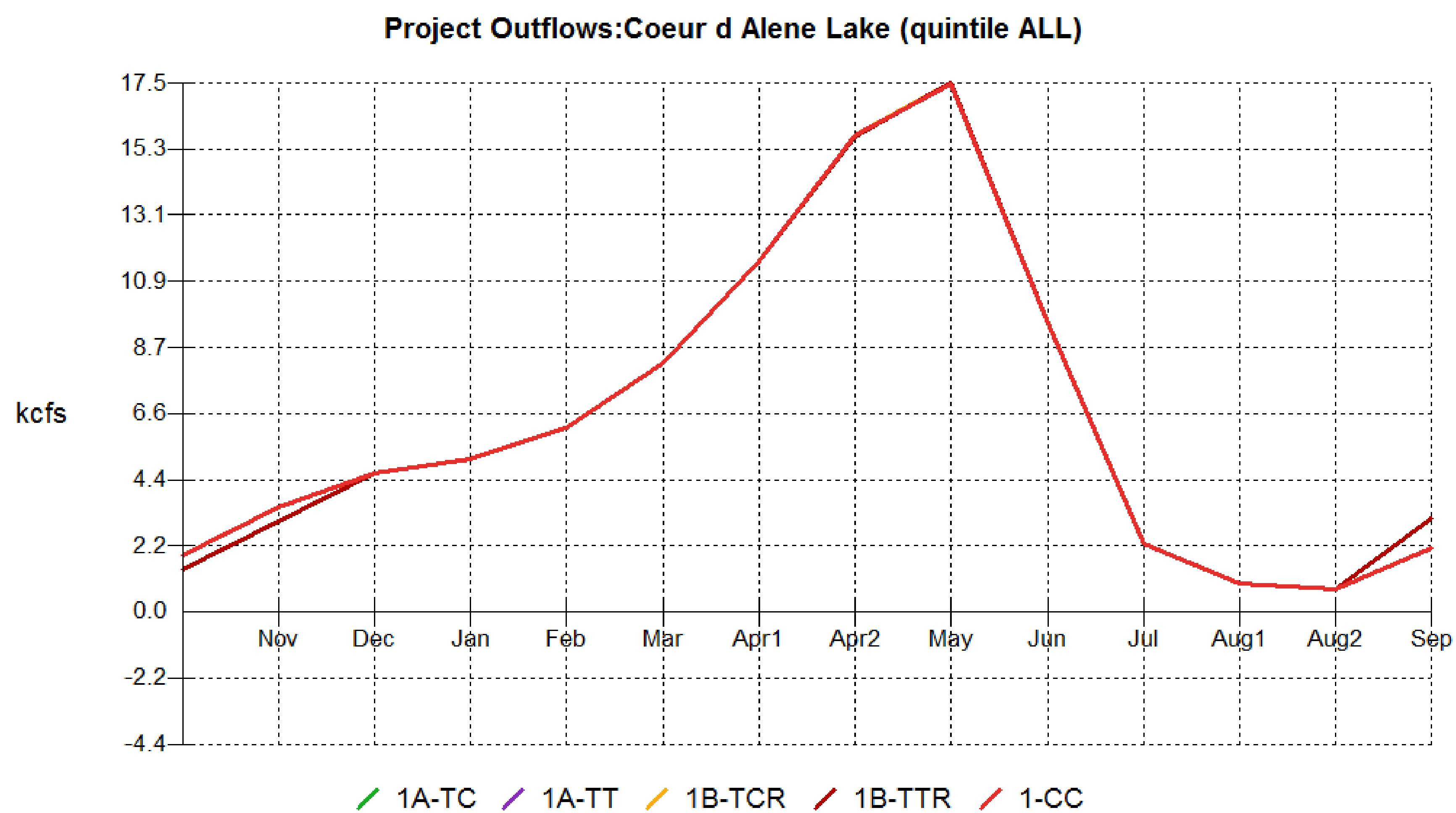
5 Alternatives - 70 Water Years



•Modeling of Treaty Terminates alternatives show potential to draft Lake ~ 1’ more in the fall (3’ in lowest water years), but in actual operations , this is not likely.

Attachment D

Coeur d’ Alene Lake Outflows
5 Alternatives - 70 Water Years



•Modeling of Treaty Terminates alternatives show potential for higher fall flows of ~ 1 kcfs from Post Falls Dam, but in actual operations , this is not likely.

Attachment D

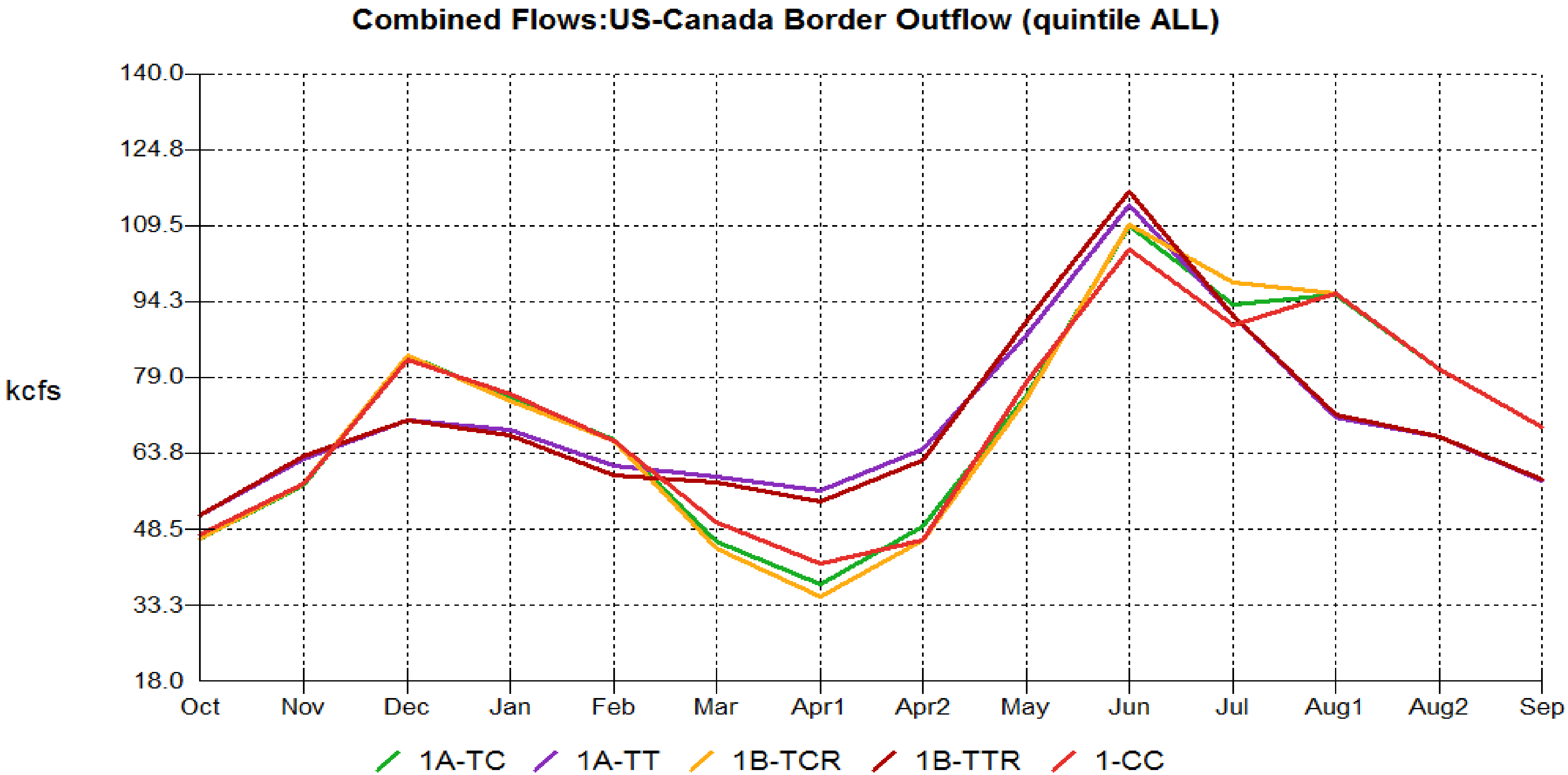
COLUMBIA RIVER BORDER to GRAND COULEE DAM

- Columbia River at Border (flowing into USA)
- Lake Roosevelt above Grand Coulee Dam
- Columbia River below Grand Coulee Dam

Attachment D

Columbia River Flows at Border

5 Alternatives - 70 Water Years

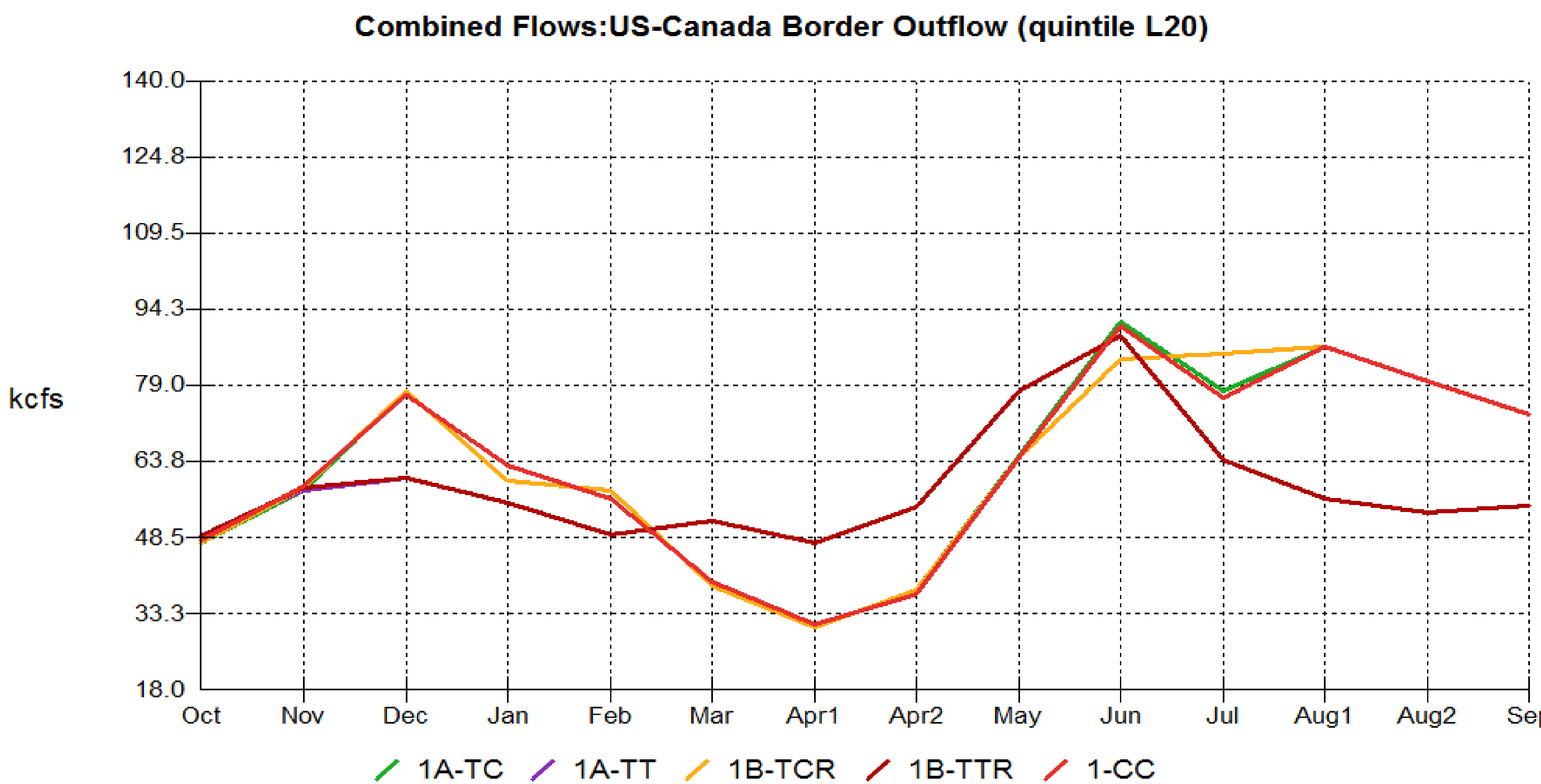


- Treaty Terminates alternatives show lower winter flows (10-13 kcfs), higher freshet flows (10-20 kcfs) and lower summer flows (10-20 kcfs).

Attachment D

Flows at Border

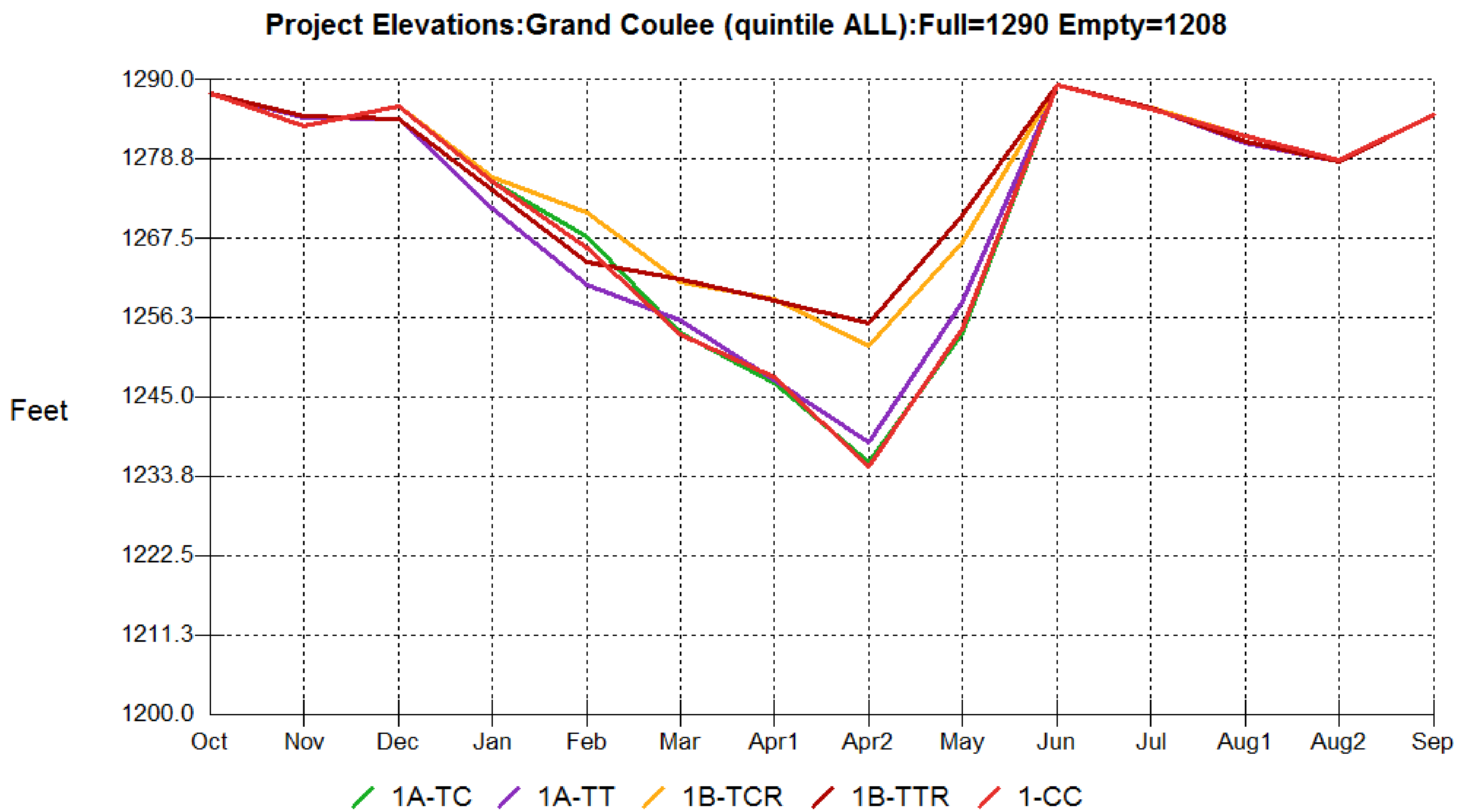
5 Alternatives – 20% Lowest Water Years



- In lower flow years, Treaty Terminates alternatives show similar flow pattern, except even lower summer flows (25-30 kcfs) .
- Flow differences are proportionately greater.

Lake Roosevelt Elevation

5 Alternatives – 70 Water Years

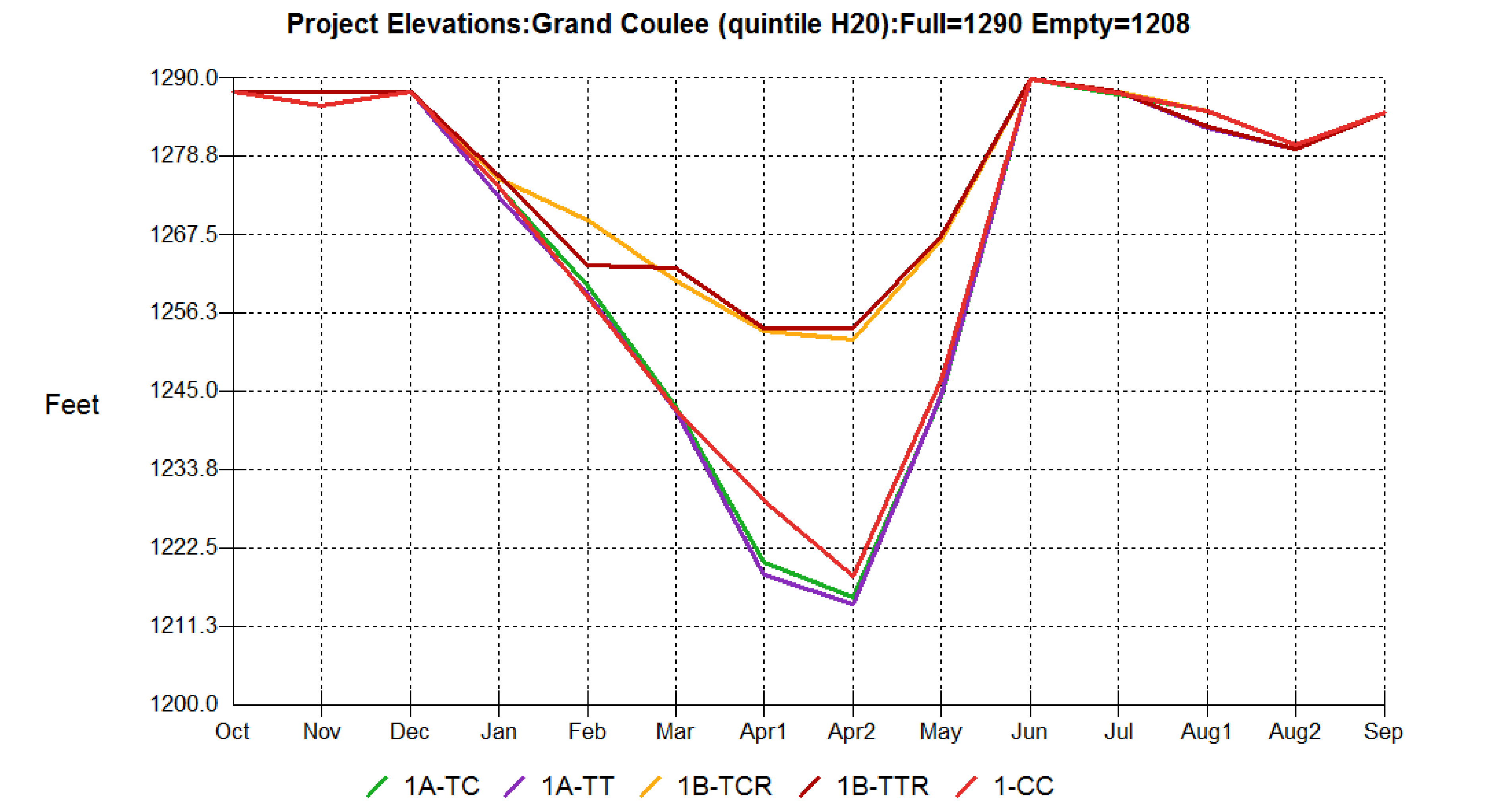


•600 alternatives draft the Lake 15’ – 20’ less in April than the 450 alternatives and Current Condition. Lake is also 10’ – 15’ higher in May.

Attachment D

Lake Roosevelt Elevation

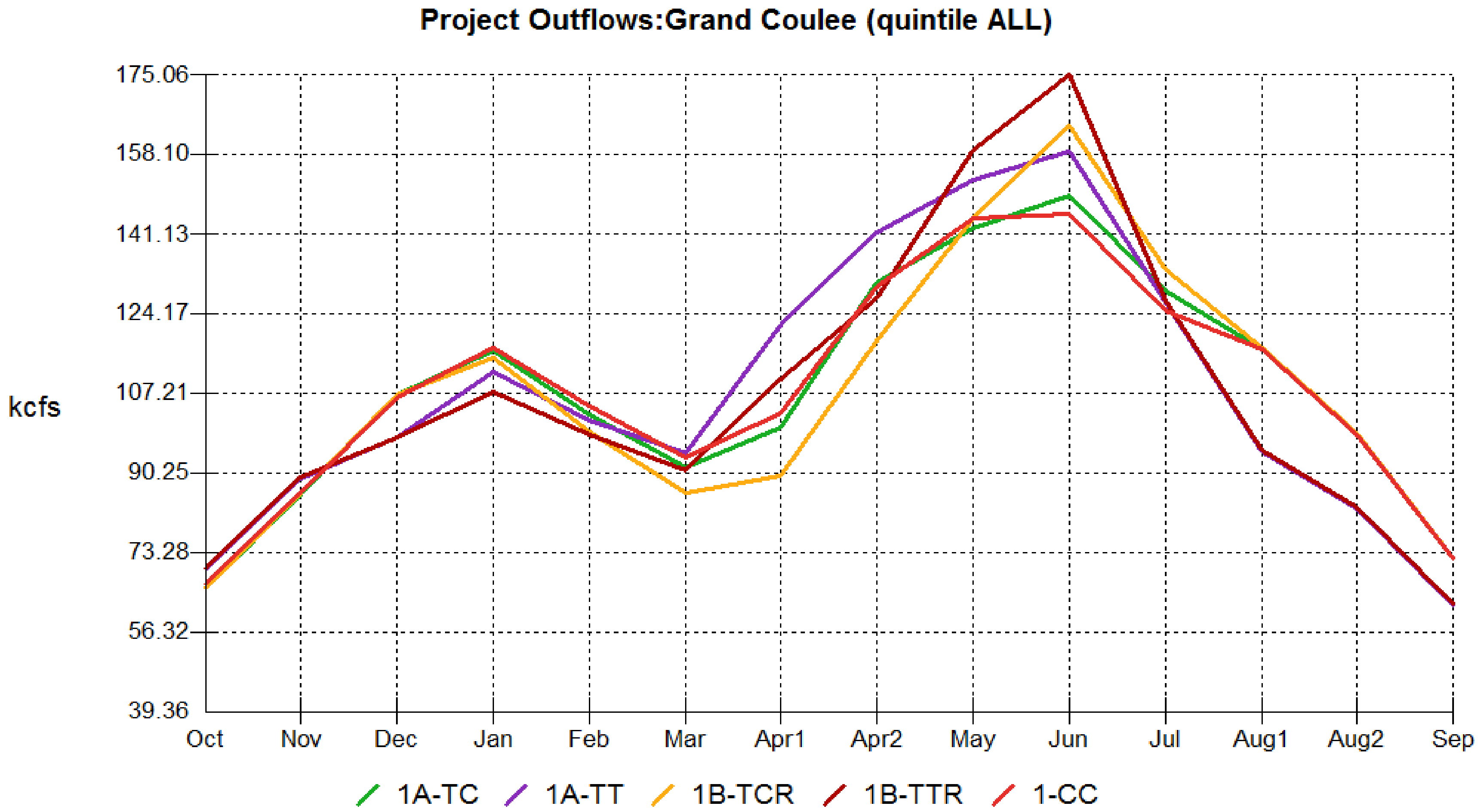
5 Alternatives – 20% Highest Water Years



•600 alternatives draft Lake 35’ to 40’ less than 450 alternatives and Current Condition.

Grand Coulee – Outflows

5 Alternatives – 70 Water Years



- Treaty Terminates alternatives provide higher spring freshet flows (13-30 kcfs), but lower late summer flows
- 600 alternatives have higher freshet flows (20-30 kcfs) compared to the Current Condition.
- In lower flow years, Treaty Terminates alternatives reduce summer flows by 20-30 kcfs.
- In higher flow years, 600 alternatives restore about 40 kcfs to the spring freshet.

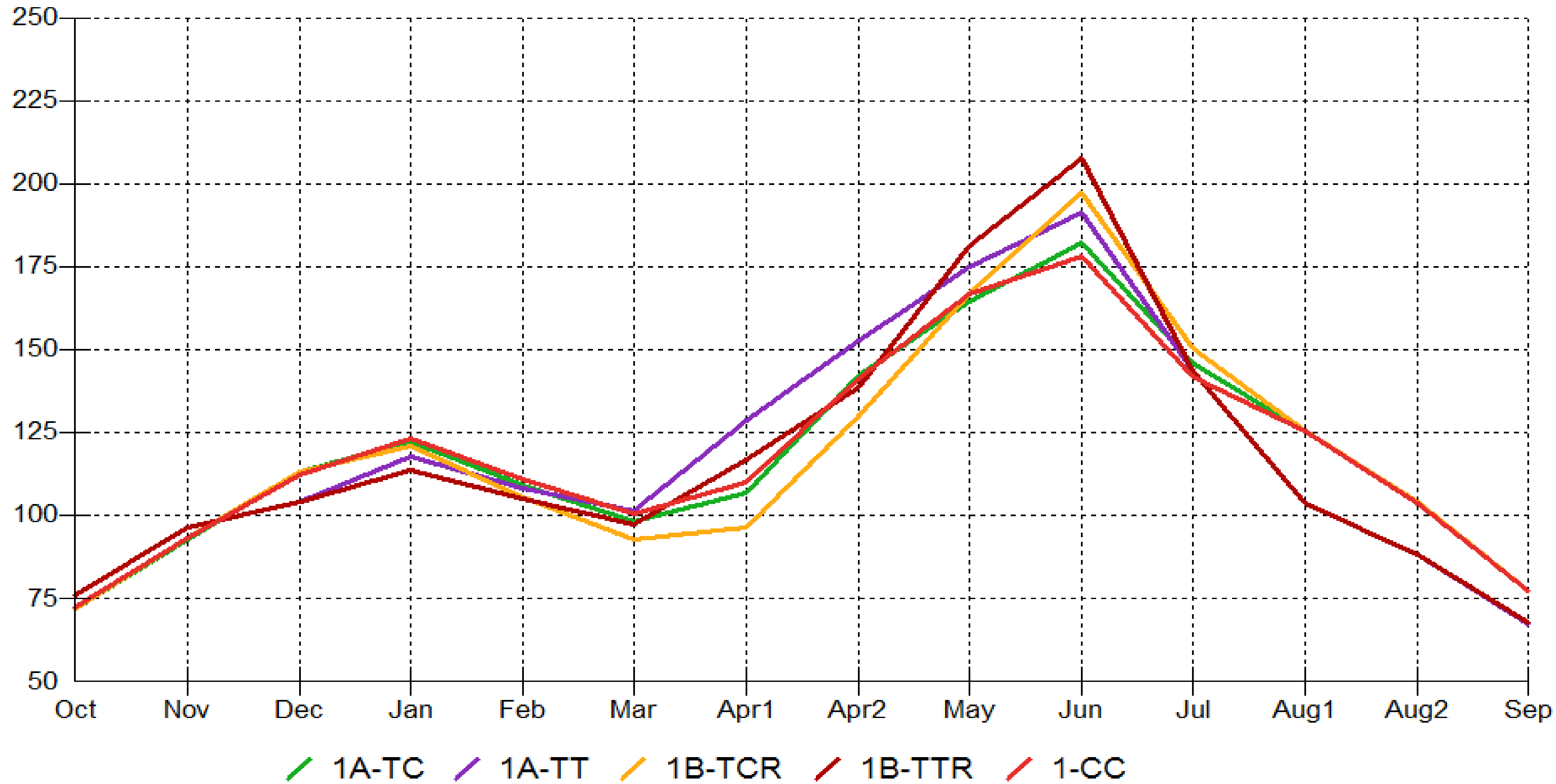
GRAND COULEE DAM to SNAKE RIVER CONFLUENCE

- Columbia River at Priest Rapids Dam
- Columbia River at Vernita Bar – <u>no change</u>

Attachment D

COLUMBIA RIVER – PRIEST RAPIDS (PRD)

70 WATER YEARS AVERAGE FLOWS (KCFS)



Attachment D

GRAND COULEE DAM to SNAKE RIVER CONFLUENCE - Key Points

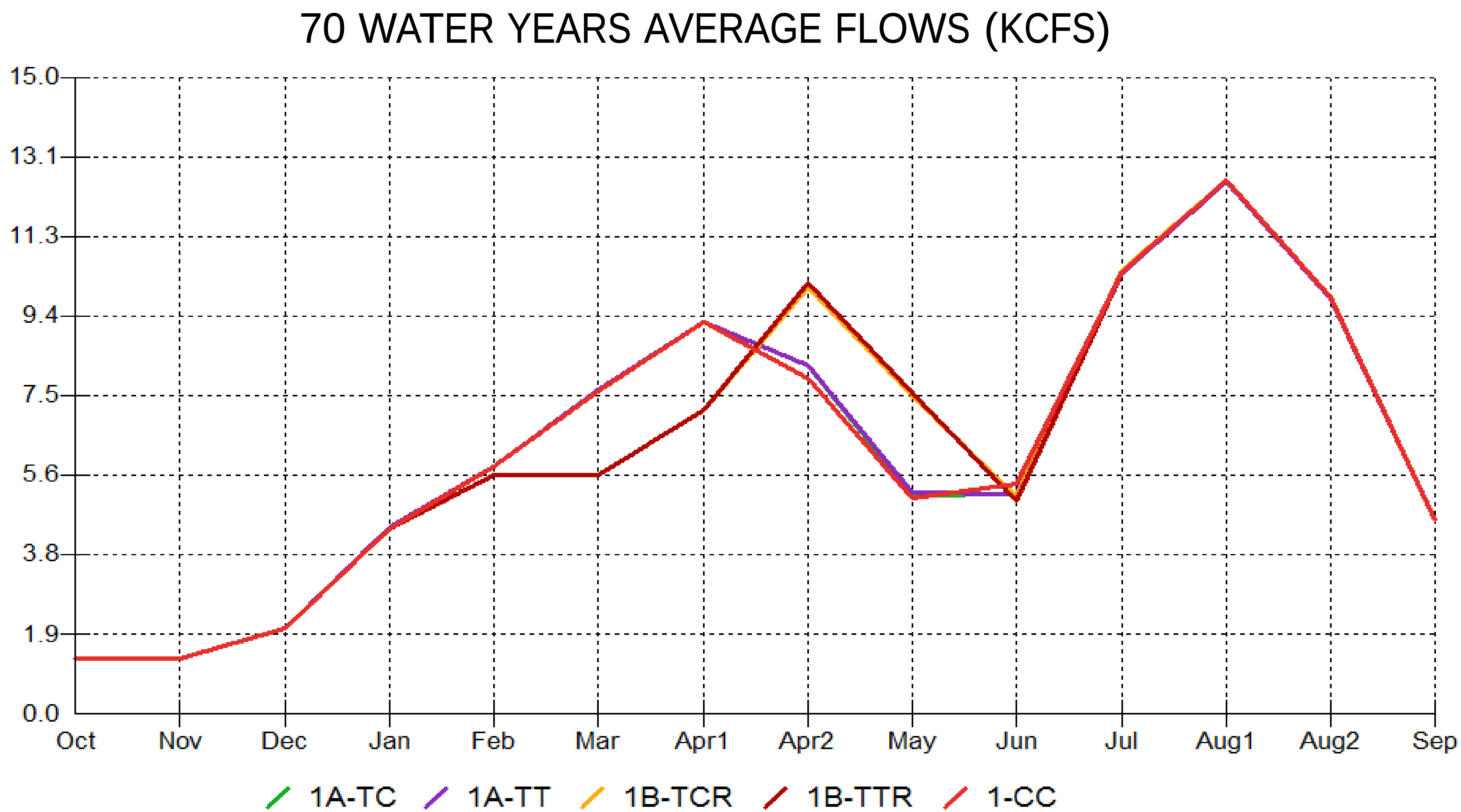
- Priest Rapids- all alternatives missed salmon BiOp spring flows of 135 Kcfs in the average of the 20% lowest water years
- All alternatives met BiOp spring flows in all 14 high water years
- For the average of the 70 year period, there was a mix of meeting and missing spring flows for all alternatives
- 600 kcfs alternatives increased June average peak flows over all other alternatives by 5-29 kcfs.
- Vernita Bar- Fall Chinook salmon flows are met for all water years (HYDSIM model methods and assumptions for Vernita Bar flows are under review).

SNAKE RIVER BASIN

- Snake River at Brownlee Dam – <u>no change</u>
- Hells Canyon Complex – <u>no change</u>
- North Fork Clearwater River at Dworshak Dam
- Lower Snake River at Lower Granite Dam – <u>no change</u>

Attachment D

NF CLEARWATER RIVER– DWORSHAK DAM (DWR)



<u>Revised 600 kcfs alternatives results</u>:

- 600 kcfs alternatives shift spring peak flows two weeks later compared to current condition and 450 kcfs alternatives.

Snake River Flows - Key Points

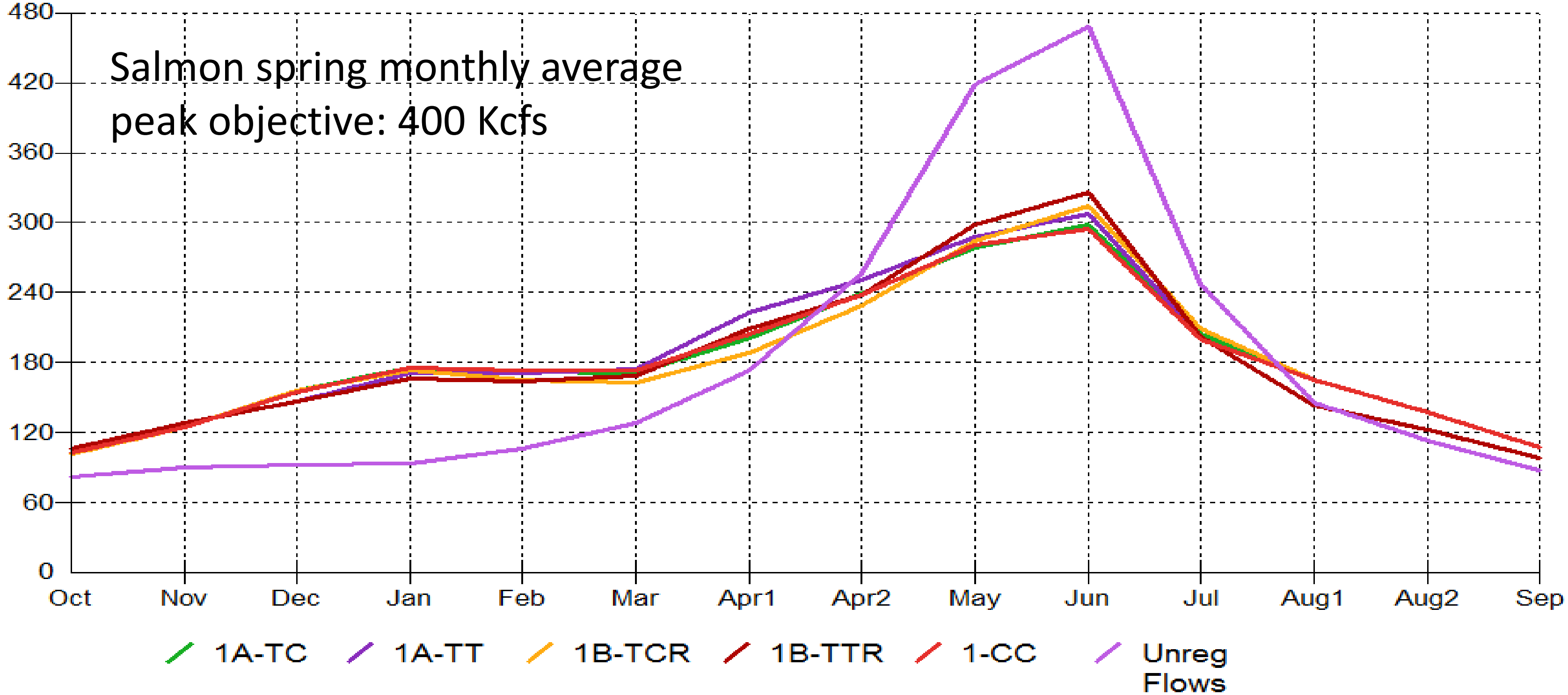
- In general, there were no differences for Snake River flows and other metrics between the iteration #1 alternatives.
- Brownlee, Hells Canyon Complex and Lower Granite - no change in monthly average flows across the alternatives.
- Dworshak - 600 kcfs alternatives have spring peak flows shifted two weeks later than other alternatives.

COLUMBIA RIVER at SNAKE RIVER CONFLUENCE to ESTUARY

- Columbia River at McNary Dam – <u>no change</u>
- The Dalles Dam
- Columbia River at Bonneville Dam (Estuary) – <u>no change</u>

COLUMBIA RIVER – THE DALLES DAM (TDA)

AVERAGE OF 70 WATER YEARS FLOWS and UNREGULATED FLOW (KCFS)



<u>600 kcfs alternatives results</u>:

- June average regulated flows greatest for 600 kcfs treaty terminates alternative, 13 to 31 kcfs higher than all other alternatives.

Lower Columbia River- Key Points

- McNary- all alternatives fail to meet BiOp spring flows all 14 low water years. All alternatives meet BiOp spring flows for the average of the all 70 and 20% high water years
- McNary- 600 kcfs treaty terminates alternatives provide higher spring but lower summer salmon flows than 600 kcfs treaty continues alternatives
- McNary- 600 kcfs treaty terminates alternative results in highest spring flows of all alternatives.
- The Dalles- Treaty terminates alternatives increase spring flows but summer flows are greater for treaty continues alternatives. The 600 kcfs treaty terminates alternative increases the June 70 year average flows by about 31 kcfs over other alternatives.
- The Dalles- 600 kcfs treaty continues alternatives increase 70 year average late summer flows by about 20 kcfs over 600 kcfs treaty terminates alternatives

Lower Columbia River- Key Points Continued

- The Dalles - June 70 year average fish flow objective of 400 kcfs was met for 600 kcfs treaty terminates alternative for 10 of the 14 highest flow years – a gain of 3 years over other alternatives.
- Bonneville – June 70 year average fish flows increased by 10 kcfs for the 600 kcfs treaty terminates alternative over 600 kcfs treaty continues alternatives.
- Bonneville- 70 year average late summer flows were lowest for the 600 kcfs treaty terminates alternatives and highest for the 600 kcfs treaty continues alternative. Average differences were about 16 kcfs.

Chelan County PUD
Draft 2012 Rocky Reach and Rock Island
Fish Spill Program Report
For HCP Coordinating Committee

2012 ROCKY REACH

Rocky Reach Summer Spill

Target species:	Subyearling Chinook
Spill target percentage:	9% of day average river flow
Spill start date:	May 26, 0001 hrs
Spill stop date:	August 9, 2400 hrs
Percent of run with spill:	**97.50%**
Summer spill percentage:	31.86% (9% plus 22.86% forced spill May 26 – Aug 9)
Average river flow at RR:	233,370 cfs (May 26- Aug 9)
Average spill rate at RR:	74,355 cfs (May 26 – Aug 9)
Cumulative index count:	5,757 subyearling Chinook (Aug 26)
Number of spill days:	76

2012 ROCK ISLAND

Rock Island Spring Spill

Target species:	Yearling Chinook, steelhead, sockeye
Spill target percentage:	10% of day average river flow
Spill start date:	April 17, 0001 hrs
Spill stop date:	May 27, 2400 hrs (immediate increase to 20% summer spill)
Percent of run with spill:	**Yrlng Chins 99.80%; Steelhead 99.75%; Sockeye 99.80%**
Cumulative index count:	25,759 Yearling Chins**;** 16,957 Steelhead**;** 46,788 sockeye
Spring spill percentage:	**16.39%** (10% plus 6.39% forced spill, April 17 - May 27)
Ave river flow at RI:	208,770 cfs (April 17- May 27)
Ave spill flow at RI:	34,210 (April 17- May 27)
Total spill days:	41

Rock Island Summer Spill

Target species:	Subyearling Chinook
Spill target percentage:	20% of day average river flow
Spill start date:	May 28, 0001 hrs
Spill stop date:	August 18, 2400 hrs
Percent of run with spill:	**97.85%**
Cumulative index count:	27,298 subyearling Chins
Summer spill percentage**:**	**27.29%** (June 4 through August 24)
Ave river flow at RI:	212,290 cfs (June 4- August 24)
Ave spill flow at RI:	57,920 cfs (June 4- August 24)
Total spill days:	83

Juvenile Index Counts 2003-2012 from the Rocky Reach Juvenile Fish Bypass sampling facility and the Rock Island Bypass Trap, April 1 – August 31.

Table 1. Rocky Reach Juvenile Bypass index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	71,683	30,935	17,575	239,185	169,937	136,206	40,758	724,394	67,879	384,224
Steelhead	10,585	6,433	5,821	4,329	4,532	8,721	6,309	4,931	5,683	4,902
Yrlng Chins	13,918	53,946	27,611	23,461	18,080	38,394	18,946	33,840	24,400	95,207
Subyrlng Chins	172,392	20,062	10,978	19,996	13,496	11,820	11,944	59,751	17,246	5,757

Table 2. Rock Island SMP index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	10,312	7,114	1,991	34,604	16,410	38,965	4,926	37,404	18,697	46,788
Steelhead	15,507	10,735	15,974	26,930	18,482	22,780	17,636	17,194	28,408	16,957
Yearling Chins	15,355	12,574	14,797	37,267	23,714	22,562	9,225	11,802	26,407	25,759
Subyrlng Chins	25,916	23,563	18,710	27,106	15,686	15,940	8,189	23,205	27,397	27,298

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	October 23, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the September 25, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met by conference call on Tuesday, September 25, 2012, from 9:30 am to 11:00 am. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Kristi Geris will post Chelan PUD's Draft 2013 HCP Comprehensive Progress Report on the Mid-Columbia HCP ftp site, and she will distribute instructions for accessing the site to the Coordinating Committees (Item II-B).
- Douglas PUD will distribute their draft HCP No Net Impact (NNI) Progress Report to the Coordinating Committees at least 10 days prior to the October 23, 2012 Coordinating Committees meeting (Item II-B).
- Steve Hemstrom will provide additional information to the Coordinating Committees on the Rocky Reach Turbine Unit 1 repair/outage scheduled for January 2, 2013, through April 31, 2013. Information will include potential operations for the month of April (Item II-C).
- Lance Keller will compile historical average fish lengths for fish passing Rocky Reach Dam during the month of April, and he will provide these data to Kristi Geris for distribution to the Coordinating Committees (Item II-C).
- Tom Kahler will provide engineering drawings of the Wells Dam fish ladders and count windows to Kristi Geris for distribution to the Coordinating Committees; the design drawings should help Committees' members evaluate proposed modifications to improve Pacific lamprey enumeration at Wells Dam (Item III-A).
- The Coordinating Committees December 2012 meeting date has been rescheduled to be held by conference call on Tuesday, December 11, 2012 at 9:30 am (Item V-A).

DECISION SUMMARY

- No Statements of Agreement (SOAs) were approved at this meeting.

AGREEMENTS

- The Rock Island and Rocky Reach Coordinating Committees representatives present accepted the 2012 Rocky Reach and Rock Island Fish Spill Report as final (Item II–A).
- Modifications to improve Pacific lamprey enumeration at Wells Dam were conditionally approved, subject to National Marine Fisheries Service (NMFS) review of engineering plans, by the Wells Coordinating Committees representatives present (Item III-A).

REVIEW ITEMS

- Kristi Geris sent an email notification to the Coordinating Committees on September 25, 2012, stating that Chelan PUD's HCP Draft 2013 Comprehensive Progress Report is out for a 60-day review period with comments due to Steve Hemstrom by November 30, 2012.

REPORTS FINALIZED

- There are no reports that have been recently finalized.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or other changes to the agenda. No additions or changes were requested.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft August 28, 2012 meeting minutes. Kristi Geris noted that a second version of the revised draft August meeting minutes had been distributed just prior to the meeting with Bill Tweit's comments incorporated, including clarification of the meaning of the term "effective use," in his presentation on the potential renegotiation of the Columbia River Treaty. Geris said all other comments and revisions received from Committees' members were incorporated in the revised minutes. The draft August 28, 2012 meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Chelan PUD

A. Final Rocky Reach and Rock Island HCP Fish Spill Report (Steve Hemstrom)

Steve Hemstrom said the 2012 Rocky Reach and Rock Island Final Fish Spill Report (Attachment B), which Kristi Geris distributed to the Coordinating Committees by email on September 14, 2012, is the final version of the draft document that was distributed at the Coordinating Committees' August 28, 2012 meeting. He said the changes were *de minimis*, other than the addition of final bypass counts for each species. Hemstrom reviewed key statistics such as percentages of runs covered by spill, seasonal spill averages, and average flows and spill rates.

Teresa Scott noted that the report provides an excellent summary of the Rocky Reach and Rock Island 2012 Fish Spill Programs. Jerry Marco asked about the difference in the cumulative index counts for Rocky Reach and Rock Island. Hemstrom said that Rock Island is a full 24-hour count whereas Rocky Reach conducts and reports 2-hour index counts; therefore, the numbers are not readily comparable. He added that trap efficiency at Rock Island is not as high as at Rocky Reach; and he said that if the same counting methods were possible, the counts would be similar. Marco added that it would be interesting to compare historical average cumulative index counts to current counts at both Rocky Reach and Rock Island to determine how much the recent high flows affected the cumulative counts. The Committees accepted the report as final.

B. Chelan PUD Draft 2013 HCP Comprehensive Progress Report (Steve Hemstrom)

Steve Hemstrom said that the Draft 2013 Comprehensive NNI Progress Report for the Rock Island and Rocky Reach HCPs was distributed today, initiating the 60-day review period. He said that Josh Murauskas, Lance Keller, Joe Miller, and he had put a lot of effort into this draft document that summarizes 10 years of accomplishments under the HCPs. Hemstrom encouraged Coordinating Committees representatives to distribute the draft plan within their respective agencies. He also noted the acknowledgement section at the back of the report, and he asked people to review the section and let him know if there were others who should be acknowledged. Kristi Geris said that she will post Chelan PUD's draft report to Anchor QEA's Mid-Columbia HCP ftp site, and she will distribute instructions for accessing the site to the Coordinating Committees.

Mike Schiewe suggested that the Coordinating Committees discuss both the Chelan PUD and Douglas PUD draft reports at the October 23, 2012 Coordinating Committees meeting. Tom Kahler said Douglas PUD will distribute their draft HCP NNI Progress Report to the Coordinating Committees at least 10 days prior to the October 23, 2012 Coordinating Committees meeting.

C. Rocky Reach Turbine Unit 1 Outage for Rotor Repair, April 2013 (Steve Hemstrom)

Steve Hemstrom notified the Coordinating Committees of a crack in the rotor (blade) of Turbine Unit 1 (C1) at Rocky Reach Dam. He said that the rotor is under warranty from the equipment manufacturer and a repair has been scheduled for January 2, 2013, through April 31, 2013; this equates to a full 4-month outage. Hemstrom said that during this 4-month outage, the month of April is the only month of concern because the Rocky Reach bypass starts operation April 1, 2013, and C1 contributes 60 cubic feet per second (cfs) to the bypass, along with fish diverted via screens from the unit intakes. He said the spring migration of juvenile salmonids has typically started to pass Rocky Reach Dam during the month of April. Hemstrom said that he will provide additional information to the Coordinating Committees on the C1 repair and outage, including potential operations for the month of April.

Bryan Nordlund asked if there was any assurance that the outage would be completed by the end of April, and he added that repairs to turbines can sometimes take longer than complete replacements. Hemstrom replied that Chelan PUD managers at Rocky Reach have assured him that the repair will be complete by April 31, 2012; and it is possible that the outage could end sooner. Lance Keller said the project managers are confident in the April deadline because Rocky Reach crews are familiar with these rotor cracks and have considerable experience repairing them on other units. Nordlund asked if other units are susceptible to these rotor cracks, and Keller said that they are, eventually. Keller added that Turbine Unit

4 (C4) has already been repaired and Turbine Unit 2 (C2) will eventually require a similar repair. Nordlund asked if Chelan PUD could provide average fish lengths for fish passing Rocky Reach Dam during the month of April, and Keller said he will compile these numbers and provide them to Kristi Geris for distribution to the Coordinating Committees.

III. Douglas PUD

A. Fishway Count-Window Modifications to Improve Lamprey Enumeration at Wells Dam (Tom Kahler)

Tom Kahler said that the Aquatic Settlement Workgroup (Aquatic SWG) asked that he present to the Coordinating Committees a memorandum requesting permission to modify the Wells Dam fishway picketed-lead bar screens to improve Pacific lamprey enumeration at Wells Dam (Attachment C). Kristi Geris distributed this memorandum to the Coordinating Committees by email on September 19, 2012.

Kahler explained that fish passing Wells Dam are guided to the counting window by picketed leads that currently are not designed to exclude small fish from passing through the picketed lead and thus bypassing the count window. He said that, based on fishway modifications at other facilities, Douglas PUD has determined that reduced spacing of the bars on the screen would likely minimize the number of lamprey passing through the picketed leads and bypassing the counting windows. Kahler said that Douglas PUD is proposing 0.5-inch-spaced bar screens (11/16-inch measured on-center), which will either replace the existing 1-inch-spaced bar screens or be placed over the existing bar screen.

Bryan Nordlund asked if the design for the new picketed lead had been finalized. Kahler said that it had not and that Douglas PUD had planned to discuss the design with Nordlund prior to finalizing. Nordlund expressed concern that if openings in the picketed leads are reduced, both elevation and velocity through the counting window area could be increased; these increases could result in a tendency for fish to reject passing through the count window area. Kahler said that there are multiple routes for water to move through the counting window area, and also that the water-surface elevation in the area is designed to fluctuate with the forebay elevation. Thus, any increase in water-surface elevation due to reduced open space of the picketed leads would only result in velocity at the count window in excess of design criteria when the forebay is at the maximum of the operating range—a condition that seldom exists. Nordlund said he needed time to consider the effects of the proposal on water velocity at the count windows and how operations influence elevation and velocities. Kahler said he will provide engineering drawings of the Wells Dam fish ladders and count windows to Nordlund for review, and also to Kristi Geris for distribution to the Coordinating Committees.

Teresa Scott asked if other counting mechanisms were considered. Kahler said that infrared (IR) cameras were considered; however, based on the time needed to review the recordings and maintain the IR cameras, they were deemed too costly and impractical for the long term. Mike Schiewe added that the Aquatic SWG also considered running the IR cameras for a specified term and then using these data to estimate a correction factor. Schiewe said that modified picketed leads have already been installed at Rocky Reach Dam, and Bob Rose confirmed that the modifications seem to work fine. Rose noted that IR cameras had been used for enumeration at other projects and were later abandoned because of the time and costs required to review data.

Scott asked about debris collection on the narrower spaced picketed leads. Kahler said there would be regular maintenance as is currently implemented; and monitoring will be conducted to determine if additional maintenance would be required with the new leads. Kahler said that Douglas PUD will be evaluating the new picketed leads as part of an active-tag study monitoring lamprey behavior at Wells Dam planned for 2013. Schiewe said the plan is to translocate and tag adult lamprey collected at Bonneville and Priest Rapids dams and monitor their behavior during fish passage.

The Wells Coordinating Committees representatives present conditionally approved modifications to improve Pacific Lamprey enumeration at Wells Dam, subject to NMFS review of engineering plans.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the HCP Tributary Committees did not officially meet in September. He noted that a few members had visited habitat restoration projects on the

Okanagan River in Canada. He added that the Tributary Committees will meet again in October.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Hatchery Committees meeting on September 19, 2012, held at the Douglas PUD:

- *SOA for Wells Hatchery Sub-Yearling Summer Chinook Release Date*: The Hatchery Committees approved an SOA memorializing the practice of releasing Wells Hatchery subyearling Chinook salmon in mid-May rather than mid-June. This is a practice that was initially agreed to in 2009; this SOA was just a matter of bookkeeping.
- *Rocky Reach Spring Chinook Production*: The Hatchery Committees continued discussion on how to meet above Rocky Reach NNI production of 61,000 spring Chinook salmon. Chelan PUD has exercised the option to terminate the sharing agreement with Douglas PUD for production at the Methow Hatchery, and a new agreement has not been negotiated. Both short-term and long-term options are being considered. Some of the possibilities discussed include (but were not limited to) rearing at Winthrop National Fish Hatchery (NFH); overwinter acclimation at Carlton or other potential Methow basin acclimation sites, and rearing at Chief Joseph Hatchery (CJH). However, CJH is not a likely option due to permitting requirements for rearing Endangered Species Act (ESA)-listed fish. Broodstock collection protocols are required by March 2013.
- *Dryden Update*: The Hatchery Committees continued discussion of efforts to meet phosphorus total maximum daily load (TMDL) limits at the Dryden facility. This issue is causing great concern because preliminary testing shows that incoming water already exceeds the proposed TMDL. Leavenworth NFH is faced with similar issues. The Hatchery Committees are discussing ways to engage Washington State Department of Ecology (Ecology) to demonstrate that the Committees are being proactive and to make clear how difficult the new TMDL limits will be to meet, given the circumstances. Tom Scribner is leading this effort and convening a group to discuss interactions with Ecology.
- *Multi-Species/Expanded Acclimation*: The Yakama Nation (YN) reintroduced their interest in the Hatchery Committees developing a long-term acclimation plan for all

HCP Plan Species. Scribner suggested and the Hatchery Committees agreed that a working group, consisting of the YN, Washington Department of Fish and Wildlife (WDFW), and U.S. Fish and Wildlife Service (USFWS), develop a draft long-term plan to present to the Hatchery Committees. A draft document will be available on December 1, 2012.

- *Authorization for a Thinning Release of Coho to the Columbia River at Starr Boat Launch*: The Hatchery Committees concurred with the YN's request to NMFS for a thinning release of 24,000 coho parr that were excess to production at Winthrop NFH.
- *Chewuch Acclimation Facility*: The Hatchery Committees agreed to the YN proposal to move forward with negotiations with Douglas PUD about acclimating coho salmon, with or without co-acclimation of spring Chinook salmon, at the Chewuch Acclimation Facility. Because a new Hatchery Genetic Management Plan (HGMP) for Methow spring Chinook salmon has not be finalized, it is unknown if Chinook salmon will be acclimated in the Chewuch in the future.

V. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

Mike Schiewe said that the Hatchery Committees' November meeting date will be adjusted to avoid the Thanksgiving holiday. The Coordinating Committees' November meeting is currently scheduled the week after the holiday and will remain as scheduled. The Coordinating Committees agreed to adjust their December meeting from December 25, 2012, to Tuesday, December 11, 2012.

The next scheduled Coordinating Committees meeting is October 23, 2012, planned for the Radisson Hotel at SeaTac, Washington. The November 27, 2012, and December 11, 2012, Coordinating Committees meetings are scheduled to be held by conference call.

List of Attachments

Attachment A – List of Attendees
Attachment B – 2012 Rocky Reach and Rock Island Final Fish Spill Report

Attachment C – Memorandum to Modify the Wells Dam Fishways Picketed-Lead Bar Screens to Improve Pacific Lamprey Enumeration at Wells Dam

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Tom Kahler*	Douglas PUD
Bob Rose*	Yakama Nation
Jerry Marco*	Colville Confederated Tribes
Bryan Nordlund*	National Marine Fisheries Service
Jim Craig*	U.S. Fish and Wildlife Service
Teresa Scott*	Washington Department of Fish and Wildlife

Notes
* Denotes Coordinating Committees member or alternate

Chelan PUD
Rocky Reach and Rock Island HCPs
Final 2012 Fish Spill Program Report

2012 ROCKY REACH

Rocky Reach Summer Spill

Target species:	Subyearling Chinook
Spill target percentage:	9% of day average river flow
Spill start date:	May 26, 0001 hrs
Spill stop date:	August 9, 2400 hrs
Percent of run with spill:	**97.42%**
Cumulative index count:	5,774 subyearling Chinook (April 1-August 31)
Summer spill percentage:	31.86% (9% plus 22.86% as forced spill May 26 - Aug 9)
Average river flow at RR:	233,370 cfs (May 26- Aug 9)
Average spill rate at RR:	74,355 cfs (May 26 – Aug 9)
Number of spill days:	76

2012 ROCK ISLAND

Rock Island Spring Spill

Target species:	Yearling Chinook, steelhead, sockeye
Spill target percentage:	10% of day average river flow
Spill start date:	April 17, 0001 hrs
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Spring spill percentage:	**16.39%** (10% plus 6.39% forced spill, April 17 - May 27)
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Ave spill flow at RI:	34,210 cfs (April 17- May 27)
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Cumulative index count:	27,464 subyearling Chinook
Summer spill percentage**:**	**24.79%** (May 28 - August 18)
Ave river flow at RI:	212,290 cfs (May 28- August 18)
Ave spill flow at RI:	59,260 cfs (May 28- August 18)
Total spill days:	83

Juvenile Index Counts 2003-2012 from the Rocky Reach Juvenile Fish Bypass and the Rock Island Smolt Monitoring Program (SMP) April 1 – August 31.

Table 1. Rocky Reach Juvenile Bypass index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	71,683	30,935	17,575	239,185	169,937	136,206	40,758	724,394	67,879	384,224
Steelhead	10,585	6,433	5,821	4,329	4,532	8,721	6,309	4,931	5,683	4,902
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Table 2. Rock Island Smolt Monitoring Program index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	10,312	7,114	1,991	34,604	16,410	38,965	4,926	37,404	18,697	46,788
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Subyrlng Chinook	25,916	23,563	18,710	27,106	15,686	15,940	8,189	23,205	27,397	27,298

MEMORANDUM

TO: Wells HCP Coordinating Committee

FROM: Chas Kyger, Aquatic Resource Biologist, Douglas PUD

DATE: September 19, 2012

SUBJECT: Modification to Wells Fishways Picketed-lead Bar Screens

Background

The Pacific Lamprey Management Plan (PLMP) is one of the six Aquatic Resource Management Plans contained within the Aquatic Settlement Agreement that directs the implementation of Protection, Mitigation, and Enhancement measures (PMEs) for Pacific lamprey (*Lampetra tridentata*) during the term of the new Wells Project operating license. The goal of the PLMP is to implement measures to monitor and address impacts, if any, on Pacific lamprey resulting from the Wells Project during the term of the new license. Objectives of the PLMP include identifying and addressing any adverse Project-related impacts on passage of adult Pacific lamprey and effectively enumerating lamprey passing Wells Dam. Pursuant to this objective, Public Utility District No. 1 of Douglas County (Douglas PUD) is conducting an adult active-tag study to 1) collect additional information on the passage characteristics and behavior of adult lamprey migrating through the Wells Project fishways (section 4.1.6 of the PLMP); and 2) to evaluate enumeration efficiency in the vicinity of the Wells Project fishway count windows (section 4.1.3 of the PLMP) toward identifying alternatives to improve adult lamprey count accuracy.

In an effort to evaluate and improve enumeration of lamprey in the fishway count windows, Douglas PUD proposes to replace the existing 1–inch-spaced bar screens of the picketed leads that lead to fishway count stations with narrower spaced 11/16th-inch bar screen (11/16" measured on-center; actual space between the 3/16"-wide bars is ½ inch). The bar screen with narrower spacing is intended to direct lamprey through the fishway count windows and prevent them from passing through the picketed leads and bypassing the count windows. In recent years, the efficacy of using narrow-spaced bar screen as a way to improve the enumeration of lamprey passing adult fishways has been tested at other public and federal projects on the Columbia River (LGL et al. 2011, ACOE 2011). The use of narrow-spaced leads has resulted in no reduction in travel time and has not increased the fallback rates of lamprey within the fish ladders at those dams tested (Peery et al. 2011).

Proposed Fishway Modification

During the 2012-2013 Wells Dam ladder maintenance period (typically from December through January), Douglas PUD proposes to replace the existing bar screens that form the picketed leads to the count windows with new 11/16th–inch-spaced bar screens within the east and west fishways at Wells Dam. As such, Douglas PUD and the Wells Aquatic Settlement Workgroup seek approval from the Wells HCP Coordinating Committee for this proposed action.

CC:
Wells Aquatic Settlement Workgroup list serve
Shane Bickford, Douglas PUD
Bill Dobbins, Douglas PUD
Mike Bruno, Douglas PUD
Tom Kahler, Douglas PUD
Andrew Gingerich, Douglas PUD

References

Army Corps of Engineers (ACOE). 2011. Pacific Lamprey Passage Improvements Implementation Plan. 2010 Final Progress Report. February 23, 2011.

LGL, Cramer Fish Sciences, Blue Leaf Environmental, and Long View Associates. 2011. Assessment of Pacific Lamprey Behavior and Passage Efficiency at Priest Rapids and Wanapum Dams. Prepared for Public Utility District No. 2 of Grant County.

Peery, C., B. McIlraith, D. Thompson, and F. Loge. 2011. Use of Non-Invasive Methods to Evaluate Pacific Lamprey Counts and Passage Behavior at John Day Dam – 2011. Presentation at the 2011 Anadromous Fish Evaluation Program. Walla Walla, WA.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	December 11, 2012
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the October 23, 2012, HCP Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met at the Radisson Hotel in SeaTac, Washington on Tuesday, October 23, 2012, from 9:30 am to 11:30 am. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Douglas PUD will distribute their draft HCP Net No Impact (NNI) Progress Report to the Coordinating Committees at least 10 days prior to the December 11, 2012, Coordinating Committees meeting (Item II-A).
- Steve Hemstrom will provide information to the Coordinating Committees on options being investigated for the Rocky Reach Surface Collector operation scheduled for April 2013 (Item III-B).
- Steve Hemstrom will provide information to the Coordinating Committees on the draft U.S. Army Corp of Engineers (USACE) avian predation proposal, including details about the comment period (Item III-C).
- Lance Keller will provide a summary to the Coordinating Committees on the outages in the middle spillway to the Rocky Reach Fishway due to a mandatory Federal Energy Regulatory Commission (FERC) inspection of the Rocky Reach spillway apron and dragons teeth (Item III-D).
- Coordinating Committees representatives will send comments on the draft statement of agreement (SOA) for a data collection strategy for sub-yearling summer/fall Chinook salmon to Steve Hemstrom no later than Friday, November 9, 2012 (Item IV-A).

- The Coordinating Committees' November 27, 2012, meeting was cancelled. The December 2012 meeting date has been rescheduled to Tuesday, December 11, 2012, to be held at the Radisson Hotel in SeaTac, Washington (Item VI-A).

DECISION SUMMARY

- No SOAs were approved at this meeting.

AGREEMENTS

- Coordinating Committees representatives present agreed to Chelan PUD's proposal to extend the Rocky Reach Dam maintenance work outage two weeks from a beginning date of January 2, 2013, to a beginning date of December 17, 2012, to allow more time to complete needed work (Item III-E).

REVIEW ITEMS

- Kristi Geris sent an email notification to the Coordinating Committees on September 25, 2012, that Chelan PUD's HCP Draft 2013 Comprehensive Progress Report is out for a 60-day review period with comments due to Steve Hemstrom by November 30, 2012.

REPORTS FINALIZED

- The 2011 Douglas PUD Pikeminnow Program Annual Report was finalized and distributed to the Coordinating Committees on October 10, 2012.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or other changes to the agenda. Chelan PUD added two items: 1) review of recent outages of the middle fishway at the Rocky Reach Dam; and 2) timing of the annual maintenance outage at the Rocky Reach fishway.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft September 25, 2012, meeting minutes. Kristi Geris said that the only outstanding comment was a question regarding the correct location name for what was referred to as Starr Landing in last month's Hatchery Committees Update. Mike Schiewe provided a brief overview of the Yakama Nation's (YN's) request for a thinning release of coho that were excess to production at Winthrop National Fish Hatchery (NFH); the proposed release location was identified as Starr Landing located upstream of Wells Dam on the Columbia River. Tom Kahler noted that the site was usually referred to as Starr Boat Launch, and the use of Starr Landing would be confusing; the Committees agreed to the change. Geris said that all other comments and revisions received from Committees' members were incorporated in the revised minutes. The draft September 25, 2012, meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Douglas PUD Draft 2013 10-year NNI Comprehensive Check-in Report (Tom Kahler)

Tom Kahler said that Douglas PUD originally discussed having a draft report ready for the October Coordinating Committees meeting; however, Douglas PUD was still waiting for a section on the Fish and Water Management Tool (FWMT) from Dr. Kim Hyatt, Department of Fisheries and Oceans Canada (DFO), that was needed to finalize the report.

Kahler explained that shortly after the implementation of the FWMT, DFO had conducted a retrospective analysis of the potential effectiveness of the FWMT, and concluded that average sockeye smolt production would increase by 55 percent. Kahler said that DFO was now documenting the actual resultant increases in smolt production from 11 years of FWMT deployment in a report to be submitted for publication in a scientific journal, and the report is not expected to be complete until early 2013. He said that Douglas PUD wants to make sure the information in the report is included in their 10-year NNI Comprehensive Check-in Report. Kahler requested one additional month before distributing Douglas PUD's draft report. He said that the report may still be missing the full FWMT component, but will cover the other species and include a draft abstract from DFO's FWMT publication. Kahler said that he will distribute the Douglas PUD draft HCP NNI Progress Report to the

Coordinating Committees at least 10 days prior to the December 11, 2012, Coordinating Committees meeting.

III. Chelan PUD

A. Chelan PUD Draft 2013 10-year NNI Comprehensive Check-in Report (Steve Hemstrom)

Steve Hemstrom said that Chelan PUD has distributed their draft 10-Year Comprehensive Report, and the report is currently in the 60-day comment period. Kristi Geris posted the draft report to the FTP site and distributed the report to the Coordinating Committees by email on September 25, 2012. Comments to the draft report are due to Hemstrom by November 30, 2012. Hemstrom said that Chelan PUD has already received edits and comments from U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). He said that Chelan PUD has nothing new to announce about the draft report, but wanted to provide this opportunity for comments or discussion if needed. No additional comments were provided at this time.

B. Rocky Reach Surface Collector Operation April 2013 (Steve Hemstrom and Lance Keller)

Steve Hemstrom said that as discussed at the September 25, 2012, Coordinating Committees meeting, Turbine Unit 1 (C1) at Rocky Reach Dam will be offline for mandatory rotor crack repair on January 2, 2013, and will be placed back online by May 1, 2013. Hemstrom and Lance Keller discussed options being investigated to provide alternative attraction flow during the Rocky Reach Surface Collector operation including using the pump station, or ramping up Turbine Unit 2 (C2). Hemstrom said that he will provide information to the Coordinating Committees on the options being investigated; and this information is also provided in Attachment B. Hemstrom also added that the bypass and sampling facility will run as usual. Bryan Nordlund asked if the entrance velocities will be affected by C1 being offline, and Keller said that entrance velocities will not be affected.

C. USACE Avian Predation Proposal – Potential Relocation of Caspian Tern Colonies to Banks Lake (Steve Hemstrom)

Steve Hemstrom briefed the Committees that the USACE is reviewing alternatives for reducing impacts of avian predation on salmonid smolts from the Columbia and Snake rivers. This is a required activity under the 2010 Federal Columbia River Power System (FCRPS)

Biological Opinion. Hemstrom said that one option being considered involves relocating a portion of the tern colonies residing in McNary Pool and Goose Island on Potholes Reservoir, to Goose Island on Banks Lake. Hemstrom said that Douglas PUD, Chelan PUD, and Grant PUD are developing a letter to USACE outlining concerns about this alternative. Hemstrom added that several other sites are also under evaluation for the relocation, including a site in Oregon. Jim Craig said that the Priest Rapids Coordinating Committee (PRCC) also discussed this proposal. Jerry Marco noted that the Colville Confederated Tribes (CCT) had already expressed concern that relocation would only move the problem, not address it. Bryan Nordlund agreed with Marco's concerns and added that he is unsure if relocating to Banks Lake would result in a net difference. Mike Schiewe said that this proposal dates back to strategies discussed in the mid-1980s regarding distribution of the avian predation problem. Craig added that planning does not include an option of decreasing the amount of tern colony habitat.

Marco suggested that the U.S. Bureau of Reclamation (Reclamation) may be involved as well, because both locations are Reclamation-owned land, which facilitates an easy move. Marco said that he thinks the Inland Avian Workgroup is involved in this particular relocation proposal, and is developing a draft management plan. He added that the report was delayed and is now not expected until summer 2013, which will allow more time to investigate other sites. Marco also added that the foraging distance is about the same from both locations.

Hemstrom reminded the group that relocation is an alternative under consideration, and not necessarily a recommended action. Hemstrom said that it is unclear how many of the approximately 400 breeding pairs, located at McNary Pool and Goose Island on Potholes Reservoir, would be relocated. Craig said that Banks Lake has the capacity for about 60 breeding pairs.

Hemstrom said that the USACE avian predation proposal is still in draft form, and that he will provide information on the draft proposal to the Coordinating Committees, including information about the comment period. Craig said that the PRCC is developing a letter to USACE; Nordlund added that the letter only outlines data, and it is not a recommendation.

Nordlund added that the letter will hopefully encourage relocating the birds to a location that is not in the upper Columbia River.

D. Recent Outages in the Middle Spillway to the Rocky Reach Fishway (Lance Keller)

Lance Keller said that, as described in an email distributed to the Coordinating Committees on October 15, 2012, FERC requested a mandatory inspection of the Rocky Reach spillway apron and dragons teeth: the inspection required intermittent closure of the middle spillway entrance to the Rocky Reach Fishway from October 15, 2012, to October 18, 2012.

Keller said that outages were required in the middle fishway for three consecutive nights in order to install barriers to inspect the entire spillway apron. Outages included: 1) at 1900 hours on October 15, 2012, restored at 900 hours on October 16, 2012; 2) at 1900 hours on October 16, 2012, restored at 900 hours on October 17, 2012; and 3) at 1900 hours on October 17, 2012, restored at 900 hours on October 18, 2012. Keller apologized for the late notification, and explained that Chelan PUD was unaware a reduction in attraction flow would be required for the inspection. Keller added that he will provide a summary memo to the Coordinating Committees on the outages.

Steve Hemstrom said that because of these outages, Chelan PUD analyzed data on upstream passage of adult salmon, as described in the email distributed to the Coordinating Committees on October 15, 2012. Hemstrom said that the analyses did not indicate any significant statistical differences among passage numbers or rates before, during, or after the outages; therefore, it was concluded that the outages had minimal effects. Bryan Nordlund said that even if Chelan PUD had been able to bring this situation to the Coordinating Committees, the Committees would have recommended Chelan PUD do as they did: perform the inspection at night, and minimize effects. Keller added that Chelan PUD is actively educating new staff on minimizing potential impacts due to project maintenance.

E. Rocky Reach fishway maintenance work outage timing (Lance Keller)

Lance Keller summarized the Rocky Reach fishway maintenance work scheduled for this winter, including fish ladder work, the C1 rotor repair, and antennae array replacement and reinstallation. He said that in order to complete the scheduled fishway maintenance, conduct a full bypass evaluation, and ensure that the C1 repair remains on schedule, Chelan PUD is proposing two additional weeks for outage. This means that fishway maintenance work would start December 17, 2012, as opposed to January 2, 2013, and that the fishway would be back online March 1, 2013.

Mike Schiewe asked if there is a downside to the earlier outage date, and Steve Hemstrom said that biologically, there is minimal passage activity in December according to the past 3 years of monitoring. Keller added that in the past 2 years, Chelan PUD has requested and been approved for even earlier outages. Coordinating Committees representatives present agreed to Chelan PUD's proposal to extend the Rocky Reach Dam maintenance work outage two weeks from a beginning date of January 2, 2013 to a beginning date of December 17, 2012, to allow more time to complete needed work.

IV. HCP Coordination

A. Follow-up on Subyearling Chinook Life History Information (Mike Schiewe and Steve Hemstrom)

Mike Schiewe said that in searching for follow-up information on additional juvenile studies, Bryan Nordlund located a 2008 document summarizing phase designations of plan species under the Rocky Reach and Rock Island Hydroelectric Projects HCPs (Attachment C). The summary document was distributed to the Coordinating Committees by Kristi Geris on October 22, 2012. Schiewe recalled that after Attachment C was finalized in 2008, the Coordinating Committees discussed a path forward that included inviting researchers from other agencies with expertise on subyearling Chinook survival studies to meet with the Coordinating Committees in 2009; they also discussed carrying forward an agreed-upon study information strategy developed by the Coordinating Committees and memorialized by an appropriated SOA. However, a SOA documenting this agreed-upon strategy was not located in reviewed records.

Steve Hemstrom said that based on the 2008 document and the agreed to follow-up, Chelan PUD has now developed a draft SOA summarizing their data collection strategy for sub-yearling summer/fall Chinook salmon (Attachment D). The draft SOA was distributed to the Coordinating Committees by Kristi Geris on October 19, 2012. Hemstrom said that the SOA discusses five items applicable to subyearling Chinook data collection, and satisfies the requirements described in the 2008 summary document that included the Coordinating Committees agreement that Phase III (additional juvenile studies) for Rock Island and Rocky Reach subyearling Chinook. Hemstrom also added that no prior agreements are supplanted by this SOA.

Schiewe noted that Douglas PUD is also at this same phase designation for Wells Project subyearling Chinook and juvenile sockeye salmon, as documented in a February 2005 SOA; and he added that the 2005 SOA is a reaffirmation of what was agreed to in the HCP for Wells. Schiewe recommended revisiting study strategies for sub-yearling Chinook after the first of the year, and before the 2013 field season begins, as more people are available to join discussions.

Bob Rose asked why life history studies on the Snake River were not mentioned in the draft SOA. Hemstrom noted that the migratory diversity of Snake River and Mid-Columbia subyearling Chinook are potentially quite different; however, where appropriate, the behavior of Snake River should be considered. Jim Craig said that the most similarity between the Mid-Columbia and Snake rivers subyearlings would be the technology used to perform the studies. Hemstrom also added that Mid-Columbia fish would likely be smaller due to temperature differences. Schiewe said that Joe Miller and Josh Murauskas have already researched what findings might result from studies on the Snake River; and Miller said that these data are still available if people are interested in reviewing the findings. Miller also added that this SOA is meant to describe a basic commitment, and is not intended to exclude the Snake River.

Tom Kahler said that he hoped to have the Douglas PUD 2011 Subyearling Study Report available for discussion at the Coordinating Committees' December meeting. He said that Douglas PUD also has preliminary results from 2012 tagging, which will contribute data on fish in the upper Columbia River. Coordinating Committees representatives agreed to send comments on the draft SOA for a data collection strategy for sub-yearling summer/fall Chinook salmon to Hemstrom no later than Friday, November 9, 2012.

V. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe reported that the HCP Hatchery Committees did not meet in October due to time conflicts for some participants, and given that Hatchery Committees topics currently under discussion are not time sensitive. Topics under current discussion include: 1) updates to Hatchery Monitoring and Evaluation (M&E) plans; 2) development of 2013 broodstock protocols; and 3) discussions of the future of Rocky Reach spring Chinook production.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Tributary Committees meeting on October 20, 2012:

- *Nason Creek Upper White Pine Reconnection – Chelan PUD Powerline Relocation Alternative Analysis Project*: The Tributary Committees approved the use of remaining project funds, in the amount of approximately $26,000, to hire a mediator with utility experience to facilitate discussions between the U.S. Forest Service (USFS) and Chelan PUD. Tom Kahler explained that Chelan County is proposing to remove all or a portion of a levee to reconnect floodplain where the power lines are located. This proposed action would threaten Chelan PUD's power poles, and an alternatives analysis was commissioned to identify options for relocating the power line/poles. Several options were discussed and the most practical, efficient alternatives involve obtaining new easements through USFS property. Joe Miller added that this issue is not just a matter of new easements, but of existing easements that predate the USFS; so this issue is about giving up something that is irreplaceable.
- *Mission Creek Fish Passage and Wenatchee Levee Removal and Riparian Restoration Projects*: Contract time extensions for the Mission Creek Fish Passage Project and the Wenatchee Levee Removal and Riparian Restoration Project were requested and approved by the Tributary Committees.
- *Small Projects Program Applications*: The Tributary Committees received a Small Projects Program Application requesting $51,257 from Plan Species Account funds to improve and restore riparian areas along a section of Peshastin Creek. After review of the proposal, the Tributary Committees were unable to make a funding decision, and requested that the sponsor explain why they were seeking funds from the Plan Species Accounts when it appears that the proposed project is better funded through a different source.

- *Acquisitions*: The Tributary Committees had been discussing the possibility of purchasing acquisitions, but it was unclear if the PUDs would be willing to hold the titles to the properties. After further consideration, the PUDs decided this was not something they wanted to do. Kahler said that a key consideration was that if property titles were donated to another entity such as Washington Department of Fish and Wildlife (WDFW), it would result in obvious public benefits (e.g., fishing access); these benefits would not necessarily result if the PUDs held the titles to the properties.

VI. HCP Committees Administration (Mike Schiewe)

A. Next Meetings

The Coordinating Committees agreed to cancel the November 27, 2012, meeting, and to reschedule the December meeting to Tuesday, December 11, 2012, at the Radisson Hotel in SeaTac, Washington. The January 2013 meeting is scheduled for January 22, 2013, and is tentatively planned for the Radisson Hotel in SeaTac, Washington.

List of Attachments

Attachment A – List of Attendees
Attachment B – Summary of options being investigated for the Rocky Reach Surface Collector operation scheduled for April 2013
Attachment C – Summary of phase designations of plan species under the Rocky Reach and Rock Island Hydroelectric Projects HCPs
Attachment D – Draft SOA for a data collection strategy for sub-yearling summer/fall Chinook salmon

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Joe Miller†	Chelan PUD
Tom Kahler*	Douglas PUD
Bob Rose*	Yakama Nation
Jerry Marco*†	Colville Confederated Tribes
Bryan Nordlund*	National Marine Fisheries Service
Jim Craig*	U.S. Fish and Wildlife Service

Notes
* Denotes Coordinating Committees member or alternate
† Joined by phone

Chelan PUD
Rocky Reach and Rock Island HCPs
Final 2012 Fish Spill Program Report

2012 ROCKY REACH

Rocky Reach Summer Spill

Target species:	Subyearling Chinook
Spill target percentage:	9% of day average river flow
Spill start date:	May 26, 0001 hrs
Spill stop date:	August 9, 2400 hrs
Percent of run with spill:	**97.42%**
Cumulative index count:	5,774 subyearling Chinook (April 1-August 31)
Summer spill percentage:	31.86% (9% plus 22.86% as forced spill May 26 - Aug 9)
Average river flow at RR:	233,370 cfs (May 26- Aug 9)
Average spill rate at RR:	74,355 cfs (May 26 – Aug 9)
Number of spill days:	76

2012 ROCK ISLAND

Rock Island Spring Spill

Target species:	Yearling Chinook, steelhead, sockeye
Spill target percentage:	10% of day average river flow
Spill start date:	April 17, 0001 hrs
Spill stop date:	May 27, 2400 hrs (immediate increase to 20% summer spill)
Percent of run with spill:	**Yrlng Chins 99.80%; Steelhead 99.75%; Sockeye 99.80%**
Cumulative index count:	25,759 Yearling Chins**;** 16,957 Steelhead**;** 46,788 sockeye
Spring spill percentage:	**16.39%** (10% plus 6.39% forced spill, April 17 - May 27)
Ave river flow at RI:	208,770 cfs (April 17- May 27)
Ave spill flow at RI:	34,210 cfs (April 17- May 27)
Total spill days:	41

Rock Island Summer Spill

Target species:	Subyearling Chinook
Spill target percentage:	20% of day average river flow
Spill start date:	May 28, 0001 hrs
Spill stop date:	August 18, 2400 hrs
Percent of run with spill:	**97.84%**
Cumulative index count:	27,464 subyearling Chinook
Summer spill percentage**:**	**24.79%** (May 28 - August 18)
Ave river flow at RI:	212,290 cfs (May 28- August 18)
Ave spill flow at RI:	59,260 cfs (May 28- August 18)
Total spill days:	83

Juvenile Index Counts 2003-2012 from the Rocky Reach Juvenile Fish Bypass and the Rock Island Smolt Monitoring Program (SMP) April 1 – August 31.

Table 1. Rocky Reach Juvenile Bypass index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	71,683	30,935	17,575	239,185	169,937	136,206	40,758	724,394	67,879	384,224
Steelhead	10,585	6,433	5,821	4,329	4,532	8,721	6,309	4,931	5,683	4,902
Yearling Chinook	13,918	53,946	27,611	23,461	18,080	38,394	18,946	33,840	24,400	95,207
Subyrlng Chinook	172,392	20,062	10,978	19,996	13,496	11,820	11,944	59,751	17,246	5,774

Table 2. Rock Island Smolt Monitoring Program index counts, 2003-2012

Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sockeye	10,312	7,114	1,991	34,604	16,410	38,965	4,926	37,404	18,697	46,788
Steelhead	15,507	10,735	15,974	26,930	18,482	22,780	17,636	17,194	28,408	16,957
Yearling Chinook	15,355	12,574	14,797	37,267	23,714	22,562	9,225	11,802	26,407	25,759
Subyrlng Chinook	25,916	23,563	18,710	27,106	15,686	15,940	8,189	23,205	27,397	27,298

Summary of Phase Designations of Plan Species under the

Rocky Reach and Rock Island Hydroelectric Projects Habitat Conservation Plans

Final

June 2008

The purpose of this document is to summarize and confirm the phase designations of Plan Species under the Rock Island and Rocky Reach Hydroelectric Projects Habitat Conservation Plans (HCP). Further, it serves to document that the Rock Island and Rocky Reach HCP Coordinating Committees (Committee) have reviewed the limitations associated with the best available technology for measuring survival of subyearling Chinook and has concluded that these limitations currently constrain the ability to make empirically based survival estimates.

Rocky Reach and Rock Island - Shared Status

Three specific areas of shared status currently exist between and the Rocky Reach and Rock Island HCP's when addressing survival standards and phase designations and they are: 1) the role of adult survival as it pertains to the 91% combined juvenile and adult survival standard, 2) the current limitations associated with conducting studies to measure or calculate project or dam survival for subyearling Chinook, and 3) the Coho hatchery compensation and interim juvenile survival value. The following discussions express the shared elements first and then conclude with project specific phase designation summaries.

Adult Survival – Inter-dam Conversion Rates

The HCP combined survival standard of 91% at Rocky Reach and Rock Island includes both juveniles and adults. Because the Committee currently agrees that adult fish survival cannot be conclusively measured for each Plan Species, the Committee reviews inter-dam conversion return rates as a surrogate for adult survival. In all years, since the HCP was signed, it appears based on this analysis that the adult survival standards (i.e., ≤2.0% passage mortality) for all Plan species has been achieved.

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Subyearling Chinook Survival Studies

In 2004, Chelan PUD attempted to measure survival of subyearling Chinook salmon passing Rocky Reach and Rock Island dams using acoustic tag technology. Results suggested that survival was low for Rocky Reach and relatively high for Rock Island. The Committee agreed that since the confidence limits were beyond the precision standards stated in the HCP for the Rocky Reach estimate, that it was not a valid study. On a parallel path, the District conducted a controlled laboratory test of fish tagged with acoustic tags identical to those used in the project survival study. These tests showed that a large percentage of the test fish died in the laboratory after tagging. In the 2004 study, the acoustic tag used weighed 0.75 grams and represented 5.3% of the median study fish's body weight (range: 0.67-8.3%). Current laboratory research indicates survival is negatively effected for fish implanted with an acoustic tag equal to or greater than 7.6% of its body weight (Brown et al. 2007). However, other factors, including temperature, and length and condition of the fish also affect survival.

A Statement of Agreement (SOA) developed by the Committee in January of 2005 addressing appropriate tag methodology for the HCP Plan Species declared that future studies with subyearling Chinook using acoustic tags shall be postponed, citing the 2004 Rocky Reach Project subyearling tag effect study. The SOA also acknowledged that PIT tag studies for subyearlings were currently not possible because of sample size requirements (App. F, 2005 Annual HCP Report).

Work in the Snake River suggests not all tagged subyearling Chinook migrate out of the system in the year that they are tagged, but instead may over-winter in reservoirs before migrating the following year (Williams et al. 2008). If this tendency occurs in the Upper Columbia Basin, the "survival" test and measurement as currently conducted is a joint probability of survival and tendency for migration. New developments in acoustic tag technology may eventually be employed to account for over-wintering of subyearling Chinook.

Calculating Subyearling Chinook Dam Survival

Juvenile dam passage survival (JDPS) is generally based on the percentage of fish passing through a route at the dam multiplied by its associated survival through that specific route. However, performing calculations of this nature at Rocky Reach and Rock Island Dams for subyearling Chinook is problematic due to lack of information pertaining to route-specific and indirect survival.

Currently, no information exists for any route-specific survival rates or route selection at Rocky Reach and Rock Island Dams for subyearlings. At this point in time, if one was to calculate JDPS, surrogate information from other species/races of Chinook would have to be used or dam passage survival information from Snake or lower Columbia River federal projects. Because of differences in life history, migration timing, abiotic factors (flow and temperature), and possibly predation rates, it is not reasonable to assume that using information from yearling fish accurately portrays the experience and hence dam passage survival of subyearling Chinook.

The Committee recognizes the difficulties associated with studying subyearling Chinook survival as previously stated, and have at this time determined that current technological and/or biological limitations preclude the ability to measure project survival. Calculations for dam passage survival are problematic due to current lack of ability to gather route-specific information and lack of good surrogate information. Given the combined current difficulties of conducting tests using subyearling Chinook, the Committee has determined that a responsible action going forward with subyearling Chinook would be to develop a well described step-wise approach to acquiring appropriate information that would enable the Committee to determine when technological advancements are available and subsequently when project or dam passage studies could occur. In doing so, the Committee recognizes that although the survival levels have yet to be determined, the phase designation most closely describing future activities of studying subyearling Chinook is Phase III (additional juvenile studies). This designation will carry with it an agreed upon study information strategy developed in Committee and memorialized by an appropriated SOA (currently in development).

Coho Salmon

In a SOA approved on June 20, 2007, the Rocky Reach and Rock Island HCP Hatchery Committees agreed to provide coho hatchery compensation as detailed in Section 8.4.3a of the HCP. Subsequently, the Rocky Reach and Rock Island Coordinating Committees agreed in a June 26, 2007 SOA that an interim juvenile survival value (HCP section 8.4.3a) of 93% will be assumed.

Project Specific Phase Designations

The current phase designations for the Rocky Reach and Rock Island HCP's are summarized in Table 1 below.

Table 1. Rocky Reach and Rock Island HCP Phase Designation summary, 2008.

Plan Species	*Rock Island	Rocky Reach
Yearling Chinook	Phase III Standard Achieved	Phase III (Provisional Review)
Steelhead	Phase III Standard Achieved	Phase III Standard Achieved
Sockeye	Phase III Standard Achieved	Phase II (Additional Tools)
Subyearling Chinook	Phase III (Additional Juvenile Studies)	Phase III (Additional Juvenile Studies)

***Rock Island operations at 20% spill – Phase I survival tests ongoing for 10% spill**

Rocky Reach Project

Upper Columbia steelhead are designated Phase III (standard achieved) base on the results of three years of testing between 2002 and 2004. A SOA recognizing the Phase III designation was formally adopted by the Committee on October 24, 2006.

Sockeye have been designated Phase II (additional tools) because two years of testing suggested that the juvenile project survival standard was likely not going to be achieved without employing some element of additional measures to increase survival. In the best interest of the long-term goals of the HCP, it was agreed that additional studies should be developed to gain information intended on improving juvenile project survival. Current studies at Rocky Reach are now focused on this effort.

Yearling Chinook salmon are considered to be in Phase III (Provisional Review) because in two years of testing (2004, 2005), the survival results were between 91 and 93% Subsequently, the Committee agreed to postpone the last year of Chinook survival testing until modifications to improve sockeye survival were made that may also benefit Chinook survival. The Committee agreed (with NMFS abstaining) to an additional year of testing modified powerhouse operations at Rocky Reach in 2008 in attempt to improve use of the surface collector by sockeye, which should also potentially benefit Chinook. If 2008 study results show no improvement in providing additional survival, then additional tools that could benefit sockeye (such as additional turbine intake screens, physical structures to improve guidance, spill, a second surface collector entrance and others), will be considered. Phase III (Provisional Review) allows the District up to 5 years (until 2011) after the end of Phase I testing to implement additional measures or conduct further studies to achieve the survival standard. As such, by 2011 the District will be required to complete yearling Chinook survival studies.

Rock Island Project

Yearling Chinook, steelhead, and sockeye

Based on the results of three years of testing under conditions of 20% spill, the Upper Columbia steelhead, yearling Chinook and sockeye are designated in Phase III (Standard Achieved).

The Rock Island HCP Committee reviewed and considered both PIT tag and acoustic tag test results for the 3 years of survival testing for yearling Chinook. The Committee agreed that the 3 year average (2002 – 2004) for either PIT or acoustic tags had exceeded the 93% survival standard required in the HCP. Tests were conducted between 2002 and 2004 for all Plan species. Phase III (Standard Achieved) designation for yearling Chinook was formally adopted through a Statement of Agreement (SOA) by the Committee on March 28, 2005, and sockeye and steelhead were formally adopted as Phase III (Standard Achieved) by Committee SOA on October 24, 2006.

The District, upon successful survival testing and Phase III designation of steelhead, yearling Chinook, and sockeye worked with the Committee to investigate the potential of achieving the 93% project survival standard with a 10% spring spill program in place. The Committee approved a SOA in December, 2006 setting in motion a process to test spring migrant plan species project survival at 10% spill operation. Survival tests at 10% level began in 2007 and are currently on-going for yearling Chinook, steelhead, and sockeye. If survival standards are not met with 10% spill for any of these species, spill levels will return to 20%.

Literature Citation

Brown, R.S., K.M. Carter, K.A. Deters, and C.A. McKinstry. 2007. Determination of a minimum fish size for implantation with a juvenile salmonids acoustic telemetry system (JSATS) tag *in*: Hockersmith, E.E., R. S. Brown, and T.L. Liedtke. 2007. Draft Comparative performance of acoustic-tagged and passive integrated transponder-tagged juvenile salmonids. Prepared for U.S. Army Corps of Engineers, Environmental Resources Branch, Planning and Engineering Division, Portland District, Portland, OR. 138 pp.

J. G. Williams, R. W. Zabel, R. S. Waples, J. A. Hutchings and W. P. Connor. 2008. Potential for anthropogenic disturbances to influence evolutionary change in the life history of a threatened salmonid. Blackwell Publishing 271–285.

Rock Island and Rocky Reach HCP Coordinating Committees

Draft Statement of Agreement

Data collection strategy for sub-yearling summer/fall Chinook salmon

October 23, 2012

Statement

The Rock Island and Rocky Reach Habitat Conservation Plans' (HCP) Coordinating Committees (CC) agree to the data collection strategy for sub-yearling summer/fall Chinook salmon outlined below. These research efforts are intended to compliment the Phase III (Additional Studies) designation assigned to sub-yearling summer/fall Chinook salmon in the briefing paper *Summary of Phase Designations of Plan Species under the Rocky Reach and Rock Island Hydroelectric Projects Habitat Conservation Plans*, reviewed and approved as final by the CC at the June 2008 meeting (Attachment A).

Data Collection Strategy

1. *Technology review* – In November of 2009, the HCP-CC joined with other state, federal, tribal, and PUD biologists in the first sub-yearling Chinook workshop. Presenters included fish biologists with expertise in statistics, active and passive telemetry, veterinary medicine, and sub-yearling life history. Workshops will occur every three to five years to inform the HCP-CC with the latest scientific opinions regarding life history and monitoring of sub-yearling Chinook salmon.

2. *Life history research* – In coordination with Douglas PUD, a passive integrated transponder (PIT) tag detector was installed at the Rocky Reach Juvenile Bypass System (JBS) in 2010. Since installation of the arrays, nearly 50,000 juvenile summer/fall Chinook salmon have been detected at the JBS, including several thousand natural-origin fish. These data will continue to provide insight to the behavior of summer/fall Chinook salmon in the mid-Columbia River.

3. *Resident fish study* – Chelan PUD is funding Washington Department of Fish and Wildlife's Large Lake Research Team to evaluate the distribution, abundance, and composition of near shore piscivorous fishes in the Rocky Reach Reservoir. These data will inform managers on predation risks to sub-yearling Chinook salmon.

4. *Monitoring and evaluation efforts* – Chelan PUD has funded extensive monitoring and evaluation (M&E) efforts on hatchery- and natural-origin summer/fall Chinook in the Wenatchee, Methow, and Okanogan river basins. Efforts include broodstock sampling (origin, age, length, sex, and fecundity), hatchery metrics (rearing, acclimation, quantity, size, condition, and survival), natural juvenile productivity (emigrant estimates), spawning surveys (redd counts and distribution, spawn timing, escapement, carcass surveys), and life history monitoring (run timing, age and size at maturity, straying, contribution to fisheries, genetics, proportion of natural influence, natural- and hatchery-replacement rates, and smolt-to-adult survivals). These data are among the most comprehensive in the Columbia River Basin and will provide valuable insight to population dynamics of summer/fall Chinook salmon.

5. *HCP requirements* – Chelan PUD maintains predator removal, operation of the Rocky Reach JBS, summer spill requirements, funding of the tributary conservation plan, and hatchery compensation requirements, consistent with the HCPs, to benefit sub-yearling summer/fall Chinook salmon in the mid-Columbia River Basin. Returns of summer/fall Chinook salmon averaged over 75,000 adults at Rock Island between 2006 and 2010, including over 40,000 natural-origin fish. Chelan PUD has further invested in aquaculture technology to increase performance of summer/fall Chinook smolts, along with funding arrangements with the new Chief Joseph Hatchery (scheduled to release up to 2.9 M juvenile summer/fall Chinook salmon annually).

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Coordinating Committees	**Date:**	January 23, 2013
From:	Michael Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the December 11, 2012 HCPs Coordinating Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Coordinating Committees met at the Radisson Hotel in SeaTac, Washington on Tuesday, December 11, 2012, from 9:30 am to 1:00 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Washington Department of Fish and Wildlife (WDFW) and Yakama Nation (YN) will submit comments on the Chelan PUD Draft 2013 10-year No Net Impact (NNI) Comprehensive Check-in Report to Chelan PUD no later than January 14, 2013 (Item II-A).
- Chelan PUD will develop a timeline summarizing their path forward for compiling and synthesizing information on subyearling Chinook salmon life history diversity and survival in the upper Columbia River. Chelan PUD will distribute the timeline to the Coordinating Committees prior to the Coordinating Committees meeting on January 22, 2013 (Item II-B).
- Steve Hemstrom will distribute Chelan PUD's recommendation for a Rocky Reach Surface Collector Operation scheduled for April 2013, including information on the cleaning system, to the Coordinating Committees prior to the Coordinating Committees meeting on January 22, 2013 (Item II-C).
- Steve Hemstrom will provide information on Rocky Reach screen velocities to Bryan Nordlund (Item II-C).
- Chelan PUD will incorporate recommended edits to the spring Chinook, sockeye, and steelhead adult conversion rates table and will distribute the revised table to the Coordinating Committees (Item II-E).

- Kristi Geris will send an email to the Coordinating Committees notifying them that the Douglas PUD Sub-yearling Report is out for a 60-day review period, with comments due to Tom Kahler and Andrew Gingerich by Monday, February 11, 2013 (Item III-A).
- Douglas PUD will distribute their draft 2013 10-year NNI Comprehensive Check-in Report to the Coordinating Committees no later than December 21, 2012 (Item III-B).
- Chelan PUD and Douglas PUD will have their respective draft 2013 HCP Action Plans ready for discussion by the time of the Coordinating Committees meeting on January 22, 2013 (Item III-C).
- Mike Schiewe will provide a summary of file sharing options to Chelan PUD and Douglas PUD before the Coordinating Committees meeting on January 22, 2013 (Item V-A).

DECISION SUMMARY

- No Statements of Agreement (SOAs) were approved at this meeting.

AGREEMENTS

- Coordinating Committees representatives present agreed to Chelan PUD's request for a Turbine Unit 2 (C2) outage at Rocky Reach Dam during the last week of August 2013 for mandatory rotor crack repair. It was also agreed to employ the same alternative Rocky Reach Surface Collector Operation as approved for the Turbine Unit 1 (C1) outage in April 2013 (Item II-D).

REVIEW ITEMS

- Kristi Geris sent an email to the Coordinating Committees on December 11, 2012, notifying them that the Douglas PUD Sub-yearling Report is available for a 60-day review period, with comments due to Tom Kahler and Andrew Gingerich by Monday, February 11, 2013.
- Kristi Geris sent an email to the Coordinating Committees on December 26, 2012, notifying them that the Douglas PUD draft 2013 Bypass Plan is available for review.

Tom Kahler indicated that he would like to request approval of this draft plan at the Coordinating Committees meeting on January 22, 2013.

- Kristi Geris sent an email to the Coordinating Committees on December 26, 2012, notifying them that the Douglas PUD draft 2013 HCP Action Plan is available for review. Tom Kahler indicated that he would like to possibly request approval of this draft plan at the Coordinating Committees meeting on January 22, 2013.
- Kristi Geris sent an email to the Coordinating Committees on December 27, 2012, notifying them that the Wells Dam draft 2013 NNI Progress Report is available for review.

REPORTS FINALIZED

- There are no reports that have been recently finalized.

I. Welcome

Mike Schiewe welcomed the Coordinating Committees and asked for any additions or other changes to the agenda. The following revisions were requested:

- Mike Schiewe reserved a moment to congratulate Jerry Marco on his retirement and give thanks for his contributions to the Coordinating Committees over the years.
- Tom Kahler removed Douglas PUD agenda item III-3, item III-4, and item III-5.
- Steve Hemstrom added a discussion regarding a one-week outage for Turbine Unit 2 (C2) at Rocky Reach Dam in August 2013.

A. Meeting Minutes Approval (Mike Schiewe)

The Coordinating Committees reviewed the revised draft October 23, 2012 meeting minutes. Kristi Geris said that all comments and revisions received from members of the Committees were incorporated in the revised minutes, and that there were no outstanding edits or questions to discuss. The draft October 23, 2012 meeting minutes were approved as revised. Geris will finalize the meeting minutes and distribute them to the Committees.

II. Chelan PUD

A. Chelan PUD Draft 2013 10-year NNI Comprehensive Check-in Report (Steve Hemstrom and Joe Miller)

Steve Hemstrom said that the 60-day review period for Chelan PUD's Draft 2013 NNI Report is complete. He said that comments on the draft report were received and incorporated and that the revised 2013 NNI Report, with tracked changes, was distributed to the Coordinating Committees by Kristi Geris on December 3, 2012. Joe Miller said that Chelan PUD would like to extend the review period for members of the Coordinating Committees who have not had the opportunity to review the report and provide comments, keeping in mind that Chelan PUD needs to finalize the report before the March 2013 deadline. He said that a draft SOA memorializing the completion of Chelan PUD's HCP 10-year comprehensive progress report was distributed to the Coordinating Committees by Kristi Geris on November 13, 2012. Teresa Scott asked whether a SOA was needed for this document. Mike Schiewe replied that all Coordinating Committees agreements are always documented in the meeting minutes; however, in general, it has been left to the sponsor of an action, study, or report to decide whether to additionally formalize approval or acceptance by the Committees with an SOA. Schiewe suggested that the 2013 NNI Report is significant enough to warrant an SOA. Scott and Bob Rose said that they have not completed their reviews of the report and requested additional time. Miller reiterated that Chelan PUD wanted every member of the Committees to have ample time for review prior to approval, and said that Chelan PUD would like to pick a date and aim for approval of the SOA at that time. Bryan Nordlund and Jim Craig said that they had already submitted comments on Chelan PUD's draft report and that neither had additional comments at this time. Neither Nordlund nor Craig said that they thought an SOA was necessary, but both were open to the use of one. Hemstrom noted that an SOA would serve to document the Committees' rigorous review and final acceptance of the report; and Schiewe said that an SOA will also make the report easier to search for and locate. Jerry Marco agreed that approving an SOA seemed reasonable.

Miller said that Chelan PUD will request approval of the SOA at the Coordinating Committees meeting on February 26, 2013. Hemstrom said that Chelan PUD had compiled a detailed list of responses to each of the comments received to date and that this list was distributed to the Coordinating Committees by Kristi Geris on December 3, 2012. Scott and

Rose confirmed that they will submit comments on the Chelan PUD Draft 2013 10-year NNI Comprehensive Check-in Report to Chelan PUD no later than January 14, 2013.

B. Subyearling Chinook and Chelan PUD Draft SOA (Steve Hemstrom and Joe Miller)

Steve Hemstrom said that Chelan PUD had revised their path forward for addressing subyearling studies and that the draft SOA distributed to the Coordinating Committees by Kristi Geris on October 19, 2012, is now obsolete and has been retracted by Chelan PUD as a decision item. Joe Miller said that, based on Coordinating Committee feedback from the retracted SOA, it was Chelan's understanding that the new path forward should focus on the following questions: 1) what subyearling Chinook data are currently available and what new data could be collected in the near future (e.g., how has technology changed to facilitate the collection of addition information in the immediate future); and 2) how should passage survival of subyearling Chinook be addressed to ensure HCP obligations are met. To address the first question, Miller said that Chelan PUD would like to gather data/information from the previous subyearling summit and compare those to what is available today. Miller explained the goal of this effort would be to initially identify and summarize how the technology available today has changed, relative to survival study design and assumptions, and then apprise the Coordinating Committee. This summary would, in turn, contribute to a decision by the Coordinating Committee bring in additional expertise (similar to the 2009 summit), collect additional data, or otherwise make specific plans for the future. Miller said that Chelan has also seen other data that were directly and indirectly connected to subyearling life histories/productivity and suggested that they would be informative to the Coordinating Committee for future decisions. Miller described Chelan's recent efforts with hatcheries and an evaluation of predator-prey interactions in Rocky Reach Reservoir. He noted one study by WDFW and BioAnalysts concerning subyearling interactions in particular, and he said that those results will be available in February 2013. Miller said that by March or April 2013, these data combined with life history information can be presented to the Coordinating Committees for evaluation. By summer 2013, he said, the Committees should be in a position to recommend next steps (e.g., outreach to additional fisheries staff with specific expertise in the conduct of survival studies with subyearling Chinook, initiate additional studies, etc.). Hemstrom added that this effort would likely include the development of an interim report by Chelan PUD to help inform a path forward; and he noted that this new proposed effort is based on the fact that project survival studies have not been performed.

Bryan Nordlund said that a better understanding of previous subyearling Chinook studies at other sites should help identify data gaps and determine what new data need to be collected in the Upper Columbia. Nordlund added that limitations need to be defined; for example, why current technology is not suitable for studying subyearling survival in the Upper Columbia River in context of why sub-yearling survival studies have not been done to date. Teresa Scott noted that where the Coordinating Committees want to get with subyearling studies and the path for getting there are two different elements. She said that the Committees should determine if studies would include several reaches or just a single reach. She also noted that the prior SOA specified that workshops be held every 3 to 5 years, and she said that as the learning curve increases, the timing of workshops may need to be more frequent.

Miller said that Chelan PUD will develop a timeline summarizing their path forward for compiling and synthesizing information on subyearling Chinook salmon life history diversity and survival in the upper Columbia River. Chelan PUD will distribute the timeline to the Coordinating Committees prior to the Coordinating Committees meeting on January 22, 2013. Nordlund emphasized that technology is quickly advancing and recommended that the Coordinating Committees keep up on these advances.

C. Rocky Reach Surface Collector Operation (scheduled for April 2013): Best Alternatives for Operation During Turbine Unit 1 Outage (Steve Hemstrom and Lance Keller)

Steve Hemstrom reviewed that Turbine Unit 1 (C1) at Rocky Reach Dam will be offline in April 2013 for repairs. He noted that C1 is equipped with screens that divert fish into the bypass system, and that it also provides attraction flow into the cul-de-sac area. Hemstrom said that Chelan PUD is still investigating options for alternative operations during the outage, and he added that choosing an option will come down to an engineering evaluation (an email outlining options being investigated for the Rocky Reach Surface Collector operation was distributed to the Coordinating Committees by Kristi Geris on December 3, 2012).

Hemstrom said that one option being investigated is an increase to the surface collector entrance flow. He said that although Rocky Reach has the infrastructure to allow this increase, the concern is that increased flows may impact smaller fish. He said that another option is to run the other screen unit (Turbine Unit 2 [C2]) above normal level from its minimum set-point flow of 12.1 thousand cubic feet per second (kcfs) to a minimum set-point flow of 15 kcfs; Hemstrom said that this option has been implemented in the past. He said that monitoring at the sampling facility would be conducted daily to monitor any adverse impacts; and added that it could be challenging to evaluate impacts. Lance Keller said that pre-season marked fish releases would ideally be carried out under the modified operations to test for descale, injury, and mortality.

Bryan Nordlund said that he ran calculations for the first option using an increased surface collector entrance flow of 6,800 cfs and concluded that there should not be a problem for salmonids, because screen approach velocities were still low enough to prevent impingement of the size of fish present. He did, however, express concern about whether the Rocky Reach bypass downwell automation could handle that flow. Nordlund asked if this increased flow could result in more turbulent bypass downwell flow, and Hemstrom said that he will ask their engineer about this concern. Nordlund asked Hemstrom to also inquire about the cleaning system, noting that it is important to the overall function of the system. Keller noted that there are extra pumps in the surface collector pump station that can be added and incorporated into existing pump station operations in order to avoid excessive wear due to above-normal use. Hemstrom added that if any undesirable outcomes were to result from the increased flow, the flow could be decreased and the options re-evaluated. He also added that testing the first option would be a good way to inform future operations in the event that pumps go down.

Hemstrom said that he will distribute Chelan PUD's recommendation for a Rocky Reach Surface Collector Operation scheduled for April 2013, including information on the cleaning system, to the Coordinating Committees prior to the Coordinating Committees meeting on January 22, 2013. He also said that he will provide information on Rocky Reach screen velocities to Nordlund.

D. Turbine Unit 2 Outage at Rocky Reach Dam in August 2013 (Steve Hemstrom and Lance Keller)

Steve Hemstrom notified the Coordinating Committees that Turbine Unit 2 (C2) at Rocky Reach Dam will need to be taken offline for the mandatory repair of a cracked rotary unit during the last week in August 2013. He said that the bypass would typically operate through August 31, 2013, so Chelan PUD is proposing an operation similar to the alternative operation approved for the Turbine Unit 1 (C1) outage in April 2013. Lance Keller said that the repair of C2 was originally scheduled for September 2012; however, the date has been moved up to the last week in August due to other unanticipated work and testing. Hemstrom said that he reviewed the past 10 years of data for the proposed time of repair and that there were very few fish using the bypass during the last week of August. Keller said that Chelan PUD needs agreement from the Committees now in order to allow ample time to schedule appropriately. The Coordinating Committees representatives present agreed to Chelan PUD's request for a C2 outage at Rocky Reach Dam during the last week of August 2013 for the mandatory repair of the cracked rotary unit. It was also agreed to employ the same alternative Rocky Reach Surface Collector Operation as approved for the C1 outage in April 2013.

E. Spring Chinook, Sockeye, and Steelhead Adult Conversion Rates Table (Steve Hemstrom and Joe Miller)

Steve Hemstrom said that Josh Murauskas developed draft adult and juvenile combined survival estimates for Rocky Reach and Rock Island dams, using adult passage conversion rate estimates for spring Chinook, sockeye, and steelhead (Attachment B). The draft estimates were distributed to the Coordinating Committees by Kristi Geris on December 7, 2012. Joe Miller said that Murauskas used passive integrated transponder (PIT)-tag data from the past 3 years for the estimates, and that Dr. John Skalski's team reviewed the analyses and provided a document with their independent analysis and findings. Skalski's estimates are described in the adult conversion rate analysis report (Attachment C) that was also distributed to the Coordinating Committees by Kristi Geris on December 7, 2012.

Miller said that these survival estimates were not available when Chelan PUD distributed the first draft of their 2013 NNI Report. He said, however, that Chelan PUD views these results as an important milestone and would like to incorporate them into the final report. He added that, under the HCP, these are very positive results. Miller noted that harvest was only included for sockeye from Rocky Reach in 2010 and 2011. He said that if the harvest component was included, survival estimates would be even higher; however, to be conservative, harvest was not included for steelhead, spring Chinook, or sockeye from Rock Island. Murauskas said that these results are "bare bones" estimates, and noted that there is no way to account for all sources of mortalities; therefore, these estimates represent more than just dam passage and hence are slightly biased in the negative direction.

Teresa Scott asked if harvest in the tributaries was considered as well as in the mainstem; Murauskas responded that only harvest in the mainstem between the projects was used. He said that the harvest component was difficult to document, and that the goal was to limit variability where possible. Bryan Nordlund suggested that calculating survival to the spawning grounds is part of the smolt-to-adult survival for the hatchery recalculation. He acknowledged that this was outside of Chelan PUD's scope of project survival; however, he noted that it would be a useful indicator of overall life cycle survival. Murauskas said that Chelan PUD has started looking at conversion rates to the spawning grounds in the Wenatchee River.

Mike Schiewe noted that juvenile and adult Chinook survivals were estimated from different populations of Chinook, and that this should be explained in a footnote. Whereas juvenile estimates represent spring-migrating yearling Chinook that include a large proportion of yearling summer/fall Chinook, adult survival estimates represent only returning spring Chinook (the latter being Endangered Species Act (ESA)-listed). Schiewe suggested that Chelan PUD more accurately characterize juveniles as "yearlings." Miller said that he believes that this distinction is worth clarifying. Schiewe also noted that juvenile years should be added to the table, and that the year 2012 should be removed from the table title, as these data represent multiple years. Nordlund also noted that not all plan species were included in the table and that the table title should be revised to reflect this omission.

Miller asked the Coordinating Committees if they would like an opportunity for separate review and approval of the table, or whether it should be incorporated in the draft 2012 10-year NNI Report and approved as part of that document. Nordlund said that he would like to review the table separately once all revisions were made. Miller said that Chelan PUD will incorporate recommended edits to the spring Chinook, sockeye, and steelhead adult passage conversion rates table and will distribute the revised table to the Coordinating Committees for approval before its incorporation in Chelan PUD's 10-year NNI Report.

III. Douglas PUD

A. Subyearling Report (Tom Kahler and Andrew Gingerich)

Tom Kahler said that the Douglas PUD 2011 subyearling report and associated presentation (Attachment D) were distributed to the Coordinating Committees by Kristi Geris prior to the Coordinating Committees meeting on December 11, 2012. Kahler introduced Andrew Gingerich to the Coordinating Committees; Kahler said that Gingerich has been working on this subyearling study for the past few years.

Gingerich reviewed the life-history hypotheses, as described in Attachment D, and noted that the hypotheses were separated into two categories: life history and tagging. Bryan Nordlund asked if $H2_{alt}$ in Attachment D implies that there is a percentage of fish that do not migrate through Wells Dam; and Gingerich replied that this hypothesis addresses how the fish are using the system (e.g., passively migrating, rearing, or actively migrating through the system). Gingerich added that one goal of the study is to identify which fish are active migrants versus fish that are rearing or residualizing; so this hypothesis is, in a way, defining the proportion of fish that are actively migrating. Nordlund asked what conclusion about life history is being sought if fish do or do not actively migrate through Wells Dam; and Kahler replied that these data would indicate whether a fish remains in the reservoir for an extended period or is an active migrant. Kahler described how fyke-netting in turbine intakes and spillways and purse-seining in the forebay, conducted in the 1980s and 1990s, captured migrants that generally exceeded the lengths of fish captured and tagged in the current study. Hypothesis 2 sought to determine whether fish of the size captured in those previous studies were actively or passively migrating. Gingerich also noted that some of the hypotheses overlap in both life history and tagging.

Gingerich reviewed capture and detection results, as described in Attachment D, and noted that fish were tagged over a 3-week period and that post-tagging seining was also employed at select locations. Gingerich noted that study methods are outlined in the report. He reviewed graphs of the size distribution of captured fish, by location and by study phase, from late May 2011 into early August 2011. He also reviewed cumulative detection variability and distribution of detections. Gingerich noted that 2011 data indicated that fish were still arriving at McNary Dam 90 days after the termination of bypass operations at Rocky Reach; he said that this was an important factor to consider in terms of tag battery life. Gingerich also noted that PIT-tag detectors operate at downstream dams beginning in April and shut down by November 15 each year, but actual termination of bypass depended on weather and other factors.

Gingerich noted that travel time results indicated that juvenile fish migrate faster as they approach the estuary. Teresa Scott suggested that, in 2011, the water year likely had a significant impact on travel time. Gingerich agreed that the 2011 water year was not an average year in terms of flow and said that after a few more years of data are collected, annual variation and covariates would be better understood.

Gingerich reviewed graphs depicting an apparent size threshold for migration in 2011 and noted that the report includes further statistical analyses, including correlation coefficients and p-values. He said that results indicate substantial variation in migration timing for fish smaller than 87 mm, in contrast with fish 87 mm and longer, but he wants to be careful not to draw any conclusions on size thresholds based on only one year of data. Nordlund asked about the 86-millimeter (mm) threshold, and Gingerich explained that the 86-mm fish length was a size threshold beyond which fish began to leave the littoral habitat. Gingerich added that the results indicate that travel time is five times faster for fish of fork lengths greater than 86 mm when compared to those fish that were smaller than that threshold at tagging. Gingerich reviewed the probability of detection for fish of fork lengths less than 87 mm and for those greater than 86 mm. He said that the results indicated higher rates of detection for larger fish. He also noted that because fish size impacts the probability of mortal injury to tagged fish, there is probably some bias in detection due to fish size even while carrying a 0.1 gram PIT tag. Gingerich explained that smaller fish are more likely to sustain mortal injury due to the smaller fish needing to increase the volume of their swim bladders, relative to larger conspecifics, to make up for the negative buoyancy of carrying a tag. The relative increase in swim bladder size makes smaller fish more susceptible to pressure changes during passage at the dam.

Gingerich said that challenges encountered during the study included the collection of fish that were too small to tag early in the season and the difficulties in locating fish later in the season. Jim Craig asked if any sampling was conducted at night, and Gingerich said that early morning sampling was conducted but that no night sampling was conducted. Jerry Marco asked about temperature differences from May 2012 to August 2012, and Gingerich said that there were differences; however, those differences were only a few degrees Celsius from when tagging began to when tagging stopped. He did note, however, that once the temperature reached about 16 to 17 degrees Celsius, no fish were caught. Gingerich said that fish of all sizes experienced a period of relatively slow growth following tagging and release. Nordlund asked if these fish eventually caught up in size, and Kahler said that some "compensatory growth" would likely occur so that they would catch up with the sizes of their cohort, but that some researchers have noted increased mortality following compensatory growth.

Gingerich reviewed the conclusions. Hemstrom asked if an increase in travel time could be expected based on different flows. Gingerich said that he believes that flows have little effect on migration time; he added that studies conducted in the Snake River also show that flows are only part, if at all, a predictor of travel time for subyearling Chinook. Scott asked how the detection rate may be impacted by flows, and Gingerich said that it is hard to tell with only one year of data. Nordlund also asked if non-migratory fish might be affected by higher flows. Kahler said that the literature reports a decrease in survival with decreasing flow, increasing temperature, and decreasing turbidity; but, he said, the effects of each variable are difficult to isolate because they are interrelated.

Gingerich said that Douglas PUD is just starting to analyze the 2012 data and is discussing how best to present the results; options considered include preparing a stand-alone report, drafting a memorandum comparing the 2011 and 2012 data, or waiting until 2013 to provide a comprehensive 3-year report. Bob Rose suggested that for 2012 it would useful for Douglas PUD to prepare and distribute the same summary graphs and figures as were developed for 2011. Gingerich said that, in 2012, almost 20,000 fish were tagged and released over a 3-week duration, and that, in 2013, they may collect and tag for a longer duration and thus tag more fish. Kahler noted that the Douglas PUD Sub-yearling Report that was just distributed to the Coordinating Committees is now out for a 60-day review period with comments due to Kahler and Gingerich by Monday, February 11, 2013.

B. Douglas PUD Draft 2013 10-year NNI Comprehensive Check-in Report (Tom Kahler)

Tom Kahler said that he will distribute the Douglas PUD draft 2013 10-year NNI Comprehensive Check-in Report to the Coordinating Committees no later than December 21, 2012.

C. Douglas PUD Draft 2013 HCP Action Plan (Tom Kahler)

Tom Kahler indicated that Douglas PUD will have their draft 2013 HCP Action Plans ready for discussion at the Coordinating Committees meeting on January 22, 2013. Chelan PUD indicated that they would have their 2013 HCP Action Plan available as well. Both plans will be on the agenda for approval at the Coordinating Committees meeting on February 26, 2013.

D. Douglas PUD Draft 2013 Bypass Operations Plan (Tom Kahler)

Tom Kahler said that the draft Wells Dam Bypass Operating Plan was distributed to the Coordinating Committees by Kristi Geris on December 7, 2012, and that there were no immediate questions or comments on the plan. The plan will be on the agenda for discussion and potential approval at the Coordinating Committees meeting on January 22, 2013.

E. Fishway Projects Planned and Underway During the 2012/2013 Winter Maintenance Period (Tom Kahler)

Tom Kahler said that several adult fishway projects were scheduled for the winter 2012/2013 fishway maintenance outages at Wells Dam, including: 1) installation of PIT-tag detection antennae in Pool 19 of the east ladder along with the new 2020 readers that record both full-and half-duplex (HD) PIT-tags; 2) installation of improved grating around the count windows in both the East and West Fish Ladders to prevent lamprey bypassing the count windows and fish stranding in the count-window bypass-chamber; 3) installation of new (or reconnection of existing) radio-telemetry (RT) antennas in both fishways, in preparation for a lamprey RT study in 2013; and 4) installation of safety railings along the tops of the walls of both fishways from Pool 37 down to Pool 6.

IV. Hatchery and Tributary Committees Update (Mike Schiewe)

Mike Schiewe said that the Hatchery Committees are meeting on December 12, 2012, and that key discussions will include updates to the Hatchery Monitoring and Evaluation (M&E) Plans, review of options for meeting Chelan PUD's spring Chinook production in the Methow Basin, and development of 2013 broodstock protocols.

Schiewe updated the Coordinating Committees on the following actions and discussions that occurred at the last Tributary Committees meeting on November 19, 2012:

- *Small Projects Program Applications*: The Tributary Committees reviewed three Small Projects Program Applications in November: 1) Twisp River Well Conversion; 2) Beaver Creek Late Season Well Test; and 3) Peshastin Creek Riparian Restoration Project. Funding for the Twisp River Well Conversion was approved; however, the Tributary Committees were unable to make a funding decision for the Beaver Creek Late Season Well Test, and elected not to fund the Peshastin Creek Riparian Restoration Project.
- *Budget Amendment*: The Rocky Reach Tributary Committee approved a budget modification requested by Trout Unlimited. The sponsor said that it took longer than expected to secure permits and that costs to complete those permits were higher than anticipated.
- *Tributary Assessment Program*: The Tributary Committees are discussing how to implement the Tributary Assessment Programs. Tom Kahler explained that the Assessment Program sets aside $200,000 per HCP each year, which is separate from the Plan Species Accounts. He said that the money was originally intended for evaluating projects funded out of the initial contributions to the Plan Species Accounts, but that there has been proliferation of other projects aimed at doing what

some envisioned would be accomplished with this money. Kahler said that the Tributary Committees are now discussing if a parallel process should be initiated, or if the funds should be used for something different. Teresa Scott noted the McNary Fisheries Compensation Committee as a potential partner to contribute to whole reach scale projects.

V. HCP Committees Administration (Mike Schiewe)

A. File Sharing

Mike Schiewe reminded the Coordinating Committees of an ongoing discussion that has yet to be resolved regarding how to manage and archive HCP project files. He introduced Relativity and SharePoint and briefly reviewed the searching capabilities and transferability of each. He said that he will provide a summary of file sharing options to Chelan PUD and Douglas PUD before the Coordinating Committees meeting on January 22, 2013. Tom Kahler reminded the Committees that Douglas PUD had previously suggested the possibility of using their Document Management Tools (DMT) platform; however, further internal discussion resulted in a decision to instead consider using the PUD's existing SharePoint platform for all of the HCP associated documents. He said that Douglas PUD Information Services is working with the Natural Resources Department on an externally available SharePoint site that can be used as a HCP data exchange platform and archive. Schiewe said that one important advantage of Relativity was that it includes a search function allowing searches within a variety of different types of files, including PDFs, whereas SharePoint only allows search within Microsoft Word files (note: Douglas County PUD Information Services confirms that SharePoint does allow searches of PDF documents with OCR capability).

B. Annual Reports

Mike Schiewe noted that the Rocky Reach Dam, Rock Island Dam, and Wells Dam 2012 Annual Reports are being prepared. Kristi Geris said that the comment periods will be from February 8, 2013, to March 6, 2013, for the Wells Dam Annual Report, and from February 21, 2013, to March 19, 2013, for the Rocky Reach Dam and Rock Island Dam Annual Reports.

C. Jerry Marco's Retirement

On this occasion of his last Coordinating Committees meeting, members thanked Jerry Marco for his many years of hard work and numerous contributions to the development and implementation of the Wells, Rocky Reach, and Rock Island HCPs. Marco said that he would notify the Colville Confederated Tribes' (CCT's) interim director that the signatories need a CCT representative for the Coordinating Committees meeting on January 22, 2013. He added that he enjoyed his tenure on the Coordinating Committees, and wished the members continued success.

D. Next Meetings

The next scheduled Coordinating Committees meeting is January 22, 2013, to be held in person in at the Radisson Hotel in SeaTac, Washington. The February 26, 2013 and March 26, 2013 meetings will be held either by conference call or in person at the Radisson Hotel in SeaTac, Washington, but this is yet to be determined.

List of Attachments

Attachment A – List of Attendees
Attachment B – Draft adult and juvenile combined survival estimates for Rocky Reach and Rock Island, with adult passage conversion rate estimates for spring Chinook, sockeye, and steelhead
Attachment C – Adult conversion rate analysis report
Attachment D – Douglas PUD 2011 Subyearling Report presentation

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Steve Hemstrom*	Chelan PUD
Lance Keller*	Chelan PUD
Joe Miller	Chelan PUD
Josh Murauskas†	Chelan PUD
Tom Kahler*	Douglas PUD
Andrew Gingerich	Douglas PUD
Jerry Marco*	Colville Confederated Tribes
Bob Rose*†	Yakama Nation
Bryan Nordlund*	National Marine Fisheries Service
Jim Craig*	U.S. Fish and Wildlife Service
Teresa Scott*	Washington Department of Fish and Wildlife

Notes
* Denotes Coordinating Committees member or alternate
† Joined by phone

Attachment B

DRAFT

Adult and Juvenile Combined Survival Estimates for Plan Species in the Rock Island and Rocky Reach Hydroelectric Projects, 2012

Table 1. Summary of juvenile, adult, and combined survival rates for Plan Species at Rock Island and Rocky Reach, 2012. Adult conversion rates calculated from adult passage data, years 2010-2012. HCP Combined Adult and Juvenile Project Survival standard is 91%.

Project	Species	Juvenile	Adult	Combined
Rock Island	Steelhead	96.75%	99.31%[1]	**96.08%**
	Spring Chinook	93.75%	99.89%[2]	**93.65%**
	Sockeye	93.27%	98.37%[1]	**91.75%**
Rocky Reach	Steelhead	95.79%	98.93%[1]	**94.77%**
	Spring Chinook	92.37%	99.90% [2,3]	**92.28%**
	Sockeye	93.59%	98.92%[4]	**92.58%**

[1] Estimate does not account for fish losses due to recreational harvest in any years.

[2] No recreational harvest occurred.

[3] Adult conversion rate and Combined Project Survival approved by SOA on August 30, 2011 using 2009-2011 passage data.

[4] Estimate adjusted for fish losses from recreational harvest in 2010 and 2011, but not for harvest losses in 2012.

Estimation of the Adult Salmon and Steelhead Conversion Rates through Rock Island and Rocky Reach Projects, 2010-2012

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5 December 2012

Introduction

This report summarizes our analysis of detections of PIT-tagged adult salmon and steelhead in the mid-Columbia River past Rock Island and Rocky Reach dams in 2010, 2011, and 2012. It extends our previous analysis of the conversion rate of adult spring Chinook salmon through the Rocky Reach Project in 2009 – 2011 to adult spring Chinook salmon through the Rock Island Project in 2010 – 2012, and to both adult sockeye salmon and adult steelhead through the Rock Island and Rocky Reach projects in 2010 – 2012.

The adult conversion rate through a hydroelectric project is a measure of the probability that an adult salmon present at the downstream end of the project (i.e., tailrace of the dam) survives past both of the dam and the reservoir. It is most simply calculated as the ratio of the number of tagged adults detected at the upstream end of the reservoir to the number detected at the downstream end of the project's tailrace. However, the PIT-tag detectors at the mid-Columbia dams are located in the adult fish ladders, and are thus offset from the dam tailraces. For this reason, a conversion rate calculated only by detections at the dam in question and the next dam upstream may assign losses to the incorrect project. Nevertheless, it is possible to make strong inferences about the minimum adult survival experienced through a given project by estimating the conversion rate through the reach that includes both the project in question and one or more of the neighboring projects. For example, a minimum estimate of survival through the Rocky Reach Project may be estimated by the conversion rate from the Rock Island ladder to the Wells ladder. Survival through the Rock Island Project may be minimally estimated by the conversion rate from the Priest Rapids ladder to the Rocky Reach ladder.

The conversion rate provides only a minimum estimate of survival through a project, both because it includes parts of projects other than the one under consideration in an effort to completely cover the given project, and because it reflects losses from factors other than Project-related mortality. In particular, it will reflect losses from straying to tributaries and harvest mortality between dams, non-detection at the upstream dam, and fallback at the downstream dam that is not followed by reascension. The multi-project conversion rate may be scaled to a single-project conversion rate by taking the square root or cubed root, as appropriate. Straying and harvest loss may be partially accounted for by records of recaptures and harvest reports, although without independent estimates of recapture and harvest reporting rates, the adjusted conversion rate will remain a minimum estimate of survival.

Methods

Rock Island Project

Adult survival through Rock Island Project was estimated using a three-project conversion rate from Priest Rapids Dam to Rocky Reach and/or Tumwater dams for adult spring Chinook salmon, steelhead, and sockeye salmon for years 2010, 2011, and 2012. Annual single-project conversion rates representing the Rock Island Project were also estimated by taking the cubed root of the three-project conversion rates. The three-year arithmetic average was reported for both the three-project conversion rate and the single-project conversion rate representing the Rock Island Project. Confidence intervals were reported at the 95% level for annual estimates and three-year average estimates. The confidence intervals and standard errors on the three-year averages were based on the annual standard error estimates, rather than on the sampling variability of the annual point estimates. This is appropriate for making inferences directly to the three years in question (2010, 2011, and 2012).

PIT-tag detections were downloaded from the PTAGIS database on 30 November 2012. For each stock and year, detections were used from the Priest Rapids, Rocky Reach, Wells, and Tumwater adult fish ladders. Spring Chinook salmon detections were limited to those from fish that had been tagged as juveniles in the Methow Basin, upstream of Wells Dam. Steelhead detections were limited to those fish that had been tagged as juveniles in the Methow and Okanogan Basins, upstream of Wells Dam. Sockeye detections came from fish tagged as adults at the Bonneville Adult Fish Facility, and thus represented non-known-source fish. Successful conversion for sockeye through the Rock Island Project was indicated by detection at either Tumwater, Rocky Reach, or Wells dams, whereas successful conversion for spring Chinook salmon and steelhead was indicated by detection at either Rocky Reach or Wells dams.

Rock Island Project: Spring Chinook Salmon

Spring Chinook detections were limited to those that passed through the Priest Rapids-Rocky Reach Dam reach before 1 July of each year, when the Chinook salmon fishery opened. To remove those fish that were migrating after the opening of the fishery, a cutoff arrival date at Priest Rapids was selected to give fish sufficient time to reach Rocky Reach Dam before the fishery opening on 1 July. The cutoff date was determined using the average observed travel time between Priest Rapids and Rocky Reach dam each year (4.5 – 5.2 days). The cutoff date used was 25 June each year. In 2010, one tag was omitted because it arrived at Priest Rapids after this date; it subsequently arrived at Rocky Reach on 1

July. In 2011, seven tags were omitted because they arrived at Priest Rapids after 25 June; each subsequently arrived at Rocky Reach on or before 1 July. No tags were omitted in 2012 because of late passage. Mini-jacks were excluded each year. The annual adult three-project conversion rate for spring Chinook salmon through the Priest Rapids – Rocky Reach Dam reach was estimated as

$$\hat{C} = \frac{n_{RR}}{N_{PR}},$$

where N_{PR} is the number of adult PIT-tagged spring Chinook salmon detected at Priest Rapids by 25 June of the given year, and n_{RR} is the number of the N_{PR} fish that were subsequently detected at Rocky Reach Dam (or Wells Dam) before 1 July. Detections of hatchery and wild fish were combined for this analysis.

Rock Island Project: Sockeye Salmon

Adult sockeye passing Priest Rapids Dam may be headed toward regions upstream of Rocky Reach and Wells dams, or they may be headed toward Tumwater Dam on the Wenatchee River. Thus, detections from Tumwater were included in estimates of the conversion rate through the Rock Island Project, as well as detections from Rocky Reach and Wells.

Sockeye fisheries opened in July of each year downstream of Wanapum Dam. However, the majority of the tagged sockeye passing Priest Rapids were detected there after 1 July each year, so no attempt was made to remove those individuals at risk to the fishery. Furthermore, no harvest data were available from that fishery, so the Rock Island Project conversion rate for sockeye was not adjusted for harvest mortality. Thus, the conversion rate may be considered only a minimum estimate of survival from Priest Rapids to Rocky Reach or Tumwater, and in particular through the Rock Island Project.

The annual adult three-project conversion rate for sockeye salmon from Priest Rapids to Rocky Reach Dam was estimated as

$$\hat{C} = \frac{n_{RR} + n_{TU}}{N_{PR}},$$

where N_{PR} is the number of adult PIT-tagged sockeye salmon detected at Priest Rapids in the given year, n_{RR} is the number of those fish that were subsequently detected at Rocky Reach Dam (or Wells

Dam) that year, and n_{TU} is the number of the Priest Rapids fish that were subsequently detected at Tumwater Dam that year. Because all sockeye were tagged as adults, it was not possible to calculate separate estimates for hatchery and wild fish, so only the combined estimate is reported.

Rock Island Project: Steelhead

Steelhead counts were adjusted to account for overwintering between Priest Rapids Dam and Rocky Reach Dam. One steelhead was detected at Priest Rapids Dam in 2011 and at Rock Island, Rocky Reach, and Wells dams in 2012. This tag contributed to the 2011 conversion rate through the Rock Island Project (and the Rocky Reach Project).

A steelhead fishery opened between Rock Island and Rocky Reach dams on 8 September in 2010 and on 22 September in 2011, and counts of reported harvest were available from the Washington Department of Fish and Wildlife (WDFW). No harvest counts were available from 2012 by the time of analysis. For 2010 and 2012, loss due to harvest was accounted for by estimating the harvest rate in the Rock Island – Rocky Reach Dam reach and adjusting the three-dam project conversion rate accordingly. Because the harvest adjustment was applied equally to all three reaches comprising the reach from Priest Rapids to Rocky Reach Dam, the resulting single-project harvest-adjusted conversion rate is only a minimum estimate of passage survival through the Rock Island Project.

Harvest rate in the reach between Rock Island and Rocky Reach dams was estimated by

$$\hat{h} = \frac{N_{harvest}}{M_{RI(ROR)}},$$

where $N_{harvest}$ is the reported harvest count in the reach between Rock Island and Rocky Reach in the given year, and $M_{RI(ROR)}$ is the total window count of adult hatchery steelhead after the opening of the fishery each year, as reported on the DART at the University of Washington (www.cbr.washington.edu/DART). Because window counts are not available through the late fall and winter, and the harvest count may be under-reported, it is possible that the harvest rate estimate is biased. Using the estimated harvest rate estimate, the harvest-adjusted conversion rate for hatchery fish was estimated as

$$\hat{C}_{h(H)} = \frac{n_{RR(H)}}{N_{PR(H)}(1-\hat{h})},$$

where $N_{PR(H)}$ and $n_{RR(H)}$ are the numbers of adult hatchery steelhead detected at Priest Rapids and again subsequently at Rocky Reach or Wells, respectively. Because harvest targeted only hatchery fish, no harvest adjustment was made for wild fish conversion rates. The combined three-project conversion rate for wild and hatchery fish was estimated as

$$\hat{C}_h = \frac{n_{RR(H)} + n_{RR(W)}}{N_{PR(H)}(1-\hat{h}) + N_{PR(W)}},$$

where $N_{PR(W)}$ and $n_{RR(W)}$ are the number of adult wild steelhead detected at Priest Rapids and again subsequently at Rocky Reach or Wells, respectively. Standard errors were estimated using the delta method.

Rocky Reach Project

Adult survival through the Rocky Reach Project was estimated using a two-project conversion rate from Rock Island Dam to Wells Dam for adult steelhead and sockeye salmon for years 2010 and 2012. Annual single-project conversion rates representing the Rocky Reach Project were calculated by taking the square root of the two-project conversion rates. Both annual estimates and the three-year arithmetic average were reported for both the two-project conversion rate and the single-project conversion rate. Confidence intervals were reported at the 95% level. The confidence intervals and standard errors on the three-year averages were based on the annual standard error estimates, rather than on the sampling variability of the annual point estimates. This is appropriate for making inferences directly to the three years in question (2010, 2011, and 2012).

PIT-tag detections were downloaded from the PTAGIS database on 30 November 2012. For each stock and year, detections were used from the Rock Island and Wells adult fish ladders. Detections of sockeye in the Tumwater adult fish ladder were used, as well. Sockeye detections came from fish tagged as adults at the Bonneville Adult Fish Facility, and thus represented non-known-source fish. Sockeye detections were limited to those that were not eventually detected at Tumwater Dam (see below). Steelhead detections were limited to those fish that had been tagged as juveniles in the Methow and Okanogan Basins, upstream of Wells Dam. For each species, successful conversion through the Rocky Reach Project was indicated by detection at Wells Dam.

Rocky Reach Project: Sockeye Salmon

Sockeye detected at Rock Island Dam may have been headed either toward Rocky Reach and Wells dams, or toward Tumwater Dam on the Wenatchee River. Those fish that remained in the Columbia River past Rocky Reach Dam also experienced a fishery on their way to Wells Dam. The standard conversion ratio is

$$\hat{C} = \frac{n_{WE}}{N_{RI}},$$

where N_{RI} is the number of tagged adults detected at Rock Island Dam, and n_{WE} is the number of the Rock Island adults subsequently detected at Wells Dam. The expected value of this estimator is the joint probability of heading toward Wells Dam (i.e., not entering the Wenatchee River) and surviving from Rock Island to Wells Dam (i.e., ϕ_{WE}). The complement of C (i.e., $1-C$) includes the probability of leaving the Columbia River for the Wenatchee, as well as mortality within the Columbia from either natural factors, harvest, or both. An alternative estimator is

$$\hat{C}_T = \frac{n_{WE}}{N_{RI} - n_{TU}},$$

where n_{TU} is the number of adult sockeye detected both at Rock Island Dam and at Tumwater Dam (possibly after detection at Wells or Rocky Reach). The expected value of this estimator is approximately

$$E(\hat{C}_T) \approx \frac{\phi_{WE}}{1-\phi_{TU}},$$

where ϕ_{TU} is the joint probability of heading toward Tumwater Dam and surviving there from Rock Island Dam. If all fish that were directed toward Tumwater Dam from Rock Island survived to reach Tumwater, then the expected value of $\hat{C}_T$ would equal survival from Rock Island to Wells Dam, assuming no harvest mortality, fallback, or other straying. However, it is not necessarily warranted to assume 100% survival from Rock Island to Tumwater Dam, and without an independent estimate of that survival probability, it is not possible to estimate the probability of survival in the Columbia River from Rock Island to Wells Dam separately from the probability of being directed to Wells Dam. On the other hand, for Rock Island – Tumwater survival less than 100%, the expected value of $\hat{C}_T$ will be less than the true survival from Rock Island to Wells Dam, so C_T may be considered a minimum estimate of that survival.

Another factor that may be accounted for is harvest mortality between Rocky Reach and Wells dams. Harvest counts were available from WDFW, and may be used to estimate a minimum harvest rate in that reach, with the understanding that imperfect harvest reporting rates result in a negatively biased harvest rate. A minimum harvest rate may be estimated by

$$\hat{h} = \frac{N_{harvest}}{M_{RR(ROR)}},$$

where $M_{RR(ROR)}$ is the number of run-of-river sockeye adults estimated to have passed Rocky Reach Dam during the dates when the fishery was open (1 July – 15 October each year), and $N_{harvest}$ is the harvest count. The harvest applies only to hatchery fish, whereas the window counts at Rocky Reach Dam are not separated for wild and hatchery sockeye, so $\hat{h}$ will be negatively biased because wild fish are included in $M_{RR(ROR)}$. Also, $N_{harvest}$ is likely an undercount of the actual sockeye harvested, which also contributes to negative bias in $\hat{h}$. The probable negative bias in $\hat{h}$ results in the harvest-adjusted conversion rate being a conservative (i.e., minimum) estimate of the two-project survival from Rock Island to Wells Dam. The harvest-adjusted conversion rate is estimated as

$$\hat{C}_{hT} = \frac{n_{WE}}{(N_{RI} - n_{TU})(1-\hat{h})}.$$

Under the assumption of 100% survival from Rock Island to Tumwater, 100% harvest reporting rate, and all hatchery fish (and assuming no other straying or fallback over Rock Island), this estimator is unbiased for survival from Rock Island to Wells Dam. With imperfect survival to Tumwater Dam, an imperfect harvest reporting rate, or a sizeable proportion of the sockeye run represented by wild fish, $\hat{C}_{hT}$ is a minimum estimate of survival from Rock Island to Wells. The square root of $\hat{C}_{hT}$ is also a minimum estimate of survival through the Rocky Reach Project. The recommended estimator of the sockeye salmon conversion rate, and that reported in the results, is $\hat{C}_{hT}$.

Rocky Reach Project: Steelhead

Steelhead detection data were adjusted to account for overwintering between Rock Island Dam and Wells Dam. One steelhead was detected at Priest Rapids, Rock Island, and Rocky Reach dams in 2010, and finally detected at Wells Dam in 2011. This was considered a successful 2010 conversion through the Rocky Reach Project. Similarly, one tag was detected at Priest Rapids, Rock Island, and Rocky Reach dams in 2011 and at Wells Dam in 2012; this tag was considered a successful 2011 conversion.

Hatchery steelhead experienced a fishery in both the reach from Rock Island to Rocky Reach, and from Rocky Reach to Wells Dam. The reach-specific harvest rate was estimated by

$$\hat{h}_{RI} = \frac{N_{harvest:RI-RR}}{M_{RI(H)}} \quad \text{and} \quad \hat{h}_{RR} = \frac{N_{harvest:RR-WE}}{M_{RR(H)}},$$

where $M_{RI(H)}$ and $M_{RR(H)}$ are the window counts of hatchery steelhead at Rock Island and Rocky Reach dams, respectively, during the summer and fall portion of the fishery each year, as reported on the DART website. Imperfect harvest reporting rates and window counts again result in possibly biased harvest rate estimates. Using the available harvest data, the harvest-adjusted conversion rate from Rock Island to Wells Dam for hatchery steelhead was defined as

$$\hat{C}_{h(H)} = \frac{n_{WE(H)}}{N_{RI(H)}(1-\hat{h}_{RI})(1-\hat{h}_{RR})},$$

where $N_{RI(H)}$ and $n_{WE(H)}$ are the counts of adult PIT-tagged hatchery steelhead detected at Rock Island and also at Wells, respectively. The combined two-project conversion rate for wild and hatchery steelhead was estimated as

$$\hat{C}_h = \frac{n_{WE(H)} + n_{WE(W)}}{N_{RI(H)}(1-\hat{h}_{RI})(1-\hat{h}_{RR}) + N_{RI(W)}},$$

where $N_{RI(W)}$ and $n_{WE(W)}$ are the number of adult wild steelhead detected at Rock Island and again subsequently at Wells, respectively. The single-dam harvest-adjusted conversion rate was estimated as the square root of $\hat{C}_h$, and represented a minimum estimate of survival through the Rocky Reach Project. Standard errors were estimated using the delta method.

Results

Results from the conversion rate analysis are presented by stock below. In each case, the three-project and/or two-project conversion rate estimates are presented, as well as the single-project conversion rate. Because conversion rates include losses from straying, fallback, and unknown (or uncorrected) harvest mortality as well as natural mortality, the multi-project conversion rate is a strong minimum estimate of survival through all projects comprising the reach. Thus, the multi-project conversion rate is also a strong minimum estimate of survival through the reach in question (either Rock Island from the three -project conversion rate, or Rocky Reach from the two -project conversion rate). The single-project conversion rate provides a minimum survival estimate on the scale of a single project, and is a reasonable estimate of survival through the project in question assuming common survival through all projects.

Spring Chinook Salmon: Rock Island Project

The three -project conversion rate from Priest Rapids Dam to Rocky Reach Dam included the Rock Island Project in its entirety. All adult spring Chinook salmon detected at Priest Rapids in 2010 or 2011 were subsequently detected in the Rocky Reach fish ladder, yielding conversion rate estimates of 1.0000 ($\widehat{SE}$ =0) in those years (Table 1). In 2012, all but 1 of the 97 tagged adult spring Chinook salmon detected at Priest Rapids were subsequently detected at Rocky Reach, producing a conversion rate estimate of 0.9897 ($\widehat{SE}$ =0.0103; Table 1). The 3-year arithmetic average of the conversion rate estimates was 0.9966 ($\widehat{SE}$ =0.0034), with an asymptotic 95% confidence interval of (0.9899, 1.0033) (Table 1). The single-project conversion rate estimates were 1.0000 ($\widehat{SE}$ =0) in 2010 and 2011, and 0.9966 ($\widehat{SE}$ =0.0034) in 2012, yielding a 3-year average estimate of 0.9989 ($\widehat{SE}$ =0.0011, 95% CI = (0.9966, 1.0011); Table 1). Because the conversion rate between Priest Rapids and Rocky Reach reflects losses from straying, fallback, and unauthorized harvest as well as natural mortality and also covers a longer river reach than the Rock Island Project, we can conclude that the 3-year average survival of adult spring Chinook salmon through the Rock Island Project was at least as high as 0.9899 (the lower limit of the 95% confidence interval for the three-dam conversion rate estimate), and is more likely as high as

0.9966 (the lower limit of the single-project confidence interval). Our best point estimate for the 3-year average is 0.9989.

Table 1. PIT-tag data and estimates of conversion rate from Priest Rapids to Rocky Reach for adult spring Chinook salmon tagged as juveniles in the Methow River Basin. The single-project conversion rate is estimated as the cubed root of the Priest Rapids – Rocky Reach conversion rate. The average is the 3-year arithmetic average. The 95% confidence intervals are profile likelihood confidence intervals for the year-specific results, and asymptotic confidence intervals for the 3-year average.

	PIT-tag detections		**Priest Rapids – Rocky Reach Conversion Rate**			**Single-Project Conversion Rate**		
Year	Priest Rapids	Rocky Reach/ Wells	Estimate	SE	95% CI	Estimate	SE	95% CI
2010	47	47	1.0000	0	(0.9600, 1.0000)	1.0000	0	(0.9865, 1.0000)
2011	232	232	1.0000	0	(0.9918, 1.0000)	1.0000	0	(0.9972, 1.0000)
2012	97	96	0.9897	0.0103	(0.9554, 0.9994)	0.9966	0.0034	(0.9849, 0.9998)
Average			0.9966	0.0034	(0.9899, 1.0033)	0.9989	0.0011	(0.9966, 1.0011)

Sockeye Salmon: Rock Island Project

Passage through the Rocky Reach, Tumwater, and Wells fish ladders was monitored for all PIT-tagged sockeye salmon detected in the Priest Rapids ladder in 2010 through 2012. This three -project conversion rate from Priest Rapids to Rocky Reach and Tumwater dams included the Rock Island Project. Annual estimates of this conversion rate, unadjusted for harvest, ranged from 0.9364 ($\widehat{SE}$ = 0.0105) in 2011 to 0.9782 ($\widehat{SE}$ = 0.0056) in 2010, with a 3-year average of 0.9520 ($\widehat{SE}$ = 0.0095) and a 95% confidence interval of (0.9431, 0.9609) (Table 2). The single-project conversion rate through this reach had estimates from 0.9784 ($\widehat{SE}$ = 0.0037) in 2011 to 0.9927 ($\widehat{SE}$ = 0.0019) in 2010, with a 3-year average estimate of 0.9837 ($\widehat{SE}$ = 0.0016). The 95% confidence interval of the 3-year average single-project conversion rate was (0.9806, 0.9868) (Table 2). Under the assumption of constant survival between Priest Rapids and Rocky Reach or Tumwater dams, the single-project conversion rate is a minimum estimate of survival through the Rock Island Project. The estimate includes an unknown amount of loss to harvest in the fishery between Priest Rapids and Wanapum dams (data unavailable), and so it is likely that survival between Priest Rapids and Wanapum is lower than the single-project conversion rate. Thus, it is likely that survival between Wanapum and Rocky Reach, and in particular through the Rock Island Project, is at least as high as the lower limit of the 95% confidence interval, 0.9806, with our best point estimate at 0.9837.

Sockeye Salmon: Rocky Reach Project

The two-project conversion rate from Rock Island to Wells Dam included the Rocky Reach Project, excluding fish that ended up at Tumwater Dam, and had estimates from 0.9595 ($\widehat{SE}$ =0.0103) in 2011 to 0.9795 ($\widehat{SE}$ =0.0061) in 2010. The 3-year average estimate of the two-project conversion rate was 0.9714 ($\widehat{SE}$ =0.0043), with a 95% confidence interval of (0.9630, 0.9799) (Table 2). We can conclude that 3-year average survival for sockeye from Rock Island to Wells Dam, and in particular through the Rocky Reach Project, was at least as high as 0.9630. The harvest rate of sockeye salmon in the fishery between Rocky Reach Dam and Wells Dam had minimum estimates of 0.0024 ($\widehat{SE}$ =0.0001) in 2010, and 0.0192 ($\widehat{SE}$ =0.0004) in 2011 (Table 3). Because the harvest rate was based on unknown-source sockeye counts at Rocky Reach Dam (including wild fish), it is likely that the harvest rate was higher than these estimates in both years. No harvest data were available in 2012. When adjusted for harvest in the reach between Rocky Reach and Wells, the 3-year average conversion rate from Rock Island to Wells was estimated at 0.9785 ($\widehat{SE}$ =0.0044). Because the actual harvest rates of hatchery fish were likely higher than the estimated rates, the true survival from the reach between Rock Island and Wells (and through the Rocky Reach Project) was likely higher than 0.9795.

The single-project conversion rate estimates for sockeye from Rock Island to Wells ranged from 0.9795 ($\widehat{SE}$ =0.0052) in 2011 to 0.9897 ($\widehat{SE}$ =0.0031) in 2010, unadjusted for harvest (Table 2). When adjusted for harvest, the 2010 estimate of the single-project conversion rate increased to 0.9909 ($\widehat{SE}$ =0.0031), and the 2011 estimate increased to 0.9891 ($\widehat{SE}$ =0.0053). The 3-year average estimate of the single-project conversion rate was 0.9856 ($\widehat{SE}$ =0.0022, 95% CI = (0.9813, 0.9899)) unadjusted for harvest, and 0.9892 ($\widehat{SE}$ =0.0022, 95% CI = (0.9849, 0.9935)) when adjusted for harvest (Table 2). The harvest-adjusted single-project conversion rate estimate is a reasonable estimate of survival in the Rocky Reach Project, although it includes undetected straying and fallback as well as unreported harvest. We can conclude that the 3-year average of survival of adult sockeye through the Rocky Reach Project was at least as high as 0.9630 (lower limit of the unadjusted 3-year average of the two-project conversion rate), and more likely higher than 0.9849 (lower limit of the adjusted 3-year average of the single-project conversion rate), with our best point estimate at 0.9892 (Table 2).

Steelhead: Rock Island Project

Passage through the Rocky Reach and Wells fish ladders was monitored for all adult steelhead tagged as juveniles in the Methow or Okanogan river basins and detected as adults in 2010 – 2012 in the Priest Rapids fish ladder. Estimates of the three -project conversion rate ranged from 0.9722 ($\widehat{SE}$ =0.0194) in 2010 to 0.9842 ($\widehat{SE}$ =0.0064) in 2012, unadjusted for harvest (Table 4). The 3-year average unadjusted conversion rate was estimated at 0.9794 ($\widehat{SE}$ =0.0072), with a 95% confidence interval of (0.9654, 0.9935) (Table 4). The estimated harvest rate of hatchery steelhead in the reach between Rock Island and Rocky Reach dams was 0.0190 ($\widehat{SE}$ =0.0021) in 2010, and 0.0663 ($\widehat{SE}$ =0.0050) in 2011 (Table 3) (data unavailable for 2012). These harvest rates may be inaccurate because of imperfect harvest reporting rates and uncertainty in run counts (i.e., mismatch between run count dates and fishery dates). Nevertheless, using these estimates of harvest, the harvest-adjusted three-project conversion rate from Priest Rapids to Rocky Reach in 2010 increased to 0.9858 ($\widehat{SE}$ =0.0182), and in 2011 increased to 1.0463 ($\widehat{SE}$ =0.0094), with the 3-year average estimate of harvest-adjusted conversion rate from Priest Rapids to Rocky Reach estimated at 1.0054 ($\widehat{SE}$ =0.0072). The harvest-adjusted estimates > 1.0 in 2011 and for the 3-year average are the result of estimating the harvest rate using aggregated harvest counts and, possibly, run counts that omit any late autumn or winter passage. Despite the uncertainty in the harvest-adjusted conversion rate estimates, we can conservatively conclude that average steelhead survival from 2010 to 2012 from Priest Rapids to Rocky Reach (and through the Rock Island Project) was at least as high as 0.9654, the lower limit of the 95% confidence interval for the unadjusted average estimate.

When measured on the scale of a single project, the annual unadjusted conversion rate point estimates were all > 0.99, with the 3-year average estimated at 0.9931 ($\widehat{SE}$ =0.0024, 95% confidence interval = (0.9883, 0.9979); Table 4). When adjusted for harvest between Rock Island and Rocky Reach, the 3-year average of the single-project conversion rate estimates was 1.0017 ($\widehat{SE}$ =0.0024, 95% confidence interval = (0.9970, 1.0064); Table 4). Again, the average estimate > 1.0 is the result of errors in the harvest rate estimate. Nevertheless, we can safely conclude that it is highly likely that the 3-year average survival through the Rock Island Project from 2010 – 2012 for adult steelhead was at least as high as 0.9883, with our best (unadjusted) point estimate at 0.9931.

Table 2. PIT-tag data and estimates of conversion rate from Priest Rapids to Rocky Reach (Project = Rock Island), and from Rock Island to Wells (Project = Rocky Reach) for adult sockeye (wild and hatchery combined) tagged as adults at the Bonneville Adult Fish Facility. Conversion rates are presented both with and without adjustment for harvest. The single-project conversion rate is estimated as the cubed root of the Priest Rapids – Rocky Reach conversion rate for the Rock Island Project, and as the square root of the Rock Island – Wells conversion rate for the Rocky Reach Project. The average is the 3-year arithmetic average. The 95% confidence intervals are profile likelihood confidence intervals for the year-specific results, and asymptotic confidence intervals for the 3-year average.

				Multi-Project Conversion Rate						**Single-Project Conversion Rate**					
		PIT-tag detections		Unadjusted for harvest			Adjusted for harvest[c]			Unadjusted for harvest			Adjusted for harvest[c]		
Project	Year	Upstream Dam[a]	Downstream Dam(s)[b]	Estimate	SE	95% CI	Estimate	SE	95% CI	Estimate	SE	95% CI	Estimate	SE	95% CI
Rock Island	2010	688	673	0.9782	0.0056	(0.9655, 0.9874)				0.9927	0.0019	(0.9884, 0.9958)			
	2011	535	501	0.9364	0.0105	(0.9134, 0.9551)				0.9784	0.0037	(0.9704, 0.9848)			
	2012	1,281	1,206	0.9415	0.0066	(0.9277, 0.9534)				0.9801	0.0023	(0.9753, 0.9842)			
	Average			0.9520	0.0045	(0.9431, 0.9609)				0.9837	0.0016	(0.9806, 0.9868)			
Rocky Reach	2010	536	525	0.9795	0.0061	(0.9651, 0.9893)	0.9818	0.0061	(0.9674, 0.9916)	0.9897	0.0031	(0.9824, 0.9946)	0.9909	0.0031	(0.9836, 0.9958)
	2011	370	355	0.9595	0.0103	(0.9361, 0.9765)	0.9783	0.0105	(0.9545, 0.9956)	0.9795	0.0052	(0.9675, 0.9882)	0.9891	0.0053	(0.9770, 0.9978)
	2012	974	950	0.9754	0.0050	(0.9644, 0.9839)	0.9754	0.0050	(0.9644, 0.9839)	0.9876	0.0025	(0.9820, 0.9919)	0.9876	0.0025	(0.9820, 0.9919)
	Average			0.9714	0.0043	(0.9630, 0.9799)	0.9785	0.0044	(0.9699, 0.9870)	0.9856	0.0022	(0.9813, 0.9899)	0.9892	0.0022	(0.9849, 0.9935)

[a] = Upstream Dam is Priest Rapids Dam for the Rock Island Project, and Rock Island Dam for the Rocky Reach Project. For the Rocky Reach Project, fish detected at Rock Island Dam and then last detected at Tumwater Dam were excluded from analysis and are not included in the Upstream Dam counts. Tumwater Dam counts were: 104 in 2010, 90 in 2011, and 190 in 2010.

[b] = Downstream Dams are Rocky Reach, Tumwater, and Wells dams for the Rock Island Project, and Wells Dam for the Rocky Reach Project.

[c] =Harvest data were unavailable for 2012 at the time of analysis, so the "adjusted" conversion rates for 2012 are not actually adjusted for harvest.

Table 3. Run counts, harvest counts, and estimated minimum harvest rates for sockeye and steelhead in the Rock Island Dam – Rocky Reach Dam and Rocky Reach Dam – Wells Dam reaches in 2010 and 2011. Run counts come from the DART website, and include both wild and hatchery fish for sockeye, and only hatchery fish for steelhead. Run counts are restricted to sockeye passing the dams between 1 July and 15 October each year, and to steelhead passing on or after 8 September in 2010 or 22 September in 2011. Harvest counts come from WDFW.

						Harvest Rate	
		Run Count		Harvest Count		RI – RR	RR - WE
Species	Year	Rock Island	Rocky Reach	Rock Island – Rocky Reach	Rocky Reach - Wells	Estimate (SE)	Estimate (SE)
Sockeye	2010	318,103	285,671		674		0.0024 (0.0001)
	2011	145,041	131,326		2,526		0.0192 (0.0004)
Steelhead	2010	4,097	4,085	78	103	0.0190 (0.0021)	0.0252 (0.0025)
	2011	2,439	2,731	162	203	0.0664 (0.0050)	0.0743 (0.0050)

Steelhead: Rocky Reach Project

In 2010, 67 steelhead were detected at Rock Island, of which 64 were subsequently detected at Wells Dam, yielding a two-project conversion rate estimate of 0.9552 ($\widehat{SE}$ =0.0253; Table 4). Higher numbers were detected in 2011 and 2012, with two-project conversion rate estimates of 0.9915 ($\widehat{SE}$ =0.0049) and 0.9897 ($\widehat{SE}$ =0.0059), respectively (Table 4). The 3-year arithmetic average conversion rate from Rock Island to Wells was estimated at 0.9788 ($\widehat{SE}$ =0.0088), with a 95% confidence interval of (0.9616, 0.9961) unadjusted for harvest. Steelhead experienced harvest pressure both between Rock Island and Rocky Reach, and between Rocky Reach and Wells dams, with estimated harvest rates between Rocky Reach and Wells of 0.0252 ($\widehat{SE}$ =0.0025) in 2010, and 0.0743 ($\widehat{SE}$ =0.0050) in 2011 (Table 3). These harvest rate estimates may be biased because of imperfect harvest reporting rates and window counts; no harvest data were available for 2012. When adjusted for these estimates of harvest, the two-project conversion rate estimates increased to 0.9861 ($\widehat{SE}$ =0.0261) in 2010, and to 1.1343 ($\widehat{SE}$ =0.0094) in 2011 (Table 4). The estimate of 1.1343 in 2011 is the result of inaccurate harvest rate estimates combined with a high estimate of the 2011 conversion rate unadjusted for harvest (0.9915). The harvest-adjusted 3-year average conversion rate estimate from Rock Island to Wells was 1.0367 ($\widehat{SE}$ =0.0094), but depends on the estimated harvest rates. Regardless of the actual harvest rate, we can conservatively conclude that the 3-year average survival through the Rocky Reach Project was at least as high as 0.9616, the lower limit of the 95% confidence interval of the unadjusted three-project conversion rate.

On the scale of a single project, the unadjusted annual conversion rate estimates ranged from 0.9774 ($\widehat{SE}$ =0.0129) in 2010 to 0.9958 ($\widehat{SE}$ =0.0024) in 2011, with a 3-year average of 0.9893 ($\widehat{SE}$ =0.0045, 95% confidence interval = (0.9805, 0.9981); Table 4). Adjusted for the observed harvest, the single-project conversion rate estimates increased to 0.9931 ($\widehat{SE}$ =0.0131) in 2010 and to 1.0650 ($\widehat{SE}$ =0.0044) in 2011, yielding a harvest-adjusted 3-year average minimum survival estimate of 1.0176 ($\widehat{SE}$ =0.0047; Table 4). Again, despite the possibility of error in the estimated harvest rate, it is safe to conclude that the 3-year average survival of steelhead through the Rocky Reach Project is at least 0.9805, with our best point estimate = 0.9893, based on the unadjusted single-project conversion rate estimates from 2010 to 2012.

Summary

- Conversion rates were estimated on both a multiple-project level and a single-project level, and were adjusted for by harvest data when possible.
- The 3-year arithmetic average of survival of adult spring Chinook salmon through the Rock Island Project from 2010 – 2012 was at least as high as 0.9899, with our best point estimate at 0.9989.
- For adult sockeye salmon, the 3-year average survival through the Rock Island Project was at least as high as 0.9431, with our best point estimate at 0.9837. For the Rocky Reach Project, the 3-year average survival from 2010 – 2012 was at least as high as 0.9630, and likely higher than 0.9849 (point estimate = 0.9892).
- For adult steelhead, the 3-year average survival from 2010 – 2012 through the Rock Island Project was at least as high as 0.9654, with our best point estimate at 0.9931. For the Rocky Reach Project, the 3-year average survival from 2010 – 2012 is conservatively at least as high as 0.9616, and more likely as high as at 0.9805 (point estimate = 0.9893).

Table 4. PIT-tag data and estimates of conversion rate from Priest Rapids to Rocky Reach (Project = Rock Island), and from Rock Island to Wells (Project = Rocky Reach) for adult steelhead (wild and hatchery combined) tagged as juveniles in the Methow and Okanogan river basins. Conversion rates are presented both with and without adjustment for harvest. The single-project conversion rate is estimated as the cubed root of the Priest Rapids – Rocky Reach conversion rate for the Rock Island Project, and as the square root of the Rock Island – Wells conversion rate for the Rocky Reach Project. The average is the 3-year arithmetic average. The 95% confidence intervals are profile likelihood confidence intervals for the year-specific results (unadjusted for harvest), and asymptotic confidence intervals for the 3-year average and annual estimates adjusted for harvest.

		Multi-Project Conversion Rate									Single-Project Conversion Rate					
		PIT-tag detections		Unadjusted for harvest			Adjusted for harvest[c]			Unadjusted for harvest			Adjusted for harvest[c]		
Project	Year	Upstream Dam[a]	Downstream Dam(s)[b]	Estimate	SE	95% CI	Estimate	SE	95% CI	Estimate	SE	95% CI	Estimate	SE	95% CI
Rock Island	2010	72	70	0.9722	0.0194	(0.9167, 0.9953)	0.9858	0.0182	(0.9501, 1.0215)	0.9907	0.0066	(0.9714, 0.9984)	0.9952	0.0061	(0.9832, 1.0072)
	2011	386	379	0.9819	0.0068	(0.9652, 0.9922)	1.0463	0.0094	(1.0278, 1.0648)	0.9939	0.0023	(0.9883, 0.9974)	1.0152	0.0031	(1.0092, 1.0212)
	2012	380	374	0.9842	0.0064	(0.9683, 0.9937)	0.9842	0.0064	(0.9683, 0.9937)	0.9947	0.0022	(0.9893, 0.9979)	0.9947	0.0022	(0.9893, 0.9979)
	Average			0.9794	0.0072	(0.9654, 0.9935)	1.0054	0.0072	(0.9914, 1.0195)	0.9931	0.0024	(0.9883, 0.9979)	1.0017	0.0024	(0.9970, 1.0064)
Rocky Reach	2010	67	64	0.9552	0.0253	(0.8880, 0.9887)	0.9861	0.0261	(0.9350, 1.0373)	0.9774	0.0129	(0.9423, 0.9943)	0.9931	0.0131	(0.9673, 1.0188)
	2011	354	351	0.9915	0.0049	(0.9782, 0.9979)	1.1343	0.0094	(1.1158, 1.1527)	0.9958	0.0024	(0.9890, 0.9989)	1.0650	0.0044	(1.0564, 1.0737)
	2012	292	289	0.9897	0.0059	(0.9736, 0.9974)	0.9897	0.0059	(0.9736, 0.9974)	0.9948	0.0030	(0.9867, 0.9987)	0.9948	0.0030	(0.9867, 0.9987)
	Average			0.9788	0.0088	(0.9616, 0.9961)	1.0367	0.0094	(1.0182, 1.0552)	0.9893	0.0045	(0.9805, 0.9981)	1.0176	0.0047	(1.0084, 1.0269)

[a] = Upstream Dam is Priest Rapids Dam for the Rock Island Project, and Rock Island for the Rocky Reach Project.

[b] = Downstream Dams are Rocky Reach and Wells dams for the Rock Island Project, and Wells Dam for the Rocky Reach Project.

[c] =Harvest data were unavailable for 2012 at the time of analysis, so the “adjusted” conversion rates for 2012 are not actually adjusted for harvest.

Attachment D

2011 Subyearling life-history and migration study results

Life-history hypotheses

- $H1_{alt}$: Ocean-type Chinook in Wells Reservoir represent multiple life-history strategies with variable migration timing including spring and summer subyearling, spring yearling, reservoir rearing, and intermediate migration types.
- $H2_{alt}$: Subyearling Chinook tagged into the Wells Reservoir, of the size observed migrating through Wells Dam, do not actively migrate through the Wells Project.
- $H3_{alt}$: Residence time in Wells Reservoir exceeds the battery life of current acoustic tags.
- $H4_{alt}$: A portion of the study-fish population migrates during periods when downstream PIT-tag detection arrays are not operational.
- $H5_{alt}$: Subyearling Chinook released above and below Wells Dam experience different river conditions, and different survival probabilities when migrating through the control reach (Rocky Reach Reservoir).

Tagging hypotheses

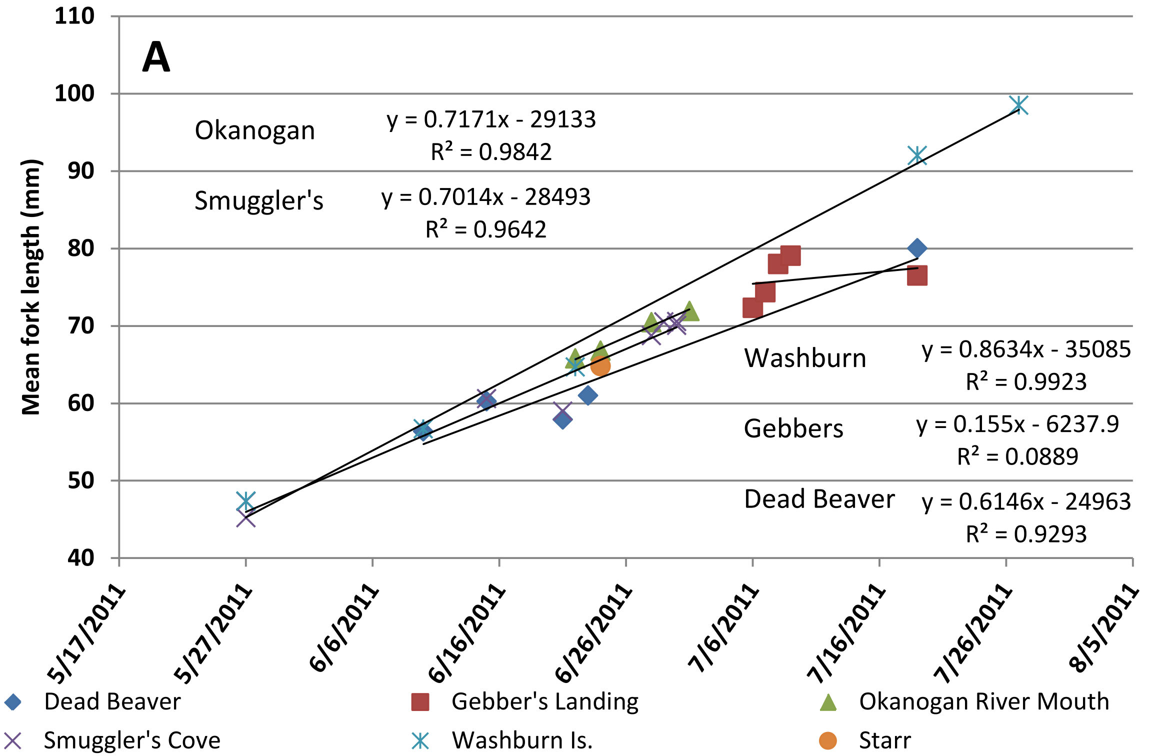
- $H6_{alt}$: The fish available for capture in the Wells Project at time t_1 are not of sufficient size for tagging with 12.5 mm tags.
- $H7_{alt}$: The fish available for capture in the Wells Project are not of sufficient size for tagging with an acoustic transmitter.
- Hypothesis H8 from the 2011 Study Plan would require a lab component to the study, and we did not include a lab component. Following the finalization of the 2011 Study Plan we added the following hypothesis:
- $H9_{alt}$: The process of capture, holding, and tagging incurs a biological cost on subyearling Chinook.

Capture/detection results

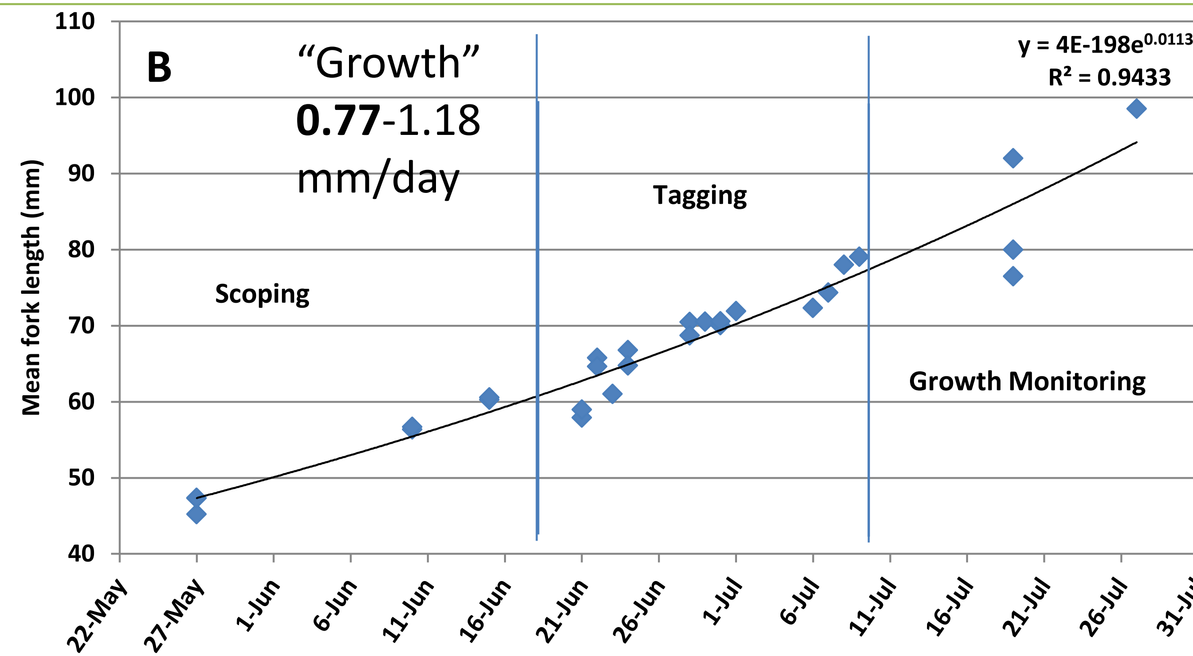
- ~18,500 subs seined→ >13,200 PIT tagged
- Collection was separated into scoping, tagging, and post-tagging/growth monitoring phases
- Fish available in many project locations but a couple ‘honey holes’ located
- >2,300 unique fish detected; 17.5% of tagged fish. Most of which were detected at RRJBS.

Size distribution of captured fish…

by location

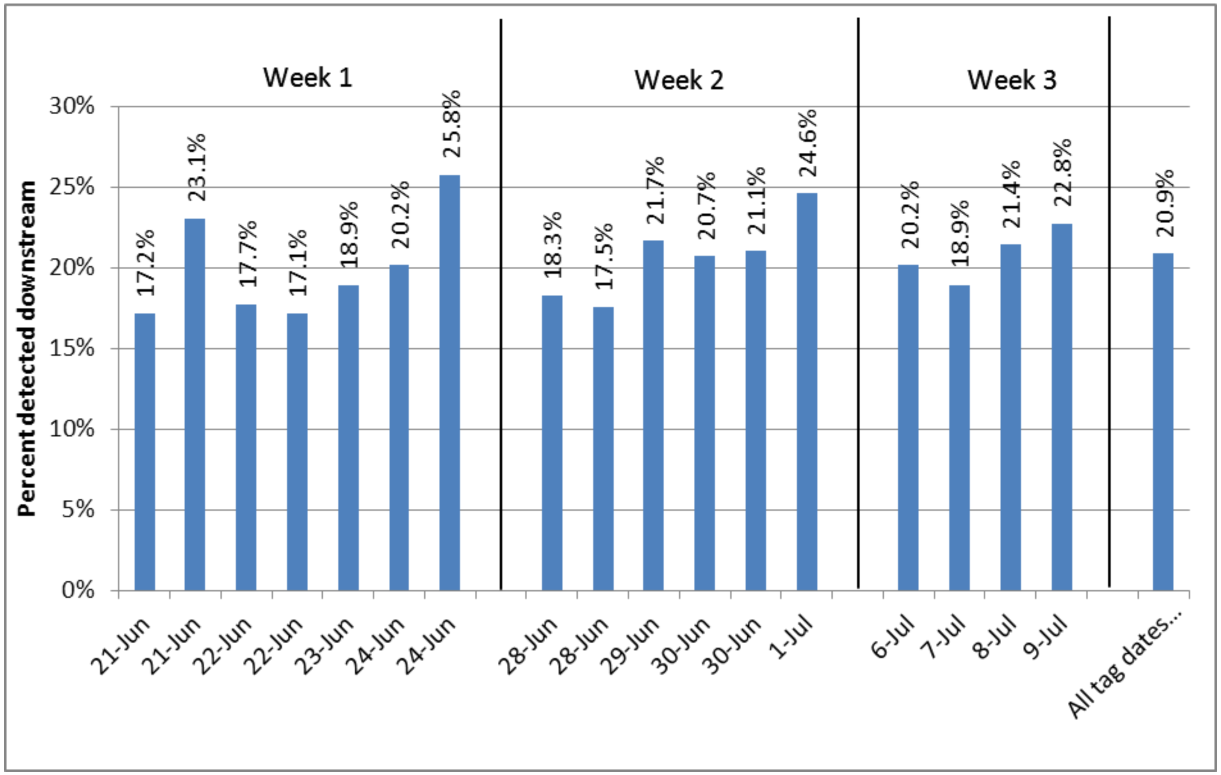


by study phase



Attachment D

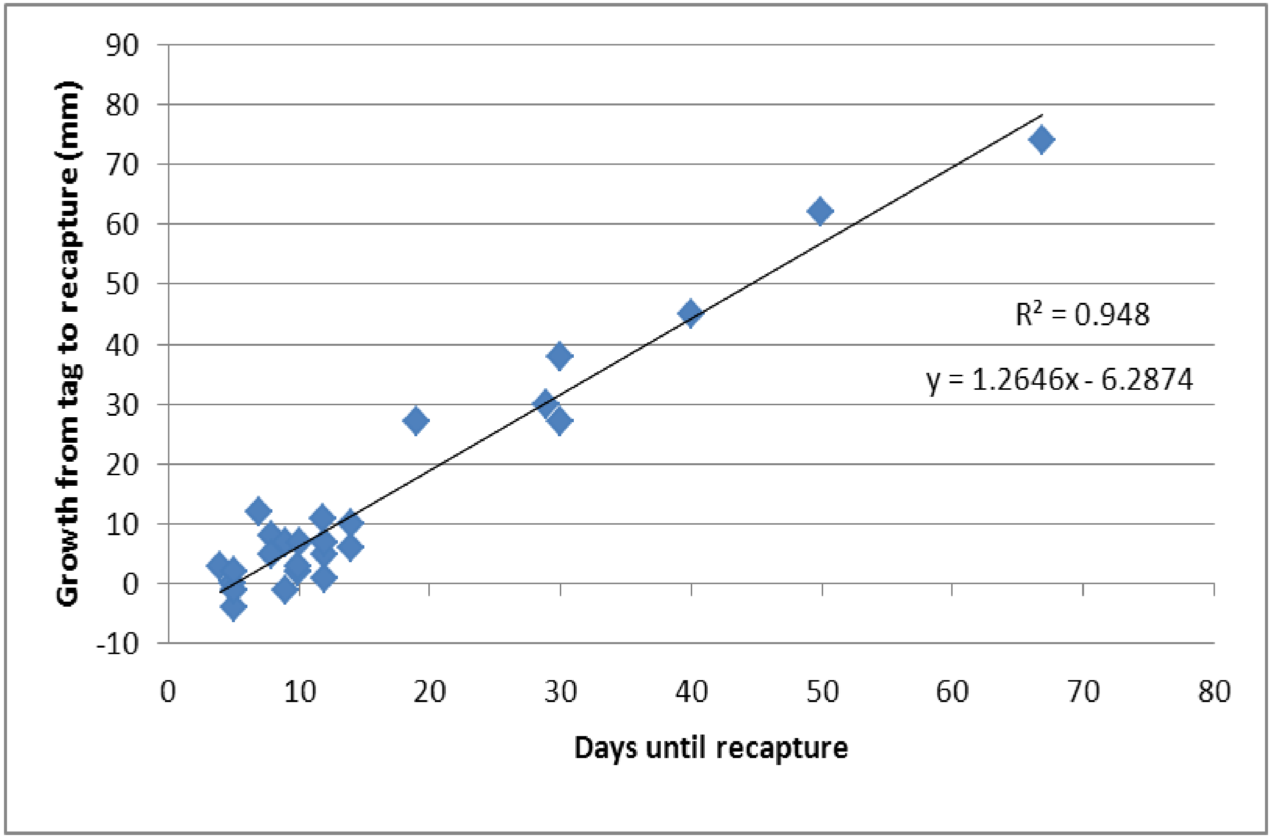
Cumulative detection probability by date (includes all detections- not just unique records)



- Duplicate dates are extra tag files on a given day

Attachment D

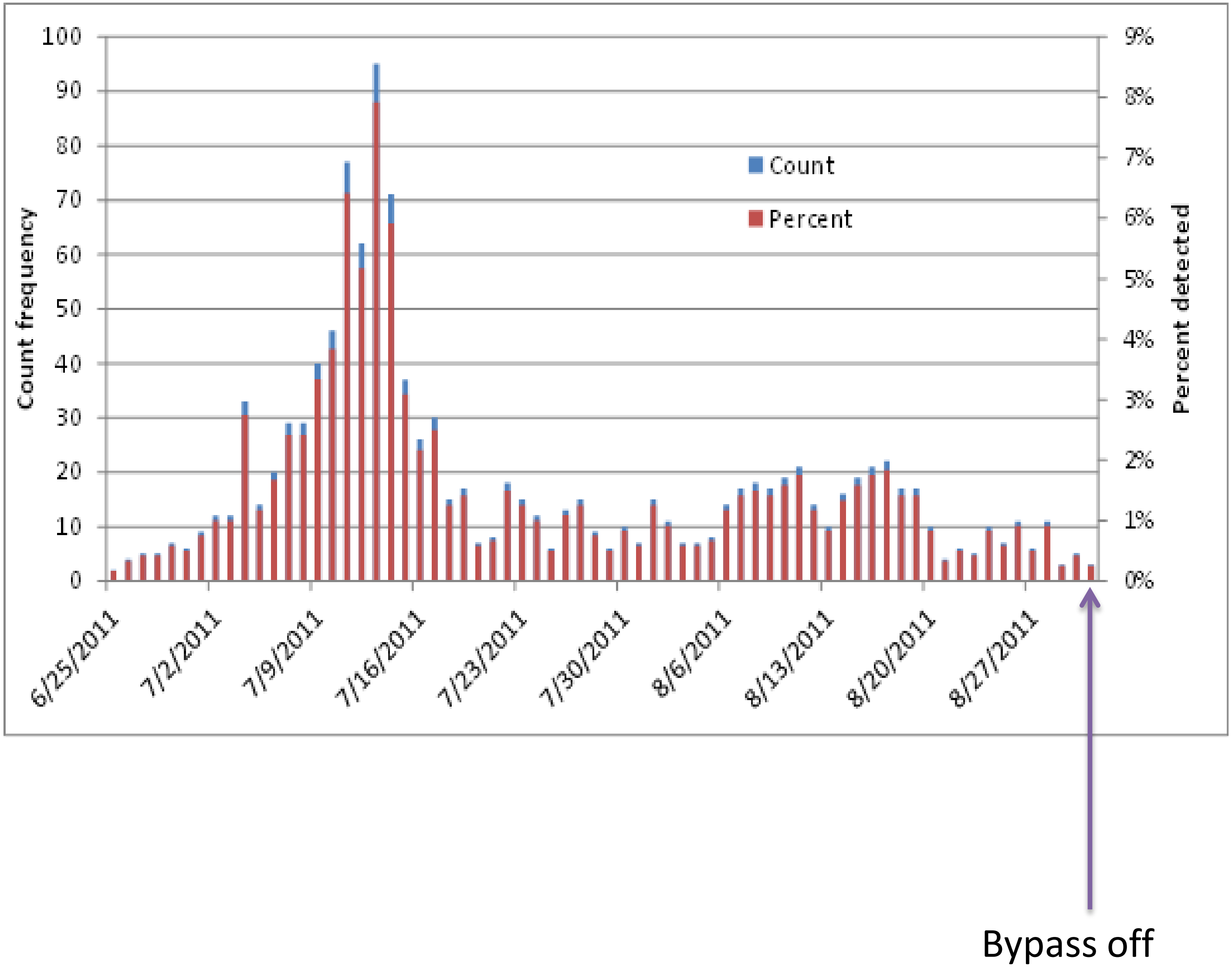
‘Growth’ of RRJBS recaptures



- 1.18 ± 0.08 mm/day.
- Recaps at Rocky Reach N= 26.
- 1,200 PITS detected at Reach; 9% of all tagged fish.

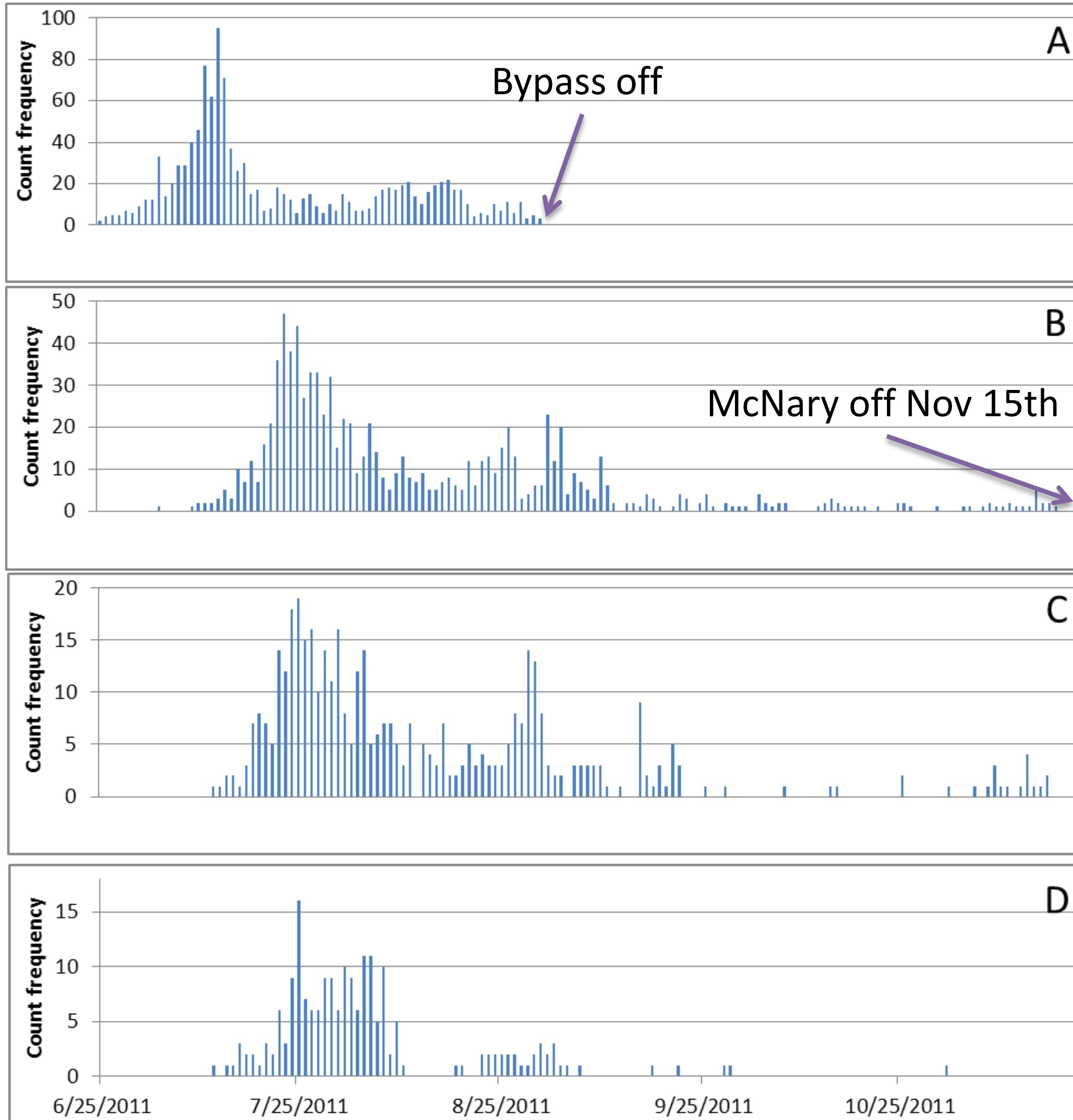
Attachment D

Distribution of detections at Reach



Distribution of detections

- A) Reach
- B) McNary
- C) John Day
- D) Bonneville



Travel time

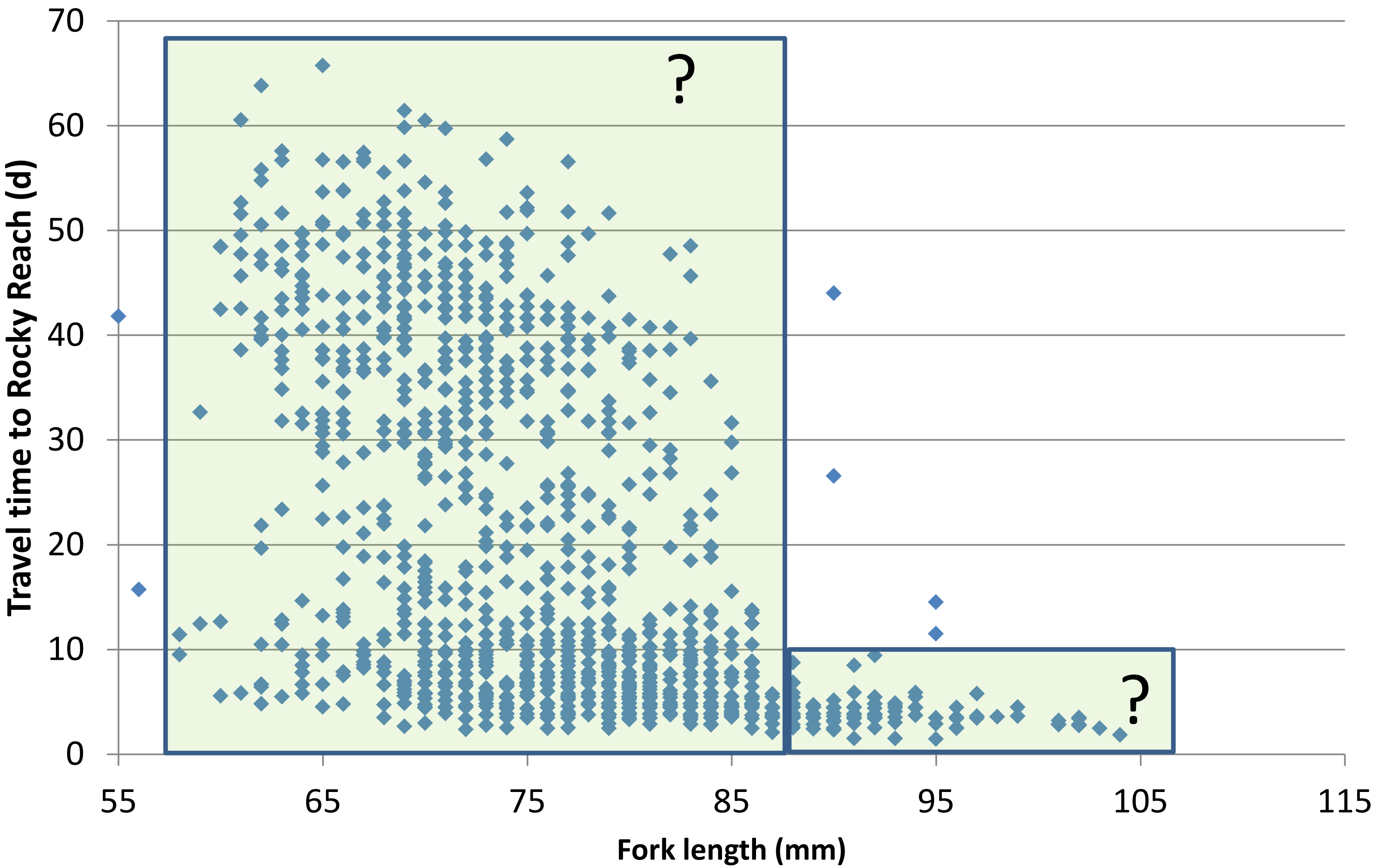
	RRH (762)		MCN (470)		JDA (347)		BON (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	19.7 (±0.48; n = 1185)	**4.8**						
RRH (762)			20.1 (±0.98; n = 188)	14.5				
MCN (470)					7.6 (±0.99; n = 99)	16.2		
JDA (347)							2.5 (±0.29; n = 33)	**44.6**

Note. Smolt index recaptures removed.

- Surprise! Fish move faster as they approach the estuary
- 10X faster from John Day to Bonn than from tag to Reach

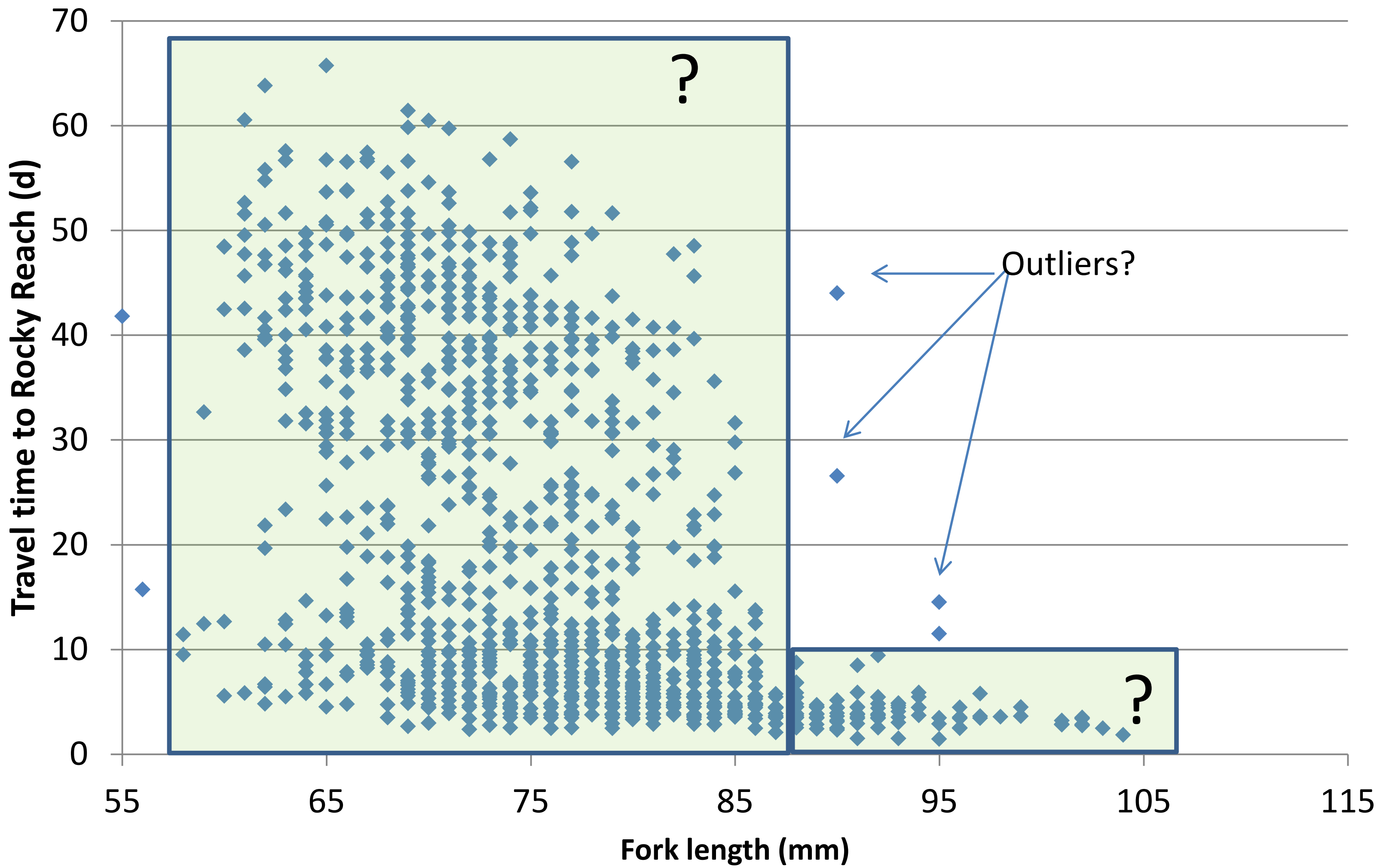
Attachment D

Size threshold for ‘migration’?



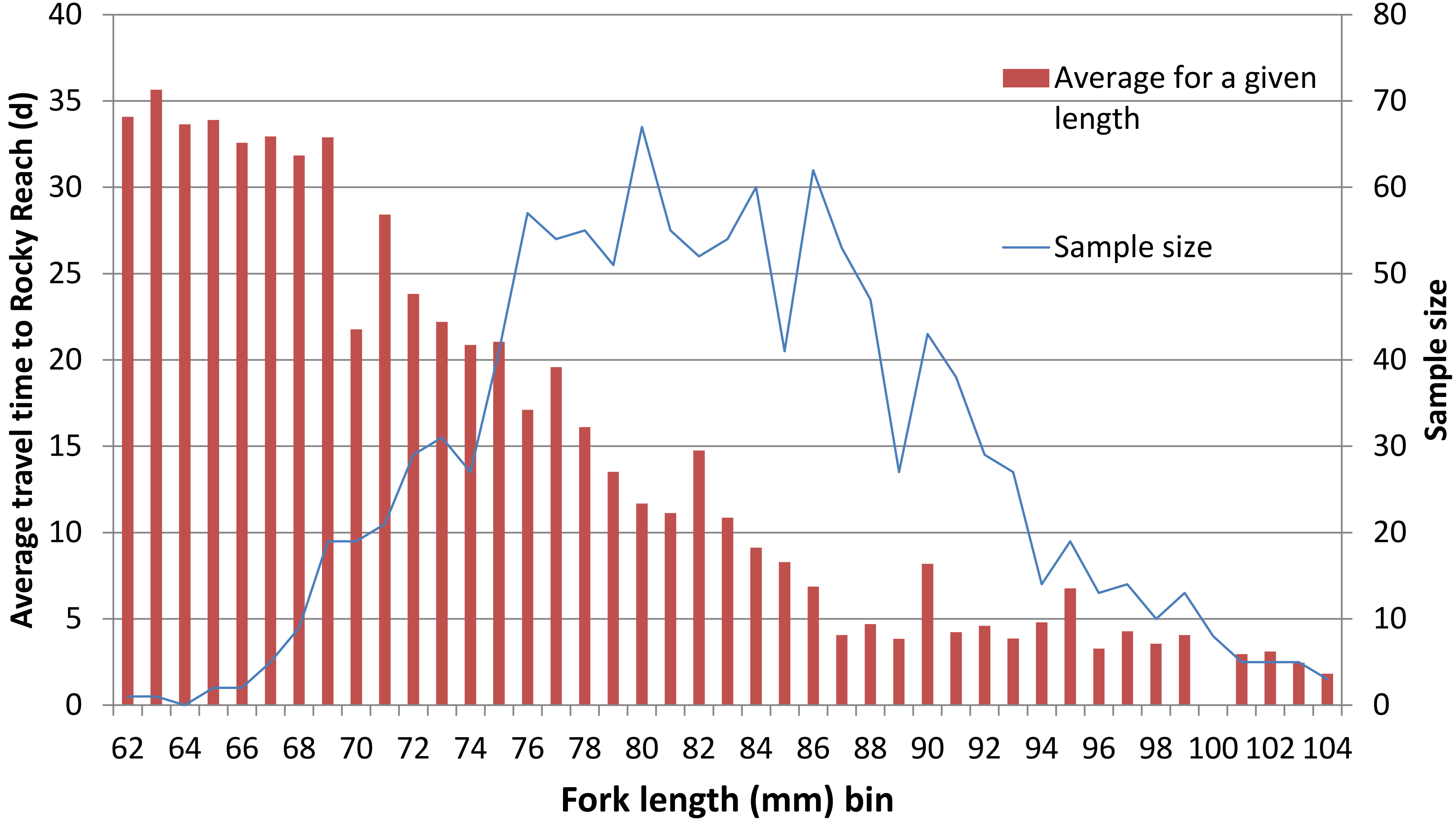
Attachment D

Size threshold for ‘migration’?



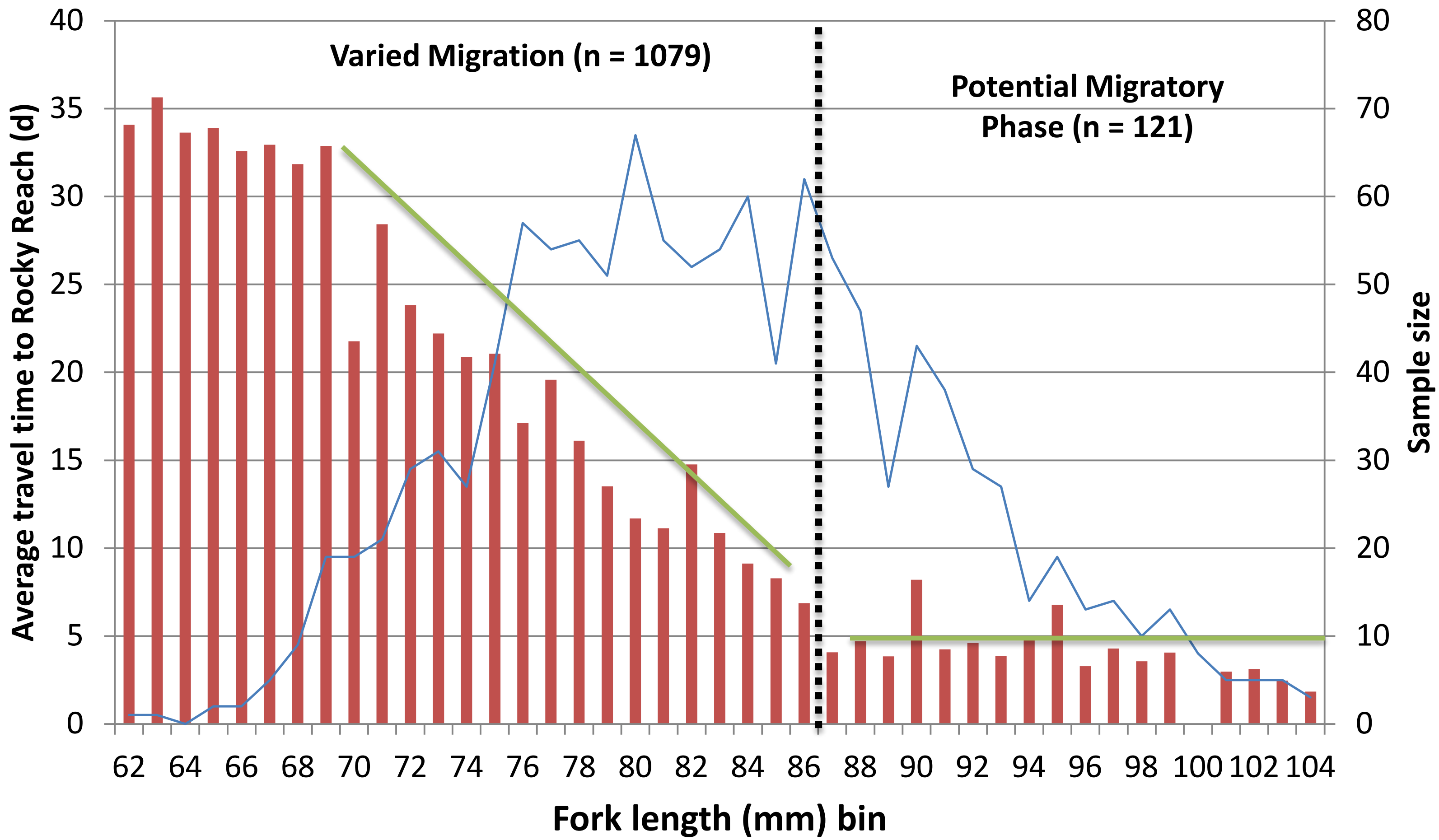
Attachment D

Size threshold for ‘migration’?



Attachment D

Size threshold for ‘migration’?



Attachment D

Size threshold for ‘migration’?

>86 mm

5X faster to Rocky Reach

	RRH (762)		MCN (470)		JDA (347)		BON (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	4.7 (±0.41; n = 121)	**20**						
RRH (762)			15.78 (±3.08; n = 17)	18.5				
MCN (470)					3.23 (±0.33; n = 6)	38.1		
JDA (347)							1.92 (±0.17; n = 7)	58.3

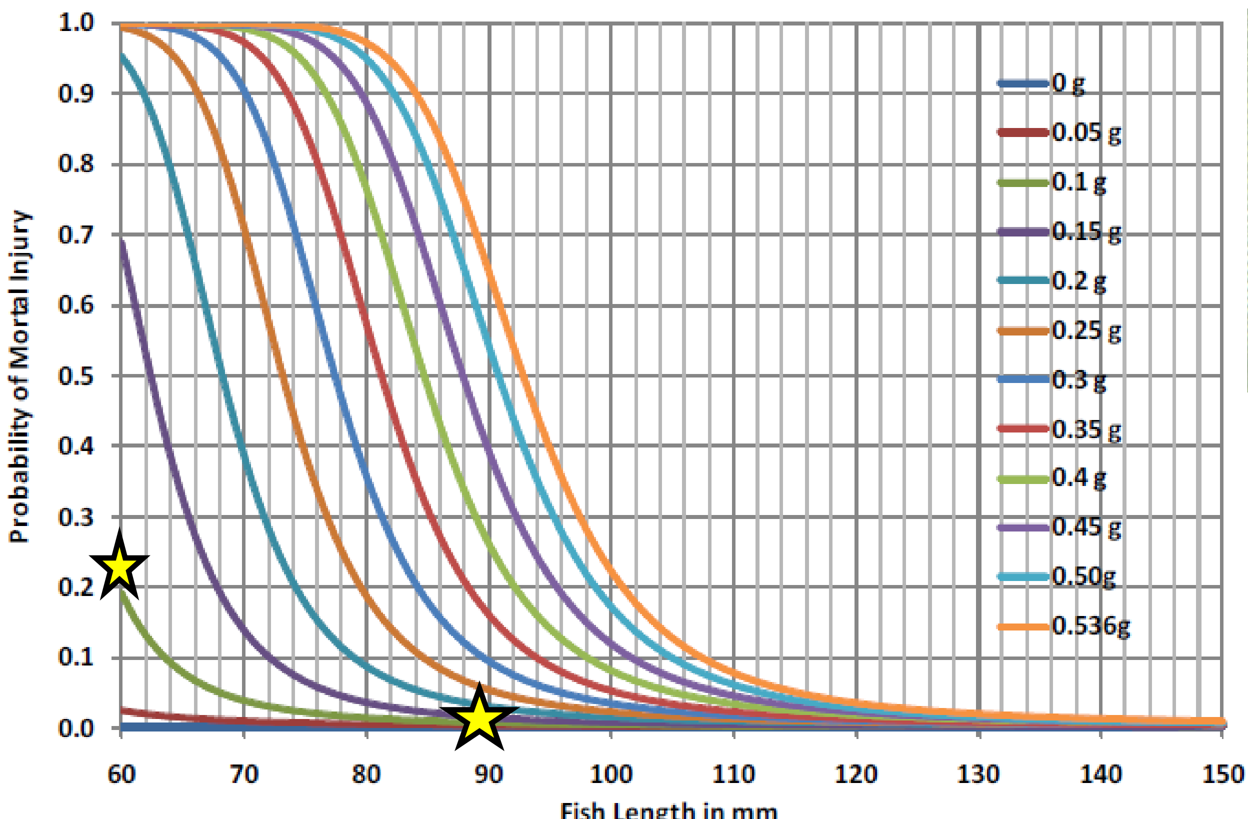
<87 mm

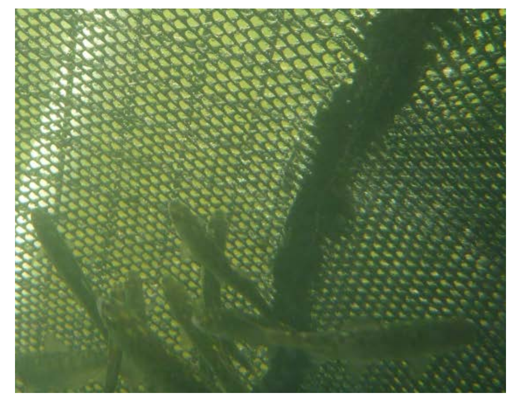
	RRH (762)		MCN (470)		JDA (347)		BON (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	21.17 (±0.5; n = 1080)	**4.4**						
RRH (762)			20.52 (±1.02; n = 173)	14.2				
MCN (470)					7.86 (±1.05; n = 93)	15.6		
JDA (347)							2.67 (±0.37; n = 26)	41.9

Attachment D

Probability of detection for two size classes

Size range (mm)	Number tagged	Number detected	Proportion detected (%)
<87	12192	2448	20.1
>86	1028	313	30.4





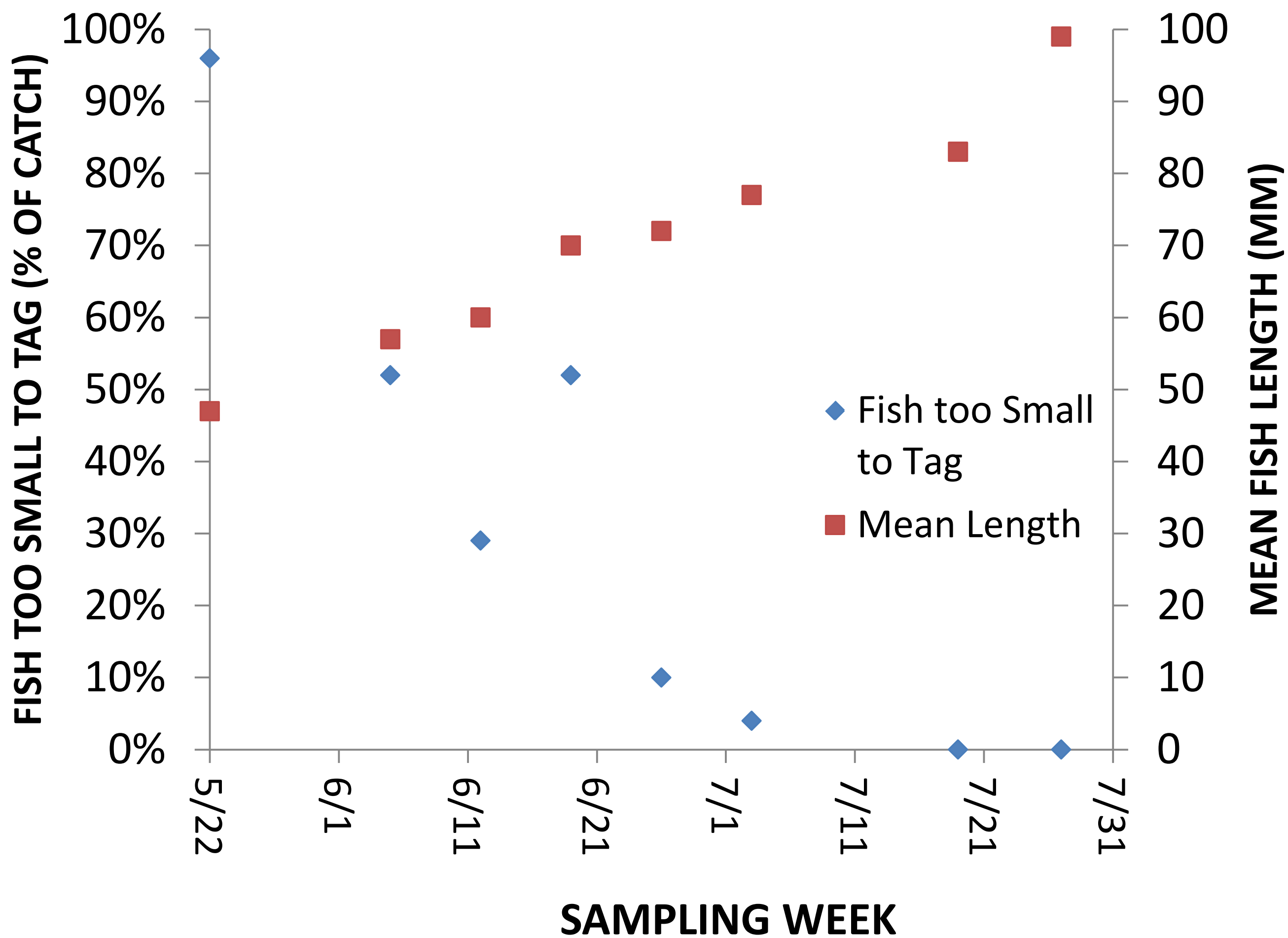
One explanation…**tag burden**: Mortal injury 20% higher on a 60 mm fish vs. a 90 mm fish carrying a 0.1 g PIT tag at the same LRP.

Attachment D

Challenges of tagging/representing the entire ‘run’

In May, subyearlings were abundant and easy to catch, but nearly all were too small to tag.

By the end of July, all fish were large enough to tag, but difficult to find.

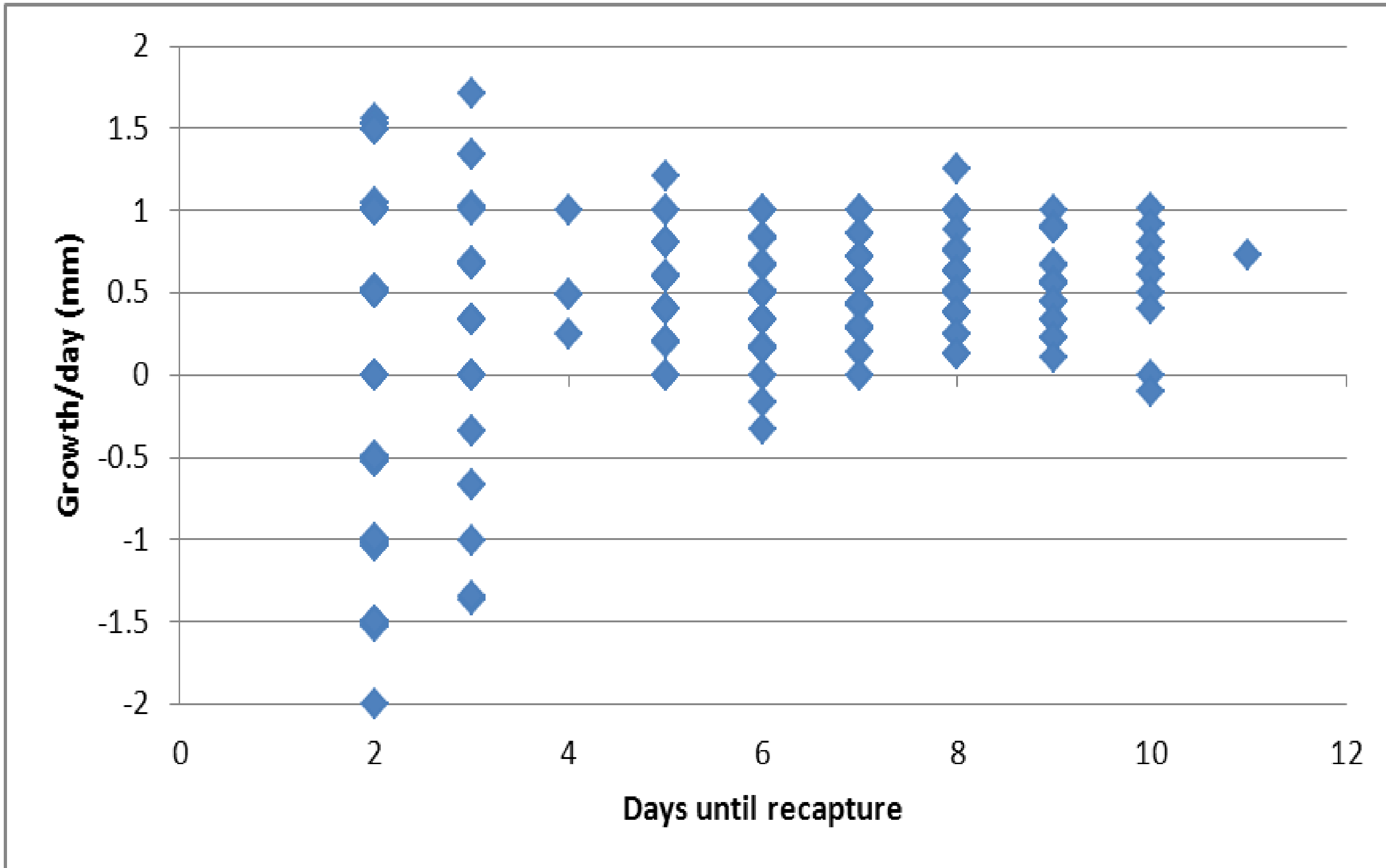


Attachment D

Cost of capture tagging holding etc.

0.34 mm/d in growth in first 11 days following tag.

0.77-1.18 mm/d growth of run at large

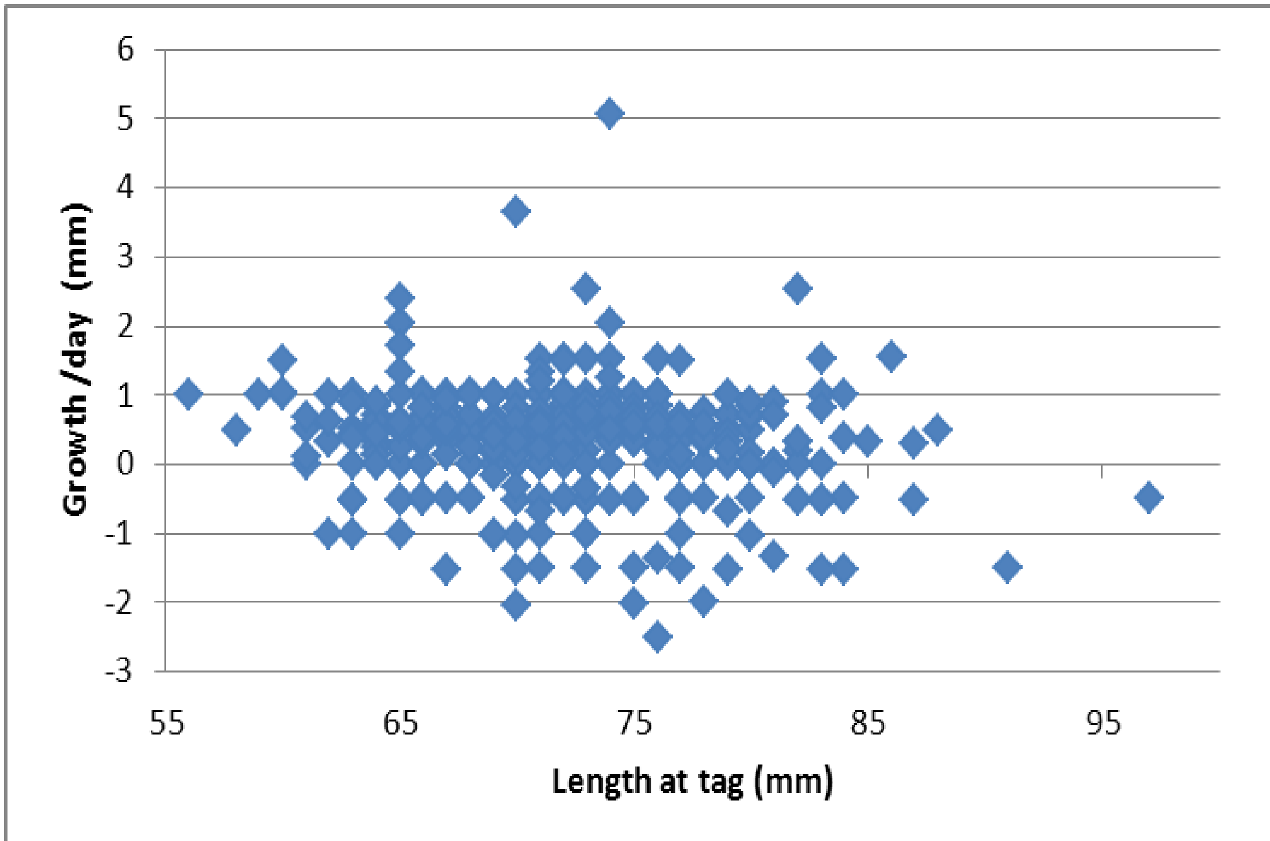


Decrease in growth following tag and release applied equally to all fish sizes

- Therefore, biological cost is associated with tagging procedure/capture/holding not tag burden
- If tag burden smaller fish would have greater cost

0.34 mm/d in growth in first 11 days following tag.

0.77-1.18 mm/d growth of run at large (untagged and tagged fish)



Conclusions

- 1. Fish clearly exhibit a continuum of migration timing: 90+ days.
- 2. The >86 mm fish length was a size threshold in 2011.
- 3. The residence time of fish, at least those less than 87 mm in length, exceeds the battery life of smallest JSATS.
- 4. A portion of the study-fish migrates during periods when all lower river PIT tag detection arrays are not operational.
- 5. Control group violation- variable migration rates trump similar survival rates between controls and treatment.
- 6. By the date when all captured fish were large enough to tag few fish were available for capture by beach seining.
- 7. Nearly all fish available for capture by beach seining are of insufficient size for tagging with the current acoustic transmitter.

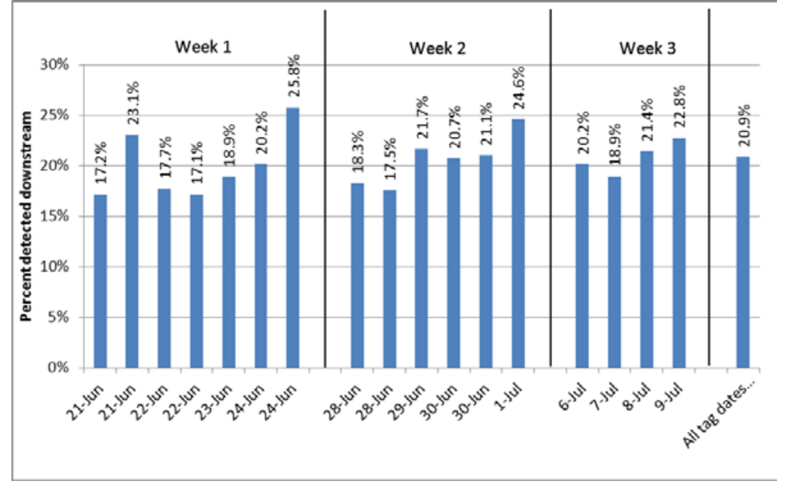
From H8 (not tested):

- 9. The process of capturing, holding, and tagging incurs a biological cost.

Attachment D

Attachment D

Cumulative detec. Prob.



				JBS								Other		
				Rocky Reach		McNary		John Day		Bonneville		BCC, BO1, MC1, MC2, RIA, RRF, WEA		
Tag Week	Tag Location	Date	Number tagged and released	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Cumulative Percent
1	Dead Beaver	21-Jun	64	8	12.5%	1	1.6%	1	1.6%	0	0.0%	1	1.6%	17.2%
	Smuggler's Cove	21-Jun	65	7	10.8%	3	4.6%	3	4.6%	1	1.5%	1	1.5%	23.1%
	Okanogan	22-Jun	418	33	7.9%	21	5.0%	10	2.4%	1	0.2%	9	2.2%	17.7%
	Washburn	22-Jun	280	19	6.8%	16	5.7%	9	3.2%	1	0.4%	3	1.1%	17.1%
	Dead Beaver	23-Jun	328	26	7.9%	20	6.1%	12	3.7%	0	0.0%	4	1.2%	18.9%
	Okanogan	24-Jun	595	52	8.7%	36	6.1%	22	3.7%	2	0.3%	8	1.3%	20.2%
	Starr	24-Jun	128	17	13.3%	10	7.8%	3	2.3%	2	1.6%	1	0.8%	25.8%
2	Okanogan	28-Jun	235	15	6.4%	14	6.0%	11	4.7%	1	0.4%	2	0.9%	18.3%
	Smuggler's Cove	28-Jun	821	65	7.9%	47	5.7%	21	2.6%	5	0.6%	6	0.7%	17.5%
	Smuggler's Cove	29-Jun	1446	145	10.0%	94	6.5%	54	3.7%	9	0.6%	12	0.8%	21.7%
	Smuggler's Cove	30-Jun	270	21	7.8%	22	8.1%	9	3.3%	1	0.4%	3	1.1%	20.7%
	Smuggler's Cove	30-Jun	1196	112	9.4%	76	6.4%	44	3.7%	9	0.8%	11	0.9%	21.1%
	Okanogan	1-Jul	1163	117	10.1%	102	8.8%	43	3.7%	9	0.8%	15	1.3%	24.6%
3	Gebber's	6-Jul	1463	135	9.2%	100	6.8%	47	3.2%	5	0.3%	8	0.5%	20.2%
	Gebber's	7-Jul	1378	120	8.7%	80	5.8%	37	2.7%	6	0.4%	18	1.3%	18.9%
	Gebber's	8-Jul	1558	144	9.2%	114	7.3%	49	3.1%	12	0.8%	15	1.0%	21.4%
	Gebber's	9-Jul	1815	164	9.0%	164	9.0%	60	3.3%	7	0.4%	18	1.0%	22.8%
Total	All locations	All tag dates dates	13223	1200	9.1%	920	7.0%	435	3.3%	71	0.5%	135	1.0%	20.9%

APPENDIX B
HABITAT CONSERVATION PLAN HATCHERY COMMITTEES 2012 MEETING MINUTES AND CONFERENCE CALL MINUTES

Note: The Hatchery Committees did not meet in October 2012.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	February 15, 2012
From:	Mike Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the January 19, 2012, HCP Hatchery Committees' Conference Call		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees' meeting was held by conference call on Thursday, January 19, 2012, from 9:30 am to 1:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Bill Gale will contact Pat Connolly, U.S. Geological Survey (USGS), to request his attendance at the March 21, 2012, Hatchery Committees' meeting to discuss potential collaboration and coordination of Passive Integrated Transponder (PIT)-tagging efforts in the Methow Basin (Item I).
- Josh Murauskas will send Chelan PUD's proposal to adjust spring Chinook hatchery-raised size-at-transfer and size-of-release criteria to Carmen Andonaegui for distribution to the Hatchery Committees; Chelan PUD will ask the Committees to approve the proposal at the February 15, 2012, meeting (Item II-A).
- Josh Murauskas will arrange for Don Larsen and Brian Beckman, National Marine Fisheries Service (NMFS), to participate by phone in the February 15, 2012, Hatchery Committees' meeting to discuss the Chelan PUD proposal to change the Chiwawa spring Chinook size-at-transfer and size-at-release targets (Item II-A).
- Josh Murauskas will provide information to the Hatchery Committees on the ratio of male-to-female returning Chiwawa spring Chinook by age-at-return for the small versus large juvenile size-at-releases (Item II-A).
- Josh Murauskas will email the draft Chelan PUD 5-Year Hatchery Monitoring and Evaluation (M&E) report to Carmen Andonaegui by February 3, 2012, for posting on the ftp site and notification to the Hatchery Committees that the draft report is

available for a 60-day review period (Item II-C).

- Josh Murauskas will finalize the Chelan PUD Spring Chinook Compensation Statement of Agreement (SOA) approved at today's meeting and email it to Carmen Andonaegui for distribution to the Hatchery Committees (Item II-D).
- Greg Mackey will revise the Draft 2012 Wells HCP Action Plan as discussed at today's meeting and email it to Carmen Andonaegui for distribution to the Hatchery Committees for review and approval at the February 15, 2012, Hatchery Committees' meeting (Item III-A).
- Tom Kahler and Joe Miller will coordinate with Kim Hyatt (British Columbia Fisheries and Oceans, Canada) and Howie Wright, Okanagan Nation Alliance (ONA), on a presentation on the Fish Water Management Tool and the Skaha Lake Sockeye Reintroduction Program at the April 18, 2012, Hatchery Committees' meeting (Item III-A).
- Craig Busack will confirm the expected duration of new Endangered Species Act (ESA) hatchery permits (Item IV-B).
- Mike Tonseth will contact Ken Warheit about providing a presentation to the Hatchery Committees on his analysis of the 2010 and 2011 Wenatchee Spring Chinook Parental Based Tagging (PBT) pilot study results at the February 15, 2012, meeting (Item IV-C).
- When cleared for distribution, Mike Tonseth will email a copy of Ken Warheit's genetic analyses of the 2010 and 2011 Wenatchee spring Chinook PBT pilot study to Carmen Andonaegui for distribution to the Hatchery Committees (Item IV-C).
- At the February 15, 2012, meeting, Carmen Andonaegui will provide to the Hatchery Committees a summary of the conclusion of the Hatchery Evaluation Technical Team (HETT) reference stream evaluation and a HETT proposal for next steps (Item V).

DECISION SUMMARY

- The Hatchery Committees approved the Chelan PUD Spring Chinook Compensation SOA – Release Year 2014, as revised (Item III-D).

REVIEW ITEMS

- The Draft 2012 Wells HCP Action Plan is out for a 30-day review for approval at the

February 15, 2012, Hatchery Committees' meeting (Item III-A).

REPORTS FINALIZED

- No reports have been finalized by the Hatchery Committees since the December 14, 2011, meeting.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. Greg Mackey requested time for a discussion of the draft Wells 2012 HCP Action Plan.

Bill Gale said that he would like to postpone, until the February 15, 2012 Committees' meeting, the discussion of items to bring to Pat Connolly's (USGS) attention regarding coordination of salmonid data collection activities in the Methow Basin. Gale will contact Connolly to request his attendance at the March 21, 2012, Committees' meeting for the discussion.

The draft November 30, 2011, conference call minutes and the draft December 14, 2011, meeting minutes were reviewed and approved as revised. Carmen Andonaegui will finalize the meeting minutes and distribute them to the Committees.

II. Chelan PUD

A. Spring Chinook Size-at-Release Target Proposal (Josh Murauskas)

Josh Murauskas introduced a preliminary analysis of the effects of spring Chinook size-at-release on performance of hatchery fish at the December 14, 2011, Hatchery Committees' meeting. On January 18, 2012, he distributed a more complete report, including a recommendation to decrease the size-at-release targets for Chiwawa spring Chinook (Attachment B). Murauskas said that analysis of PIT-tag data showed that there was no performance benefit associated with larger smolts, and that smaller smolts produce fewer jacks and minijacks and a greater proportion of 3-year salt returns. He said that during the past 5 years, Chiwawa spring Chinook releases averaged about 15 fish per pound (fpp), even though the target release size was 12 fpp. Murauskas suggested that if release size targets were decreased even further (i.e., smaller size at release, more fish per pound), the benefits should be fewer jacks and minijacks. Mike Tonseth noted that jacks and minijacks tend to stray at a higher rate than do older returning adults. Further, Tonseth said that the length-to-weight relationship used currently in the hatchery program is not consistent with achieving the desired condition factor. He said that 94 millimeters (mm) is about the average size of wild fish caught in smolt traps. Even with wild fish survival to McNary Dam 5 to 15 percent lower than hatchery fish survival to McNary, adult returns for wild fish are higher than for hatchery fish. Murauskas said that adjusting size-at-release target sizes is an opportunity to capitalize on findings from 5-Year M&E analysis. Bill Gale said that 18 fpp is the size-at-release target for the Leavenworth National Fish Hatchery (NFH) and that there is literature showing that going to smaller release sizes yields higher adult returns. Tonseth said he and John Penny, Washington Department of Fish and Wildlife (WDFW), are supportive of an evaluation to determine a more appropriate, program-specific size-at-release target, and that smaller release sizes could be achieved in the hatchery.

Murauskas said that Chelan PUD was not requesting action by the Committees approving a change in release size today, but was looking for Committees' members questions and suggestions for a path forward. Craig Busack asked for the origin of the current size-at-release targets. Murauskas said that during relicensing settlement agreement discussions during the 1980s and 1990s, release targets were discussed in terms of fish per pound and it was thought that bigger release sizes equated to higher survival. Busack agreed that the Chelan PUD size-at-release targets were large and said that he supported going to smaller size-at-release. Kirk Truscott asked if the sizes presented in the figures were size-at-tagging or size-at-release. Murauskas said they are size-at-release. The Committees discussed the effects of rearing hatchery fish for release at sizes more commensurate with wild smolt sizes, specifically the effect on decreasing minijacks returns and increasing age-at-return. Murauskas said survival of hatchery spring Chinook, from release to McNary Dam, is 20 percent higher than that of natural origin smolts but that hatchery fish return as minijacks at a higher rate while natural origin juveniles return as older salt fish. Overall, he said there is an increase in adult returns of wild over hatchery juveniles if you subtract minijack returns.

Keely Murdoch asked about correlation of length to minijack rate and a correlation of length to survival. Murauskas said the relationship between wild and hatchery fish length and age-at-return is significant (Figure 1 in the Spring Chinook Size Target Proposal). He also said that the hatchery fish were tagged in August and September and the wild fish were tagged as smolts. The Committees discussed the effect of hatchery feeding regimes on fish growth (Attachment C) and the constraints imposed by facility limitations (i.e., availability of space and chillers) and hatchery management considerations (i.e., fish disease issues, size-at-transfer targets).

Tonseth requested that Chelan PUD provide a study proposal to the Committees containing a size-at-transfer target and recommendations on how to manipulate fish growth curves to meet that target. He said that the proposal should consider facility limitations and fish physiological limitations. Busack said that when targeting fish sizes, maintaining variability needs to be considered. Tonseth said that the current brood of spring Chinook will be ponded soon, so there is limited time to reach a decision on size-at-release targets. He asked that the proposal provide size-at-release targets for the 2011 and 2012 broodyear, which may be different due to the narrowing down of what can be done with the 2011 broodyear to manipulate early growth. Murauskas will discuss the implications of decreasing size-at-release targets and setting size-at-transfer targets with Don Larsen and Brian Beckman of NMFS and with hatchery management staff. He said that he would most likely recommend a size-at-release target of 18 fpp, which is not a big change from the past 5 years which averaged a 15 fpp release size. Murauskas will send Chelan PUD's proposal to adjust spring Chinook hatchery-raised size-at-transfer and size-of-release criteria to Carmen Andonaegui for distribution to the Committees; Chelan PUD will ask the Committees to approve the proposal at the February 15, 2012, meeting. Murauskas will invite Larsen and Beckman to participate by phone during the February 15, 2012, Committees' meeting to participate in the discussion.

Truscott asked about the expected effect of a smaller release size on female adult returns. He suggested that if larger overall adult returns were achieved but there was a lower proportion of females in those returns, that might be a net loss for productivity. Murauskas will provide information to the Committees on the ratio of male-to-female returning Chiwawa spring Chinook by age-at-return, for the small versus large juvenile size-at-releases.

B. Feasibility of Overwintering Summer Chinook at Dryden and Carlton (Alene Underwood)

Alene Underwood said that Chelan PUD plans to conduct its feasibility evaluations of the overwintering programs separate from and parallel to those being conducted by Grant PUD. Chelan PUD is evaluating whether to convert either the Dryden or Carlton facility to a permanent overwintering facility. She said that most of the discussions were related to the Dryden facility, and that the feasibility investigation has three components—technical, regulatory, and contractual, summarized below:

- Technical Component: This component of the feasibility investigation considers the physical and biological attributes of the sites. The main technical concern with the Dryden site is related to chronic fish health problems and the concern that longer acclimation at the site could result in higher mortality. There are no technical concerns currently identified for the use of the Carlton site.
- Regulatory Component: Beyond normal permit needs for modifying a facility to accommodate overwintering, a concern with the Dryden site is the ability to meet the phosphorus compliance requirements for the Wenatchee Total Maximum Daily Load (TMDL), which will become effective in 2018. Underwood said that Chelan PUD will start with getting a baseline condition for phosphorus discharges from Dryden Pond when fish are on station. Chelan PUD is also waiting for the U.S. Environmental Protection Agency (EPA) to decide whether they will allow the TMDL to be amended to allow for phosphorus input from the Dryden facility; they believe this decision is imminent, but the process is advancing slowly. Underwood said it could take as long as a year to get resolution on the issue of amending the TMDL. Another concern is obtaining ESA take coverage under Section 10, which will be necessary to accommodate overwintering at Dryden. Chelan PUD will want assurance that ESA take coverage will be available under a new permit or that the current Section 10 permit will be extended. Also, a water rights acquisition will be needed to provide overwintering at Dryden. There are no regulatory concerns, only standard permitting needs, related to providing overwintering at the Carlton site.
- Contracting Component: Underwood said that Chelan PUD will continue to work with Grant PUD on a long-term hatchery sharing agreement, which will need to be executed before any facility modifications are started.

Underwood said that she will provide an update to the Hatchery Committees at the February 15, 2012, meeting.

C. Completed Draft M&E 5-Year Report (Josh Murauskas)

Josh Murauskas said that the draft 5-Year Hatchery M&E Report is almost complete and that he will email a copy to Carmen Andonaegui by February 3, 2012, for distribution to the Hatchery Committees. Mike Schiewe said that the draft report will be available for the standard 60-day review period, during which time the Committees can hold discussion on the content of the report. Murauskas said that Chelan PUD is interested in the Committees' ideas on how the M&E Program could be improved to support achieving program goals.

D. Chelan PUD Spring Chinook Compensation 2014 Release Year SOA (Josh Murauskas)

Josh Murauskas said that the spring Chinook compensation SOA was in response to a Joint Fisheries Party (JFP) request to increase Chiwawa spring Chinook production starting with the 2014 release year, moving Methow Basin production to the Chiwawa Facility.

Kirk Truscott asked if Grant PUD would be backfilling the 60,000 Chelan PUD Methow production in 2014. Todd Pearsons said that the Priest Rapid Coordinating Committee (PRCC) Hatchery Subcommittee (HSC) voted to approve Grant PUD's transfer of production of 60,000 spring Chinook to the Methow Basin and that this approval will go to the PRCC, where an SOA will be up for approval. If approved by the PRCC, Grant PUD will make a request to Douglas PUD to produce the fish necessary to meet the Methow production obligation. Truscott asked that this background information be added to Chelan PUD's SOA. Murauskas said that he will add language to the SOA stating that the Committees' approval of the SOA is contingent on Chelan PUD's Methow 60,000 spring Chinook production being backfilled by Grant PUD. Murauskas emailed a revised SOA to Carmen Andonaegui for distribution to the Committees. The Committees reviewed the revisions and approved the SOA as revised. Murauskas will finalize the SOA and email it to Andonaegui for distribution to the Committees.

III. Douglas PUD

A. Draft 2012 Wells Action Plan (Greg Mackey)

Greg Mackey said that the draft Wells HCP Action Plan (Action Plan) had been sent to members of the HCP Coordinating, Hatchery, and Tributary committees for review. He said that the Action Plan had general due dates for major HCP actions and deliverables for 2012. The second page of the Action Plan contains the 2012 actions that pertain to the Hatchery Committees. Mackey said that all actions captured in the Action Plan were routine except for Item 3, Hatchery Program Review. He said that the 2012 Action Plan included the required HCP 10-Year Hatchery Program review, but that analyses and reports already completed, such as the 5-Year M&E Report, Annual M&E reports, and the analyses performed for hatchery recalculation are essentially redundant with a 10 Year Review, and such a review should be based upon such documents. He said that Douglas PUD would welcome input from the Committees about how all these data and analyses could be used, but that Douglas PUD needs to meet the timeline presented in the Action Plan. Tom Kahler said that the Coordinating Committees do an overall 10-year review of progress towards meeting No Net Impact (NNI) and he described how the Hatchery Committees' report would be a component of the overall report on meeting NNI. Joe Miller said that Chelan PUD had the same requirement in their HCP and that they were working on their draft 2012 HCP Action Plan. Kahler said that he would ask for approval of the Wells 2012 HCP Action Plan at the February 15, 2012, Committees' meeting.

Kahler asked if the Committees would like a presentation on the application of the Okanagan Fish-Water Management Tool and the Skaha Lake Sockeye Reintroduction Program (the HC is typically provided with annual presentations on these programs in August or September, but the 2011 presentations were postponed for various reasons). He said that Kim Hyatt offered to come speak to the Committees at the April 18, 2012, meeting regarding the Okanagan Fish-Water Management Tool. The Committees agreed to a presentation by Hyatt; Kahler will coordinate with him. In addition, Chelan PUD will talk with Howie Wright, ONA, about participating in the same meeting to review ONA progress on the Skaha Lake Sockeye Reintroduction Program.

Kirk Truscott asked about the status of planned modifications to the Wells Hatchery. Mackey said that design planning will start in 2012. He said that it will be a couple years before any construction is started. Truscott asked about including planning, design, and construction related to the Well Hatchery modifications in the Action Plan, given that it has ties to implementation of the HCP hatchery programs. Mike Schiewe said he thought including it would be a good idea. Mackey said that Douglas PUD would evaluate the Wells Hatchery modification project as it relates to the HCP and then add to the appropriate Action Plan items and timelines. Mackey said that in February 2012, Douglas PUD will contact HCP Party signatories independently to ask about their interests related to modernization of the hatchery.

B. Announcements (Greg Mackey)

Greg Mackey said that Douglas PUD is advertising for a senior aquatic scientist and asked Hatchery Committees' members to please pass the advertisement to anyone who might be interested.

IV. NMFS

A. HGMP Update (Craig Busack)

Craig Busack said that NMFS had been discussing ways to speed up review of Upper Columbia hatchery programs; and he said that he would like to schedule regular conference calls with Douglas PUD and the USFWS to talk about their spring Chinook and steelhead hatchery programs in the Methow. Busack said he is aware that the fisheries agencies and tribes and the PUDs have been working on adult management plans. Greg Mackey confirmed that Douglas PUD had been working on this.

Bill Gale updated the Committees on progress toward development of a Winthrop NFH spring Chinook external marking plan, saying that the issue is not completely resolved in *US v OR,* but that it is close to being resolved. He said that the U.S. Fish and Wildlife Service (USFWS) proposal was to adipose-clip (ad-clip) Winthrop NFH spring Chinook based on the following priorities: 1) ensuring that the Methow Fish Hatchery spring Chinook salmon hatchery program is fully supplied so that, in low return years, the priority would be supplying eggs for the Methow spring Chinook program; 2) ensuring that the Winthrop NFH can release up to 400,000 spring Chinook salmon into the Methow Basin; 3) if more than

400,000 Winthrop NFH spring Chinook salmon are produced, ensuring that the extra fish would be transferred to the Okanogan Basin. Any Winthrop NFH production of more than 200,000 would be ad-clipped. If less than 200,000 fish are produced, no hatchery fish would be ad-clipped. All hatchery spring Chinook would be coded-wire-tagged (CWT) regardless of the number of fish produced. Gale said that the USFWS proposal was fairly well received, but that now it has to go to through *US v OR* policy review. He said that there was consensus in support of the proposal within the *US v OR* ad-hoc technical committee. Gale said that he would report to the Committees the outcome of the spring Chinook marking proposal. Busack said that the USFWS would be asked to revise their Winthrop spring Chinook Hatchery Genetic Management Plan (HGMP), if the marking plan was approved. This would allow NMFS to begin consultation on the Winthrop HGMP because it would then be in line with *US v OR* management agreement.

Gale asked if there was any talk by NMFS about finalizing the Entiat biological opinion. Busack said that NMFS was working to get it done. Greg Mackey said that Douglas PUD wanted to meet with NMFS on their HGMPs, and asked if any progress on the Wells steelhead or Methow spring Chinook HGMPs had been made. Busack said that he had started reviewing them and that regularly scheduled conference calls with Douglas PUD and the USFWS would help to move them forward. Gale and Mackey agreed.

Kirk Truscott said that with almost all Upper Columbia hatchery program permits expiring in 2013, it sounded unlikely that Biological Opinions and new ESA Section 10 permits would be ready in time. He asked what plan NMFS had to provide certainty so the hatchery programs could continue. Busack said that once an HGMP has been accepted by NMFS as sufficient for consultation, the sufficiency letters are evidence that the applicant has done all they can to meet permit progress requirements. Busack said that NMFS was not planning to provide any interim permitting. He said that he expected to have all the hatchery programs permitted by the end of 2012. He indicated that his highest priority is the Snake River fall Chinook HGMP; the next priority is the Upper Columbia HGMPs.

B. Federal Hatchery Program EIS Update (Allyson Purcell/NOAA)

Allyson Purcell said that the draft Mitchell Act Environmental Impact Statement (EIS), now referred to as the Federal Hatcheries EIS, was released in August 2011 (Attachment D). NMFS received about 1,000 comments in letters. The scope of the draft EIS was the entire Columbia River Basin, looking at all funding distribution options. The structure of the draft EIS was to provide five very general alternatives and to provide one implementation scenario for each alternative. There was no preferred alternative or preferred implementation scenario identified in the draft EIS. Purcell said that in the final EIS, a preferred alternative would be created using parts of all the implementation scenarios. She said NMFS now had a draft preferred alternative and that it was very general and goal-oriented. Purcell provided a handout of the goals and principle captured by the preferred alternative (Attachment E).

Purcell said that starting in May 2011, working with hatchery managers, NMFS developed an implementation scenario, which they are still modeling. She said that they had not yet decided whether they would release a supplemental draft EIS or a final EIS with the preferred alternative, and in either case, the preferred alternative needs to be completed first. NMFS anticipates completing it and having a final or a supplemental draft EIS ready by late summer 2012. Purcell said that the EIS is not intended to make a determination on whether individual hatchery programs meet ESA requirements, and she said that the HGMP process would not be slowed or delayed by this EIS. She added that the EIS was expected to provide a foundation of information that will be useful for making ESA and National Environmental Policy Act (NEPA) determinations. Purcell said the idea was for the HGMP NEPA processes to be tiered off the Federal Hatcheries EIS once it is final. She said the decision whether to issue a supplemental or final EIS would be based on how many comments were received; there is usually 1 year between producing a draft and releasing a final EIS. If a final EIS is produced, the EIS could potentially be put to use the summer of 2012. She said that HGMPs that are already being processed will not be held up by the EIS process. The Committees asked how the timing of the EIS might influence processing HGMPs that were not yet under review or those HGMPs that have yet to be submitted. Purcell asked for comments or edits to the handout on the goals and principle of the preferred alternative. Bill Gale asked about the duration of HGMP ESA permits, which he thought were 5 years, but which Purcell had indicated were 10 years. Craig Busack said that he would confirm the expected duration of new ESA hatchery permits.

C. 2011 PBT Study Results (Craig Busack)

Craig Busack said that he had discussed the 2010 PBT study report with Ken Warheit of the WDFW genetics laboratory. Warheit said that the probability acceptance threshold for parental assignment had perhaps been set too high, that not a large enough sample was obtained, and that the results were not adequately explained. Keely Murdoch said that she recalled that WDFW had told the Yakama Nation to assume 90 percent assignment of at least one parent for the purposes of collecting broodstock at Tumwater Dam.

Busack said that the message is that PBT works but that a large sample size is important. He suggested Warheit be invited to the next Committees' meeting to give a presentation of his review. Mike Schiewe asked if Warheit's review would affect interpretation of the results for both 2010 and 2011. Busack said that Warheit had re-analyzed the results for both years and that the revised report was undergoing internal review. Schiewe asked about the need for a third year of the pilot study. Busack said that another year of sampling at Priest Rapids Dam would not change the outcome. He said that at issue was whether enough fish can be captured to assign parentage. Joe Miller agreed that a third year of study was not needed, but that a presentation to the Committees from Warheit on his re-analysis would be helpful. Mike Tonseth will contact Warheit about providing a presentation to the Committees on his re-analysis of the 2010 and 2011 PBT study results at the February 15, 2012, meeting. When cleared for distribution, Tonseth will email a copy of Warheit's re-analysis of the 2010 and 2011 PBT study results to Carmen Andonaegui for distribution to the Committees.

V. HETT Update

Carmen Andonaegui reported that the HETT met on January 10, 2012. She reported that the HETT had taken the task of identifying reference streams for the HCP Plan Species supplemented populations as far as they were able. Reference streams have been selected for spring Chinook and for summer Chinook. The HETT determined that reference streams could not be identified for steelhead or sockeye due to limited data. The method developed by the HETT for identifying reference streams is being finalized and will be included as an appendix in the PUD 5-Year M&E Reports.

The HETT previewed a demonstration run of the Predation, Competition, and Disease (PCD) Risk model that will be used for the non-target taxa of concern (NTTOC) risk assessment. Individuals have been identified to conduct model runs for USFWS and Douglas PUD hatchery programs and the Yakama Nation's coho programs. Josh Murauskas said that he would conduct the model runs for the Chelan PUD hatchery programs but could not get to this until February. Kirk Truscott said that he would provide a staff person's name to run the Chief Joseph hatchery program model runs. Over the next couple of months, the HETT will work on completing all the model runs. At the February 15, 2012, meeting, Andonaegui will provide to the Hatchery Committees a summary of the conclusion of the HETT reference stream evaluation and a HETT proposal for any next steps.

VI. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees' meetings are February 15, 2012 (Chelan PUD office), March 21, 2011 (Douglas PUD office), and April 18, 2011 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – Chelan PUD Spring Chinook Size-at-Release Proposal
Attachment C – BY 2007 Chiwawa Spring Chinook Growth Rates
Attachment D – NMFS Federal Hatcheries EIS Update Presentation
Attachment E – Draft NMFS Federal Hatcheries EIS Preferred Alternative handout

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Alene Underwood	Chelan PUD
Joe Miller*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Keely Murdoch*	Yakama Nation
Jayson Wahls	WDFW
Kirk Truscott*	CCT
Mike Tonseth*	WDFW
Craig Busack*	NMFS
Allyson Purcell	NMFS
Bill Gale*	USFWS
Todd Pearsons	Grant PUD

Notes:

* Denotes Hatchery Committees' member or alternate

Use of monitoring and evaluation data to identify appropriate size at release targets for hatchery-origin Chiwawa River spring-run Chinook salmon *Oncorhynchus tshawytscha*

J. G. Murauskas

Natural Resources Department, Chelan Public Utilities District, Wenatchee, WA

Abstract–We examined smolt survival and adult returns of Chiwawa River spring Chinook salmon *Oncorhynchus tshawytscha* using passive integrated transponder tags to determine if juvenile length influenced these results. A logistic regression indicated that increasing juvenile length at tagging significantly increased the probability of both wild- and hatchery-origin smolts returning at younger age classes, including mini-jacks (p = 0.03 and p < 0.01, respectively). Despite significantly smaller size at release and 21.4% lower smolt survival rate on average, wild-origin fish had a 49.2% greater rate of adult returns compared to hatchery-origin fish (p < 0.01). Hatchery-origin smolts were divided into small and large groups by median length at tagging for comparison. The large half of hatchery-origin fish had statistically indifferent juvenile survival compared to the small half, but produced 135% more mini-jacks (p = 0.03), 194% more jacks (p < 0.01) , 6% more 2-salt adults (p = 0.38), and 56% fewer 3-salt adults (3-salt adults from the 2009 releases have not yet returned; p = 0.11). These results indicate that large length targets of hatchery programs do not translate to increased smolt survival or adult returns and further increase the disparity between population demographics of hatchery- and wild-origin populations. We propose that a size target of 126 mm and 25 g (~ 18 fish per pound) in hatchery-reared spring Chinook would provide measurable benefits in terms of adult returns and conservation of an ESA-listed stock.

Introduction–Chiwawa Hatchery (Chiwawa) is located at the confluence of the Chiwawa and Wenatchee rivers approximately 15 miles north of Leavenworth, Washington. Chiwawa was constructed in 1990 as a component of the Eastbank Hatchery Complex designed to rear up to 672,000 spring Chinook smolts to mitigate for losses incurred at hydroelectric projects owned and operated by Chelan County Public Utilities District (PUD). The juvenile fish are transferred from Eastbank Hatchery in the fall prior to migration, over-wintered at Chiwawa, and released directly into the Chiwawa River.

Chelan PUD has funded extensive monitoring and evaluation efforts of Chiwawa spring Chinook since 1989. A comprehensive report on monitoring and evaluation efforts over the past five years is currently being developed. Two recommendations within the report indicate that (1) "more realistic [size] targets should be set based on the length-weight relationship specific to Chiwawa spring Chinook and the size of natural-origin smolts produced in the Chiwawa Basin;" and, (2) "hatchery fish matured at an earlier age than natural-origin fish. This may be related to the size of released hatchery smolts" (Hillman et al. 2011a).

Several researchers have identified relationships between length at release and survival and age at maturity in Chinook and other *Oncorhynchus* spp. (Neilson and Geen 1986; Vøllestad et al. 2004; Scheuerell 2005; Claiborne et al. 2011; Tipping 2011). The current size target for hatchery spring Chinook released in the Chiwawa River is 176 mm FL and 38 g (~ 12 fish per pound), whereas wild-origin fish have averaged 94 mm FL and 9.3 g (~ 50 fish per pound; Hillman et al. 2011b). The purpose of the analyses contained herein is to test the hypotheses that (1) larger spring Chinook smolts lead to a decrease in age at maturity; and, (2) larger spring Chinook smolts do not have a full life cycle survival advantage compared to smaller smolts.

Methods–Data were retrieved from the PIT Tag Information System for the Columbia River Basin (PTAGIS; Pacific States Marine Fisheries Commission 2011). A "tagging detail" query was submitted to obtain records of PIT-tagged spring Chinook that were released from Chiwawa Ponds (CHIP; hatchery-origin smolts only) and Chiwawa Trap (CHIWAT; natural-origin smolts only) during the juvenile migrations of 2006, 2007, 2008, and 2009 (hatchery-origin smolts were not PIT-tagged in 2006). Wild-origin spring Chinook tagged after the month of June are considered sub-yearling juveniles and were excluded from analyses. Descriptive statistics were generated of tagging data for both hatchery- and wild-origin smolts.

An "interrogation summary" query was submitted to obtain observation records of the fish included in the "tagging detail" query described above. The data were filtered to only include observations at the Rock Island adult fishway to identify returning fish. The year of the last observation date at Rock Island was considered the return year, and the difference between the return year and the release year was considered "ocean residence." All juvenile detections in the adult fishway that were last detected the same year as release were considered mini-jacks. Adult returns detected the year following release were considered jacks; two years following release were considered "2 salt" fish, and so forth. Data were tabulated to determine the composition of returns.

A logistic regression was used to model the probability of returning to freshwater after a particular ocean residence (the ordinal variable) as a response to fork length at tagging (the continuous variable). Results were separated by hatchery- and wild-origin smolts. The Whole Model Test was used to determine if the model fits better than constant response probabilities (analogous to the Analysis of Variance table for a continuous response model). *p* values were reported for the Chi-square test used to evaluate how well the categorical model fits the data. Results were considered significant at $p \leq 0.05$ (SAS 2009).

PitPro 4.19 was used to generate Cormack/Jolly-Seber survival estimates and harmonic mean travel time of spring Chinook from release to McNary Dam to examine relative in-river performance of smolts during the outmigration (CBR 2011; Jolly 1965; Seber 1965; Cormack 1964). Fish were initially separated by rear-type (hatchery or wild). Subsequent survival estimates and harmonic mean travel times were generated for hatchery-origin spring Chinook based on a division of fish size each year. Median fork length at tagging was determined for each year and used to divide the "small half" and "large half" subsequently used in comparisons of returns and survival. The small half had larger sample sizes since the median length was included in this group.

Rates of return (RORs) were calculated by dividing the number of PIT-tagged fish detected in the adult fishway at Rock Island Dam (i.e., returns) by the number of fish released. RORs were calculated and compared for specific ages or ocean residence, and also for all adults combined (i.e., 2-salt or greater). A pooled sampling proportion *Pooled* (i.e., for both RORs in comparisons) was calculated by:

$$Pooled = \frac{[(ROR_1 \times n_1) + (ROR_2 \times n_2)]}{(n_1 + n_2)}$$

and SE_{Pooled} was calculated by:

$$SE_{Pooled} = \sqrt{(1 - Pooled)} \times [(1/n_1) + (1/n_2)]$$

The test statistic (two-proportion z-test), *z*, was calculated as:

$$z = \frac{(ROR_1 - ROR_2)}{SE_{Pooled}}$$

The test statistic and resulting *p* value was obtained from a standard normal table. Data manipulation and descriptive and inferential statistics were performed in JMP ® 8.0.2. Results were considered significant at $p \leq 0.05$.

Results–Over 65,000 spring Chinook were PIT-tagged between 2006 and 2009, including 29,906 hatchery- and 14,142 wild-origin yearling smolts. Hatchery fish were tagged between June and August the year prior to the smolt migration; natural-origin fish were tagged between March and June during the smolt migration. Hatchery-origin smolts averaged 93.1 mm (± 0.1 mm SE) and wild-origin smolts averaged 94.0 mm (± 0.1 mm SE) in fork length. Size at tagging was similar, though wild-origin smolts are tagged 8 to 9 months later on average. Nearly 50,000 detections of these fish occurred subsequent to release, including only 346 observations of unique fish within the Rock Island Dam adult fishway.

Two hundred ninety-three (293) returns were observed in the Rock Island Dam adult fishway, including 192 hatchery-origin fish and 101 wild-origin fish. The majority of returns were 2-salt fish for both hatchery- and wild-origin fish, though hatchery-origin fish had a greater number of mini-jacks and jacks and fewer 3-salt returns. RORs, to account for varying release sizes, show that hatchery-origin fish had 24% more mini-jacks (p = 0.30), 893% more jacks ($p < 0.01$), and 33% fewer ≥ 2-salt adults ($p < 0.01$) than wild-origin fish on average (Table 1). The logistic regression indicated that fish length at tagging significantly influenced the probability of returning after a specific period of ocean residence for both hatchery- (n = 192, $P < 0.01$) and wild-origin (n = 101, $P = 0.03$) fish. The probability of returning as a mini-jack or jack increased significantly with increasing length at tagging for all fish (Figure 1).

Hatchery-origin smolts had an average estimated survival to McNary Dam of 56.6% (range 43.0-65.0%), compared to an average of 44.5% for wild-origin smolts (range 38.5-47.3%). The difference in estimated survival to McNary Dam was 27% greater on average for hatchery-origin fish, ranging from -5% to 69% over comparable years. Hatchery-origin smolts generally traveled to McNary Dam slightly faster during comparable years, though rates were comparable between groups. Estimated survival to McNary Dam was similar between the small half and large half of hatchery fish as was harmonic mean travel time. These results suggest that hatchery-origin smolts have a downstream survival advantage over wild-origin smolts, though a size advantage within hatchery-origin smolts was not observed (Table 2, Figure 2).

RORs from both the small and large half of hatchery smolts show similar rates of ≥ 2-salt fish (p = 0.48), with the large half returning 6% more 2-salt adults (p = 0.38) and 56% fewer 3-salt adults (p = 0.11) compared to the small half. Mini-jack and jack rates were greater in the large half: the large half produced 135% more mini-jacks (p = 0.03) and 194% more jacks ($p < 0.01$) compared to the small half (Table 1). The mini-jack rate for the small half was also inflated by the 2007 smolt year where the median hatchery-origin fish were over 20% larger than in 2008 and 2009; outside of 2007, no mini-jacks were observed in the small half of hatchery-origin smolts.

Even greater differences were noticed between the large half of hatchery-origin smolts and wild-origin smolts. The large half hatchery-origin fish produced on average 50% more mini-jacks (p = 0.09), 1,186% more jacks ($p < 0.01$), an equal number of 2-salt adults (p = 0.41), and 90% fewer 3-salt adults ($p < 0.01$). Generally speaking, all three groups (wild, small half, and large half) produced similar rates of 2-salt fish, whereas large half smolts produced fewer 3-salt fish, more mini-jacks, and more jacks than wild or small half smolts (Table 1). The composition of returns among these three groups demonstrate that most (88%) wild-origin smolts resulted in ≥2-salt adults over the time period observed, compared to 79% in the small half hatchery-origin smolts, and 57% in the large half hatchery-origin smolts (Figure 3).

Discussion–Our first hypothesis – that larger smolts lead to decreased age at maturity in Chiwawa River spring Chinook – is supported by these findings in both wild- and hatchery-origin fish. Neilson and Geen (1986), Scheuerell (2005), Chamberlin et al. (2011), Claiborne et al. (2011), and Tipping (2011) found similar results in Chinook, where the age of maturation decreased with increasing smolt size. Considering the importance of size at age and age at maturity in Chinook salmon (Kinnison et al. 2011), size at release may have considerable implications on the effectiveness of hatchery releases in the Chiwawa River. At a minimum, a disproportionate rate of mini-jacks and precocious males do not contribute favorably to harvest. Likewise, mini-jack and jack Chinook likely have a limited, if not negative, contribution to conservation-based supplementation efforts (Heath et al. 1994, 2002; Asbjørn Vøllestad et al. 2004; Pearsons et al. 2009; Larsen et al. 2010; Williamson et al. 2010). Our results, in combination with the observed size distribution of wild-origin Chinook and the intent to mimic the wild population for supplementation, provide evidence that a reduced target size for hatchery smolts will improve the population demographics of hatchery spring Chinook salmon in the Chiwawa River.

Our second hypothesis – that larger spring Chinook salmon smolts do not have a full life cycle survival advantage over smaller smolts – is also supported by these data. While some researchers have found smolt survival to be greater for larger smolts (e.g., Miyakoshi et al. 2001; Saloniemi et al. 2004), our results are unable to support these findings. Similar results to our study were observed in Imnaha River spring Chinook, where larger hatchery smolts (12-14 fish per pound) did not have a survival advantage over smaller smolts (20-25 fish per pound). Further, while overall smolt-to-adult survival was similar between small and large hatchery smolts, the smaller Imnaha River hatchery smolts had a significantly greater survival to Age 5 (i.e., 3-salt adults; Feldhaus et al. 2011). In either case, the rate and composition of returns – not smolt performance – is a more important metric in evaluating performance. For example, a 10% increase in smolt survival would not be beneficial if it were accompanied by a 50% increase in mini-jack rates. Therefore, supplementation programs intended to promote conservation of wild-origin stocks should focus on RORs, especially absent any evidence of a survival benefit of rearing larger smolts.

The PIT-tagged Chiwawa River spring Chinook provide a unique opportunity to compare wild- and hatchery-origin salmon. The hatchery uses wild-origin brood and resulting progeny are genetically similar to the wild-origin cohorts. In other words, the major difference between the wild- and hatchery-origin smolts is the rearing. Knudsen et al. found hatchery-origin spring Chinook matured at an earlier age just one generation removed from wild-origin cohorts and that minimizing the results of artificial rearing was difficult (2006). Larsen et al. found that changes in feeding rations can reduce mini-jack rates, creating a leaner and smaller hatchery smolt more similar to a wild counterpart (2006). Feldhaus et al. observed smaller hatchery spring Chinook smolts returning at older age classes compared to larger smolts (2011). With our results indicating that the most apparent difference between wild- and hatchery-origin fish is the age structure and associated RORs, and that the size of hatchery smolts is a predictor of these results, we recommend a reduction in the target size of the hatchery program.

While the current hatchery size target is 179 mm FL and 37.8 g (12 fish per pound), the observed lengths and weights have averaged roughly 136 mm and 32 g (~15 fish per pound) over the past five years (brood years 2004-2008; Hillman et al. 2011). Further, a length-weight relationship developed on the data used in our analyses indicate that the current size targets are not achievable (i.e., a 37.8 g smolt would be roughly 140 mm, not 179 mm). Feldhaus et al. (2011) evaluated Imnaha River hatchery spring Chinook smolts in the 18-23 g range (average weight of 21 g, 20-25 fish per pound). The Imnaha River target weights would translate to roughly a 120 mm and 22 fish per pound target in the Chiwawa Program. We recommend beginning with an intermediate size target of 126 mm and 25 g (approximately 18 fpp) and supporting continued PIT-tagging to evaluate the efficacy of this approach.

In conclusion, these results support previous findings highlighting significant differences between wild- and hatchery-origin salmon. While the disparity may be unsolvable, it is apparent that the large size targets and unnatural growth rates decrease age at maturity in Chiwawa River spring Chinook. These results further indicate that smaller hatchery smolts are more similar to wild-origin counterparts and that larger hatchery smolts may even pose a negative impact. A reduced hatchery size target could reduce some of these discrepancies, as well as provide additional benefits, such as lower rearing densities, and reduced adult management obligations.

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Table 1. Observations and rate of return of PIT-tagged Chiwawa River hatchery- and wild-origin spring Chinook in the Rock Island Dam adult fishway, release years 2006-2009.

			Ocean residence (years)				Rates of return				
Origin	**Tag year**	**PIT tags**	**0**	**1**	**2**	**3**	**Mini-jacks**	**Jacks**	**Age 2**	**Age 3**	**Adults**
Hatchery	2007	9,981	16	16	29	1	0.160%	0.160%	0.291%	0.010%	0.301%
	2008	9,894	2	14	58	10	0.020%	0.141%	0.586%	0.101%	0.687%
	2009	10,031	3	12	31	0	0.030%	0.120%	0.309%	0.000%	0.309%
	All	**29,906**	**21**	**42**	**118**	**11**	**0.070%**	**0.140%**	**0.395%**	**0.037%**	**0.431%**
Wild	2006	2,355	0	0	12	5	0.000%	0.000%	0.510%	0.212%	0.722%
	2007	2,697	2	0	2	0	0.074%	0.000%	0.074%	0.000%	0.074%
	2008	6,719	5	1	36	26	0.074%	0.015%	0.536%	0.387%	0.923%
	2009	2,374	1	1	10	0	0.042%	0.042%	0.421%	0.000%	0.421%
	All	**14,145**	**8**	**2**	**60**	**31**	**0.057%**	**0.014%**	**0.424%**	**0.219%**	**0.643%**
Hatchery (small)	2007	5,569	7	2	18	1	0.126%	0.036%	0.323%	0.018%	0.341%
	2008	5,394	0	2	30	7	0.000%	0.037%	0.556%	0.130%	0.686%
	2009	5,193	0	8	14		0.000%	0.154%	0.270%	0.000%	0.270%
	All	**16,156**	**7**	**12**	**62**	**8**	**0.043%**	**0.074%**	**0.384%**	**0.050%**	**0.433%**
Hatchery (large)	2007	4,412	9	14	11	0	0.204%	0.317%	0.249%	0.000%	0.249%
	2008	4,500	2	12	28	3	0.044%	0.267%	0.622%	0.067%	0.689%
	2009	4,838	3	4	17		0.062%	0.083%	0.351%	0.000%	0.351%
	All	**13,750**	**14**	**30**	**56**	**3**	**0.102%**	**0.218%**	**0.407%**	**0.022%**	**0.429%**

Table 2. Probability of survival and harmonic mean travel time (days) to McNary Dam of hatchery- and wild-origin spring Chinook smolts, 2006-2009.

Origin	**Tag year**	**PIT tags**	**Survival to McNary**	**SE**	**Travel to McNary (d)**
Hatchery	2007	9,981	65.0%	2.0%	28.3
	2008	9,894	61.7%	3.9%	29.0
	2009	10,031	43.0%	2.0%	30.4
	Average		**56.6%**	**2.6%**	**29.2**
Wild	2006	2,355	47.3%	3.0%	20.1
	2007	2,697	38.5%	2.2%	27.9
	2008	6,719	47.0%	2.6%	29.4
	2009	2,374	45.2%	4.6%	36.6
	Average		**44.5%**	**3.1%**	**28.5**
Hatchery (small)	2007	5,569	66.0%	2.6%	28.5
	2008	5,394	68.4%	6.1%	29.7
	2009	5,193	42.7%	2.8%	31.4
	Average		**59.0%**	**3.8%**	**29.9**
Hatchery (large)	2007	4,412	63.6%	3.1%	28.1
	2008	4,500	54.8%	4.8%	28.3
	2009	4,838	43.4%	2.8%	29.4
	Average		**53.9%**	**3.6%**	**28.6**

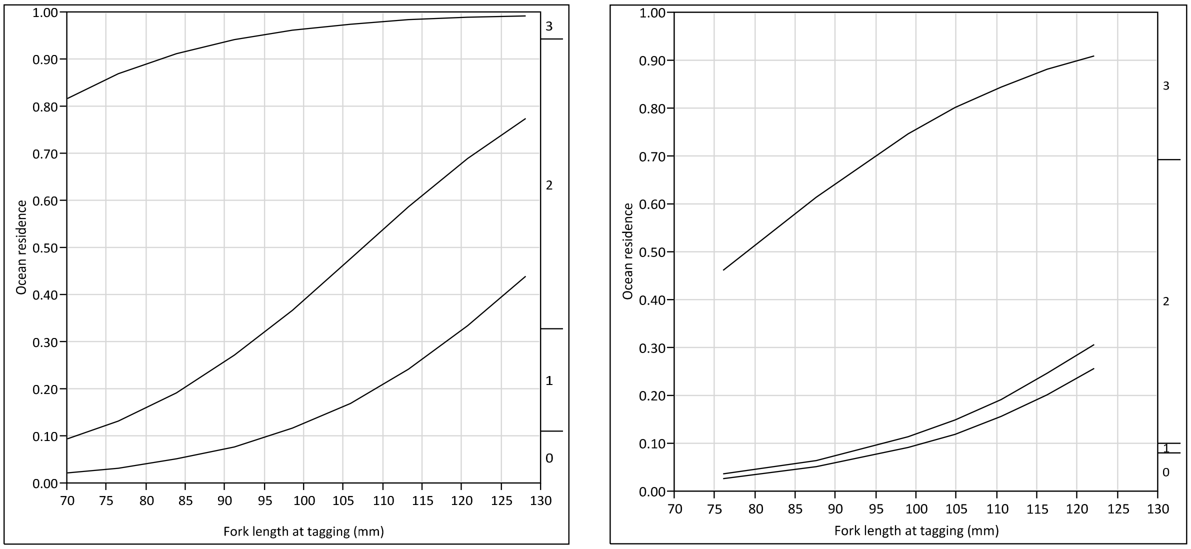


Figure 1. Logistic fit of ocean residence by fork length (mm) at time of tagging for hatchery (left) and wild-origin (right) Chiwawa River yearling spring Chinook. Whole Model Tests indicate a significant relationship for both hatchery ($P < 0.01$) and wild-origin ($P = 0.03$) fish, with an increasing probability of ocean residence = 0 (i.e., mini-jack) with increasing size at tagging.

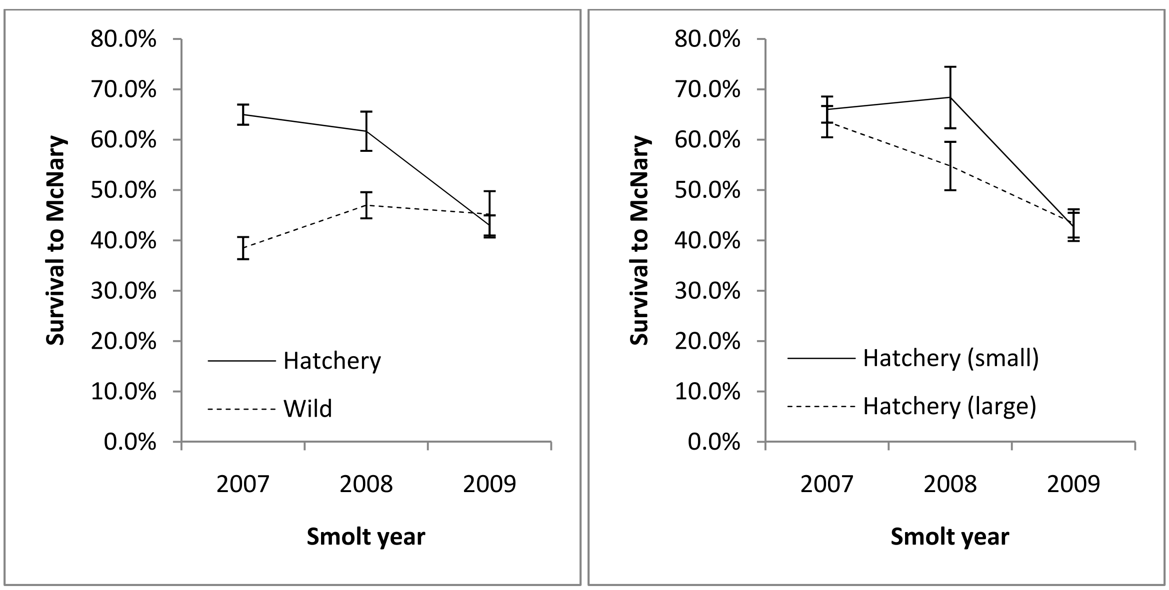


Figure 2. Estimated survival (± SE) to McNary Dam of hatchery and wild spring Chinook smolts (left), and small and larger hatchery-origin smolts (right).

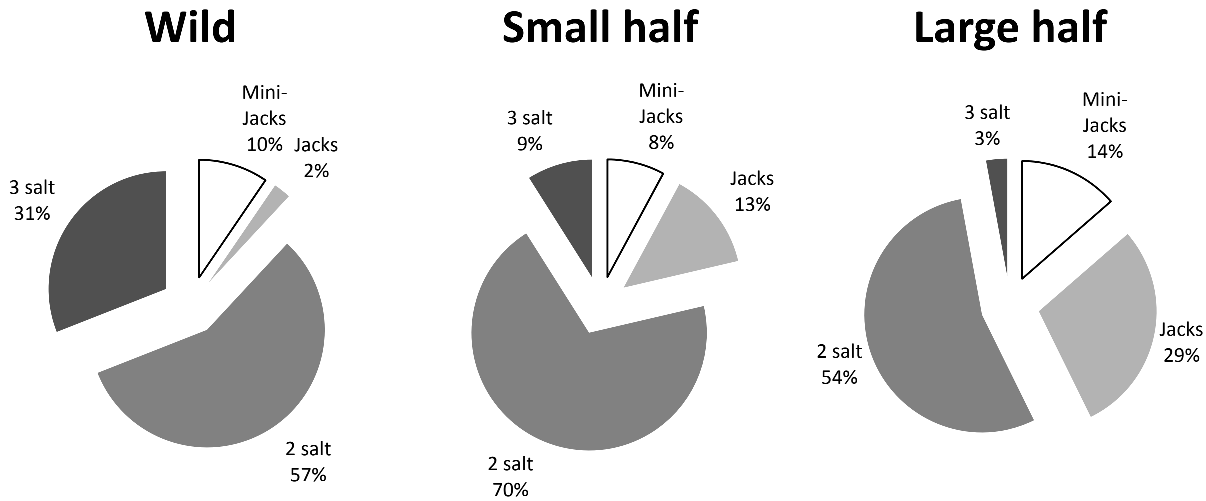
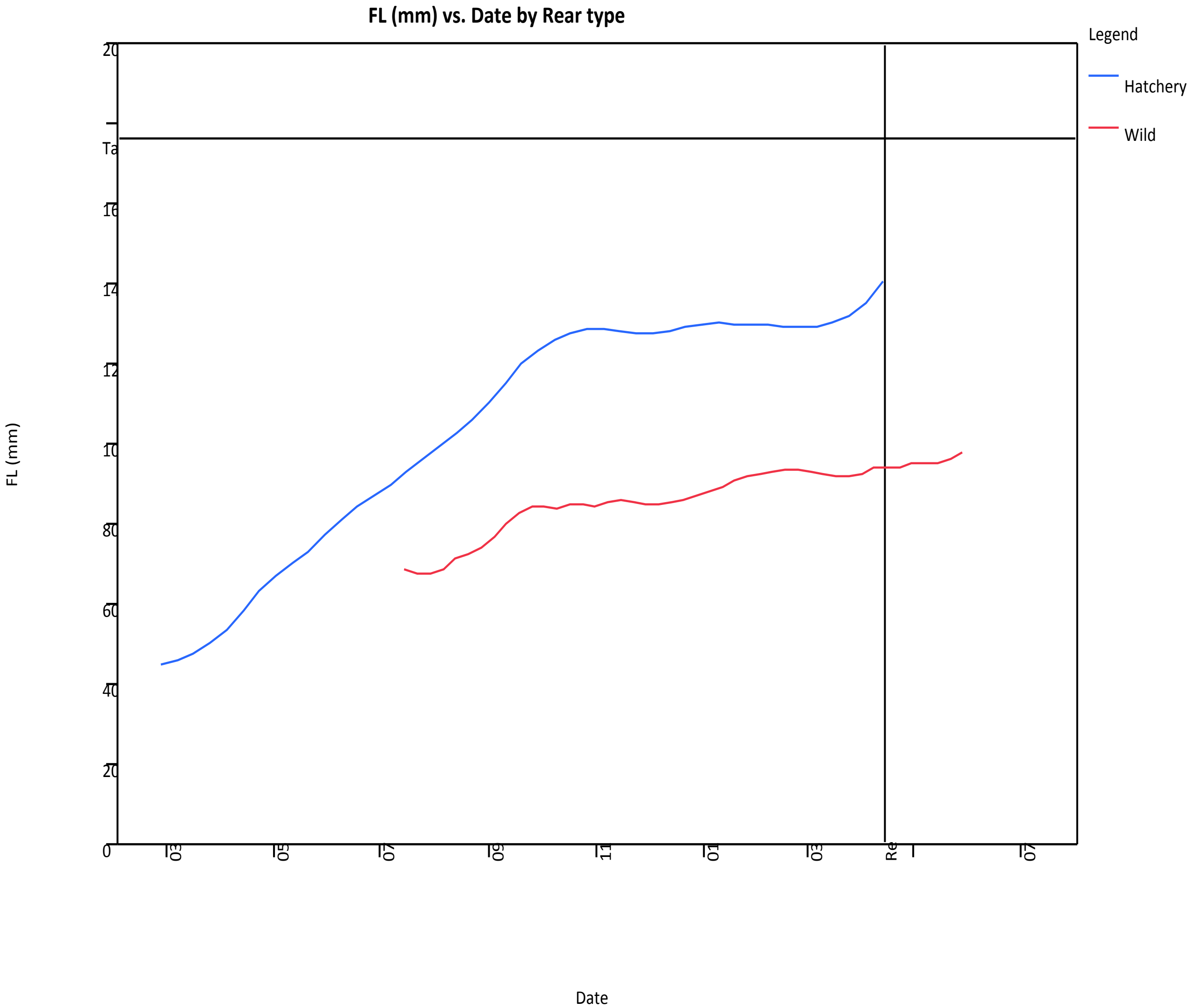


Figure 3. Distribution of returns from wild- and hatchery-origin spring Chinook smolts released in the Chiwawa River, 2007-2009. Hatchery smolts were separated by median fork length at time of tagging and returns from 2009 do not yet include 3-salt fish.

Attachment C

Graph Builder



Attachment D

Science, Service, Stewardship

UPDATE on EIS to Inform Columbia River Basin Hatchery Operations & the Funding of Mitchell Act Hatchery Programs

(AKA: The Mitchell Act EIS)

NOAA FISHERIES SERVICE

Science, Service, Stewardship

Background

- NMFS released a draft EIS on August 6, 2010.
- It was available for a 120-day public comment period.
- A total of 418 letters were received.

Hatcheries and Facilities in the Columbia and Snake River Basins

Prepared by Parametix, Inc. January 19, 2010 (DEIS_Figure_1-3_20100119.mxd).

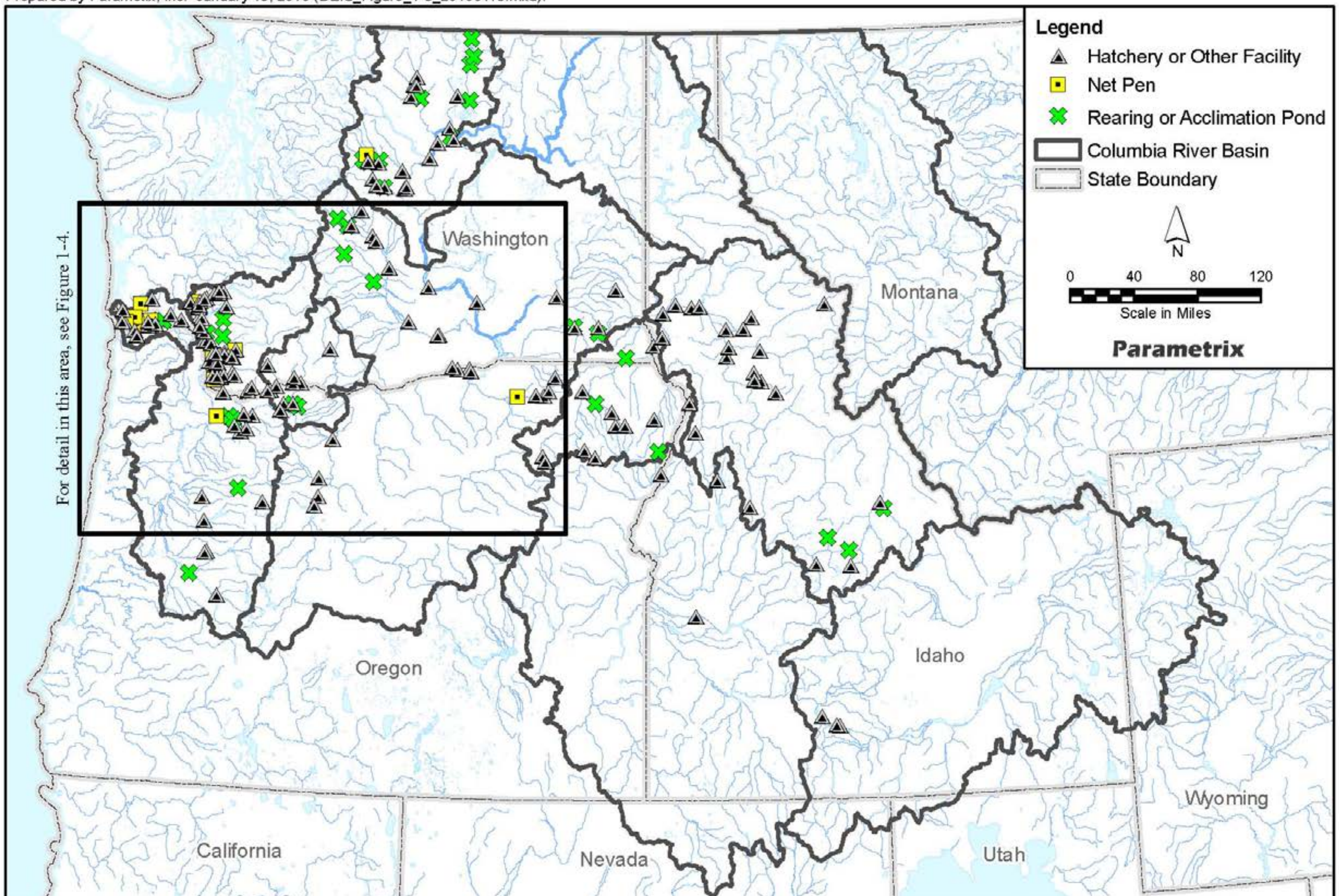


Figure 1-3. Hatcheries and facilities in the Columbia and Snake River basins.

Science, Service, Stewardship

Structure of EIS

- 5 alternatives including status quo
- Each alternative centers around a general policy direction

Science, Service, Stewardship

Structure of EIS

- NMFS developed one example implementation scenario for each alternative for the sake of analysis. Innumerable other scenarios exist.
- No preferred alternative (or implementation scenario) in draft EIS.
- The draft EIS indicated that the Preferred Alternative would likely combine components of more than one of the alternatives.

Science, Service, Stewardship

Changes to Draft

- Update information to reflect the most recent years of information.
- Update description of Alternative 1 (status quo).
- Add clarifying information (e.g., do a better job describing how EIS relates to other policies and plans).

Science, Service, Stewardship

Changes to Draft

- Fix errors.
- Identify a Preferred Alternative
- Evaluate potential effects of the Preferred Alternative in an example implementation scenario

Draft Preferred Alternative

- Combines elements of Alternatives 1, 4, and 5.
- Applies stronger performance goals throughout basin.
- Does not limit production or the construction of new hatchery facilities.
- Does not identify pHOS or PNI goals.

Example Implementation Scenario for Preferred Alternative

- Developed with help of hatchery managers.

- Risks of the hatchery programs are minimized in a manner that applies basin-specific strategies after taking into account the status of the natural population, applicable recovery goals, and commitments that have been made in other plans and agreements (e.g., US v OR, Pacific Salmon Treaty, FCRPS Accords).

Supplemental v. Final

- NMFS has not determined whether the EIS will be released as a supplemental draft or a final EIS.

- NMFS must first finalize the Preferred Alternative and complete the analysis of its potential impacts.

Science, Service, Stewardship

Schedule

- NMFS expects to release a revised EIS in the summer of 2012.

Science, Service, Stewardship

How does this EIS relate to the HGMP process?

- This EIS will not make determination of whether any hatchery program meets the requirements of the ESA.
- HGMP process will not be slowed down by EIS.
- However, the EIS will provide a comprehensive foundation of information that will be useful when NMFS makes future determinations under the ESA and NEPA.

Draft Preferred Alternative

Environmental Impacts Statement (EIS) to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs

November 3, 2011

This is a draft document for the purpose of discussion and coordination.

Alternative 6 (Preferred Alternative)

Alternative 6 is the Preferred Alternative. It is a hybrid of Alternatives 1, 4, and 5 found in the draft EIS. Under Alternative 6, the policy direction would be defined by the following goals and/or principles:

- The stronger performance goal (see below or page 2-13 in the draft EIS) would be applied to all Columbia River basin hatchery programs that affect ESA-listed, primary and contributing, salmon and steelhead populations in the Columbia River basin.
- Conservation hatchery programs would be operated at a level determined by conservation need. Benefits of conservation hatchery programs must outweigh their risks.
- BMPs, tailored to site-specific conditions, would be applied in all hatchery programs.
- New conservation hatchery programs would be initiated throughout the Columbia River basin, where appropriate.
- New harvest hatchery programs would be initiated (i.e., increased hatchery production) and/or existing hatchery programs would be changed to better support harvest opportunities throughout the Columbia River basin and in ocean fisheries.
- Different approaches to hatchery management would be tested and evaluated.[1]
- Mitchell Act funds would be disbursed in support of the above goals and/or principles.

Development of the Implementation Scenario for Alternative 6 (Preferred Alternative): The implementation scenario for Alternative 6 (Preferred Alternative) will be an implementation scenario that NMFS develops with co-manager input based upon the goals and principles stated in Alternative 6. In the implementation scenario for Alternative 6, risks of the hatchery programs are minimized in a manner that applies basin-specific strategies after taking into account the status of the natural population, applicable recovery goals, and commitments that have been made in other plans and agreements (e.g., US v OR, Pacific Salmon Treaty, FCRPS Accords).

[1] This principle will also be added to Alternatives 1 through 5.

Future Funding Decisions (add to Chapter 1): Funding is not limited within EIS alternatives. However, based on history, funding levels will be limited, so an allocation plan will be put together annually, consistent with the alternative adopted in the ROD, other current agreements and plans in the basin, and after considering other potential sources of funds that may be available for each proposal.

Future ESA Decisions (add to Chapter 1): NMFS will continue to review Columbia River hatchery programs under the ESA. This EIS will inform NMFS of the aggregating effects of proposed hatchery programs in the context of all Columbia River basin hatchery production.

Stronger performance goals = performance goals that promote beneficial effects and that minimize adverse effects of hatchery programs on salmon and steelhead populations.

Intermediate performance goals = performance goals that in most cases reduce adverse effects of hatchery programs on salmon and steelhead populations when compared to status quo conditions.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	March 28, 2012
From:	Mike Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the February 15, 2012, HCP Hatchery Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees' meeting was held at the Chelan PUD Headquarters Building in Wenatchee, Washington, on Wednesday, February 15, 2012, from 9:30 am to 3:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Greg Mackey will revise the Wells 2012 HCP Action Plan as agreed to and email a copy to Carmen Andonaegui for distribution to the Hatchery Committees (Item II-A).
- Greg Mackey will send notice to Carmen Andonaegui when the Draft 5-Year Monitoring and Evaluation (M&E) Report is ready for review; Andonaegui will email Hatchery Committees' members that the report is ready for download from the HCP ftp site (Item II-B).
- Greg Mackey will email a copy of the revised Steelhead Reproductive Success Study Report to Carmen Andonaegui when Douglas PUD has completed internal review, for distribution to the Hatchery Committees (Item II-B).
- Mike Tonseth will provide to Maureen Hess a list of broodstocks by Upper Columbia hatchery program and facility (Item IV-A).
- Maureen Hess will email Carmen Andonaegui, for distribution to the Hatchery Committees, a proposal for their participation in expanding the Snake River Parental-Based Tagging (PBT) study to Upper Columbia hatcheries (Item IV-A).
- Keely Murdoch will draft a request from the Hatchery Committees to the Hatchery Evaluation Technical Team (HETT), assigning them the task of developing a distributed acclimation plan for the Upper Columbia (Task IV-B).
- Josh Murauskas will revise the Chiwawa Spring Chinook Size-at-Release Target Statement of Agreement (SOA) as agreed to at today's meeting, and email it to

Carmen Andonaegui for distribution to the Hatchery Committees (Item VI-B).

- Josh Murauskas will inform the Hatchery Committees when Chelan PUD will be able to complete the Non-Target Taxa of Concern (NTTOC) Predation, Competition, and Disease (PCD) Risk model runs for Chelan PUD's hatchery programs (Item VI-C).

SOA DECISION SUMMARY

- The Hatchery Committees approved in principal the Spring Chinook Size-at-Release Target SOA, as revised (Item VI-B).

AGREEMENTS

- The Hatchery Committees approved the Wells 2012 HCP Action Plan as revised (Item II-A).

REVIEW ITEMS

- The Chelan PUD Draft 2012 Rocky Reach and Rock Island HCP Action Plan is available for a 30-day review. Comments are due to Steve Hemstrom with a copy to Josh Murauskas by March 1, 2012.
- The Chelan PUD Draft 5-Year M&E Report is available for a 60-day review. Comments are due to Tracy Hillman by April 6, 2012.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. Bill Gale added to the agenda his memo updating the Committees on changes to the spring Chinook hatchery program at the Winthrop National Fish Hatchery (NFH).

The draft January 19, 2012, meeting minutes were reviewed, additional revisions were discussed, and the minutes were approved as revised. Carmen Andonaegui will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Wells 2012 HCP Action Plan (Greg Mackey)

Greg Mackey said that the draft Wells 2012 HCP Action Plan (Action Plan) was distributed to the Hatchery Committees by email on January 18, 2012, and discussed at the January 19, 2012, Committees' meeting. During the January discussion, Kirk Truscott requested that the Wells Hatchery modernization be added to the Action Plan as a 2012 activity. Mackey said that the Wells Hatchery modernization activity had been added to the revised version emailed to the Committees' on February 10, 2012, and under consideration today. The Committees discussed how and when Douglas PUD should involve them in the design process for the hatchery modernization. Mackey will use the Hatchery Committees as the forum for keeping co-managers and appropriate parties advised of the planning and progress related to modernization of the Wells Hatchery. He will add to the Action Plan, under the Wells Hatchery Modernization activity, the following tasks: *1)* monthly updates to the Committees; and *2)* periodic review of modernization designs. Mackey will also make the following correction to the Action Plan: change "2010 Broodstock Collection Protocol" in Number 4 to "2012 Broodstock Collection Protocol." The Action Plan was approved with these revisions. Mackey will revise and finalize the Hatchery Committees' portion of the Action Plan and will email a copy to Carmen Andonaegui for distribution to the Committees once the Coordinating Committees have approved the full plan.

B. Update on Douglas PUD 5-Year M&E Report and the Genetics Analysis Report for the Steelhead Reproductive Success Study (Greg Mackey)

Greg Mackey said that the draft Douglas PUD 5-Year M&E Report was undergoing internal review and was almost ready for distribution to the Hatchery Committees for review. He said that he would notify Carmen Andonaegui when the Draft 5-Year Report is ready; Andonaegui will then notify Hatchery Committees by email when the report is ready for download from the HCP ftp site.

Mackey said that Todd Seamons, Washington Department of Fish and Wildlife (WDFW), had provided Douglas PUD with a 2009/2010 Genetics Analysis Report for the Steelhead Reproductive Success Study and that Douglas PUD was currently reviewing it. WDFW had previously issued the report, but discovered some errors and issued a new version of the report in February 2012. In coming years, the report will typically be available in September or October. Mackey will email a copy of the revised report to Carmen Andonaegui, for distribution to the Committees, when Douglas PUD has completed their internal review.

III. WDFW

A. 2010 and 2011 PBT Study Results Re-analysis (Ken Warheit, WDFW)

Ken Warheit was introduced and gave a presentation to the Hatchery Committees on what he called the Wenatchee Basin parentage analysis, rather than what has been referred to as the Wenatchee Basin PBT study (Attachment C). He provided the Committees with two reports relevant to today's presentation (Attachments D and E). Warheit explained that the genetic sampling and analysis conducted for the Wenatchee experiment was geared towards parental assignment to river of origin for sampled fish, whereas true PBT is an attempt to assign parentage for any offspring of hatchery parents at any life stage. In summary, Warheit concluded that parental analysis could be used to successfully identify Wenatchee-origin spring Chinook, saying that an LOD ≥10 and a two-parent assignment should result in 90 to 100 percent correct assignment; however, parental analysis would require a sampling rate at Priest Rapids Dam that exceeds the average annual return of Wenatchee-origin spring chinook, as well as 100 percent handling of all spring Chinook (both wild- and hatchery-origin fish) at TWD. Warheit reported that the population most limiting the ability to reliably assess parental origin for adult spring Chinook sampled at Tumwater Dam (TWD) was the White River population. There would be permitting difficulties associated with this level of sampling and handling of ESA-listed fish. Warheit said that sampling at TWD rather than at Priest Rapids Dam would work also, and might require a smaller sample size, but that sampled adults would need to be held while the samples were sent to a lab and PBT analysis was completed. Warheit also stressed the importance of maintaining the White River spring Chinook as a separate stock, citing its unique haplotypes relative to the Chiwawa River and Nason Creek.

Warheit said that questions on his analysis can be emailed to him. He will provide a copy of his PowerPoint presentation to Carmen Andonaegui for posting on the ftp site.

IV. Yakama Nation

A. *Expanding Snake River Broodstock PBT "Marking" to the Upper Columbia (Maureen Hess, CRITFC)*

Maureen Hess, Columbia River Inter-Tribal Fish Commission (CRITFC), said that she had been involved in PBT work in the Snake River Basin where CRITFC has been using single nucleotide polymorphisms (SNPs) to assign parentage to sampled fish (Attachment F). She listed the benefits of the use of genetic tagging of hatchery broodstocks, which allowed for the identification of hatchery-of-origin and age of hatchery-produced offspring. Hess said that the Snake River PBT project was a collaborative effort with Idaho Fish and Game (IDFG), sampling 100 percent of fish used in Snake River Chinook and steelhead hatchery programs in 2008 and continuing in 2012. This is a Bonneville Power Administration (BPA), Fish Accord-funded project.

Hess said that the goal was to extend genetic sampling to 100 percent of Chinook and steelhead hatchery fish upstream of Bonneville Dam starting in 2012. She said that she would like to include Upper Columbia hatchery programs, and requested access to archived tissue samples, as well as newly collected tissue samples, once funding can be arranged through BPA. She said that the genetic data, once analyzed, would be available to all interested parties in a regional database. Mike Tonseth said that he would provide Hess with a list of broodstocks by hatchery program and facility. Hatchery Committees' members expressed willingness to archive genetic samples in the short term, but require a written proposal before making a final commitment. Hess will email Carmen Andonaegui, for distribution to the Hatchery Committees, a proposal for their participation in expanding the Snake River PBT study to the Upper Columbia hatcheries.

B. *Multi-Species Acclimation Workgroup Formation (Keely Murdoch)*

Keely Murdoch requested the Hatchery Committees' assistance in forming a working group to develop a long-term plan for acclimation in the upper Columbia River. She said that the Yakama Nation would like to be proactive on this issue and was therefore asking the Hatchery Committees to work on a multi-year strategy. Tonseth said that he supported the idea. For the March 23, 2012, meeting, Mike Schiewe asked Murdoch to draft a request from the Committees to the HETT, assigning them the task of developing a distributed acclimation plan for the Upper Columbia. He asked that the request include task objectives and timelines, and identify recommended participants in the HETT effort. Josh Murauskas asked that the location of the acclimation sites be included in the draft request, along with the number and species of fish proposed for acclimation at each site.

V. NMFS

A. HGMP Update (Craig Busack)

Craig Busack reported that he has been directed to focus his work efforts on the upper Columbia River hatchery programs' Hatchery and Genetic Management Plan (HGMP) consultations in the coming months. He said that he will therefore be minimizing his participating in the Hatchery Committees' meetings for the near future. He said that he was meeting with Methow Basin hatchery owners and operators the following week and that, afterwards, he would have a better idea of the status of the Methow HGMPs. Busack said that Rob Jones was working on the Entiat HGMPs, and that an employment recruitment announcement had been advertised for refilling Mark Chilcote's former position with NMFS conducting hatchery consultations.

Craig Busack clarified by email on February 14, 2012, to Carmen Andonaegui, that the duration of the Endangered Species Act (ESA) Section 10 permits for hatchery operations would be 10 years for hatcheries operated under the HCP. Non-HCP hatchery ESA Section 10 permits for hatchery operations would be issued for a period of 5 years unless indicated otherwise.

VI. Chelan PUD

A. Rocky Reach and Rock Island Draft 2012 HCP Action Plan (Josh Murauskas)

Josh Murauskas said that the draft 2012 Rocky Reach and Rock Island HCP Action Plan (Action Plan) was available for a 30-day review. He said that the Action Plan provided a timeline for Rocky Reach and Rock Island projects activities. Comments are due to Steve Hemstrom by March 1, 2012.

B. Spring Chinook Size-at-Release Target SOA (Josh Murauskas)

Josh Murauskas introduced Chelan PUD's SOA for adjusting Chiwawa spring Chinook hatchery program size-at-release targets from 12 fish per pound (fpp) to 18 fpp. He provided a proposal describing the request (Attachment G), reporting that while there was no apparent benefit to larger hatchery smolts, there was an apparent drawback, that smaller hatchery smolts perform more similarly to wild fish, and that there was no effect on female returns from transitioning to a smaller size-at-release. Murauskas presented a summary of his analyses of juvenile spring Chinook, comparing size of wild versus hatchery smolts to performance and age at maturity (Attachment H). His analyses included: 1) comparisons of proportions of age class returns and rate-of-returns between wild fish and small and large size-at-release hatchery fish (<2 salt returns are highest for large half, and 3 salt returns are highest for wild fish); 2) the relationship between stray rates and the proportion of jacks in the return (stray rates increase with the increasing proportion of jacks); 3) the proportion of females in a return year related to size-at-tagging (larger smolts do not contribute to female adult returns); and 4) a comparison of the proportion of jills wild versus hatchery fish (higher in hatchery fish). Murauskas also reported on the feed schedule related to meeting fpp targets.

The Hatchery Committees discussed the analysis and the SOA, agreeing in principle to the SOA, which puts forth the interim change to 18 fpp in the size-at-release target beginning with brood year 2012; the Committees' agreement is contingent on adding to the SOA the following agreed to revisions: 1) more detail in the Background section explaining the request for the decrease in size-at-release targets; 2) a proposed rearing protocol with interim size and feeding targets/goals, in coordination with Chris Moran, Bob Rogers, and John Penny; and 3) a statement that continued M&E will be used to evaluate the effects of the change. Josh Murauskas will revise the Chiwawa Spring Chinook Size-at-Release Target SOA as agreed to at today's meeting, and email it to Carmen Andonaegui for distribution to the Hatchery Committees.

C. HETT Discussion (Josh Murauskas)

Josh Murauskas opened the discussion by saying that Chelan PUD needed objectives and timelines for HETT tasks in order to know how much time would be needed to dedicate to HETT efforts. Mike Schiewe said that the reference stream task had been completed until the next round of M&E reviews opens up. He said that the NTTOC risk assessment was ongoing and that this task was taking an unexpectedly long time to complete. Schiewe asked for input from Hatchery Committees' members who were also HETT members, as to when the task would be completed and how the information would be used.

Keely Murdoch agreed that the NTTOC task was taking a long time to complete, but said that the assessment has turned out to be a lot more complicated than originally thought. She said that she thought the product will be very good given the detailed approach that had been taken and all the data that had gone into the effort. Murdoch said that when the analysis was completed, the Committees would be able to identify where negative interactions are occurring as a result of hatchery supplementation activities. She said that the results of the NTTOC risk assessment would be part of the next 5-Year M&E review. Carmen Andonaegui said that the HETT had discussed a timeline of about 3 to 6 months for completion of the model runs, depending on the level of participation and how quickly modeling glitches are resolved. Greg Mackey said that two management-related outcomes are possible from the risk assessment: obvious negative interactions of an individual program that would draw attention to a particular activity; or a low-level impact across the board resulting in what may be a larger, cumulative impact. The first scenario would be fairly straightforward for managers to address, but the latter would likely be problematic for managers to address. Schiewe said that the objective of the task was to meet the regional M&E objective of analyzing NTTOC impacts, and that whether any management actions are taken was a separate issue.

Murauskas questioned the use of time needed to conduct model runs. Schiewe reviewed how the Committees had not approved modeling as part of the risk assessment, but rather a compilation of data for use in a Dephi process. Todd Pearsons said that, as the HETT worked on the risk assessment, they realized that with the large amounts of information they were compiling, the effects could be modeled. He said that an expert panel would still be used to estimate NTTOC risks based on data provided, but that the modeling process helped to organize and prepare the large amounts of data for use by the expert panelists. In addition, the approach will allow comparison of model and Delphi panel results, which may provide a long-term benefit by increasing confidence in model results. Murdoch and Pearsons spoke about the number of interactions (more than 500) there were to consider, given the number of programs, releases, and geographic area, and the need for a model to handle this degree of complexity. Schiewe asked if the risk assessment could still be meaningful if the Colville Confederated Tribes (CCT) were not able to provide input on their proposed hatchery programs. Mackey said that he thought the assessment would still work for some locations, but that it would leave gaps in areas where CCT hatchery program fish interacted with fish from other hatchery programs. Pearsons said that it would take 3 to 6 months to complete the model runs, but that another year would likely be needed to complete the expert panel assessment. Schiewe asked if there was some way to reduce this time. Mackey said that the HETT could consider the effects on the assessment of only doing model runs on key interactions rather than on all 500+ interactions. Murauskas agreed to inform the Committees when Chelan PUD would be able to complete the model runs for Chelan PUD's hatchery programs.

D. Draft 5-Year M&E Report Review (Josh Murauskas)

Josh Murauskas reported that the draft Chelan PUD 5-Year M&E Report was available for a 60-day review, with comments due to Tracy Hillman by April 6, 2012. He encouraged comments from Hatchery Committees' members.

VII. USFWS

A. Winthrop NFH changes (Bill Gale)

Bill Gale said that he had drafted a memo to the Hatchery Committees informing them of changes to the spring Chinook hatchery program at the Winthrop NFH. He emailed the memo to Carmen Andonaegui today for distribution to the Hatchery Committees. He said the memo reflected agreements reached through the *US v OR* forum that would result in the external marking of all spring Chinook beginning in 2012.

VIII. HETT Update

Carmen Andonaegui reported that the HETT met on February 14, 2012. She said that it had completed the reference stream evaluation and provided a summary of that effort, including the HETT's recommendation for evaluating supplementation effects in the future for steelhead for which no suitable reference streams were found (Attachment I). Schiewe said that as Hatchery Committees' members review the draft PUD 5-Year M&E reports, they could consider how to evaluate steelhead supplementation effects without the benefit of reference streams.

Regarding the HETT NTTOC risk assessment, Andonaegui said that the HETT was working on completing PCDRisk-1 model runs for all Upper Columbia hatchery programs. Once the model runs are completed, the HETT will review the results for anomalies. When the HETT has determined that the data are clean, the data will be ready to send to the expert panel. She said that the HETT anticipated that getting the data ready for the expert panel would take 3 to 6 months, depending on the level of effort and number of issues to resolve to complete the model runs.

IX. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees' meetings are March 21, 2012 (Douglas PUD office); April 18, 2012 (Chelan PUD office); and May 16, 2012 (Douglas PUD office).

Bill Gale said that he had delayed inviting Pat Connolly, U.S. Geological Survey (USGS), to attend the March 21, 2012, Hatchery Committees' meeting to discuss potential collaboration and coordination of PIT-tagging efforts in the Methow Basin. He said that he would extend the invitation to Connolly to attend a later meeting. Tom Kahler said that he is working with Chelan PUD and Grant PUD to schedule Howie Wright, Okanagan Nation Alliance (ONA), and Kim Hyatt, British Columbia Fisheries and Oceans, Canada, for a presentation on the Skaha Lake Sockeye Reintroduction Program and the Fish Water Management Tool, respectively, at the April 18, 2012, Hatchery Committees' meeting.

List of Attachments

Attachment A – List of Attendees
Attachment B – Draft Wells 2012 HCP Action Plan
Attachment C – Warheit PowerPoint presentation on the results of 2002/2010 Wenatchee Spring Chinook parental analysis
Attachment D – Warheit et al. 2012, Wenatchee Spring Chinook PBT Project - Two-Year Summary Analysis
Attachment E – Draft WDFW PBT Feasibility Test Report Memo
Attachment F – CRITFC Snake River PBT Presentation
Attachment G – Chiwawa Spring Chinook Size-at-Release Target Presentation
Attachment H – Chiwawa Spring Chinook Size-at-Release Target Proposal
Attachment I – Summary of the HETT Reference Stream Evaluation

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Alene Underwood	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Keely Murdoch*	Yakama Nation
Kirk Truscott*†	CCT
Craig Busack*†	NMFS
Don Larsen†	NMFS
Jayson Wahls	WDFW
Mike Tonseth*†	WDFW
Ken Warheit†	WDFW
Maureen Hess†	CRITFC
Bill Gale*	USFWS
Russell Langshaw	Grant PUD
Todd Pearsons	Grant PUD

Notes:

* Denotes Hatchery Committees' member or alternate

† Joined by phone

DRAFT 2012 ACTION PLAN
WELLS HCP

WELLS HCP COORDINATING COMMITTEE

1. Bypass Operating Plan

a. Draft to Coordinating Committee (CC): .... February 2012
b. Approval deadline: .... March 2012
c. Period of implementation: .... April 9 to August 19, 2012
d. Report deadline: .... October 2012

2. 2013 NNI Progress Report (per Wells HCP §6.9)

a. Douglas/CC develop report outline .... March 2012
b. CC provides direction on status update for Plan Species .... May 2012
c. Douglas submits Draft NNI Progress Report to the CC .... March 2013

3. Predator Control Programs

a. Pikeminnow removal – Wells Project: .... March – August 2012
b. Draft 2011 pikeminnow report to DCPUD: .... January 2012
c. 2011 pikeminnow report internal review and submission to CC: .... February 2012
d. Avian predator hazing at Wells: .... October 2011 – May 2012

4. Sub-yearling Chinook Life-history Study

a. Draft 2011 report to CC: .... February 2012
b. Final 2011 report: .... April 2012
c. Update study plan: .... January-April 2012
d. Tag and release study fish: .... June-July 2012
e. Monitor study fish: .... through life cycle
f. Draft 2012 report to CC: .... February 2013
g. Final 2012 report: .... April 2013

5. Annual Monitoring of Juvenile Migration Run Timing

a. Skalski analysis of index data from RR: .... September 2012
b. Draft of Skalski's report to DCPUD: .... September 2012
c. Final report presented to CC: .... October 2012

6. Installation of HDX PIT-tag Detection System at Wells Dam

a. Contractor noise testing and site analysis .... January 2012
b. Fabrication and installation of partial system in the west ladder ...... January/February 2012
c. Complete installation in the west ladder .... December 2012
d. Complete installation in the east ladder .... January/February 2013

7. Lamprey Entrance Efficiency Study

a. Study plan .... June 2012
b. Conduct velocity test and efficiency study .... July – August 2012
c. Draft report .... November 2012
d. Final report .... February 2013

WELLS HCP HATCHERY COMMITTEE

1. **Implement 5-year Hatchery Monitoring and Evaluation (M&E) Plan**
   a. Ongoing implementation: ....January – December 2012
   b. Draft annual report for 2011 to Douglas PUD:.. June 2012
   c. Draft annual report to Hatchery Committee (HC): ....July 2012
   d. Final annual report to HC: ....October 2012
   e. Draft 5-year synthesis/analysis report to HC: .... February 2012
   f. Final 5-year synthesis/analysis report:.. April 2012
   g. Draft 2013 implementation plan to HC: ....October 2012

2. **Review and Update 5-year M&E Plan (per Wells HCP §8.5.1 and 8.8)**
   a. Draft to HC: ....July 2012
   b. Final to HC:..October 2012

3. **2013 Hatchery Program Review (per Wells HCP §8.8)**
   a. Data and analyses for the Hatchery Program Review are contained within several existing documents or documents scheduled for completion in 2012:
      1. Douglas 5-Year M&E Report (to HC in 2012) addresses all aspects of the Hatchery Program Review for Methow Hatchery spring Chinook and Wells Hatchery steelhead and summer Chinook.
      2. Chelan 5-Year M&E Report (to HC in 2012) addresses all aspects of the Hatchery Program Review for Carlton Pond summer Chinook.
      3. Hatchery M&E annual reports (2003-2011) provide detailed data necessary for the Hatchery Program Review.
      4. Methow Spring Chinook HGMP (2010) included thorough review of the program and redesigned the program based on the review.
      5. Wells Complex Summer Steelhead HGMP (2011) included thorough review of the program and redesigned the program based on the review.
      6. Adjustment of hatchery compensation (2011) conducted review and assessment of SARs, adults returns, hatchery and natural smolt production.
      7. Fish-Water Management Tool (FWMT) Progress Report (Hyatt et al. in prep) provides an analysis of the multi-year data set to determine the contribution of FWMT implementation to average production of Okanagan sockeye.
   b. HC directs the development of summary report:..................................June – August 2012
   c. HC reviews draft summary report: ....September – October 2012
   d. Final summary report to HC: ....December 2012
   e. Final summary report from HC to CC: .... January 2013

4. **2012 Broodstock Collection Protocol**
   a. Draft to HC: .... March 2012
   b. Approval deadline:... April 2012
   c. Implementation: ....May 2012 to April 2013

5. **Annual Implementation Report - Sockeye Fish/Water Management Tools**
   a. Period covered: ....Water Year 2011-2012 (October – September)
   b. Draft to HC: ....*to be determined*

c. Presentation to HC: .... August or September 2012
d. Draft 2013 FWMT progress report to Douglas PUD: .... August 2012
e. Draft 2013 FWMT progress report to HC: .... October 2012
f. Final 2013 FWMT progress report to HC: .... December 2012
g. HC delivers final 2013 FWMT progress report to CC: .... January 2013

6. **HGMP – Methow Spring Chinook**
   a. Draft Spring Chinook HGMP to HC: .... Complete November 2009
   b. Final Spring Chinook HGMP to NMFS: .... Completed March 2010
   c. NMFS approval of Spring Chinook HGMP: .... *to be determined*

7. **HGMP – Wells Steelhead**
   a. Draft Steelhead HGMP to HC: .... Completed February 2011
   b. Final Steelhead HGMP to NMFS: .... Completed March 2011
   c. NMFS approval of Steelhead HGMP: .... *to be determined*

8. **Methow Steelhead Relative Reproductive Success Study**
   a. Implementation: .... March 2010 - December 2021
   b. Interim reports: .... September 2012
   c. Final report: 2021/2022

9. **Wells Hatchery Modernization**
   a. Update on rearing criteria and Master Plan: .... December 2012
   b. Provide updates to the HC .... Monthly
   c. Provide opportunities for HC input.. Periodically

WELLS HCP TRIBUTARY COMMITTEE

1. **Plan Species Account Annual Contribution**
   a. $176,178 in 1998 dollars.. January 2012

2. **Annual Report - Plan Species Account Status**
   a. Draft to Tributary Committee (TC): .... February 2012
   b. Approval Deadline:.. March 2012
   c. Period Covered: ....January to December 2011

3. **2012 Funding-round – General Salmon Habitat Program**
   a. Request for project pre-proposals:........................... *To be determined* (typically in March)
   b. Pre-proposals to TC: .... *To be determined* (typically in early May)
   c. Tours of proposed projects: ....*To be determined* (typically in late May)
   d. Project sponsor presentations to TC: .... *To be determined* (typically in early June)
   e. Final project proposals to TC:............................*To be determined* (typically in early July)
   f. RTT project rating decisions:......................................*To be determined* (typically in July)
   g. Supplemental sponsor presentations ....*To be determined*
   h. TC final funding decisions:......................... *To be determined* (typically before December)

4. **Small Project Program**
   a. Project review and funding decision.................................. Applications accepted any time

5. **Tributary Assessment Program**
   a. Proposal to TC for year-5 of 5 for ORRI monitoring ....July 2012
   b. Develop monitoring plan for remaining funds... March 2012
   c. Implement monitoring plan...*To be determined* (2012)
   d. Monitoring plan final product.. December 2012
   e. TC delivers final product to CC... January 2013

Priest Rapids Dam – Wenatchee River Spring Chinook salmon Parentage-based Tagging Project: Two-year Summary of Testing Accuracy of Parentage Assignments

Kenneth Warheit[1], Todd Seamons, Sonia Peterson, Sewall Young, and Cheryl Dean
Washington Department of Fish and Wildlife, Molecular Genetics Laboratory, Olympia, WA 98501

January 18, 2012

Introduction:

To evaluate the efficacy of the Wenatchee River spring Chinook salmon parentage-based tagging (PBT) project, the Washington Department of Fish and Wildlife Molecular Genetics Laboratory (WDFW-MGL) was asked to assess the accuracy of genetically assigning parents with known spawning locations within the Wenatchee River Basin to returning adult spring Chinook salmon captured at Priest Rapids Dam. DNA samples from migrating adults captured in 2010 and 2011 at Priest Rapids were genotyped and compared with genotypes from adults within the Wenatchee Basin from spawn years 2005-2008. Here, we provide a summary of the accuracy of the parentage assignments, which should contribute to the overall assessment of the effectiveness of the project.

Methods:

As part of a research program led by Dr. Michael Ford (NOAA), DNA samples were taken from adults (parents) captured on spawning grounds located within the Wenatchee River Basin, including locations in the mainstem Wenatchee River, and tributaries Nason Creek, Chiwawa River, White River, and Little Wenatchee River. Samples from each of these collections were genotyped at a set of 13 microsatellite loci (Table 1) by staff at NOAA and those genotypes were provided to WDFW-MGL staff. This set included eight GAPS microsatellites (Seeb et al. 2007) and five non-GAPS microsatellites. Returning adult Chinook salmon, putative offspring of Wenatchee River Chinook salmon, were captured, DNA sampled, and tagged with PIT tags at Priest Rapids Dam in 2010 and 2011. Tissue samples from these fish were processed and genotyped at WDFW-MGL using a set of 19 microsatellite loci that included the same 13 loci used by NOAA (Table 1). To ensure that alleles of parents and offspring were standardized and that a uniform allele nomenclature was used, we genotyped a subset of 96 samples

[1] Email contact: kenneth.warheit@dfw.wa.gov

from parents genotyped by NOAA in order to translate all NOAA-generated genotypes to WDFW-MGL and GAPS standard nomenclature. To conduct the PBT analysis, we assumed an age range of 3-5 years for each of the putative offspring and thus, limited the NOAA parental dataset to years 2005 – 2008, which would encompass all potential parents for 3-5 year old fish spawning in 2010 and 2011.

For parentage analysis we used the software FRANz (Riester 2009). We assigned parents separately for the putative offspring migrating in 2010 and 2011. For each group, all parents from 2005-2007 and 2006-2008, respectively, were considered simultaneously, regardless of sampling location or year. Parents with 6 or fewer loci (out of the 13 loci) scored were excluded, as were offspring with eight or fewer loci (out of the 13 loci). In assigning parents to putative offspring we permitted up to 4 mismatches or genotypic incompatibilities between the putative offspring and parent(s). We considered assignments of two (trio) or one (dyad) parent(s) with an offspring, and evaluated the assignments using $\log_e$ of likelihood-odds ratio (LOD) score. Here, LOD is the log of the ratio between the likelihood that the trio or dyad is parent-offspring versus that the trio or dyad are unrelated (see Marshall et al. 1998, Kalinowski et al. 2007, Riester 2009). We assigned individuals as parents if the trio or dyad had the highest LOD score, regardless of the size of the score.

We do not know the true parentage of the putative offspring. Therefore, to evaluate the accuracy of the PBT analysis, we needed to establish criteria to determine which parentage assignments were correct. In principle, a "correct trio" would have both parents spawning in the same year and within the same river, and the offspring's final PIT detection occurring within the river where the parents spawned. However, not all offspring or potential parents were identified by sex or spawning location. Therefore, we established an attribute table to classify "correctness" at different levels of resolution (Table 2). We then compared this classification to different LOD categories to create PBT criteria that would minimize assignment error.

Results and Discussion:

We received and genotyped samples from 282 putative offspring from the sampling facility at Priest Rapids Dam. Although each of these fish was tagged with a PIT tag, the geographic precision for last detection varied among the fish. We defined three areas as the last detected basins: Wenatchee (for detections within the Wenatchee Basin), Columbia Mainstem (for last detection at Priest Rapids Dam [initial capture location], Rock Island Dam, and Rocky Reach Dam), and Out-of-basin (for last detection within the Entiat or Methow Basins). We differentiated Columbia Mainstem from Out-of-basin because last detection at either Priest Rapids or Rock Island Dam did not preclude the Wenatchee Basin as the "intended" final destination for the fish, and Rocky Reach Dam is the location of Eastbank hatchery, the primary facility for Wenatchee spring Chinook salmon hatchery operations. Fish with last detections within either Entiat or Methow Basin have already passed the Wenatchee River suggesting (more strongly for the Methow) that the fish intended to spawn in systems upriver to the Wenatchee River.

The 282 offspring were divided into 18 attribute categories that defined last detection of offspring and parental spawn years and locations (Table 2). The 18 attributes were divided into eight classes of correctness, depending on the attribute resolution: "Correct-System" (if the highest level of resolution among the parent(s) and offspring was river basin), "Correct-River" or "Correct-System; Incorrect River" (if the highest level of resolution among the parent(s) and offspring was a river within a basin), "Correct – no assigned parents" (if the last detection was out-of-basin and no parents were assigned[2]), "Consistent" (if the last detection was Columbia Mainstem and two parents were assigned with the same spawn year and location), "Indeterminate" (if there was insufficient information on the parental and/or offspring locations), "Incorrect or stray" (if the last detection was out-of-basin and either (1) assigned parents' spawn years and locations are the same, or (2) only one parent was assigned), and "Incorrect" (if two parents were assigned with incompatible spawn year or location) (Table 2). Please note that a "Correct-System; Incorrect River" determination may also be the result of an offspring fish straying from its natal river.

If all parentage assignments were accepted, without regard to the LOD scores, 132 of the 282 fish (47%) were correctly assigned (Attribute # 1-6, 9; Table 2), 129 (46%) were incorrectly assigned (Attribute #7-8, 13-18), and 21 (7%) had indeterminate assignments (Attribute # 10-12). However, we use the LOD scores to determine the strength of the assignments, and low LOD scores may not afford sufficient confidence to maintain the assignment. For LOD scores of base-e or natural logarithms, a zero LOD

[2] Chinook salmon spawn in four major basins above Priest Rapids Dam, the Wenatchee, Entiat, Methow, and Okanogan River basins, so a returning adult (putative offspring) in our sample from Priest Rapids might not have had true parents from the Wenatchee River basin, and therefore would not have had parents in our reference data set of Wenatchee spawner genoytpes.

indicates equivalence between the assigned parents and a random set of genotypes, LOD = 1 indicates that that the assignment is only 2.7 times as likely as a random set of genotypes, while LOD = 10 means that the assignment is 22,000 times as likely as a random set of genotypes, and so on. Clearly, low LOD scores may indicate low confidence for assigning parents to offspring. However, limiting assignments to only those with higher LOD scores will reduce the number of putative offspring with assigned parents.

To best assess the accuracy of the PBT analysis, we limited the evaluation to only those assignments with two parents and all parental and offspring attributes known (Table 3). This reduced the number of offspring with assigned parents to only 29 of the 282 (10%), but depending on the LOD threshold, the percent correctly assigned ranged from a low of 76% to a high of 100%. Limiting assignments to LODs of 10 or greater achieved a correct assignment rate of 91%, while reducing the number of offspring with assigned parents to 23 from 29 (79%) (Table 3). When we allowed for unknown attributes, but still maintained the requirement that two parents needed to be assigned, we increased the number of assigned offspring to 131 (46%) (Table 4). In this group of assignments, the percent correctly assigned for LOD scores of 0-5 ranged 52-55%, not much better than a coin flip. That percent increased to a range 72-94% for LOD scores 10-20. These percentages represent minimum estimates because we assumed that fish do not stray from natal rivers or even natal basins.

Compared to two-parent assignments, one-parent assignments (dyads) had overall lower LOD scores, lower percent correctly assigned and reduced confidence in the parentage assignments (Table 5). For LOD scores 0-5, randomly assigning parents may be more successful than using a statistical approach. For LOD = 10, 100% of the offspring have correctly assigned parents, but the total number of offspring with LOD scores equal to or greater than 10 is only 4 out of the 99 dyads.

Although the purpose of this study was to assess the accuracy of assigning fish to particular rivers based on a PBT analysis, we included not only those fish that returned to the Wenatchee system, but also fish that were never detected in spawning rivers or fish that returned to out-of-basin areas. Neither of the latter sets of fish would be considered for a Wenatchee-based supplementation program. When we limited our analysis to only those fish that returned to the Wenatchee system, and allowed for both two- and one-parent assignments (Attribute # , 1-5, 7-8, and 15-16), our assignment rates are consistently above 85% correct assignment for all LODs. However, most of the correct assignments were to the "Correct-System" (i.e., Wenatchee Basin), an easy achievement given that we limited the analysis to fish returning to the Wenatchee Basin (Table 6). When we removed the Correct-System category from the analysis, the percent correctly assigned reduced to 63-83%, with 72% for LOD = 10, the same percentage as when we allowed for unknown attributes, but still maintained the requirement that two parents needed to be assigned (Table 4).

Conclusions:

This study did not include an ideal set of datasets. Microsatellite loci are known to have different allele calls among different laboratories, and between different instruments within a laboratory. This study required that parental assignments were made using disparate data sets, collected in two different laboratories. This means that this analysis combined standard and expected genotyping errors from two different laboratories, and required an ad-hoc method to translate allele calls from one laboratory to another. We expect that as a result of these non-standard QA/QC procedures, PBT assignment rates were negatively affected. Nevertheless, we showed that with higher LOD scores and two-parent assignments (e.g., Table 3), we can correctly assign a relatively high number of trios. Based on this analysis, we recommend that when using PBT to assign fish to natal rivers, assignments be limited to only those where two parents are assigned (trios) with a minimum LOD score = 10. However, this will reduce the number of fish assigned, thereby limiting the PBT-based program. To compensate, the program would need to increase sampling rates at the Priest Rapids facility to ensure an appropriate number of fish are assigned to parents and are available for supplementation programs. We further recommend minimizing genotyping errors, which can negatively affect parentage assignment rates, by performing genotyping in only one laboratory, using standardized and uniform allele nomenclature.

Literature Cited

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Riester, M., Stadler, P.F., and Klemm, K. 2009. FRANz: reconstruction of wild multi-generation pedigrees. Bioinformatics 25:2134–2139.

Seeb, L.W., Antonovich, A., Banks, M.A., and 17 coauthors. 2007. Development of a standardized DNA database for Chinook salmon. Fisheries 32(11): 540 – 552.

Table 1. Standard Chinook salmon microsatellite panels used by WDFW-MGL and by NOAA. To conduct PBT analysis, WDFW established in-house protocols for the NOAA-Only set, and standardized the Ford-NOAA version of the GAPS set.

Microsatellite Locus	Standard Microsatellite Panels		Used in Priest Rapids PBT Analysis
	WDFW Only	Michael Ford (NOAA)	
Ogo-2	GAPS - Standardized	GAPS - Unstandardized	Yes
Ogo-4	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-201b	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-208b	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-211	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-213	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-3M	GAPS - Standardized	GAPS - Unstandardized	Yes
Ssa-408	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots-9	GAPS - Standardized	not used	-
Ots-G474	GAPS - Standardized	not used	-
Ots-212	GAPS - Standardized	not used	-
Oki-100	GAPS - Standardized	not used	-
Omm-1080	GAPS - Standardized	not used	-
Ots 10M	not used	NOAA Only	Yes
Ots 2M	not used	NOAA Only	Yes
Oke4	not used	NOAA Only	Yes
Ots 104	not used	NOAA Only	Yes
Ots D9	not used	NOAA Only	Yes
Ssa-197	WDFW Only	not used	-

Table 2. Attribute table for PBT assignments for the 282 spring Chinook salmon sampled and PIT tagged at Priest Rapids Dam in 2010-2011. The assigned parents data were collected by Michael Ford (NOAA) Wenatchee spring Chinook salmon data set for years 2005-2008. All parents captured and sampled in the Wenatchee Basin. The River and Sex designations are generic labels to denote the same or different rivers or sex (e.g., River A versus River A, or River A versus River B, respectively). N = the number of offspring out of the 282 samples that fit into each attribute category. See text for definitions of Last Detected Basin and Determination.

#	Offspring		Parent 1			Parent 2			Determination	Comments	N
	Last Detected Basin	Last Detected River	Spawn Year	Spawn Basin	Spawn River	Spawn Year	Spawn Basin	Spawn River			
1	Wenatchee	River A	Year A	Wenatch.	River A	Year A	Wenatch.	River A	Correct-River		6
2	Wenatchee	River A	Year A	Wenatch.	River A	Year A	Wenatch.	unknown	Correct-River		16
3	Wenatchee	River A	Year A	Wenatch.	River A	----- no assignment -----			Correct-River		1
4	Wenatchee	River A or unknown	Year A	Wenatch.	River A or unknown	Year A	Wenatch.	River A or unknown	Correct - System	Either offspring or parent location is not know but both parents spawned in same year	45
5	Wenatchee	River A or unknown	Year A or unknown	Wenatch.	River A or unknown	----- no assignment -----			Correct - System	One parent, both offspring and parent from Wenatchee system, but either or both river locations not know. Same as #4, but with one parent	22
6	Out-of-basin (Methow or Entiat)	na	----- no assignment -----			----- no assignment -----			Correct - no assigned parents		41
7	Wenatchee	River A	Year A	Wenatch.	River B	Year A	Wenatch.	River B	Correct - System; Incorrect-River	Two parents with matching spawn year and location, but location differs from offspring	2
8	Wenatchee	River A	Year A	Wenatch.	River B	----- no assignment or no locality -----			Correct - System; Incorrect-River	Two or one parents, but only one parental location, and that location does not match offspring	5

Table 2 (con't).

#	Offspring		Parent 1			Parent 2			Determination	Comments	N
	Last Detected Basin	Last Detected River	Spawn Year	Spawn Basin	Spawn River	Spawn Year	Spawn Basin	Spawn River			
9	Columbia mainstem (Priest Rapids, Rocky Island or Rocky Reach Dams)	na	Year A	Wenatch.	River A or unknown	Year A	Wenatch.	River A or unknown	Consistent	Parents match at river and year, but no final location for offspring	1
10	Columbia mainstem (Priest Rapids, Rocky Island or Rocky Reach Dams)	na	Year A or unknown	Wenatch.	River A or unknown	----- no assignment -----			Indeterminate	One parent version of #9	10
11	Columbia mainstem (Priest Rapids, Rocky Island or Rocky Reach Dams)	na	----- no assignment -----			----- no assignment -----			Indeterminate		2
12	Wenatchee	River A or unknown	----- no assignment -----			----- no assignment -----			Indeterminate		9
13	Out-of-basin (Methow or Entiat)	na	Year A	Wenatch.	River A or unknown	Year A	Wenatch.	River A or unknown	Incorrect or stray	Parents identified and spawned same year. No conflict in parental location, but one or both locations may not be know, except from Wenatchee Basin. Offspring found elsewhere	42
14	Out-of-basin (Methow or Entiat)	na	Year A or unknown	Wenatch.	River A or unknown	----- no assignment -----			Incorrect or stray	One parent version of #13	66
15	Wenatchee	River A or unknown	Year A	Wenatch.	River A or unknown	Year B	Wenatch.	River A or unknown	Incorrect	Regardless of match of location, parents did not spawned the same year	5
16	Wenatchee	River A or unknown	Year A	Wenatch.	River A	Year A	Wenatch.	River B	Incorrect	Parents spawned the same year, but not same river; offspring matches one of the parents location	1
17	Out-of-basin (Methow or Entiat)	na	Year A	Wenatch.	River A or unknown	Year B	Wenatch.	River A or unknown	Incorrect		7
18	Columbia mainstem (Priest Rapids, Rocky Island or Rocky Reach Dams)	na	Year A	Wenatch.	River A or unknown	Year B	Wenatch.	River A or unknown	Incorrect		1

Table 3. Parentage assignment results when both parents are assigned, and the complete location (river basin and river) and spawn year information are known for both parents and offspring. In all 29 cases below, parents spawned during the same year. LOD Thresholds are cumulative. That is, a LOD score threshold of 5 would include all assignments with LOD equal to or greater than 5.

Offspring-Parent Attribute #	Determination	Correct Assignment	LOD Threshold				
			5	8	10	15	20
1	Correct-River	Yes	6	6	6	5	2
2	Correct-River	Yes	16	15	15	10	3
7	Correct - System; Incorrect-River	No	2	2	1	1	0
8	Correct - System; Incorrect-River	No	5	1	1	1	0
	Total		29	24	23	17	5
	Correctly Assigned		0.76	0.88	0.91	0.88	1.00

Table 4. Same as Table 3 (both parents assigned), except location and spawn year information may be unknown for some combination of the parents and offspring. Correct assignment is based on the level of information known. For example, Correct – System is considered a correct assignment because we were only able to evaluate the parentage assignment to the level of Wenatchee Basin, and not down to the river within the basin.

Determination	Correct Assignment	LOD Threshold							
		0	1	3	5	8	10	15	20
Consistent	Yes	1	1	1	1	1	1	0	0
Correct - System	Yes	45	45	45	43	38	36	24	11
Correct - System; Incorrect-River	No	7	7	7	7	3	2	2	0
Correct-River	Yes	22	22	22	22	21	21	15	5
Incorrect	No	14	14	13	13	11	9	3	1
Incorrect or stray	No	42	40	39	35	23	12	2	0
Total		131	129	127	121	97	81	46	17
Correctly Assigned		0.52	0.53	0.54	0.55	0.62	0.72	0.85	0.94

Table 5. Same as Table 4, except data are limited to one-parent assignments only. Contrasting this table with Table 4 compares the relative accuracy of one- versus two-parent assignments

Determination	Correct Assignment	LOD Threshold					
		0	1	3	5	8	10
Correct-River	Yes	1	1	1	1	1	0
Correct - System	Yes	22	21	18	9	5	3
Indeterminate	na	10	9	9	4	1	1
Incorrect or stray	No	66	58	43	26	4	0
Total		99	89	71	40	11	4
Correctly Assigned		0.26	0.28	0.31	0.28	0.60	1.00

Table 6. Parentage assignment results when analyses are limited to only those offspring with Wenatchee as the Last Detected Basin. Both one- and two-parent assignments are included and location and spawn year information may be unknown for some combination of the parents and offspring. Correctly Assigned 1 includes all Determination categories. Correctly Assigned 2 excludes Correct – System category, which allows us to compare this analysis to with Table 3 and contrast correct assignment rates between two-parent only (Table 3) and one and two parent (this table).

Determination	Correct Assignment	LOD Threshold							
		0	1	3	5	8	10	15	20
Correct - System	Yes	67	66	63	52	43	39	24	11
Correct - System; Incorrect-River	No	7	7	7	7	3	2	2	0
Correct-River	Yes	23	23	23	23	22	21	15	5
Incorrect	No	6	6	6	6	6	6	3	1
Total		103	102	99	88	74	68	44	17
Correctly Assigned 1		0.87	0.87	0.87	0.85	0.88	0.88	0.89	0.94
Correctly Assigned 2		0.64	0.64	0.64	0.64	0.71	0.72	0.75	0.83

Attachment D

Priest Rapids Dam – Wenatchee River Spring Chinook salmon PBT: Two-year Summary

Wells, Rocky Reach, and Rock Island HCP Hatchery Committees' Meeting

February 15, 2012, Wenatchee, WA

(via WebEx from Olympia, WA)

Kenneth I. Warheit

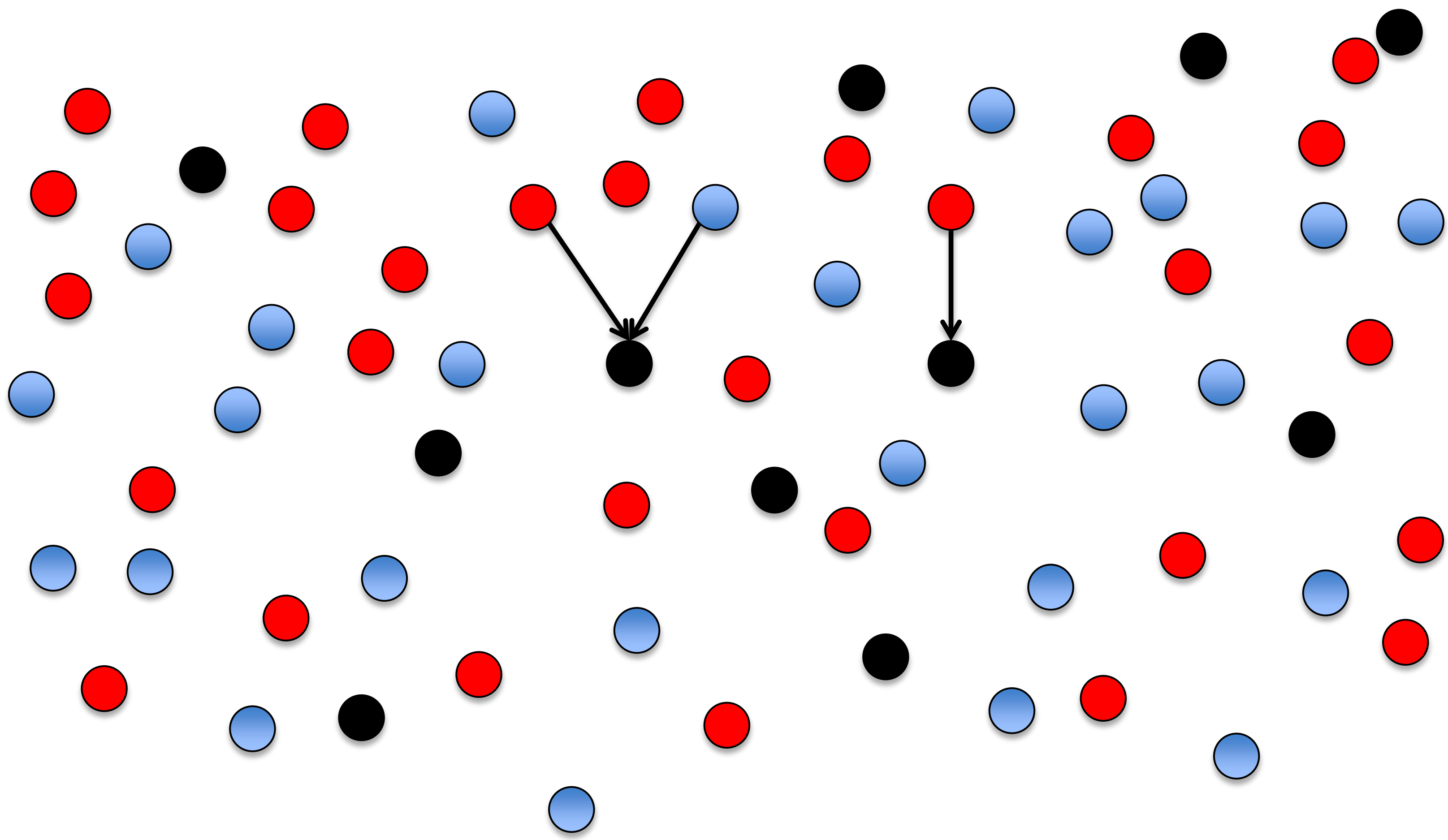
Director, WDFW Molecular Genetics Laboratory

Structure of Discussion

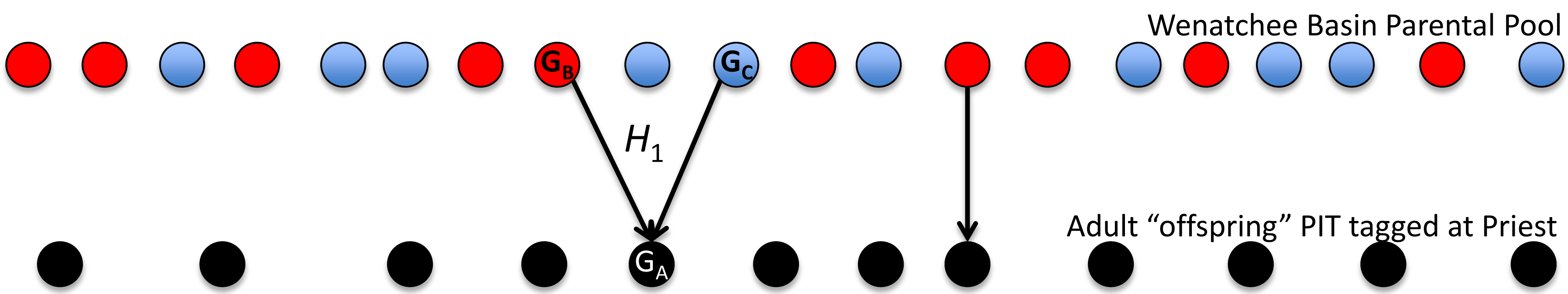
- Parentage Analysis
- Marker types
  - Microsatellite and SNPs
- Summary of Priest Rapids Project (PBT)
  - Limitations
  - Parentage assignment results
  - Sampling issues
- Sampling only at Tumwater Dam
  - Parentage
  - Genetic Stock Identification
  - Power to detect different populations

Attachment D

Parentage Analysis



Parentage Analysis



H_1: Triad = Two parent – offspring relationship
H_2: Triad = Unrelated

$$LOD\ (G_A, G_B, G_C) = \log \frac{Pr(G_A, G_B, G_C \mid H_1)}{Pr(G_A, G_B, G_C \mid H_2)} = \log \frac{T(G_A \mid G_B, G_C)}{Pr(G_A)}$$

1. Calculate LOD scores for all candidate parents
2. Accept triad (or dyad) with highest LOD
3. Evaluate LOD to determine if it is acceptable

From Riester et al. 2009. Bioinformatics 25:2134-2139. FRANz

Attachment D

LOD	Times as Likely
0	1.0
0.1	1.1
0.5	1.6
1	2.7
2	7.4
5	148.4
10	22,026.5
15	3,269,017.4
20	485,165,195.4

Priest Rapids – Wenatchee River Spring Chinook PBT Project

- Goals
  - Test logistics of sampling and PIT tagging at Priest, genotyping in Olympia, and locating at Tumwater
  - Test efficacy of parentage analysis
- Parents (2005 – 2008)
  - Genotyped by NOAA at 13 microsatellite loci.
  - Specific spawning location not known for all samples
- Adult Offspring (2010 – 2011)
  - Genotyped by WDFW at 19 microsatellite loci
  - Final status of individuals not known for all samples
- Last detection of offspring and parents, spawn year, basin, river, sex, and triad or dyad = <u>18 categories</u>

Microsatellite Locus	Standard Microsatellite Panels: WDFW Only	Standard Microsatellite Panels: Michael Ford (NOAA)	Used in Priest Rapids PBT Analysis
Ogo-2	GAPS - Standardized	GAPS - Unstandardized	Yes
Ots 104	not used	NOAA Only	Yes
Ots D9	not used	NOAA Only	Yes
Ssa-197	WDFW Only	not used	-

Microsatellites

- Existing parental genotypes from NOAA
- Sufficient power
  - Average # alleles/locus = 27
  - 13 loci
  - Population unique genotypes = 27^{13}
  - 4×10^{18} (4 quintillion)
- Panel of 96 SNPs
  - 8×10^{28} (80 octillion)

Table 3. Parentage assignment results when both parents are assigned, and the complete location (river basin and river) and spawn year information are known for both parents and offspring. In all 29 cases below, parents spawned during the same year. LOD Thresholds are cumulative. That is, a LOD score threshold of 5 would include all assignments with LOD equal to or greater than 5.

Offspring-Parent Attribute #	Determination	Correct Assignment	LOD Threshold				
			5	8	10	15	20
1	Correct-River	Yes	6	6	6	5	2
2	Correct-River	Yes	16	15	15	10	3
7	Correct - System; Incorrect-River	No	2	2	1	1	0
8	Correct - System; Incorrect-River	No	5	1	1	1	0
	Total		29	24	23	17	5
	Correctly Assigned		0.76	0.88	0.91	0.88	1.00

Table 6. Parentage assignment results when analyses are limited to only those offspring with Wenatchee as the Last Detected Basin. Both one- and two-parent assignments are included and location and spawn year information may be unknown for some combination of the parents and offspring. Correctly Assigned 1 includes all Determination categories. Correctly Assigned 2 excludes Correct – System category, which allows us to compare this analysis to with Table 3 and contrast correct assignment rates between two-parent only (Table 3) and one and two parent (this table).

Determination	Correct Assignment	LOD Threshold							
		0	1	3	5	8	10	15	20
Correct - System	Yes	67	66	63	52	43	39	24	11
Correct - System; Incorrect-River	No	7	7	7	7	3	2	2	0
Correct-River	Yes	23	23	23	23	22	21	15	5
Incorrect	No	6	6	6	6	6	6	3	1
Total		103	102	99	88	74	68	44	17
Correctly Assigned 1		0.87	0.87	0.87	0.85	0.88	0.88	0.89	0.94
Correctly Assigned 2		0.64	0.64	0.64	0.64	0.71	0.72	0.75	0.83
		Two parent only:			0.76	0.88	0.91	0.88	1.00

Required Sample Sizes

	Escapement		For Egg Take (Females)		Total # Needed @ Tumwater
	Number	Proportion	Number	Proportion	
Chiwawa	2032	0.72	59	0.40	118
Nason	702	0.25	60	0.40	120
White	83	0.03	30	0.20	60
	2817		149		298

From Michael Tonseth & Michael Hughes, WDFW

2,000
(PIT tagged at Priest)

Category	Number	Proportion
Total PIT tagged at Priest Rapids	282	
Returned to Wenatchee River	103	0.37
Minimum LOD = 10	68	0.24
Two-parent assignment	23	0.08

5,405
8,333
25,000
(PIT tagged at Priest

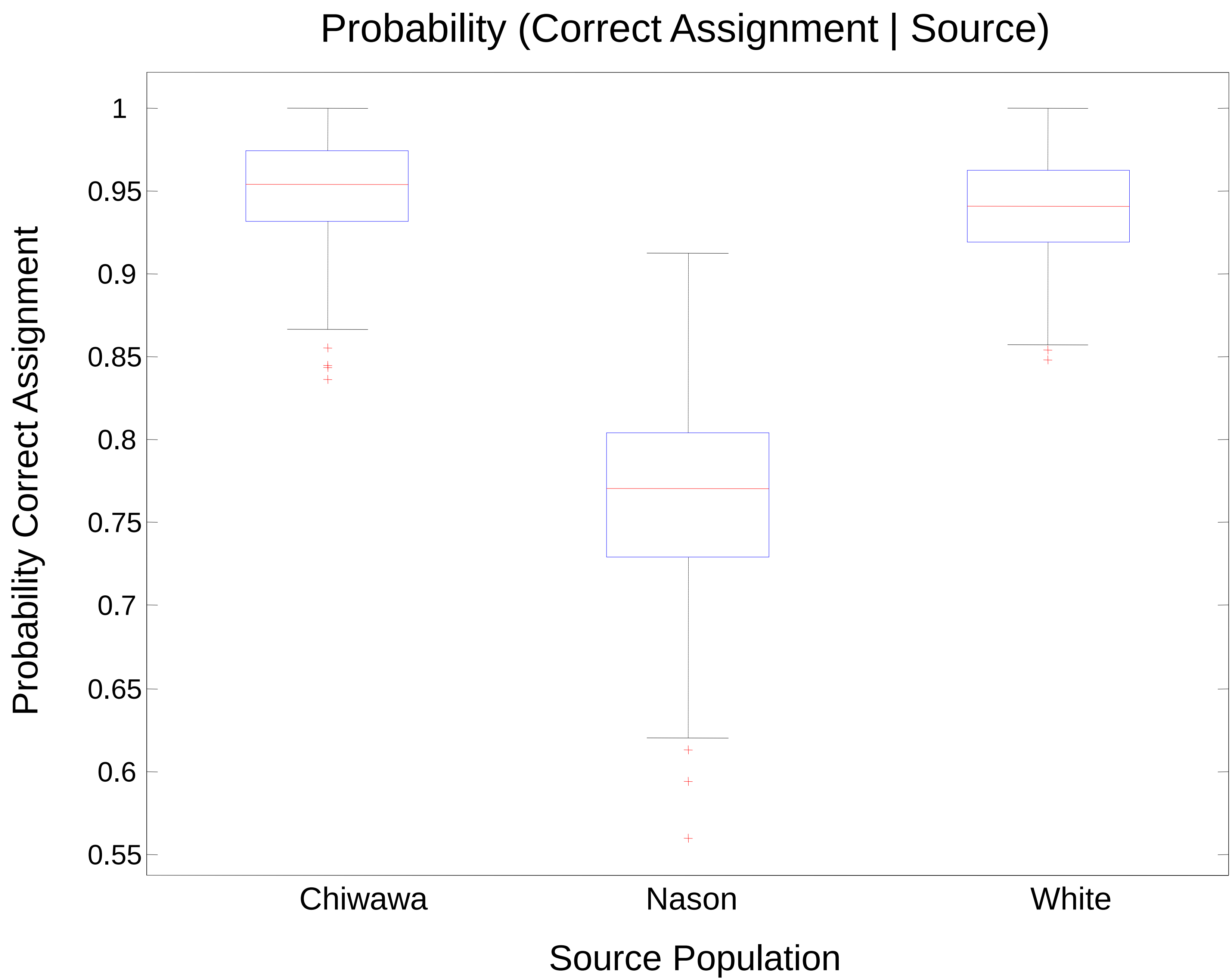
Priest Rapids – Wenatchee River Spring Chinook PBT Project: Summary

- Logistics: Feasible
- Parentage Analysis:
  - Limited by incomplete adult/offspring information (18 categories)
  - Limited by sample size
  - Possible bias resulting from microsatellite conversions between laboratories
  - LOD ≥ 10, two parent assignment = 90 - 100% correct assignments
  - LOD ≥ 10, one/two parent assignment = 72 – 83% correct assignment
  - More information required (complete parent data) and higher LOD will reduce # of offspring assigned
- Requires high sampling rate at Priest Rapids Dam

Sampling Only at Tumwater

- Parentage Analysis
  - Requires holding fish
  - Rapid turn-around from WDFW-MGL
- Genetic Stock Identification
  - Requires holding fish
  - Rapid turn-around from WDFW-MGL
  - Does not require parental information
  - Does require a good baseline for each population
    - Microsatellite Baseline: exists
    - SNPs Baseline: Not completed
  - Sufficient power?

Attachment D



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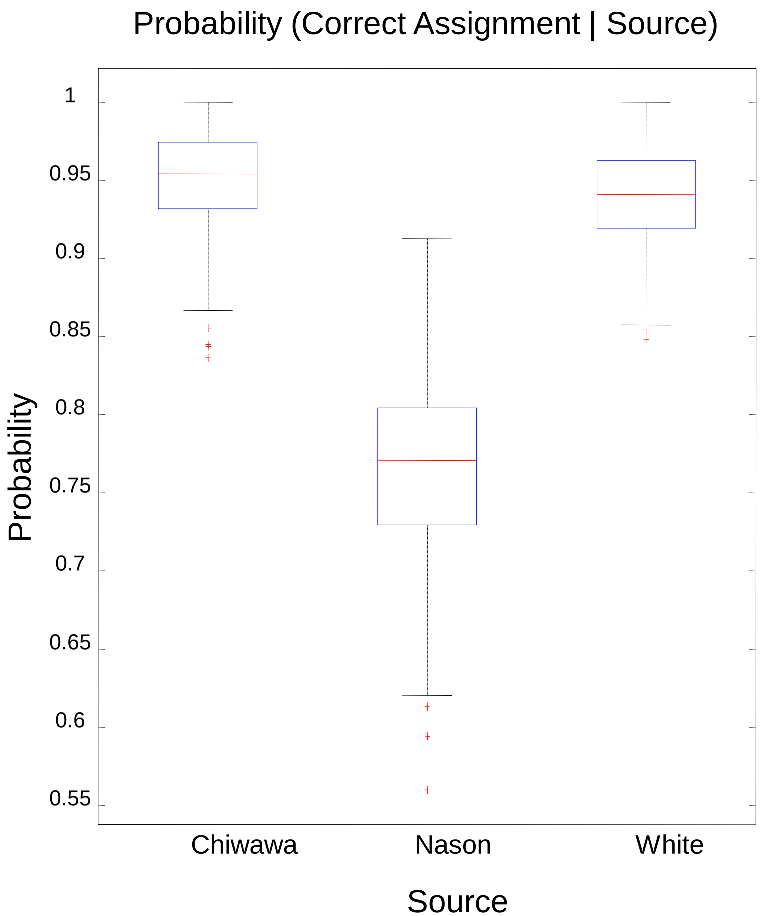
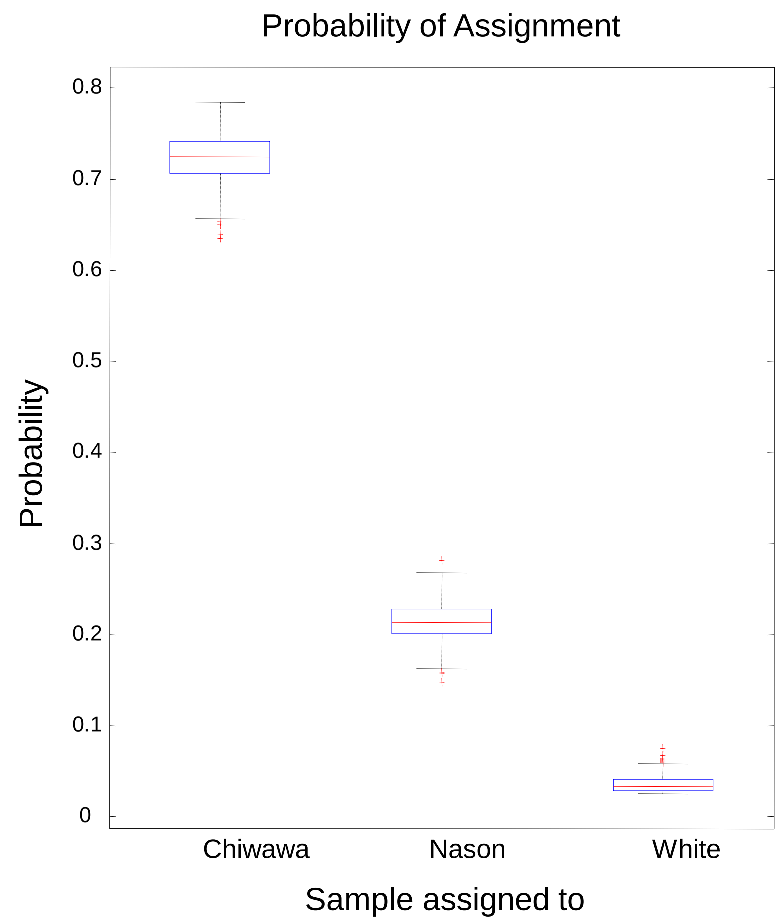


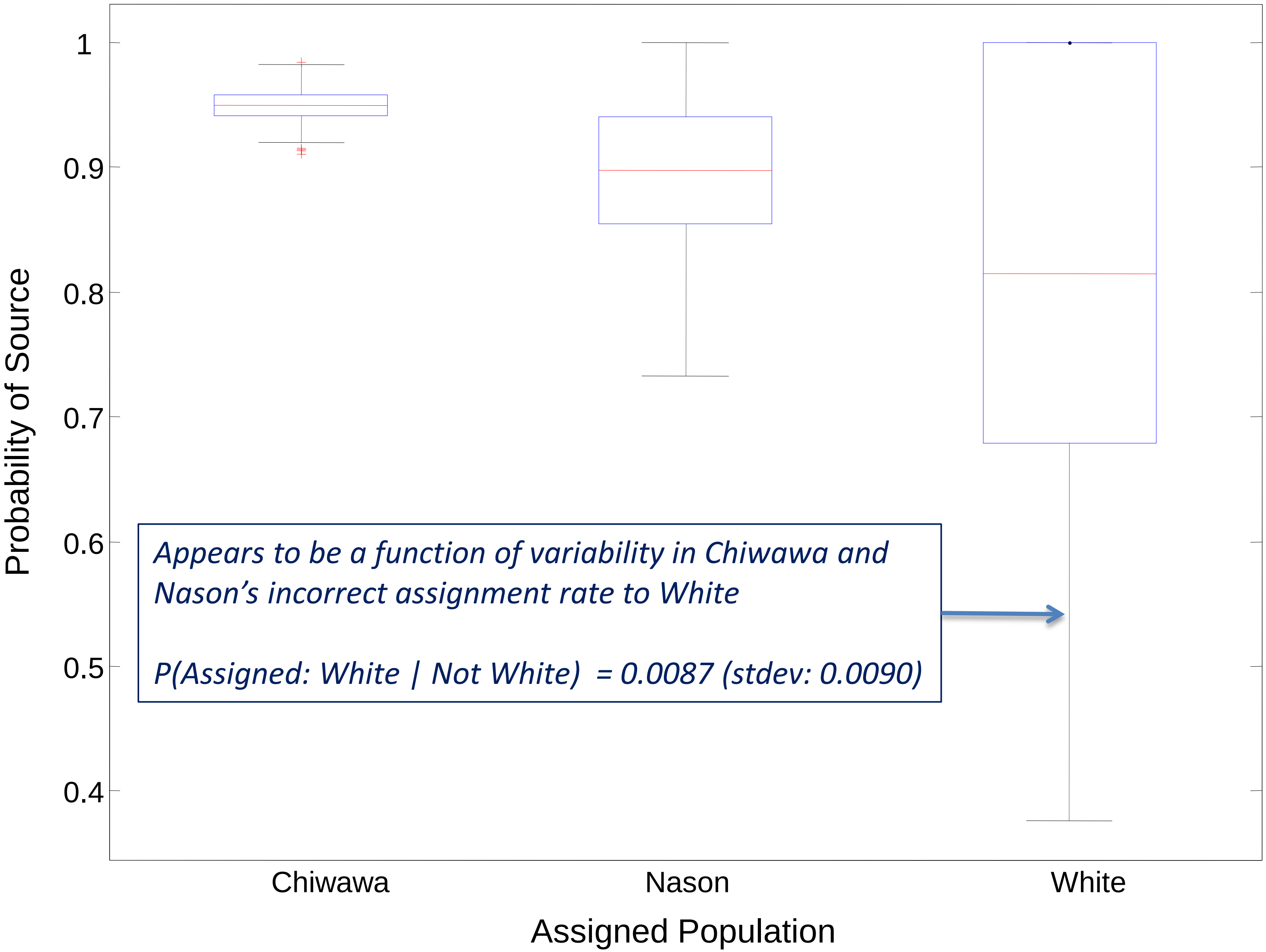


- From same analysis – calculate Pr(Not Correct Assign | Source)
- Probability of Source = escapement proportions (C: 0.72, N: 0.25, W: 0.03)
- Calculate Probability of Assignment

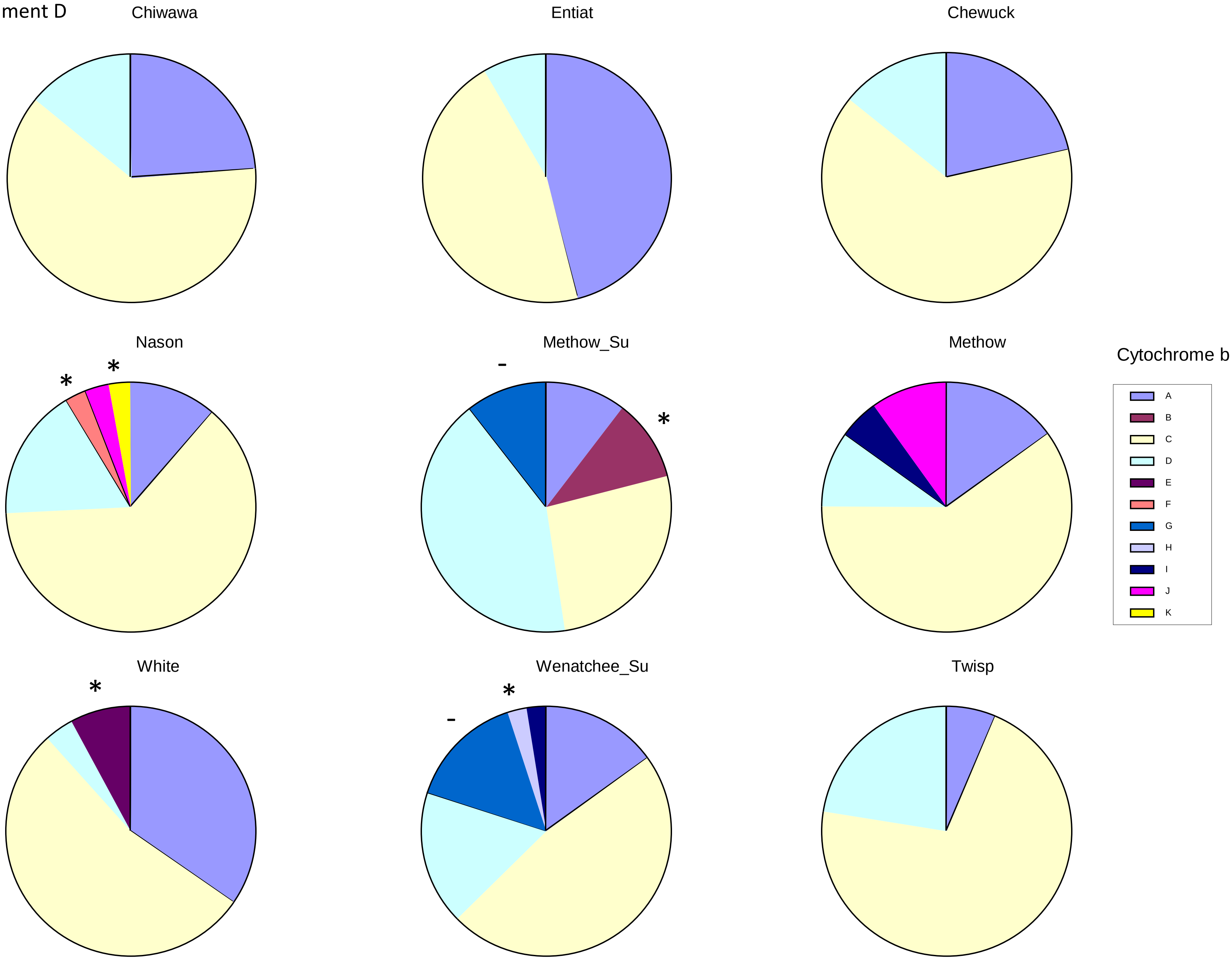
Attachment D

Probability (Source | Assignment)

Probability of making a correct assignment



Attachment D



STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM -SCIENCE DIVISION
SUPPLEMENTATION RESEARCH TEAM
3515 Chelan Hwy, Wenatchee, WA 98801
Voice (509) 664-3148 FAX (509) 662-6606

January 24, 2012

To: Joe Miller, Chelan County PUD

From: Travis Maitland and Ken Warheit

Subject: 2010 and 2011 Parental-Based Tagging Project at Priest Rapids Dam

In 2010 and 2011 the PBT Feasibility Test was intended to address several objectives necessary for the evaluation of PBT as an alternative brood stock collection method. Specifically, this test was intended to provide an evaluation of (1) trapping and handling effects; (2) logistical feasibility and (3) accuracy of parental based assignments.

Methods

Adult trapping and sampling

Sampling at the Priest Rapids Off Ladder Adult Fish Trap (OLAFT) occurred during two different two week periods in May and June of 2010 and 2011 respectively. In 2010 trapping occurred from May 1st through May 14th. In 2011 trapping occurred from June 1st through June 16th. The shift in sample period from 2010 to 2011 was implemented in an effort to target a higher proportion of Wenatchee River Basin bound spring Chinook as indicated by PIT tag detections during 2008 through 2010. This sampling would consist of (1) trapping spring Chinook at the facility, (2) PIT-tagging up to 200 wild individuals and (3) collecting a tissue sample from each tagged fish. During the two week period in 2010, trapping was conducted for up to five days in a row for a period of up to 16 hours per day to evaluate the potential for trapping effects on adult passage. The target number of natural origin fish sampled was 100 per week. This sampling approach was intended to provide a snap-shot of the effects of operating the OLAFT under conditions simulating full implementation, however, the number of fish sampled (i.e., 200 natural origin Chinook) and duration of the test (i.e., two weeks) would limit the potential for large scale un-anticipated negative effects.

Results from 2010 indicated that there were no significant negative trapping and handling effects. Hence, trapping in 2011 was conducted only up to the point at which the sample goals were met to include all weekdays and weekend days up to 12 hours per day. The target number of natural origin fish sampled was 200 during the sampling period.

After tagging, tissue samples were analyzed by the WDFW genetics lab and assignment probabilities were generated for each fish (with respect to parental genotypes for the Chiwawa River, White River and Nason Creek). Finally, throughout the spring and summer, all Wenatchee bound PIT tagged fish would be detected at Tumwater Dam and interrogated at tributary PIT tag detection arrays to evaluate the conversion from Priest Rapids Dam, and to determine the accuracy of predicted parental based assignments to individual tributaries.

Analysis

Objective 1: Trapping and handling effects- The metrics contributing to this objective would be (a) observed mortality/injury during handling at the OLAFT, (b) relative ratio of fish passage at right and left ladders during the OLAFT operation and periods outside of operation (2010 only), and (c) conversion rates and travel times of PBT PIT-tagged Chinook versus lower River PIT-tagged Chinook (and other sources) from Priest Rapids Dam to Rock Island Dam.

Any observed mortality or injury of fish during sampling was recorded and summarized. In 2010, the proportion of spring Chinook utilizing the left bank ladder when the trap was not operating was compared to the proportion when the trap was operating using a t-test. Proportions were arc-sine square root transformed to meet assumption of normality. Comparisons of travel times of fish sampled and not sampled were also conducted using a t-test. We used previously PIT tagged fish from the Chiwawa River (hatchery and wild) that passed Priest Rapids Dam in May as our control for fish sampled at Priest Rapids Dam. Conversion rates were calculated using the query available on the DART website (http://www.cbr.washington.edu/dart/pit_obs_adult_obs_de.html). However, because relatively large homogenous groups of PIT tagged fish may increase tag collision (i.e., not be detected) at Rock Island Dam, a separate query of fish tagged at Priest Rapids Dam was performed for all possible locations upstream of Rock Island Dam.

Objective 2: Logistical Feasibility- The metrics contributing to this objective would be (a) evaluation by crews operating and maintaining the OLAFT; (b) turn-around time for the WDFW genetics lab; (c) evaluation by crews operating Tumwater Dam (TWD); (d) PIT tag detection rates at Tumwater Dam and tributary arrays; and (e) conversion rates from Priest Rapids Dam to Rock Island Dam and Tumwater Dam are similar to past years -- of those assigned to tributaries above Tumwater Dam, >83% actually arrive at TWD.

Objective 3: Accuracy of parental based assignments – See Appendix A.

Results

Objective 1: Trapping and handling effects

In 2010, the spring Chinook run timing in the Columbia River was later than expected and adequate numbers of fish were not observed until the middle of May. The OLAFT was operated for 43 hours the week of May 9 and 41 hours the week of May 16. A total of 1,984 spring Chinook were passed upstream during trap operation and 196 wild fish were DNA sampled and PIT tagged. Of which, seven fish were PIT tagged as a juvenile at a smolt trap or adult at Bonneville Dam. No mortalities or injuries were reported. No difference was found in the proportion of spring Chinook that used the left ladder on trapping (91.8%) versus non-trapping (87.9%) days (t-test: t= -1.21, P = 0.233; Figure 1). No difference was detected in the travel time from Priest Rapids Dam to Rock Island Dam for fish sampled (3.41 days; N = 175;) and those not sampled (4.07 days; N = 47) during the month of May (t-test: t= 1.71, P = 0.09).

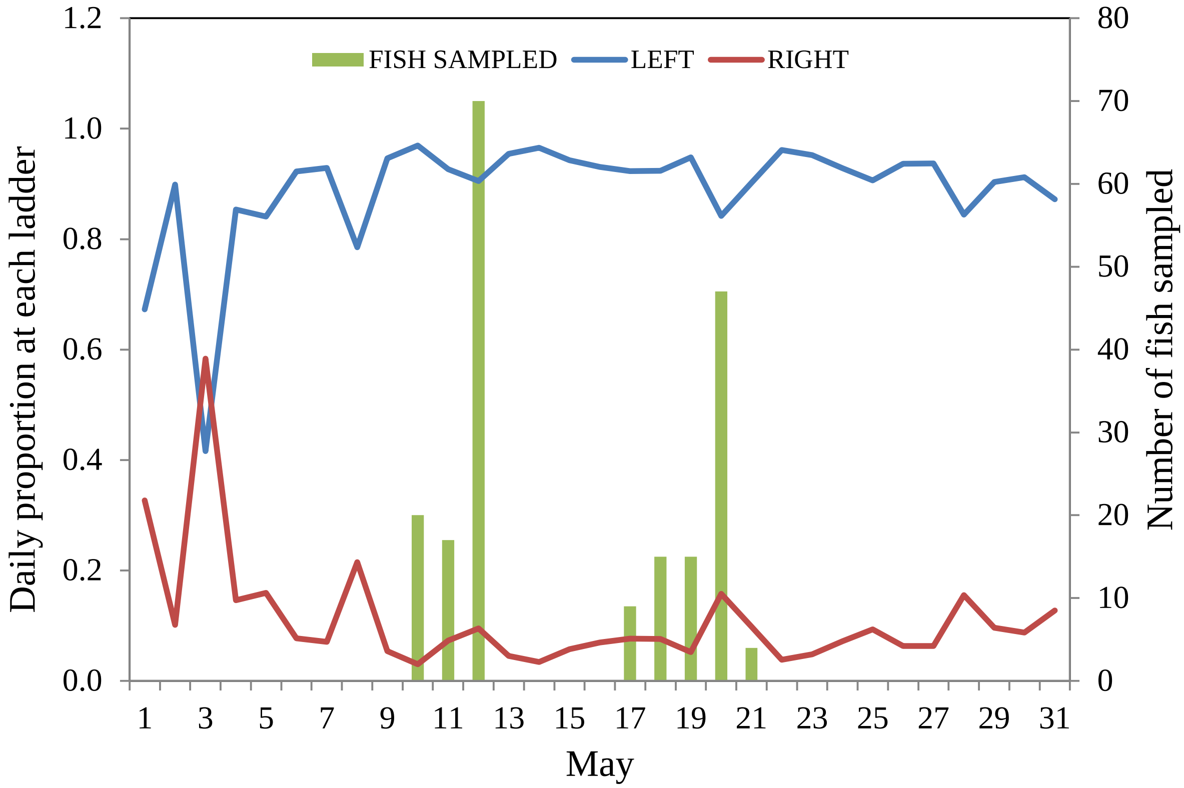


Figure 1. Proportion of spring Chinook using left and right bank ladder trap at Priest Rapids Dam in 2010. Green bars denote number of fish sampled on each day.

In 2011, the spring Chinook run timing in the Columbia River at Priest Rapids Dam was once again later than that of the 10 year average as well as the run timing in 2010. The OLAFT was operated for approximately 170 hours during the sampling period (June 1 through June 18), with June 5 being the only day the trap was not operated due to mechanical issues. A total of 406 spring Chinook (adults and jacks) were passed upstream during trap operation and 86 presumed naturally produced spring Chinook were DNA sampled and PIT tagged. Of which, four fish were determined to be of summer Chinook race and four fish were determined to be of hatchery origin after scale analysis was conducted and three fish were tagged as a juvenile at smolt traps. No mortalities or injuries were reported. No difference was detected in the travel time from Priest Rapids Dam to Rock Island Dam for fish sampled (5.07 days; $N = 39$) and those not sampled (4.06 days; $N = 85$) during the month of June (t-test: t= 1.74, $P = 0.08$).

In 2010, conversion rates of PIT tagged fish from Priest Rapids to Rock Island Dam using the standard DART query resulted in similar rates for those fish that were PIT tagged as juveniles and not sampled (Table 1). In 2011, conversion rates of PIT tagged fish from Priest Rapids to Rock Island Dam using the standard DART query resulted in higher conversion rates than those fish that were PIT tagged as juveniles and not sampled (Table 2). Because fish sampled at PRD were PIT tagged in large groups on a daily basis in 2010, the likelihood of tag collision at Rock Island Dam may be higher when compared to fish return from throughout the run. This was most likely not an issue in 2011 due simply to the fact that there were far fewer fish tagged on a daily basis. A user defined query using PTAGIS of all PBT study fish found that 98% and 95% were detected at or upstream of Rock Island Dam in 2010 and 2011 respectively.

Table 1. Conversion rates of PIT tagged fish at Priest Rapids Dam to Rock Island Dam in 2010.

Tagging location	Number of fish at PRD	Number of fish detected	Conversion rate
Chiwawa smolt trap	54	51	0.944
Chiwawa River	16	15	0.938
Chiwawa Hatchery	98	87	0.888
Entiat River	62	62	1.000
LNFH	127	123	0.969
Methow Trap	3	1	0.333
Methow River	6	6	1.000
Nason Creek	11	11	1.000
Rocky Reach Bypass	1	1	1.000
Twisp River	23	21	0.913
Wenatchee River	2	2	1.000
Wenatchee Trap	7	6	0.857
White River Trap	1	1	1.000
WNFH	19	19	1.000
subtotal	**430**	**406**	**0.944**
Priest Rapids Dam	187	176	0.941
Study Fish	196	192	0.980

Table 2. Conversion rates of PIT tagged fish at Priest Rapids Dam to Rock Island Dam in 2011.

Tagging location	Number of fish at PRD	Number of fish detected	Conversion rate
Chiwawa Smolt Trap	70	60	0.857
Chiwawa River	23	21	0.913
Chiwawa Hatchery	118	91	0.771
Entiat River	49	44	0.898
LNFH	72	68	0.944
Methow Hatchery	75	54	0.720
Methow River	4	3	0.750
Nason Creek	14	11	0.786
Rocky Reach Bypass	1	1	1.000
Twisp River	20	15	0.750
Wenatchee River	1	1	1.000
Upper Wenatchee Trap	4	4	1.000
Lower Wenatchee Trap	2	1	0.500
Wolf Creek	107	73	0.680
WNFH	33	30	0.909
Wells Dam	2	2	1.000
subtotal	**595**	**479**	**0.805**
Priest Rapids Dam	83	79	0.952
Study Fish	86	82	0.953

Objective 2: Logistical Feasibility

During operation of the OLAFT in 2010, no injuries to fish or issues operating the trap were identified. Trapping was conducted as planned without incident. Similarly, the Tumwater fish trapping facility was also operated without incident. Results of pedigree assignments for fish sampled during the two week period were completed on May 21 (7 d) and June 1 (8 d), respectively. In 2010, travel time from Priest Rapids Dam to Tumwater Dam averaged 41.8 d (SD = 7.6) with a median of 42.4 days. The shortest travel time was 27 days.

In 2011, travel time from Priest Rapids Dam to Tumwater Dam averaged 34.4 d (SD = 10.11) with a median of 31.1 days for those fish sampled at the OLAFT. The shortest travel time was 23 days. During operation of the OLAFT in 2011, no injuries to fish were identified. With the exception of one day (June 5), trapping was conducted as planned without incident. Similarly, the Tumwater fish trapping facility was also operated without incident. However, due to the lack of wild spring Chinook that were encountered while trapping at the OLAFT, the sample size goal for Priest Rapids (N = 200) was not achieved. This may have been due in part to adjusting the sampling period to the first two weeks in June rather than the last two weeks in May, as was the case in 2010. A further investigation of PIT tag detections at the antennae array located in the ladder just above the OLAFT revealed that fish may have waited until daily trapping operations were concluded before moving upstream (i.e., trap avoidance). We also experienced a relatively high and extended river discharge which may have contributed to the poor trapping efficiency. We also examined the conversion rate of known Wenatchee River adults to Tumwater Dam (Table 3). Overall, 87% and 84% of the PIT tagged fish detected at PRD were also detected at Tumwater Dam in 2010 and 2011, respectively. Of those fish detected at Tumwater Dam, 55% and 83% were detected at various arrays in the upper Wenatchee Basin in 2010 and 2011, respectively (Table 4).

Table 3. Conversion rates of wild adult spring Chinook tagged in the Wenatchee Basin as juveniles to Tumwater Dam in 2010 and 2011.

Trap site	Number at PRD	Number at Tumwater	Conversion rate
	2010 Conversion Rates		
Chiwawa	72	62	0.86
Nason	11	10	0.91
Wenatchee	7	6	0.86
Total	90	78	0.87
	2011 Conversion Rates		
Chiwawa	70	58	0.83
Nason	14	13	0.93
Wenatchee	4	3	0.75
Total	88	74	0.84

Table 4. Conversion rates of wild adult spring Chinook at Tumwater Dam to PIT tag instream arrays in 2010 and 2011.

Trap site	Number at Tumwater Dam	Number at PIT tag arrays	Conversion rate
	2010 Conversion Rates		
Chiwawa	62	38	0.61
Nason	10	8	0.80
Wenatchee	6	3	0.50
Priest Rapids Dam	34	13	0.38
Total	112	62	0.55
	2011 Conversion Rates		
Chiwawa	58	51	0.88
Nason	13	10	0.77
Wenatchee	3	3	1.00
Priest Rapids Dam	29	21	0.72
Total	103	85	0.83

Objective 3: Accuracy of parental based assignments

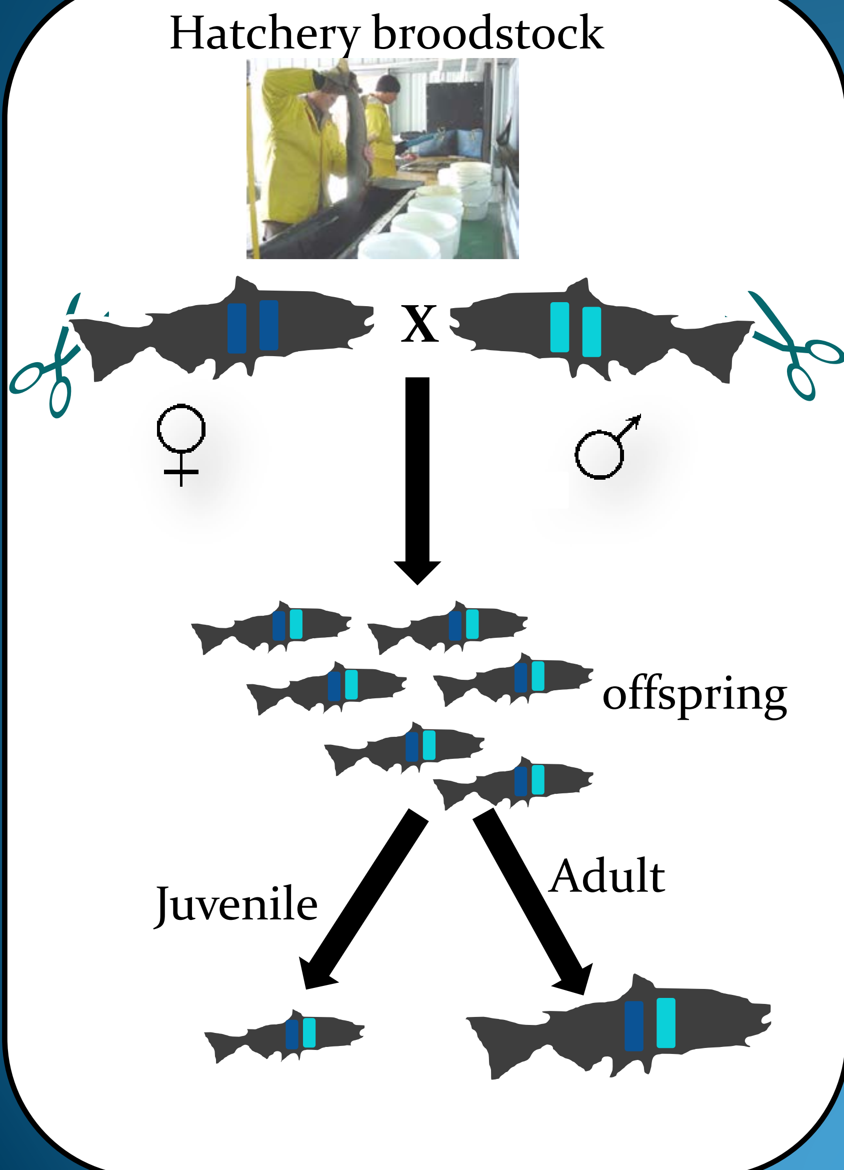
See Appendix A.

Discussion

Trapping and sampling adult spring Chinook at the OLAFT did not appear to have a significant effect on fish passage or survival in either year. A potential trap avoidance problem may have been encountered in 2011 that prevented sample size goals from being met. The proportion of fish assigned to a spawning tributary were much lower than expected and was most likely influenced by the proportion of parents assigned to a spawning tributary between 2005 and 2007. In recent years, the proportion of fish upstream of Tumwater Dam assigned to spawning tributary has greatly increased (~85%). Thereby increasing the probability that a Wenatchee River bound fish sampled at Priest Rapids Dam would be correctly identified to a tributary of origin. Furthermore, to best assess the accuracy of the PBT analysis, we limited the evaluation to only those assignments with two parents and all parental and offspring attributes known. This further reduced the number of offspring that we were able to assign to only 29 of the 282 (10%). Any future program would need to increase sampling rates at the Priest Rapids facility to ensure an appropriate number of fish (i.e., broodstock goal) are assigned to two parents with a minimum LOD score of 10. However, we recognize that without extensive modifications to the OLAFT facilities to increase trapping efficiency, sufficient sample rates in all likelihood cannot be achieved. We further recommend minimizing genotyping errors, which can negatively affect parentage assignment rates, by performing genotyping in only one laboratory, using standardized and uniform allele nomenclature.

What is parentage based tagging (PBT)

Genetic tags (PBT)

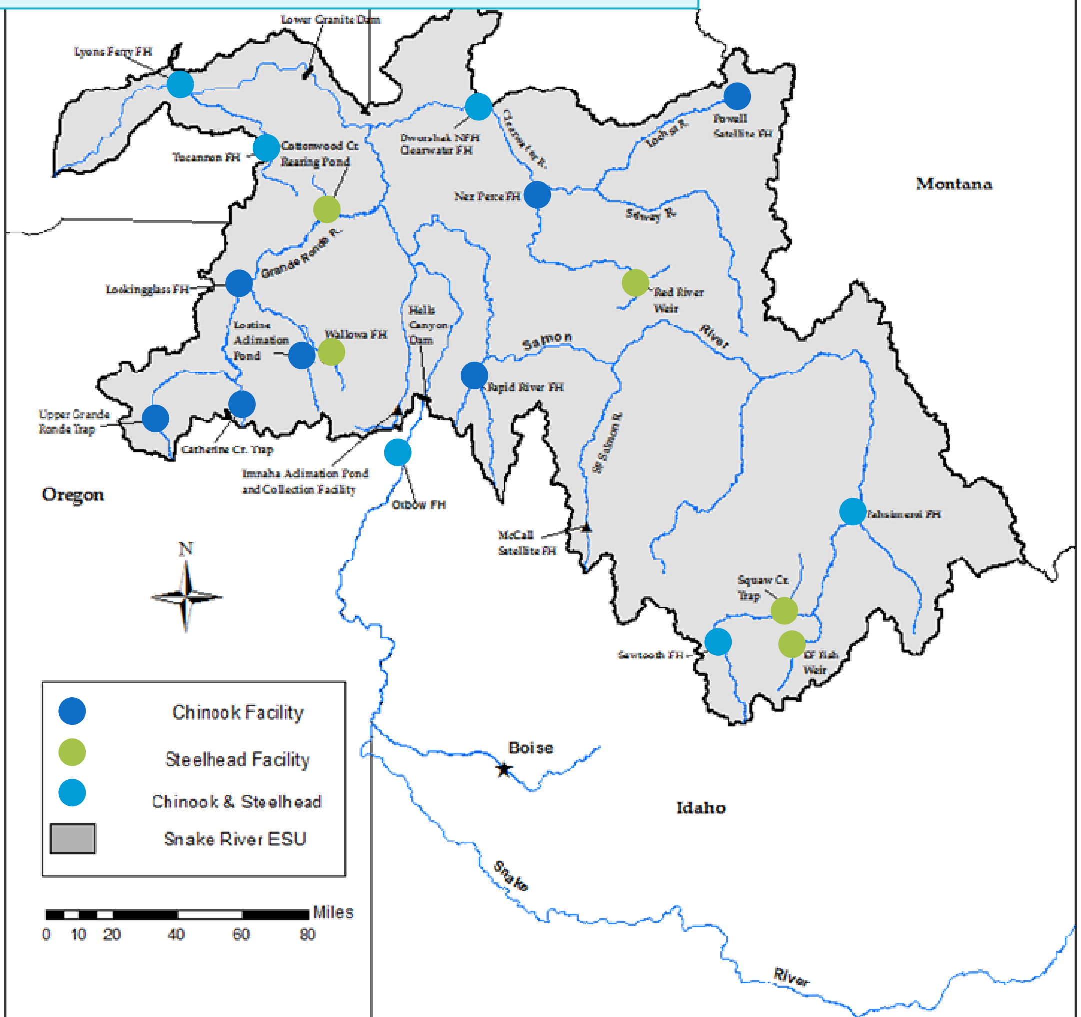


- Genetic tagging of hatchery broodstock = can identify hatchery of origin and age for ANY offspring produced
    - Passive mark (no handling of juveniles)
    - Nearly 100% tagging rate of hatchery fish
    - Eliminates issues with tag loss, tag detection, handling mortality
    - Non-lethal sample to recover tag from offspring
        - ➢ Stock contribution to various fisheries
        - ➢ Survival trends
        - ➢ Escapement estimates
        - ➢ Origin of strays and kelts

Attachment F

Snake River basin PBT

Identified genetic marker sets for both species that provide sufficient power for accurate parentage assignments (Steele et al., in prep)

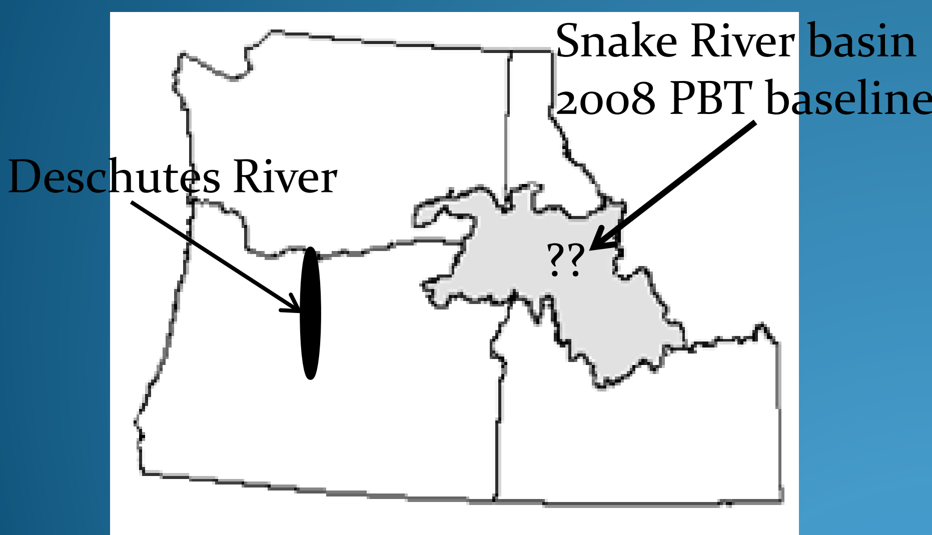


- Sample all hatchery broodstock:
  ~5,000 steelhead/yr
  ~9,000 Chinook salmon/yr
- Parental sampling complete for 2008 -2011
- All hatcheries record spawn dates and gender (many provide lengths and spawn cross)
- Permanently "tag" ~20 million smolts/yr!

Attachment F

An example application of PBT: Origin of hatchery steelhead strays in the Deschutes River

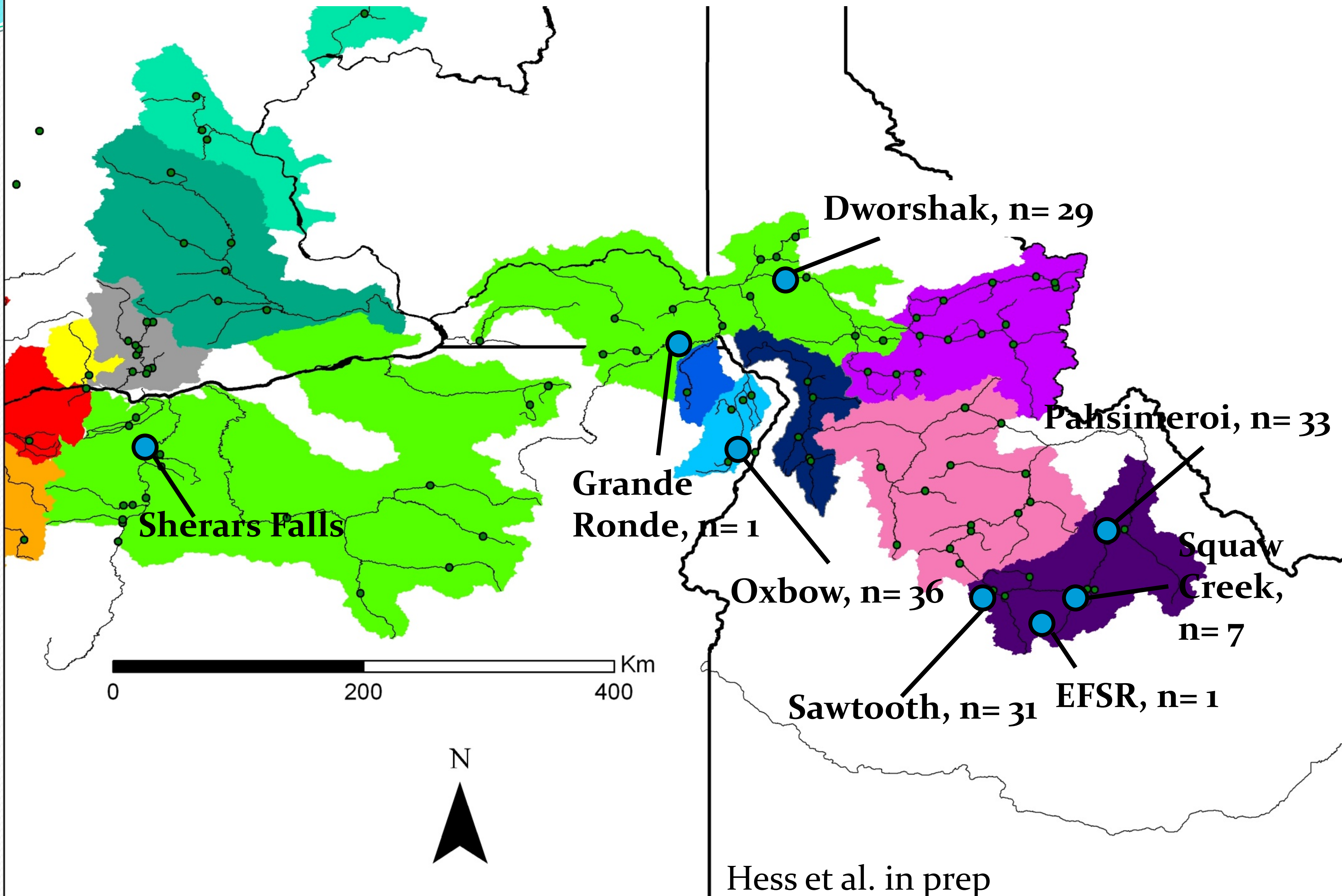
- 462 hatchery steelhead sampled at Sherars Falls, Deschutes River in 2011
  (unknown portion of 3 year old genetically tagged fish)
- Portion of strays from the Snake River basin?



- Steelhead sampled by Rod French ODFW and genotyped by CRITFC
- Sampling continuing in 2012

Hess et al. in prep

Of the 462 hatchery-origin returns, 138 (~30%) assigned to the 2008 Snake River basin PBT baseline



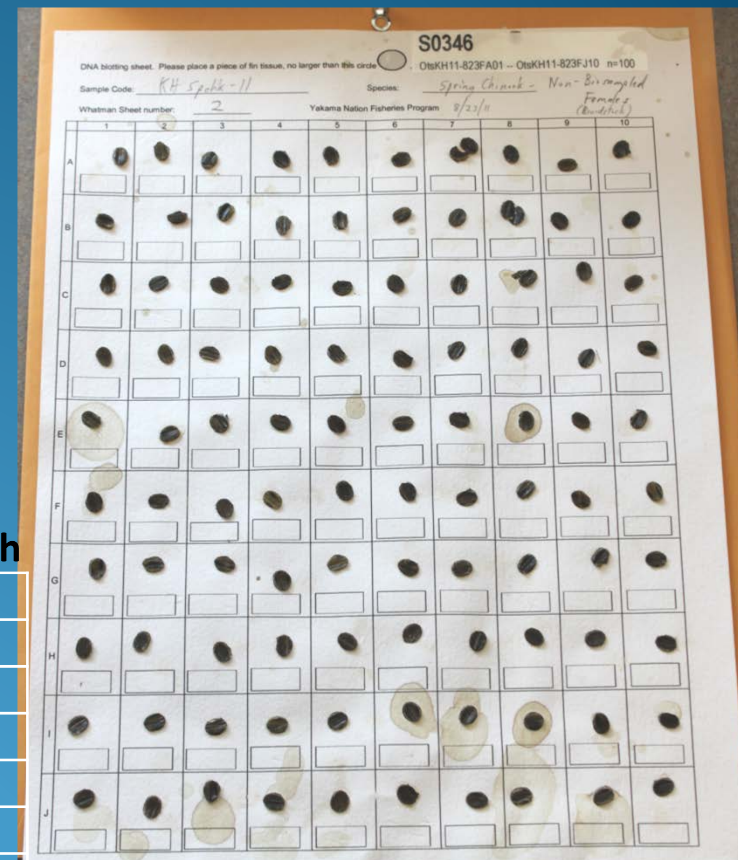
Attachment F

Goal: Extend PBT sampling to ALL Chinook salmon and Steelhead hatcheries above Bonneville Dam beginning 2012

Large collaborative effort between the tribes, ODFW, WDFW, IDFG, USFWS

Required as fish are spawned:

- Fin tissue
- Spawn date
- Gender



Sample ID	Spawn Date	Gender	Cross 1	Cross 2	Length
PAH12-0001	4/10/2012	M			600
PAH12-0002	4/10/2012	M			730
PAH12-0003	4/10/2012	F	PAH12-0001	PAH12-0007	640
PAH12-0004	4/10/2012	F	PAH12-0009		640
PAH12-0005	4/14/2012	F	PAH12-0002	PAH12-0007	620
PAH12-0006	4/14/2012	F	PAH12-0001		600
PAH12-0007	4/14/2012	M			590
PAH12-0008	4/20/2012	F	PAH12-0007		620
PAH12-0009	4/20/2012	M			620

Attachment F

Hatchery rearing facilities identified in US v OR management production table document (2/7/11)

Steelhead rearing facilities

Need assistance with identifying broodstock collection facilities & sample coordination

- Prosser
- Ringold
- Wells
- Winthrop NFH
- Irrigon
- Oak Springs
- Skamania for Klickitat

- Umatilla
- Clearwater
- Dworshak NFH
- Hagerman NFH
- Lyons Ferry
- Hagerman NFH
- Niagara Springs
- Pahsimeroi
- Sawtooth

Chinook salmon rearing facilities

- Carson NFH
- Cle Elum Hatchery
- Eastbank
- Entiat NFH
- Leavenworth NFH
- Methow
- New Grant PUD facility
- Priest Rapids Hatchery
- Prosser
- Turtle Rock
- Wells
- Winthrop NFH
- Bonneville
- Little White Salmon NFH
- Round Butte
- Spring Creek NFH

- Klickitat Hatchery
- Umatilla
- Warm Springs NFH
- Clearwater. FH
- Dworshak NFH
- Kooskia NFH
- Lookingglass
- Lyons Ferry
- McCall Hatchery
- Nez Perce Tribal Hat
- Oxbow
- Pahsimeroi
- Rapid River
- Sawtooth

Juvenile Spring Chinook Size, Survival, and Age at Maturity

Josh Murauskas

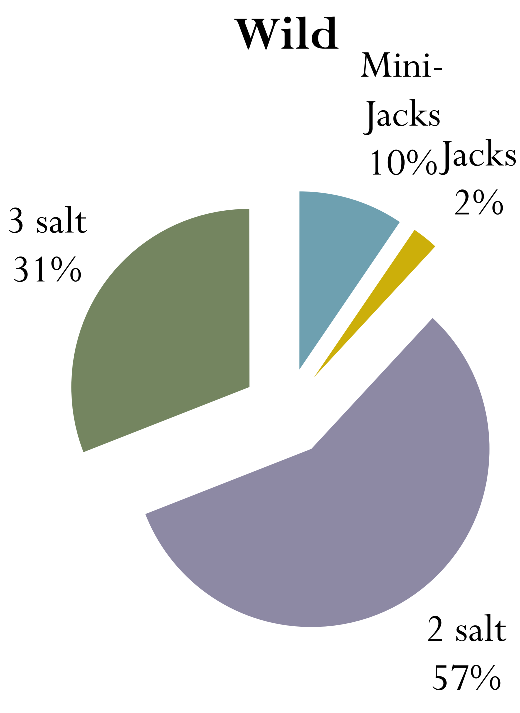
Chelan PUD Natural Resources Department

February15, 2012

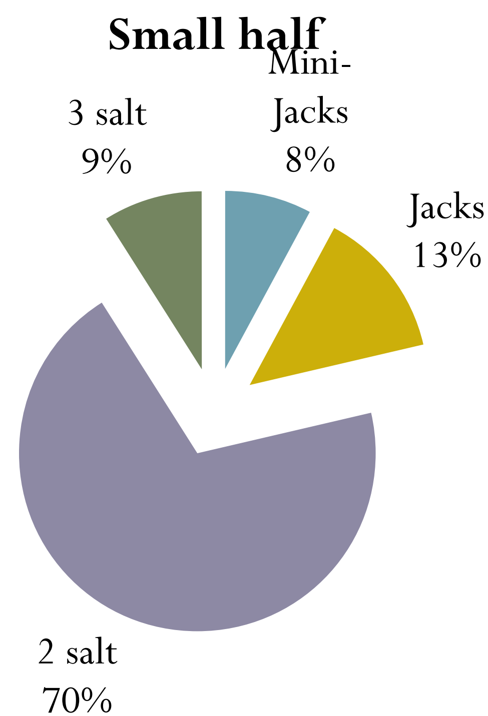
Summary of analyses to date

- No apparent benefit in larger hatchery smolts
- Apparent drawback in larger hatchery smolts
- Smaller hatchery smolts perform more similarly to wild fish
  - No effect on female returns

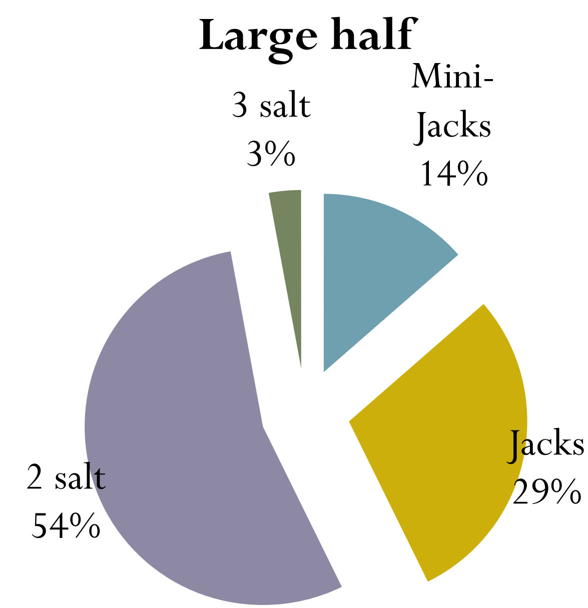
Proportion of age classes by group



12% < 2 salt fish

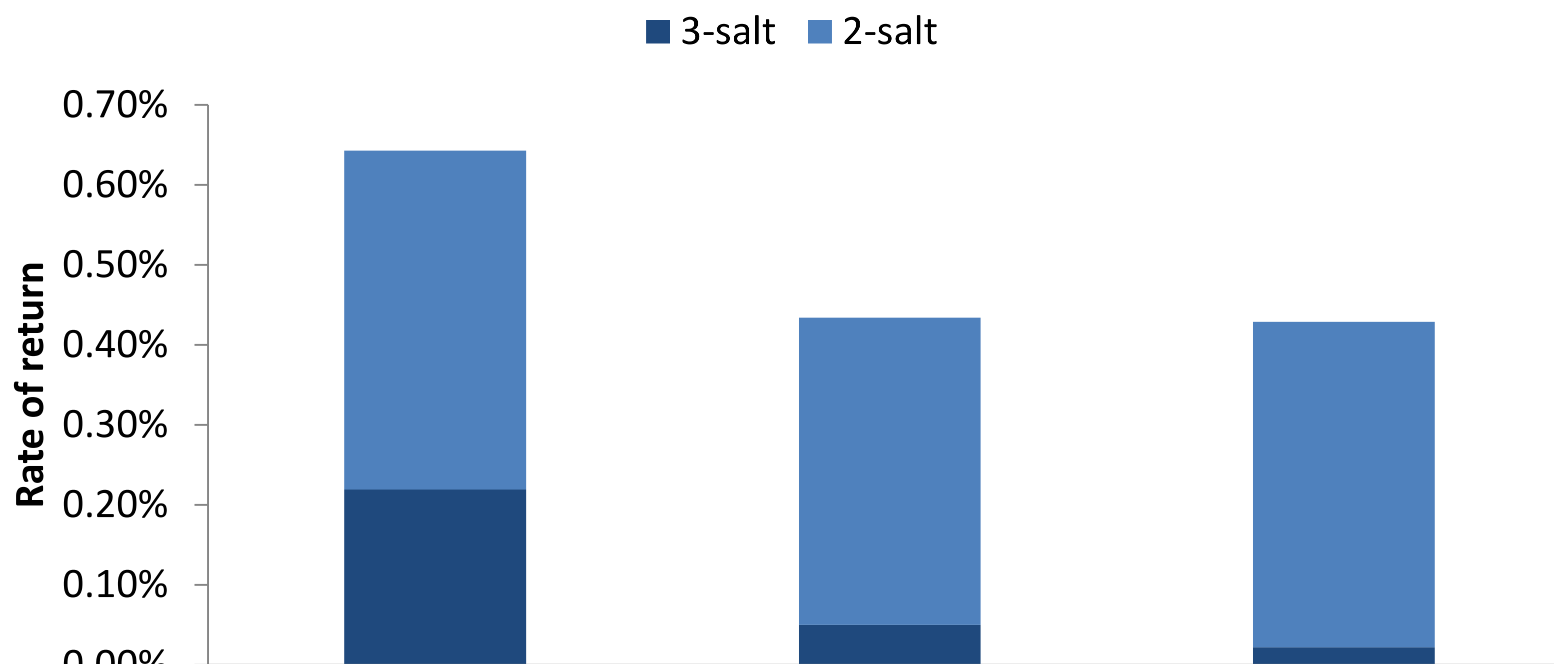


21% < 2 salt fish



43% < 2 salt fish

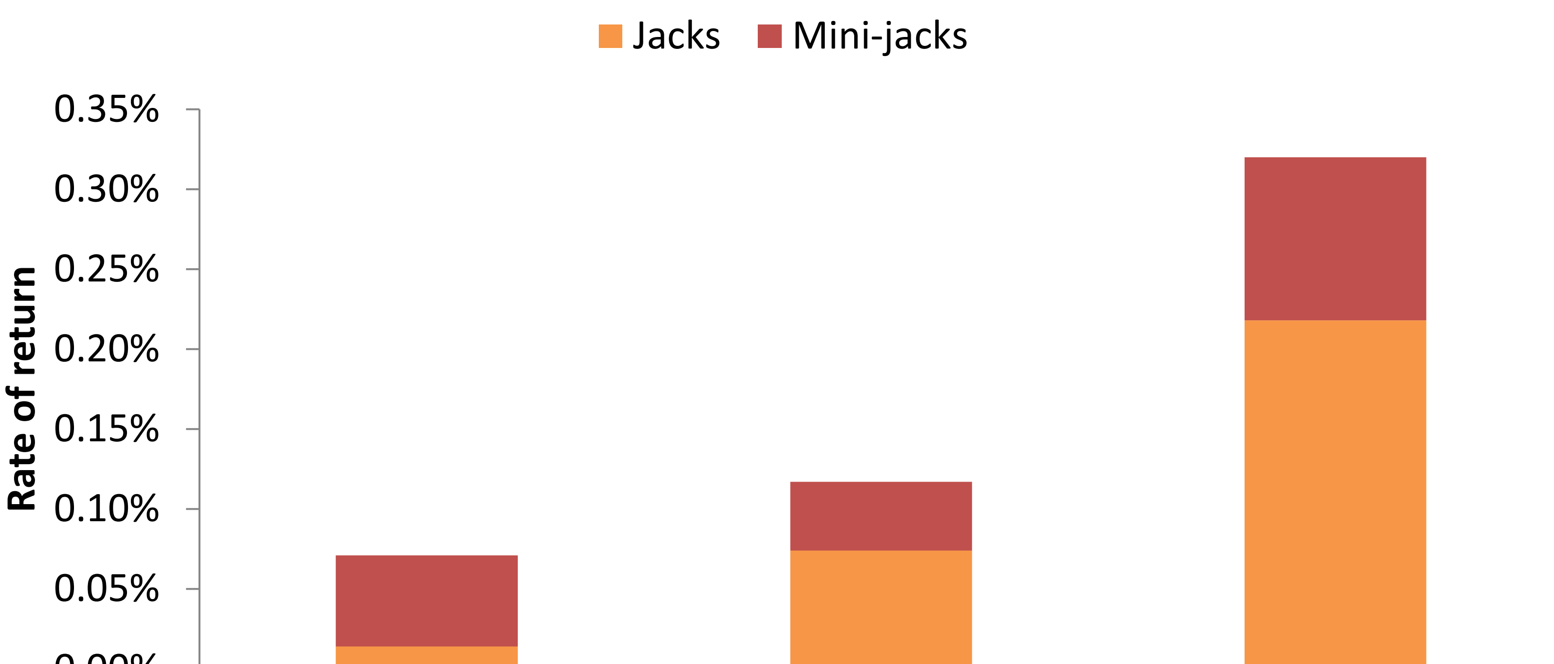
Average returns from Chiwawa R.



	Wild	Hatchery (small)	Hatchery (large)
2-salt	0.42%	0.38%	0.41%
3-salt	0.22%	0.05%	0.02%

Group

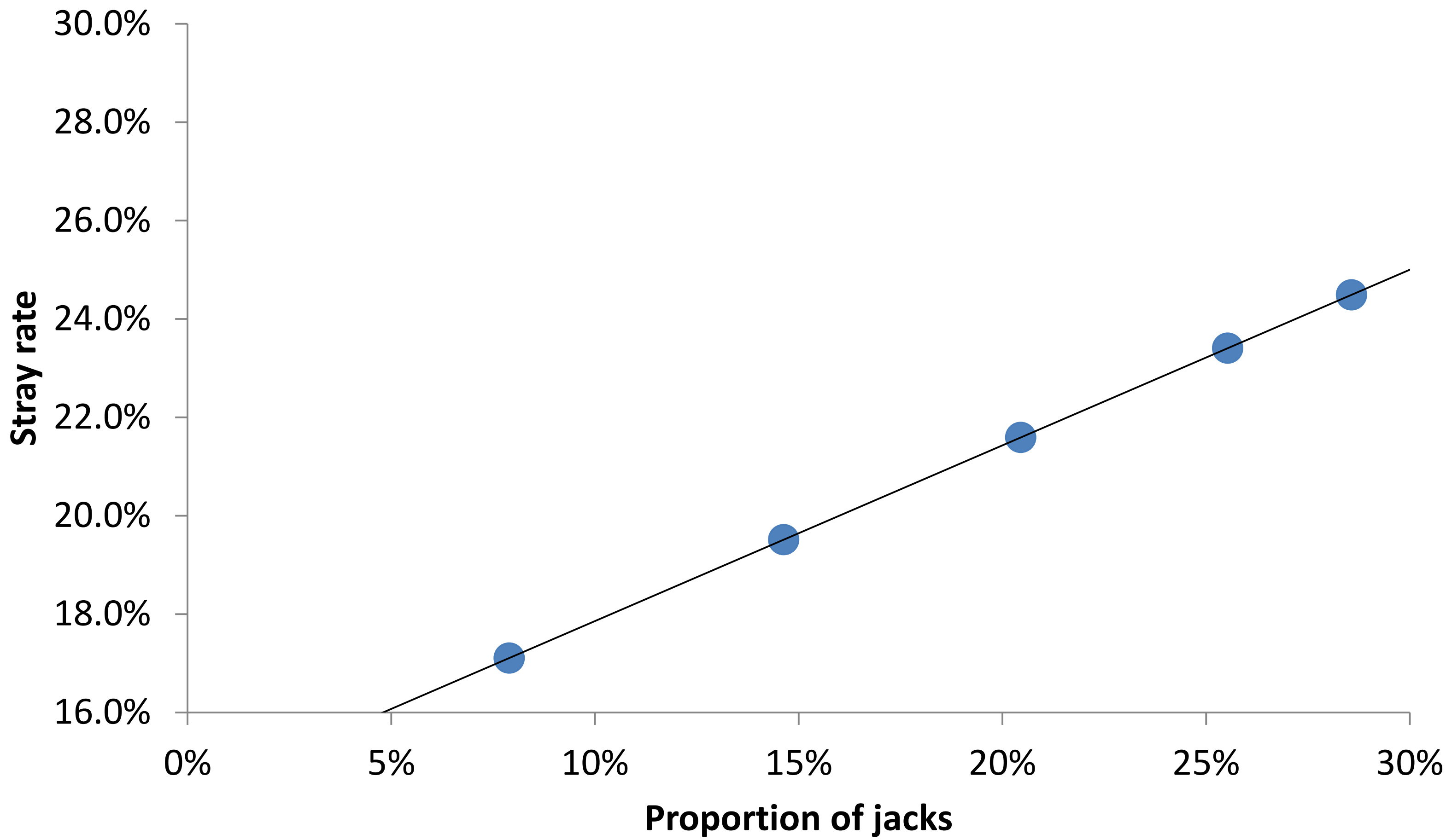
Average returns from Chiwawa R.



	Wild	Hatchery (small)	Hatchery (large)
Mini-jacks	0.06%	0.04%	0.10%
Jacks	0.01%	0.07%	0.22%

Group

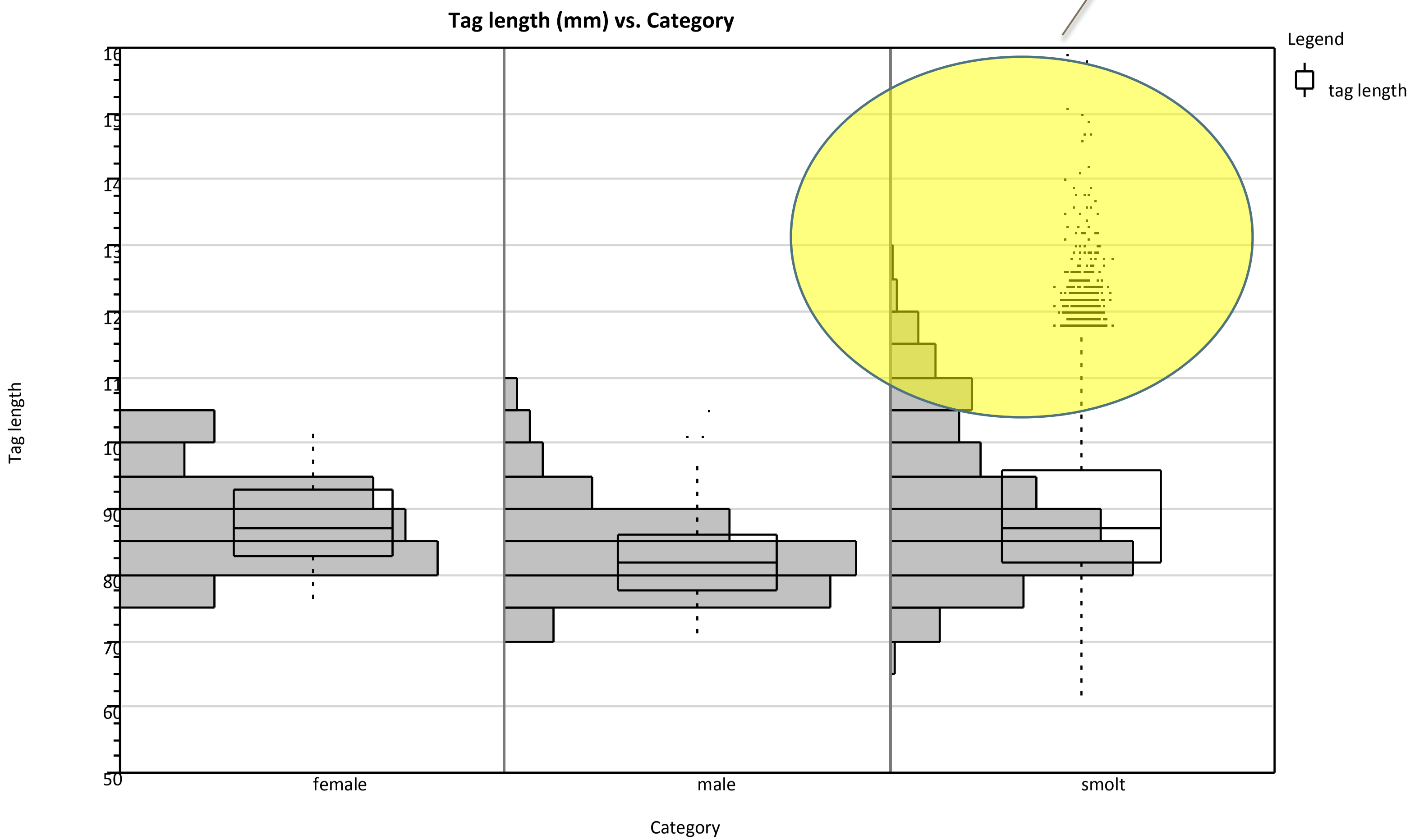
Stray rates



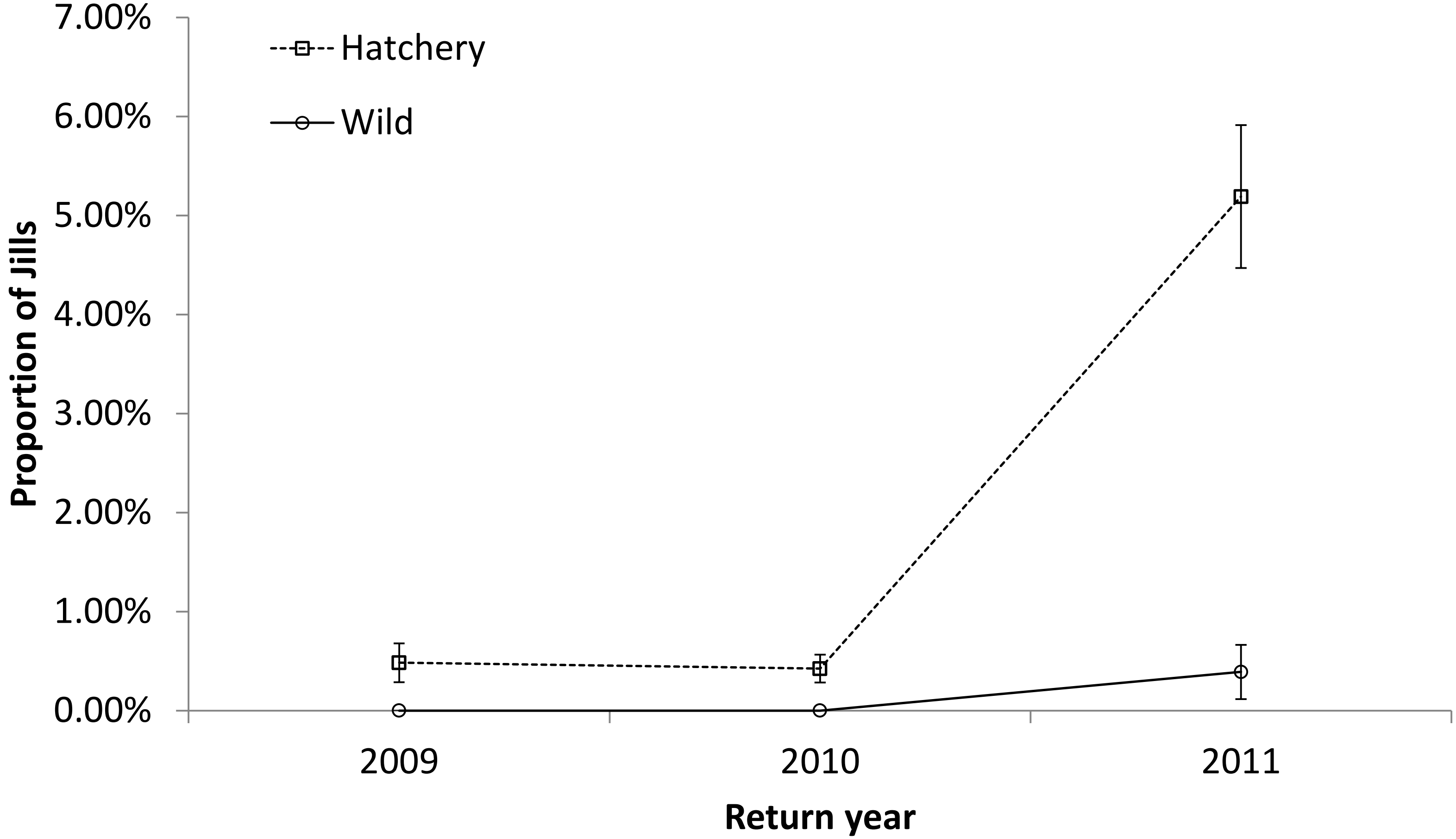
Data from A. Murdoch, WDFW

Female returns

Larger smolts do not contribute to adult returns

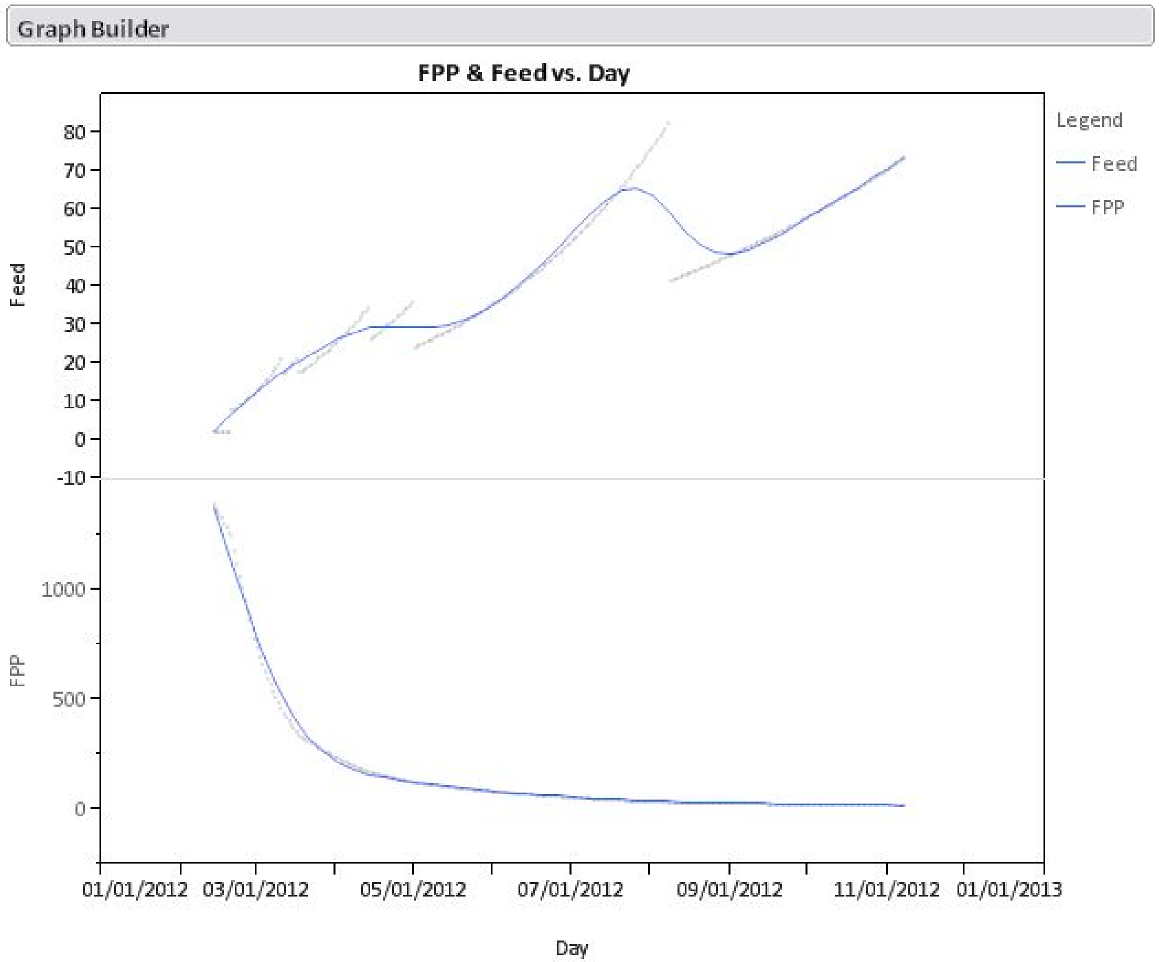


Jill rates


Proportion of Jills
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Hatchery
Wild
2009
2010
2011
Return year

Attachment G

Feed schedule



Implications

- Mimic wild populations
- Maximize age at return
- Minimize stray rates
- PNI goals for the Wenatchee
- Consistent with M&E results and NOAA recommendations

Questions?

Use of monitoring and evaluation data to identify appropriate size at release targets for hatchery-origin Chiwawa River spring-run Chinook salmon *Oncorhynchus tshawytscha*

J. G. Murauskas

Natural Resources Department, Chelan Public Utilities District, Wenatchee, WA

Abstract–We examined smolt survival and adult returns of Chiwawa River spring Chinook salmon *Oncorhynchus tshawytscha* using passive integrated transponder tags to determine if juvenile length influenced these results. A logistic regression indicated that increasing juvenile length at tagging significantly increased the probability of both wild- and hatchery-origin smolts returning at younger age classes, including mini-jacks ($p = 0.03$ and $p < 0.01$, respectively). Despite significantly smaller size at release and 21.4% lower smolt survival rate on average, wild-origin fish had a 49.2% greater rate of adult returns compared to hatchery-origin fish ($p < 0.01$). Hatchery-origin smolts were divided into small and large groups by median length at tagging for comparison. The large half of hatchery-origin fish had statistically indifferent juvenile survival compared to the small half, but produced 135% more mini-jacks ($p = 0.03$), 194% more jacks ($p < 0.01$) , 6% more 2-salt adults ($p = 0.38$), and 56% fewer 3-salt adults (3-salt adults from the 2009 releases have not yet returned; $p = 0.11$). These results indicate that large length targets of hatchery programs do not translate to increased smolt survival or adult returns and further increase the disparity between population demographics of hatchery- and wild-origin populations. We propose that a size target of 126 mm and 25 g (~ 18 fish per pound) in hatchery-reared spring Chinook would provide measurable benefits in terms of adult returns and conservation of an ESA-listed stock.

Introduction–Chiwawa Hatchery (Chiwawa) is located at the confluence of the Chiwawa and Wenatchee rivers approximately 15 miles north of Leavenworth, Washington. Chiwawa was constructed in 1990 as a component of the Eastbank Hatchery Complex designed to rear up to 672,000 spring Chinook smolts to mitigate for losses incurred at hydroelectric projects owned and operated by Chelan County Public Utilities District (PUD). The juvenile fish are transferred from Eastbank Hatchery in the fall prior to migration, over-wintered at Chiwawa, and released directly into the Chiwawa River.

Chelan PUD has funded extensive monitoring and evaluation efforts of Chiwawa spring Chinook since 1989. A comprehensive report on monitoring and evaluation efforts over the past five years is currently being developed. Two recommendations within the report indicate that (1) "more realistic [size] targets should be set based on the length-weight relationship specific to Chiwawa spring Chinook and the size of natural-origin smolts produced in the Chiwawa Basin;" and, (2) "hatchery fish matured at an earlier age than natural-origin fish. This may be related to the size of released hatchery smolts" (Hillman et al. 2011a).

Several researchers have identified relationships between length at release and survival and age at maturity in Chinook and other *Oncorhynchus* spp. (Neilson and Geen 1986; Vøllestad et al. 2004; Scheuerell 2005; Claiborne et al. 2011; Tipping 2011). The current size target for hatchery spring Chinook released in the Chiwawa River is 176 mm FL and 38 g (~ 12 fish per pound), whereas wild-origin fish have averaged 94 mm FL and 9.3 g (~ 50 fish per pound; Hillman et al. 2011b). The purpose of the analyses contained herein is to test the hypotheses that (1) larger spring Chinook smolts lead to a decrease in age at maturity; and, (2) larger spring Chinook smolts do not have a full life cycle survival advantage compared to smaller smolts.

Methods–Data were retrieved from the PIT Tag Information System for the Columbia River Basin (PTAGIS; Pacific States Marine Fisheries Commission 2011). A "tagging detail" query was submitted to obtain records of PIT-tagged spring Chinook that were released from Chiwawa Ponds (CHIP; hatchery-origin smolts only) and Chiwawa Trap (CHIWAT; natural-origin smolts only) during the juvenile migrations of 2006, 2007, 2008, and 2009 (hatchery-origin smolts were not PIT-tagged in 2006). Wild-origin spring Chinook tagged after the month of June are considered sub-yearling juveniles and were excluded from analyses. Descriptive statistics were generated of tagging data for both hatchery- and wild-origin smolts.

An "interrogation summary" query was submitted to obtain observation records of the fish included in the "tagging detail" query described above. The data were filtered to only include observations at the Rock Island adult fishway to identify returning fish. The year of the last observation date at Rock Island was considered the return year, and the difference between the return year and the release year was considered "ocean residence." All juvenile detections in the adult fishway that were last detected the same year as release were considered mini-jacks. Adult returns detected the year following release were considered jacks; two years following release were considered "2 salt" fish, and so forth. Data were tabulated to determine the composition of returns.

A logistic regression was used to model the probability of returning to freshwater after a particular ocean residence (the ordinal variable) as a response to fork length at tagging (the continuous variable). Results were separated by hatchery- and wild-origin smolts. The Whole Model Test was used to determine if the model fits better than constant response probabilities (analogous to the Analysis of Variance table for a continuous response model). *p* values were reported for the Chi-square test used to evaluate how well the categorical model fits the data. Results were considered significant at $p \leq 0.05$ (SAS 2009).

PitPro 4.19 was used to generate Cormack/Jolly-Seber survival estimates and harmonic mean travel time of spring Chinook from release to McNary Dam to examine relative in-river performance of smolts during the outmigration (CBR 2011; Jolly 1965; Seber 1965; Cormack 1964). Fish were initially separated by rear-type (hatchery or wild). Subsequent survival estimates and harmonic mean travel times were generated for hatchery-origin spring Chinook based on a division of fish size each year. Median fork length at tagging was determined for each year and used to divide the "small half" and "large half" subsequently used in comparisons of returns and survival. The small half had larger sample sizes since the median length was included in this group.

Rates of return (RORs) were calculated by dividing the number of PIT-tagged fish detected in the adult fishway at Rock Island Dam (i.e., returns) by the number of fish released. RORs were calculated and compared for specific ages or ocean residence, and also for all adults combined (i.e., 2-salt or greater). A pooled sampling proportion *Pooled* (i.e., for both RORs in comparisons) was calculated by:

$$Pooled = \frac{[(ROR_1 \times n_1) + (ROR_2 \times n_2)]}{(n_1 + n_2)}$$

and SE_{Pooled} was calculated by:

$$SE_{Pooled} = \sqrt{(1 - Pooled)} \times [(1/n_1) + (1/n_2)]$$

The test statistic (two-proportion z-test), *z*, was calculated as:

$$z = \frac{(ROR_1 - ROR_2)}{SE_{Pooled}}$$

The test statistic and resulting *p* value was obtained from a standard normal table. Data manipulation and descriptive and inferential statistics were performed in JMP ® 8.0.2. Results were considered significant at $p \leq 0.05$.

Results–Over 65,000 spring Chinook were PIT-tagged between 2006 and 2009, including 29,906 hatchery- and 14,142 wild-origin yearling smolts. Hatchery fish were tagged between June and August the year prior to the smolt migration; natural-origin fish were tagged between March and June during the smolt migration. Hatchery-origin smolts averaged 93.1 mm (± 0.1 mm SE) and wild-origin smolts averaged 94.0 mm (± 0.1 mm SE) in fork length. Size at tagging was similar, though wild-origin smolts are tagged 8 to 9 months later on average. Nearly 50,000 detections of these fish occurred subsequent to release, including only 346 observations of unique fish within the Rock Island Dam adult fishway.

Two hundred ninety-three (293) returns were observed in the Rock Island Dam adult fishway, including 192 hatchery-origin fish and 101 wild-origin fish. The majority of returns were 2-salt fish for both hatchery- and wild-origin fish, though hatchery-origin fish had a greater number of mini-jacks and jacks and fewer 3-salt returns. RORs, to account for varying release sizes, show that hatchery-origin fish had 24% more mini-jacks (p = 0.30), 893% more jacks ($p < 0.01$), and 33% fewer ≥ 2-salt adults ($p < 0.01$) than wild-origin fish on average (Table 1). The logistic regression indicated that fish length at tagging significantly influenced the probability of returning after a specific period of ocean residence for both hatchery- (n = 192, $P < 0.01$) and wild-origin (n = 101, $P = 0.03$) fish. The probability of returning as a mini-jack or jack increased significantly with increasing length at tagging for all fish (Figure 1).

Hatchery-origin smolts had an average estimated survival to McNary Dam of 56.6% (range 43.0-65.0%), compared to an average of 44.5% for wild-origin smolts (range 38.5-47.3%). The difference in estimated survival to McNary Dam was 27% greater on average for hatchery-origin fish, ranging from -5% to 69% over comparable years. Hatchery-origin smolts generally traveled to McNary Dam slightly faster during comparable years, though rates were comparable between groups. Estimated survival to McNary Dam was similar between the small half and large half of hatchery fish as was harmonic mean travel time. These results suggest that hatchery-origin smolts have a downstream survival advantage over wild-origin smolts, though a size advantage within hatchery-origin smolts was not observed (Table 2, Figure 2).

RORs from both the small and large half of hatchery smolts show similar rates of ≥ 2-salt fish ($p = 0.48$), with the large half returning 6% more 2-salt adults ($p = 0.38$) and 56% fewer 3-salt adults ($p = 0.11$) compared to the small half. Mini-jack and jack rates were greater in the large half: the large half produced 135% more mini-jacks ($p = 0.03$) and 194% more jacks ($p < 0.01$) compared to the small half (Table 1). The mini-jack rate for the small half was also inflated by the 2007 smolt year where the median hatchery-origin fish were over 20% larger than in 2008 and 2009; outside of 2007, no mini-jacks were observed in the small half of hatchery-origin smolts.

Even greater differences were noticed between the large half of hatchery-origin smolts and wild-origin smolts. The large half hatchery-origin fish produced on average 50% more mini-jacks ($p = 0.09$), 1,186% more jacks ($p < 0.01$), an equal number of 2-salt adults ($p = 0.41$), and 90% fewer 3-salt adults ($p < 0.01$). Generally speaking, all three groups (wild, small half, and large half) produced similar rates of 2-salt fish, whereas large half smolts produced fewer 3-salt fish, more mini-jacks, and more jacks than wild or small half smolts (Table 1). The composition of returns among these three groups demonstrate that most (88%) wild-origin smolts resulted in ≥2-salt adults over the time period observed, compared to 79% in the small half hatchery-origin smolts, and 57% in the large half hatchery-origin smolts (Figure 3).

Discussion–Our first hypothesis – that larger smolts lead to decreased age at maturity in Chiwawa River spring Chinook – is supported by these findings in both wild- and hatchery-origin fish. Neilson and Geen (1986), Scheuerell (2005), Chamberlin et al. (2011), Claiborne et al. (2011), and Tipping (2011) found similar results in Chinook, where the age of maturation decreased with increasing smolt size. Considering the importance of size at age and age at maturity in Chinook salmon (Kinnison et al. 2011), size at release may have considerable implications on the effectiveness of hatchery releases in the Chiwawa River. At a minimum, a disproportionate rate of mini-jacks and precocious males do not contribute favorably to harvest. Likewise, mini-jack and jack Chinook likely have a limited, if not negative, contribution to conservation-based supplementation efforts (Heath et al. 1994, 2002; Asbjørn Vøllestad et al. 2004; Pearsons et al. 2009; Larsen et al. 2010; Williamson et al. 2010). Our results, in combination with the observed size distribution of wild-origin Chinook and the intent to mimic the wild population for supplementation, provide evidence that a reduced target size for hatchery smolts will improve the population demographics of hatchery spring Chinook salmon in the Chiwawa River.

Our second hypothesis – that larger spring Chinook salmon smolts do not have a full life cycle survival advantage over smaller smolts – is also supported by these data. While some researchers have found smolt survival to be greater for larger smolts (e.g., Miyakoshi et al. 2001; Saloniemi et al. 2004), our results are unable to support these findings. Similar results to our study were observed in Imnaha River spring Chinook, where larger hatchery smolts (12-14 fish per pound) did not have a survival advantage over smaller smolts (20-25 fish per pound). Further, while overall smolt-to-adult survival was similar between small and large hatchery smolts, the smaller Imnaha River hatchery smolts had a significantly greater survival to Age 5 (i.e., 3-salt adults; Feldhaus et al. 2011). In either case, the rate and composition of returns – not smolt performance – is a more important metric in evaluating performance. For example, a 10% increase in smolt survival would not be beneficial if it were accompanied by a 50% increase in mini-jack rates. Therefore, supplementation programs intended to promote conservation of wild-origin stocks should focus on RORs, especially absent any evidence of a survival benefit of rearing larger smolts.

The PIT-tagged Chiwawa River spring Chinook provide a unique opportunity to compare wild- and hatchery-origin salmon. The hatchery uses wild-origin brood and resulting progeny are genetically similar to the wild-origin cohorts. In other words, the major difference between the wild- and hatchery-origin smolts is the rearing. Knudsen et al. found hatchery-origin spring Chinook matured at an earlier age just one generation removed from wild-origin cohorts and that minimizing the results of artificial rearing was difficult (2006). Larsen et al. found that changes in feeding rations can reduce mini-jack rates, creating a leaner and smaller hatchery smolt more similar to a wild counterpart (2006). Feldhaus et al. observed smaller hatchery spring Chinook smolts returning at older age classes compared to larger smolts (2011). With our results indicating that the most apparent difference between wild- and hatchery-origin fish is the age structure and associated RORs, and that the size of hatchery smolts is a predictor of these results, we recommend a reduction in the target size of the hatchery program.

While the current hatchery size target is 179 mm FL and 37.8 g (12 fish per pound), the observed lengths and weights have averaged roughly 136 mm and 32 g (~15 fish per pound) over the past five years (brood years 2004-2008; Hillman et al. 2011). Further, a length-weight relationship developed on the data used in our analyses indicate that the current size targets are not achievable (i.e., a 37.8 g smolt would be roughly 140 mm, not 179 mm). Feldhaus et al. (2011) evaluated Imnaha River hatchery spring Chinook smolts in the 18-23 g range (average weight of 21 g, 20-25 fish per pound). The Imnaha River target weights would translate to roughly a 120 mm and 22 fish per pound target in the Chiwawa Program. We recommend beginning with an intermediate size target of 126 mm and 25 g (approximately 18 fpp) and supporting continued PIT-tagging to evaluate the efficacy of this approach.

In conclusion, these results support previous findings highlighting significant differences between wild- and hatchery-origin salmon. While the disparity may be unsolvable, it is apparent that the large size targets and unnatural growth rates decrease age at maturity in Chiwawa River spring Chinook. These results further indicate that smaller hatchery smolts are more similar to wild-origin counterparts and that larger hatchery smolts may even pose a negative impact. A reduced hatchery size target could reduce some of these discrepancies, as well as provide additional benefits, such as lower rearing densities, and reduced adult management obligations.

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Table 1. Observations and rate of return of PIT-tagged Chiwawa River hatchery- and wild-origin spring Chinook in the Rock Island Dam adult fishway, release years 2006-2009.

			Ocean residence (years)				Rates of return				
Origin	**Tag year**	**PIT tags**	**0**	**1**	**2**	**3**	**Mini-jacks**	**Jacks**	**Age 2**	**Age 3**	**Adults**
Hatchery	2007	9,981	16	16	29	1	0.160%	0.160%	0.291%	0.010%	0.301%
	2008	9,894	2	14	58	10	0.020%	0.141%	0.586%	0.101%	0.687%
	2009	10,031	3	12	31	0	0.030%	0.120%	0.309%	0.000%	0.309%
	All	**29,906**	**21**	**42**	**118**	**11**	**0.070%**	**0.140%**	**0.395%**	**0.037%**	**0.431%**
Wild	2006	2,355	0	0	12	5	0.000%	0.000%	0.510%	0.212%	0.722%
	2007	2,697	2	0	2	0	0.074%	0.000%	0.074%	0.000%	0.074%
	2008	6,719	5	1	36	26	0.074%	0.015%	0.536%	0.387%	0.923%
	2009	2,374	1	1	10	0	0.042%	0.042%	0.421%	0.000%	0.421%
	All	**14,145**	**8**	**2**	**60**	**31**	**0.057%**	**0.014%**	**0.424%**	**0.219%**	**0.643%**
Hatchery (small)	2007	5,569	7	2	18	1	0.126%	0.036%	0.323%	0.018%	0.341%
	2008	5,394	0	2	30	7	0.000%	0.037%	0.556%	0.130%	0.686%
	2009	5,193	0	8	14		0.000%	0.154%	0.270%	0.000%	0.270%
	All	**16,156**	**7**	**12**	**62**	**8**	**0.043%**	**0.074%**	**0.384%**	**0.050%**	**0.433%**
Hatchery (large)	2007	4,412	9	14	11	0	0.204%	0.317%	0.249%	0.000%	0.249%
	2008	4,500	2	12	28	3	0.044%	0.267%	0.622%	0.067%	0.689%
	2009	4,838	3	4	17		0.062%	0.083%	0.351%	0.000%	0.351%
	All	**13,750**	**14**	**30**	**56**	**3**	**0.102%**	**0.218%**	**0.407%**	**0.022%**	**0.429%**

Table 2. Probability of survival and harmonic mean travel time (days) to McNary Dam of hatchery- and wild-origin spring Chinook smolts, 2006-2009.

Origin	**Tag year**	**PIT tags**	**Survival to McNary**	**SE**	**Travel to McNary (d)**
Hatchery	2007	9,981	65.0%	2.0%	28.3
	2008	9,894	61.7%	3.9%	29.0
	2009	10,031	43.0%	2.0%	30.4
	Average		**56.6%**	**2.6%**	**29.2**
Wild	2006	2,355	47.3%	3.0%	20.1
	2007	2,697	38.5%	2.2%	27.9
	2008	6,719	47.0%	2.6%	29.4
	2009	2,374	45.2%	4.6%	36.6
	Average		**44.5%**	**3.1%**	**28.5**
Hatchery (small)	2007	5,569	66.0%	2.6%	28.5
	2008	5,394	68.4%	6.1%	29.7
	2009	5,193	42.7%	2.8%	31.4
	Average		**59.0%**	**3.8%**	**29.9**
Hatchery (large)	2007	4,412	63.6%	3.1%	28.1
	2008	4,500	54.8%	4.8%	28.3
	2009	4,838	43.4%	2.8%	29.4
	Average		**53.9%**	**3.6%**	**28.6**

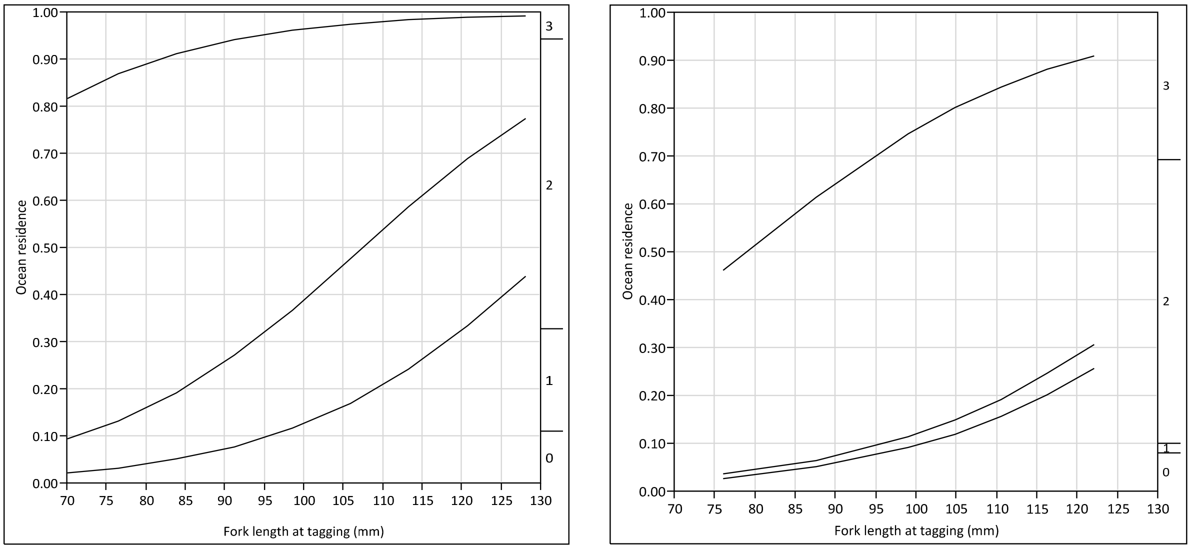

Figure 1. Logistic fit of ocean residence by fork length (mm) at time of tagging for hatchery (left) and wild-origin (right) Chiwawa River yearling spring Chinook. Whole Model Tests indicate a significant relationship for both hatchery ($P < 0.01$) and wild-origin ($P = 0.03$) fish, with an increasing probability of ocean residence = 0 (i.e., mini-jack) with increasing size at tagging.

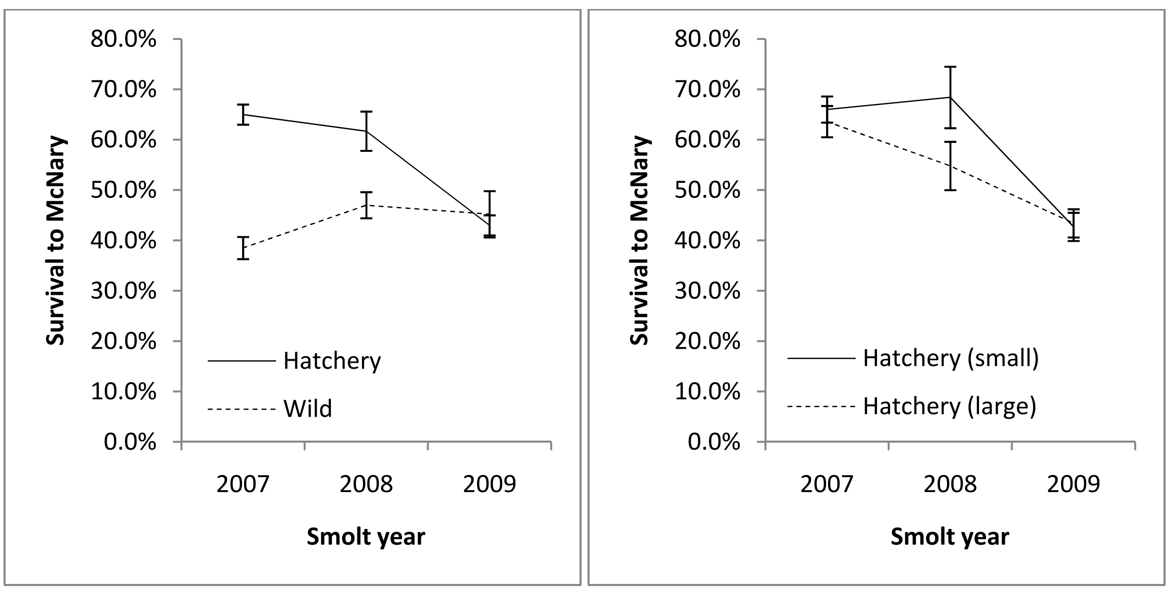

Figure 2. Estimated survival (± SE) to McNary Dam of hatchery and wild spring Chinook smolts (left), and small and larger hatchery-origin smolts (right).

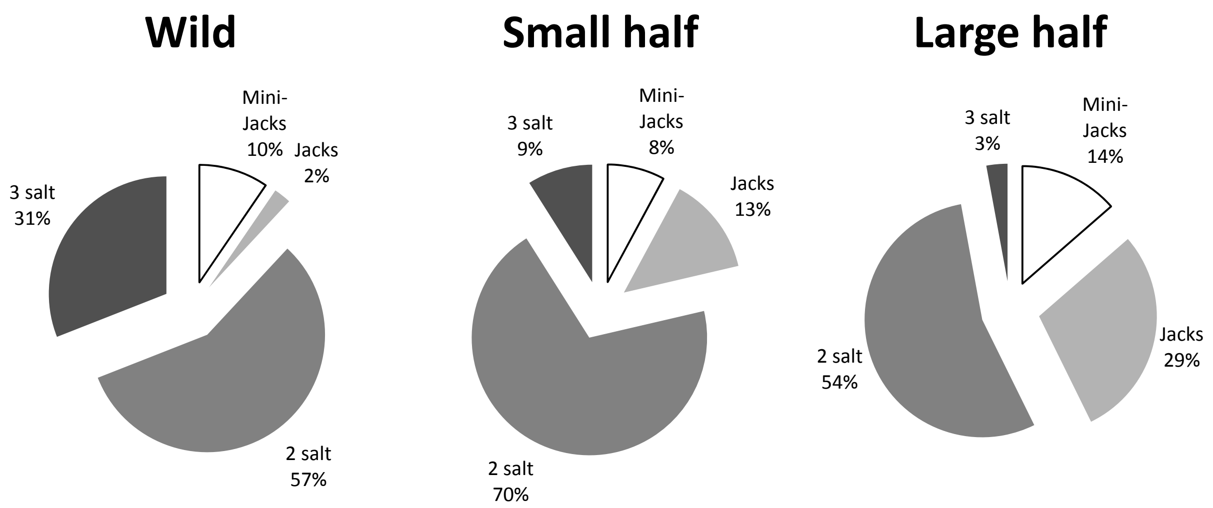

Figure 3. Distribution of returns from wild- and hatchery-origin spring Chinook smolts released in the Chiwawa River, 2007-2009. Hatchery smolts were separated by median fork length at time of tagging and returns from 2009 do not yet include 3-salt fish.

Attachment I

ANCHOR QEA

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MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCP Hatchery Committees	**Date:**	February 15, 2012
From:	Carmen Andonaegui, Anchor QEA		
Cc:	Mike Schiewe, Anchor QEA - Chair		
Re:	Summary of the conclusion of the HETT reference stream evaluation and a HETT recommendation for next steps		

In 2007, the HETT was tasked with making recommendations to the Hatchery Committees on reference/control streams for use in the Chelan PUD and Douglas PUD Hatchery Monitoring and Evaluation (M&E) programs. The HETT has developed a three-phased approach for selecting suitable reference populations for use in assessing the effects of supplementation programs on spawner abundance, recruitment, and productivity. The approach is described in a paper titled, *Methods for Identifying Reference Populations and Testing Differences in Abundance and Productivity Between Reference Populations and Supplemented Populations: Chiwawa Spring Chinook Case Study* (Hillman et al. 2011), and is included as Appendix C to Chelan PUD's and Douglas PUD's Five-Year M&E Reports. Suitable reference populations were found for spring Chinook and summer Chinook but no suitable reference populations could be identified for steelhead or sockeye, for which there is a lack of data.

Identification of appropriate references populations was challenging because the candidate populations rarely met all of the characteristics desirable. Hillman et al. 2011 describes the approach developed by the HETT, using the Chiwawa River as an example.

A qualitative sieve approach was used to identify candidate reference populations and then a quantitative approach was used to weight the most favorable reference populations. Qualitative factors included:

- Similar life-history characteristics (e.g., run timing, migration characteristics, etc.);
- No or few hatchery fish in the reference area;
- Accurate abundance estimates;

- Long time series of natural-origin abundance and productivity estimates (ranging from at least 1981 to present);
- Similar trends in freshwater habitat;
- Similar out-of-basin effects (i.e., similar migration and ocean survivals); and
- Harvest estimates for adjusting escapement estimates.

None of the candidate reference populations matched the supplemented population on all the qualitative criteria; however, some of the potential reference populations were *similar* to the supplemented population on several criteria, warranting further investigation. The HETT therefore developed a quantitative scoring method for comparing candidate reference populations to the supplemented populations using five criteria:

- The proportion of natural-origin spawners (pNOS) in the reference population for the period before supplementation (pre-pNOS);
- pNOS in the reference population for the period following supplementation (post-pNOS);
- The correlation between the reference and supplemented populations before supplementation;
- The relative difference in slopes between the reference and supplemented populations before supplementation; and
- The coefficient of variation (CV) of the ratio of supplemented to reference population before the period of supplementation.

Each selection criteria was scored from 0 to 1, with 0 being the worst possible score and 1 being the best, and these criteria were weighted. The total score for a reference population was calculated by multiplying the estimated value, which ranged from 0 to 1, by its weight. The sum of the five weighted values provided a total score, which ranged from 0 to 100. Based on several simulations, the HETT set the cut-off score for candidate reference populations at 81. That is, if the total score for a given reference population equaled or exceeded 81, the population was included as a suitable reference population. If the total score fell below 81, the population was not considered a suitable reference population.

Conclusions of the effects of supplementation on unsupplemented streams without comparison to reference populations often conflicted with conclusions based on comparisons using reference populations. This conflict demonstrated the importance of using appropriate references for evaluation of supplementation programs and demonstrated that results that do not incorporate comparisons to references should be interpreted with caution.

In 2017, the PUDs are required to produce the next 5-Year M&E Report. The HETT recommends that in the lead up to the development of the next 5-Year M&E Report, the Hatchery Committees begin considering how best to evaluate the effects of supplementation when no reference populations are available, as in the case of steelhead and sockeye. For steelhead for example, data that have only started to be collected in the recent past will be available. The HETT believes that these new data will be useful in evaluating the effect of supplementation for developing an existing condition for comparison over time to future conditions.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	April 19, 2012
From:	Mike Schiewe, Chair		
Cc:	Carmen Andonaegui		
Re:	Final Minutes of the March 28, 2012, HCP Hatchery Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at the Douglas PUD Headquarters' Auditorium in East Wenatchee, Washington, on Wednesday, March 28, 2012, from 9:30 am to 2:00 pm. Attendees are listed in Attachment A of these meeting minutes.

ACTION ITEM SUMMARY

- Josh Murauskas will confirm with Tracy Hillman, BioAnalysts, the delivery date for the Draft 2011 Hatchery Monitoring and Evaluation (M&E) Annual Report (draft M&E Annual Report) to the Hatchery Committees (Item II-B).
- Josh Murauskas will revise and finalize the Spring Chinook Size Target Statement of Agreement (SOA) as approved and email it to Carmen Andonaegui for distribution to the Hatchery Committees (Item III-C).
- Keely Murdoch will provide confirmation to Mike Tonseth that the Yakama Nation will be requesting collection of additional Wells summer Chinook broodstock in 2012 (Item IV-A).
- Comments on the Draft 2012 Broodstock Collection Protocols (Draft Protocols) are due to Mike Tonseth by April 6, 2012 (Item IV-A).
- By April 6, 2012, Keely Murdoch, in coordination with Tonseth, will model selected proportions of conservation versus safety-net Chiwawa spring Chinook program production using the 2012 production levels and evaluate the effects on Proportion Natural Influence (PNI) (Item IV-A).
- Mike Tonseth will confirm with Ken Warheit, Washington Department of Fish and Wildlife (WDFW), WDFW's support of Maureen Hess', Columbia River Inter-tribal Fish Commission (CRITFC), request to collect genetic samples for steelhead and spring Chinook (Item V-B).

STATEMENT OF AGREEMENT DECISION SUMMARY

- The Rocky Reach and Rock Island Hatchery Committees approved the Chiwawa Spring Chinook Size-at-Release Target SOA (Item III-C).

AGREEMENTS

- The Hatchery Committees decided not to assign the task of developing recommendations for multi-species acclimation to the Hatchery Evaluation Technical Team (HETT) at this time (Item V-A).
- The Hatchery Committees agreed that the Yakama Nation could use actively migrating coho and steelhead smolts from Rohlfing Pond to test smolt trap efficiency (Item V-C).

REVIEW ITEMS

- The Chelan PUD Draft 5-Year M&E Report is available for a 60-day review. Comments are due to Tracy Hillman by April 6, 2012.
- The Douglas PUD Draft 5-Year M&E Report is available for a 60-day review. Comments are due to Greg Mackey by April 27, 2012.

FINALIZED REPORTS

- Comments on the Chelan PUD 2012 Rocky Reach and Rock Island HCP Action Plan were due by March 1, 2012. Chelan PUD will finalize the Action Plan and email it to Carmen Andonaegui for distribution to the Hatchery Committees.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. The following agenda items were added:

- Keely Murdoch added an update on Nason Creek steelhead trapping.
- Greg Mackey added a request to change the submittal date of the Douglas PUD draft 2011 M&E Annual Report to the Hatchery Committees from June 1 to September 1, 2012.

The draft February 15, 2012, meeting minutes were reviewed and approved as revised. Carmen Andonaegui will finalize the meeting minutes and distribute them to the Committees.

II. Douglas PUD

A. Methow Steelhead Safety-Net Broodstock Collection for Spring of 2012 (Greg Mackey)

Greg Mackey updated the Hatchery Committees that measures for early implementation of the Wells steelhead HGMP for the Methow safety-net program had been proposed and considered during discussions with WDFW, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) and added to the Committees' March 28, 2012, meeting agenda for discussion. The proposed measures would have used hatchery-origin steelhead captured at the Twisp Weir for broodstock in spring 2012. However, fisheries managers later realized that there were already hatchery-by-wild (HxW) steelhead crosses available at the Wells Hatchery for this program, and implementing the Twisp hatchery-origin broodstock collections would have meant surplusing wild progeny or broodstock already on station.Therefore, the proposed action was found to be inappropriate for this brood year.

B. Draft HCP Hatchery M&E Annual Report Submittal Date (Greg Mackey)

Greg Mackey said that Douglas PUD was requesting approval to submit the draft 2011 HCP Hatchery M&E Annual Report for the Hatchery Committees' review no later than September 1, 2012, to accommodate a schedule change requested by Charlie Snow, WDFW. Mackey said that the September 1 submittal date would allow WDFW more time to complete analyses and incorporate the results into the draft M&E Annual Report. Mike Schiewe said that the original June 1 date was initially set to meet the required submittal date to the National Marine Fisheries Service (NMFS). He said that he had confirmed with Craig Busack, NMFS, that permanently changing the draft submission date to the Committees to September 1 would be acceptable. Schiewe asked Mackey if he wanted to permanently change the due date for submitting draft M&E Annual Reports to the Committees for review. Mackey said that he was only asking for a change for 2012, but that the current and future implementation plans would use the July 1 date for submittal of a draft annual Hatchery M&E report to Douglas PUD, with a September 1 delivery to the Committees. The Committees' members approved the change. Josh Murauskas will confirm with Tracy Hillman, BioAnalysts, the delivery date for the Chelan PUD draft HCP Hatchery M&E Annual Report to the Committees.

III. Chelan PUD

A. Updates to PUD Hatchery Programs M&E (Josh Murauskas)

Josh Murauskas suggested that with completion of the 5-Year M&E Report that the Hatchery Committees begin to review Hatchery M&E objectives, methods, and results, and determine whether program changes are needed. He said that Chelan PUD planned to provide recommended changes to the Committees in the near future. Greg Mackey said that a formal adaptive management framework document to guide decisions based on M&E results would be helpful. Murauskas agreed.

B. Dryden Overwintering Site Feasibility (Josh Murauskas)

Josh Murauskas said that at the January Hatchery Committees' meeting, Alene Underwood, Chelan PUD, reported on the initial results of Chelan PUD's facilities evaluation at Dryden in support of overwintering juvenile summer Chinook. Overwintering was proposed by the Joint Fisheries Parties (JFP) as an alternative acclimation method to improve smolt-to-adult returns (SARs) and to reduce straying. Murauskas introduced an alternative approach using the water re-use facilities at East Bank Hatchery for overwinter rearing, with spring acclimation at Dryden to achieve the same goals (Attachment B). He suggested that reducing size-at-release targets would also contribute to improved SARs and reduced stray rates by reducing mini-jack and jack rates. Murauskas said that Chelan PUD is concerned that the JFP have not adequately considered risks to smolt production associated with overwinter acclimation at the Dryden Facility, and Chelan PUD would need assurances from the JFP that facility modifications would indeed improve performance of hatchery smolts, therefore eliminating risks associated with modifying the facility without empirical data.

Keely Murdoch said that the general conclusion of the JFP is that overwintering improves adult returns. She said that if there were to be an opposite result, having modified the Dryden Facility to accommodate overwinter rearing would not preclude using it for spring acclimation. Murauskas asked what data were used in developing the conclusion by the JFP that overwintering improves adult returns. He reminded the HC that the report authored by JFP members indicated that a nearly 3-fold increase in SARs was observed in previous comparisons between over-winter and spring acclimation. Kirk Truscott suggested that an SOA could be drafted to include language that would provide assurances to Chelan PUD and Grant PUD (who would also be using Dryden summer/fall Chinook production to meet requirement in their Settlement Agreement).

Murauskas questioned whether overwintering would adequately reduce straying, saying that stray rates tended to be greater in younger adults, which, in turn are negatively correlated with size-at-release. In his presentation, Murauskas provided the results of his analysis of summer Chinook initially reared using water re-use, followed by spring acclimation at Dryden. Initial results suggested that the jack rate of spring-acclimated Dryden summer Chinook reared using the water re-use facility at Eastbank was up to 37 percent lower than that of to conventional raceway-reared fish. These data suggested that a smaller size-at-release would reduce jack and minijack rates, further reducing the stray rate. Muruaskas said that these results suggested there were alternative approaches to improving SARs and reducting stray rates. Results also indicated that adult returns were up to 74 percent greater and mini-jack rates were nearly half in re-use compared to raceway smolts.

Mike Tonseth said that the primary risk he sees from overwinter acclimation is related to disease. He said that he had long been an advocate of having an independent water supply for the Dryden Facility rather than using irrigation water from the canal. Mike Schiewe suggested that the Committees should first identify the goals for the Wenatchee summer/fall Chinook program (e.g., target SARs and stray rates) and then consider the available evidence supporting which acclimation alternative/rearing protocol would best meet those goals. Murdoch identified the development of a dedicated water source at the Dryden Facility as an important benefit of upgrading the facility for overwintering acclimation and said that developing a dedicated water source at the site would be important no matter which alternative was preferred.

Schiewe asked about the timing of Dryden improvements and hence the urgency of making a decision about rearing and acclimation alternatives. Tonseth said that the Grant PUD Priest Rapids Coordinating Committee (PRCC) Habitat Subcommittee (HSC) was already working on a Basis of Design for modifying the Dryden Facility for overwinter acclimation and that they had scheduled a pre-application meeting with Chelan County for discussing construction activities. Permit submission is scheduled for May 2012. Currently Chelan PUD has a Hatchery Sharing Agreement with Grant PUD to place Grant PUD juveniles at the Dryden Facility if surplus capacity is available. Tonseth said that he sees two pieces to the discussion of feasibility of overwintering at Dryden: 1) operation of the facility for acclimation (reuse, overwintering, etc.); and, 2) whether Chelan PUD can support Grant PUD making facility improvements at Dryden for acclimation whether re-use or overwintering. Each carries a different risk, and he asked that the two discussions be conducted separately. Schiewe recommended that Chelan PUD proceed with development of an analysis and a presentation for their preferred acclimation alternative, both in terms of the biological benefit and in terms of the costs and benefits of implementing a facility upgrade.

Tonseth noted that SARs for current Chelan PUD programs were exceeding the baseline target SARs in the Hatchery and Genetic Management Plans (HGMPs). He suggested that program goals would need to be revised to reflect observed SARs based upon periodic review of M&E data.

C. Status of the Chiwawa Spring Chinook Size-at-Release Target SOA (Josh Murauskas)

Josh Murauskas said that he emailed the revised Chiwawa Spring Chinook Size-at-Release Target SOA on March 26, 2012, to Carmen Andonaegui for distribution to the Hatchery Committees. He summarized the revisions to the SOA as agreed to at the February 15, 2012, meeting and asked if Committees members found the revisions acceptable. There were no objections. The SOA was approved, as revised. Kirk Truscott pointed out an editorial error in the "Statement" section. Murauskas will correct the error and email the revised and approved SOA to Andonaegui for distribution to the Committees.

IV. WDFW

A. Draft 2012 Broodstock Collection Protocols (Mike Tonseth)

Mike Tonseth provided highlights of the Draft Protocols, asking that comments from Hatchery Committees members be provided to him by email in track changes no later than April 6, 2012 (Attachment C). The Final 2012 Broodstock Collection Protocols are due to NMFS by April 15, 2012.

The changes highlighted by Tonseth were captured in the Draft Protocols. Kirk Truscott asked whether there would be a start date for steelhead adult collections at Tumwater Dam (TWD). Tonseth estimated August 2012. Keely Murdoch said that broodstock collection priorities should be identified and listed in the Draft Protocols in case not enough adults are available at the preferred location. For example, Murdoch asked if WDFW would backfill natural-origin steelhead broodstock with hatchery-origin adults if not enough natural-origin adults were available at TWD. Tonseth said that he did not anticipate a lack of natural-origin adults at TWD but agreed that a discussion was needed. He also cautioned that their Endangered Species Act (ESA) Take Permit defined the limits of what could be done regarding activities that have the potential to affect ESA-listed salmonid species. Truscott agreed that it would be good to have a list of broodstock collection priorities in case there was a need to backfill. Tonseth said that he would add a prioritized broodstock collection list to the Draft Protocols. Tonseth said that he would correct the eleventh bullet in the Draft Protocols to say that collection of adult steelhead at the Twisp Weir will occur in spring 2013, not 2012 as indicated. He said that the Committees would need to approve the collection of additional Wells summer Chinook in support of the U.S. Fish and Wildlife Service (USFWS) and Yakama Nation programs, both of which were approved for 2011. Murdoch will confirm whether the Yakama Nation will request additional Wells summer Chinook in 2012.

Murdoch questioned the 50/50 split between conservation and safety-net smolt production in 2012 for the Chiwawa spring Chinook program (Table 8 on page 12 of Draft Protocols). She said that when modeling the effects of varying proportions of conservation versus safety-net smolt production on PNI goals, a total program production level of 300,000 fish was used. Murdoch said that effects on PNI of various splits at the 2012 program production level of 204,452 should to be modeled. Tonseth said that the 50/50 split between conservation and safety-net production is a placeholder only. Murdoch said that there are also marking implications to consider when planning a program with both conservation and safety-net production. Conservation fish would need to be marked differently so that they could be differentiated during potential harvest of safety-net fish. Tonseth said that there needs to be a path forward for resolving Murdoch's concerns consistent with the April 15, 2012, due date to NMFS. Murdoch recommended that the proportion of conservation production be kept at 150,000 as originally modeled, because producing 150,000 smolts for conservation production was the number of smolts that achieved modeled PNI goals. Murdoch said that without revisiting the modeling she was unsure whether the production of only 102,000 conservation smolts would achieve the goals identified in the Wenatchee Spring Chinook Management Plan, which is included as an addendum to the draft Wenatchee Spring Chinook HGMP submitted to NMFS. She said that the order of priority for production in meeting conservation versus safety-net program goals was developed during earlier JFP planning efforts. Tonseth said that adult management needs have to be considered in the context of achieving PNI goals. In coordination with Tonseth, and using the 2012 production levels, Murdoch will re-run the models with varying proportions of conservation versus safety-net program production to evaluate the effects on PNI goals. Murdoch said that she had similar questions about the split for steelhead production.

Murdoch said that she had heard that WDFW and Douglas PUD were considering discontinuing the use of the Chewuch acclimation site. Tonseth said there had been discussions during HGMP meetings with NMFS, WDFW, USFWS and Douglas PUD regarding whether or not to discontinue use of the Chewuch acclimation site but that a change to the management plan had not been developed yet, and that the Draft Protocols do not include or exclude the use of the Chewuch acclimation site for the MetComp production. Murdoch said that the Chewuch acclimation site was identified for acclimation in the *US v OR* forum.

Mike Schiewe said that if there are suggestions for substantive changes to the Draft Protocols, Tonseth could notify him and a Committees' conference call could be convened to review changes.

V. Yakama Nation

A. Multi-species Acclimation Task – Request to the HETT from the Hatchery Committees (Keely Murdoch)

As requested at the February 15, 2012, Hatchery Committees meeting, Keely Murdoch said that she had drafted a memorandum from the Committees to the HETT assigning them the task of developing recommendations regarding the use of temporary natural acclimation sites (Attachment D). She said that the draft memorandum had been distributed to the Committees on March 13, 2012. Murdoch asked for the Committees' approval to forward the request to the HETT. Josh Murauskas asked for discussion on whether the HETT has time to complete the task. Murdoch said that she thought the task would take the HETT a few meetings to complete with the product being an acclimation plan. She said that she would like the task addressed by the HETT or addressed by a different workgroup if the Committees do not want this sent to the HETT.

Mike Tonseth said that he had concerns with developing an acclimation plan in the face of upcoming major reductions in hatchery production following NNI recalculation and uncertainties associated with addressing some of the results of the 5-Year M&E Report. Murdoch said that the development of an acclimation plan would only be for the purpose of determining whether different and/or additional acclimation sites were needed. Tonseth said that he did not think it was appropriate for the HETT to develop an acclimation plan. Mike Schiewe reminded the Committees that HETT would only be developing a recommendation, and that all decision authority was the responsibility of the full Committees. Murdoch reiterated that the Yakama Nation would like to define the role multi-species natural acclimation sites play in the hatchery programs and to identify where acclimation sites are needed. Murdoch explained that the HETT was still working on completing Non-Target Taxa of Concern (NTTOC) risk assessment model runs but that those efforts occurred outside the HETT meetings so it would be a good time for the HETT to take on this task.

Greg Mackey said that the new HGMPs are specific about where fish are raised and released, but that the HGMPs also include options and flexibility based on M&E results. Mackey said that with hatchery programs being reduced 40 to 60 percent starting in 2012, there was a need to wait and allow time to look at outcomes after new production levels have been implemented. He said that when data are available, issues such as spatial distribution of spawners and proportion of effective hatchery-origin spawners (pHOS) could be addressed.

Mackey noted that the draft HGMPs did not use recalculated production levels, because they had been developed prior to completion of recalculation. He said that population dynamics and genetics should be considered as part of an acclimation plan. Tom Kahler said that a lot of information will be needed to evaluate the effects of location of an acclimation site on hatchery program goals and on target and non-target species. Murdoch said that the idea behind tasking the HETT with evaluating available data and making recommendations to the Committees was that each HETT member will pull together data from their respective organizations and bring it to the table and collaboratively develop recommendations. For example, she said that the HETT might identify acclimation needs based on identification of a disproportionate spawning distribution of wild and hatchery fish. Kahler countered that responding to a disproportionate spawning distribution of wild and hatchery fish by extending spawning until both are spatially proportional would only be a "need" if you believed that spawning distribution for wild and hatchery fish should be proportional. Therefore, the decisions on the applicability of dispersed acclimation were of a management nature rather than technical, and thus more appropriately the purview of the Hatchery Committee rather than the HETT. Murdoch noted that if an objective of the hatchery M&E program was to supplement wild spawners, then extending hatchery spawning proportional to wild spawners would be a program need. Mackey said that this type of analysis was included in the 5-Year M&E Reports and should be reviewed. Kirk Truscott agreed with Mackey that the 5-Year M&E evaluation needed to be reviewed to see how the results could help inform to what extent program objectives were being met. If program objectives were not being met, and the effects of not meeting those objectives were biologically significant, then Truscott suggested that the Committees needed to determine if additional scientific information was needed, different M&E protocols were needed, or if program changes were in order. Truscott said that the degree of integration of a given hatchery program needed to be considered when evaluating the success of a hatchery program in that it would have bearing on how many hatchery fish should be integrated into a breeding program and how far up to expand spawning.

Schiewe summarized that there were a couple of issues being considered: 1) Murdoch's request to identify, in a collaborative manner, acclimation site locations and numbers of fish to acclimate at each site; and 2) the extent to which this task is technical or more a management issue. Schiewe said that each year the Committees had agreed to Yakama Nation requests for hatchery fish for their multi-species acclimation sites and asked if the Committees had any problem in the short-term with meeting these Yakama Nation annual requests, or if the Committees felt that the issue needed to be addressed on more than an annual basis. Truscott agreed that it was important for program managers to be able to have certainty that comes with a long-term plan approved by the Committees. Tonseth asked if with the more focused effort in the Upper Columbia Region to use multi-species acclimation, whether NMFS felt that this will affect their ability to conduct consultations on these programs when multi-species acclimation or alternative acclimation sites are only foot notes in the HGMPs or presented as unspecified potential alternatives that may be employed if needed. Craig Busack said that the permits can be written to allow for minor adjustments to the program as long as the rationale for the changes are science based. Tonseth said that much discussion had evolved around the abundance of hatchery fish on spawning grounds and that expanding hatchery spawning into areas where there are no means to control adult returns may be problematic. Busack agreed that NMFS had concerns about too many hatchery fish on spawning grounds and that programs were currently designed to take advantage of an ability to manage adults. He said that where the ability to manage returning adults exists, expanding spawning may be appropriate. Busack asked that NMFS be allowed to complete their consultation on the Methow hatchery programs before being asked to considering expanding spawning. Mackey reiterated that existing data and analysis needed to be considered and reviewed prior to making recommendations on program changes. Busack agreed that a structured review of the 5-Year M&E Reports' results should be part of determining whether spawning needed to be expanded.

Schiewe summarized by saying that he is hearing that Committees' members believe that with the new 5-Year M&E Reports' results available, with new hatchery program sizes, and with pending consultations on the HGMPs, there is a need to move forward more slowly with developing an acclimation plan, allowing time to see how the newly sized programs and possible program adjustments might affect meeting program objectives. Additionally, he said, NMFS was saying that they would design permits with the option for adaptive management. The Committees decided not to assign the task of developing recommendations for multi-species acclimation to the HETT at this time.

B. CRITFC Proposal for Participation in the Collection of Hatchery Steelhead and Chinook Genetic Samples (Keely Murdoch)

Keely Murdoch said that as requested at the February 15, 2012, Hatchery Committees' meeting, Maureen Hess, CRITFC, had prepared a proposal for the Committees requesting their participation in the collection of hatchery steelhead and Chinook genetic samples (Attachment E). Hess is asking that genetic samples be collected (CRITFC will supply

Whatman sheets for the collections where needed) for the spawning year 2012, including at a minimum the spawn date and gender for each tissue sample for the programs listed in the request.

Mike Tonseth said that WDFW was already collecting DNA samples for spring Chinook and steelhead for 100 percent of the broodstock collected for Douglas PUD and Chelan PUD hatchery programs, leaving only summer Chinook unsampled. Tonseth said the genetic samples were placed in alcohol for the Douglas PUD programs and that for the Chelan PUD programs, samples were placed on blotter sheets for spring Chinook and in alcohol for steelhead. Tonseth said that he needed clarification from Ken Warheit, WDFW, before agreeing to the request but that he saw no problem with collecting genetic samples because this was already being done. Greg Mackey agreed for Douglas PUD, but said that he would need to check on the status of summer Chinook sampling. Josh Muruaskas said that if the fisheries co-managers wanted genetic samples collected, Chelan PUD saw no problem with it. Those Committees' members present were generally supportive of Hess' request. Tonseth will speak with Warheit and confirm with Mike Schiewe that WDFW also is supportive of the request.

C. Rohlfing Pond Steelhead Trap (Keely Murdoch)

Keely Murdoch said that more fish were needed for smolt-trap efficiency trails for the Nason Creek steelhead smolt trap than were available instream at this time. She said that the Yakama Nation would like to use actively migrating coho and steelhead from Rohlfing Pond, where coho and steelhead juveniles are being co-mingled for acclimation. The plan would be to net fish that are coming out of Rohlfing Pond each night. Murdoch said that they are trying to target specific flows for the efficiency trails, so timing of the tests would depend on flows. She said that all steelhead would be scanned for passive integrated transponder (PIT) tags and that all fish captured coming out of Rohlfing Pond would be PIT-tagged. Murdoch said that the release site for the efficiency trails was approximately 1 mile upstream from the trap. She said that for the efficiency trials they would be using standard PIT-tagging protocols used both in the Wenatchee and Methow subbasins, with a goal of 100 fish per trail. Murdoch said that the protocol is the same as that used for spring Chinook in the White River. The Hatchery Committees discussed the reliability of efficiency tests given the possible biases introduced by tag shedding, handling and holding effects, and the number of fish for each test. Committees' members agreed to support the proposal.

VI. NMFS

A. HGMP Update (Craig Busack)

Craig Busack reported that NMFS had hired a new biologist to assist with processing HGMPs; however, the staff person, James Dixon, would not likely be on-board until April 23, 2012. Busack said that Dixon would begin by helping to complete consultations which have already been started for the Upper Columbia and Snake River fall Chinook rather than starting new consultations. He said that NMFS continued to have discussions regarding Wenatchee Hatchery programs with a focus on completing the National Environmental Policy Act (NEPA) process. Busack said that NMFS had also been discussing Methow hatchery programs with the hatchery operators and that NMFS had been keeping Steve Parker, Yakama Nation, apprised of these discussions, including following up with Parker on discussions begun at an earlier meeting regarding potential sites for weirs in the Methow basin.

VII. HETT Update

Carmen Andonaegui reported that the HETT had decided to limit modeling of NTTOC/hatchery program interactions to a subset of all possible interactions to reduce the level of effort and time to completion of the NTTOC risk assessment. The subset would include only hatchery programs that are representative of certain types of interactions that may occur and that were necessary to model in order for the analysis to remain robust. She said that the HETT would continue to complete the model runs. Andonaegui said that timing-to-completion of the NTTOC risk assessment was a function of the level of participation and the amount of time HETT members had to commit to HETT tasks.

The Hatchery Committees discussed the level of participation by Committees' members. Kirk Truscott said that he did not anticipate being able to start model runs any time soon.

Josh Murauskas questioned the utility of Chelan PUD's participation in the NTTOC risk assessment. Keely Murdoch said that the NTTOC risk assessment was a Regional Objective (Objective 10) for monitoring and evaluation of PUDs' hatchery programs. Mike Schiewe asked Murauskas for a recommendation for an alternative approach to addressing Objective 10; he asked whether Truscott disagreed that the NTTOC should be a regional objective. Truscott responded that he considered Objective 10 as the lowest priority M&E objective. He said that he had not envisioned each Committees' member having to conduct model runs, but did anticipate having to provide data for use in the assessment, which he had provided. Schiewe said that because the NTTOC risk assessment is an M&E objective, it needs to be addressed by either using the current approach or by an alternative method agreed to by the Committees.

Greg Mackey said that Douglas PUD intended to meet their obligation to assess NTTOC risk from hatchery programs but that what might be done with the results would be a fisheries management issue. However, he said he does not see addressing risks to NTTOC as taking precedence over ESA species management. He said that if Chelan PUD and the Colville Confederated Tribes (CCT) were not able to participate in the assessment there would be missing data for portions of the Wenatchee subbasin not covered by USFWS or Yakama Nation hatchery programs, for the mainstem Columbia River, and for the Okanogan subbasin. Schiewe said that unless there were an alternate proposal agreed to by the Committees, all Parties should plan to participate in the completion of this exercise.

VIII. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees meetings are April 18 (Chelan PUD office), May 16 (Douglas PUD office), and June 20, 2012 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees

Attachment B – Chelan PUD PowerPoint Presentation on the Feasibility of Overwinter Acclimation at Dryden Ponds

Attachment C – 2012 draft Broodstock Collection Protocols

Attachment D – Multi-species Acclimation HETT Request

Attachment E – CRITFC Proposal to Participate in Collecting Genetic Samples for Hatchery Steelhead and Chinook

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Keely Murdoch*	Yakama Nation
Kirk Truscott*	CCT
Craig Busack*†	NMFS
Mike Tonseth*	WDFW
Todd Pearsons	Grant PUD

Notes:

* Denotes Hatchery Committees member or alternate

†Joined by phone

Attachment B

Feasibility of Overwinter Acclimation at Dryden Ponds

J. Murauskas
Natural Resources Dept.
Chelan County PUD
March 28th, 2012

Introduction

- Construction of a new facility to accommodate overwinter acclimation has been proposed by the JFP at Dryden Ponds

- The construction of the facility is intended to:
  - (1) improve SARs
  - (2) reduce stray rates

Background

- Analysis conducted by WDFW indicated that overwintered fish had stray rates 47% and SARs 329% of those observed in spring-acclimated fish

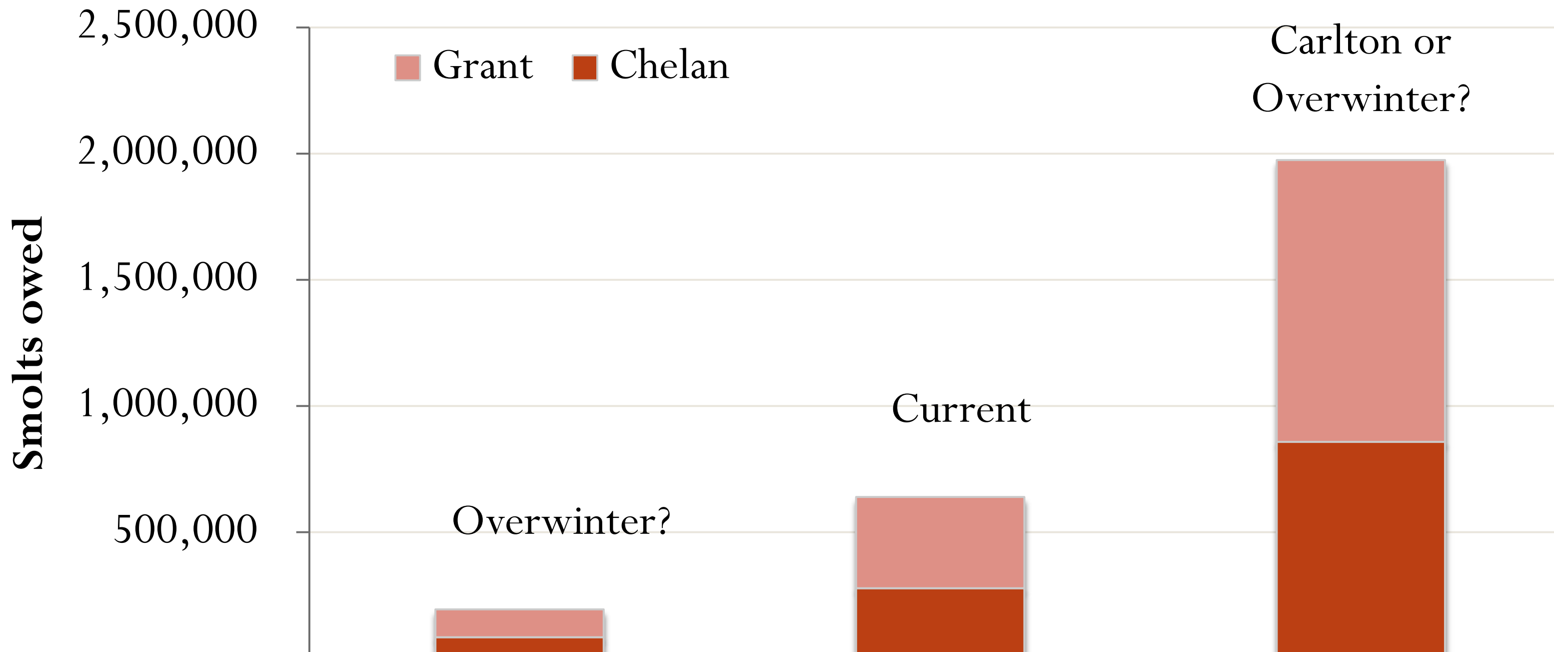
- Dryden stray rates (11%) and SARs (0.632%) would change to 5% and 2.081%, respectively, if ratios held true to DFW analysis (with 10.4% less project mortality)

Risks of Overwintering (by DFW)

- Increased exposure to disease
- Weather (e.g., frazzle ice)
- Inability to reach size targets
  - Increased mini-jacks or jacks because of feed schedule
- Increased precocity
  - Competition
  - Predation
  - Disease
  - Lower SARs
- Not meeting goals and increasing obligations

Attachment B

Effect of SARs on Dryden



	2.08%	0.63%	0.21%
Grant	109,994	362,180	1,116,573
Chelan	84,556	278,421	858,351

SAR

* Represents <u>only</u> wild-origin mitigation

Rocky Reach and Rock Island HCPs

- Section 8.6 and facility modifications: "…*the existing facility as modified is compatible with and does not compromise ongoing programs*"

- Chelan PUD must consider risks involved with reconstructing HCP facilities with undefined outcomes

- Use of the scientific approach or receive assurance from JFP before jeopardizing HCP facilities

Alternative approaches

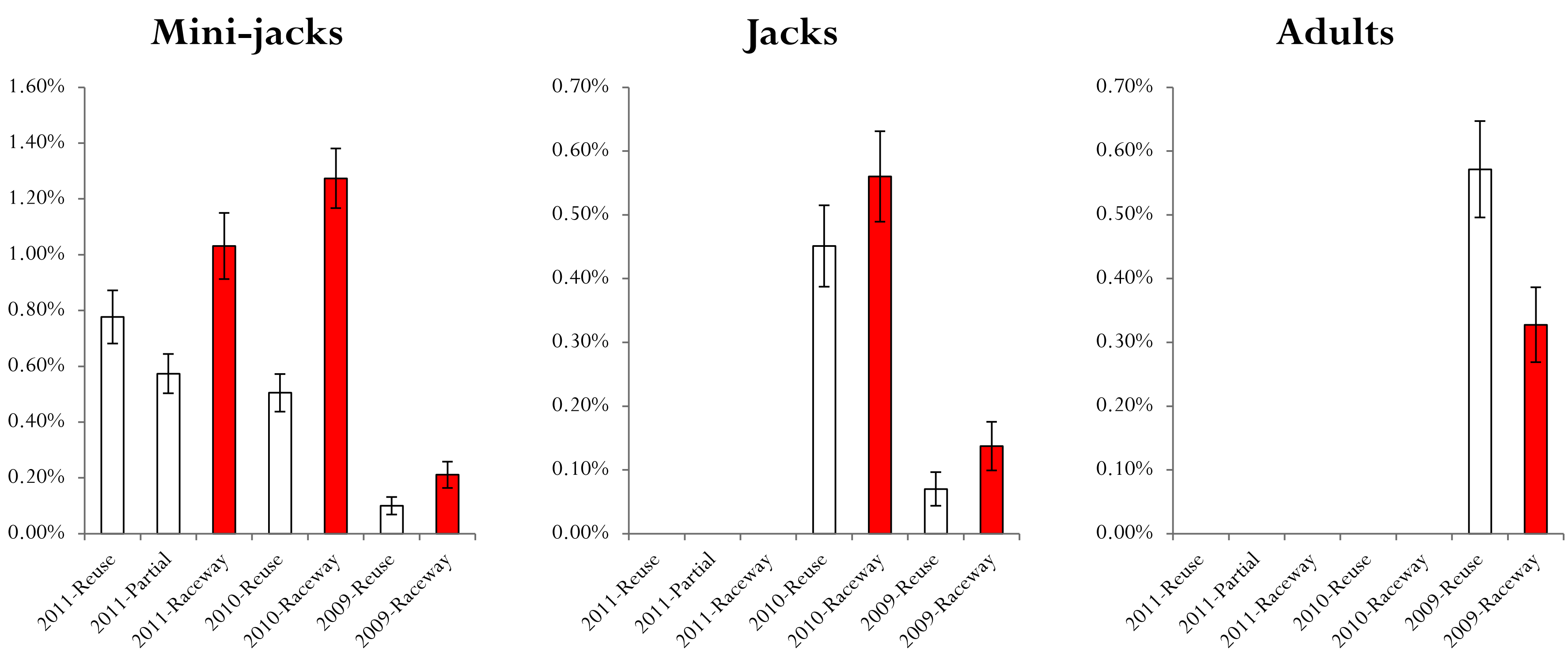
- Set program goals (BAMP = 0.3% SAR)

- Re-use technology
  - Greater smolt survival
  - Faster travel time
  - Greater SARs
  - Fewer Age-2 and -3 returns
  - Fewer strays

- Potential test scenarios
  - Control/test at Similkameen
  - Control/test at Dryden

Attachment B

Survival of re-use vs. raceway



Survival of re-use vs. raceway

- **Mini-jacks**
  - 0.46% vs. 0.84% (**182% greater in raceway**)
- **Jacks**
  - 0.17% vs. 0.23% (**134% greater in raceway**)
- **Adults**
  - 0.19% vs. 0.11% (**174% greater in re-use**)
  - Only 2-salt fish available

- Results based on large size-at-release targets
  - Could be further improved

Summer jacks and straying?

- 26.4% of Dryden-origin jacks stray

- Up to 49% reduction in jacks observed with re-use
  - Without adjusting size target
- Up to 37% of summer Chinook over RIS are jacks

- Reduction in jack rate could therefore decrease stray rates
  - Return in 2000 [37% jacks] = 10% stray due to jacks alone;
  - 49% reduction [19% jacks] = 5% stray due to jacks alone;
  - Hatchery production creates majority of jacks

Summary

- Chelan’s feasibility of facility modifications at Dryden include:
  - Rigorous scientific analyses for informed decisions
  - Stepwise approaches to improve program performance
  - Assurance that modifications do not jeopardize the program

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March 23, 2012

To: HCP-HC and PRCC-HSC committee members

From: Mike Tonseth, WDFW

Subject: **DRAFT 2012 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS**

The attached protocol was developed for hatchery programs rearing spring Chinook salmon, sockeye salmon, summer Chinook salmon and summer steelhead associated with the mid-Columbia HCPs, spring Chinook salmon and steelhead programs associated with the 2008 Biological Opinion for the Priest Rapids Hydroelectric Project (FERC No. 2114) and fall Chinook consistent with Grant County Public Utility District and Federal mitigation obligations associated with Priest Rapids and John Day dams (ACOE funded), respectively. These programs are funded by Chelan, Douglas, and Grant County Public Utility Districts (PUDs) and are operated by the Washington Department of Fish and Wildlife (WDFW). Additionally, the Yakama Nation's (YN) Coho Reintroduction Program broodstock collection protocol, when provided by the YN, will be included in this protocol due to the overlap in trapping dates and locations.

This protocol is intended to be a guide for 2012 collection of salmon and steelhead broodstocks in the Methow, Okanogan, Wenatchee, and Columbia River basins. It is consistent with previously defined program objectives such as program operational intent (i.e., conservation and/or harvest augmentation), mitigation production levels (HCPs, Priest Rapids Dam 2008 Biological Opinion), changes to programs as approved by the HCP-HC, and to comply with ESA permit provisions.

Notable in this years protocols are:

- No sockeye in 2012.
- No age-3 males will be incorporated into spring or summer Chinook programs
- All NNI programs will have reductions in adult collection requirements due to re-calculation of NNI impacts per HCP's and Settlement Agreements.
- Implementation of the draft Production Management Plan (Appendix B), for all programs where possible, to ensure mitigation production levels are met and that the permitted production ceiling is not exceeded at release.

- Utilization of genetic sampling/assessment to differentiate Twisp River and non-Twisp River natural-origin spring Chinook adults collected at Wells Dam, and CWT interrogation during spawning of hatchery spring Chinook collected at the Twisp Weir, Methow FH and Winthrop NFH to differentiate Twisp and Methow Composite hatchery fish for discrete management of Twisp and Methow Composite production components.

- The collection of hatchery-origin spring Chinook for the Methow River Basin program in excess of production requirements, for BKD management.

- A smolt production target for the Chiwawa program in 2012 (2014 release) of 204,452 smolts (144,026 for Wenatchee basin mitigation and a one year agreement to produce CPUD's Methow obligation of 60,516 smolts).

- Targeted collection of 100% of the Wenatchee summer Chinook and Wenatchee hatchery origin steelhead broodstock at Dryden Dam to reduce the number of activities that may contribute to delays in fish passage at Tumwater Dam (some adult collections at Tumwater may be necessary if sufficient adults cannot be acquired at Dryden Dam).

- Targeted collection of 100% of the natural origin steelhead broodstock at Tumwater Dam

- Collection of summer Chinook broodstock from the Wells Hatchery volunteer channel, sufficient to meet a 576K yearling juvenile Chelan Falls program. For 2012 the adults will be transferred to Eastbank FH.

- Collection of 24-natural origin steelhead at the Twisp Weir in spring 2012. Adults will be transferred to Methow Hatchery for spawning and biosecure, isolated incubation through the eyed-egg stage after which they will be moved to Wells FH for the remainder of rearing. The collection of adults will occur in spring of 2013.

- Collection of surplus hatchery origin steelhead from the Twisp Weir (up to 25% of the required broodstock) to produce the 100K Methow on-station-released smolts (up to 13 adults). The remainder of the broodstock (37) will be WNFH returns collected at WNFH and surplus to the WNFH program needs. The collection of adults will occur in spring of 2013.

- The collection of natural-origin summer Chinook adults for the 2012 BY Okanogan summer Chinook program in the Wells Reservoir via purse seine (approximately 112 fish). Adults collected for the DC portion of the Okanogan summer Chinook mitigation (26 adults) will be transferred, spawned, incubated, and early reared at Wells FH.

- The collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the USFWS, Entiat NFH summer Chinook programs (requires agreement of the HCP Hatchery Committee [HC]).

- The collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the Yakama Nation (YN) summer Chinook re-introduction program in the Yakima River Basin (requires agreement of the HCP HC). Transfer will occur as gametes.

- Active integration of integrated fall Chinook programs utilizing adults collected at Priest Rapids volunteer channel and/or Priest Rapids Dam OLAFT.

These protocols may be adjusted in-season, based on actual run monitoring at mainstem dams and/or other sampling locations. Additional adaptive management actions as they relate to broodstock objectives may be implemented as determined by the HCP-HC or PRCC-HSC and within the boundaries of applicable permits.

Above Wells Dam

Spring Chinook

Inclusion of natural-origin fish in the broodstock will be a priority, with natural-origin fish specifically being targeted. Collections of natural-origin fish will not exceed 33% of the MetComp and Twisp natural-origin run escapement to maximize natural origin fish on the spawning grounds.

To facilitate BKD management, comply with ESA Section 10 permit take provisions, and to meet programmed production, hatchery-origin spring Chinook will be collected in numbers excess to program production requirements. Based on historical Methow FH spring Chinook ELISA levels above 0.12, the hatchery origin spring Chinook broodstock collection will include hatchery origin spring Chinook in excess to broodstock requirements by approximately 19.4%. For purposes of BKD management and to comply with maximum production levels and other take provisions specified in ESA Section 10 permit 1196, culling will include the destruction of eggs from hatchery-origin females with ELISA levels greater than 0.12 and/or that number of hatchery origin eggs required to maintain production at 223,765 yearling smolts. Culling of eggs from natural-origin females will not occur unless their ELISA levels are determined by WDFW Fish Health to be a substantial risk to the program. Progeny of natural-origin females, with ELISA levels greater than 0.12, will be differentially tagged for evaluation purposes. Annual monitoring and evaluation of the prevalence and level of BKD and the efficacy of culling in returning hatchery- and natural-origin spring Chinook will continue and will be reported in the annual monitoring and evaluation report for this program.

Recent WDFW genetic assessment of natural-origin Methow spring Chinook (Small et al. 2007) indicated that Twisp natural-origin spring Chinook can be distinguished, via genetic analysis, from non-Twisp spring Chinook with a high degree of certainty. The Wells HCP Hatchery Committee accepted that Twisp-origin fish could be genetically assigned with sufficient confidence that natural origin collections can occur at Wells Dam. Scale samples and non-lethal tissue samples (fin clips) for genetic analysis will be obtained from adipose-present, non-CWT, non-ventral-clipped spring Chinook (suspected natural-origin spring Chinook) collected at Wells Dam, and origins assigned based on that analysis. Natural-origin fish retained for broodstock will be PIT tagged (dorsal sinus) for cross-referencing tissue samples/genetic analyses. Tissue samples will be preserved and sent to WDFW genetics lab in Olympia Washington for genetic/stock analysis. The spring Chinook sampled will be retained at Methow FH and will be sorted as Twisp or non-Twisp natural-origin fish prior to spawning. The number of natural-origin Twisp and Methow Composite (non-Twisp) spring Chinook retained will be dependent upon the number of natural-origin adults returning and the collection objective limiting extraction to no greater than 33% of the natural-origin spring Chinook return to the Methow Basin. Based on the broodstock-collection schedule (3-day/week, 16 hours/day), extraction of natural-origin spring Chinook is expected to be approximately 33% or less.

Weekly estimates of the passage of Wells Dam by natural-origin spring Chinook will be provided through stock-assessment and broodstock-collection activities. This information will facilitate in-season adjustments to collection composition so that extraction of natural-origin spring Chinook remains less than 33%. Twisp and Methow Composite hatchery-origin spring Chinook will be captured at the Twisp Weir, and Methow FH outfall. Trapping at the Winthrop NFH will be included if needed because of broodstock shortfalls.

Pre-season run-escapement of Methow-origin spring Chinook above Wells Dam during 2012 are estimated at 3,090 spring Chinook, including 2,609 hatchery and 481 natural origin spring Chinook (Table 1 and Table 2). In-season estimates of natural-origin spring Chinook will be adjusted proportional to the estimated returns to Wells Dam at weekly intervals and may result in adjustments to the broodstock collection targets presented in this document.

The following broodstock collection protocol was developed based on the re-calculated program production levels (223,765 smolts), BKD management strategies, projected return for BY 2012 Methow Basin spring Chinook at Wells Dam (Table 1 and Table 2), and assumptions listed in Table 3.

The 2012 Methow spring Chinook broodstock collection will target up to 166 adult spring Chinook (24 Twisp, 142 Methow). Based on the pre-season run forecast, Twisp fish are expected to represent 6% of the adipose present, CWT tagged hatchery adults and 16% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution and a collection objective of no less than 50% NOR's and to limit extraction to no greater than 33% of the natural-origin spawning escapement to the Twisp, the 2012 Twisp origin broodstock collection will total 24 fish (at least 12 wild and the remainder, maximum = 12, hatchery origin, or 1:1 wild:hatchery if wild broodstock are less than 12), representing 100% of the broodstock necessary to meet Twisp program production of 40,000 smolts. Methow Composite fish are expected to represent 43% of the adipose present CWT tagged hatchery adults and 84% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution and a collection objective to limit extraction to no greater than 33% of the natural-origin recruits, the 2012 Methow broodstock collection will be predominantly natural origin and total 142 spring Chinook (133 wild and 9 Hatchery [alternative if estimated pHOS > 0.5: 71 wild + 71 hatchery]). The broodstock collected for the Methow program represents 100% of the broodstock necessary to meet Methow program production of 183,765 smolts. The Twisp River releases will be limited to releasing progeny of broodstock identified as wild Twisp and or known Twisp hatchery origin fish, per ESA Permit 1196. The Methow FH releases will include progeny of broodstock identified as wild non-Twisp origin and known Methow Composite hatchery origin fish. Age-3 males ("jacks") will not be collected for broodstock.

Table 1. Brood year 2007-2009 age class-at-return projection for wild spring Chinook above Wells Dam, 2012.

Brood year	Smolt Estimate		Age-at-return: Twisp Basin				Age-at-return: Methow Basin				
	Twisp[1/]	Methow Basin[2/]	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total	SAR[3/]
2007	9,715	99,417	2	35	**17**	54	27	361	**167**	555	0.005581
2008	11,932	56,337	8	**50**	9	67	7	**227**	80	314	0.005581
2009	5,124	31,212	**9**	17	3	29	**11**	142	21	174	0.005581
Estimated 2011 Return			**9**	**50**	**17**	**76**	**11**	**227**	**167**	**405**	

[1/]-Smolt estimate is based on sub-yearling and yearling emigration (Charlie Snow, personal communication).
[2/]-Estimated Methow Basin smolt emigration based on Twisp Basin smolt emigration, proportional redd deposition in the Twisp River and Twisp Basin smolt production estimate.
[3/]- Mean Chiwawa NOR spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 2. Brood year 2007-2009 age class and origin run escapement projection for UCR spring Chinook at Wells Dam, 2012.

Stock	Projected Escapement – Origin: Hatchery				Origin: Wild				Total: Methow Basin			
	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total
MetComp	184	898	42	**1,124**	11	227	167	**405**	195	1,125	209	**1,529**
%Total				43%				84%				49%
Twisp	29	123	5	**157**	9	50	17	**76**	38	173	22	**233**
%Total				6%				16%				8%
Winthrop (MetComp)	113	967	248	**1,328**					113	967	248	**1,328**
%Total				51%								43%
Total	326	1,988	295	**2,609**	20	277	184	**481**	346	2,265	479	**3,090**

Table 3. Assumptions and calculations to determine the number of broodstock needed for BY 2012 production of 223,765 smolts.

Program Assumptions	Twisp standard	Twisp program	Methow standard	Methow program	Total program
Smolt Release		40,000		183,765	**223,765**
Fertilization-to-release survival	*88%*		*85%*		
Total egg take target		45,455		216,194	**261,649**
Egg take (production)					
Cull allowance[1/]		45,455	*19.4*	268,231	**313,686**
Fecundity[2/]	*3,952*		*3,851*		
Female Target					
Female to male ratio	*1:1*		*1:1*		
Broodstock target					
Pre-spawn survival	*96%*		*98%*		
Total broodstock collection		**24**		**142**	

[1/]-Hatchery origin MetComp. component only, and is based on the projected natural origin collection and assumption that all Twisp (hatchery and wild) and wild MetComp. fish will be retained for production.
[2/]-Based on historical age-4 fecundities and expected 2012 return age structure (Table 1).

Trapping at Wells Dam will occur at the East and West ladder traps beginning on 01 May, or at such time as the first spring Chinook are observed passing Wells Dam, and continue through 22 June 2012. The trapping schedule will consist of 3-day/week (Monday-Wednesday), up to 16-hours/day. Two of the three trapping days will be concurrent with the stock assessment sampling activities authorized through the 2012 Douglas PUD Hatchery M&E Implementation Plan. Natural origin spring Chinook will be retained from the run, consistent with spring Chinook run timing at Wells Dam (weekly collection quota). Once the weekly quota target is reached, broodstock collection will cease until the beginning of the next week. If a shortfall occurs in the weekly trapping quota, the shortfall will carry forward to the following week. All natural origin spring Chinook collected at Wells Dam for broodstock will be held at the Methow FH.

To meet Methow FH broodstock collection for hatchery origin Methow Composite and Twisp River stocks, adipose-present coded-wire tagged hatchery fish will be collected at Methow FH, Winthrop NFH and the Twisp Weir beginning 01May or at such time as spring Chinook are observed passing Wells Dam and continuing through 24 August 2012. Natural origin spring Chinook will be retained at the Twisp Weir as necessary to bolster the Twisp program production so long as the aggregate collection at Wells Dam and Twisp River weir does not exceed 33% of the estimated Twisp River natural origin spawners to maximize pNOS in the Twisp. All hatchery and natural origin fish collected at Methow FH, Twisp Weir and Winthrop NFH for broodstock will be held at the Methow FH.

Steelhead

Steelhead programs located upstream of Wells Dam and at Wells Hatchery are presented in Table xx.

Table XX. Steelhead Programs at Wells Hatchery and Upstream of Wells Dam

Program	Hatchery	Owner	Release Location	Number to be Released	Broodstock
Twisp Conservation	Methow Hatchery (incubation); Wells Hatchery (rearing)	Douglas PUD	Twisp Acclimation Pond	48,000	Twisp WxW
Methow Safety-Net	Wells Hatchery	Douglas PUD	Methow Hatchery	100,000	HxH: Twisp Hatchery (25%) + WNFH Hatchery (75%)
Mainstem Columbia Safety-Net	Wells Hatchery	Douglas PUD	Wells Hatchery	160,000	HxH: Methow Hatchery returns (1st option); Wells Stock (2nd option)
WNFH Conservation Program	WNFH	USFWS	WNFH	100,000	Up to 25 collected at Wells Dam/Hatchery; remaining 25 collected by USFWS
Omak Creek	Wells Hatchery	Grant PUD	Omak Creek	Up to 50,000[1]	Omak Creek returns (up to 25 wild or hatchery)
Okanogan	Wells Hatchery	Grant PUD	Okanogan Basin	Up to 100,000[1]	Wells Stock collected at Wells Dam/Hatchery

1/ The Grant PUD programs will total 100,000, with Omak Creek taking precedence, and the Okanogan program = 100,000 – Omak production.

Steelhead mitigation programs above Wells Dam (including the USFWS steelhead program at Winthrop NFH) utilize adult broodstock collections at Wells Dam, Twisp Weir, Methow Hatchery volunteer trap, and WNFH volunteer trap (Table xxx) and incubation/rearing at Wells Fish Hatchery (FH) and incubation at Methow Hatchery (Twisp program). The Wells Steelhead Program has provided eggs for UCR steelhead reared at Ringold FH, not as a mitigation requirement, but rather an opportunity to reduce the prevalence of early spawn hatchery steelhead in the mitigation component above Wells Dam. However, the Methow steelhead program is shifting to locally collected Twisp wild broodstock (Twisp conservation program), and hatchery origin broodstock representative of the Twisp and WNFH conservation programs (Methow safety-net program). Therefore, surplus broodstock will not be collected for the

Methow steelhead programs to address the spawn-timing issue of the Wells stock. The Wells Hatchery Columbia River releases will use returns to the Methow Hatchery volunteer trap to the extent possible, and will be augmented with Wells stock as required to fulfill the program. Therefore, surplus broodstock collection to address spawn timing will not occur. However, the local collections of broodstock in the Methow Basin will occur in the spring, 2013. To ensure the safety-net programs have broodstock, some broodstock will be collected at Wells Dam in the autumn, 2012, and held at Wells Hatchery. These autumn-collected Wells stock fish will be considered surplus to the spring-collected Methow and Okanogan broodstock, and eggs from these surplus broodstock may be transferred to Ringold Hatchery. In addition, Wells Hatchery will be used for adult management and steelhead removed for adult management may be retained for the Ringold program.

The following broodstock collection protocol was developed based on mitigation program production objectives (Table 4), program assumptions (Table 5), and the probability that sufficient adult steelhead will return in 2012/2013 to meet production objectives absent a preseason forecast at the present time.

Table xxx. Broodstock Collection Locations, Number, and Origin by Program

Program	**Wells Dam or Hatchery**		**Twisp Weir**		**WNFH**		**Methow Hatchery**		**Omak Creek**	
	H	W	H	W	H	W	H	W	H	W
Twisp Conservation			0	24						
Methow Safety-Net			Up to 50	0	Up to 50 (backup)	0				
Mainstem Columbia Safety-Net	82 (backup)	0					82	0		
WNFH Conservation Program	8	17								
Omak Creek									Up to 25[1]	
Okanogan	Up to 33	Up to 17								
Ringold[2]	Up to 103	0								
Total	144	34	50	24	0	0	82	0	25	

1/ Wild origin preferred, but hatchery origin broodstock will also be collected to meet target.
2/ Broodstock derived from adult management at Wells Hatchery and surplus brood collected as backup for Methow and Okanogan programs

Trapping at Wells Dam will selectively retain 250 steelhead (east and west ladder collection) and will comprise 21 natural origin fish and 229 hatchery origin fish. Ringold FH production component will comprise 100% hatchery origin returns collected at Wells Dam and Hatchery volunteer channel. In the spring of 2013, 24 wild steelhead will be targeted at the Twisp Weir and transferred to the Methow Hatchery for spawning and incubation to the eyed-egg stage after which they will be moved to Wells Hatchery for the balance of rearing. In addition, 50 surplus hatchery-origin steelhead (to meet the 100K Methow Safety-Net release) will be targeted at the Twisp Weir and moved to Wells Hatchery for spawning. Surplus WNFH hatchery returns will be used to augment the Twisp hatchery-origin collection if needed. Should there be inadequate surplus steelhead from these two sources, steelhead captured at the Methow Hatchery volunteer trap will be used to fulfill the program, and then Wells stock held at the Wells Hatchery will be used as a final option. Approximately, 16 (up to 25) adult steelhead will be targeted in Omak Creek for a 20K (up to 50K) endemic program operated by the CCT and funded by GCPUD as part of their 100K UCR steelhead mitigation obligation. Overall collection for the programs will be 340 fish and limited to no more than 33% of the entire run or 33% of the natural origin return (NOR contribution to the broodstock is estimated at 26%). Hatchery and natural origin collections will be consistent with run-timing of hatchery and natural origin steelhead at Wells Dam. Ladder trapping at Wells Dam will begin on 01 August and terminate by 31 October and will be operated concurrently, three days per week, up to 16 hours per day, if required to meet broodstock objectives. Trapping will be concurrent with summer Chinook broodstocking efforts through 15 September on the west ladder. If insufficient steelhead adults are encountered on the west ladder, the east ladder trap may be considered. Adult return composition including number, origin, age structure, and sex ratio will be assessed in-season at Priest Rapids and Wells dams. Broodstock collection adjustments may be made based on in-season monitoring and evaluation. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.

Table 4. Adult steelhead collection objectives for programs supported through 2012 return year adult steelhead broodstock collected at Wells Dam, Twisp Weir, and Omak Creek (CCT endemic program).

Program	# Smolts	# Green eggs	% Wild	# Wild	# Hatchery	Total Adults
DCPUD[1/]	160,000	226,629	0%		82	82
DCPUD[2/]	100,000	141,643	0%		50	50
DCPUD Twisp	48,000	67,989	100%	24		24
GCPUD[3/]	80,000	113,315	33%	13	27	40
GCPUD Omak	20,000	40,000		16		16[4/]
USFWS	50,000	70,821	33%	8	17	25
Sub-total	**458,000**	**660,397**	26%	**61**	**176**	**237**
Ringold	180,000	285,714	0%	0	103	103
Sub-total	**180,000**	**285,714**	**0%**	**0**	**103**	**103**
Grand Total[5/]	**638,000**	**946,111**	**18%**	**61**	**279**	**340**

1/-Mainstem Columbia releases at Wells Dam. Target HxH parental adults as the hatchery component.

2/- Methow hatchery release of HxH fish produced from either adults returning from the Winthrop conservation program and/or surplus hatchery adults from the Twisp weir.

3/- Okanogan Basin releases as part of GCPUD's 100K summer steelhead obligation. Broodstock need is dependent on the Omak collection to achieve 100,000 smolts total.

4/- Broodstock targeted is 16 total (8 male/8 female) of mixed origin composition based upon what is trapped. Collection could range up to 25 broodstock (50,000 smolt program maximum)

[5/]- *Based on steelhead production consistent with Mid-Columbia HCP's, GCPUD BiOp and Section 10 permit 1395.*

Table 5. Program assumptions used to determine the number of adults required to meet steelhead production objectives for programs above Wells Dam and at Ringold Springs Fish Hatchery.

	Standard	
Program assumptions	**Hatchery**	**Wild**
Pre-spawn survival	95.4%	97.6%
Female : Male ratio	1.0:1.0	1.0:1.0
Fecundity	5,822	5,800
Fertilization-to-yearling release	70.6%[1/]	70.6%[1/]

[1/]-*Not applicable to Ringold Springs Fish hatchery.*

Summer/fall Chinook

Summer/fall Chinook mitigation programs above Wells Dam utilize adult broodstock collections at Wells Dam and incubation/rearing at Eastbank Fish Hatchery. The total production level target is 414,669 summer/fall Chinook smolts for two acclimation/release sites on the Methow and Similkameen rivers (Carlton Pond and Similkameen Pond, respectively).

The TAC 2012 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2007, 2008 and 2009 spawn escapement to tributaries above Wells Dam indicate sufficient summer Chinook will return past Wells Dam to achieve full broodstock collection for supplementation programs above Wells Dam. The following broodstock collection protocol was developed based on initial run expectations of summer Chinook to the Columbia River, program objectives and program assumptions (Table 6).

For 2012, WDFW will retain up to 107 natural-origin summer/fall Chinook at Wells Dam east and/or west ladders, including 52 females for the Methow summer Chinook program (this total does not include the balance of the Similkameen program that may not be achieved through the CCT purse seine efforts). Collection will be proportional to return timing between 01 July and 15 September. Trapping may occur up to 3-days/week, 16 hours/day. Age-3 males ("jacks") will not be collected for broodstock.

Additionally, in collaboration with the Colville Tribes, in 2012 attempts will be made to collect up to 100% (N=112; 56 females) of the natural origin adults needed to meet the Okanogan summer Chinook obligation through the CCT purse seine efforts. If logistics or capture efficiency become prohibitive to achieving broodstock goals with this collection activity this season, broodstock collection for the balance will revert back to Wells Dam. In addition, if broodstock collection through the CCT's purse seining efforts falls behind by more than 25%, the difference between the fish collected to date and what should have been collected, will be made up at Wells Dam west ladder trap. Fish collected through the CCT trapping effort will be uniquely tagged from fish collected at Wells Dam to evaluate relative differences in disease, mortality, spawn timing, among other metrics.

For the 2012 brood year, 48,540 summer/fall Chinook will be reared at Wells Hatchery from broodstock collected by the CCT through purse seining in the Wells Reservoir. The fish will be reared to a point at which they can be transferred to the Chief Joseph Hatchery, Omak Riverside Acclimation Facility for further grow-out in 2013 and release in 2014.

To better assure achieving the appropriate female equivalents for program production, the collection will utilize ultrasonography to determine the sex of each fish retained for broodstock. If the probability of achieving the broodstock goal is reduced based on passage at the west ladder or actual natural-origin escapement levels, broodstock collections may be expanded to the east ladder trap and/or origin composition will be adjusted to meet the broodstock collection objective. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.

Table 6. Assumptions and calculations to determine the number of broodstock needed for summer/fall Chinook production goals in the Methow and Okanogan river basins.

Program Assumptions	Standard	Carlton Pond	Similkameen Pond	Wells FH/CCT	Total
Smolt release		**200,000**	**166,569**	**48,540**	**414,669**
Fertilization-to-release survival	81.2				
Eggtake target		**246,305**	**205,134**	**59,236**	**510,675**
Fecundity	4,990				
Female target		**49**	**41**	**12**	**102**
Female:male ratio	1:1				
Broodstock target		**99**	**82**	**24**	**205**
Pre-spawn survival	95.5				
Total collection target		**104**	**86**	**26**	**216**

Coho – Placeholder for YN Methow Coho broodstock plan. This plan will be submitted to NMFS independently by the YN.

Columbia River Mainstem below Wells Dam

Summer/fall Chinook

Summer/fall Chinook mitigation programs that release juveniles directly into the Columbia River between Wells and Rocky Reach dams are supported through adult broodstock collections at Wells Dam and the Wells Hatchery volunteer channel. The total production level supported by this collection is 896,000 yearling (320K Wells and 576K Chelan Falls programs) and 484,000 sub-yearling Chinook (Wells Hatchery). Upon agreement in the HCP-HC, the 2012, summer Chinook broodstock collections at Wells FH may also include 345,000 green eggs to support the Yakama Nation (YN) reintroduction of summer Chinook to the Yakima River Basin and up to 266 adults or 509,009 green eggs for the USFWS Entiat program pending agreements between USFWS and DCPUD. If approved by the HCP Hatchery Committee, YN eggs will be the last eggs taken and will be the responsibility of staff associated with the YN program. Adults for the

Entiat program will be transferred to Entiat NFH by either WDFW or USFWS staff (arrangements between USFWS and DCPUD will have been made prior to implementation).

Adults returning from the Wells and Chelan Falls programs are to support harvest opportunities and are not intended to increase natural production and have been termed segregated harvest programs. These programs have contributed to harvest opportunities; however, adults from these programs have been documented contributing to the adult spawning escapement in tributaries upstream and downstream from their release locations. Because of CCT concerns about sufficient natural origin fish reaching spawning grounds, incorporation of natural origin fish for the Wells program will be limited to fish collected in the Wells volunteer channel. The following broodstock collection protocol was developed based on mitigation objectives and program assumptions (Table 7).

WDFW will collect about 1,287 run-at-large summer Chinook from the volunteer ladder trap at Wells Fish Hatchery outfall. Overall extraction of natural-origin fish to Wells Dam (Wells program and above Wells Dam summer/fall Chinook programs) will not exceed 33 percent. East and/or West ladder collections will begin 01 July and will be completed by 14 September and will be consistent with run timing past Wells Dam. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project. Due to fish health concerns associated with the volunteer collection site (warming Columbia River water during late August), the volunteer collection will begin 11 July and terminate by 31 August. Age-3 males ("jacks") will not be collected for broodstock.

Table 7. Assumptions and calculations to determine the number of broodstock needed for summer/fall Chinook production goals for programs relying on adult collection at Wells Dam or Wells Hatchery in 2012.

Program Assumptions	**Standard**		**Wells FH**		**Chelan Falls FH**	**YN**[1/]	**USFWS**[2/]	
	Sub-yearling	**Yearling**	**Sub-yearling**	**Yearling**	**Yearling**	**Green eggs**	**Green eggs**	**Total**
Smolt release			**484,000**	**320,000**	**576,000**		**400,000**	**NA**
Green egg-to-release survival	76.1%[4/]	83.6%						NA
Eggtake target			**636,005**	**382,775**	**688,995**	**345,000**	**509,009**	**2,561,784**
Fecundity	4,487	4,487						
Female target			**142**	**86**	**154**	**77**	**129**	**588**
Female:Male ratio	1:1	1:1						
Broodstock target			**284**	**242**[3/]	**308**	**154**	**258**	**1,246**
Pre-spawn	96.8%	96.8%						

survival						
Total collection target	**294**	**250**	**318**	**159**	**266**	**1,287**

[1/]-Green eggs for YN reintroduction program in the Yakima River Basin.
[2/]-Adults for USFWS summer Chinook program in the Entiat River Basin.
[3/]- Includes 70 adults collected for the Lake Chelan triploid Chinook program.

Wenatchee River Basin

Spring Chinook

The Eastbank Fish Hatchery (FH) rears spring Chinook salmon for the Chiwawa River acclimation pond located on the Chiwawa River. The HCP HC approved program production level target for 2012 is 204,452 smolts, requiring a total broodstock collection of 120 spring Chinook (54 natural and 66 hatchery origin; Table 8). The production level for 2012 represents agreements made early in 2012 by the Chelan PUD HCP HC to allow CPUD's spring Chinook obligation for the Methow basin (60,516 smolts) to be produced in the Wenatchee basin (CPUD's post 2013 release re-calculated production obligation for the Chiwawa is 144,026 smolts). The gap in production in the Methow is being compensated for by allowing the difference in Grant PUD's Wenatchee spring Chinook at the White River and Nason Creek to be met at Methow Hatchery. This is a one year agreement.

Table 8. Assumptions and calculations to determine the number of broodstock needed in an anticipated 2012 Chiwawa program release of 204,452 smolts.

Program Assumptions	Standard	Conservation	Safety Net	Full program
Smolt Release		**102,226**	**102,226**	**204,452**
Fertilization-to-release survival	*84.5%*			
Total egg take target		120,978	120,978	**241,956**
Egg take (production)			136,826	**257,804**
Cull allowance	*13.1%*			**15,848**
Fecundity	*4,711 W* *4,279 H*			
Female Target		26	32	**58**
Female to male ratio	*1:1*			
Broodstock target		52W	64H	**116**
Pre-spawn survival	*98.0%W/98.5H*			
Total broodstock collection		**54W**	**66H**	**120**

Inclusion of natural origin fish into the broodstock will continue to be a priority, with natural origin fish specifically being targeted. Consistent with ESA Section 10 Permit 1196, natural origin fish collections will not exceed 33 percent of the return to the Chiwawa River and will provide, at a minimum, 33 percent of the total broodstock retained.

In addition to production levels and ESA permit provisions, the 2012 broodstock collection, will target both hatchery and natural origin Chiwawa spring Chinook at the Chiwawa Weir.

Pre-season estimates project 3,819 spring Chinook are destined for the Chiwawa River, of which 481 (12.6%) and 3,338 fish (87.4%) are expected to be natural and hatchery origin spring Chinook, respectively (Tables 9 and 10). These protocols target approximately 120 spring Chinook (54 natural origin and 66 hatchery origin) for broodstock purposes, representing 100% of the program production objectives. In-season assessment of the magnitude and origin composition of the spring Chinook return above Tumwater Dam will be used to provide in-season adjustments to hatchery/wild composition and total broodstock collection, consistent with ESA Section 10 Permit 1196.

Table 9. BY 2007-2009 age class return projection for wild spring Chinook above Tumwater Dam during 2012.

Brood year	**Smolt Estimate**[1/]		**Chiwawa Basin**[2/]				**Wenatchee Basin above Tumwater Dam**[2/]				
	Chiwawa	Wen. Basin	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total	SAR[3/]
2007	65,539	103,460	24	271	**71**	366	38	427	**112**	577	0.005581
2008	91,229	168,630	35	**384**	85	504	65	**718**	159	942	0.005581
2009	51,417	88,650	**26**	249	13	287	**8**	387	100	495	0.005581
Estimated 2012 Return			**26**	**384**	**71**	**481**	**8**	**718**	**112**	**838**	

[1/]-Smolt production estimate for Chiwawa River derived from juvenile smolt data (Hillman et al. 2010); smolt production estimate for Wenatchee Basin is based upon proportional redd disposition between Chiwawa River and Wenatchee River basin and the Chiwawa smolt production estimate.
[2/]-Based upon average age-at-return (return year 2007-2011), for natural origin spring Chinook above Tumwater Dam (WDFW unpublished data).
[3/]-Mean Chiwawa spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 10. BY 2007-2009 age class return projection for Chiwawa hatchery spring Chinook above Tumwater Dam during 2012.

Brood	**Smolt Estimate**	**Adult Returns**				
Year	Chiwawa[1/]	Age-3[2/]	Age-4[2/]	Age-5[2/]	Total	SAR
2007	305,542	780	1,760	**88**	2,628	0.0086[3/]
2008	609,789	1,229	**2,839**[4/]	139	4,208	0.0069[5/]
2009	438,651	**411**	1,827	88	2,326	0.0053[6/]
Estimated 2012 Return		**411**	**2,839**	**88**	**3,338**	

[1/]-Chiwawa smolt release (Hillman et. al. 2009).
[2/]-Based on average age-at-return for hatchery origin spring Chinook above Tumwater Dam, 2005-2009 (WDFW,

unpublished data) and total estimated BY return.
[3/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 1997-2002).
[4/]-Age-4 returns in 2012 may be significantly underestimated due to age-3 returns in 2011 being in excess of 260% of the 2011 forecast.
[5/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 1998-2003).
[6/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 2000-2004).

Collection at the Chiwawa Weir will be based on weekly quotas, consistent with average run timing at Tumwater Dam. If the weekly quota is attained prior to the end of the week, retention of spring Chinook for broodstock will cease. If the weekly quota is not attained, the shortfall will carry forward to the next week. The number of hatchery origin fish retained for broodstock will be adjusted in-season, based on estimated Chiwawa River natural-origin returns provided through extrapolation of returns past Tumwater Dam. If hatchery origin Chinook are retained in excess to that required to maintain a minimum 33% natural origin composition in the broodstock, excess fish will be sampled, killed and either used for nutrient enhancement or disposed of in a landfill depending upon fish health staff recommendations.

Broodstock collection at the Chiwawa Weir will begin 01 June and terminate no later than 11 September. Spring Chinook trapping at the Chiwawa Weir will follow a 4-days up and 3-days down schedule, consistent with weekly broodstock collection quotas that approximate the historical run timing and a maximum 33 percent retention of the projected natural-origin escapement to the Chiwawa River. If the weekly quota is attained prior to the end of the 4-day trapping period, trapping will cease. If the weekly quota cannot be accomplished with a 4-days up and 3-days down schedule, a 7-day per week schedule may be implemented to facilitate reaching the collection objectives. Under the 7-day per week schedule, no more than 33% (1 in 3) of the fish collected will be retained for broodstock. If the weekly quota is not attained within the trapping period, the shortfall will carry forward to the next week.

All spring Chinook in excess of broodstock needs and all bull trout trapped at the Chiwawa weir will be transported by tank truck and released into a resting/recovery pool at least 16.0 km upstream from the Chiwawa River Weir. Age-3 males (“jacks”) will not be collected for broodstock.

Steelhead

The steelhead mitigation program in the Wenatchee Basin use broodstock collected at Dryden and Tumwater dams located on the Wenatchee River. Per ESA section 10 Permit 1395 provisions, broodstock collection will target adults necessary to meet a 50% natural origin – conservation oriented program and a 50% hatchery origin – safety net program, not to exceed 33% of the natural origin steelhead return to the Wenatchee Basin. Based on these limitations and the assumptions listed below (Table 12), the following broodstock collection protocol was developed.

WDFW will retain a total of 130 mixed origin steelhead for broodstock for a smolt release objective of 247,300 smolts (Table 12). The 66 hatchery origin adults will be targeted at Dryden Dam and if necessary Tumwater dam. The 64 natural origin adults will be targeted for collection at Tumwater Dam. Collection will be proportional to return timing between 01 July and 12

November.   Collection may also occur between 13 November and 3 December at both traps, concurrent with the Yakama Nation coho broodstock collection activities. Hatchery x wild and hatchery x hatchery parental cross and unknown hatchery parental cross adults will be excluded from the broodstock collection. Hatchery steelhead parental origins will be determined through evaluation of VIE tags, adipose/cwt presence/absence, and PIT tag interrogation during collection. Adult return composition including number, origin, age structure, and sex ratio will be assessed in-season at Priest Rapids and at Dryden Dam. In-season Broodstock collection adjustments may be made based on this monitoring and evaluation. To better assure achieving the appropriate females equivalents for program production, the collection will implement the draft Production Management Plan, including ultrasonography to determine the sex of each fish retained for broodstock.

In the event steelhead collections fall substantially behind schedule, WDFW may initiate/coordinated adult steelhead collection in the mainstem Wenatchee River by hook and line. In addition to trapping and hook and line collection efforts, Tumwater and Dryden dams may be operated between February and early April the subsequent spring to supplement broodstock numbers if the fall trapping effort provides fewer than the required number of adults.

Table 12. Assumptions and calculations to determine the number and origin of Wenatchee summer steelhead broodstock needed for Wenatchee Basin program release of 247,300 smolts.

Program Assumptions	Standard	Wenatchee program
Smolt Release		**123,650 Conservation** **123,650 Safety net**
Fertilization-to-release survival	*68.6%*	
Egg take target		**360,496**
Fecundity	*5,749 H* *5,893 W*	
Female Target		**32 H** **31 W**
Female to male ratio	*1:1*	
Broodstock target		**126**
Pre-spawn survival	*96.9%H/97.9%W*	
Total broodstock collection		**130**
Natural:Hatchery ratio	1:1	
Natural origin collection total		**64**

Hatchery origin collection total	**66**

Summer/fall Chinook

Summer/fall Chinook mitigation programs in the Wenatchee River Basin utilize adult broodstock collections at Dryden and Tumwater dams, incubation/rearing at Eastbank Fish Hatchery (FH) and acclimation/release from the Dryden Acclimation Pond. The total production level target for BY 2012 is 500,001 smolts (181,816 GCPUD mitigation and 318,185 CCPUD mitigation).

The TAC 2012 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2007, 2008 and 2009 spawn escapement to the Wenatchee River indicate sufficient summer Chinook will return to the Wenatchee River to achieve full broodstock collection for the Wenatchee River summer Chinook supplementation program. Review of recent summer/fall Chinook run-timing past Dryden and Tumwater dam indicates that previous broodstock collection activities have omitted the early returning summer/fall Chinook, primarily due to limitations imposed by ESA Section 10 Permit 1347 to minimize impacts to listed spring Chinook. In an effort to incorporate broodstock that better represent the summer/fall Chinook run timing in the Wenatchee Basin, the broodstock collection will front-load the collection to account for the disproportionate collection timing. Approximately 43% of the summer/fall Chinook destined for the upper Basin (above Tumwater Dam) occurs prior to the end of the first week of July; therefore, the collection will provide 43% of the objective by the end of the first week of July. Weekly collection after the first week of July will be consistent with run timing of summer/fall Chinook during the remainder of the trapping period. With concurrence from NMFS, summer Chinook collections at Dryden Dam may begin up to one week earlier. Collections will be limited to a 33% extraction of the estimated natural-origin escapement to the Wenatchee Basin. Based on these limitations and the assumptions listed below (Table 13), the following broodstock collection protocol was developed.

WDFW will retain up to 274 natural-origin, summer Chinook at Dryden and/or Tumwater dams, including 137 females. To better assure achieving the appropriate females equivalents for program production, the collection will implement the draft Production Management Plan, including ultrasonography to determine the sex of each fish retained for broodstock. Trapping at Dryden Dam may begin 01 July and terminate no later than 15 September and operate up to 7-days/week, 24-hours/day. Trapping at Tumwater Dam if needed may begin 15 July and terminate no later than 15 September and operate up to 48 hours per week.

Table 13. Assumptions and calculations to determine the number of Wenatchee summer Chinook salmon broodstock needed for Wenatchee Basin program release of 864,000 smolts.

Program Assumptions	Standard	Grant PUD	Chelan PUD	Total Wenatchee Program
Smolt Release		**181,816**	**318,185**	**500,001**
Fertilization-to-release survival	*75.6%*			
Egg take target		**240,497**	**420,880**	**661,377**

Fecundity	*5,135*			
Female Target		**47**	**82**	**129**
Female to male ratio	*1:1*			
Broodstock target		**94**	**164**	**258**
Pre-spawn survival	*94.1%*			
Total broodstock collection		**100**	**174**	**274**

Coho – Placeholder for YN Wenatchee Coho broodstock plan. This plan will be submitted to NMFS independently by the YN.

White River Spring Chinook Captive Brood

Smolt production associated with the White River Captive Broodstock Program (150,000 smolts) will be separate from the smolt production objective associated with the Chiwawa River adult supplementation program. Spawning, incubation, rearing acclimation and release will be consistent with provisions of (expired) ESA Permit 1592.

Nason Creek Spring Chinook

Consistent with agreements made in 2012 in both the HCP-HC and PRCC-HSC, Grant PUDs spring Chinook obligation will be met with primarily production from the White River captive brood program with the balance of the obligation being met with spring Chinook at Methow FH. These agreements allow for Chelan PUD to move their Methow spring Chinook obligation to the Chiwawa to maintain the total Wenatchee Basin spring Chinook production at the recalculated level of 367,696 smolts. Total Methow Basin spring Chinook production will be maintained at the re-calculated level of 223,765 smolts. This agreement is only in place for the 2012 brood.

Priest Rapids Fall Chinook

Collection of fall Chinook broodstock at Priest Rapids Hatchery will generally begin in early September and continue through mid November. Smolt release objectives specific to Grant PUD (5,000,000 sub-yearlings), Federal (1,700,000 sub-yearlings + 3,500,000 eggs – collection of broodstock for the federal programs are conditional upon having contracts in place with the ACOE) and Yakama Nation (500,000 eggs), mitigation commitments. Biological assumptions are detailed in Table 14. Smolt release objectives for Ringold Springs occur as green eggs collected at Priest Rapids FH and incubated at Bonneville prior to eyed-egg transfers to Ringold Springs. The Yakama program would be green egg transfers from Priest Rapids FH. After the new Priest Rapids FH rebuild there will no longer be incubation capacity for programs above GCPUD mitigation obligations.

For 2012 WDFW is proposing to implement active integration of the fall Chinook programs to meet a pNOB of 0.4, an estimated 2,860 females will need to be spawned to meet the 12,298,851 eggs required to meet the current four up-river bright (URB) programs which rely on adults collected at the Priest Rapids Hatchery volunteer channel trap and/or the Priest Rapids Dam off ladder trap (OLAFT). To meet an integrated program with a pNOB = 0.4, an estimated 1,950 natural origin fish will need to be collected (Table 14). Although hatchery returns in 2012 will be comprised of 100% marked fish (otolith, adipose clipped, and/or coded wire tagged), because natural origin fish cannot be differentiated without lethally sampling otolith marked adults, additional adipose present non-wired fish will need to be collected to ensure sufficient natural origin adults are present in the broodstock population to meet, or be significantly closer, to the target pNOB metric of 0.4. As such it is estimated that 2,322 adipose present, non-wired fish collected from the OLAFT under a 6-day/week, 8-hours/day trap operation will yield approximately 1,578 natural origin fish (Table 15). In addition, approximately 4,818 adipose present, non-wired adults collected from the PRH volunteer trap will yield an estimated 267 natural origin fish for a total NOR broodstock component of 1,845 fish (Table 15). Depending upon pre-spawn survival performance of the broodstock, we can reasonably expect to achieve a pNOB of between 0.348 and 0.378 (Table 15).

<u>Implementation Assumptions</u>

1) Consistent with the Priest Rapids Fall Chinook HGMP, SOA 2009-01, SOA 2008-03, HSRG recommendations, and WDFW's Fish and Wildlife Commission policy (POL-C3619), 2012 marks the first year of moving toward meeting the metrics of the program and the overall Hanford Reach fall Chinook population (2012 is the first year for all age classes to return from 100% marked releases – otolith, CWT, adipose clip, or any combination thereof).

2) For 2012, the fall Chinook program will be operated to actively integrate natural origin fish into the program (e.g. determination of origin will be made at spawning). Fish/gametes, from natural origin fish will be prioritized over hatchery fish.

3) For 2012, production will be guaranteed while transitioning the programs to meet a pNOB of 0.4.

4) Broodstock will be collected at both the PRD off ladder trap (OLAFT) and the Priest Rapids Hatchery volunteer channel trap.

5) Assumptions used to determine egg/adult needs is based upon current program performance metrics and is consistent with the draft 2012 Broodstock Collection protocols.

6) For adults collected at the Priest Rapids volunteer channel, the encounter rate is based upon the average of the most recent five year returns to the hatchery volunteer channel (N=15,962).

7) Broodstock retained from the volunteer channel will exclude age-2 and 3 males by age (or otoliths if parties prefer however that will increase the number of broodstock to be retained and otolith sampled by approximately 43%) to address genetic risks/concerns of younger age-at-maturity males producing offspring which return at a younger age (decreased age-at-maturity).

8) All adipose present, non-wired fish encountered at the OLAFT will be retained for broodstock.

9) All gametes of fish spawned from natural origin adults (as determined through real-time otolith reading at spawning) will be incorporated into the URB programs.

10) As production obligations are met throughout spawning, hatchery x hatchery eggs in excess of program needs will be culled to maintain incubation capacity and minimize production overages.

Table 14. Juvenile production objectives and associated broodstock needs for fall Chinook programs using upriver bright (URB) adults collected at Priest Rapids Hatchery/Dam in 2012 to meet a pNOB of 0.4 consistent with the Priest Rapids fall Chinook HGMP, SOA's, HSRG recommendations and WDFW FWC policy (#POL-C3619).

Current Programs	Juvenile Release Target		Green eggs	Females spawned	Females collected	Adults required 2:1 F:M	NOR's required @pNOB=0.4 2:1 F:M
	Sub-yearling	Fry					
GCPUD	5,000,000	0	5,747,126	1,337	1,519	2,278	911
John Day (PRH)	1,700,000		1,954,023	454	516	775	310
John Day (Ringold)	3,500,000		4,022,989	936	1,063	1,595	638
John Day (YN)	500,000		574,713	134	152	228	91
Total	**10,700,000**	**0**	**12,298,851**	**2,860**	**3,250**	**4,875**	**1,950**

Table 15. Estimated number adipose present fish encountered and retained for broodstock from the Priest Rapids Dam off ladder trap (OLAFT) and Priest Rapids Hatchery volunteer channel trap in 2012.

Trapping facility/broodstock source	Adipose present, non-wired fish collected	Natural origin fish collected at 69% NOR contribution (2011 data)	Natural origin fish collected at 3% NOR contribution rate	Total number of broodstock retained by site[1]
Operation of OLAFT 6d/week,8hr/day	2,322	1,578		**2,322**
PRH Volunteer Trap – assumes 56.7% ad-present[2]	8,897		267	**4,818**
Total Estimated NOR's	1,845			
Estimated pNOB (%NOR'S)	0.378			
Adjusted pNOB	0.348[3]			
Total Ad-present fish encountered	11,219			**7,140[4]**

[1] Includes both unmarked hatchery and natural origin fish retained for broodstock.
[2] Based upon current adipose clip and/or coded wire tag rates for juvenile fish released.
[3] Adjusted for pre-spawn survival of broodstock from collection to spawning (0.88)
[4] Adjusted for exclusion of age-2 and 3 hatchery origin males (by size) at collection. This represents the cumulative number of broodstock which will need to be retained from both the OLAFT and PRH volunteer trap. All fish will have to be otolith sampled at time of spawning to determine H/W origin.

To achieve the number of broodstock retained, as identified in Table 2, an estimated 18,801 adults will have to be handled at the PRH volunteer trap (15,962) and the OLAFT (2,839; Table 3). This will produce approximately 95% of the natural origin adults required to meet an integrated program.

Table 16. Estimate of total and NOR adult fall Chinook, handled and retained at the Priest Rapids Hatchery volunteer channel trap and Priest Rapids Dam OLAFT, in 2012.

Collection Location	Estimate of fish handled	Estimate of ad present non-wired fish handled	Estimate of ad present non-wired fish retained	Estimate of NOR's by location
OLAFT	2,839	2,322	2,322	1,578
Volunteer trap	15,962	8,897	4,818[1]	267
Total	18,801	11,219	7,140	1,845

[1] Adjusted for exclusion of age-2 and 3 hatchery origin males (by size) at collection.

Alternate Table 16 – if active integration does not occur

Table 14. Assumptions and calculations to determine the number of fall Chinook salmon broodstock needed for non-actively integrated Priest Rapids program release of 6,700,000 sub-yearling fall Chinook in addition to 3,500,000 for Ringold and 500,000 for the Yakama Nation, in 2012.

Program Assumptions	Standard	Program objective
Juvenile Production Level		
Grant PUD Mitigation-PUD Funded		**5,000,000**
John Day Mitigation-Federally Funded		**1,700,000**
John Day Mitigation [1]-Ringold Springs-ACOE funding.		**3,500,000**
John Day Mitigation [2]-Yakama N Request		**500,000**
Total Program Objectives		**10,700,000**
Fertilization-to-release survival	*87%*	
Egg take target		**12,298,851**
Fecundity	*4,300*	
Female Target		**2,860**
Female to male ratio	*2:1*	

Pre-spawn survival	*88%*	
Broodstock target		
Females		**3,250**
Males		**1,625**
Total broodstock collection		**4,875**

[1] As of brood year 2009, Priest Rapids Hatchery is taking 3,500,000 eggs for release at Ringold-Meseberg Hatchery funded by the ACOE – incubation of this program occurs at Bonneville.
[2] The Yakama Nation has requested 500,000 fall Chinook eyed eggs from Priest rapids Hatchery for 2012. This request has been submitted to GCPUD and will be conditional upon agreements between YN and GCPUD.

Appendix A

Columbia River Mouth Fish Returns Actual and Forecasts[a/]			
	2011 Forecast	**2011 Return**	**2012 Forecast**
Spring Chinook Upriver Total	**198,400**	**221,200**	**314,200**[b/]
Upper Columbia (total)	22,400	16,500	32,600
Upper Columbia (wild	2,000	2,200	2,800
Snake River Spring/Summer (total)	91,100	127,500	168,000
Snake River (wild	24,700	31,600	39,000
Summer Chinook	**91,100**	**80,600**	**91,200**
Sockeye	**161,900**	**187,300**	**462,000**
Wenatchee	33,000	41,800	28,800
Okanogan	126,800	143,500	431,300
Snake River	2,100	1,900	1,900

a/ Numbers may not sum due to rounding
b/ TAC used a log-normal sibling regression model to forecast the 2012 4-year old returns from the 2011 Bonneville Dam jack count. Log-normal models appear to work relatively well when jack counts are large, and the 2011 jack count at Bonneville Dam was the second highest on record.

Appendix B

DRAFT
Hatchery Production Management Plan

The following management plan is intended to provide life-stage-appropriate management options for Upper Columbia River (UCR) PUD salmon and steelhead mitigation programs. Consistent, significant over-production or under-production risks the PUD's not meeting the production objectives required by FERC and overages in excess of 110% of program release goals violates the terms and conditions set forth for the implementation of programs under ESA and poses potentially significant ecological risks to natural origin salmon communities.
Under RCW 77.95.210 (Appendix A) as established by House Bill 1286, the Washington Department of Fish and Wildlife has limited latitude in disposing of salmon and steelhead eggs/fry/fish. While this RCW speaks more specifically to the sale of fish and/or eggs WDFW takes a broader application of this statute to include any surplus fish and/or eggs irrespective of being sold or transferred.

We propose implementing specific measures during the different life-history stages to both improve the accuracy of production levels and make adjustments if over-production occurs. These measures include (1) Improved Fecundity Estimates, (2) Adult Collection Adjustments, (3) Within-Hatchery Program Adjustments, and (4) Culling.

Improved Fecundity Estimates

A) Develop broodstock collection protocols based upon the most recent 5-year mean in-hatchery performance values for female to spawn, fecundity, Green egg to eye, and green egg to release.

B) Use portable ultrasound units to confirm gender of broodstock collected (broodstock collection protocols assume a 1:1 male-to-female ratio). Ultrsonography, when used by properly trained staff will ensure the 1:1 assumption is met (or that the female equivalents needed to meet production objective are collected). Spawning matrices can be developed such that if broodstock for any given program are male limited sufficient gametes are available to spawn with the females.

Adult Collection Adjustments

C) Make in-season adjustments to adult collections based upon a fecundity-at-length regression model for each population/program and origin composition needs (hatchery/wild). This method is intended to make in-season allowances for the age structure of the return (i.e. age-5 fish are larger and therefore more fecund than age-4 fish), but will also make allowances for age-4 fish that experienced more growth through better ocean conditions compared to an age-5 fish that reared in poorer ocean conditions.

Within-Hatchery Program Adjustments

D) At the eyed egg inventory (first trued inventory), after adjustments have been made for culling to meet BKD management objectives, the over production will be managed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;
- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;
- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;

- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and

- Governmental hatcheries in Washington, Oregon, and Idaho; or

- Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or

- Distribution to approved organizations/projects for research.

E) At tagging (second inventory correction) fish will be tagged up to 110% of production level at that life stage. If the balance of the population combined with the tagged population amounts to more than 110% of the total release number allowed by Section 10 permits then the excess will be distributed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;

- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;

- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;

- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and

- Transfer to another resource manager program such as CCT, YN, or USFWS program;

- Governmental hatcheries in Washington, Oregon, and Idaho;

- Placement of fish into a resident fishery (lake) zone, provided disease risks are within acceptable guidelines; or

- Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or

- Distribution to approved organizations/projects for research.

F) In the event that a production overage occurs after the above actions have been implemented or considered, and deemed non viable for fish health reasons in accordance with agency aquaculture disease control regulations (i.e. either a pathogen is detected in a population that may pose jeopardy to the remaining population or other programs if retained or could introduce a pathogen to a watershed where it had not previously been detected) then culling of those fish may be considered.

All, provisions, distributions, or transfers shall be consistent with the department's egg transfer and aquaculture disease control regulations as now existing or hereafter amended. Prior to department determination that eggs of a salmon stock are surplus and available for sale, the department shall assess the productivity of each watershed that is suitable for receiving eggs.

To: Hatchery Evaluation Technical Team (HETT)

From: HCP Hatchery Committees

Date: 13 March 2012

RE: Request for HETT to develop recommendations regarding the use of temporary natural acclimation sites.

The YN, through the Columbia River Fish Accords, is developing and evaluating natural acclimation sites in the Wenatchee and Methow sub-basins. Acclimation sites developed through this program could be operated as either singles species sites or multi-species sites. A short-term goal of this program is to evaluate potential sites throughout the Wenatchee and Methow basins, with the longer term goal of integrating their use in existing hatchery programs. The potential benefits of the greater use of distributed acclimation include increased distribution of spawners within the spawning habitat (when compared to a single release location), and increased homing fidelity in situations where limited acclimation is currently available. Ultimately, this may contribute to the understanding of how acclimating and releasing fish in a manner that mimics natural systems can increase the effectiveness of integrated hatchery programs.

Consistent with the discussion at the February 2012 HCP Hatchery Committee meeting, the YN is requesting that the Hatchery Committees approve assigning the HETT the task of developing a long-term plan for expanding the use of distributed acclimation sites in existing Wenatchee and Methow sub basin hatchery programs. Specific task would include:

1) Identify priority locations for developing short-term natural acclimation sites based on biological and geographical consideration., Examples of biological and geographical considerations may include current spawning distribution of hatchery and natural fish and available habitat, and potential to address high stray rates.

2) Identify appropriate numbers of fish for natural acclimation versus traditional hatchery or existing acclimation site release locations based on geographical need.

3) Identify monitoring and evaluation needs beyond those already included in the Douglas PUD and Chelan PUD Hatchery Monitoring Programs, including criteria for successful and continued use of an acclimation site.

It is expected that the recommendations received from HETT will be used by the Committees in planning the future role that natural short-term acclimation sites can play in supporting HCP, PRCC, and USFWS (note: USFWS programs are not under the purview of the Committees or HETT).

It is expected that this is a task that the HETT can complete in within the next four months.

Proposal to collect tissue samples from Chinook salmon and steelhead broodstock annually at facilities under the oversight of the HCP Hatchery Committee and PRCC Hatchery Sub Committee

Submitted to:
HCP Hatchery Committee and PRCC Hatchery Sub Committee

Requesting agency:
Columbia River Inter-Tribal Fish Commission
3059-F National Fish Hatchery Rd.
Hagerman, Idaho 83332

Contact information:
Maureen Hess, CRITFC, hesm@critfc.org, 208-837-9096 x1117
Shawn Narum, CRITFC, nars@critfc.org, 208-837-9096 x1120

Objective

In order to expand parentage based tagging (PBT) throughout the Columbia River basin for Chinook salmon and steelhead, we are requesting that tissue samples be collected from all broodstock as fish are spawned in hatcheries above Bonneville Dam starting in 2012 and continuing for the foreseeable future. We are specifically requesting that the following hatchery programs collect tissue samples from 100% of broodstock, and tissues be sent to the appropriate operating agency's genetics lab for storage until the anticipated funding is in place to genotype samples (herein WDFW, USFWS):

Facility	**Species/Program**	**Operator**
Methow Hatchery	Twisp Spring Chinook, MetComp Spring Chinook, Twisp Steelhead, Methow Steelhead	WDFW
Wells Hatchery	Steelhead, Methow Summer Chinook	WDFW
Eastbank	Chiwawa Spring Chinook, Wenatchee Summer Chinook, TurtleRock/Chelan Falls Summer Chinook	WDFW
Willard/LWS	White River Spring Chinook Captive Brood	USFWS
Priest Rapids	Fall Chinook	WDFW

CRITFC can provide sampling supplies in the form of Whatman sheets for spawn year 2012. At a minimum, we ask that a tissue sample be collected upon spawning from every individual fish used as broodstock, and the corresponding spawn date and gender be recorded for each individual. Optional information would include spawn cross records (i.e., which fish were mated together), length, or any other associated data recorded by hatchery staff. It is critical to begin genetically tagging parents in 2012 in order to recover tags from returning adults in subsequent years.

The comprehensive effort of obtaining tissues and implementing the PBT approach will include all salmonid genetics labs (CRITFC, ODFW, WDFW, IDFG, USFWS, NOAA) involved in research in the Columbia River basin, and data is intended to be shared within a centralized database.

Background

Several committees and science review groups have recommended that large-scale evaluations of PBT technology be performed (PFMC 2008; PSC 2008; ISAB/ISRP 2009). Thus far, PBT has been effectively applied to Chinook salmon and steelhead populations in California (Anderson & Garza 2006; Anderson 2010) and throughout the Snake River basin (Steele et al. 2011) for accomplishing a variety of objectives including identification of hatchery parents of harvested fish, strays, returning adults, and outmigrating juveniles.

PBT technology greatly reduces the problem of small sample sizes encountered with CWTs, and thus would provide the statistical power needed to improve escapement estimates and identification of stock contributions to fisheries. By genotyping 100% of parental broodstock, 100% of all offspring are genetically tagged. Implementation of PBT involves annual sampling of hatchery broodstock to create a parental genotype baseline. Offspring produced by these parents must then be sampled (e.g. non-lethal fin clips) either as adults or juveniles, and then genotyped to be assigned back to their parents – thus identifying their age and hatchery of origin. This new PBT approach will provide many opportunities to address additional questions related to fisheries management and strongly complements the existing CWT program in the Columbia Basin.

Literature cited

Anderson EC, Garza JC. 2006. The power of single-nucleotide polymorphisms for large-scale parentage inference. Genetics 172: 2567–2582.

Anderson EC. 2010. Computational algorithms and user-friendly software for parentage-based tagging of Pacificc salmonids. Report submitted to the Pacific Salmon Commission. http://swfsc.noaa.gov/publications/CR/2010/2010Anderson.pdf

Hankin DG, Fitzgibbons J, Chen T. 2009. Unnatural random mating policies select for younger age at maturity in hatchery Chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Sciences 66: 1505–1521.

Steele CA, Campbell MR, Ackerman M, McCane J, Hess MA, Campbell N, Narum SR. 2011. Parentage Based Tagging of Snake River hatchery steelhead and Chinook salmon. Bonneville Power Administration. Annual Progress Report, Project number 2010-031-00. https://research.idfg.idaho.gov/Fisheries%20Research%20Reports/Res11-111Steele2010%20Parentage%20Based%20Tagging%20Snake%20River%20Steelhead%20Salmon.pdf

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	May 21, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the April 18, 2012, HCP Hatchery Committees' Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees' meeting was held at the Chelan PUD Headquarters Auditorium in East Wenatchee, Washington, on Wednesday, April 18, 2012, from 9:30 am to 3:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Chelan PUD will convene a sub-group of the Hatchery Committees to develop a conceptual proposal for evaluating the relative benefits of overwinter acclimation versus alternative rearing strategies (e.g., water re-use in circular tanks) to improve smolt-to-adult survival rates (SARs) and reduce straying in summer Chinook hatchery programs (Item II-A).
- Mike Schiewe will contact Craig Busack to discuss the timing of the National Marine Fisheries Service (NMFS) developing Endangered Species Act (ESA) Section 10 permits for HCP hatchery programs, and the Hatchery Committees planned update of the Hatchery Monitoring and Evaluation (M&E) Plan (Item II-B).
- Greg Mackey will provide an overview of the Principles of Adaptive Management at the May 17, 2012 Hatchery Committees' meeting, as it relates to the Hatchery M&E Plan update (Item II-B).
- Josh Murauskas will email a copy of Dr. Kim Hyatt's, Fisheries and Oceans Canada, presentation to Kristi Geris for distribution to the Hatchery Committees (Item IV-A).
- Bill Gale will email to Kristi Geris, for distribution to the Hatchery Committees, scientific papers regarding the volitional release of hatchery smolts (Item V-A).
- Josh Murauskas will email Chelan PUD's data on the volitional release of Chiwawa hatchery steelhead to Kristi Geris for distribution to the Hatchery Committees (Item

V-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- The Hatchery Committees agreed to defer voting on Columbia River Inter-Tribal Fish Commission's (CRITFC's) Steelhead and Spring Chinook Genetic Sampling Request Statement of Agreement (SOA) (Item III-A).

AGREEMENTS

- The Hatchery Committees agreed to begin discussions on updating the Hatchery Program M&E Plan and communicating with NMFS on the pending Section 10 permits (Item II-B).

REVIEW ITEMS

- The Douglas PUD Draft 5-Year M&E Report is available for a 60-day review. Comments are due to Greg Mackey by April 27, 2012.
- The Chelan PUD Draft 2011 Hatchery M&E Annual Report is available for a 60-day review. Comments are due to Tracy Hillman by June 4, 2012.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and introduced Kristi Geris as new Anchor QEA support staff to the Committees. Schiewe reviewed the agenda; the following agenda items were added:

- Mike Tonseth added a discussion of disposition of residual juvenile steelhead following spring 2012 releases.
- Josh Murauskas said he would like to include in the same agenda item a discussion of volitional versus forced release of juvenile steelhead from the Chiwawa Facility.

Mike Schiewe said that the Priest Rapids Coordinating Committee (PRCC) had asked if the Hatchery Committees could move their May 2012 meeting from May 16 to May 17 to accommodate PRCC Hatchery Subcommittee attendance at the Chelan County Commissioners' meeting on May 16 to discuss development of Grant PUD's Nason Creek Acclimation Facility. Schiewe asked for Committees members' availability to accommodate the requested meeting date change. All Committees members agreed to changing the May meeting date to May 17, 2012, pending Chelan PUD and Douglas PUD confirmation to Schiewe of their availability. Greg Mackey will confirm the availability of a meeting room at Douglas PUD.

The revised draft March 28, 2012 meeting minutes were reviewed. Carmen Andonaegui said that the draft minutes were initially provided to the Committees by email on April 16, 2012. A revised draft was emailed to the Committees today, April 18, 2012, just prior to the meeting. Committees members discussed the revised draft meeting minutes. The Committees discussed the meeting protocols. Andonaegui will clarify in the March 28, 2012 meeting minutes that informal agreements reached at the meeting were those of the Committees members present. For the record, Gale stated his approval with the decision items at the March 28, 2012, meeting. The Committees approved the March 28, 2012, meeting minutes, as revised.

II. Chelan PUD

A. Dryden Overwintering Feasibility (Josh Murauskas)

Josh Murauskas initiated discussion of potential benefits of overwinter acclimation at Dryden (i.e., reduced stray rates, increased SARs) by reviewing empirical data collected as part of the Hatchery M&E Program (Attachment B and C). He presented a multivariate analysis on roughly 60 variables collected over the past 17 years through the M&E prorgram. The data suggested that there are several operational factors at the Dryden Facility that contribute to stray rates, SARs, and mini-jack rates. For example, the multivariate model significantly ($p < 0.05$) explained a majority of the variation in stray rates through release timing and proportion of natural-origin brood.

The Hatchery Committees discussed the multiple variables associated with the acclimation conditions used in the analysis and how the variation might have affected SARs. In response to a question about the Join Fisheries Parties' (JFP's) preferred alternative of modifying facilities and converting to overwinter acclimation at Dryden, Murauskas said that Chelan PUD wanted the Committees to consider water re-use and circular tank rearing at Eastbank Hatchery, and continued spring acclimation at Dryden Facility for the summer Chinook program. Joe Miller said that the Washington State Department of Ecology's (Ecology) addendum to the Wenatchee Total Maximum Daily Load (TMDL) established a modified phosphorus target not to exceed 743 micrograms per liter for the entire Wenatchee River. Miller said that he hoped the Committees would develop an agreeable, pragmatic approach for acclimation at the Dryden Facility that will meet hatchery program goals and targets using available M&E data. Bill Gale said that it was his impression that overwintered juvenile fish had better SARs, especially for the Okanogan smolts. Mike Tonseth said the Similkameen program was an example of a program showing the benefits of overwintering for SARs. Tom Kahler said that it was not clear whether the improved SARs were the result of overwintering or the result of other hatchery practices affecting those juvenile fish such as growth rates, relative size at age, or water temperature. Keely Murdoch said that there was other literature that documented the benefits of the use of surface water and overwinter acclimation. The Committees discussed the potential to empirically test the effects of overwinter acclimation versus the effects of water re-use and circular tanks and continued spring acclimation. Murauskas reiterated that he was not recommending water re-use and circular tanks as the best acclimation strategy to improve survival and productivity, but that his intent was to approach the question based on the analysis of empirical data, and that re-use acclimation tanks and smaller size-at-release were examples of changes that should be considered.

Gale suggested that it was important to consider changing the water source for the Dryden Facility from irrigation canal water to another water source. The Committees discussed the benefits of having a dedicated water supply other than from the irrigation canal, and the relative risks associated with developing or not developing an alternate water source. Miller suggested first identifying the hatchery operations that might influence straying and improve SARs, and then discussing the facility infrastructure modifications needed to implement those operations. Mike Schiewe asked Chelan PUD if they would be willing to develop for review by the Committees a study proposal to evaluate the benefits of overwintering compared to other alternatives. Kirk Truscott suggested that Chelan PUD develop a conceptual approach to which the Committees could respond, rather than a fully developed study proposal, and that Chelan PUD do so in coordination with the Committees. Gale and Truscott said that they would like to participate in the development of a conceptual proposal. Murdoch reiterated that she still sees the need for a dedicated water intake to provide an alternate source of water for facility operations. Tonseth said he would like to see consideration of fish health at the Dryden Facility included as an objective in the conceptual proposal. Chelan PUD agreed to convene a subgroup of the Committees to develop a conceptual approach to investigating Dryden Facility improvement needs for the Committees' review and further development.

B. Draft 2011 Hatchery M&E Annual Report (Josh Murauskas)

Josh Murauskas said that Tracy Hillman, BioAnalysts, had completed the draft 2011 Hatchery M&E Annual Report and it was available for review, with comments due June 4, 2012. He said that comments on the Chelan PUD draft 5-Year M&E Report were due April 6, 2012; and Hillman is finalizing this report. Mike Schiewe said that, at the next Hatchery Committees meeting, he would like to begin discussion of the conclusions from the 5-Year M&E Report. He said that the Committees should consider whether Hatchery M&E Program objectives need to be revisited, whether the analytical framework needs to be updated, and whether new information needs to be collected. Schiewe asked for the Committees' preference on how to move forward with updating the Hatchery M&E Program in consideration of the conclusions reached in the 5-Year M&E Report.

Murauskas said that the PUDs had been discussing adjustments to their M&E Plans with the goal of improving M&E program efficiency. Greg Mackey said that the M&E Plan update was scheduled by the HCPs to occur in 2012, and that the 5-Year M&E Report should inform the update as well as the consideration of new monitoring technology. Bill Gale inquired about changing the M&E Program prior to completion of the NMFS Hatchery Genetic Management Plan (HGMP) consultations. Mike Schiewe said that he would contact Craig Busack to discuss the linkage between the ESA Section 10 permit in consideration of the Committees' planned update of the M&E Plan. Mike Tonseth said that it is critical that M&E activities not result in take of ESA-listed species that exceeds what is specified in the Incidental Take Statements of the new Section 10 permits because exceeding take automatically triggers reinitiation of ESA consultation. The Committees agreed to begin discussions on updating the M&E Plan and communicating with NMFS on the emerging Section 10 permits. Mackey said that he would make a presentation on the Principals of Adaptive Management at the May 17, 2012 meeting; Kristi Geris will place this item on the May agenda. Chelan PUD and Douglas PUD will begin compiling information for use by the

Committees for the M&E Plan update. Schiewe encouraged other Committees members to bring forward relevant information to the Committees.

III. Yakama Nation

A. CRITFC Steelhead and Spring Chinook Genetic Sampling Request SOA (Keely Murdoch)

Mike Schiewe said that Craig Busack's email on April 9, 2012, stated that he was not ready to approve the SOA without additional details being worked out on the CRITFC sampling proposal. He said that the lack of approval of the SOA did not keep individual parties from providing samples as interested. Keely Murdoch said that she would talk with Busack to find out what his specific concerns were with the proposal. Mike Tonseth said that Washington Department of Fish and Wildlife (WDFW) geneticists had expressed the same concerns as those he had heard expressed by Busack regarding the need for standardization of sampling methods and analyses. He added that WDFW was supportive of the concept but that discussions regarding details were still ongoing among federal and state geneticists. Murdoch agreed that the CRITFC proposal was not ready for a vote today. Schiewe suggested that Murdoch talk with Maureen Hess about further coordination with agency geneticists and then bring the request back to the Committees if CRITFC so chooses.

IV. Douglas PUD

A. Fish Water Management Tool (Kim Hyatt and Margo Stockwell, Fisheries and Oceans Canada)

Mike Schiewe introduced Dr. Kim Hyatt and Margo Stockwell, Fisheries and Oceans Canada, to summarize recent implementation of the Fish and Water Management Tool (FWMT). He said that Rich Bussanich, Okanagan Nation Alliance (ONA), was on the phone. Bussanich coordinates the Skaha Lake Hatchery Program. Hyatt provided an overview of the FWMT (Attachment D). He presented background data on the Columbia River sockeye population, saying that 81 percent of the sockeye return aggregate (1970-2011) was made up of Okanagan wild sockeye, based on counts at Bonneville Dam and harvest data. He presented information on the factors contributing to rebuilding of the Okanagan sockeye salmon run since 2004-2005, when the FWMT was first implemented, and he provided information on the geography of the Okanagan River Basin, its water management control points, and its hydrology. Hyatt described the factors that drive water management decisions in the Okanagan River Basin, the issues that affect water management decisions, and the history of compliance with providing fishery flows prior to 1997. He noted that the lack of compliance was often the result of competing rules and objectives.

Hyatt described the development of the FWMT, starting with the development of a program to model flow versus water needs during key sockeye salmon life stages. He described how available habitat was modeled as a function of flow and how the quantity of habitat could be controlled by flow. Hyatt presented the results of an evaluation of risks, by life stage, to the Osoyoos Lake sockeye population as a result of a temperature-oxygen "squeeze," a density-independent rearing limitation in Osoyoos Lake, during the drought year of 2008-2009. He said that flows into Okanagan Lake were monitored on a real-time basis, allowing water managers to monitor potential effects on fish in Osoyoos Lake, and to make informed decisions on water use for fish. He noted that these decisions were especially important during drought years. Hyatt described in detail conditions and water management during the high snowpack in 2010-2011 when fry emergence was monitored and the FWMT was used to allow for as-early-as-possible water releases for flood control.

Hyatt presented data on potential escapement levels that the Okanagan River Basin could support, given access to habitat and water management, and the lack of density-dependent factors. He said that sockeye natural production has been increased 5-to-10 fold in the Okanagan River Basin through use of the FWMT. Hyatt said that later this year he will prepare a report to the Hatchery Committees providing an overview of the FWMT and the contributions it has made to natural sockeye production. He said that it would be a weight-of-evidence assessment on how changing water use has reduced density-independent losses and that the increase in population abundance is primarily a function of the FWMT, not a function of ocean conditions.

Josh Murauskas asked whether favorable ocean and river conditions could result in exceeding the maximum habitat carrying capacity in the Osoyoos Lake. Hyatt said that the fish were already testing the upper limits of carrying capacity by placing eggs into marginal habitat. However, he said that even with 10 million fry in Osoyoos Lake, there did not appear to be an effect on food supply. Hyatt said that spawning ground capacity would become limiting before lake rearing capacity becomes an issue. He said that he thinks Osoyoos Lake could support an average annual production of 100,000 adults with escapement of 60,000. Hyatt responded to Committees' questions regarding production potential of the entire Okanagan River Basin system. He said that natural fry production limited abundance and discussed the fisheries managers' opposition to restoring anadromy to Okanagan Lake. He discussed how opposition to free passage into Skaha Lake was initially based on perceived competition between kokanee and sockeye, but that if the current experiment proves that both resident fish and anadromous fish could be sustained in Skaha Lake, then free passage may be instated.

Josh Murauskas said he will email a copy of Dr. Kim Hyatt's, Fisheries and Oceans Canada, presentation to Kristi Geris for distribution to the Hatchery Committees.

V. WDFW

A. Residual Steelhead Associated With Juvenile Steelhead Releases (Mike Tonseth)

Mike Tonseth said that there is a need to discuss the management of non-migrating juvenile hatchery steelhead because the ESA Section 10 permit under which the hatcheries operate limits the release of non-migrating fish. He said that currently hatchery managers have been employing volitional release at Wells Hatchery, with varying numbers of non-migrants ultimately being forced out. Volitional release has also been used for Wenatchee steelhead reared in water-re-use circular tanks as well, with non-migrants also ultimately being forced out. Because of the Section 10 limitations, he was looking for recommendations from the Hatchery Committees on the management of non-migrating Wells and Chiwawa steelhead in 2012.

Bill Gale said that at the Winthrop National Fish Hatchery, the U.S. Fish and Wildlife Service (USFWS) will use volitional release this year in its steelhead program, and transfers non-migrant steelhead to ponds for recreational fishing. Gale said that there are two published studies supporting this approach, and indicated that he will email these to Kristi Geris for distribution to the Hatchery Committees. Gale suggested keeping track of the number of non-migrants at the Wells Hatchery and the Chiwawa Facility, so the number of non-migrants produced could be tallied to monitor the extent to which the residualism rate might be reducing smolt production. Non-migrants that did not carry a passive integrated transponder (PIT) tag could be collected and placed in ponds for recreational fishing, and PIT-tagged non-migrants could be forced out of the acclimation ponds and their behavior monitored. The Committees discussed possible alternatives for setting an endpoint for the volitional release period, forcing out or collecting the non-migrants, and transferring all or only non-PIT-tagged non-migrants to ponds for fisheries. Tonseth said that he did not need a decision at today's meeting, but that he would need a decision by mid-May 2012, about what to do with non-migrants from the Wells Hatchery and the Chiwawa Facility. Tonseth said that he will look at the draft Wenatchee steelhead HGMP to see what it says about how non-migrant hatchery steelhead are to be handled. Keely Murdoch said that she wanted to discuss the issue internally with staff. Tonseth said that, because this was an ESA issue, he would also discuss it with NMFS.

Josh Murauskas said that, based on 2010 and 2011 results, which showed no significant difference in survival and travel time to McNary Dam between volitional and non- volitional fish, the Committees may want to consider eliminating volitional release of Wenatchee steelhead reared in the water re-use circular tanks at the Chiwawa Facility, and release them all at once. Kirk Truscott indicated that he favored continuing the volitional release of Chiwawa steelhead as there were less than 20 percent non-migrants. Truscott noted that a letter of approval would be needed from NMFS if non-migrants were used in a fishery, as was required for Blackbird Pond. Greg Mackey said that Douglas PUD would support a proposal to transfer non-migrants to ponds for fisheries, but that Douglas PUD would want credit for the juvenile production. Gale said that a meeting of the JFP was being scheduled, and that they would further discuss management of non-migrant steelhead. Gale said that if the JFP reached a consensus on an approach to managing the non-migrants, he would contact Mike Schiewe for full Hatchery Committees' approval. Truscott said that the JFP also needed to discuss whether the 200,000 Wenatchee steelhead reared in raceways at Chiwawa would be treated the same as the circular tank steelhead (i.e., volitional release and then push out the non-migrants). Murauskas said that the 2010 and 2011 PIT-tagging results showed that a significant proportion of the "non-migrants" that were forced out actually migrated to McNary Dam at a significant rate and he would send to Geris, for distribution to the Committees, these results.

VI. HETT Update

Mike Schiewe said that, with Carmen Andonaegui's departure from Anchor QEA, Anchor QEA would play a lesser role in the Hatchery Evaluation Technical Team (HETT) until the

Non-Target Taxa of Concern (NTTOC) risk analysis group completed the modeling, and should again need administrative support. At that time, Anchor QEA can resume providing administrative support, if requested.

VII. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees' meetings are May 17, 2012 (Douglas PUD office), June 20, 2012 (Chelan PUD office), and July 18, 2012 (Douglas PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – Chelan PUD Dryden Feasibility Discussion Presentation
Attachment C – Chelan PUD Dryden Monitoring and Stray Data
Attachment D – Fish and Water Management Tool Presentation

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Carmen Andonaegui	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Joe Miller	Chelan PUD
Bill Gale	USFWS
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Rick Klinge†	Douglas PUD
Keely Murdoch*	Yakama Nation
Kirk Truscott*	CCT
Kim Hyatt	Fisheries and Oceans Canada
Margo Stockwell	Fisheries and Oceans Canada
Rich Bussanich†	Okanagan Nation Alliance
Mike Tonseth*	WDFW
Todd Pearsons	Grant PUD

Notes:

* Denotes Hatchery Committees member or alternate

†Joined by phone for the presentation on the Fish-Water Management Tool (Item IV-A)

Attachment B

Dryden Feasibility Discussion

J. Murauskas

April 18, 2012

Program improvements

- All parties benefit from:
  - Increased SARs
  - Decreased stray rates
  - Increased age at maturity
  - Decreased environmental footprint
  - Successful program modifications

Empirical evidence at Dryden

- Hatchery Monitoring and Evaluation
- Re-use technology
- Size-at-release and maturity

M&E data (stray rates)

- Over 60 variables – 17 years
- Pair-wise correlations on 15 variables
- Subsequent multiple regression
- Inverse predictions

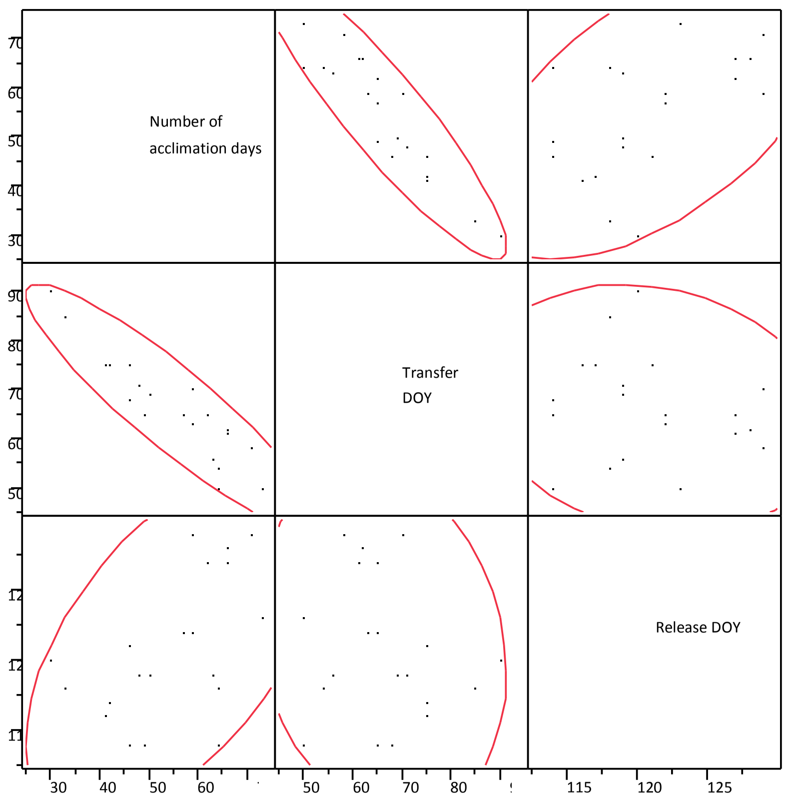
M&E data (stray rates)

- Release DOY (40.5%, p < 0.01)
- pNOB (39.6%, p < 0.01)
- Smolts released (26.3%, p = 0.04)

Significant

- Days acclimated (18.0%, p = 0.09)
- SARs (17.9%, p = 0.09)

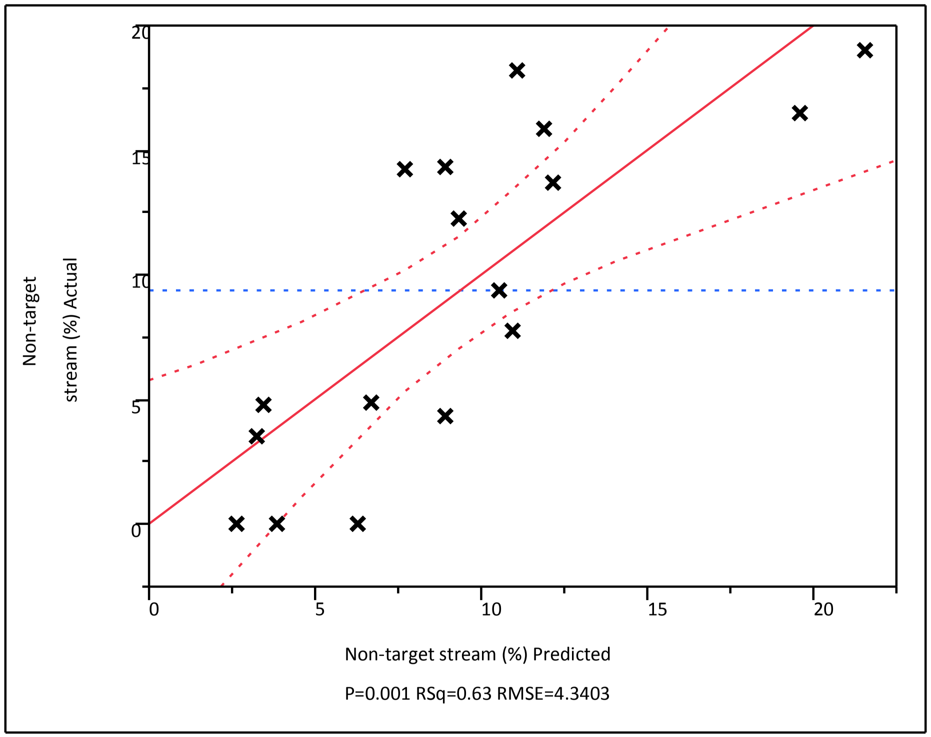
Release DOY vs. other dates



- Release DOY
  - <u>Significant</u>
  - Not related to transfer
  - Moderate relation to days
- Transfer DOY
  - <u>Not significant</u>
  - Related to total days
- Total days
  - <u>Not significant</u>
  - Related to transfer DOY

Attachment B

Modeling results



- Only two variables
  - Release DOY
  - pNOB
- Model results
  - $R^2 = 63\%$
  - $p = 0.001$
- Other variables
  - Not significant in predicting stray rate

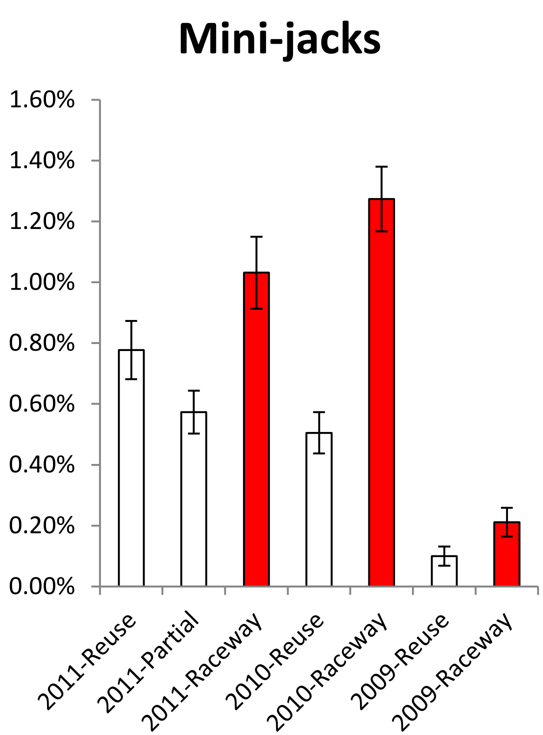
Inverse predictions

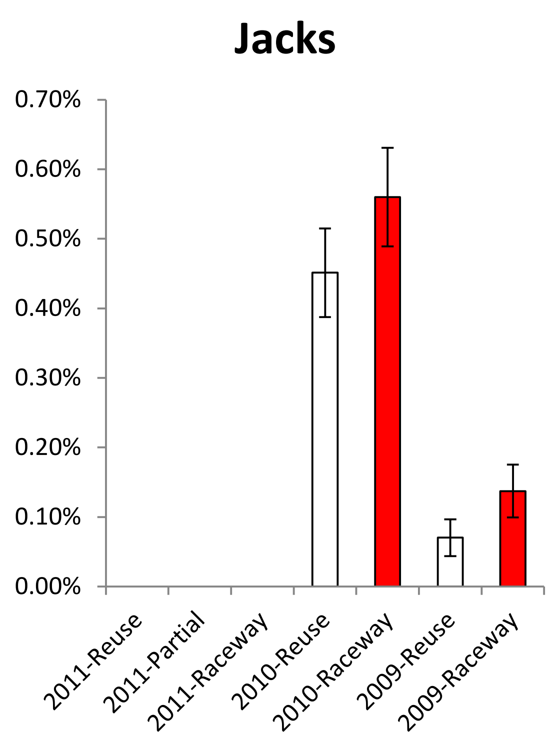
Stray Rate	DOY = 130	DOY = 125	pNOB = 100%
Non-target stream (%)	Predicted pNOB	Predicted pNOB	Predicted Release DOY
5.0	85%	100%	125.1
7.5	73%	88%	121.0
10.0	60%	75%	116.9
12.5	48%	63%	112.8

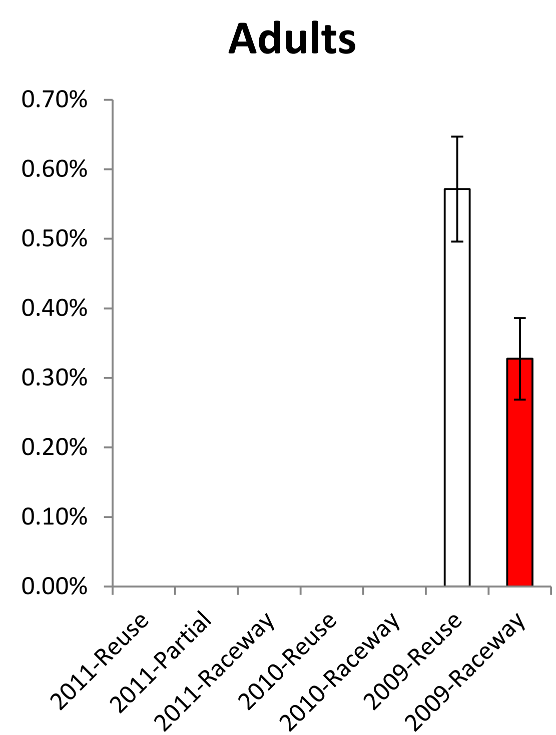
*DOY 125 = May 4^{th}

Re-use results (SARs and age)

- Re-use = lower Age 2/3, higher Age 4+



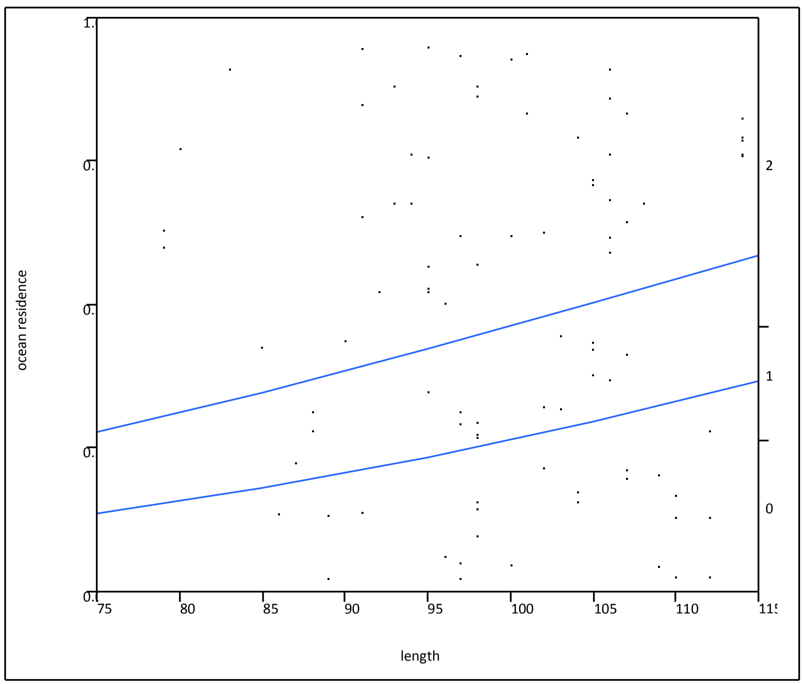




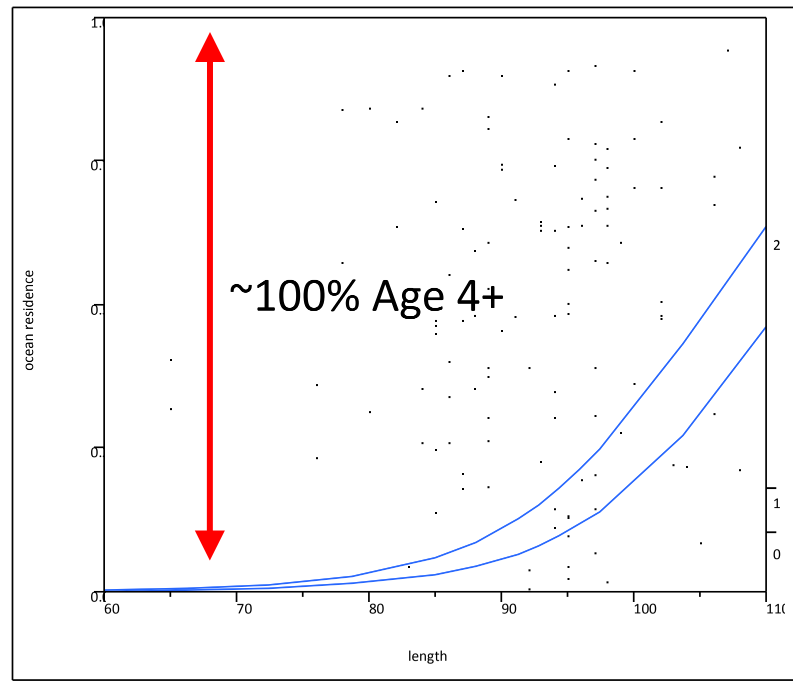
Attachment B

Size-at-release (age)

Raceway (*p* = 0.194)



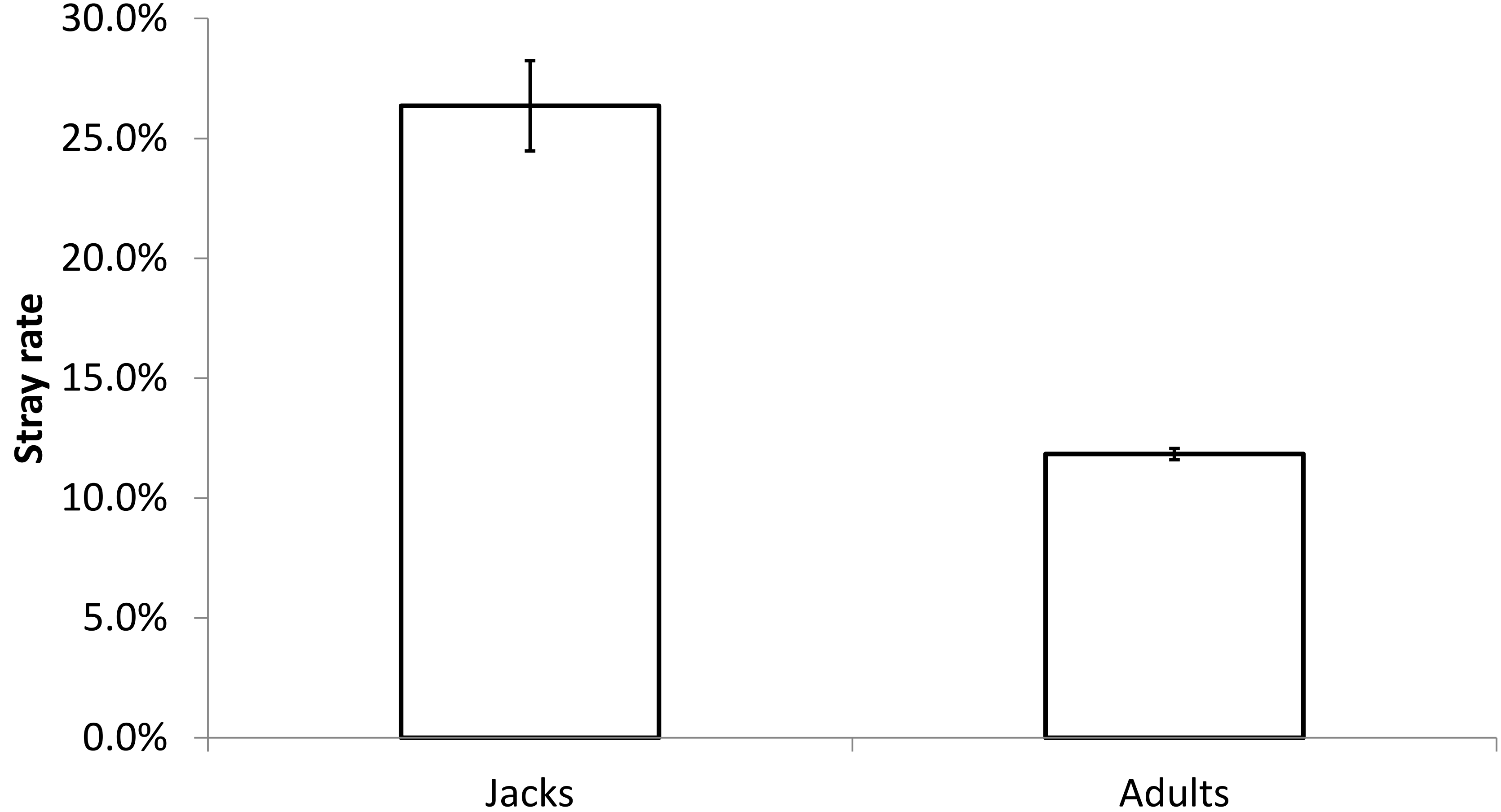
Re-use (*p* < 0.01)



** Re-use fish benefit from reduced size targets*

Attachment B

CWT data (BY ‘89-’05)



Conclusions

Decreased stray rates

- Operational changes
  - Delay releases
  - Increased pNOB
  - Decrease program size
  - Improve other programs
- Improved age structure
  - Increase FPP targets
  - Use of circular rearing

Improved survival

- Circular rearing
  - Faster smolt travel times
  - Higher smolt survival
  - ≥ 74% increase in adults
- Decrease mini-jack rates
  - MJs = mortality in SARs
  - Ecological interactions

DRYDEN MONITORING AND STRAY DATA

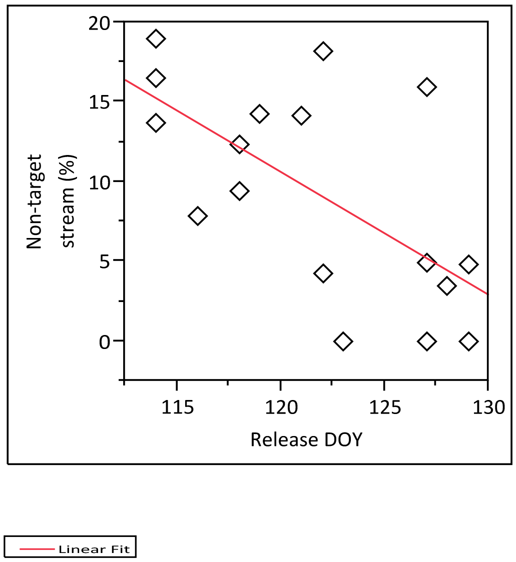
ABSTRACT

Multivariate analyses were conducted on 15 variables measured at Dryden Acclimation Ponds (Dryden) over a 17-year period to determine which variables were strongly related to stray rates. Variables with strongest correlations were subsequently analyzed by linear regression then modeled in a multiple regression using standard least squares with an emphasis on effect leverage (hereafter, model). Findings indicated that release day of year (DOY) was most related to stray rates, explaining 40.5% of the annual variation ($p < 0.01$). Proportion of natural-origin brood (pNOB) was found to be the second-most related factor to stray rates, explaining 39.6% of the annual variation ($p < 0.01$). The number of smolts released was found to be the third-most related factor to stray rates, explaining 26.3% of the annual variation ($p = 0.04$). Number of days in acclimation had a slight negative relationship to stray rates, though the relationship was not significant ($R^2 = 18.0\%$, $p = 0.09$). Likewise, smolt-to-adult returns (SARs) had a positive relationship with stray rates, though the relationship was not significant ($R^2 = 17.9\%$, $p = 0.09$). The model was ran with all five variables and only two factors were found to be significant in predicting stray rates: release DOY and pNOB. The model including only these two variables combined was highly significant ($p = 0.001$) and able to account for 62.6% of the annual variation in stray rates. Inverse predictions indicate that stray rates would be reduced under a static release date in combination with increasing pNOB, or, alternatively, an increasing release date with a 100% pNOB.

CONTENTS

LINEAR REGRESSIONS

BIVARIATE FIT OF NON-TARGET STREAM (%) BY RELEASE DOY



Linear Fit

Non-target stream (%) = 103.43796 - 0.7735229*Release DOY

Summary of Fit

RSquare	0.404995
RSquare Adj	0.365328
Root Mean Square Error	5.292045
Mean of Response	9.341176
Observations (or Sum Wgts)	17

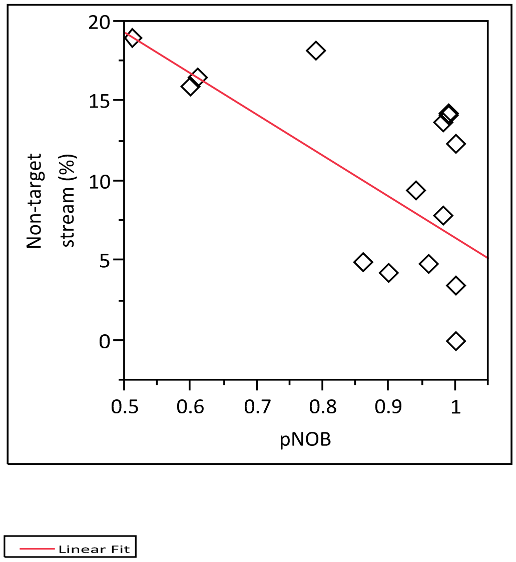
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	285.93501	285.935	10.2099
Error	15	420.08616	28.006	**Prob > F**
C. Total	16	706.02118		0.0060*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	103.43796	29.47656	3.51	0.0032*
Release DOY	-0.773523	0.242082	-3.20	0.0060*

BIVARIATE FIT OF NON-TARGET STREAM (%) BY PNOB



Linear Fit

Non-target stream (%) = 32.214233 - 25.734081*pNOB

Summary of Fit

RSquare	0.395811
RSquare Adj	0.355532
Root Mean Square Error	5.332731
Mean of Response	9.341176
Observations (or Sum Wgts)	17

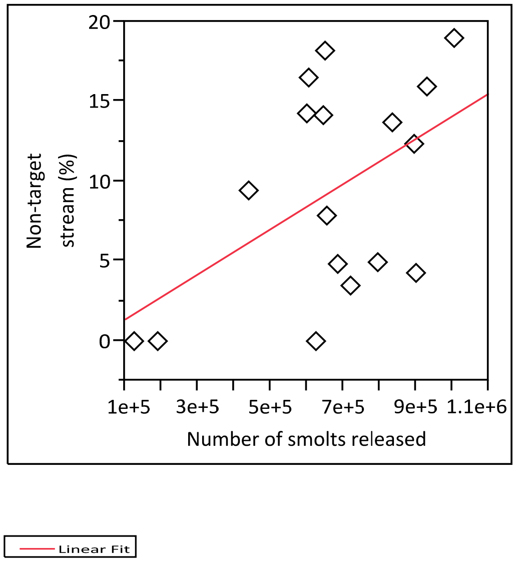
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	279.45092	279.451	9.8267
Error	15	426.57025	28.438	**Prob > F**
C. Total	16	706.02118		0.0068*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	32.214233	7.410353	4.35	0.0006*
pNOB	-25.73408	8.209289	-3.13	0.0068*

BIVARIATE FIT OF NON-TARGET STREAM (%) BY NUMBER OF SMOLTS RELEASED



Linear Fit

Non-target stream (%) = -0.097447 + 0.0000142*Number of smolts released

Summary of Fit

RSquare	0.263111
RSquare Adj	0.213985
Root Mean Square Error	5.889308
Mean of Response	9.341176
Observations (or Sum Wgts)	17

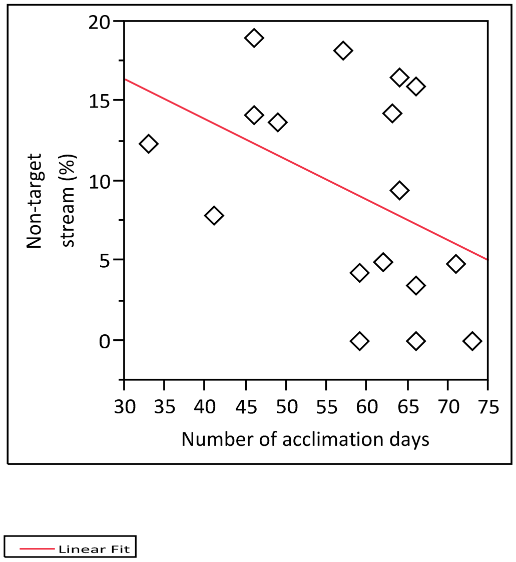
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	185.76186	185.762	5.3558
Error	15	520.25932	34.684	**Prob > F**
C. Total	16	706.02118		0.0352*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.097447	4.321337	-0.02	0.9823
Number of smolts released	0.0000142	6.134e-6	2.31	0.0352*

BIVARIATE FIT OF NON-TARGET STREAM (%) BY NUMBER OF ACCLIMATION DAYS



Linear Fit

Non-target stream (%) = 24.0023 - 0.2530346*Number of acclimation days

Summary of Fit

RSquare	0.180007
RSquare Adj	0.125341
Root Mean Square Error	6.212527
Mean of Response	9.341176
Observations (or Sum Wgts)	17

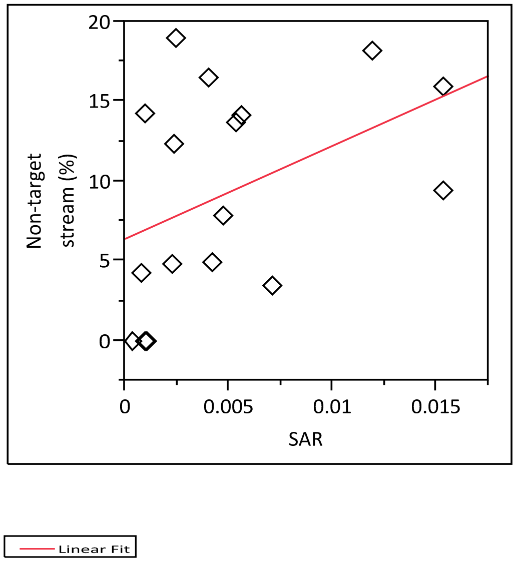
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	127.08887	127.089	3.2928
Error	15	578.93231	38.595	**Prob > F**
C. Total	16	706.02118		0.0896

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	24.0023	8.218748	2.92	0.0105*
Number of acclimation days	-0.253035	0.139442	-1.81	0.0896

BIVARIATE FIT OF NON-TARGET STREAM (%) BY SAR



Linear Fit

Non-target stream (%) = 6.4433522 + 581.75499*SAR

Summary of Fit

RSquare	0.179202
RSquare Adj	0.124483
Root Mean Square Error	6.215574
Mean of Response	9.341176
Observations (or Sum Wgts)	17

Analysis of Variance

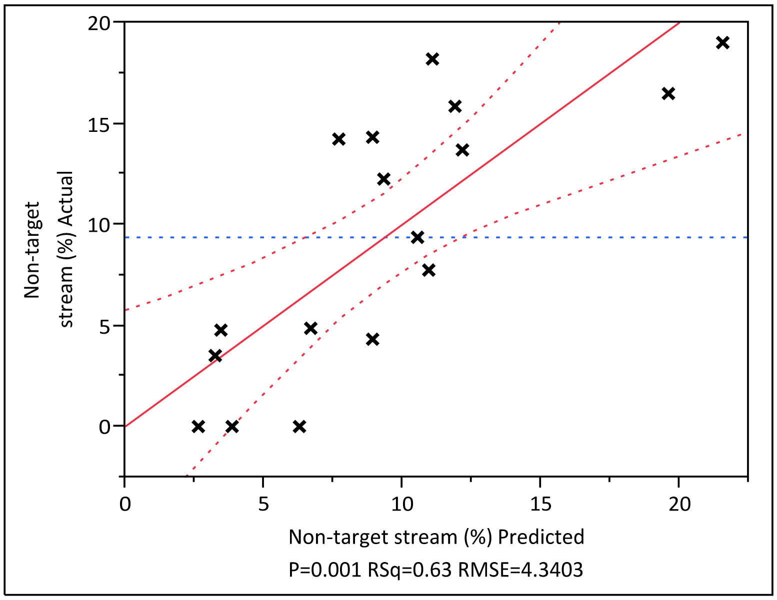
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	126.52076	126.521	3.2749
Error	15	579.50042	38.633	**Prob > F**
C. Total	16	706.02118		0.0904

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	6.4433522	2.199252	2.93	0.0103*
SAR	581.75499	321.47	1.81	0.0904

MULTIPLE REGRESSION MODEL (STANDARD LEAST SQUARES; EFFECT LEVERAGE)

ACTUAL BY PREDICTED PLOT



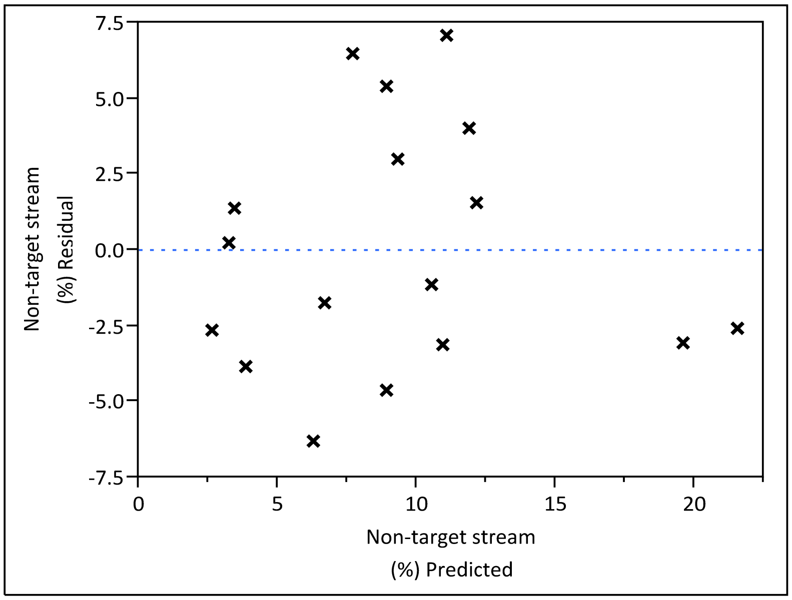
Summary of Fit

RSquare	0.626445
RSquare Adj	0.57308
Root Mean Square Error	4.340322
Mean of Response	9.341176
Observations (or Sum Wgts)	17

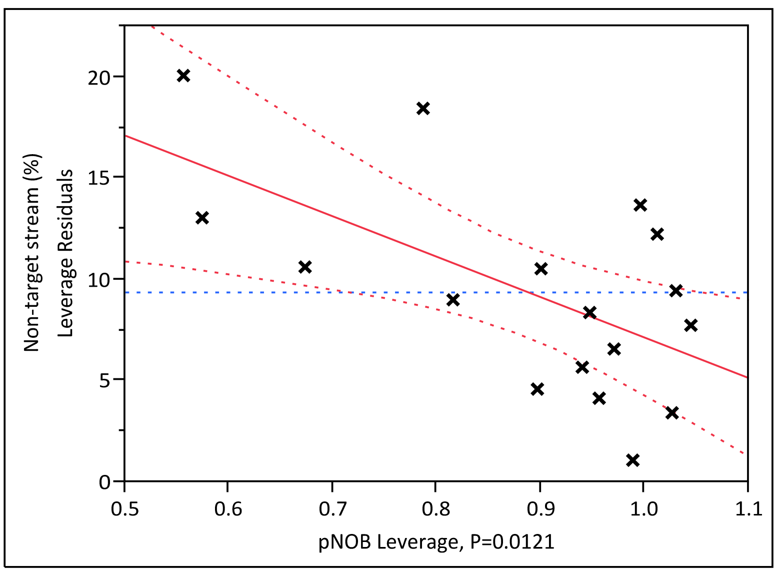
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	442.28367	221.142	11.7389
Error	14	263.73751	18.838	**Prob > F**
C. Total	16	706.02118		0.0010*

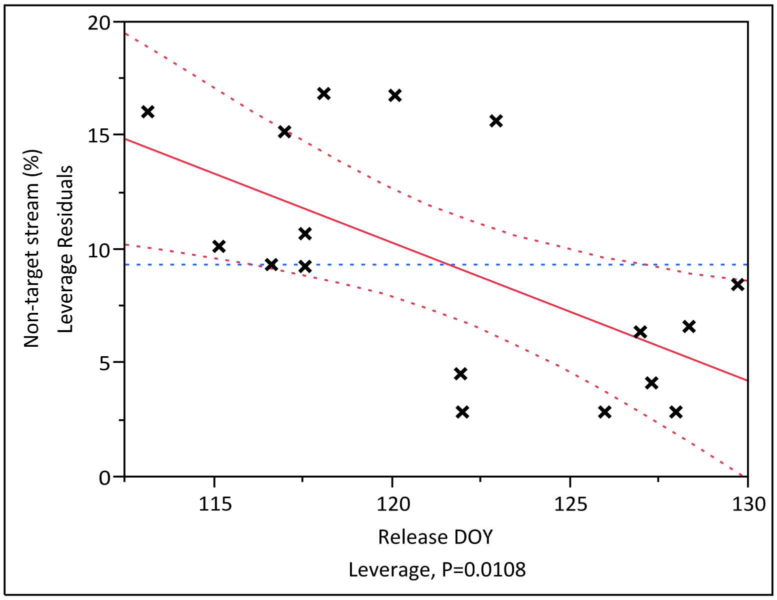
RESIDUAL BY PREDICTED PLOT



PNOB LEVERAGE PLOT



RELEASE DOY LEVERAGE PLOT



INVERSE PREDICTIONS

INVERSE PREDICTION, DOY = 130

Non-target stream (%)	Predicted pNOB	Lower Limit	Upper Limit	1-Alpha
5.000000	0.852132776	0.35952764	1.08165429	0.9500
7.500000	0.727387764	-0.05667284	0.93812679	
10.000000	0.602642753	-0.51090399	0.83262995	
12.500000	0.477897742	-0.98037177	0.74236974	

INVERSE PREDICTION, DOY = 125

Non-target stream (%)	Predicted pNOB	Lower Limit	Upper Limit	1-Alpha
5.000000	1.00376008	0.86505962	1.35932925	0.9500
7.500000	0.87901507	0.62306007	1.04160082	
10.000000	0.75427006	0.21581084	0.88912206	
12.500000	0.62952505	-0.24672821	0.79193313	

INVERSE PREDICTION, PNOB = 100%

Non-target stream (%)	Predicted Release DOY	Lower Limit	Upper Limit	1-Alpha
5.000000	125.123991	120.238506	135.550844	0.9500
7.500000	121.010451	111.957157	126.245655	
10.000000	116.896910	99.093687	121.522587	
12.500000	112.783370	84.698574	118.331161	

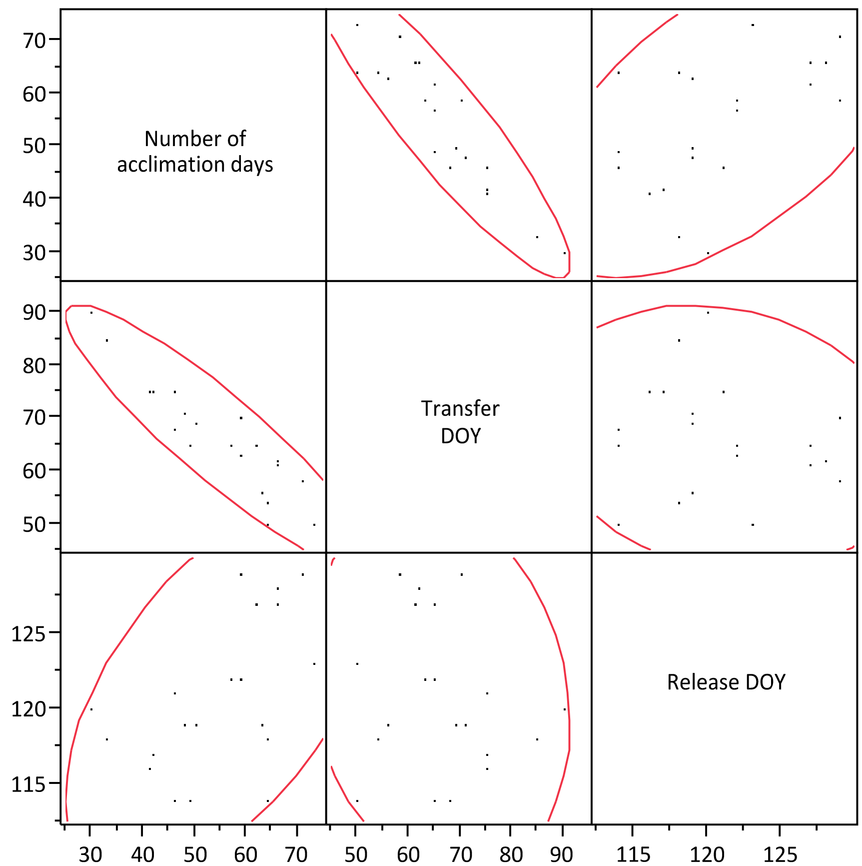
Attachment C

MULTIVARIATE CORRELATIONS (ACCLIMATION PERIOD)

	Number of acclimation days	Transfer DOY	Release DOY
Number of acclimation days	1.0000	-0.9138	0.5571
Transfer DOY	-0.9138	1.0000	-0.1719
Release DOY	0.5571	-0.1719	1.0000

The correlations are estimated by REML method.

SCATTERPLOT MATRIX



PAIRWISE CORRELATIONS

Variable	by Variable	Correlation	Count	Lower 95%	Upper 95%	Signif Prob	Plot Corr
Transfer DOY	Acclimation days	-0.9138	21	-0.9649	-0.7963	<.0001*	
Release DOY	Acclimation days	0.5571	21	0.1652	0.7971	0.0087*	
Release DOY	Transfer DOY	-0.1719	21	-0.5619	0.2806	0.4563	

Attachment D

Okanagan Fish-and-Water Management Tools (Ok-FWMT) Project Contributions to Stock Rebuilding of Okanagan Sockeye Salmon

HCP Briefing, Wenatchee, April 18, 2012.

Douglas County Public Utility District

Fisheries and Oceans Canada / Pêches et Océans Canada

Department of Fisheries and Oceans Canada

British Columbia

BC Ministry of Water Land and Air Protection

Okanagan Nation Alliance

ESSA Technologies

Kim Hyatt and Margot Stockwell

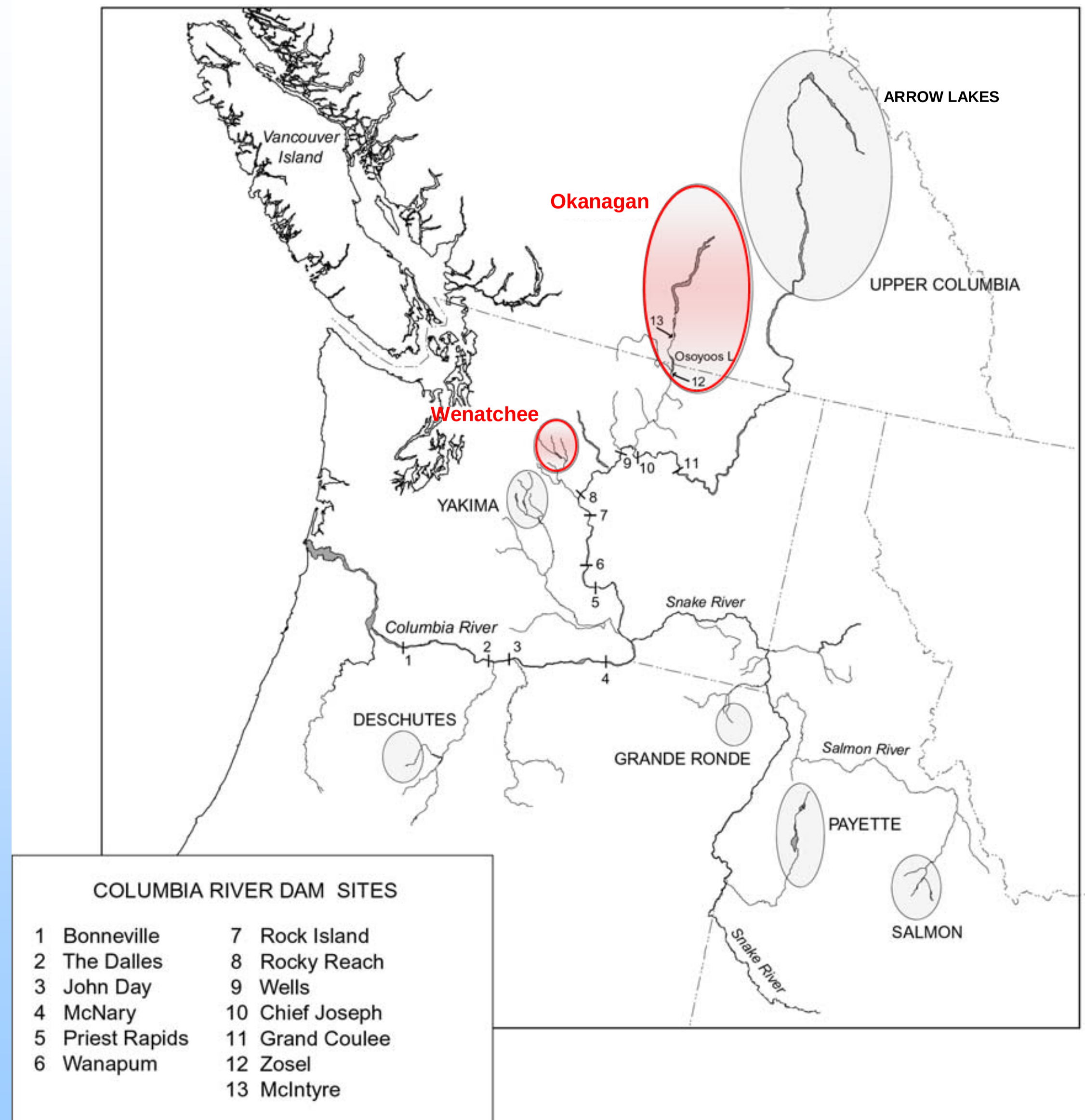
Fisheries and Oceans Canada

Columbia River Sockeye Salmon Populations

Attachment D

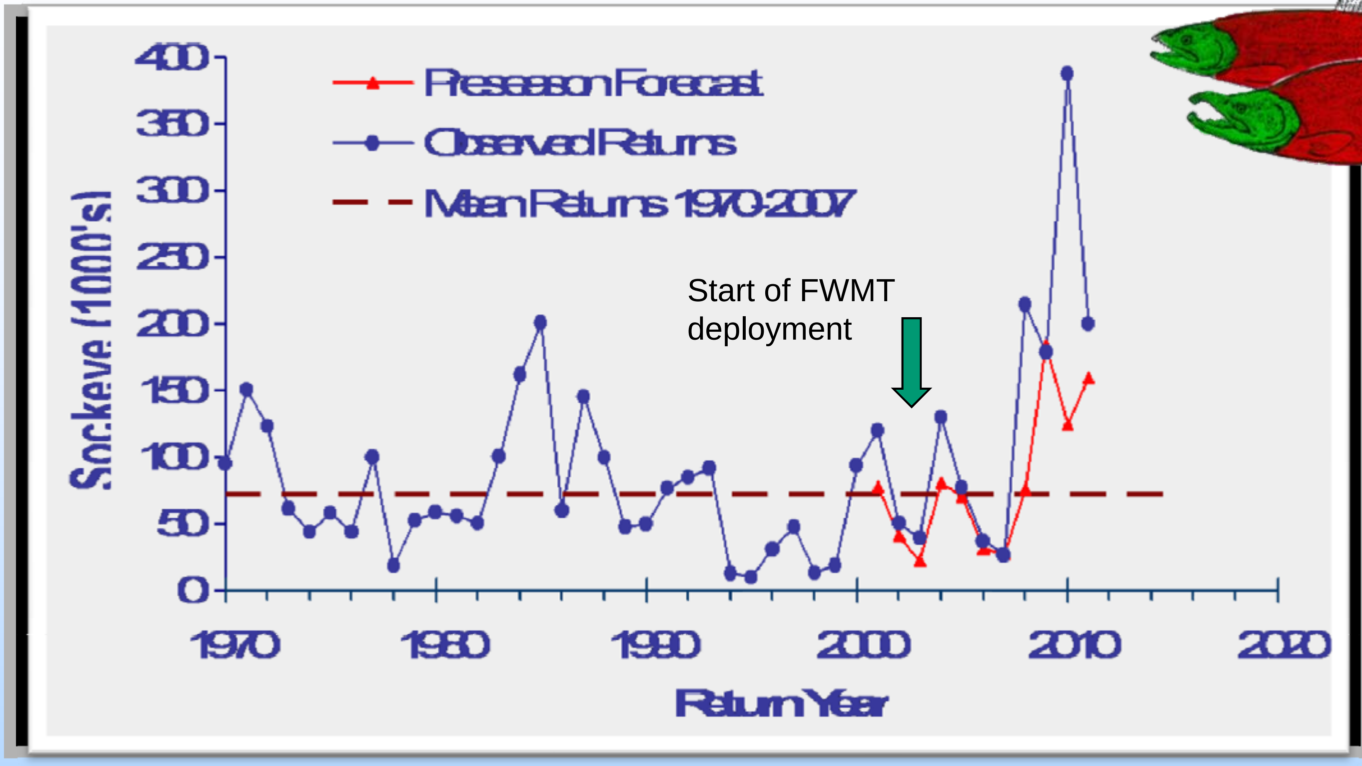
Columbia River sub-basins historically accessible to sockeye

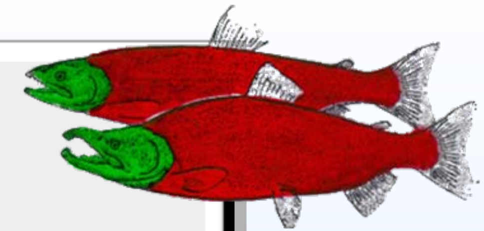
Columbia River sub-basins with present day viable sockeye populations



Attachment D

Columbia R. Adult Sockeye Returns 1970 - 2011





Percent Okanagan Sockeye in Columbia River Returns

	1970 - 2003	2004 - 2011
Mean:	54%	81%
Range:	15-85%	63-90%

Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

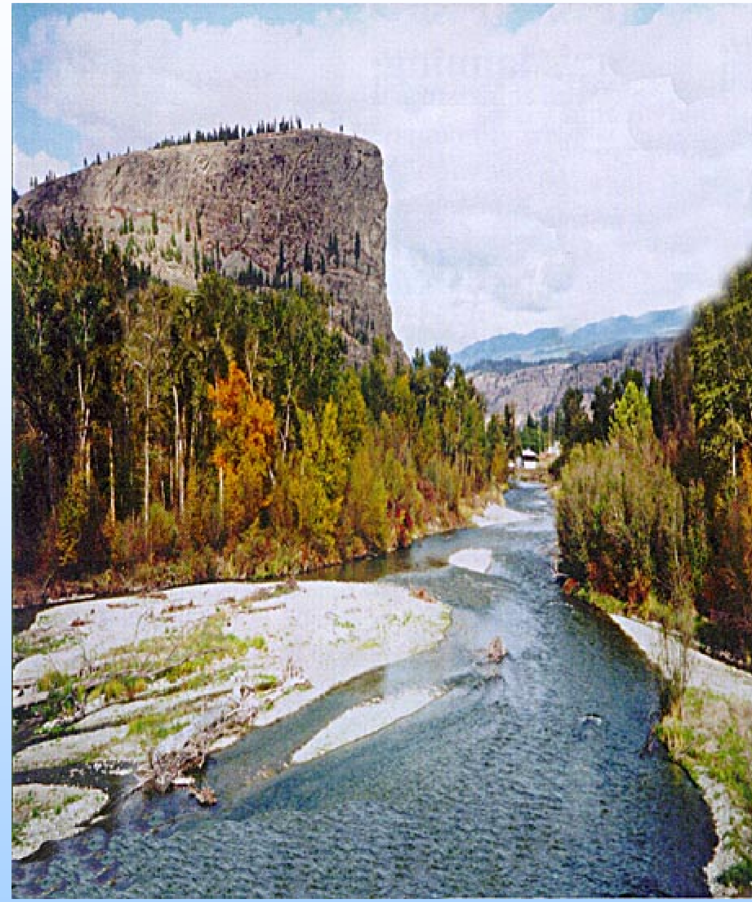
Factors or Events Contributing to Rebuilding of Okanagan Sockeye Salmon Since Inception of FWMT Deployment in 2003-04

- [x] Revised escapement objectives to utilize full carrying capacity of freshwater spawning and rearing environments,
- [X] Development /deployment of FWMT decision support system to facilitate "fish friendly" flows to reduce losses of eggs & fry to density independent mortality events,
- [X] FWMT mitigation of rearing habitat reductions for juvenile sockeye due to oxygen-temperature "squeeze" conditions in Osoyoos L.
- [x] Supplemental production of hatchery-origin sockeye from Skaha L.
- [ ] Improvements in juvenile fish-passage in the Columbia River,
- [x] Recent survival-favourable conditions for southern sockeye stocks in coastal marine waters.

Attachment D

OLR-System Management Begins in the Okanagan Lake Headwaters of the Okanagan River

Drainage area = 6,090 sq km
Surface area = 341 sq km
Average outflow = 14.7 m3/s



Okanagan R: Natural = 8.4 km
Channelized= 16.2 km
Average outflow = 14.7 m3/s

Okanagan Lake Dam at Penticton is the major control point in the system

Attachment D

Okanagan Lake Dam (Penticton)

Attachment D

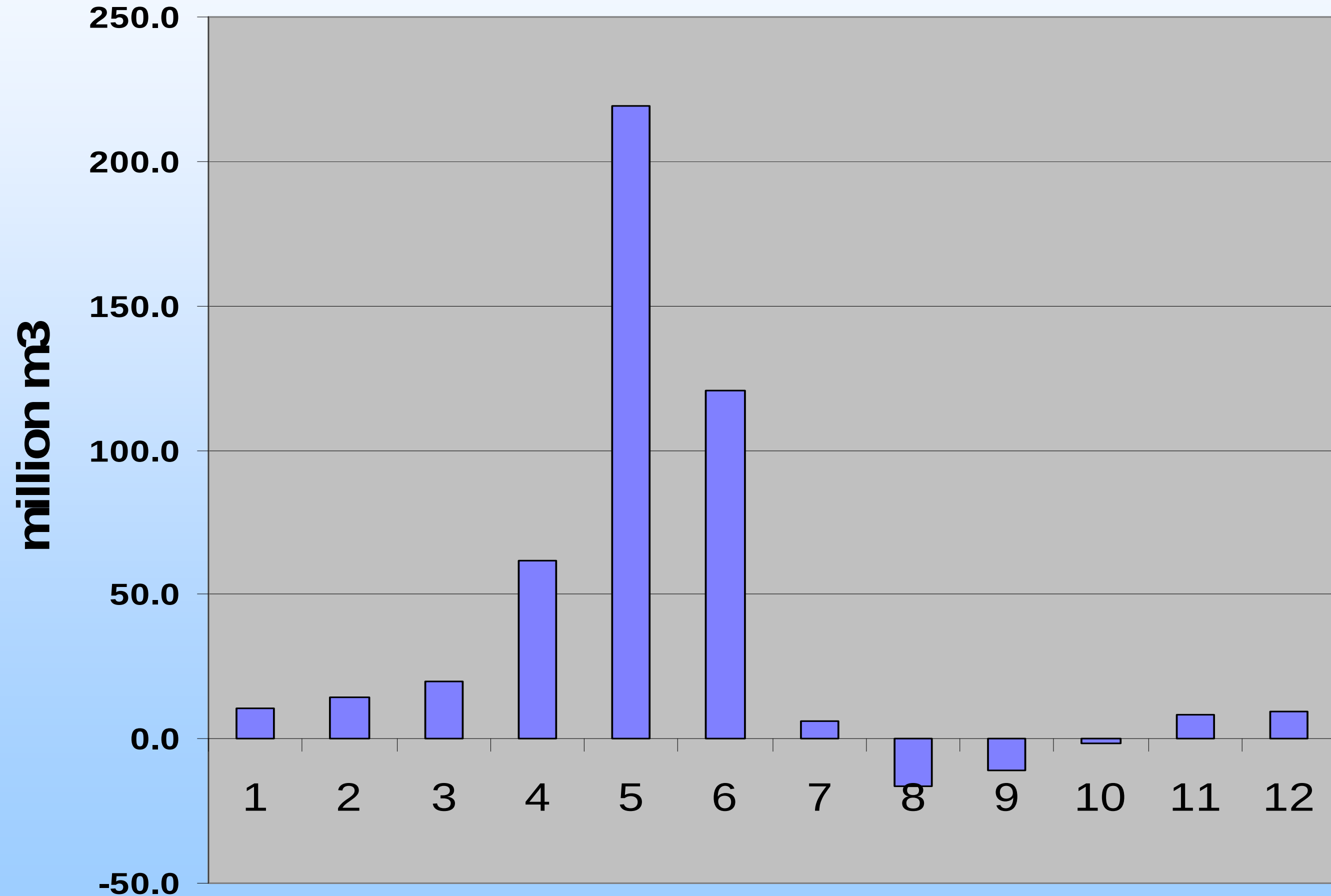
OKANAGAN LAKE HYDROLOGY

- Annual inflow hydrograph dominated by snowmelt runoff
- Large range of annual inflows:

- 78 million to 1.4 billion m^3
- 0.23 m to 4.12 m stage change

Attachment D

Mean Monthly Inflows to Okanagan L.
(85 % of inflow from Apr-Jun)

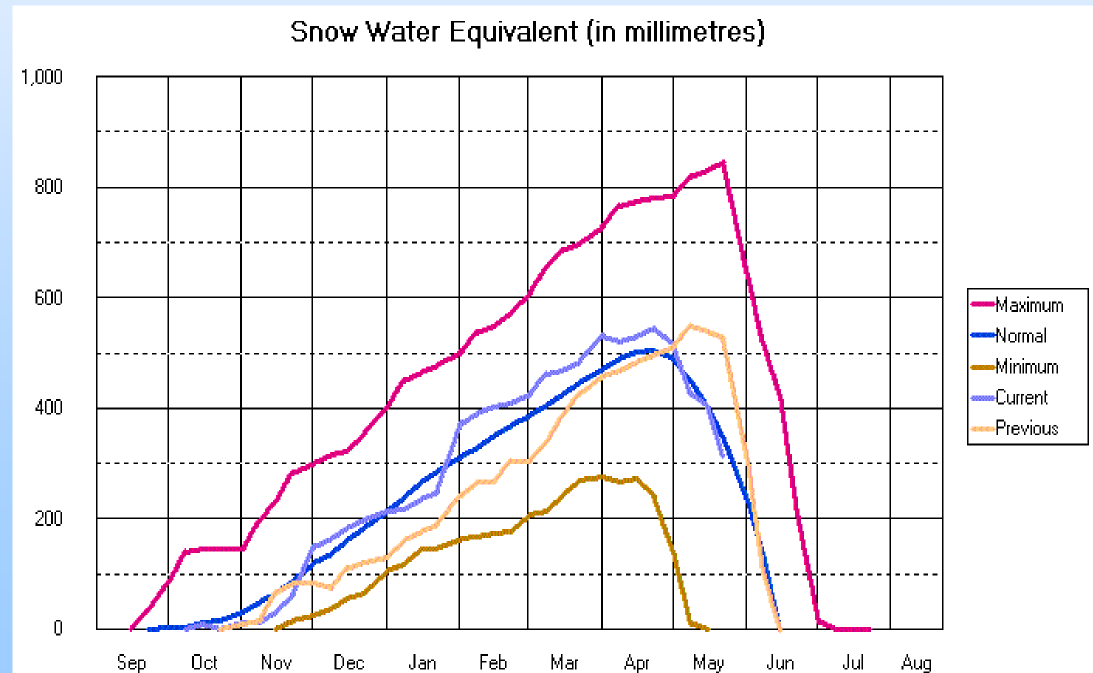


Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Inflow Forecasts and Discharge Observations Drive Management Decisions

Inflow forecasts are based on seasonal precipitation, snow packs & tributary inflow data.

2003-04 Mission Ck. Snow Pillow @2F05P



OLRS OPERATIONS

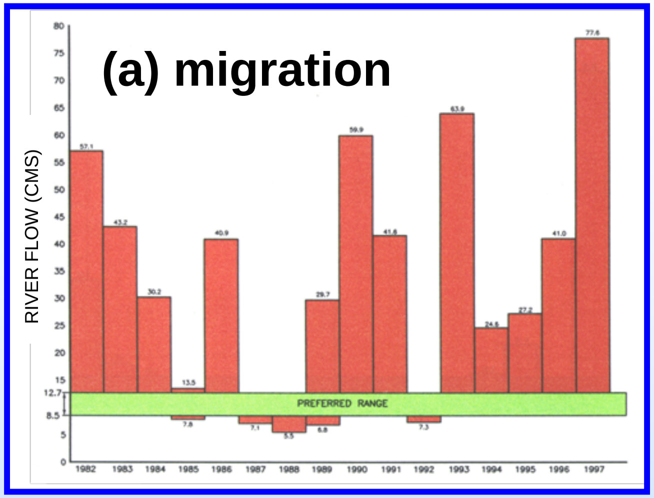
- OBA rules specify seasonal lake levels and flows.
- Operating plans/decisions reflect inflow forecasts.
- Decisions address competing objectives to satisfy: flood control, fisheries values, water storage/extraction, navigation, tourism, international agreements, etc.

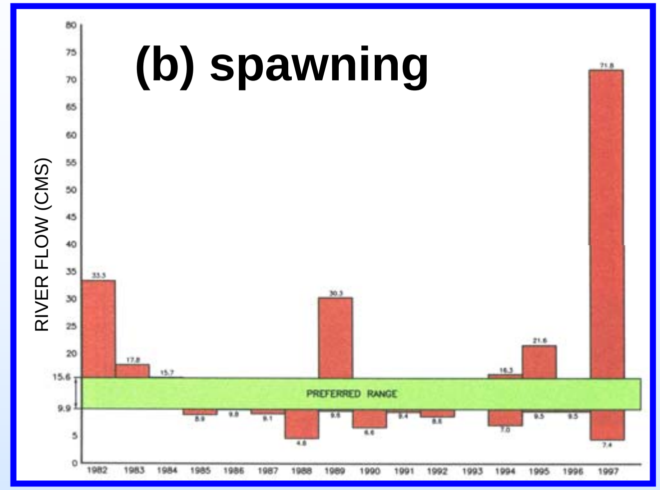
OPERATOR CHALLENGES

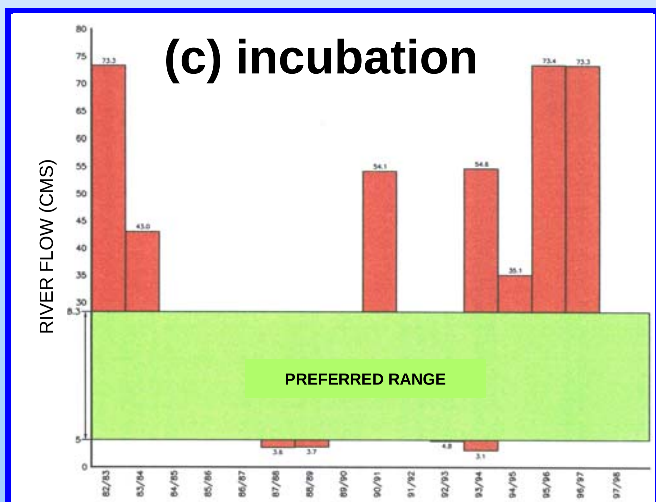
- Forecast uncertainty re: freshet inflow volumes and capacity to match lake spill or storage to spring inflows (“bathtub” analogy).
- Effects of environmental variability (water levels, flow, temp.) on risk assessments given competing economic, social & environmental demands of multiple “parties” & authorities.
- **OLRS decisions re: water storage or release based on rules of thumb, past experience & incomplete information.**

Attachment D

Compliance with OBA Fishery Flows was low prior to 1997.







OBA preferred flow range

Observed flow range

From 1982-1997 river discharge exceeded OBA fishery flows in:

(a) 13 of 16 yrs for adult migration

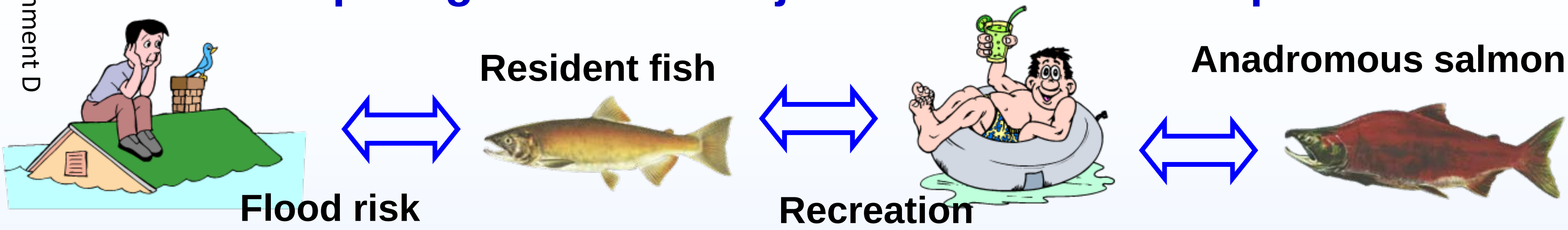
(b) 7 of 16 yrs for spawning and

(c) 7 of 16 yrs for egg incubation & fry migration

Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

Competing “Rules”& Objectives Reduce Compliance



Rule 1: Don’t fill Okanagan Lake above 342.56 meters (i.e. 10 cm rise above 342.56 incurs $5-$10 million in “property” losses !)

Rule 2: Try to avoid drafting to lake levels below 341.50 meters. (i.e. problems with docks, water intakes & vessel navigation become severe).

Rule 3: Minimize draw-down of Okanagan L. between the time of kokanee spawning and 100% fry emergence (i.e. minimize dewatering kokanee eggs & fry but don’t risk violatin of “rules” 1 or 6,7,8, & 9)

Rule 4: Minimize the number of buildings flooded at Penticton

Rule 5: Provide summer flows for recreation if possible

Rule 6: Sox. Migration – maintain flows (@ Oliver) between 8.5 & 12.7 cms during Aug 1 to Sept 15 to allow “easy” passage of VDS.

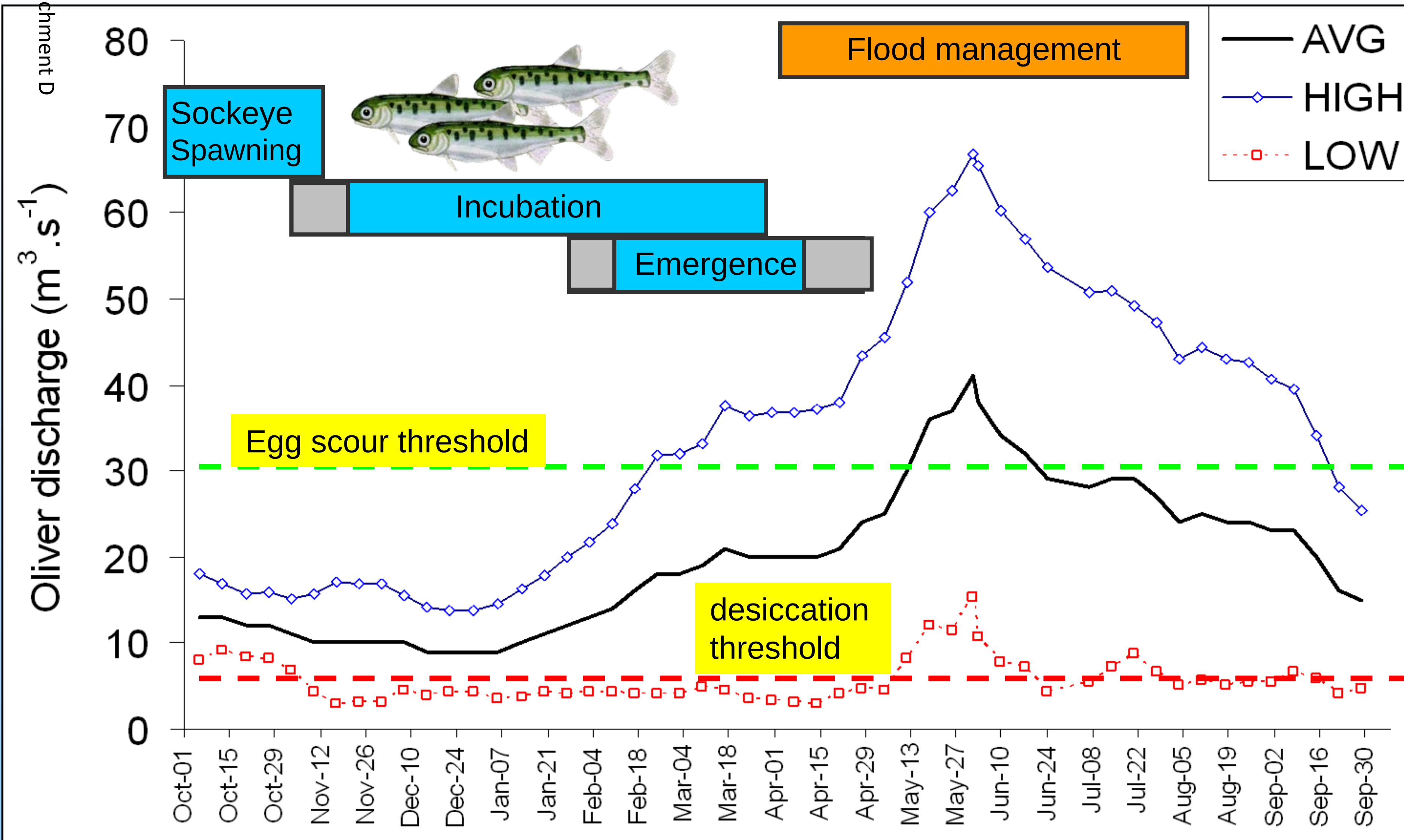
Rule 7: Sox. Spawning – maintain flows between 9.9- 15.6 cms during Sept 16- Oct 31 to maximize “good” spawning habitat.

Rule 8: Sox Incubation- flows at 5.0- 28.3 cms during Nov 1- Feb 15 i.e. egg incubation flows greater than or equal to 50 % of spawning flows & must not exceed 28.3 cms to avoid redd desiccation & scouring.

Rule 9: Sox. Fry emergence-migration- flows during Feb16- Apr 30 at 5.0- 28.3 cms.

Event timing & natural variations determine whether fish-and-water managers satisfy OBA rules & competing objectives

Attachment D

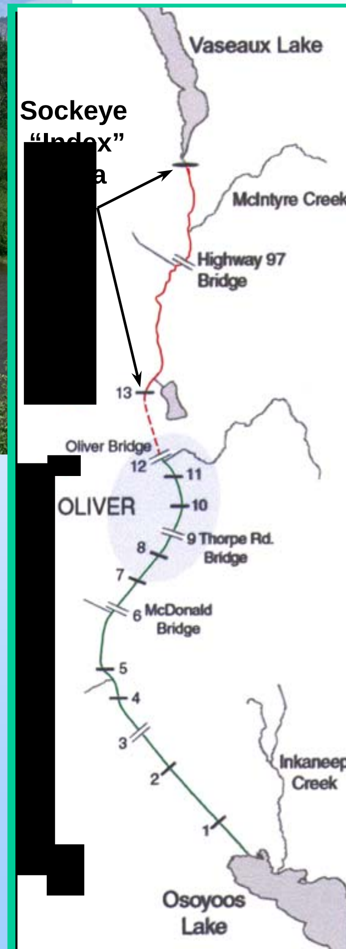


Attachment D

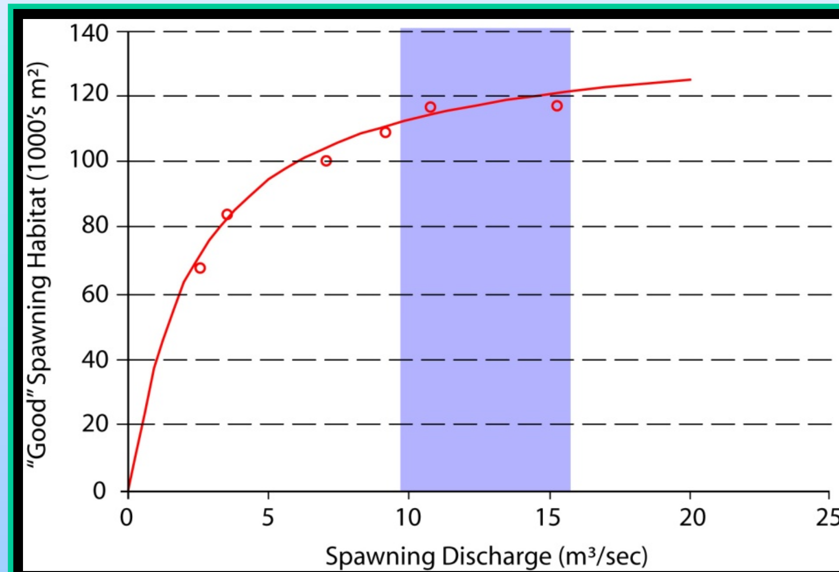
Available Spawning Habitat is Controlled by Flow

Paul Rankin photo

Okanagan Nation Alliance photo



Recommended flows for Okanagan sockeye spawning are: **9.9 m³/sec to 15.6 m³/sec**



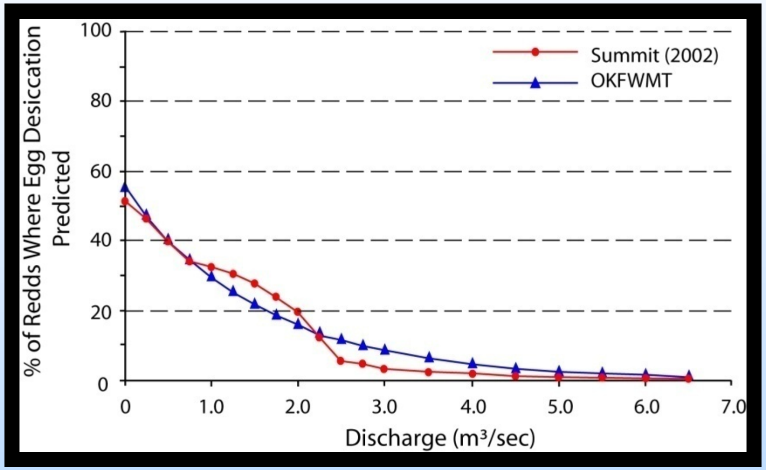
Data Sources: Anon. 1983; Hyatt et al. 2005

Attachment D

Discharge and Okanagan Sockeye Incubation

Dewatering/desiccation or flood-and-scour processes control incubation and emergence success of sockeye eggs and alevins.

(a) % Eggs Dewatered



(b) % Alevins Stranded

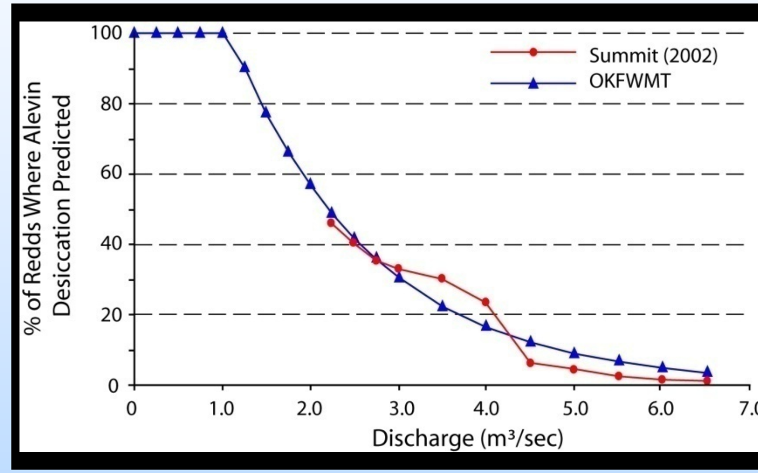
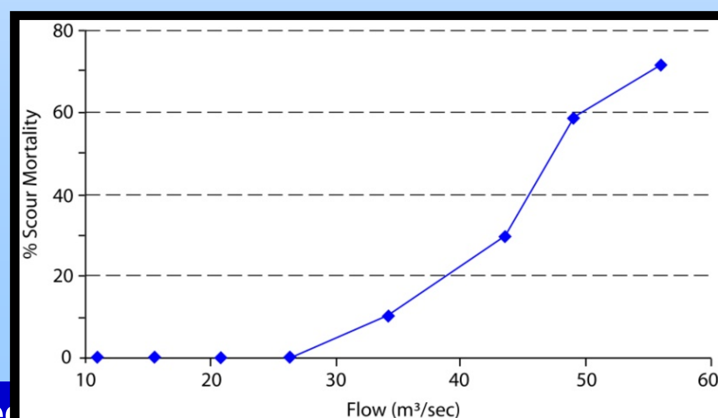
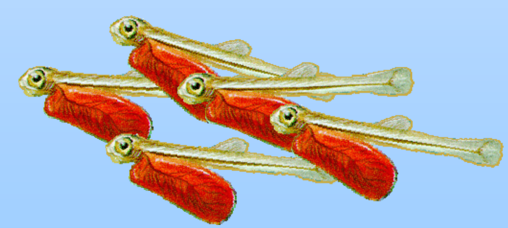


photo: www.nbis.org

(c) % Eggs / Alevins Scoured





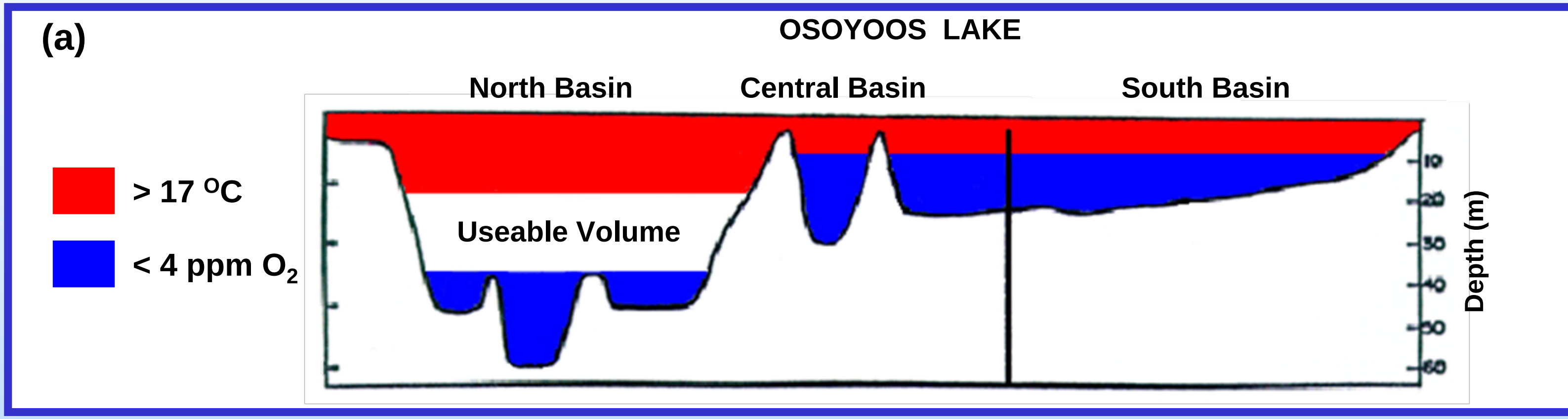
Hyatt and Stockwell, HCP Me

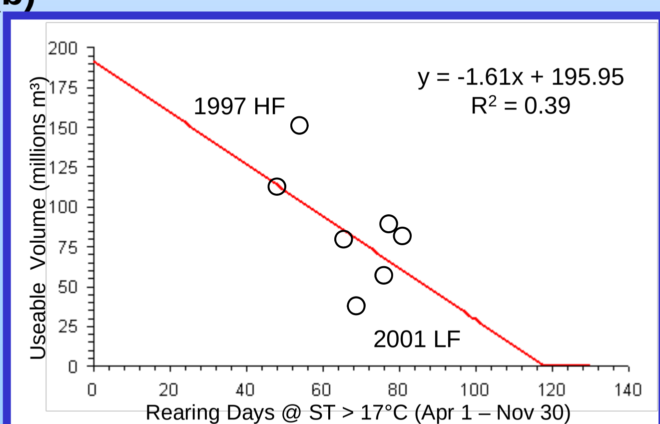
Data Source: Hyatt et al 2005

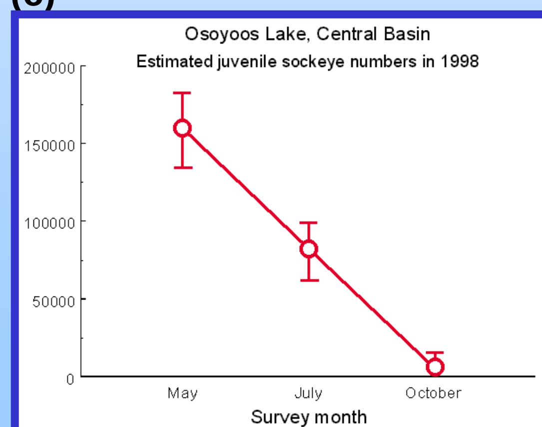
Attachment D

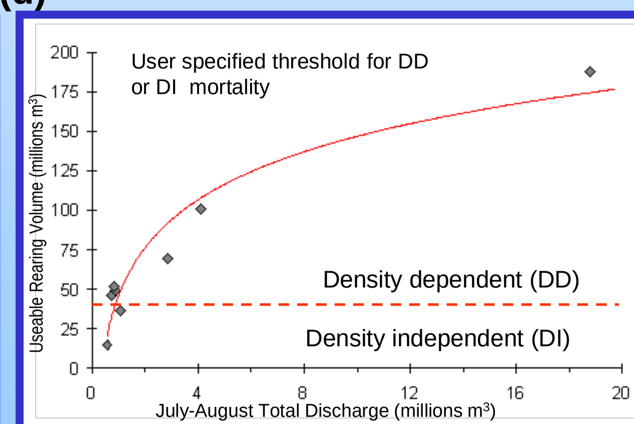
Temperature-Oxygen "Squeeze" and Density-Independent Rearing Limitations in Osoyoos L.

Hyatt et al (2007, in review CJFAS) have established that seasonal temperature and oxygen extremes may operate together to restrict the useable rearing volume of Osoyoos Lake which can induce density-independent mortality processes.





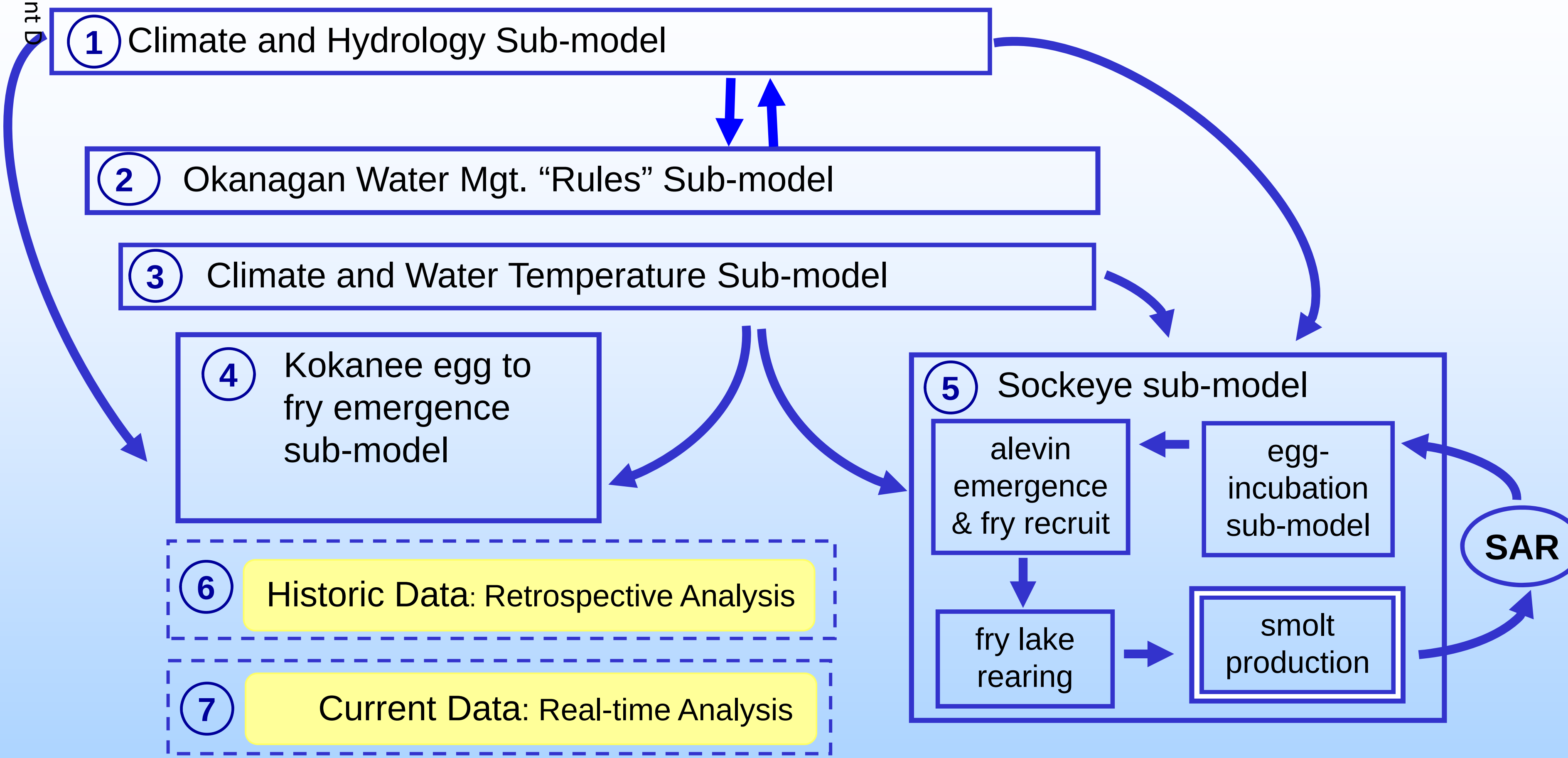




Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

FWMT Decision Support System



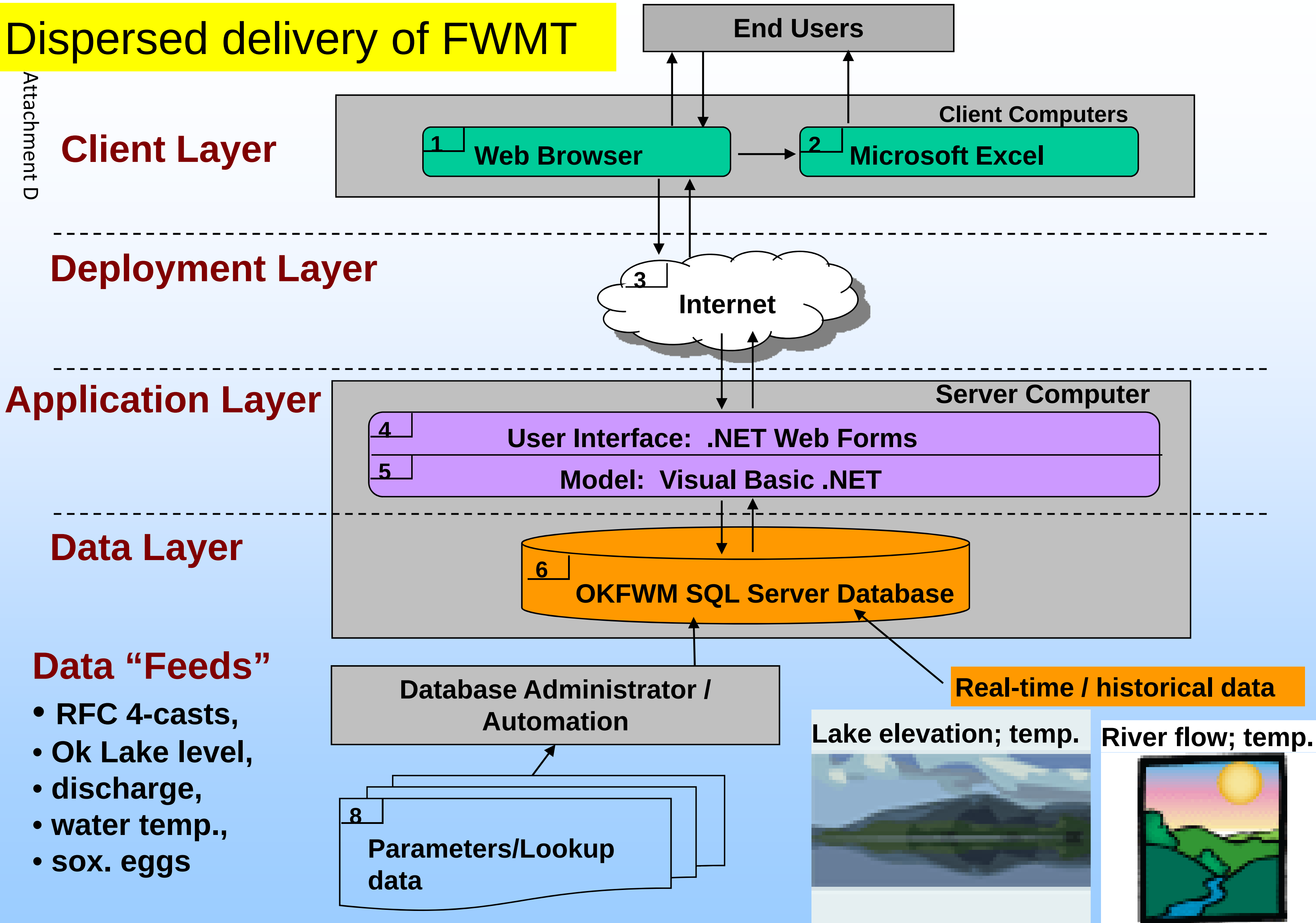
The FWMT System is a coupled set of biophysical models of key relationships (among climate, water, fish & property) used to predict the consequences of water mgt. decisions for fish & other water users.

FWMT may be used to explore water management decision impacts in an operational mode employing real-time data, a prospective-mode going forward or in a retrospective-mode looking back on historic water supply, climate & fish years.

Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

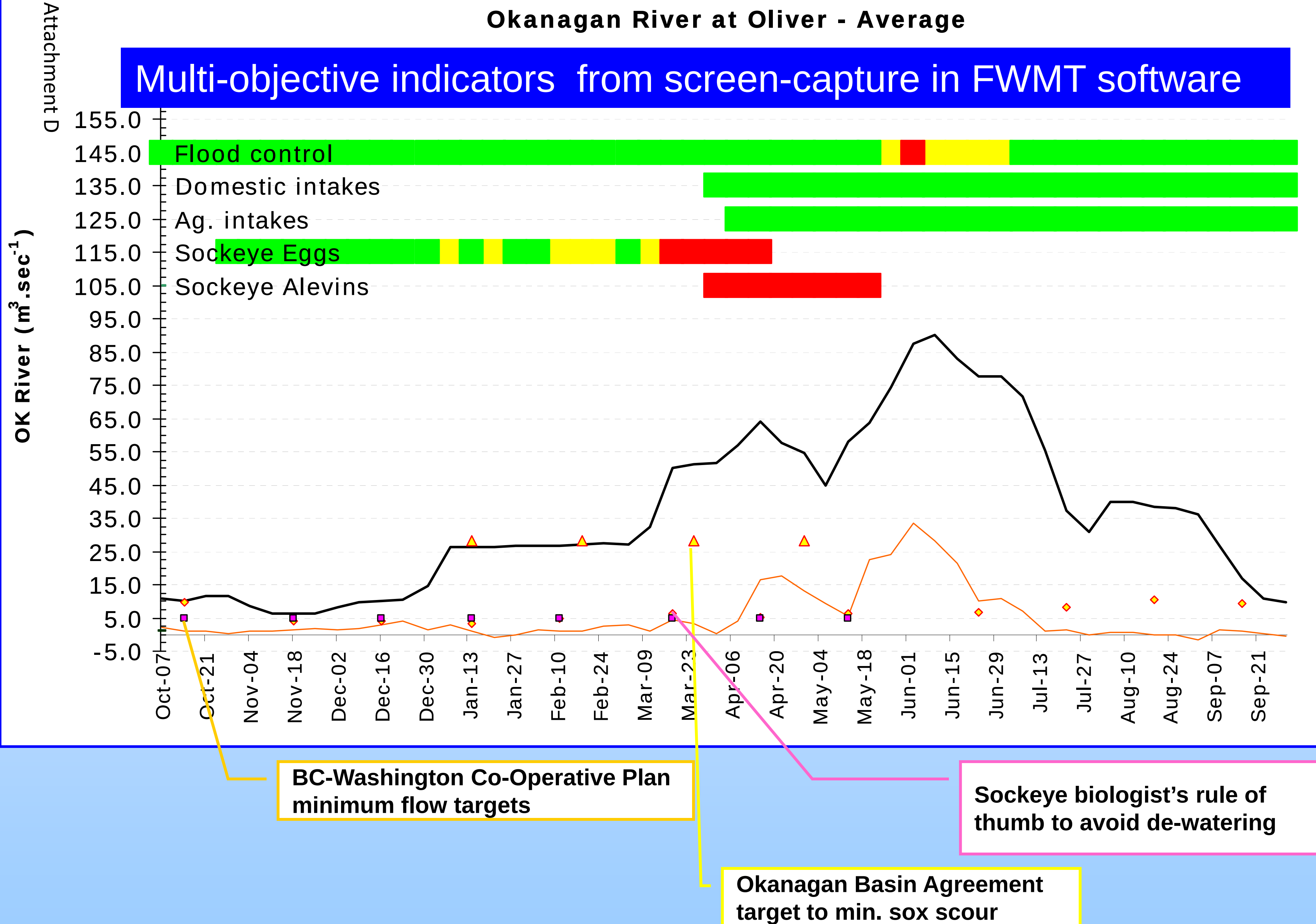
Dispersed delivery of FWMT

Attachment D



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

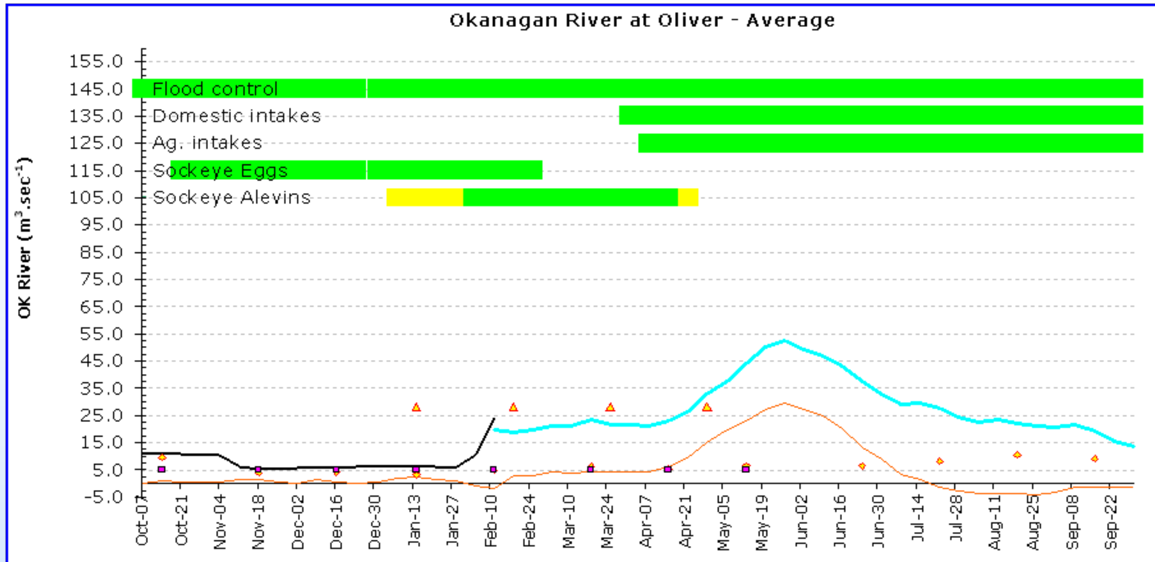


Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

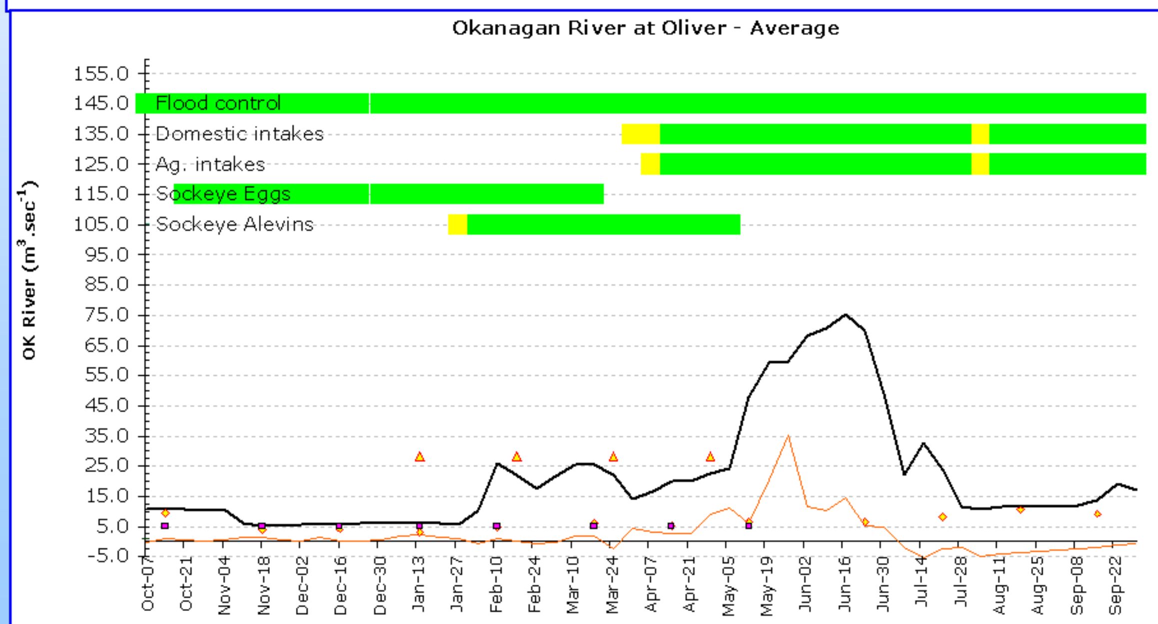
Attachment D

OKANAGAN FWMT 2005-2006 WATER MANAGEMENT YEAR

(A) Actual and predicted flows at Oliver (sockeye spawning grounds) 9-Feb-06

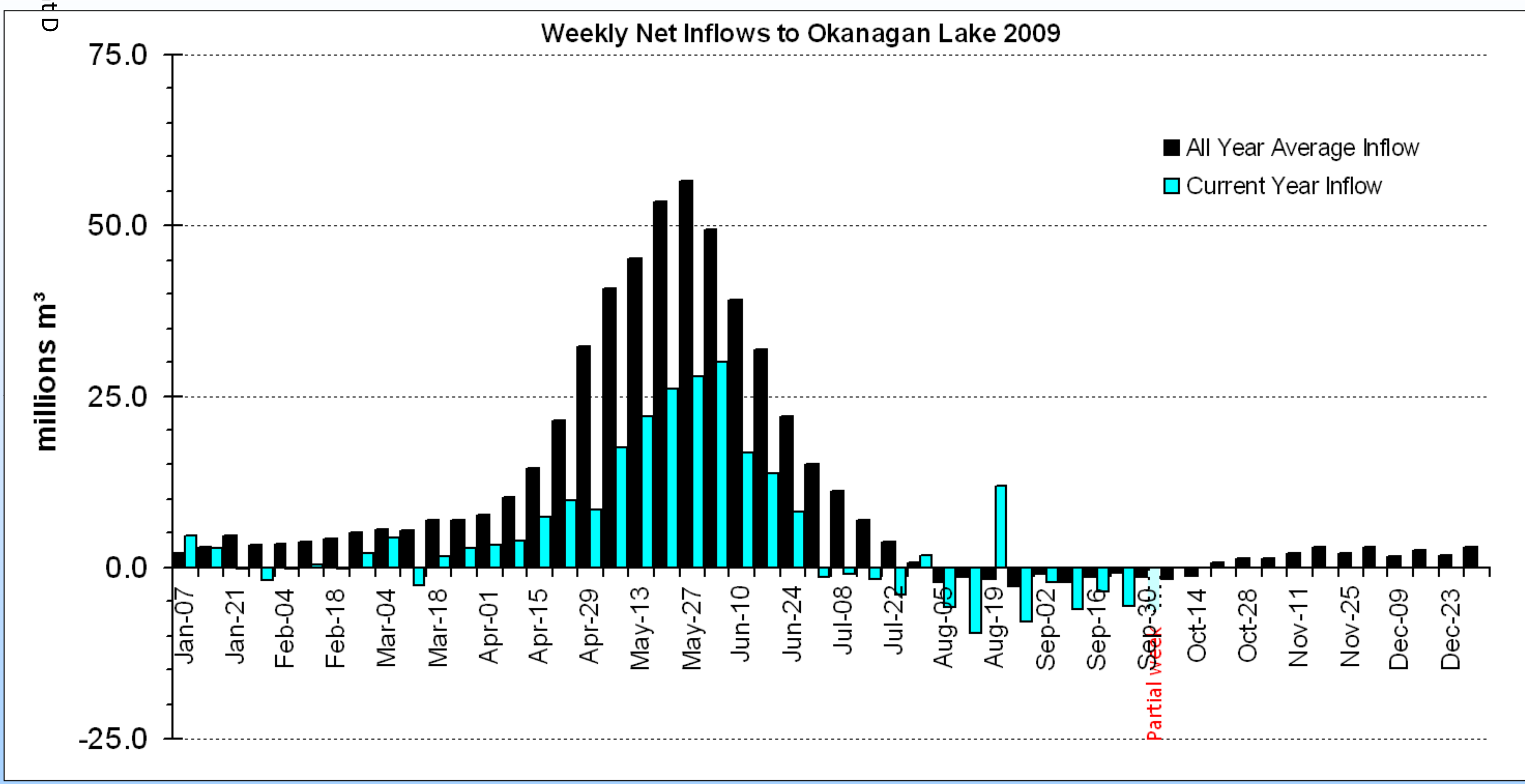


(B) Final outcome at Oliver (sockeye spawning grounds) 30-Sep-06



Attachment D

Net Weekly Inflows to Okanagan L. 08-09 Fish-and-Water Year



Below average snow-pack (203 vs 525 million m^3), late melt, high peak water yield, early transition to drought.

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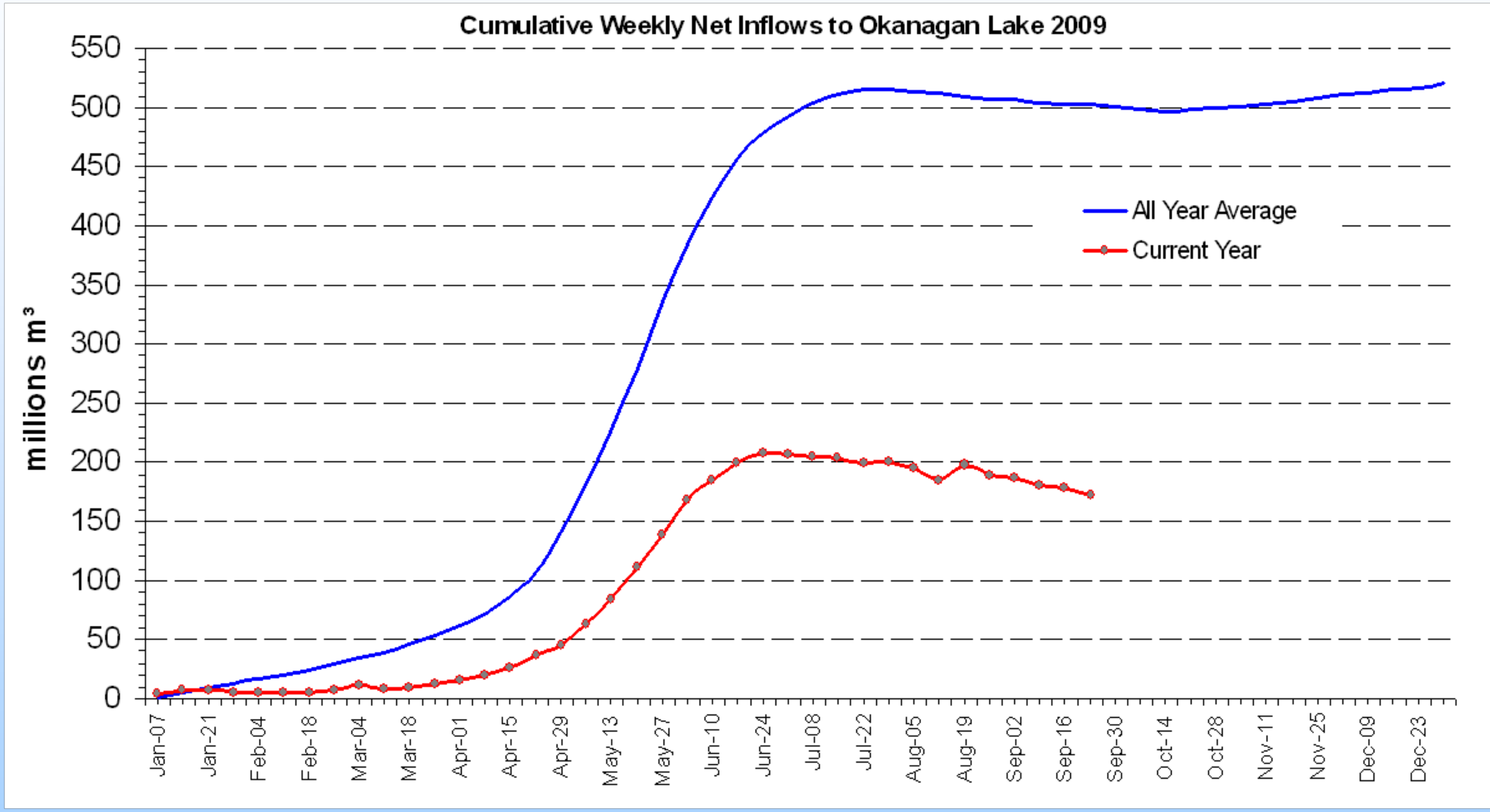
FWMT WATER YEAR 2008 - 2009

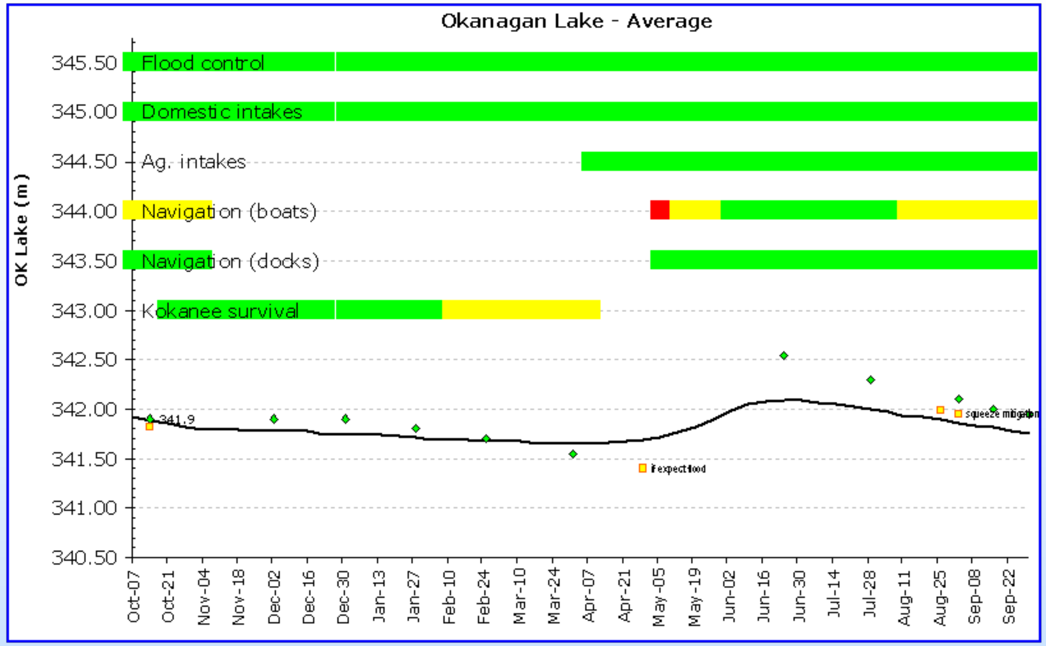


Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

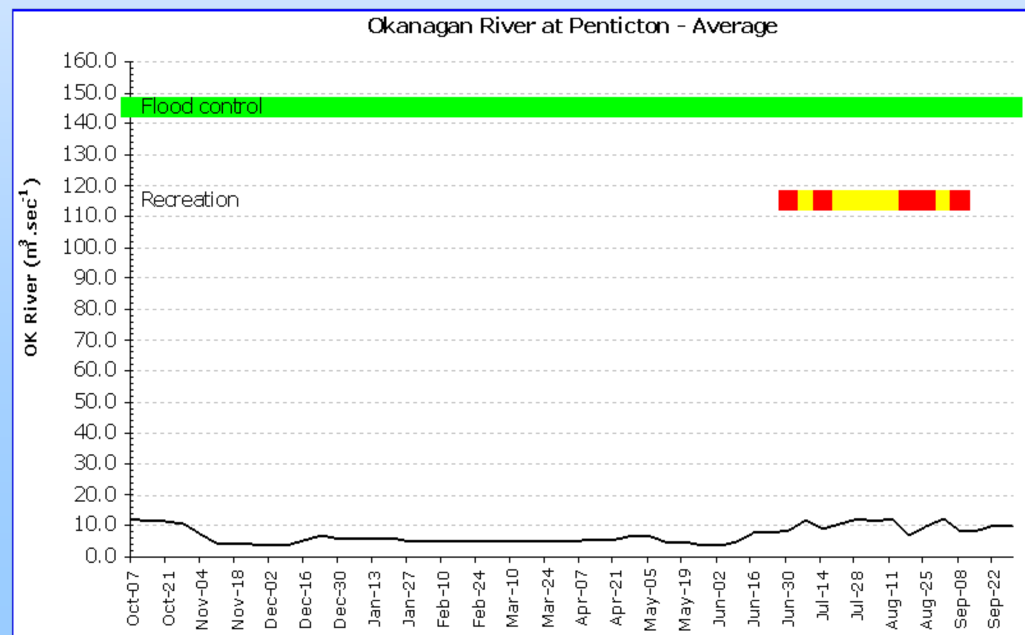
Attachment D

2008 – 2009 Drought

A. Okanagan Lake



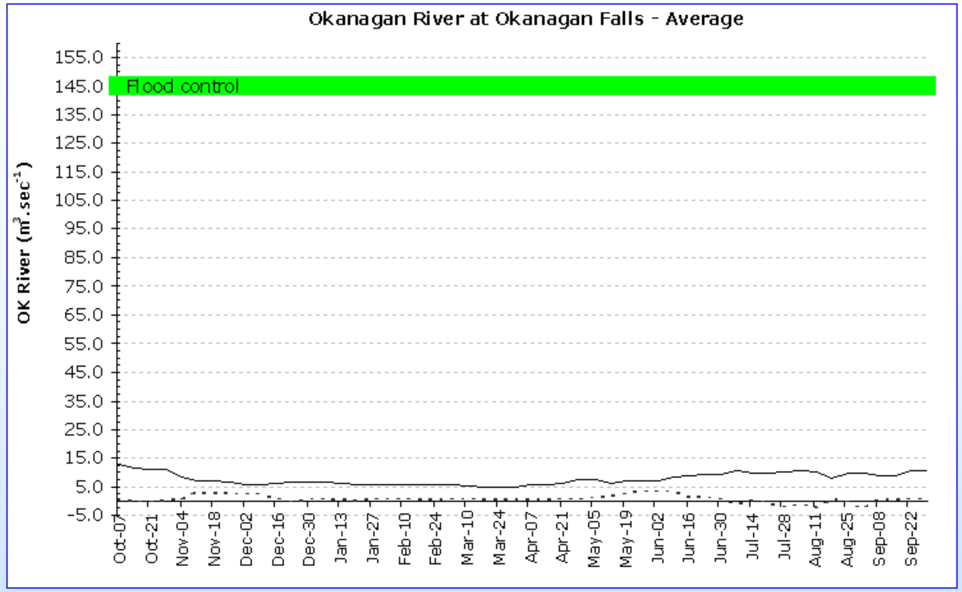
B. Okanagan River at Penticton



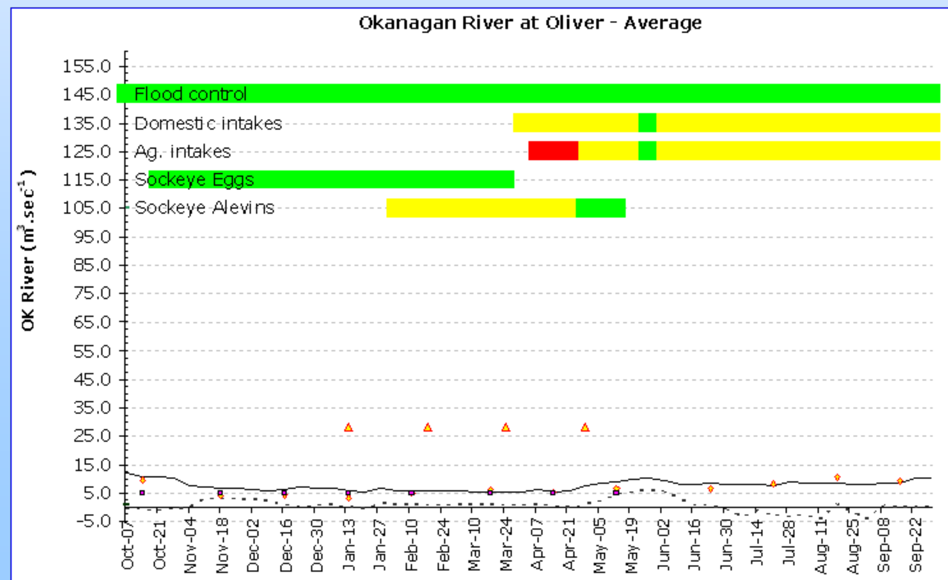
Attachment D

2008 – 2009 Drought

C. Okanagan River
at Ok Falls



D. Okanagan River
at Oliver



Attachment D

Attachment D

FWMT WATER YEAR 2008 - 2009

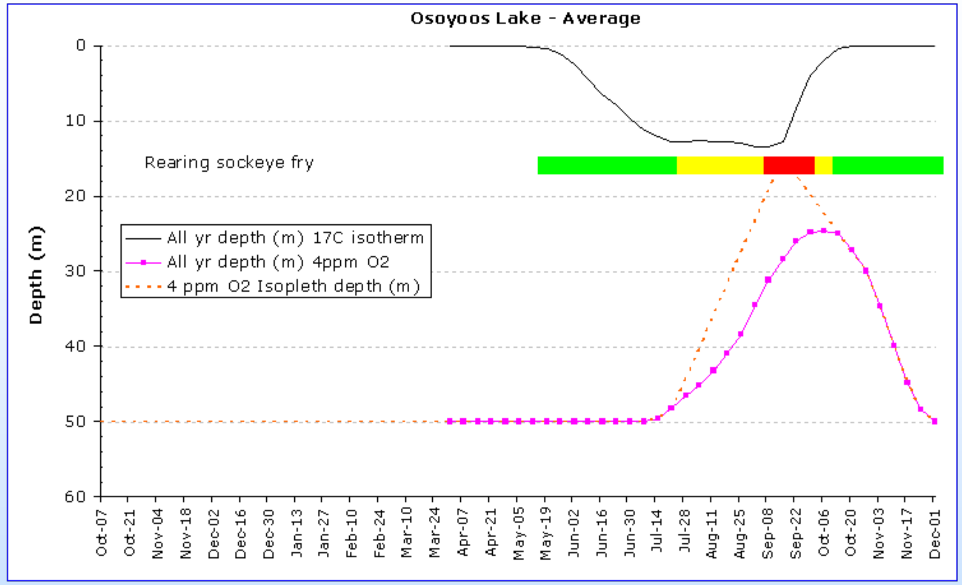
Table 1. A summary by location & issue of consequences associated with adoption of three alternate flow scenarios (FWMT-569, 561,568) during Aug-Sept, 2009.

		FWMT-569		FWMT-561		FWMT-568
Location/Issue [1]		Current (10.7 cms)		OBA max (12.7 cms)		Mitigate squeeze (18.3 cms)
Ok Lk levels predicted (Sept 30, 2009) [2]		341.76		341.72		341.69
Domestic intakes [3]						
Agricultural intakes [3]						
Navigation boats [4]						
Navigation docks [4]						
Kokanee spawn/survival [5]						
Ok Lk levels expected by Oct 14, 2009 [5]		341.72		341.66		341.64
Okanagan River						
Recreation at Penticton [6]						
Domestic intakes-Oliver [7]						
Agricultural intakes-Oliver [8]						
Osoyoos Lake						
Juvenile sockeye rearing [9]						
Adult sockeye holding [9]						
Ok Lk levels expected by April 1, 2010 [10]		341.48		341.42		341.40

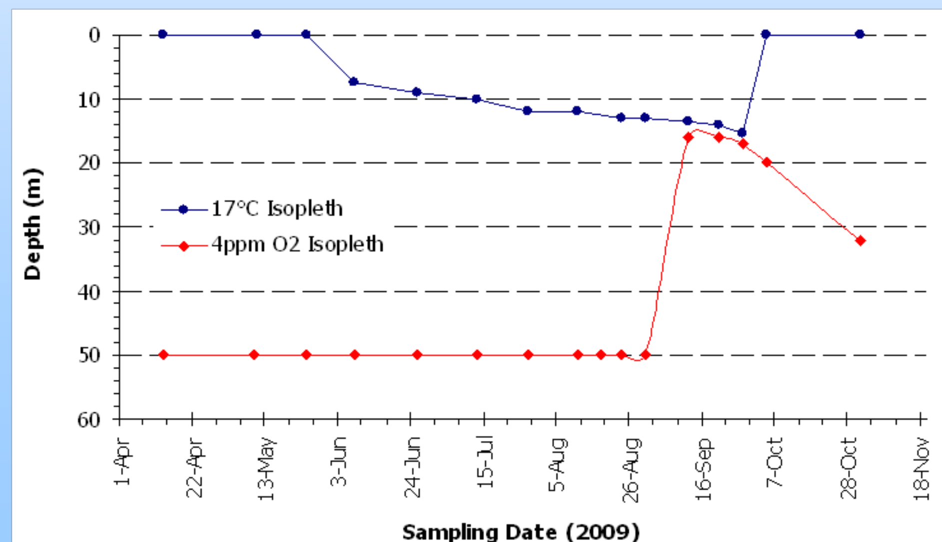
Attachment D

FWMT WATER YEAR 2008 - 2009

Predicted "Squeeze"

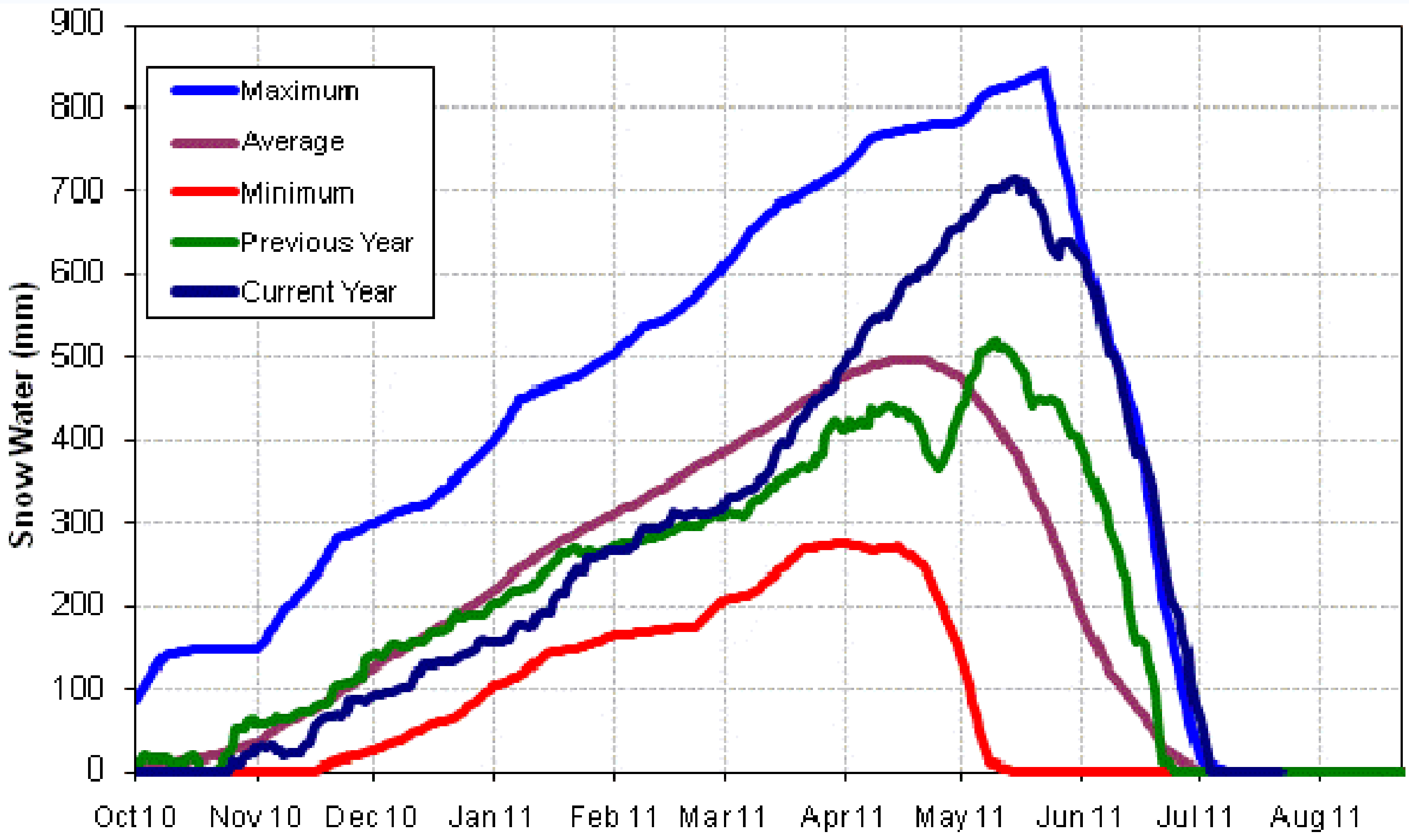


Observed "Squeeze"



FWMT WATER YEAR 2010 - 2011

A. Mission Creek Automated Snow Pillow 2F05P (Elevation 1794m



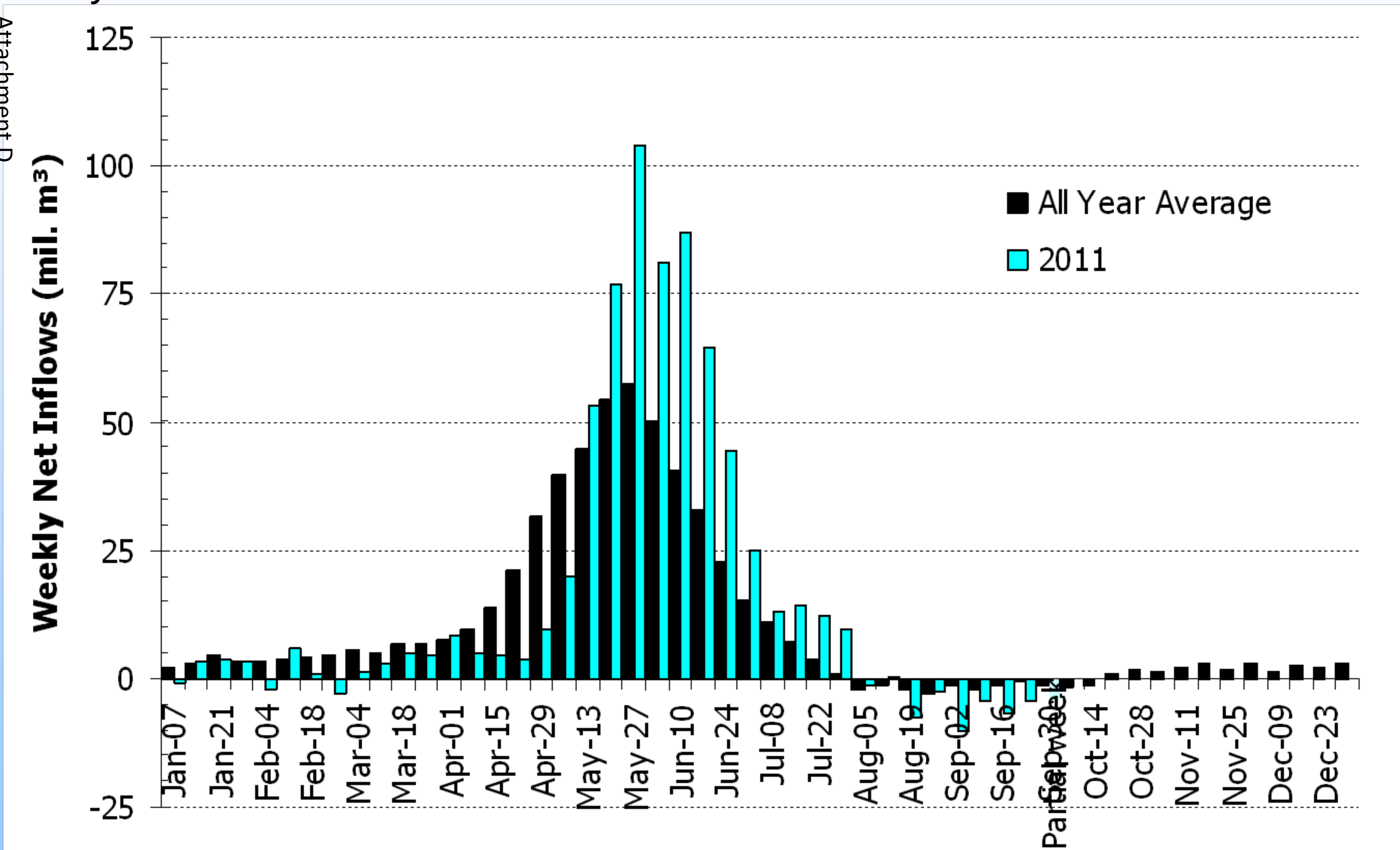
Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

FWMT WATER YEAR 2010 - 2011

Figure A1. FWMT report of observed weekly net inflows (million m³) into Okanagan Lake January to October 2011.

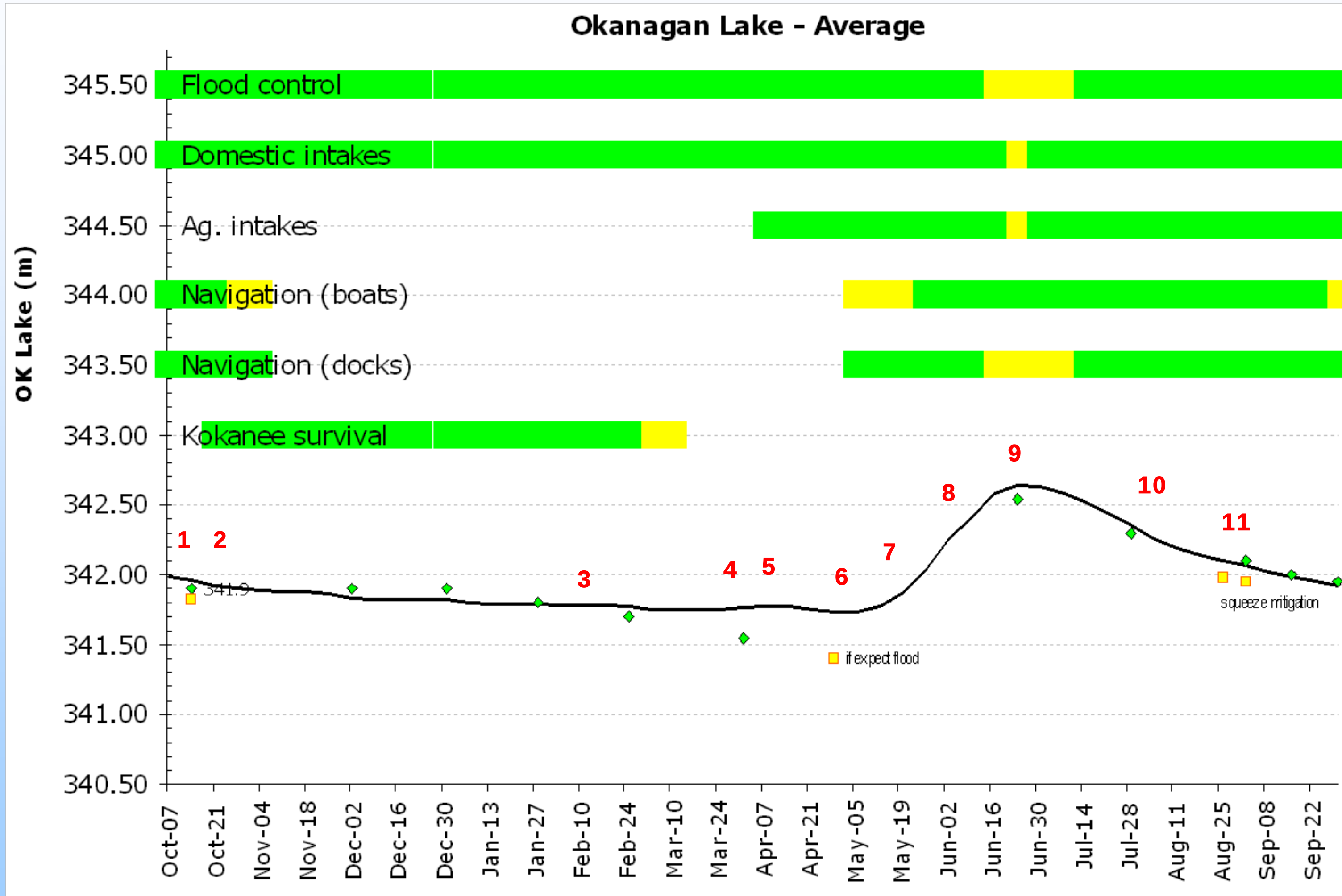
Attachment D



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

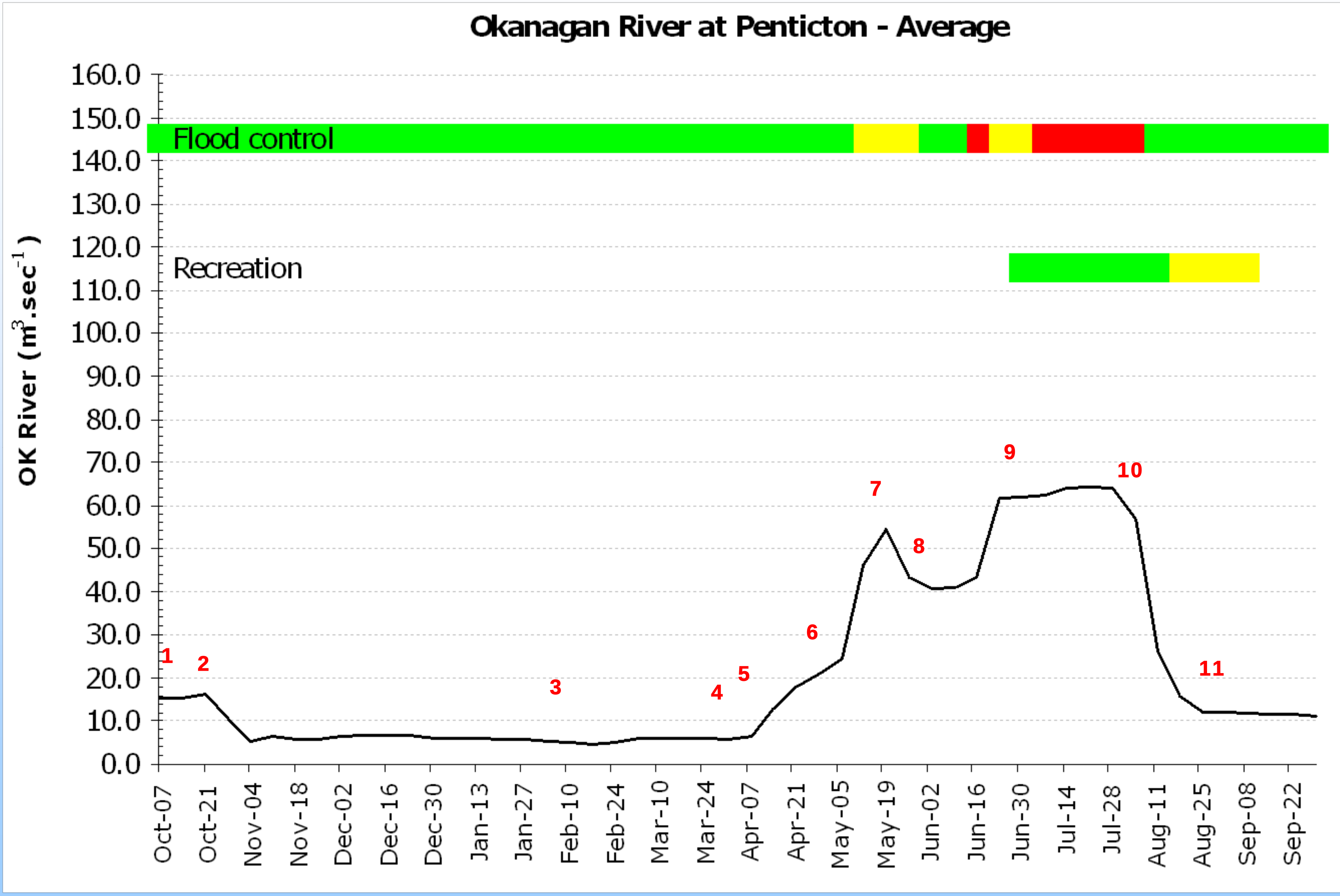
FWMT WATER YEAR 2010 - 2011



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

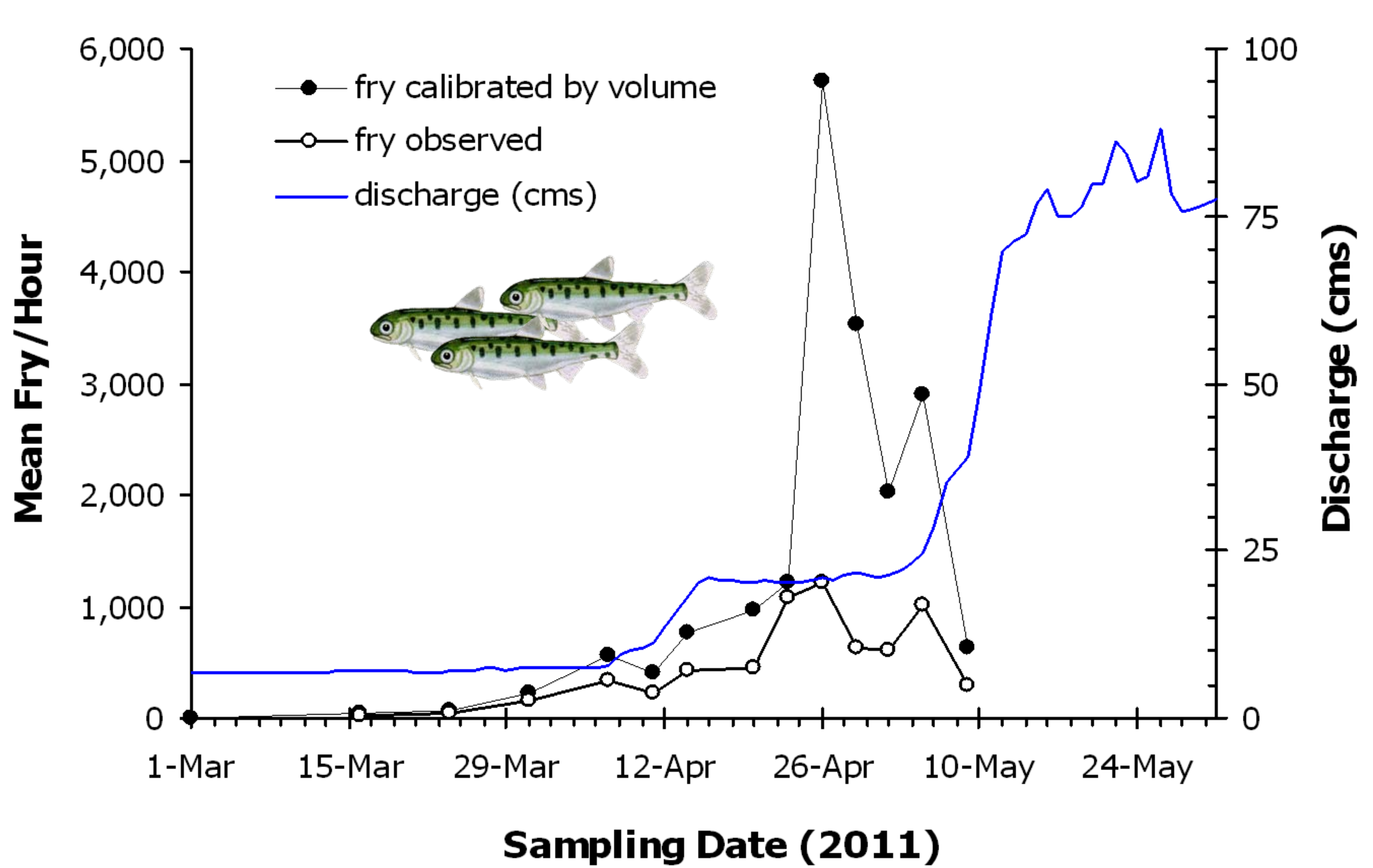
FWMT WATER YEAR 2010 - 2011



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

FWMT WATER YEAR 2010 - 2011

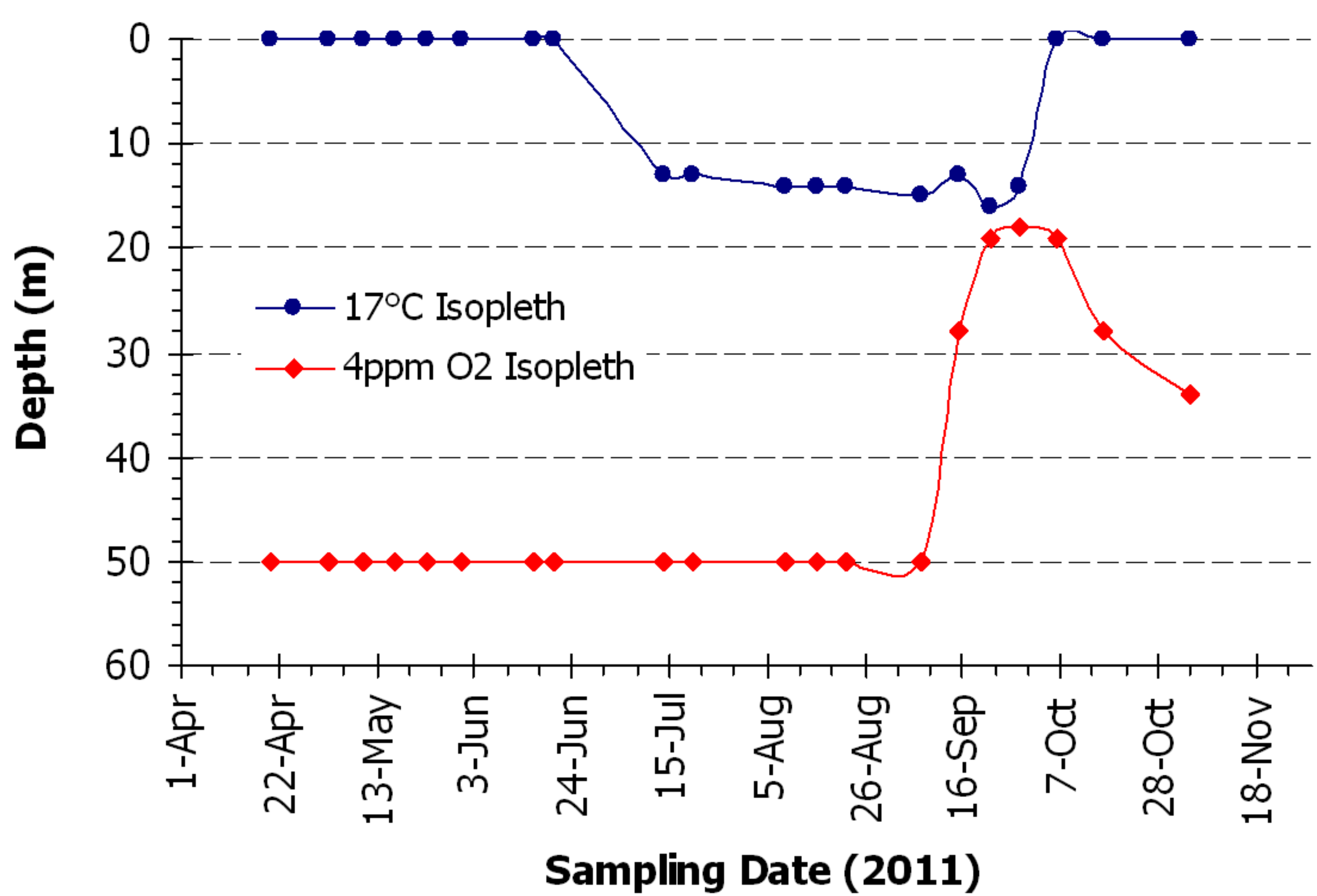


Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

FWMT WATER YEAR 2010 - 2011

Minor (<2 weeks) temp-oxygen squeeze event in late Sept. as per “in-season” predictions re: date of onset and duration



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

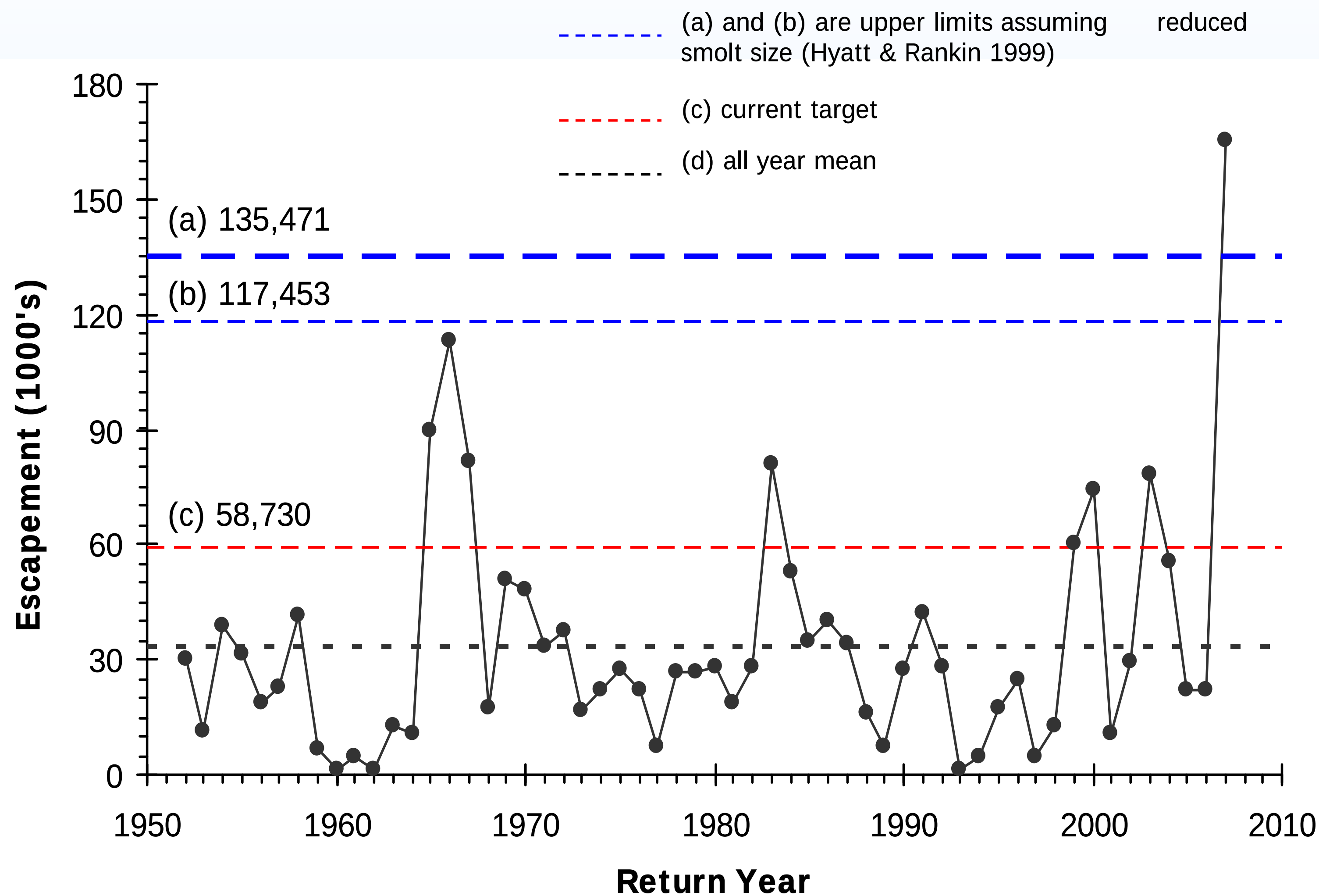
Ok-FWMT Results to Date

- balances consideration of multiple objectives (*i.e.* social, economic, cultural, ecological)
- recognizes inflow forecast uncertainties,
- uses "rich" information sources refreshed in real-time (*i.e.* annual to daily imports of biophysical data),
- facilitates effective input from limited pool of expertise,
- provides record of annual strategy & outcomes to assess performance against multiple objectives.
- since deployment in fall of 2005 we have avoided (a) major drought and desiccation or flood and scour losses of fry production in-river and (b) most temp-O2 induced losses of lake-rearing fry (i.e. reduced density-independent losses of fry & smolt production).

Influence of FWMT plus other factors on sockeye recovery ?

Escapement Revisions, Hyatt & Rankin 1996

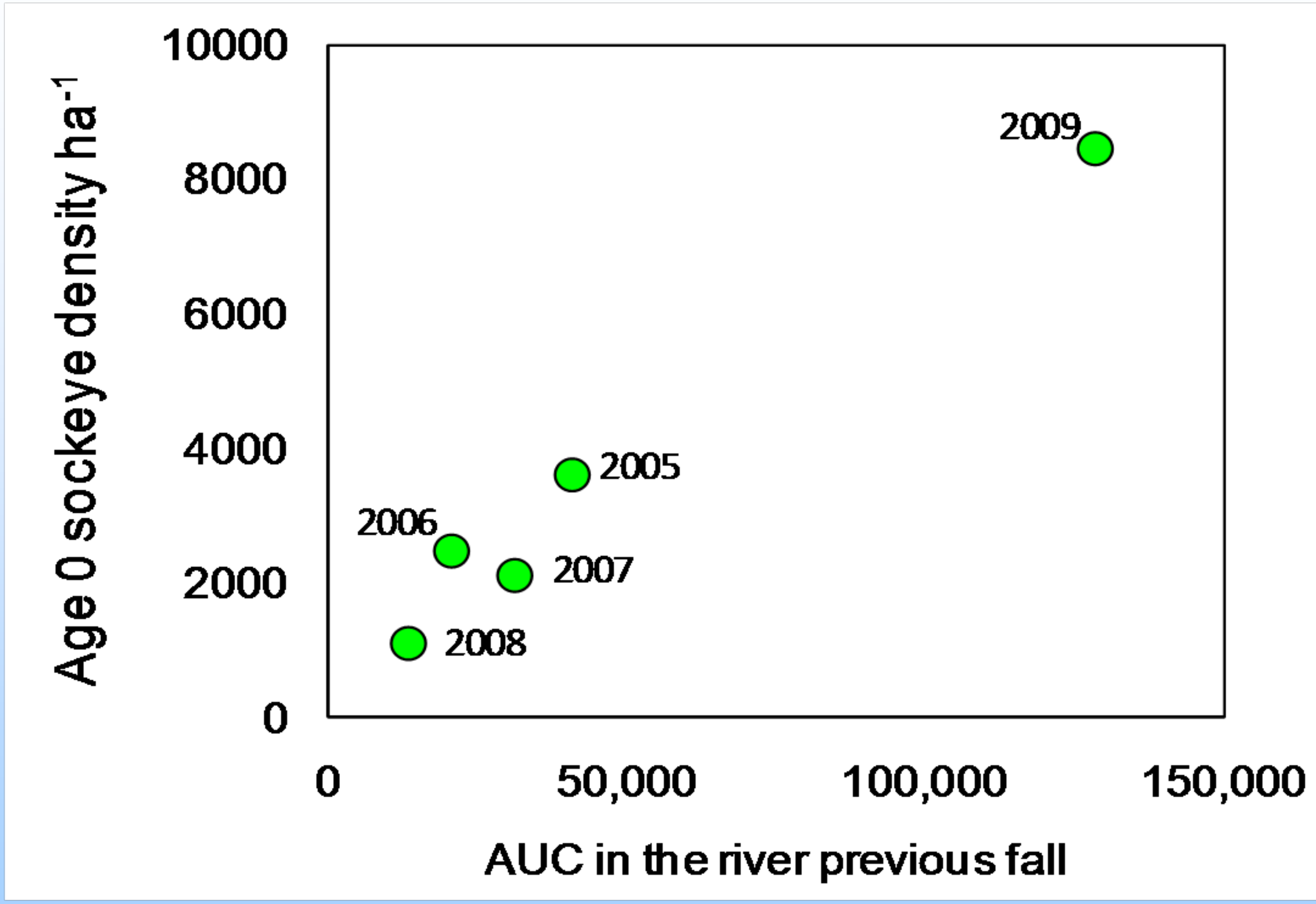
Attachment D



Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

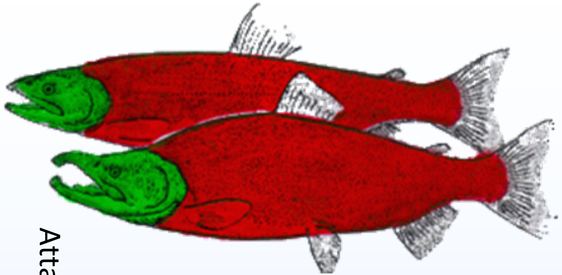
Where do all the sockeye come from ?



Post FWMT deployment, more adult spawners clearly lead to more smolt production as per Hyatt & Rankin (1996) analysis of carrying capacity of river and lake habitats.

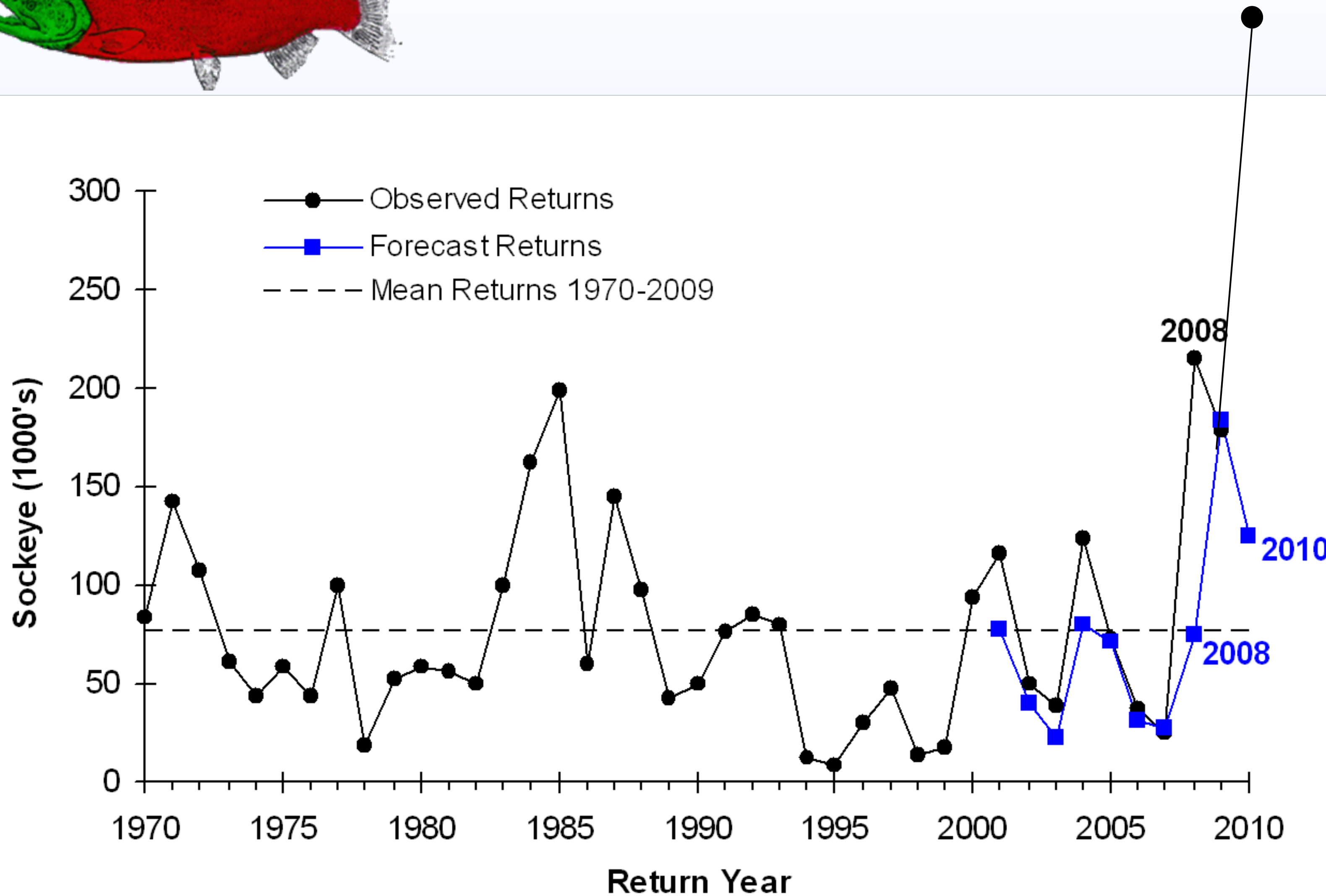
Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D



Columbia R. Sockeye Returns 1970-2010.

Okanagan = 75-80% of all Columbia R. Sockeye after 1980

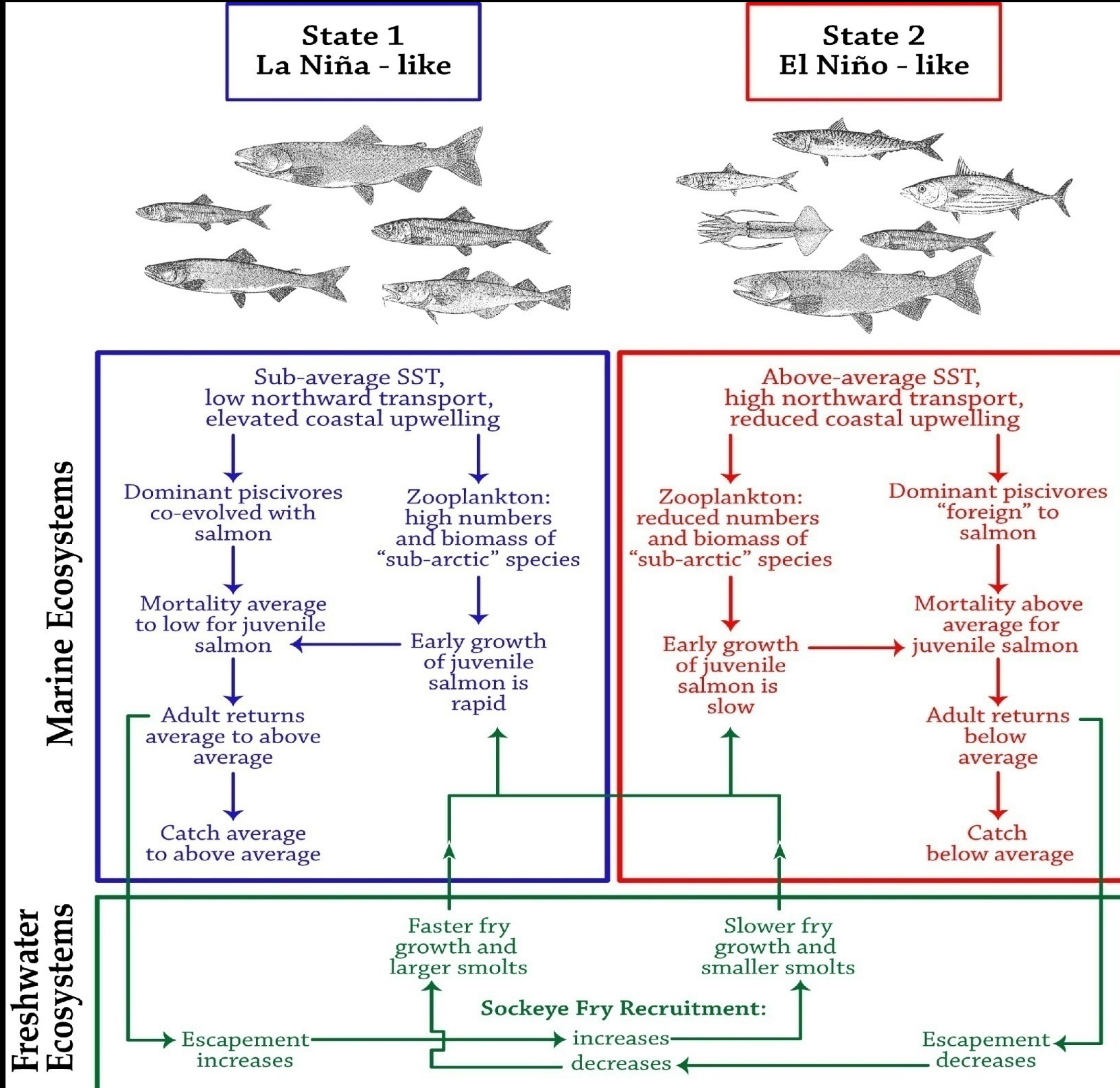


Hyatt and Stockwell, HCP Meeting, Wenatchee, April 18, 2012.

Attachment D

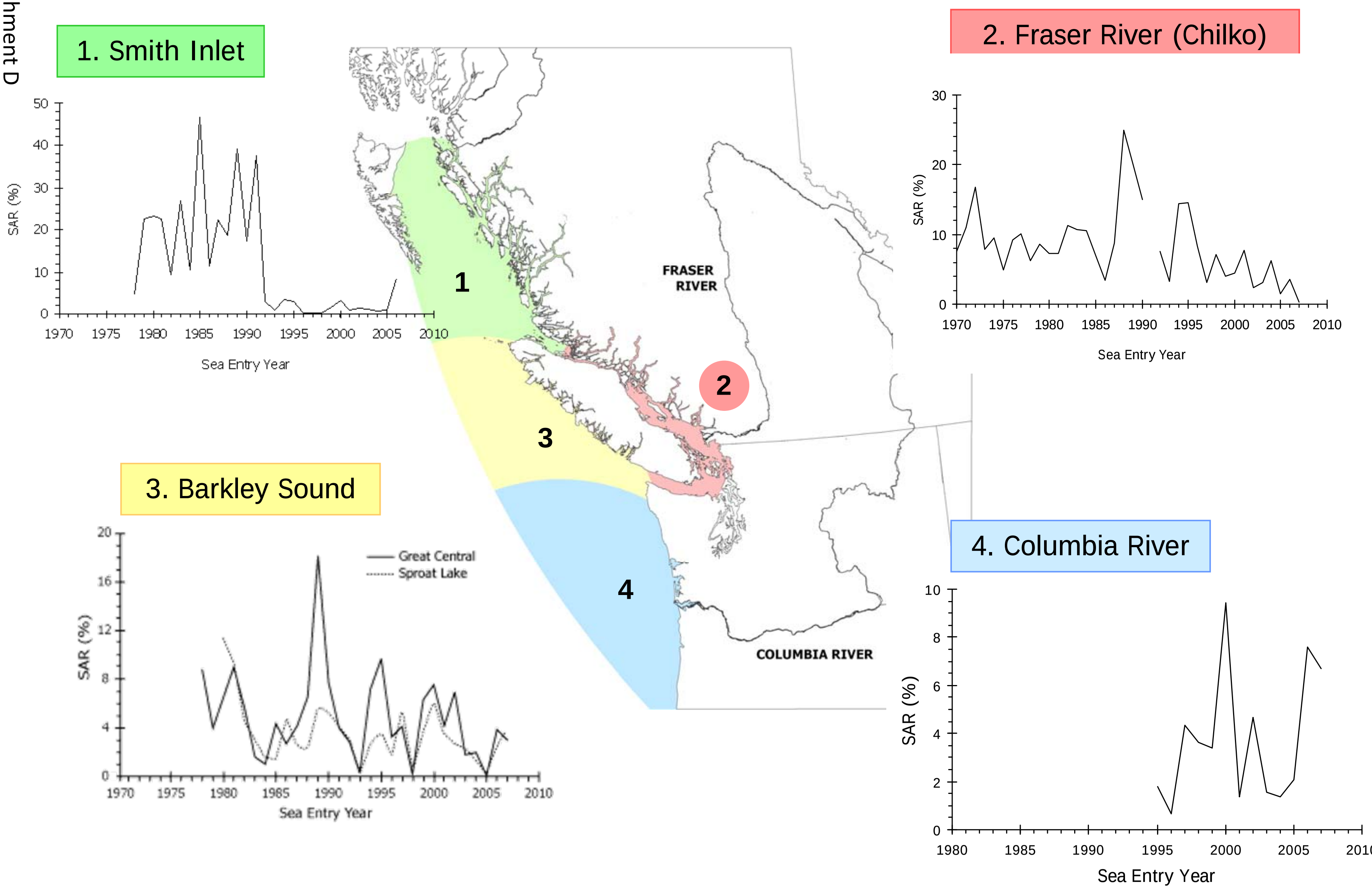
Out of Basin Effects

Two-state model of ocean conditions and salmon survival for Barkley Sd sockeye & the origin of the "HOMS hypothesis"
(Hyatt & Steer 1988)



Attachment D

Sockeye Salmon Index Stocks Marine Survival Trends



Recent among stock comparisons provide compelling evidence supporting the "HOMS hypothesis" (Hyatt et al. 2010, *in prep*) !

Conclusions

- FWMT deployment has stabilized smolt production per spawner by reducing density-independent losses from flood-and-scour or drought-and-desiccation events.
- Higher escapements more fully utilize inherent habitat capacity for spawning, egg incubation and rearing fry with resultant increases in annual smolt production
- Average annual output of smolts from Osoyoos L. increased 5-10 fold in 1998-2010 relative to the 1970-1997 interval.
- Record returns of Columbia R. sockeye principally reflect wild Okanagan sockeye increases in escapement, fry (*from the Okanagan R.*), smolt production (*from Osyoos L.*) and favourable smolt-to-adult survival (*in the Columbia R and Pacific Ocean*).

Questions ?

Attachment D

Fisheries and Oceans Canada — Pêches et Océans Canada

Canada

ANCHOR QEA

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Seattle, Washington 98101
Phone 206.287.9130
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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	June 20, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the May 17, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Douglas PUD Headquarters in East Wenatchee, Washington, on Thursday, May 17, 2012, from 9:30 am to 12:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Chelan and Douglas PUDs will present at the June 20, 2012 Hatchery Committees meeting potential paths forward for reviewing and revising the Hatchery Monitoring and Evaluation (M&E) Programs using the results from the Final 5-Year M&E Reports (Item II-A).
- Bill Gale will email to Kristi Geris for distribution to the Hatchery Committees a revised draft Statement of Agreement (SOA) for the Collection of Adult Broodstock at Wells Hatchery for Entiat National Fish Hatchery. Background language in the draft SOA will be revised to indicate that the estimated broodstock required from Wells Hatchery in later years may be adjusted dependent on 2012 returns (Item II-B).
- Joe Miller will email to Kristi Geris for distribution to the Hatchery Committees revisions to the Dryden Conceptual Study Approach, including additional information on issues associated with constructing a dedicated surface water intake at the Dryden facility (Item III-C).
- Steve Lewis will provide to Joe Miller, Mike Tonseth, and Mike Schiewe editorial comments to the 2012 Tumwater Operations request for concurrence; Kristi Geris will distribute these comments to the Hatchery Committees (Item III-E).
- Keely Murdoch will email to Kristi Geris for distribution to the Hatchery Committees additional information on future hatchery space requirements for the Yakama Nation

(YN) Coho Restoration Program, including timelines and details on the split between Methow- and Wenatchee-released fish (Item IV-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- No SOAs were approved at this meeting.

AGREEMENTS

- The Rocky Reach and Rock Island Hatchery Committees, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS) agreed on Tumwater Dam operations for 2012 (Item III-E).
- The Hatchery Committees agreed to continue discussions on updating the Hatchery Programs M&E Plans at the June 20, 2012 Hatchery Committees meeting.

REVIEW ITEMS

- No reports are currently out for review.

FINALIZED REPORTS

- The Chelan PUD Final 5-Year M&E Report was posted and became available for download from the Anchor QEA FTP site on May 7, 2012.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. The following revisions were made to the agenda items:

- Joe Miller removed Chelan PUD's agenda items III-A, B, and D.
- Kirk Truscott requested that the decision agenda item III-E be discussed at the beginning of the meeting.
- Keely Murdoch added a discussion of the YN Coho Restoration Program.

The revised draft April 18, 2012 meeting minutes were reviewed. Kristi Geris said all comments and revisions received on the draft meeting minutes were incorporated and there are no outstanding items remaining to be discussed. Bill Gale clarified that the USFWS plans to use volitional release for this year's Winthrop National Fish Hatchery (NFH) steelhead program. The Committees approved the April 18, 2012 meeting minutes, as revised.

II. Douglas PUD

A. Principles of Adaptive Management (Greg Mackey)

Greg Mackey presented an overview of adaptive management (Attachment B) to facilitate discussion of possible paths forward for reviewing and revising Chelan and Douglas PUDs' Hatchery M&E Programs. This review is required every 5 years under the HCP. Mackey reminded the Hatchery Committees of the electronic article on adaptive management that Kristi Geris distributed to the Committees via email on May 8, 2012, and pointed out that the article contained insight on all aspects of adaptive management. Mackey's presentation provided an overview of the HCP process, the adaptive management process, and decision analysis, and how the three processes overlap. Mackey discussed the advantages of developing detailed HCP hatchery objectives in an adaptive management framework so that actions feed back into an iterative adaptive management loop. Mackey invited discussion from the Committees.

Keely Murdoch pointed out that the HCP analytical framework does include an outline for an adaptive management process (i.e., review the 5-Year M&E Reports for potential changes, thus making objectives); however, the Committees have yet to adopt a plan to initiate the process. Mackey suggested that when the M&E Plans are updated, they can be updated based upon actions and assessment. For example, if actions aren't helping to inform management actions, they don't need to be included in the plan.

Mike Schiewe said that sometimes management doesn't anticipate tomorrow's questions; developing a knowledge base to be proactive has merit, and that should be on the table as well. Schiewe said that Chelan PUD's 5-Year M&E Plan is final, and Mackey said Douglas PUD is addressing some final questions on the Douglas PUD 5-year M&E Plan, and they should be ready to finalize it prior to the Hatchery Committees' June 20, 2012 meeting.

Bill Gale said that although adaptive management can save resources and improve performance, this concept can collapse without an awareness of what resources exist. Joe Miller added that when the target is not well defined, it is hard to accomplish anything.

Schiewe reminded the Committees that during last month's Hatchery Committees meeting, it was decided that when both M&E 5-Year Reports are finalized, the group should evaluate and discuss how the 5-year findings can inform decisions and management. Mackey said that Douglas, Chelan, and Grant PUDs are already having conversations regarding the 5-year update of the M&E plans. Mackey pointed out that in order to allow enough time for review, approval, and incorporation into next year's M&E implementation plan, the updated M&E plan would need to be finalized by the end of September. Miller added that, within this timeframe, a request for proposals (RFP) needs to be developed as well.

Schiewe acknowledged the need to move quickly, and proposed that Chelan and Douglas PUDs present at the June 20, 2012 Hatchery Committees meeting their potential paths forward in reviewing and revising the Hatchery M&E Programs using the results from the Final 5-Year M&E Reports. The Hatchery Committees agreed to this path forward and timeframe.

B. Broodstock Protocol Update (Greg Mackey)

Greg Mackey asked Mike Tonseth to provide the Hatchery Committees with a brief update on the status of the 2012 Broodstock Protocol. Tonseth said the protocols were completed and submitted to NMFS by April 15, 2012, as required under Section 10 permits 1395, 1347, and 1196. He said that NMFS has tentatively approved them, pending final agreement on the Wenatchee steelhead program.

C. SOA Entiat National Fish Hatchery Summer Chinook Broodstock Collection (Greg Mackey)

Greg Mackey distributed to the Hatchery Committees a draft SOA for the Collection of Adult Broodstock at Wells Hatchery for Entiat National Fish Hatchery. Mackey said that, at this point, the SOA is for discussion purposes only, but he hoped to gain approval on the SOA at the Hatchery Committees' June 20, 2012 meeting. Mike Tonseth requested that the background language in the draft SOA be revised to indicate that the estimated broodstock required from Wells Hatchery in later years may be adjusted dependent on 2012 returns. Gale said he will make the revision and email the revised draft SOA to Kristi Geris for distribution to the Hatchery Committees (Attachment C). Gale indicated his approval of the

SOA during today's meeting because a USFWS representative may not be available to attend the Hatchery Committees' June 20, 2012 meeting.

III. Chelan PUD

A. Discussion: Steelhead Releases from Chiwawa (Joe Miller)

This item was removed from today's agenda.

B. Discussion: Updates to Hatchery M&E (Joe Miller)

This item was removed from today's agenda.

C. Discussion: Dryden Feasibility Study (Joe Miller)

Joe Miller presented to the Hatchery Committees the draft Dryden Conceptual Study Approach (Attachment D). He said that he and Josh Murauskas, Bill Gale, and Kirk Truscott worked together to develop the study strategy. Miller pointed out that a key feature of this study is to identify a target for Dryden, and that target is smolt-to-adult returns (SARs) greater than or equal to those observed at Similkameen Ponds. Miller reviewed the objective, methods, and timeline of the study as outlined in Attachment D. Miller noted that the disease evaluation survey, study, and experiment (collectively, the fish health study; Method 3 in Attachment D) were developed in coordination with Chris Good of Freshwater Institute. Miller said this study will provide important new information to guide future direction.

Kirk Truscott emphasized that, as Table 1 indicates, testing moves forward down parallel paths. Truscott also noted that the Similkameen program was chosen as a reference for success because overwinter acclimation had been successfully implemented there. Truscott said that for comparison to Dryden performance, Similkameen performance would need to be adjusted to account for additional mortalities for dam passage.

Bill Gale said he was concerned that there is no replication possible in the experimental strategy. He said this concern could be eliminated if the experiment was conducted where the 'pond effect' can be controlled. Miller said that if this study produces results with the reuse technology that are consistent with previous results, then the program could be made more efficient.

Keely Murdoch said that she is concerned with the direction the discussion had taken regarding implementation of overwinter acclimation at Dryden. Murdoch said the Priest Rapids Coordinating Committee Hatchery Subcommittee (PRCC-HSC) had agreed to overwinter acclimation for Grant PUD production at Dryden, and this has always been the goal for Grant PUD's program. Murdoch indicated that YN may not support future sharing agreements between the PUDs. Miller noted that there is no agreement between Chelan PUD and Grant PUD, presently, to make improvements at Dryden. Further, Murdoch said it is her understanding that the Joint Fisheries Parties (JFP) support construction of a new dedicated surface-water intake at the Dryden facility. The new intake, Murdoch said, will increase flexibility as to how programs are operated, and will provide an alternative to the irrigation canal water source and subsequent fish health issues at Dryden. Murdoch said that she would like to see separate consideration of the benefits of the new intake, and of how the program is operated.

Miller reviewed a document developed by Chelan PUD and distributed by Kristi Geris to the Committees via email on May 16, 2012, which outlined several questions and responses related to Chelan PUD's Dryden Acclimation Facility (Attachment E). After reviewing the document, Miller explained that Chelan PUD needs to fully understand the fish health problem before a new intake is installed.

Mike Tonseth said he understands having a target at Dryden and the need to evaluate how best to achieve that target; however, Tonseth said he also sees the benefit of a dedicated surface-water intake. To be fully dependent on the canal, Tonseth said, risks that the water supply might be unavailable at some time in the future. Miller said Chelan PUD is not backing away from the idea of a new intake, but it will require water quality data to know what the options are. Miller added that if a new intake does not resolve the fish health issue, or is sized to meet a flow rate that precludes necessary future treatment, the program performance will not improve. Tonseth also pointed out the significant difference in water quality between the lower and upper Wenatchee River. Tonseth said the rearing and acclimation experiment element of the conceptual design (Method 4) does not take this into consideration, and he would like to see this issue acknowledged.

Gale said that water chemistry can be evaluated; however, it may not be possible to get reliable information on pathogen concentrations in the water. Tonseth suggested contacting the Freshwater Institute to determine if concentrations of Saprolegnia spores could be measured. Gale suggested that Chelan PUD could use a RFP to determine what type of water quality testing is possible. Mike Schiewe suggested that the signatories could also each reach out within their own organizations for water quality and fish health expertise.

Tonseth asked whether Chelan PUD had decided how to make phosphorus allocations. Miller said that, according to Ecology, there is no transferability. Tonseth pointed out that this will be an issue in trying to achieve the target at Dryden. Miller said that this is one of the reasons water quality and quantity issues need to be determined.

Truscott said that he did not think a new intake at Dryden would affect Total Maximum Daily Load (TMDL). Miller responded that there is an interaction between phosphorus wasteload and flow/discharge (Q), and from a due diligence standpoint, Chelan PUD cannot support installing a new intake without understanding how one parameter will affect the other. Miller said for example, if it turned out that whatever is causing the fish health problems at Dryden required UV treatment, intake size/discharge would need to be reduced (from the current proposal) which would reduce the total daily wasteload allocation. Specifically, the relationship between wasteload allocation and flow is not constant – the daily allocation grams per day decreases as discharge decreases. Miller said that a recirculation system could potentially reduce phosphorus in the effluent and meet the wasteload allocation, at lower discharge levels, but the intake would need to be sized accordingly. Schiewe reminded the Hatchery Committees that the TMDL would not limit production (if it limits it at all) until 2018, and he said that this research strategy would produce data to inform a decision before then.

Murdoch said she would like to see a revision of the study proposal to include more detail on the independent evaluation of a new intake at Dryden. Miller said the current focus of the study design is performance, and to commit to infrastructure at this point would preclude several potential options to achieve the target performance. Murdoch added that she did not approve of a study being drawn out to 2017 in order to use SARs as a performance metric.

Miller agreed to update the Dryden Conceptual Study Approach to incorporate interests concerning the potential installation of a dedicated surface water intake at the Dryden facility. Kristi Geris will distribute the revisions to the Hatchery Committees.

D. Discussion: Spring Chinook Imprinting Study (Joe Miller)

This item was removed from today's agenda.

E. NMFS and USFWS Approval of Tumwater Operations for 2012 (Joe Miller)

Joe Miller introduced the Tumwater Trapping Plan for operations beginning June 1, 2012 (Attachment F). Miller said the plan is the same as last year, and he said that Chelan PUD has asked NMFS and USFWS for approval of the plan. Miller summarized actions included in the plan as described on page 2 (of Attachment F). Mike Tonseth said NMFS had already sent a letter of concurrence, and Steve Lewis joined the meeting by phone for discussion and approval.

Lewis asked Miller about potential effects of the operation on bull trout. Lewis said he had only one editorial comment regarding the underlined language on page 1 of the plan. Lewis said he will provide specific editorial comments to Miller, Mike Tonseth, and Mike Schiewe, and with those edits, Lewis said, USFWS approves the plan. Kristi Geris will distribute the final operation plan to the Hatchery Committees.

IV. Yakama Nation

A. Coho Restoration (Keely Murdoch)

Keely Murdoch said that juvenile coho salmon for the YN Upper Columbia Coho Reintroduction Program are currently being reared at Willard NFH, but this space may be redirected for John Day mitigation in the future. Accordingly, the YN is looking for hatchery space to rear approximately 1.25 million fish (eyed egg to smolt). Murdoch requested information from the PUDs regarding space that might be available at East Bank, Wells, or Methow hatcheries. The Committees had several questions regarding the timeline, the split between Methow- and Wenatchee-released fish, etc., and Murdoch agreed to get answers to these questions to Kristi Geris for distribution to the Hatchery Committees.

V. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees Meetings are on June 20, 2012 (Chelan PUD office), July 18, 2012 (Douglas PUD office), and August 15, 2012 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees

Attachment B – Presentation on Adaptive Management and the HCP

Attachment C – Revised Draft SOA Entiat Summer Chinook Broodstock

Attachment D – Dryden Conceptual Study Design

Attachment E – Chelan PUD Dryden Questions

Attachment F – Tumwater Operations Letter

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Joe Miller*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Todd Pearsons	Grant PUD
Jayson Wahls	WDFW
Keely Murdoch*	Yakama Nation
Kirk Truscott*	CCT
Bill Gale*	USFWS
Mike Tonseth*	WDFW
Steve Lewis†	WDFW

Notes:

* Denotes Hatchery Committees member or alternate

†Joined by phone for Tumwater Operations discussion

Attachment B

Adaptive Management and the HCP

Gregory Mackey
Douglas PUD

May 17, 2012
HCP Hatchery Committee Meeting

How did the HCP address adaptive management?

HCP

- "…is intended to constitute a comprehensive and long-term adaptive management plan for Plan Species and their habitat as affected by the Project." (Wells HCP, page 1)

HCP Adaptive Management Structure

- Overall Objective: Achieve NNI
  - Combined adult and juvenile survival >= 91%
  - Compensation for Unavoidable Project Mortality
    - 7% Hatchery Programs
    - 2% Tributary Programs

HCP Adaptive Management Structure

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  - Combined adult and juvenile survival >= 91%
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HCP Hatchery Program Objectives

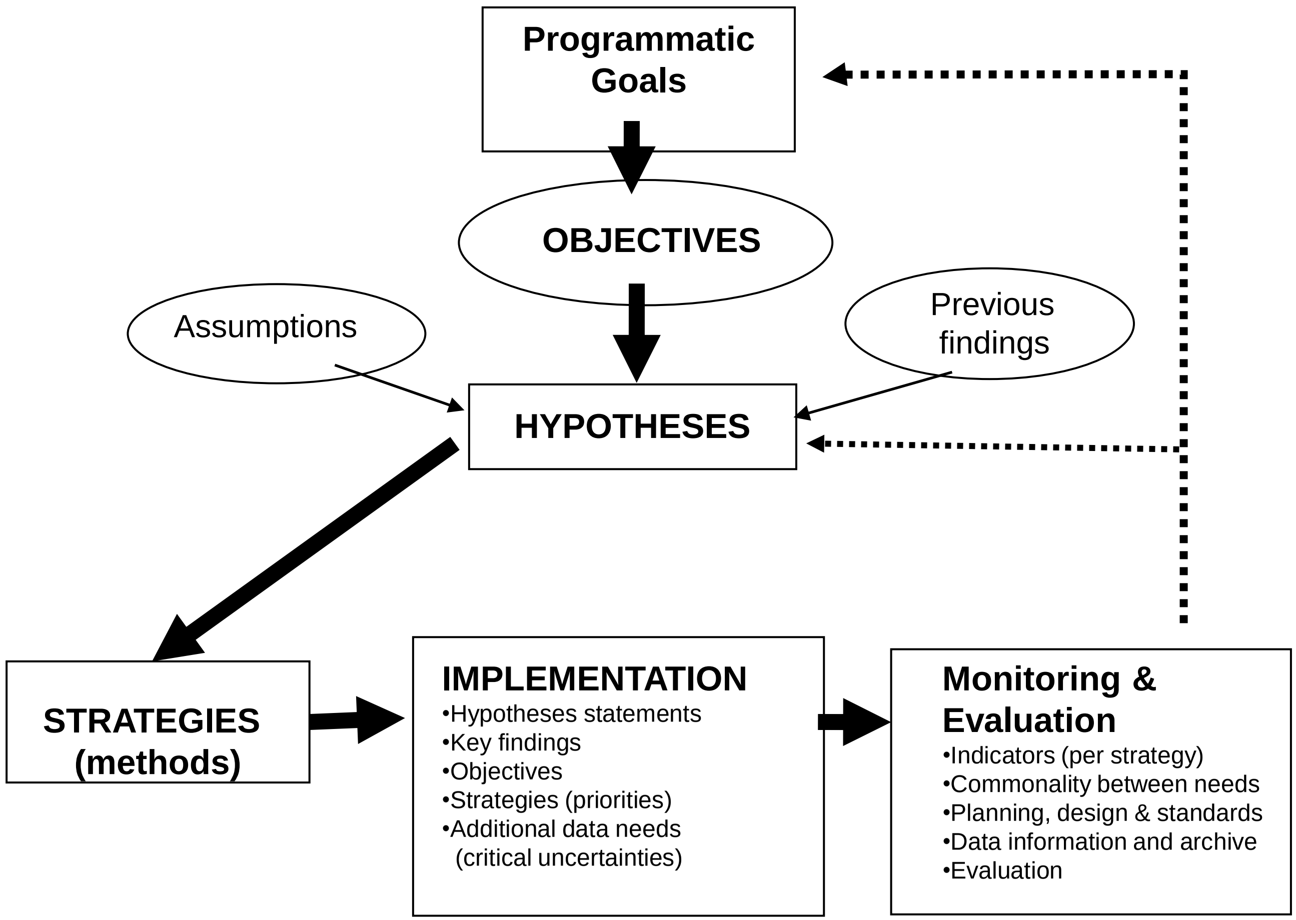
- Overall Objectives: Rebuild natural populations and achieve NNI
  - Contribute to rebuilding and recovery of naturally reproducing populations
  - Maintain genetic diversity
  - Support harvest

Hatchery Program Adaptive Feedback Cycles

- Adjustment of Hatchery Compensation
  - Survival Studies (i.e. adjustment of NNI for project survival)
  - Population Dynamics (i.e. recalculation of NNI)
- Monitoring and Evaluation Program
  - Scheduled updates every 5 years
  - Annual and 5-Year reports (not in HCP)
- Program Modifications as Necessary to Achieve NNI as Determined by the M&E Program
- NMFS under ESA can make changes to the programs
  - Provision for changes that do not effect NNI
  - Provision for changes to do effect NNI
- 10 Year Program Reviews
  - Determine if operating consistent with goals in evaluation plan
  - Adult-to-Smolt survival
  - Smolt-to-Adult survival
  - Hatchery Program Goals and Objectives in Hatchery Plan, Section 10 Permits
  - If Goals and Objectives are not being met, then the Hatchery Committee shall be responsible for establishing alternative plans

Attachment B

M&E Adaptive Management



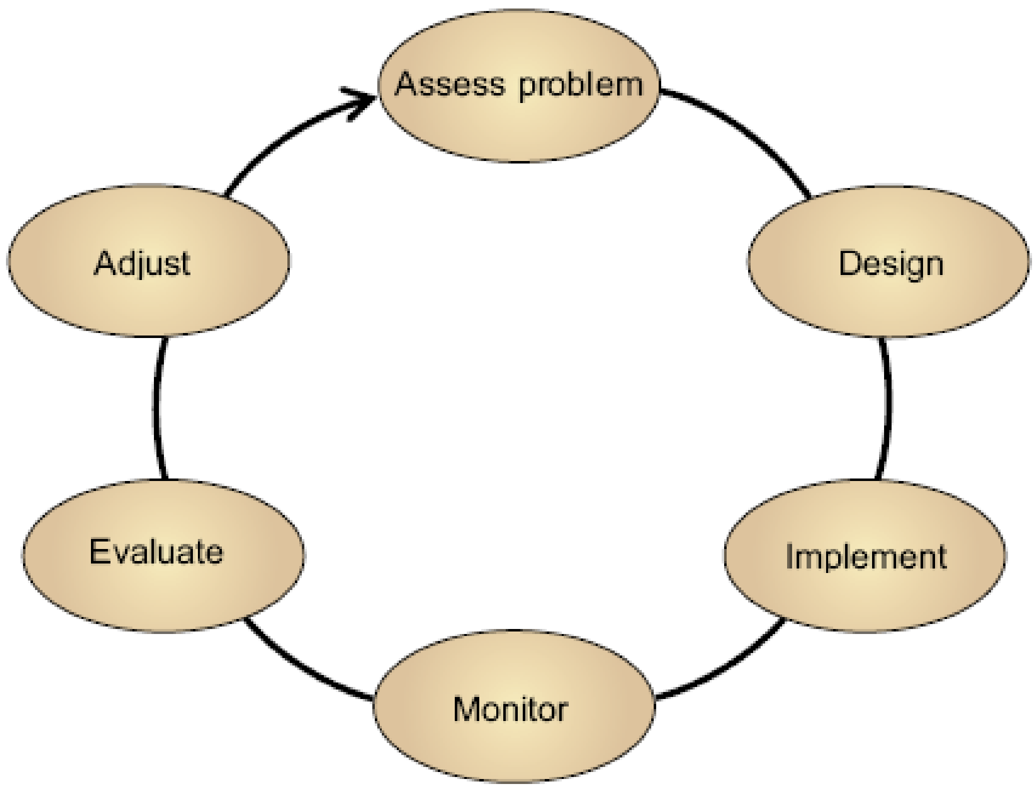
M&E Assessment (Hypotheses)

1. Determine if supplementation has increased naturally spawning and naturally produced adults relative to, and if NRR is similar to non-supplemented population(s)
2. Determine if migration and spawn timing and spatial spawning distribution of hatchery and wild fish are similar.
3. Determine if phenotypes, genetic diversity, population structure, and effective population size have changed in natural spawning populations.
4. Determine if HRR is greater than NRR, and meeting expected HRR.
5. Determine if stray rates are below acceptable levels.
6. Determine if hatchery fish were released at the programmed size and number.
7. Determine if pHOS affects freshwater productivity compared to non-supplemented streams.
8. Determine if harvest opportunities have been provided.

Overview of Adaptive Management

Attachment B

“Adaptive management is not really much more than common sense. But common sense is not always in common use.” (Holling 1978)



Adaptive Management

- Decision process that promotes decision making in the face of uncertainties as outcomes from management actions become better understood.
- Designed to address key uncertainties by iteratively using feedback from the system being managed to reduce those key uncertainties.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Crawford, S., S. Matchett, and K. Reid. 2005. Decision Analysis/Adaptive Management (DAAM) for Great Lakes fisheries: a general review and proposal. Draft discussion paper presented at IAGLR (International Association for Great Lakes Research).

Or…

We can use management structured as an experiment to learn about the system and how to systematically improve management of the system.

Adaptive Management is easy to understand - almost

- Adaptive management is not:
  - Trial and error
  - "Flexible" management
  - Consensus from all stakeholders
  - Sophisticated modeling
  - A panacea that can solve all problems

From Crawford et al. 2005.

Walters: Learning by doing

- Integrate existing interdisciplinary experience and scientific information to create dynamic models that make predictions about alternative management actions
  - Clarifies the problem
  - Screens options that are incapable of doing much good
  - Identifies key knowledge gaps

Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online]1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1/

Attachment B

ASSESS

- Define management objectives, possible suites of actions, clear indicators of performance.
- Scope key uncertainties
- Predict how management option(s) will affect performance indicators

Design

- Management Plan – detailed
- Monitoring Plan – detailed

Implement the Management Plan

- Practitioners must understand the logic of the design
- All aspects must be adhered to
- Deviations and their rationales must be clearly documented

Monitor

- Monitor implementation of management plan
- Monitor indicators for efficacy of actions
- Monitor indictors to test alternative hypotheses

Evaluate

- Were predicted outcomes accurate?
- Which actions best achieved desired outcomes?

Adjust (Revise)

- Management objectives/policies, indicators, uncertainties, and hypotheses
- Which actions best achieved desired outcomes?

Attachment B

Decision Analysis

Making hard decisions in the face of uncertainty

Decision Analysis

- Explicitly and quantitatively takes into account key uncertainties as quantitative variables in order to evaluate the effects of various management options.
- Reduces complex problems to more manageable components (can later re-assemble)
- Rank management options
- Determine best management option over a range of hypothesized responses to management actions

Attachment B

State management objectives

Identify management options

Uncertain states of nature: Explicitly state logically possible explanations of cause and effect (hypotheses)

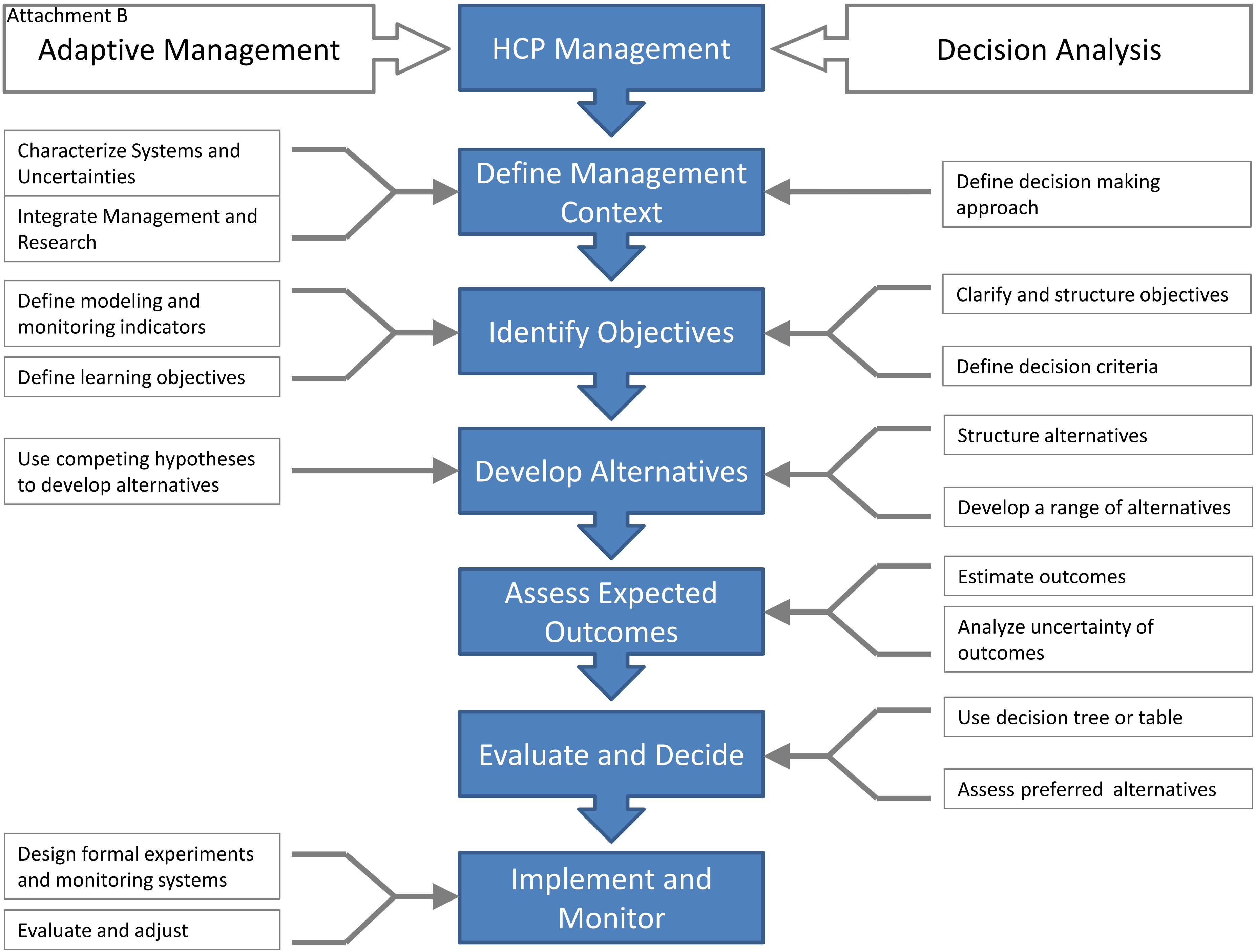
Place probabilities on each hypothesis

Model outcomes for each management option across possible states of nature

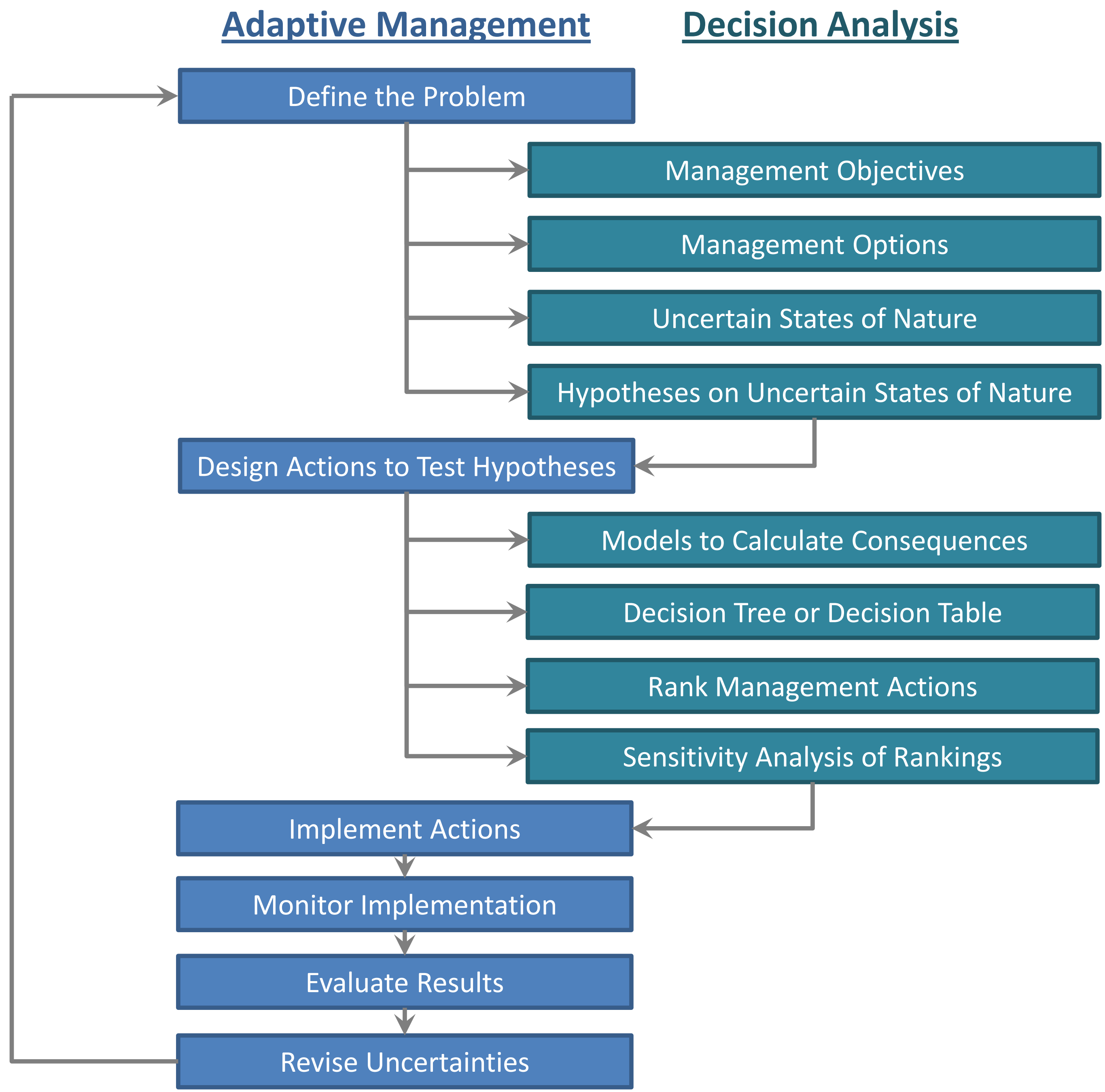
Use decision trees or tables to assess outcomes

Rank management actions (outcome weighted by probability of occurrence)

Sensitivity analysis: Does the rank order of management actions change under different management objectives, hypotheses, or probabilities?


Attachment B
Adaptive Management
HCP Management
Decision Analysis
Characterize Systems and Uncertainties
Integrate Management and Research
Define Management Context
Define decision making approach
Define modeling and monitoring indicators
Define learning objectives
Identify Objectives
Clarify and structure objectives
Define decision criteria
Use competing hypotheses to develop alternatives
Develop Alternatives
Structure alternatives
Develop a range of alternatives
Assess Expected Outcomes
Estimate outcomes
Analyze uncertainty of outcomes
Evaluate and Decide
Use decision tree or table
Assess preferred alternatives
Design formal experiments and monitoring systems
Evaluate and adjust
Implement and Monitor

Attachment B



Attachment B

Strength and Weaknesses of the HCP Programs

Strength	Weakness
HCP Defines Overarching Goals	Specific goals/objectives are not defined
HCP provides schedule for some adjustment decisions	Specific management actions are not tied to formal adaptive management process or decision analysis
	Management is not set up as an “experiment,” greatly limiting assessment of management options
M&E Plan defines hypotheses and analyses	Hypotheses are not tied to management options or decision analysis
	Uncertain states of nature have not been fully scoped and incorporated into management
	Management option outcomes are not predicted
Detailed Monitoring Plan has been developed	Detailed Management Plans not yet developed
Committee of “stakeholders” already in place to make management decisions	Decision Analysis is not used and some aspects of management decisions fall outside the authority of the Committee.

References

- Crawford, S., S. Matchett, and K. Reid. 2005. Decision Analysis/Adaptive Management (DAAM) for Great lakes fisheries: a general review and proposal. Draft discussion paper presented at IAGLR (International Association for Great Lakes Research).

- Walters, C. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology [online]1(2):1. Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1/

- Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Draft 5-16-2012

Wells HCP Hatchery Committee

Statement of Agreement

Collection of Adult Broodstock at Wells Hatchery for Entiat National Fish Hatchery

Approved on XX June 2012

Statement

The Wells HCP Hatchery Committee approves the collection of additional summer Chinook (up to 135 pair) during broodstock collection efforts at the Wells Hatchery volunteer ladder trap for the 2012, 2013, and 2014 brood years. These additional brood will be transferred to the US Fish and Wildlife Service's (USFWS) Entiat NFH to support the Entiat summer Chinook program. Broodstock collection for the Entiat program will take place after Douglas PUD's and Chelan PUD's programs have achieved their broodstock collection goals. Logistical and financial arrangements for these collections will be determined by Douglas County PUD and the USFWS.

Background

The USFWS, in conjunction with other parties (Yakama Nation, the Confederated Tribes of the Colville Reservation NOAA, WDFW, BOR), is implementing a new summer Chinook hatchery production program at Entiat NFH. The long-term goal of this program is to provide fish for tribal, commercial, and sport harvest, and to meet tribal trust responsibilities as mitigation for Grand Coulee Dam. A Hatchery and Genetics Management Plan (HGMP) for this program was submitted to NOAA in July of 2009. This HGMP has also been distributed to all of the relevant co-managers.

The USFWS uses volunteer summer Chinook returns to Wells Hatchery as interim broodstock for the Entiat NFH program, and expects that the Entiat NFH will be self-sufficient starting in 2015 (see Table). Broodstock collection efforts have historically entailed the transfer of eggs in the first year of partial production (BY 2009), and transfer of adults in BYs 2010 and 2011 (and for subsequent years until sufficient numbers of adults return to Entiat NFH). Full production will require the collection of up to 270 hatchery origin summer Chinook adults (enough to provide up to 400K eggs). Funding for this new program is the responsibility of the USFWS and BOR.

Brood Year	Estimated Broodstock Required from Wells Hatchery
2012	270
2013	270
2014	135
2015	0

The above forecasted need for broodstock is based on an assumed SAR of 0.3%. Adults from the Entiat NFH program are expected to begin returning in 2012 but will consist of 2 year old jacks only. As 3 and 4 year old adults return in 2013 and 2014 the need for collection of brood at Wells Hatchery may need to be extended or refined. Any extension of brood collection (past 2014) at Wells Hatchery for the Entiat NFH program would require additional discussion and agreement of the Wells HCP parties.

Broodstock collection for the Entiat program will take place after Douglas PUD's and Chelan PUD's programs have achieved their broodstock collection goals.

Attachment C

Draft 5-16-2012

Dryden Conceptual Study Approach

Objective

The purpose of this study is to determine the efficacy of program modifications intended to increase SARs at Dryden Acclimation Ponds while keeping stray rates within acceptable limits. SARs greater than or equal to those observed at Similkameen Ponds, adjusted for additional project mortality, would be considered successful. Additional infrastructural improvements would not be required if a suitable method was developed to reach SAR and stray rate objectives. Out-of-basin stray rate targets will remain as specified in the M&E plan (e.g., 5% of the receiving population).

Methods

1) Survey of overwinter acclimation

A review of data and literature on overwinter acclimation of yearling summer Chinook salmon will be conducted to inform discussions.

2) Re-use experiment

Test groups of summer Chinook from Eastbank Hatchery released in 2009, 2010, and 2011 will be evaluated in terms of comparative performance between raceway and re-use reared smolts. Performance will be documented through smolt travel time and survival to McNary Dam, mini-jack rates, adult survival (SARs), and age structure of returning adults. Overall performance will be compared among treatments and to historic and ongoing results from Similkameen.

3) Disease evaluation survey, study, and experiment

Past data on fish health at Dryden will be analyzed to determine the severity of disease and likely causes. Saprolegnia infections will be monitored beginning in 2013, along with occurrences among treatments and rearing densities (the program size will be reduced by 42% beginning with the 2014 releases). Water samples will be collected from the potential intake location on the Wenatchee River and current location on the irrigation canal during current or potential acclimation periods to determine water chemistry and pathogen load (detailed monitoring forthcoming). These tests will continue for three years unless compelling information is obtained at an earlier date. If analyses from water samples suggest that the sources are significantly different, fish health will be tested using a test/control approach.

4) Rearing and Acclimation Experiment

Three PIT-tagged test groups will be evaluated beginning with the 2013 releases: (1) a control group consisting of raceway-rearing at Eastbank and spring acclimation of smolts at Dryden; (2) a test group consisting of re-use rearing at Eastbank and spring acclimation of smolts at Dryden; and (3) a test group consisting of raceway-rearing at Eastbank and winter-acclimation of smolts at Chiwawa with a final spring acclimation at Dryden. The re-use test group will be reared to two different (e.g., 16 fpp and 22 fpp) sizes to determine how size influences the results. These tests will continue for three years unless compelling information is obtained at an earlier date.

Timeline

The survey of overwinter acclimation will begin in 2012 and conclude by 2013. Age ≤ 4 adults from the initial re-use experiment will be available for analysis in 2013. The Dryden water quality and comparative PIT-tagging will begin with the 2013 releases, potentially continuing through 2015 with Age ≤ 4 adult returns continuing through 2017. Decisions could be made in 2013 if re-use and rearing strategies were found to be effective in meeting goals; subsequent decisions on water quality and acclimation strategies could be made as data become available to support decisions. The following table shows a timeline of testing at Dryden.

Table 1. Testing schedule of acclimation strategies at Dryden.

	Year of completion [1]				
Test	2013	2014	2015	2016	2017
1) Survey of overwinter acclimation	X				
2) Re-use experiment	X				
3) Disease evaluation survey, study, and experiment	X	?	?	?	
4) Rearing and Acclimation Experiment	X	X	X	?	?

[1] Potential decision points could occur in 2013 or later depending on availability of compelling information.

Attachment E

For Discussion 5-12-2012
Submitted by Joe Miller, Chelan PUD

Questions Regarding

This document addresses several recurring questions related to Chelan PUD's Dryden Acclimation Facility and potential future modifications.

1. **Do Chelan PUD and Grant PUD have a sharing agreement that precludes options at Dryden or limits consideration of alternative acclimation sites?**
   No

2. **Does the existing contract limit Grant PUD's ability to meet full production using existing capacity at Dryden?**
   No-Grant can produce their full obligation.

3. **Does Chelan PUD have any philosophical problems with overwintering fish?**
   No. However, it is Chelan's understanding that the HC desires the methodology that achieves the highest performance possible.

4. **Why does Chelan PUD have any concerns?…Isn't Grant is paying for everything?**
   The short-term costs may be Grant's responsibility but Chelan will be responsible for the long term performance of the program. More bluntly, if SARs drop we own the consequences and any inefficiency in the commitment of waste load allocation is also borne by Chelan (we have wastewater responsibilities outside of hatcheries). In summary we are financially responsible.

5. **Why is Chelan taking so long?**
   The combined Dryden program was established by the Hatchery Committee in December 2011. We received our phosphorus allocation from Ecology on March 28th, 2012. We are working as fast as possible. Chelan has constructed over $10M worth of upgrades and new facilities to meet HCP requirements in 2011 including capacity for Grant PUD at Eastbank.

6. **Why does Chelan have an issue with Grant immediately building a new intake at Dryden?**

   A new intake may be necessary but it needs to be sized consistent with waste discharge and treatment requirements. An intake would require a discharge commitment that affects our wasteload allocation.

   DOE has provided a discharge allotment of 743 ug/L phosphorus @ Q = 33cfs. The interaction between intake size, phosphorus and Q will have bearing on compliance with the TMDL. It is not possible to build an intake that does not create discharge (i.e., commitment of Q) or a create phosphorus load. We cannot make a short-term commitment (i.e., expedited process without a feasibility assessment) that could jeopardize our long term ability to meet the TMDL requirements. This includes creating a separate, isolated intake/facility within our property boundary.

At present the HC has noted a chronic fish health problem at Dryden and indicated a desire to address the issue. If the problem is endemic to river water in the vicinity of Dryden (i.e., not the existing canal system), then creating a large new intake for single pass water would effectively eliminate treatment options such as UV. At the same time there are no data to indicate that the canal is the source of the fish health problem. Funding and building an intake without attempting to identify the cause of the fish health issue may do nothing to alleviate the problem and create an additional liability.

7. **Why does Chelan insist on considering other options (i.e., different than overwinter).**
   We are held responsible for the performance of the program at Dryden. The PUD has funded extensive monitoring and evaluation programs as well as pilot programs and we suggest that data from this work should be considered prior to modifying the current program. If another method yields higher performance, why wouldn't we advocate for it?

8. **What is Chelan proposing?**
   See Dryden Conceptual Study Approach.

Attachment F

April 25, 2012

Dr. Craig Busack
Salmon Recovery Division
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232

Mr. Steve Lewis
U.S. Fish and Wildlife Service
Central Washington Field Office
215 Melody Lane, suite 119
Wenatchee WA, 98801

Re: Tumwater Trapping Plan for operations beginning June 1, 2012

Dear Dr. Busack and Mr. Lewis:

The Washington Department of Fish and Wildlife (WDFW) and Chelan PUD (District) is proposing continuation of the Tumwater Trapping Plan (Plan) submitted and approved by NMFS and USFWS (Services) in 2011 (initial correspondence dated May 5, 2011). The purpose of this correspondence is to request concurrence from both NMFS and USFWS that (1) the Services support continuation of the Plan during 2012, and (2) the Services are satisfied that the Plan will result in "take" of Endangered Species Act (ESA) –listed salmon, steelhead, and bull trout that is consistent with the manner and extent previously approved by the Services through WDFW's Section 6 cooperative agreement, USFWS's biological opinion on Rocky Reach relicensing, and NMFS's Section 10 permits and associated biological opinions for these activities.

The 2011 spring migration was the first year of implementing modified trapping protocols at Tumwater Dam. PIT tag data indicate that the Plan reduced passage delays. The proportion of fish last detected on the downstream array in the Tumwater fishway was significantly lower for both sockeye ($p < 0.0001$) and Chinook ($p < 0.0001$) compared to previous years. Likewise, the delay of fish in the Tumwater fishway was significantly shorter in duration for both sockeye ($p < 0.0001$) and Chinook ($p < 0.0001$) compared to previous years (Table 1). While environmental conditions and run sizes varied between years, the data suggest that passage under the Plan was improved.

Table 1. Median delays and proportion of adults last detected on the downstream array for previously-tagged sockeye and adult (Age 4+) spring Chinook salmon.

	Median delay		Percent last detected at Weir 15	
	2010	**2011**	**2010**	**2011**
Sockeye	210 hours	6 minutes	38 %	< 1 %
Spring Chinook	190 hours	17 hours	26 %	6 %

For 2012, WDFW and the District are proposing to continue actions identified in the Plan submitted in 2011. Specifically, these actions include (summarized from the initial Plan):

- Real-time monitoring to ensure that median delays are not exceeding 48 hours.
- Relocation of broodstock collection away from the Tumwater trap.
- Improved fish handling efficiency through infrastructure and process improvements;
- Active trapping from June 1 to July 15 to ensure that trapped fish are moved quickly and effectively. The fishway will be opened for volitional passage when staff are not present.
- Limited operations (3 days/week, ≤ 16 hours/day) from July 16 to August 31 to facilitate upstream passage of sockeye.

The WDFW and District recognize the importance of the actions proposed at the Tumwater Trapping Facility and the active support that NMFS and USFWS have provided as both ESA administrators in the Habitat Conservation Plan Hatchery Committees and participants in the proposed trapping activities at Tumwater (i.e., removal of Leavenworth hatchery strays [USFWS]; and co-principal-investigators of the two ongoing relative reproductive success studies [NMFS]). It is our desire to meet the objectives of all parties benefitting from the Tumwater Trapping Facility. However, <u>we are asking for confirmation from NMFS and the USFWS that the operations Plan implemented in 2011 and the proposed continuation of these approaches during the 2012 migration are covered under existing ESA approvals</u>. This letter does not anticipate or request any changes in quantified take levels for any species. Therefore, before allowing trapping to proceed on June 1st pursuant to the Plan, we require written affirmation from both NMFS and USFWS that (1) the Services support continuation of the Plan, and (2) the Services are satisfied that the plan will result in take of ESA-listed salmon, steelhead and bull trout consistent with the manner and extent previously approved by the Services.

Thank you for considering continuation of the Plan. We hope the results from 2011 provide assurance that the Plan is benefiting migratory fishes in the Wenatchee River Basin and should be continued to allow the research and management activities at Tumwater Dam. We also look forward to input from the Services regarding any potential improvements to the plan.

Sincerely,

Josh Murauskas
Senior Fisheries Biologist
Chelan County PUD

Mike Tonseth
UCR Fisheries Biologist
Washington Department of Fish & Wildlife

May 24, 2012

Dr. Craig Busack
Salmon Recovery Division
National Marine Fisheries Service
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232

Mr. Steve Lewis
U.S. Fish and Wildlife Service
Central Washington Field Office
215 Melody Lane, suite 119
Wenatchee WA, 98801

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- Active trapping from June 1 to July 15 to ensure that trapped fish are moved quickly and effectively. The fishway will be opened for volitional passage when staff are not present.
- Limited operations (3 days/week, ≤ 16 hours/day) from July 16 to August 31 to facilitate upstream passage of sockeye.

The WDFW and District recognize the importance of the actions proposed at the Tumwater Trapping Facility and the active support that NMFS and USFWS have provided as both ESA administrators in the Habitat Conservation Plan Hatchery Committees and participants in the proposed trapping activities at Tumwater (i.e., removal of Leavenworth hatchery strays [USFWS]; and co-principal-investigators of the two ongoing relative reproductive success studies [NMFS]). It is our desire to meet the objectives of all parties benefitting from the Tumwater Trapping Facility. However, we are asking for confirmation from NMFS and the USFWS that the operations Plan implemented in 2011 and the proposed continuation of these approaches during the 2012 migration are covered under existing ESA approvals. This letter does not anticipate or request any changes in quantified take levels for any species. Therefore, before allowing trapping to proceed on June 1st pursuant to the Plan, we require written affirmation from both NMFS and USFWS that (1) the Services support continuation of the Plan, and (2) the Services are satisfied that the plan will result in take of ESA-listed salmon, steelhead and bull trout consistent with the manner and extent previously approved by the Services.

Thank you for considering continuation of the Plan. We hope the results from 2011 provide assurance that the Plan is benefiting migratory fishes in the Wenatchee River Basin and should be continued to allow the research and management activities at Tumwater Dam. We also look forward to input from the Services regarding any potential improvements to the plan.

Sincerely,

Josh Murauskas	Mike Tonseth
Senior Fisheries Biologist	UCR Fisheries Biologist
Chelan County PUD	Washington Department of Fish & Wildlife

ANCHOR QEA

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	July 18, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the June 20, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Chelan PUD Headquarters in Wenatchee, Washington, on Wednesday, June 20, 2012, from 9:30 am to 2:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Greg Mackey will provide the final approved Statement of Agreement (SOA) for Collection of Entiat National Fish Hatchery (NFH) Summer Chinook Broodstock at Wells Hatchery to Kristi Geris for distribution to the Hatchery Committees (Item II-A).
- Douglas and Chelan PUDs will coordinate meeting logistics for a Hatchery Monitoring and Evaluation (M&E) Programs Workgroup. This workgroup is open to all Hatchery Committees' members and will review and recommend revisions to the Hatchery M&E Plans (Item III-A).
- Mike Tonseth will provide to the Hatchery Committees an overview of the marking schemes for hatchery programs (Item V-B).
- Chelan and Grant PUDs will develop a detailed timeline, including milestones, for evaluating options to address compliance with the proposed Wenatchee River phosphorus total maximum daily load (TMDL) at the Dryden Rearing Facility (Item VII-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- The SOA for Collection of Entiat NFH Summer Chinook Broodstock at Wells Hatchery was approved by the Wells Hatchery Committees representatives present.

Kirk Truscott gave his approval by email as distributed to the Hatchery Committees prior to the meeting on June 20, 2012 (Item II-A).

AGREEMENTS

- The Hatchery Committees representatives present agreed to the Request Authorization for Four (4) Additional Hatchery-Origin Wenatchee Spring Chinook for the Continuation of the Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study. Kirk Truscott agreed to the request by email as distributed to the Hatchery Committees prior to the meeting on June 20, 2012 (Item IV-A).
- The Wells HCP Hatchery Committee agreed to release 27 natural-origin Carson lineage adult spring Chinook, collected as broodstock for the Methow Hatchery program, into the Methow River, with the understanding that the broodstock collection target for the Methow Hatchery will likely still be achieved (Item IV-B).

REVIEW ITEMS

- No reports are currently out for review.

FINALIZED REPORTS

- The Douglas PUD Final 5-Year M&E Report was distributed to the Hatchery Committees and was posted and became available for download from the Anchor QEA FTP site on May 21, 2012.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. The following revisions were made to the agenda:

- Mike Tonseth removed Washington Department of Fish and Wildlife's (WDFW's) agenda item IV-B regarding an additional fish request for micro-chemistry evaluation, and added a Methow spring Chinook broodstock collection update.
- Josh Murauskas removed Chelan PUD's agenda item V-B regarding performance of 2012 Passive Integrated Transponder (PIT)-tagged summer Chinook, and added a discussion on marking schemes for hatchery programs.
- Craig Busack added a National Marine Fisheries Service (NMFS) Hatchery Genetic

Management Plan (HGMP) and permitting update.

The revised draft May 17, 2012 meeting minutes were reviewed. Kristi Geris said all comments and revisions received on the draft meeting minutes were incorporated and there are no outstanding items remaining to be discussed. Geris also noted a minor revision received on June 14, 2012, from U.S. Fish and Wildlife Service (USFWS) after the revised May 17, 2012 meeting minutes were distributed on June 12, 2012. Hatchery Committees members present approved the May 17, 2012 meeting minutes, as revised. Kirk Truscott approved the May meeting minutes by email as distributed to the Hatchery Committees prior to the meeting on June 20, 2012

II. Douglas PUD

A. DECISION: Collection of Entiat NFH Summer Chinook Broodstock at Wells Hatchery SOA (Greg Mackey)

Greg Mackey said that Douglas PUD and the USFWS were requesting approval of an SOA for the Collection of Entiat NFH Summer Chinook Broodstock at Wells Hatchery (Attachment B), which was distributed to the Hatchery Committees by Kristi Geris on June 7, 2012. Mackey noted that as requested by the Committees, Bill Gale developed and incorporated additional language to the background section to indicate that the estimated broodstock required in later years may be refined, necessitating an extension of broodstock collection that would require agreement of the Committees. Wells Hatchery Committee representatives present approved the SOA. Kirk Truscott gave his approval by email as distributed to the Hatchery Committees prior to the meeting on June 20, 2012. Mackey agreed to provide a finalized version of the approved SOA to Kristi Geris for distribution to the Hatchery Committees.

III. Douglas PUD and Chelan PUD

A. Discussion: 5-Year Update of the M&E Plan (Greg Mackey & Josh Murauskas)

Josh Murauskas presented Chelan PUD's draft proposal for reviewing and revising the Hatchery M&E goals, objectives, and monitoring activities (Attachment C), which was distributed to the Hatchery Committees by Kristi Geris on June 19, 2012. Murauskas said he divided Chelan PUD's M&E objectives into three categories (see Table 1 of Attachment C): 1) in-hatchery monitoring, which focused on survival in the hatchery; 2) in-river performance;

and 3) long-term monitoring. Each category had an objective and purpose, and proposed action(s) depending on results of the monitoring.

Keely Murdoch questioned whether the categories were different. Murdoch said that Table 1 suggests assessing the outcomes of the categories independently, but Murdoch reminded Murauskas that the M&E Analytical Framework acknowledged that individual objectives would be evaluated in relation to all categories. Murdoch noted that there is a relationship between the productivity indicators and monitoring indicators that was not captured in the handout. Craig Busack added that, conceptually, the first two categories address performance of the hatchery fish, and the third category addresses the effect of the hatchery program on the natural production. Busack suggested framing the categories to reflect that distinction. Todd Pearsons suggested using two categories—an overall hatchery performance category and a natural environment category—and then adding subcategories under those two main categories. Mike Tonseth added that it is important to: 1) make sure the hatchery and natural aspects of monitoring are clearly laid out; 2) review existing objectives and purposes; and 3) determine how many categories are needed to adequately describe the process. Further, Tonseth said, when the current objectives are reviewed, it is important to determine if those objectives are still relevant, or if some of the objectives need to be dropped or revised. Tonseth said it is also important to consider emerging issues such as the effects of residualism, and make sure they are included in the M&E Programs. Murauskas added that there will likely be several changes to the M&E Programs in response to new knowledge, emerging technology, and evolving agency policies.

Greg Mackey presented Douglas PUD's initial approach to reviewing and revising their M&E Program, using a flow chart (Attachment D), which was distributed to the Committees by Geris prior to the meeting this morning on June 20, 2012. Mackey said that each slide of the flow chart relates to an HCP goal, and that the M&E plan was developed to further define objectives within these goals. Mackey mentioned that the 5-year report tends to discuss each objective with equal weight, when in fact some objectives are clearly more important than others, particularly the productivity and monitoring indicators. He said that this presents a challenge in conveying the true hierarchy of objectives.

Mackey identified several areas that Douglas PUD thought needed attention during the review and revision process. Among these areas were the following: 1) genetic monitoring-hypotheses need to be examined for their relationship and applicability to management and the reporting should include a synopsis of findings as they relate to management; 2) patterns of straying (which can fall into multiple categories) and a more precise definition of what constitutes a stray; 3) spatial distribution of spawners and, in particular, a focus on the spatial distribution of natural spawning hatchery and wild fish; 4) the relationship between proportion of hatchery-origin spawners (pHOS) and productivity, and the confounding problem of the correlation of pHOS and spawner abundance; 5) an assessment of whether fish size targets are still valid; and 6) the usefulness of smolt estimates from screw traps versus other PIT-tag-based approaches to estimating juvenile production and survival.

Regarding the question of spatial distribution of spawning, Busack said there are cases of overlap and cases of partial overlap; Busack said his impression of genetic monitoring has been that the goal was to have hatchery-origin fish behave as much as possible like natural-origin fish because such behavior would suggest that there has been minimal genetic impact. Mackey responded that it may be beneficial in some cases for hatchery fish to spawn where natural fish spawn, but it may also be good to leave some areas for wild fish only. Mike Schiewe added that the purpose of a supplementation program is to increase overall production without impacting existing natural production.

Schiewe asked the Hatchery Committees what they would like to see accomplished next as a path forward. Tonseth said the current objectives are responses to questions already asked, and it is important to review the objectives and determine whether these are still the right questions. Tom Kahler suggested determining what the current M&E programs have accomplished that did not result in anything useful, and which efforts have provided the data that we now recognize as essential. Murdoch suggested that a workgroup may be needed to review the objectives. It was agreed that any workgroup should be open to all Hatchery Committees' members, including a Grant PUD representative, and that the workgroup should review and recommend changes to goals and objectives of the Hatchery M&E Plans. Douglas PUD and Chelan PUD will coordinate the meeting logistics for this workgroup.

IV. WDFW

A. Additional Fish Request for Egg-To-Fry Study (Mike Tonseth)

Mike Tonseth reviewed the Request Authorization for Four (4) Additional Hatchery-Origin Wenatchee Spring Chinook for the Continuation of the Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study (Attachment E), and the 2012 Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study Proposal (Attachment F), which were both distributed to the Hatchery Committees by Kristi Geris on June 8, 2012. The Hatchery Committees representatives present agreed to the request, and Kirk Truscott agreed to the request by email as distributed to the Hatchery Committees prior to the meeting on June 20, 2012

B. Methow Broodstock Collection Update (Mike Tonseth)

Mike Tonseth reviewed the status of Methow spring Chinook broodstock collected at Wells Dam. Tonseth said that WDFW is proposing to release a total of 67 fish, of which 21 have been assigned to the Wenatchee/Entiat Basins and will be released below Wells Dam, 27 are natural-origin fish with a high probability of assignment to Winthrop/Carson lineage, 11 are unmarked hatchery fish (as identified by scale pattern analysis) that will be released into the Methow River, and 8 are unassigned wild fish to be released into the Wells pool. Tonseth said all releases are scheduled for Friday, June 23, 2012.

Tonseth said that Methow broodstock collection is on track to meet its target, and WDFW would like Hatchery Committees' guidance on the disposition of the 27 Carson lineage fish. Keely Murdoch asked how long it has been since Carson fish have been released from Winthrop NFH. Tonseth said it was decided in 2006 to eliminate Carson-origin fish in the program. Mackey said that if the 27 fish are kept, there would be 80 broodstock (27 would be Carson lineage fish), but if they are released, that could mean replacing those fish with hatchery-origin Methow Hatchery fish. Therefore, the question before the Committees is if it would be preferable to keep the natural-origin Carson lineage fish in the broodstock, or release them knowing that they may be replaced with hatchery-origin broodstock? The other issue is if releasing the Carson lineage fish will impair the ability of the program to meet the broodstock collection target. The broodstock target should be able to be met, at least with hatchery-origin fish, if the Carson lineage fish are released. Murdoch and Craig

Busack both requested that, in the future, a better understanding of criteria for genetic assignment and a report of methodologies for this analysis be provided. They also requested a post-season report describing this situation and the outcome. Tonseth said the 27 Carson lineage fish can be held a little longer, but he would like to move them as soon as possible to minimize holding. Tonseth indicated that if the 27 fish are of Carson lineage, he would recommend releasing them in the Methow River, where they would still have a chance to contribute to the population, but not perpetuate them in the hatchery program. Of the Hatchery Committees members present, Douglas PUD, WDFW, and USFWS all agreed to the release of the 27 fish, and the Yakama Nation abstained. Tonseth said the fish will be released.

V. Chelan PUD

A. Discussion: Steelhead Residualism and Predation (Josh Murauskas)

Josh Murauskas presented findings on Wenatchee steelhead residuals and predation (Attachment G). Murauskas said the concern was that if steelhead were released late in May or June, then avian predation may increase and affect survival. Avian predation was measured by recovering PIT tags from Island 18, Foundation Island, Badger Island, and Crescent Island. A logistic regression on hatchery releases from April 15 through May 25 showed a significant correlation between later release and a higher likelihood of recovering a PIT tag on one of the islands. Keely Murdoch commented that the correlation does not confirm causation; while an increase in predation may be inferred, this analysis does not conclusively prove it. Mike Tonseth added that there are other variables that could potentially affect interpretation of these data. Tom Kahler also noted that these data could vary from year to year based on, for example, weather, which affects both the migration timing of the fish and the timing of bird reproduction. Fish migrating prior to the hatching of eggs on the bird colonies should be subjected to lower rates of predation by birds. Murauskas acknowledged that his preliminary interpretations were based on correlations, but that these data show that survival and predation are linked, and that hatchery fish are more likely than wild fish to show up on the island; hatchery fish are larger and released later. Mike Schiewe suggested touching base with Dan Roby or Julia Parrish to integrate bird biology into this study. Tonseth said it is important that these types of discussions and analyses are closely tied to monitoring, and they should be incorporated into the revised

M&E Plans. Murauskas said migratory timing is an objective, so there already are direct links. Regarding residualism, Tonseth said that part of the problem is determining what a natural rate of residualism is. Murauskas concluded that these data indicate a significant relationship between date of release of hatchery steelhead and bird predation, with the later May releases suffering greater losses than the early May releases. Murauskas recommended adjusting release strategies to match wild origin run distributions.

B. Marking Schemes for Hatchery programs (Josh Murauskas)

Mike Tonseth suggested moving this agenda item to the July Hatchery Committees meeting. Tonseth agreed to provide an overview of the marking schemes for hatchery programs to distribute to the Hatchery Committees.

VI. NMFS

A. HGMP Update (Craig Busack)

Craig Busack reported that NMFS is currently working on the Snake River fall Chinook and Chiwawa spring Chinook Biological Opinions. He noted that the draft Entiat and Snake River Biological Opinions are currently out for review. In the Methow, he said NMFS is working on fairly radical cutbacks for spring Chinook and steelhead, targeting a pHOS of 25 to 30 percent for spring Chinook and steelhead. NMFS is in discussions with WDFW, Douglas PUD, and the affected tribes regarding the Methow programs. Busack also mentioned that NMFS is taking a second look at the White River Project, and considering alternatives because of local land use permitting issues. Lastly, Busack said it was clear that there are significant differences of opinion regarding the effects of trapping at Tumwater Dam, and that NMFS is planning to further investigate the basis for these differences.

VII. Chelan PUD

A. Presentation: Dryden Phosphorus/TMDL (Sam Dilly)

Josh Murauskas briefly reviewed Chelan PUD's response to a request by the Joint Fisheries Parties (JFP) to clarify their position on the proposed modifications to the Dryden Acclimation Facility (Attachment H). This response was distributed by email to the Hatchery Committees by Kristi Geris on June 15, 2012. Murauskas said the presentation by Sam Dilly should help to further clarify Chelan PUD's concerns about making immediate modifications to the Dryden Facility before the ramifications of the new Wenatchee River phosphorus TMDL were fully understood (Attachment I). Joe Miller introduced Sam Dilly, Chelan PUD engineer, to help describe the situation and clarify some of the engineering concerns.

Dilly's presentation began with a table showing a sliding scale of allowable phosphorus concentrations that decreased with increasing discharge flow. He said Chelan PUD received these proposed discharge limits from the Washington State Department of Ecology (Ecology) earlier this year. Based on preliminary testing, Dilly said that incoming water at Dryden already exceeded the proposed TMDL standard. He said that Chelan PUD had already been discussing the potential for use of low phosphorus feed and automated feeders to minimize the addition of phosphorus to the discharge. Dilly said pilot studies indicate some feeding methods are more efficient and produce better conversion rates. Keely Murdoch asked Todd Pearsons about the results of a low phosphorus feed trial that Grant PUD was conducting, and Pearsons indicated that the results would not be available until later in the year. Pradeep Mugunthan (Anchor QEA) a water quality consultant working with the Yakama Nation, suggested that by the time the TMDL is implemented, the background concentrations of phosphorus in the Wenatchee River would likely be lower than they are now. He thought compliance might be achievable with low-phosphorus feed and automated feeders. Dilly said Chelan PUD was not willing to go forward with a facility plan based on speculated future concentrations unless those future concentrations were agreed to by Ecology. Dilly said that, in fact, Ecology had already told Chelan PUD that the concentration of phosphorus in their water source was Chelan PUD's responsibility to treat. Jim Craig said Ecology often acknowledges that a water source already contains elevated concentrations of a chemical they are regulating, but they still do not allow further exceedences. Dilly suggested that rather than requesting a change in the TMDL and management of phosphorus, the Hatchery Committees should instead work with Ecology to find methods to rear fish and meet phosphorous standards.

Mike Tonseth suggested that the Committees needed to put together contingency plans for continuing to raise the 500,000 summer/fall Chinook being reared at Dryden if the TMDL issue cannot be resolved. Given the technology available, Tonseth said, it seems that a flow of 4 cubic feet per second (cfs) may be the upper limit for a water supply. He questioned whether that would be enough to produce 500,000 smolts. Dilly said that from an engineering feasibility perspective, the Committees might want to start developing design criteria by doing the following: 1) establishing a smolt-to-adult return (SAR)-based goal for the facility; 2) determining how many smolts would need to be produced; 3) identifying the unknown; 4) developing options to meet the criteria; and 5) considering associated risks. Tom Scribner said that additional analyses were needed, and that, collectively, the Committees needed to put together a plan to collect the needed information. Dilly proposed developing an outline of data needs to support developing design criteria; with these data, the Committees could produce three to five alternatives, and pick whichever alternative works best and present it to Ecology. Scribner asked if this was feasible to complete in time to meet the 2018 deadline. Dilly said it was very feasible. Murauskas asked how a reduced size at release target would impact phosphorus. Dilly said it would significantly affect phosphorous because smaller fish size equates to lower phosphorus. Tonseth said that reducing fish size is a possibility; however, WDFW is not ready to take this step yet. Jim Craig said Leavenworth NFH is now looking into water reuse technology to see how well spring Chinook adapt to rearing under this condition. Craig said the U.S. Bureau of Reclamation (the agency that funds Leavenworth NFH) sees the phosphorus TMDL issue as potentially limiting the hatchery's ability to meet its production target. Chelan PUD and Grant PUD agreed to develop a detailed timeline, including milestones, for evaluating options to address compliance with the proposed Wenatchee River phosphorus TMDL at the Dryden Rearing Facility.

VIII. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees Meetings are on July 18, 2012 (Douglas PUD office), August 15, 2012 (Chelan PUD office), and September 19, 2012 (Douglas PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – SOA for Collection of Entiat NFH Summer Chinook Broodstock at Wells Hatchery
Attachment C – Chelan PUD 2013 Hatchery M&E Objectives draft document
Attachment D – Douglas PUD M&E Flow Chart

Attachment E – Request Authorization for Four (4) Additional Hatchery-Origin Wenatchee Spring Chinook for the Continuation of the Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study

Attachment F – 2012 Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study Proposal

Attachment G – Wenatchee Steelhead Predation and Residuals Presentation

Attachment H – Response to JFP Memo

Attachment I – Dryden Phosphorus/TMDL Presentation

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Pradeep Mugunthan††	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Joe Miller**	Chelan PUD
Sam Dilly**	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Todd Pearsons	Grant PUD
Keely Murdoch*	Yakama Nation
Tom Scribner*††	Yakama Nation
Craig Busack†	NMFS
Jim Craig	USFWS
Mike Tonseth*	WDFW

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone

** Joined for Dryden phosphorus/TMDL presentation

†† Joined by phone for Dryden phosphorus/TMDL presentation

Draft 6-7-2012

Wells HCP Hatchery Committee

Statement of Agreement

Collection of Adult Broodstock at Wells Hatchery for Entiat National Fish Hatchery

Approved on 20 June 2012

Statement

The Wells HCP Hatchery Committee approves the collection of additional summer Chinook (up to 135 pair) during broodstock collection efforts at the Wells Hatchery volunteer ladder trap for the 2012, 2013, and 2014 brood years. These additional brood will be transferred to the US Fish and Wildlife Service's (USFWS) Entiat NFH to support the Entiat summer Chinook program. Broodstock collection for the Entiat program will take place after Douglas PUD's and Chelan PUD's programs have achieved their broodstock collection goals. Logistical and financial arrangements for these collections will be determined by Douglas County PUD and the USFWS.

Background

The USFWS, in conjunction with other parties (Yakama Nation, the Confederated Tribes of the Colville Reservation NOAA, WDFW, BOR), is implementing a new summer Chinook hatchery production program at Entiat NFH. The long-term goal of this program is to provide fish for tribal, commercial, and sport harvest, and to meet tribal trust responsibilities as mitigation for Grand Coulee Dam. A Hatchery and Genetics Management Plan (HGMP) for this program was submitted to NOAA in July of 2009. This HGMP has also been distributed to all of the relevant co-managers.

The USFWS uses volunteer summer Chinook returns to Wells Hatchery as interim broodstock for the Entiat NFH program, and expects that the Entiat NFH will be self-sufficient starting in 2015 (see Table). Broodstock collection efforts have historically entailed the transfer of eggs in the first year of partial production (BY 2009), and transfer of adults in BYs 2010 and 2011 (and for subsequent years until sufficient numbers of adults return to Entiat NFH). Full production will require the collection of up to 270 hatchery origin summer Chinook adults (enough to provide up to 400K eggs). Funding for this new program is the responsibility of the USFWS and BOR.

Brood Year	Estimated Broodstock Required from Wells Hatchery
2012	270
2013	270
2014	135
2015	0

The above forecasted need for broodstock is based on an assumed SAR of 0.3%. Adults from the Entiat NFH program are expected to begin returning in 2012 but will consist of 2 year old jacks only. As 3 and 4 year old adults return in 2013 and 2014 the need for collection of brood at Wells Hatchery may need to be extended or refined. Any extension of brood collection (past 2014) at Wells Hatchery for the Entiat NFH program would require additional discussion and agreement of the Wells HCP parties.

Broodstock collection for the Entiat program will take place after Douglas PUD's and Chelan PUD's programs have achieved their broodstock collection goals.

HATCHERY M&E FIVE-YEAR REVIEW

SUMMARY

Monitoring and evaluation (M&E) of Chelan PUD's hatchery programs is required in the Rock Island and Rocky Reach Anadromous Fish Agreement Habitat and Conservation Plans (HCPs). The M&E strategy as first developed by the Hatchery Committee (HC) will reach the five-year update in 2013 as stipulated in the HCPs. At this time, the HC "shall look back comprehensively at the previous five year plan to help prepare the next five year plan." The review provides the opportunity to incorporate new information and technologies, identify adjustments, and update the M&E program consistent with general objectives for each Plan Species. The HC is responsible for conducting the hatchery program review and developing a summary report. The table is intended to initiate discussion on the overarching goals of the M&E program

DRAFT FOR DISCUSSION PURPOSES

TABLE 1. SUMMARY OF HATCHERY MONITORING AND EVALUATION OBJECTIVES, PURPOSE, AND ACTIONS.

Category	Objective	Original objectives	Purpose	Resulting action(s)
In-hatchery monitoring	Are programs releasing target size and number of smolts?	# 1 [a] # 6 [b]	Determine if programs are capable of producing intended number and quality of smolts required by HCP.	No: Utilize data to inform changes that will increase probability of meeting objectives. Maybe: Continue and/or increase monitoring. Yes: Continue and/or decrease monitoring.
In-river performance	What are the migratory timing, distribution, stray rates, and survival of natural- and hatchery-origin fish in supplemented streams?	# 2, 4, 5 [b]	Determine if programs are capable of producing smolts with acceptable post-release performance.	No: Utilize data to inform changes that will increase probability of meeting objectives. Maybe: Continue and/or increase monitoring. Yes: Continue and/or decrease monitoring.
Long-term monitoring	Are programs affecting the abundance, genetic diversity, and population structure of natural-origin spawners, productivity, incidence of disease, and non-target taxa?	# 1, 2 [a] #1, 3, 7, 9, 10 [b]	Determine if programs conserve the long-term fitness of natural populations.	No: Utilize data to inform changes that will increase probability of meeting objectives. Maybe: Continue and/or increase monitoring. Yes: Continue and/or decrease monitoring.

[a] Biological Assessment and Management Plan. Mid Columbia River Program. April, 1998.
[b] Conceptual approach to monitoring and evaluating the Chelan County Public Utility District Hatchery programs. July, 2005.

Attachment D

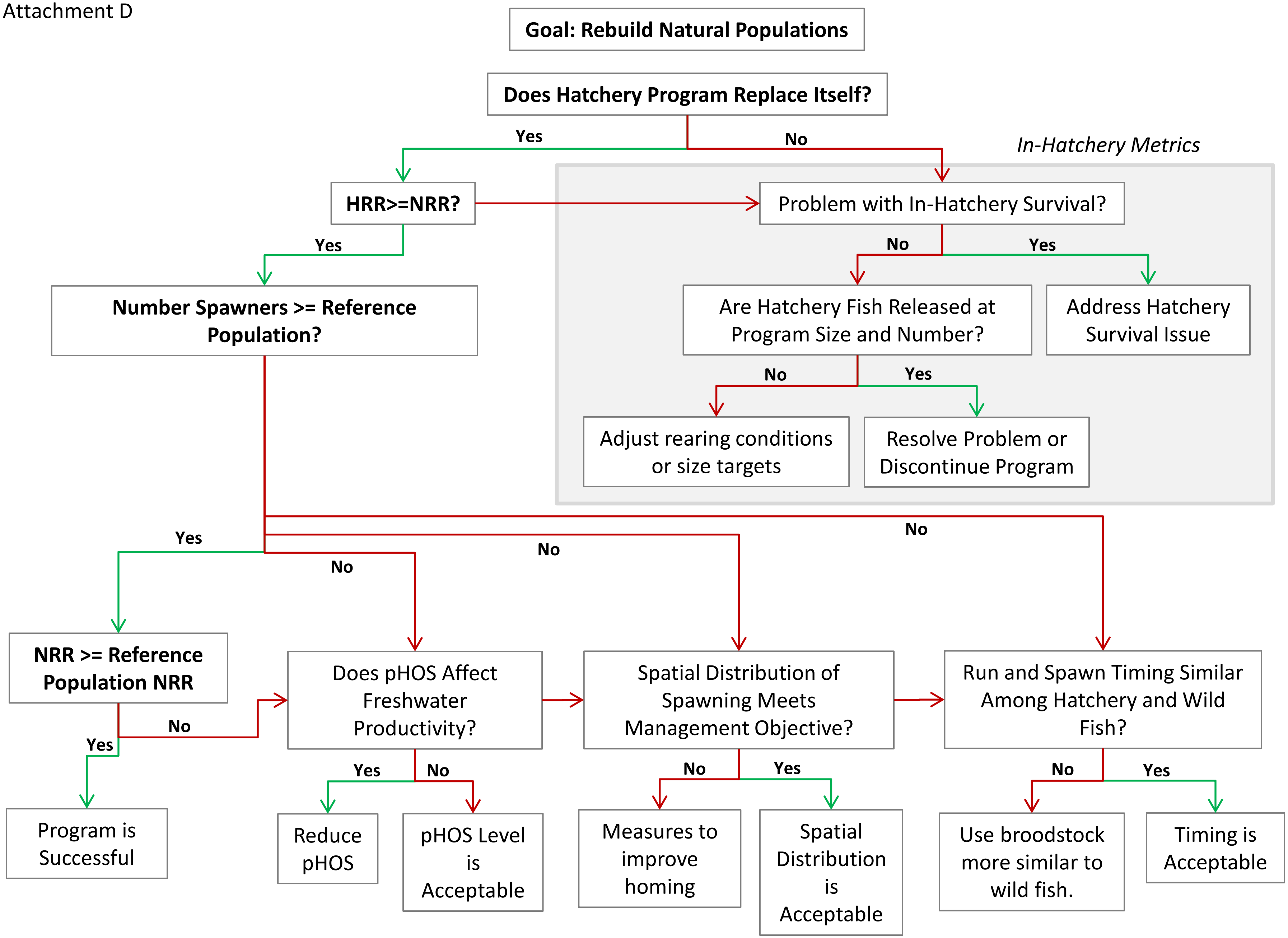
5-Year M&E Update: Draft Hierarchical Flow of Goals, Objectives and Assessments

Douglas PUD

June 20, 2012

HCP Hatchery Committee Meeting

Attachment D



Attachment D
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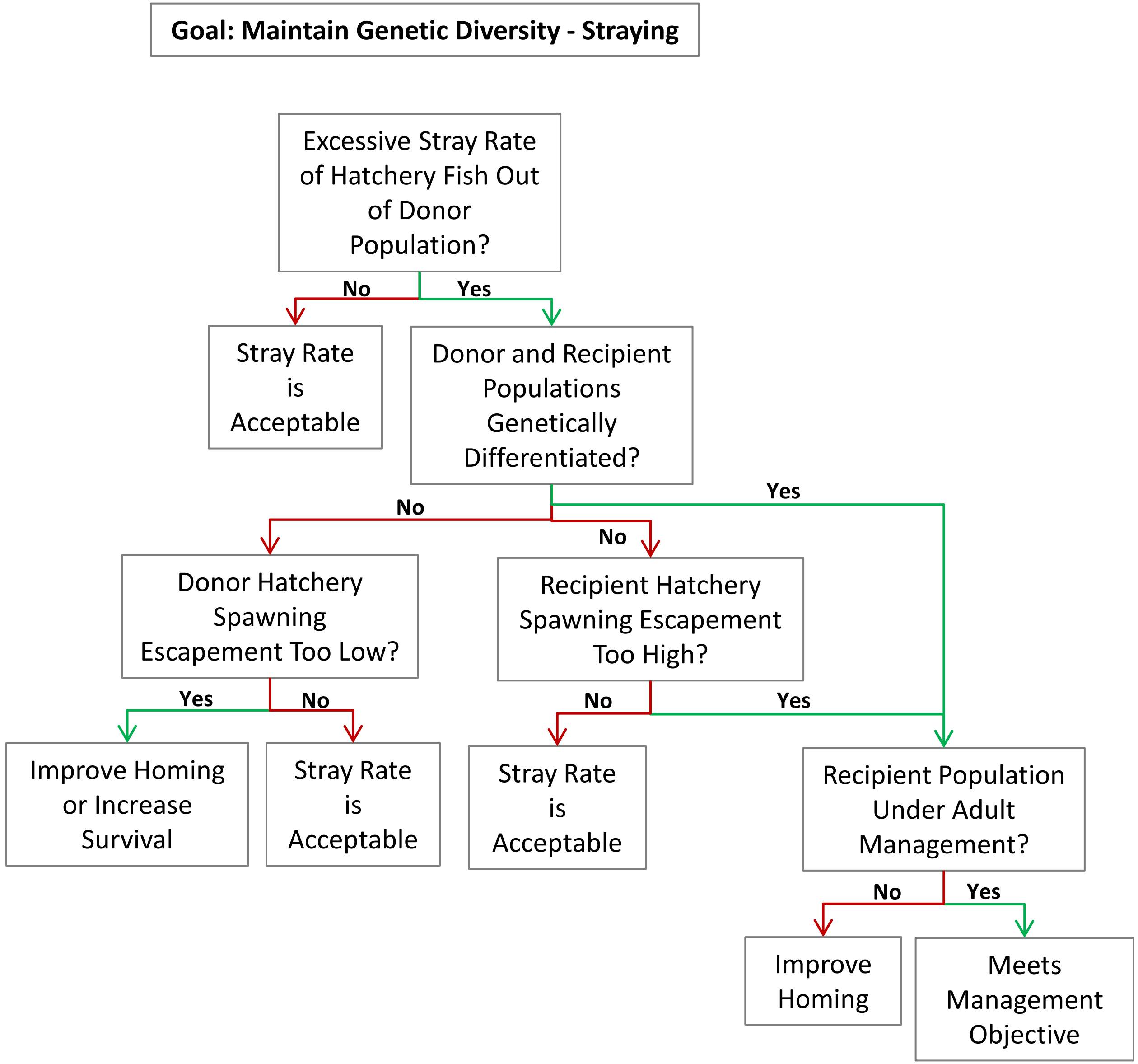
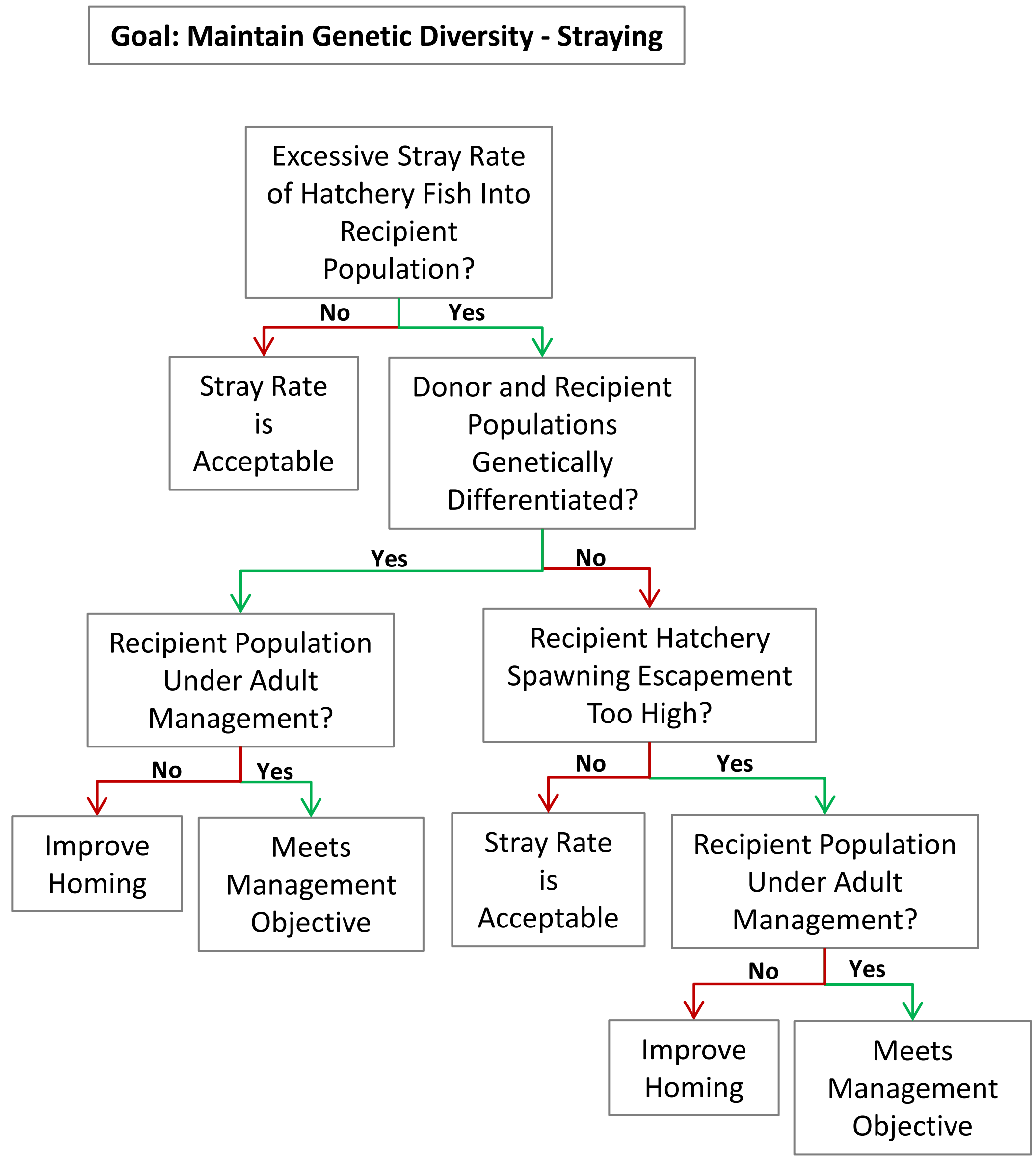
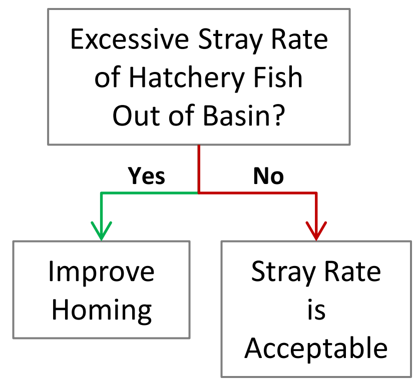



Goal: Maintain Genetic Diversity - Straying
Excessive Stray Rate of Hatchery Fish Into Recipient Population?
No
Yes
Stray Rate is Acceptable
Donor and Recipient Populations Genetically Differentiated?
Yes
No
Recipient Population Under Adult Management?
Recipient Hatchery Spawning Escapement Too High?
No
Yes
Improve Homing
Meets Management Objective
No
Yes
Stray Rate is Acceptable
Recipient Population Under Adult Management?
No
Yes
Improve Homing
Meets Management Objective

Goal: Maintain Genetic Diversity - Straying



Attachment D

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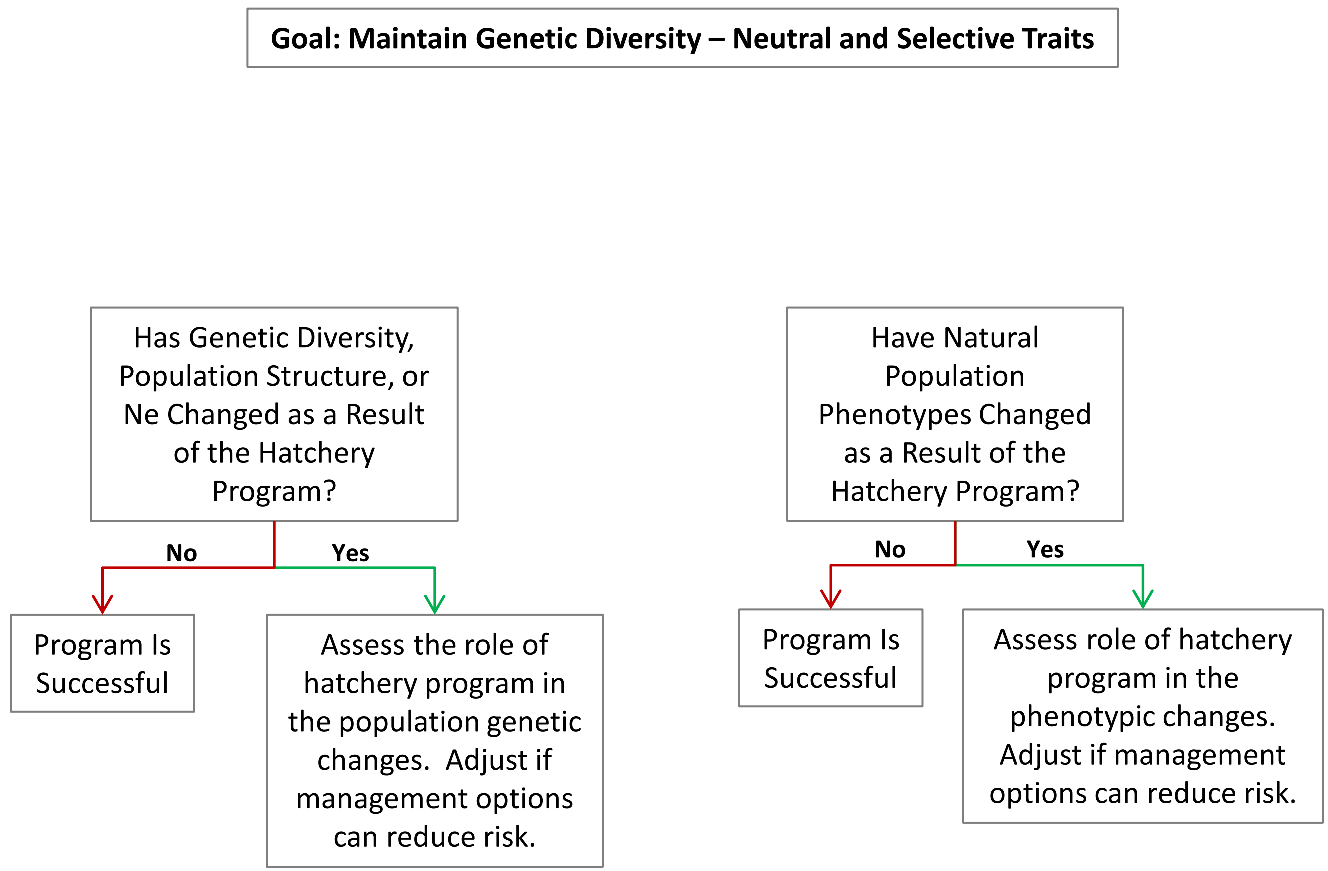

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Wenatchee Field Office

Mailing Address: 3515 State Hwy 97A · Wenatchee, WA 98801 · (509) 664-3148, TTY (800) 833-6388
Main Office Location: Natural Resources Building · 1111 Washington Street SE · Olympia, WA

June 6, 2012

To: Rock Island Habitat Conservation Plan Hatchery Committee

From: Chris Moran, Washington Department of Fish and Wildlife

Re: Request authorization for four (4) additional hatchery-origin Wenatchee Spring Chinook for the continuation of the *Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study*.

The Washington Department of Fish and Wildlife requests authorization to collect two additional adult female, and two additional adult male, hatchery-origin Wenatchee Spring Chinook during 2012 broodstock collection activities. This request is to facilitate the continuation of the *Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study*. To meet the needs of our study design, a total of 5,400 eggs will be collected over three week period during spawning activities (1,800 eggs per week). The collection of four additional adult Chinook are needed in order to supplement agreed to egg take targets for hatchery spawning activities. Please see the attached report to view a detailed description of the study and preliminary results to date.

Your consideration is appreciated.

Sincerely,

Chris Moran
WDFW

Wenatchee Spring Chinook Salmon Egg-To-Fry Survival Study Proposal

Submitted to

Rock Island Habitat Conservation Plan
Hatchery Committee

by

Andrew Murdoch
Chris Johnson
Anthony Fritts
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Michael Hughes

Washington Department of Fish and Wildlife
Hatchery-Wild Interaction Unit
Science Division, Fish Program
Wenatchee, WA

Short Description of Proposal: Rigorous estimates of egg-to-fry survival across a range of habitat conditions are needed to populate life cycle models to predict the effects of improvements in freshwater habitat on salmon productivity and recovery. In the fourth year of the study WDFW and NOAA seek to obtain gametes from returning hatchery spring Chinook adults at Eastbank FH to place in egg boxes in three reaches in the Chiwawa River during the fall of 2012. It is intended that this study could be expanded to include additional reaches within those two tributaries or other tributaries in the Wenatchee River Basin or upper Columbia Basin (e.g., Methow spring Chinook, Wenatchee summer Chinook). The fourth year of a similar study is ongoing in the Yakima River.

Additional Detail: Funding is available through NOAA and the FCRPS BiOp to generate estimates of egg-to-fry survival, one of the major factors thought to limit freshwater production and recovery of spring Chinook salmon populations, across a range of habitat conditions. Other work on egg to fry survival has generally been focused on a low number of redds, only one or two areas/habitat types within a watershed, and/or used other methods such as egg plates which are known to maximize survival to hatching. The Whitlock-Vibert boxes that we propose to use allow movement of sediment into and out of the box and have been used in sedimentation studies. They have been shown to be a fair representation of the conditions in the redd so we believe that any habitat differences such as sedimentation and intra-gravel flow will result in an observable difference in survival that can be related to habitat.

The eggs we propose to use are from returning marked hatchery origin adults that are taken back to Eastbank Fish Hatchery as part of the Chelan County PUD spring Chinook mitigation in the Chiwawa River basin. Single matings (one female and one male) are fertilized and incubated in individual Heath incubation trays through hatching. This will provide an opportunity for controls and to monitor for variation in fertility of individual fish, as the same parental crosses will be utilized in the artificial redds. In addition, because gametes to be placed in the river sites are held for 24 hrs (due to logistics of collecting gametes and getting them placed in the artificial redds within daylight hours), we propose evaluating potential differences in fertilization rates for day of spawn and the 24 hr hold groups.

Just as the case was in 2010 and 2011, three reaches are proposed in the Chiwawa River (within areas of known spawning). These reaches were chosen because the spring Chinook reproductive success study has determined that spawning success in upper and lower reaches of these rivers is different. This study may provide insight as to the cause of those differences, if the differences are habitat related. Three sites in each reach will be selected that are known spawning areas. Six artificial redds will be constructed in each site, each containing one egg pocket with 100 fertilized eggs, for a total of 5,400 eggs. Additional redds to check development rate may be constructed if time allows. Therefore, we request up to 6,500 hatchery origin eggs if available. Consultation with others such as the redd survey crew must be made to ensure this work does not affect other ongoing projects. See attached draft of the proposed methods for more details regarding the experimental design.

Proposed Action: Use up to 6,500 hatchery origin eggs from 2012 Chiwawa spring Chinook broodstock to perform egg-to-fry survival study.

Long-term Study Objectives:

1) Measure egg to fry (hatch) survival under a range of habitat conditions.
2) Compare egg to fry survival of hatchery and wild fish.
3) Develop efficient techniques for measuring egg to fry survival.
4) Understand mechanisms at site/redd that are influencing differences in survival among redds, sites, and reaches.

2012 Objectives

1) Continue the development of a sampling scheme for measuring egg to fry survival.
2) Measure egg to fry survival at a subset of habitat conditions.
3) Incorporate temperature probes at each redd.
4) Compare sediment intrusion between redd locations.

Field Methods

Study reaches and sites

Study reaches were likely too large and contained too few egg boxes in 2009 to detect differences between reaches. We propose replicating methods used in 2010 and 2011 by using the same three study-reaches in the Chiwawa River for 2012. These reaches represent the upper and lower spring Chinook spawning areas in Chiwawa River. Two reaches are proposed in the lower Chiwawa River because two different channel types are utilized by spring Chinook (pool-riffle and plane-bed). Three sites for egg box placement will be selected within each of the three reaches. These sites will be selected based on both the proximity of spawning females at the time of egg box placement, and historical spawning densities. Six Whitlock-Vibert egg boxes, retrofitted with finer mesh to prevent fry from escaping, each containing 100 bank-fertilized eggs, will be placed in artificial redds at each site. The total number of egg boxes for the study proposed is 54 (3 reaches x 3 sites x 6 egg boxes) and the total number of eggs 5,400 (900 per female, 6 females, two spawning pairs from each of three weekly spawning events; Appendix A). In each of the three reaches there will be two additional egg boxes placed in the lowest site (one on week one and one on week three) as test redds to determine development at the specified pull date (based upon temperature units). In addition, to test for differences in fertilization rates between gametes spawned the day of and those held for 24 hrs, an additional 100 eggs from each cross will be held 24 hrs prior to being fertilized and incubated at Eastbank FH.

Fish collection

Adults will be collected at Tumwater Dam or Chiwawa Weir and transported to the Eastbank Fish Hatchery where eggs will be collected from hatchery origin adults. These collections will correspond with yearly brood stock collection. Eastbank FH staff spawns a proportion of the collected brood once a week over the duration of the spawning period. Because eggs will only be available one day a week and because it is unlikely that we could place all of the egg boxes in one day, box placement will occur at weekly intervals. Timing of the placement of the boxes will be consistent with the peak spawn timing in each of the two tributaries. This will likely require that egg boxes be pulled throughout the late winter and early spring of 2013. One crew will be utilized on each of the three spawning dates, each composed of three to four individuals, in order to maximize consistency in the fertilization of eggs and their placement in each site. One hundred eggs from two adult crosses (900 eggs per cross) will be stocked weekly within each site, one at each of three sites (18 egg boxes per week). Using these methods, all eggs will be placed in three spawning days (i.e., three weeks).

Gamete collection/fertilization:

After spawning at the hatchery, eggs from each hatchery females will be counted into six freezer bags and milt from each hatchery males will also be stored in six freezer bags. Gametes will be stored in freezer bags filled with tanked oxygen overnight and while being transported to the study reaches. During transportation, gametes will be kept cool by transporting on layers of burlap placed over ice in a cooler. Bags will be labeled by desired cross, and numbered for placement sequence in order to avoid confusion when placing eggs in the artificial redds. Eggs will be fertilized on the bank directly prior to their placement within the WV boxes. A bucket filled with fresh river water will hold a submerged egg box, containing substrate collected during construction of the artificial redd. A freezer bag containing one hundred eggs from the appropriate female will then be fertilized with at least two or three drops of milt from the appropriate male in an area shaded from direct sunlight. River water will then be added and the contents gentry swirled to mix the milt throughout, thus activating the eggs. The contents of each will then be placed directly into the prepared Whitlock-Vibert box. The time of gamete collection, time of spawning, water temperature at spawning, and depth of box in relation to surrounding substrate will be recorded at this time. The boxes will then be gently transferred to a pre-constructed artificial redd and carefully backfilled. The time separating gamete collection and egg placement will be as short as possible, and every effort will be made to ensure that gametes are handled in a consistent manner.

Egg box construction and substrate

All egg boxes will be mesh-lined to prevent escapement of fry. Whitlock-Vibert egg boxes will be modified by placing 1/8" mesh across those areas of the box from which fry could escape (middle and top slots). This modification was successful in preventing the escapement of fry under experimental conditions in CESRF spawning channel (WDFW, unpublished data) and showed no increase in accumulated sediment when compared to unscreened boxes. Gravel for use within each egg box will be collected at the time of redd construction and will be consistent with surrounding substrate. Fine sediments will be excluded as these are normally carried away by the current during redd construction. The top trays of the WV boxes will be removed to provide additional room for gravel.

Redd/egg pocket construction

Artificial redds will be created prior to the time of spawning so that all eggs can be deposited as soon as possible after collection. Redds will be constructed using bottomless buckets that will be placed at each redd location and substrate will be removed by shovel or hand and placed into another labeled bucket. As substrate is removed, the bottomless bucket will be pushed into the substrate until the desired depth of 30 cm is reached. Substrate removed from each redd location will be placed into a perforated labeled bucket so the substrate can be placed back into the original redd. The perforated bucket will also facilitate the “washing” of the substrate to remove fine sediment that would have been removed through the natural redd construction process. Egg boxes will be carefully placed in the substrate by hand and substrate carefully placed back in the bottomless bucket, which will then be removed. Additional substrate will be collected by raking substrate particles directly upstream of the redd. Each box will be buried 30cm deep (see DeVries 1997). Each artificial redd will be flagged, and its exact position triangulated using two reference points along the bank. Rebar markers will be used if sufficient natural markers are not present. Point locations, if not rebar, will be marked with green paint. Redd locations will also be recorded using GPS and reference photos. A PIT tag will be affixed to the inside of each WV box to assist in determining the exact location of the egg boxes. The PIT tag will also be used to track data for each respective artificial redd. Lastly, color coded strings will be affixed to each upper corner of the egg boxes so that their location and orientation can be found without disturbing the box itself during excavation.

<u>Habitat and Substrate</u>

Reach scale
Reach morphology and characteristics such as gradient, confinement, and channel type will be obtained from currently existing sources (e.g. GIS, mapping software, Cram et al.).

Site scale
If logistically possible, existing substrate conditions will be categorized by Wolman pebble counts (Wolman 1954) and volumetric substrate samples, using standard methodology, prior to the construction of artificial redds at each site.

Redd scale
Percent of fines will be evaluated by measuring the amount of fines that has accumulated in the WV boxes between placement and removal. Whitlock-Vibert boxes (both standard and modified with additional screening) have been shown to provide conditions of sediment accumulation similar to that of surrounding spawning gravels, and can therefore be used to provide representative results in incubation studies (Garrett and Bennett 1996). Boxes will be carefully extracted by excavating around the box and then carefully placing it into a separate plastic Ziploc bag. This will minimize the loss of fine sediments (Riser, D. Sear, and P. Roni, personal communication). Gravel and fines will then be sifted for a volumetric measure of fine sediment. Scour chains will be placed at each redd site to monitor bed load movements.

<u>Egg to fry survival</u>

Temperature data loggers placed within each reach will be used to measure basin temperatures. Thermal units from those data or other sources will be used to predict the approximate date egg boxes should be removed from the gravel (i.e., calculated fifty percent emergence). To aid in determining the most appropriate date, a small number of additional WV boxes may be placed within the study area and retrieved periodically as the expected target emergence date approaches.

On the determined removal date, boxes will be located via their GPS location, presence of flagging, and their triangulated position relative to bank points and/or PIT tags. A bottomless barrel will be placed over the egg pocket to protect the area from flow while the box is excavated. The gravel and other material will be carefully removed around the box, and the box then placed in a plastic bag while still submerged. The WV boxes will then be opened on site, the contents placed in a fine mesh sieve and the number of dead eggs, live eggs, and live and dead fry counted. All fine sediment accumulated within the box will be saved for subsequent classification.

2009 Results

Two tributaries of the Wenatchee River were selected for the study pilot, Nason Creek, and the Chiwawa River. Two reaches were selected in each tributary, and three study sites within each reach. At each site, hatchery origin spring Chinook eggs were bank fertilized and placed in three artificially constructed redds within modified Whitlock-Vibert egg boxes, using methods defined in Johnson et al. (2009). Egg boxes were removed shortly after reaching a target of 900 accumulated thermal units (degrees C). Pull dates ranged between February 11th and March 30th 2010 in Nason Creek sites and between March 16th and April 12th 2010 in the Chiwawa River.

Survival was similar between reaches, but variable between sites: Nason Creek lower reach: (mean, 57.0; SD, 33.8), Nason Creek upper (mean, 66.6; SD, 30.8), Chiwawa lower (mean, 71.1; SD, 11.5), and Chiwawa upper (mean, 74.7; SD, 11.7). No detectable difference in survival was found between reaches (ANOVA: $F_{2,31} = 0.45$, $P = 0.64$), or between the adult crosses used in the study (ANOVA: $F_{4,31} = 1.2$, $P = 0.34$).

Minimum detectable difference was calculated using the following formula presented by Zar (1999. p.195 eq. 10.36):

$$\delta = \sqrt{\frac{2ks^2\phi^2}{n}}$$

where:
n = group sample size
δ = minimum detectable difference
k = number of groups
s^2 = sample variance
ϕ = among groups variance

Estimated minimum detectable difference in percent survival between reaches in the pilot study was approximately 20.7; or 30.7 percent of the overall mean (67.6 percent).

No difference in the percentage of fine sediment accumulated in the boxes was detected between sites (ANOVA: $F_{3,29} = 1.8$, $P = 0.17$). However, the overall percentage of fines was quite high (mean, 17.7; SD, 9.0). There was no significant correlation between the percentage of fines upon recovery and survival ($R^2 = 0.05$, $P = 0.23$, Figure 1.), although the negative trend was similar to a small but significant trend detected in the Yakima River Basin (Figure 2).

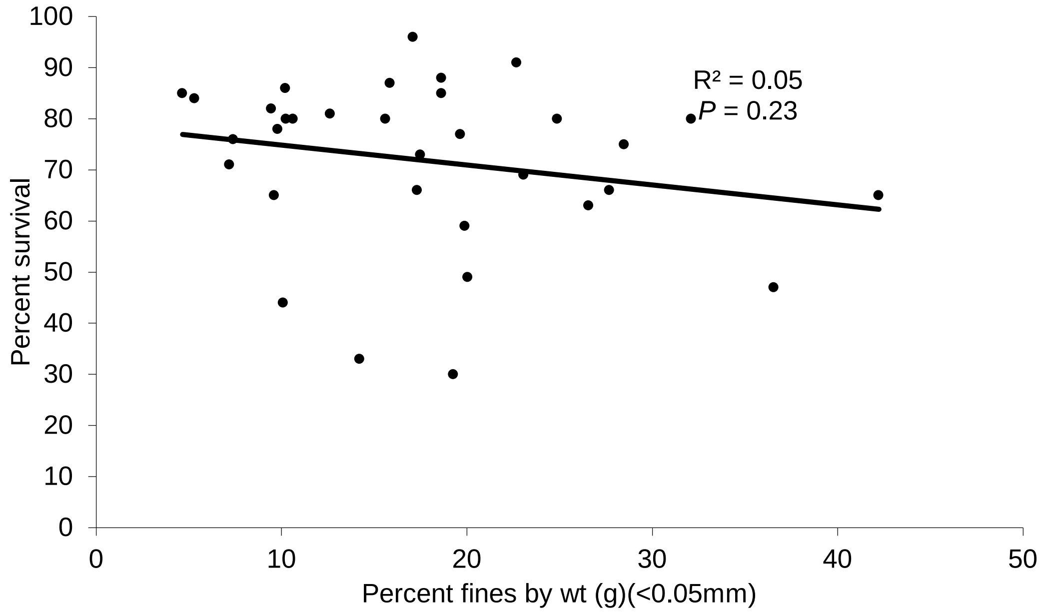

Figure 1. Negative trend in survival with increasing percentage of fine sediment in egg boxes recovered from the Wenatchee River Basin.

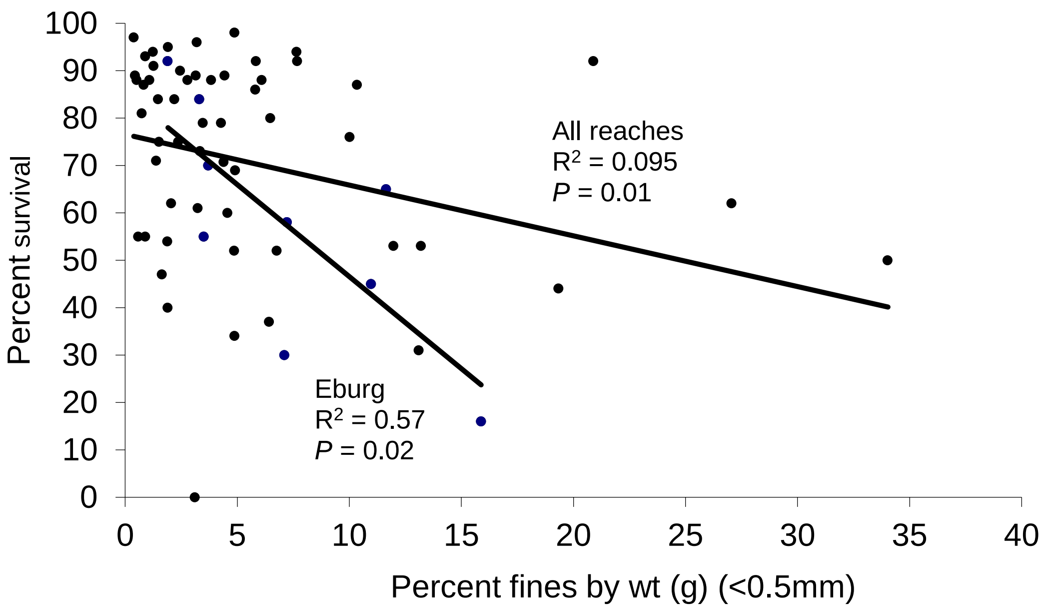

Figure 2 .Significant negative trends in survival with increasing percentage of fine sediment in egg boxes recovered from the Yakima River Basin.

In contrast to findings in the Wenatchee Basin pilot, significant differences in survival were detected in the Yakima River Basin between both reaches and adult cross. Likewise, although there was no detectable decrease in survival with increasing levels of fines in Nason Creek or the Chiwawa River, the trend is similar to that observed in the Yakima Basin where a small but significant relationship between survival and percent fines was detected with a larger sample size

We expect that by decreasing the within-reach variance may allow a more successful analysis of differential egg to fry survival and factors affecting survival in the Wenatchee River Basin. An increase of sample size within each reach, and a decrease in reach length should decrease the level of uncertainty around estimates of survival.

2010 Results

Because 2009 study reaches were likely too large and there were too few egg boxes to detect differences between reaches, we selected three reaches in the Chiwawa River in 2010 and increased the number of egg boxes per site. At each site, hatchery origin spring Chinook eggs were bank fertilized and placed in six artificially constructed redds within modified Whitlock-Vibert egg boxes, using methods defined in Johnson et al. (2009). Egg boxes were removed shortly after reaching a target of 900 accumulated thermal units (degrees C). Removal dates ranged between March 18th and April 18th 2011.

Mean survival was greatest in the upper Pool-Riffle study reach (mean, 60.9; SD, 27.5) and lowest in the Plane-Bed reach (mean, 44.1; SD, 26.7). Survival by adult cross ranged between 69.7 (SD, 11.5), and 33.5 percent (SD, 29.9). Although a positive trend in survival was observed from lower to upper reaches, we found no detectable difference in survival among the three Chiwawa River study reaches (ANOVA: $F_{2, 39} = 2.3$, $P = 0.11$; Figure 3) or among the adult crosses used in the study (ANOVA: $F_{5, 39} = 2.0$, $P = 0.10$; Figure 4).

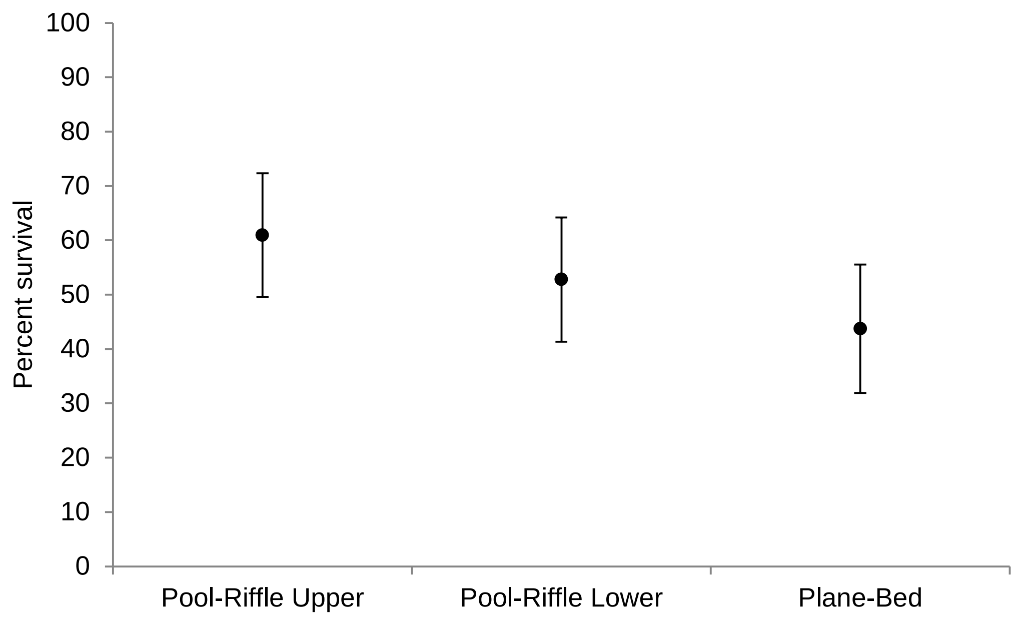

Figure 3. Estimated spring Chinook survival by study reach in the Chiwawa River 2010 (2011 emergent fry). Error bars represent ninety-five percent confidence intervals.

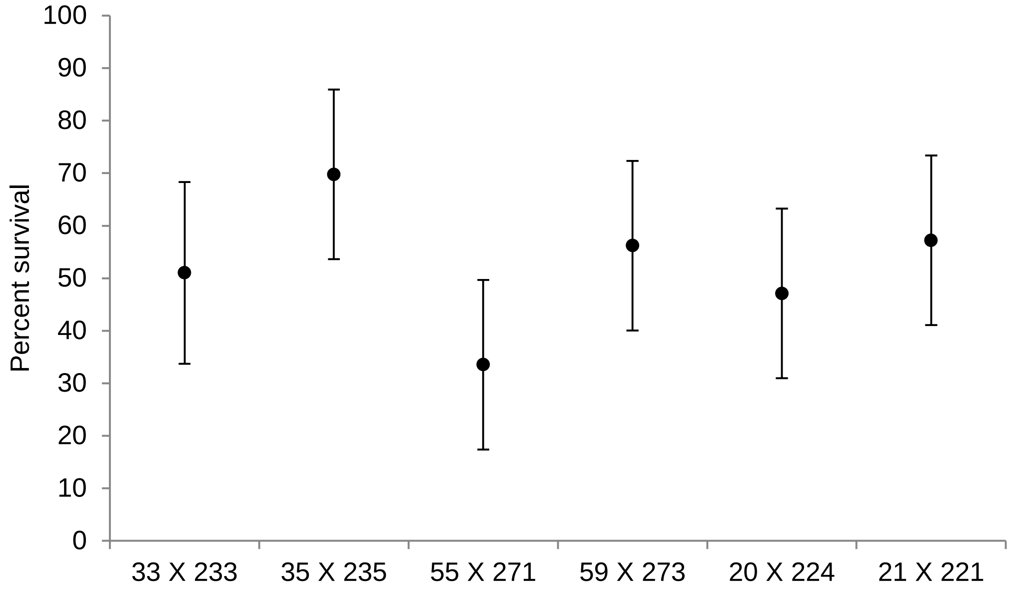

Figure 4. Estimated spring Chinook survival by adult cross in the Chiwawa River 2010 (2011 emergent fry). Error bars represent ninety-five percent confidence intervals.
No difference in the percentage of fine sediment accumulated in the boxes was detected between reaches (ANOVA: $F_{2,48} = 2.2$, $P = 0.12$).

Percent fines in recovered egg boxes averaged 12.9 percent (SD, 8.4). No significant correlation between the percentage of fines upon recovery and survival was detected ($R^2 = 0.02$, $P = 0.13$, Figure 3.), although the negative trend was similar to a small but significant trend detected in the Yakima River Basin (Figure 5).

Although our preliminary results have shown no detectable differences among reaches, we did observe a positive trend in survival from low to high on a reach scale. These observations are consistent with what has been found relative to differences in reproductive success. For this reason, we would like to replicate field methods carried out in 2010.

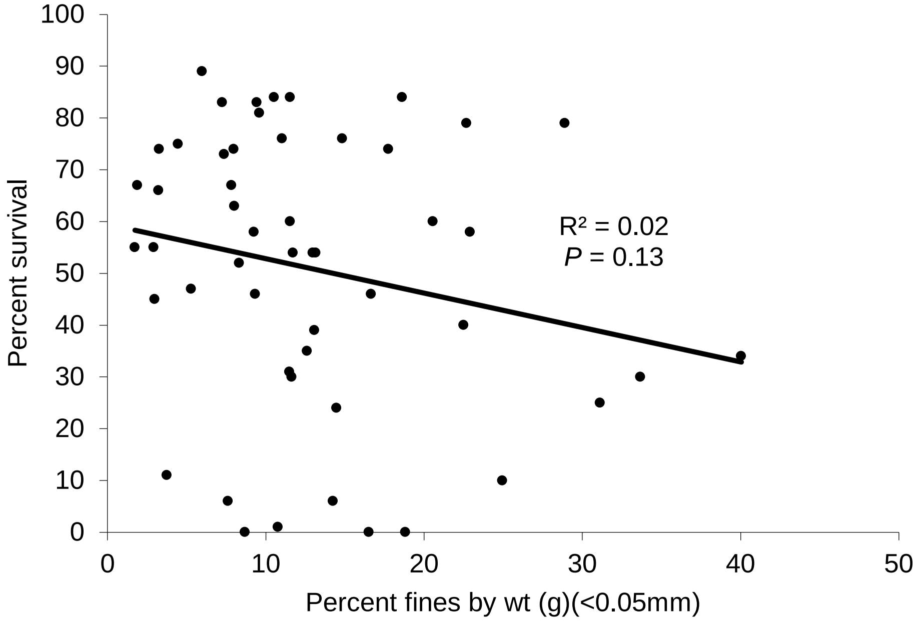

Figure 5. Negative trend in survival with increasing percentage of fine sediment in egg boxes recovered from the Wenatchee River Basin.

2011 Results

The study design and protocols implemented in 2010 were replicated in 2011. At each site, hatchery origin spring Chinook eggs were bank fertilized and placed in six artificially constructed redds within modified Whitlock-Vibert egg boxes, using methods defined in Johnson et al. (2009). Egg boxes were removed shortly after reaching a target of 900 accumulated thermal units (degrees C). Removal dates ranged between March 8th and May 10th 2012. Due to high water, five egg boxes were unable to be recovered.

Adjusted mean survival (i.e., adjusted for differences in female fertilization success) was greatest in the lower pool-riffle reach (mean, 0.60; SD, 0.24) and lowest in the plane-bed reach (mean, 0.43; SD, 0.29; Figure 6). Adjusted mean survival by adult cross ranged between 0.65 (SD, 0.31), and 0.39 percent (SD, 0.29; Figure 7). While the observed mean survival was higher in the two pool-riffle reaches relative to the plane-bed reach, no significant difference were detected among the three study reaches (ANOVA: $F_{2, 46} = 1.65$, $P = 0.20$). Likewise no significant differences were detected among the adult crosses used in the study (ANOVA: $F_{5, 43} = 0.68$, $P = 0.64$). Preliminary substrate composition analyses have not been completed, and therefore, its influence on survival is not presented in this report at this time.

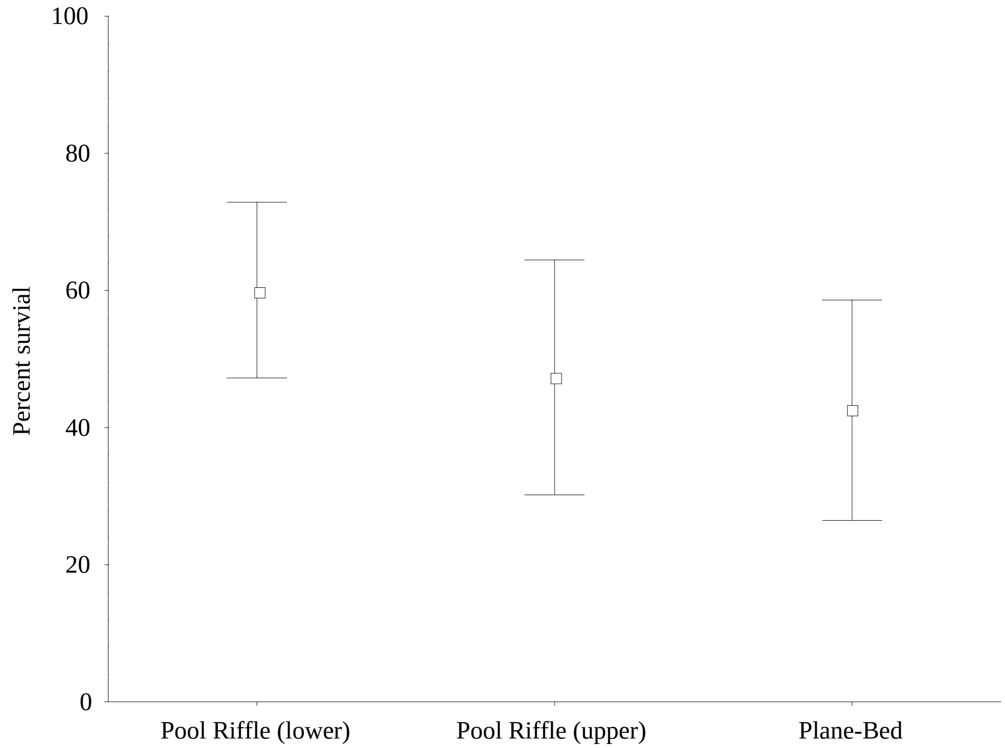

Figure 6. Estimated spring Chinook survival by study reach in the Chiwawa River 2011 (2012 emergent fry). Error bars represent ninety-five percent confidence intervals.

The modified sampling design used in 2010 and 2011 was implemented in an attempt to decrease the within-reach variance and attain a more accurate examination of differential egg-to-fry survival in the Chiwawa River. While our preliminary results have shown no detectable differences among reaches, observed trends are similar with those found relative to differences in reproductive success. However, our inability to retrieve a number of egg boxes, a consequence of high water in 2011, restricted the ability to attain desired sample sizes, especially in the lower and uppermost reaches of the Chiwawa River in 2011. For this reason, we would like to replicate field methods carried out in the previous two field seasons to further attempt to decrease the levels of uncertainty around survival estimates.

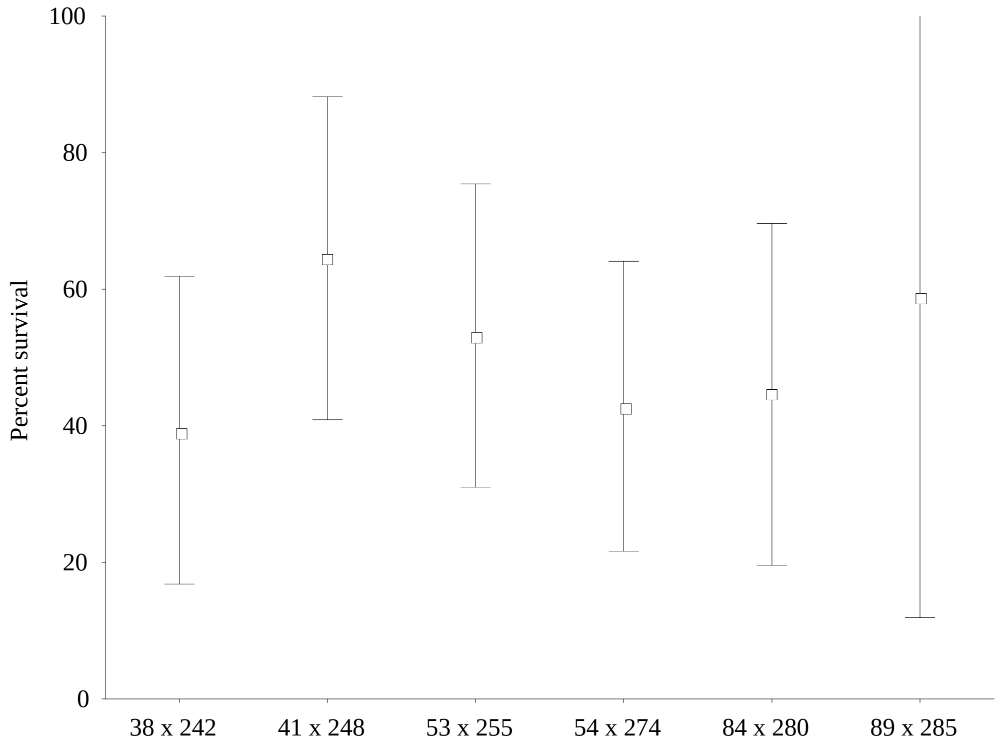

Figure 7. Estimated spring Chinook survival by adult cross in the Chiwawa River 2010 (2011 emergent fry). Error bars represent ninety-five percent confidence intervals.

References

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Appendix A. Experimental design for egg to fry study.

River	Reach/Channel type	Site	Redd #	Female	Male
Chiwawa	Upper/ pool-riffle	1	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
		2	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
		3	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
	Lower/ plane-bed	1	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
		2	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
		3	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
	Lower/ Pool-riffle	1	A	1	1
			B	2	2
			C	3	3
			D	4	4
			E	5	5
			F	6	6
		2	A	1	1

	B	2	2
	C	3	3
	D	4	4
	E	5	5
	F	6	6
3	A	1	1
	B	2	2
	C	3	3
	D	4	4
	E	5	5
	F	6	6

Attachment G

Wenatchee steelhead predation and residuals

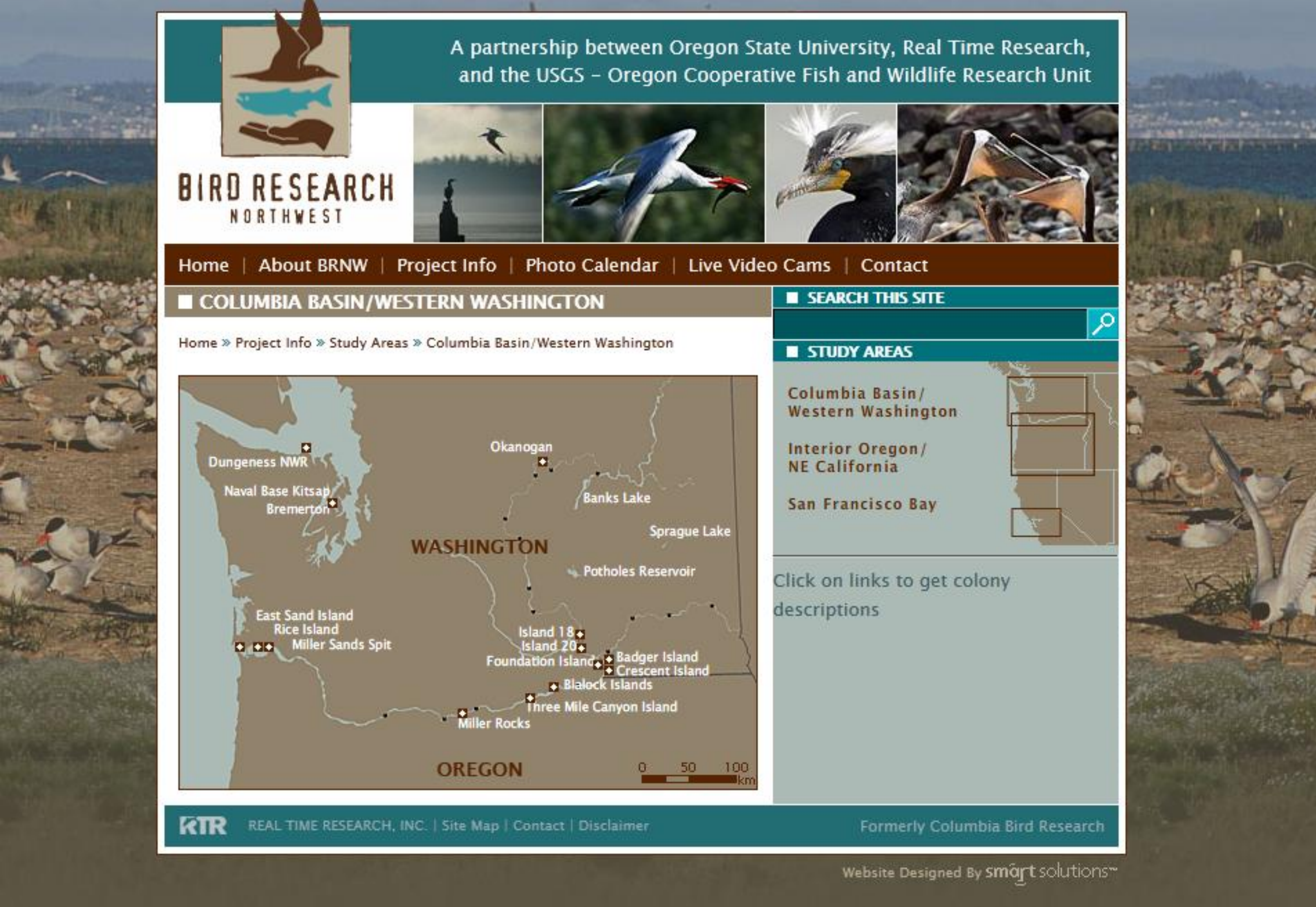
JOSH MURAUSKAS

JUNE 20, 2012

Steelhead predation

- PIT tags recovered from 18, Foundation, Badger, and Crescent Islands
- Releases from the Wenatchee River Basin
  - CHIWAR, NASONC, WENATR (mostly hatchery)
  - CHIWAT, WENATT (mostly wild)

Attachment G



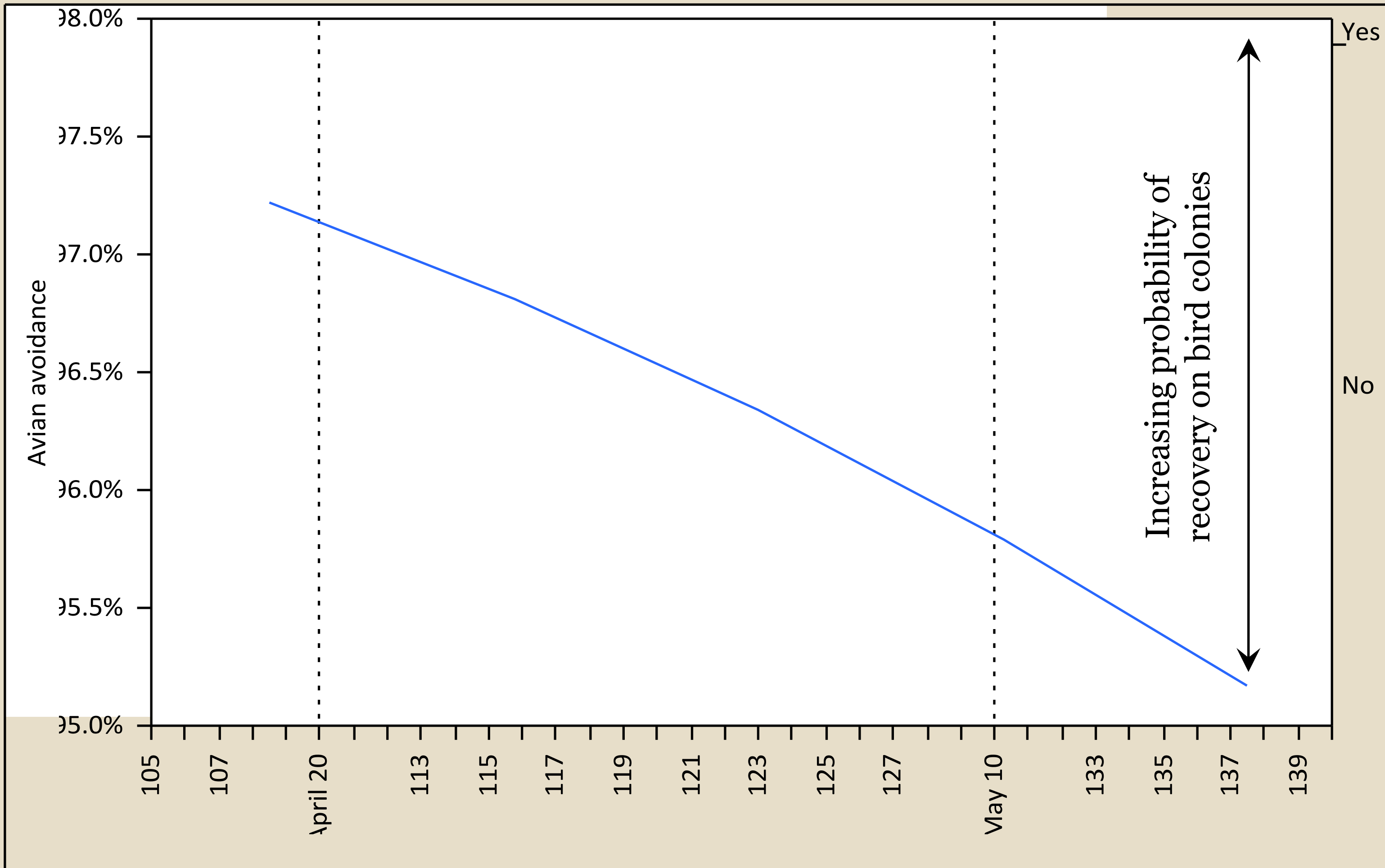
Steelhead predation

- Hatchery releases 510% more likely to be recovered
  - H = 3.83%, W = 0.75%; $p < 0.0001$
- Release site related to mortality
  - Hatchery-origin ($p = 0.0227$)
    - CHIWAR > WENATR > NASONC
  - Natural-origin ($p < 0.0001$)
    - WENATT > WENATR > CHIWAT > CHIWAR > NASONC

Attachment G

Later releases = greater predation

$P < 0.0001$



Steelhead residuals

- Tags released in the Wenatchee R. Basin, 2006-2010
- Release dates between April 15 and May 31
- Observations anywhere in system over 60 days and less than one year considered a residual

Steelhead residuals

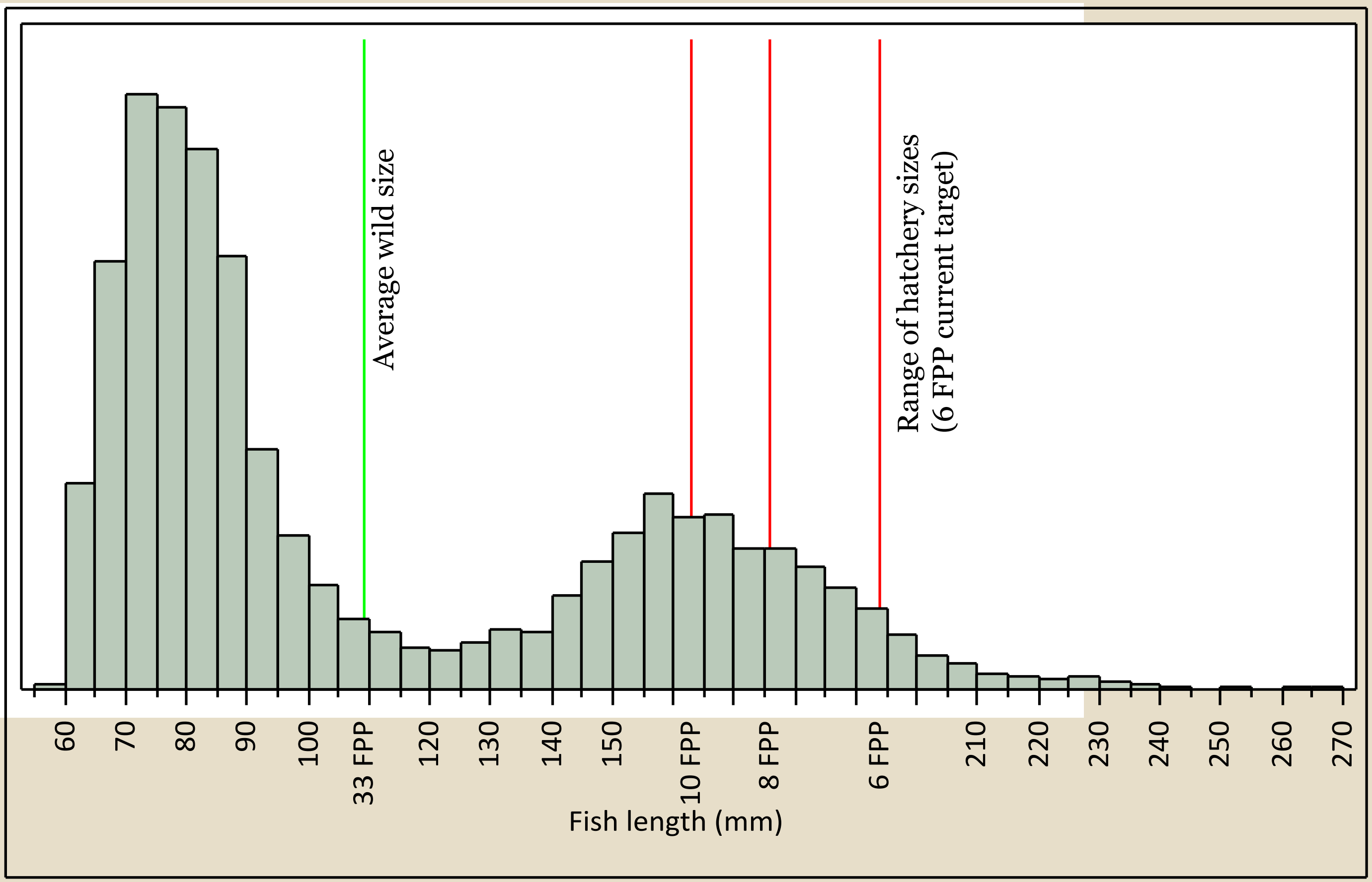
- Wild fish significantly more likely to reside
    - Wild = 1.04%, hatchery = 0.14%; $p < 0.0001$
- Release site related to residualism
    - Hatchery-origin ($p = 0.0458$)
        - CHIWAR > WENATR > NASONC
    - Natural-origin ($p = 0.0080$)
        - NASONC > CHIWAT > WENATT > CHIWAR

Steelhead residuals

- Relationship to release date
  - Hatchery fish ($p = 0.1074$)
  - Wild fish ($p = 0.0362$)
- Relationship to size
  - Varies by year

Attachment G

Steelhead size distribution



Conclusions and recommendations

- Hatchery releases = greater bird predation
- Later releases = greater bird predation
  - Recommend structuring release strategy around wild-origin run distribution
  - Avoid later releases subject to increased predation

Conclusions and recommendations

- No evidence of residual problem in Wenatchee
- May be selecting against a natural trait
  - Consider adjusting size target to mimic wild-origin fish
  - Realistic size targets could reduce avian predation and more closely mimic wild-origin fish

Questions?

Attachment H



PUBLIC UTILITY DISTRICT NO. 1 of CHELAN COUNTY
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(509) 663-8121 • Toll free 1-888-663-8121 • www.chelanpud.org

June 14, 2012

Craig Busack
Senior Fish Biologist
NOAA Northwest Regional Office

Dear Dr. Busack:

This letter is in response to the request from members of the Rock Island and Rocky Reach Habitat Conservation Plans' Hatchery Committees (HCP-HC) that Chelan County Public Utility District (Chelan) provide a written statement clarifying our position on proposed modifications to the Dryden Acclimation Ponds (Dryden) to accommodate over-winter acclimation. While Chelan agreed to examine the feasibility of overwinter acclimation at Dryden, there has been no commitment to modify the facility in lieu of defined performance targets or in the absence of data identifying risks and benefits of the proposal. Chelan has presented these concerns numerous times over the past few years, including detailed analyses presented at the March and April HCP-HC meetings. It is unexpected that you feel we have not adequately conveyed our position on the matter.

In our preliminary evaluation of the proposed modifications, we have presented the following results collected in the HCP-HC-approved monitoring and evaluation programs (Figure 1 and 2, Table 1):

- SARs for Chinook reared and released at Similkameen and Dryden are not statistically different and exceed the HCP standards.
- There is no significant relationship between observed SARs and acclimation survival rates.
- Acclimation mortality rates are significantly greater in overwinter compared to spring-acclimated programs.
- Acclimation survival in Dryden pond exceeds HCP-defined targets, and increases considerably with decreased densities such as those scheduled for future releases.
- Stray rates have a significant probability to decrease under planned reduced smolt releases.
- WDFW has reported (Murdoch et al. unpublished) that risks of overwinter programs include increased exposure to disease, inability to reach size targets, increased precocity, and inability to reach programmed releases.
- Dryden's phosphorous discharge and Ecology's TMDL criteria could make permits unattainable. In 2012, background concentrations exceeded future pond discharge limits (See Table 2). The observed influent phosphorus level in late April was 42.2ug/L, which exceeds the TMDL wasteload allocation at the proposed intake size of 17 CFS (prior to adding any additional waste). A new intake will not solve this problem and may become obsolete shortly after construction.

- If the baseline phosphorus levels require a higher wasteload concentration, the size of the intake will need to be reduced (see Table 2). Establishing the baseline is a critical first step to designing an intake.

As you are also aware, Chelan has advocated an alternative option to expand the circular vessel and partial water re-use program at Eastbank Hatchery as a means to improve performance at Dryden. This option is based on the following data:

- Travel time to McNary Dam for smolts reared in circular vessels has averaged 12.8% faster compared to traditional rearing strategies.
- Survival to McNary Dam of smolts reared in circular vessels has averaged 12.7% greater compared to traditional rearing strategies.
- Age structure of returning adults reared as smolts in circular vessels show significant improvements, including a 45.8% reduction in Age 2 (mini-jacks), a 34.2% reduction in Age 3 (jacks), and a 74.5% increase in Age 4+ (adults) returns compared to traditional rearing strategies.
- PIT data from the 2009 and 2010 releases in Wenatchee and Okanogan rivers indicate that adult returns from circular vessels have potential to double the next best alternative.

Based on these results, Chelan remains concerned that constructing the proposed intake poses regulatory, financial and performance risks that are not outweighed by a defined benefit. Alternatively, our feasibility analysis indicates that expansion of the partial water re-use program at Eastbank Hatchery is likely to significantly increase performance at Dryden as risks and benefits have been defined over multiple years of research. At this point, Chelan is advocating two options: (1) a scientific approach to identify the risks and benefits of facility modifications; or (2) expansion of the circular vessel and partial water re-use program at Eastbank Hatchery. Regardless of the path forward, Chelan will need to obtain all necessary regulatory approvals and permits (including ESA Section 10) prior to any modifications Dryden.

Chelan is committed to using the best science available to improve our ability to exceed hatchery standards defined in the HCPs. Similarly, we have supported facility modifications at the Carlton Acclimation Ponds by Grant, and will continue to provide hatchery capacity to meet all of Grant's summer Chinook obligations for both the Wenatchee and Methow rivers.

Thank you once again for considering our findings and please do not hesitate to contact our department should you have further questions.

Regards,

Josh Murauskas
Senior Fish Biologist, HC Representative
Chelan County Public Utilities District

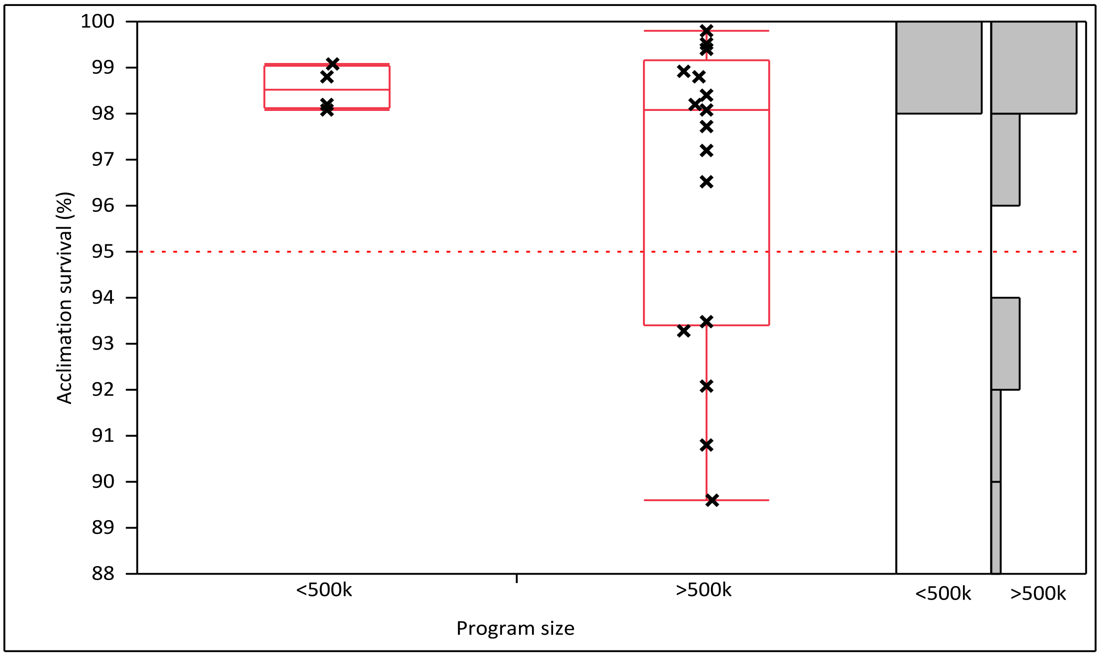


Figure 1. Acclimation survival at Dryden Ponds by program size, brood years 1989-2009.

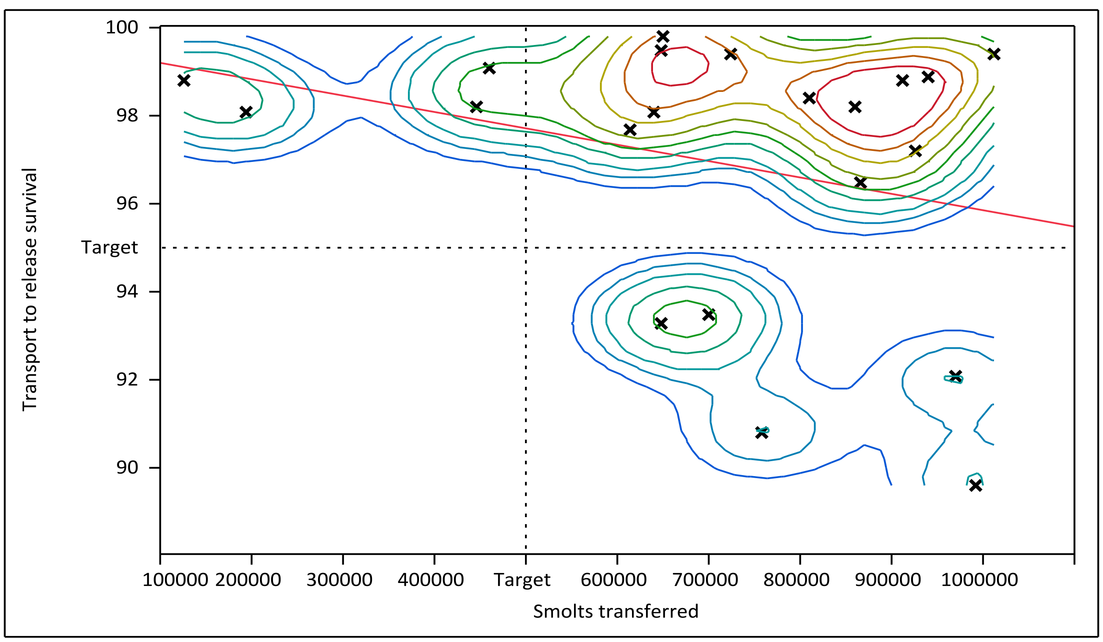


Figure 2. Transport to release survival (%) of summer Chinook smolts transferred to Dryden by program size, brood years 1989-2009.

Table 1. Examples of observed performance metrics from various program configurations possible at Dryden.

Stage	Option A	Option B	Option C
Smolts transferred	500,000	500,000	500,000
Facility survival[1]	96.9%	85.0%	98.6%
Smolts released	484,600	424,850	492,750
Survival to MCN[2]	54.4%	43.5%	72.4%
Mini-jack rate[3]	0.21%	0.26%	0.10%
Estimated smolts downriver	**263,065**	**184,497**	**356,393**

Table 2. Dryden TMDL waste load allocation.

Dryden Q **CFS**	Phosphorus Concentration **ug/L**	Load **g/d**
33	9.2	743
17	16.1	670
8	32.0	626
4	62.3	610
2	122.8	601
1	243.6	596

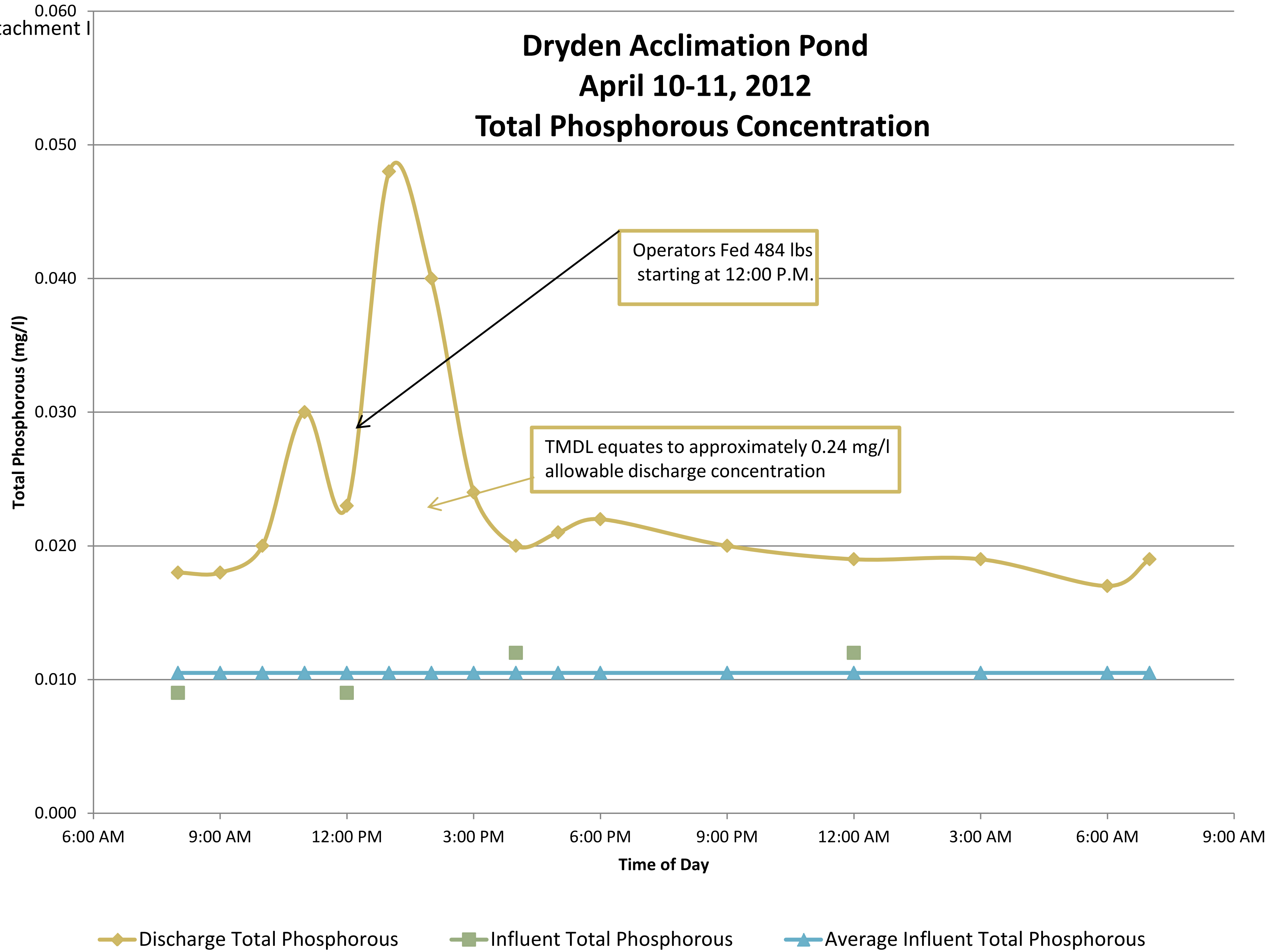
[1] From M&E data collected over program history.
[2] From PIT-based single-release survival estimates in 2009 and 2010.
[3] From PIT-based observations of Age 2 returns from 2009 and 2010 releases.

Attachment I

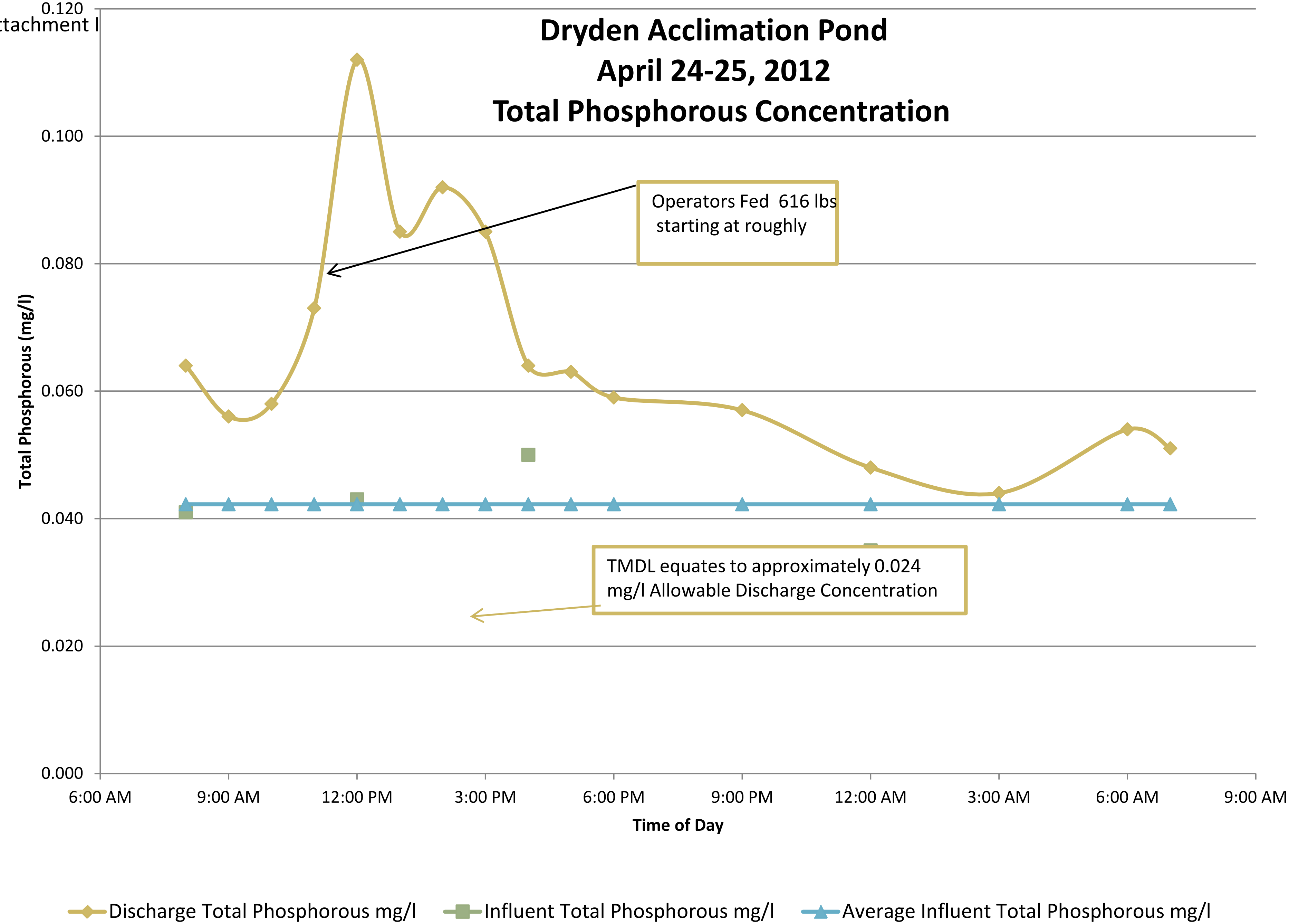
Load Allocation
Dept. of Ecology 3/12

Dryden Flow	Total Phos. Concentration	Total Phos. Load	Total Phos. Load
CFS	ug/l	grams/day	lbs/day
33	9.2	743	1.64
17	16.1	670	1.48
8	32	626	1.39
4	62.3	610	1.35
2	122.8	601	1.35
1	243.6	596	1.31

Attachment I



Attachment I



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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	August 15, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the July 18, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Douglas PUD Headquarters in East Wenatchee, Washington, on Wednesday, July 18, 2012, from 9:30 am to 12:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Mike Tonseth will provide to the Hatchery Committees an overview of the marking schemes for Mid-Columbia hatchery programs (Item I).
- Chelan PUD will develop a draft study plan for investigating size-at-release of summer/fall Chinook salmon released at selected locations, including the Dryden Rearing Facility (Item II-A).
- Alene Underwood will distribute to the Hatchery Committees for discussion the draft Dryden Total Maximum Daily Load (TMDL) and Fish Health Sampling Plans, as they become available (Item II-B).
- Alene Underwood will ask Sam Dilly to contact Tom Scribner regarding the sizing of a dedicated surface-water intake at the Dryden Rearing Facility (Item II-B).
- Josh Murauskas will finalize meeting logistics for a Hatchery Monitoring and Evaluation (M&E) Program working session, and he will distribute this information to the Hatchery Committees (Item II-C).
- Josh Murauskas will distribute to the Hatchery Committees Chelan PUD's draft timeline for the 5-year review and updating of the Hatchery M&E Program (Item II-C).
- Mike Schiewe will contact Kirk Truscott and request a presentation on the Colville Confederated Tribes' (CCT's) Chief Joseph hatchery programs and their M&E plans

(Item II-D).

- Keely Murdoch will distribute to the Hatchery Committees multi-species acclimation data collected from the back-channel at Winthrop (Item IV-A).
- Greg Mackey will notify the Hatchery Evaluation Technical Team (HETT) that the Hatchery Committees would like HETT to resume meeting and he will set up a meeting to move forward with discussions on the Non Target Taxa Of Concern (NTTOC) risk modeling results (Item V-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- No Statements of Agreement (SOAs) were approved at this meeting.

AGREEMENTS

- Chelan PUD agreed to meet internally with fisheries and hatcheries staff to discuss the best approach to: 1) engage Washington State Department of Ecology (Ecology) with the Committees' efforts to meet the upcoming Wenatchee River phosphorus TMDL at the Dryden Rearing Facility; and 2) share applicable baseline water quality data. Chelan PUD also agreed to the concept of approaching Ecology pending the outcome of the internal meeting; which the Hatchery Committees discussed should involve preparing a presentation of the proposed 2013 and 2014 study design and collectively presenting these items to Ecology (Item II-B).

REVIEW ITEMS

- No reports are currently out for review.

FINALIZED REPORTS

- No reports have been finalized since the last Hatchery Committees meeting.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees, and Chas Kyger, a new Douglas PUD Aquatic Resource Biologist, was introduced to the Committees. Schiewe reviewed the agenda, and the following revisions were requested:

- Josh Murauskas moved Chelan PUD's agenda item II-A after item II-B to accommodate arrangements with Don Larsen to speak on the summer Chinook growth modulation experiment discussion.
- Josh Murauskas added an update on the Chelan PUD Methow Sharing Agreement.
- Keely Murdoch added an update on the Yakama Nation (YN) Coho Restoration Program.
- Bill Gale requested a HETT update.

The revised draft June 20, 2012 meeting minutes were reviewed. Kristi Geris said there was one outstanding comment remaining to be discussed regarding the action item to develop an overview of the marking schemes for Mid-Columbia hatchery programs. The Hatchery Committees agreed to carry this item forward as a July action item, and agreed that Mike Tonseth was the appropriate individual to address this item. Keely Murdoch also requested a revision to clarify her question about how long it had been since Carson stock spring Chinook had been released in the Methow. Hatchery Committees members present approved the June 20, 2012 meeting minutes, as revised.

II. Chelan PUD

A. Summer Chinook Growth Modulation Experiment (Josh Murauskas)

Josh Murauskas said Chelan PUD has been working with Brian Beckman and Don Larsen (National Marine Fisheries Service [NMFS] Northwest Fisheries Science Center) to develop a conceptual draft Mid-Columbia Chinook Salmon Precocity Studies design (Attachment B). Kristi Geris distributed this draft study design to the Hatchery Committees on July 18, 2012, prior to the meeting. Murauskas said the purpose of this draft is to put forward potential approaches to develop biologically-based growth regimes and size targets (via altering lipid levels and rearing strategies) for Mid-Columbia River hatchery yearling Chinook salmon.

Don Larsen said the focus of this research is the development of biologically-based size targets for yearling summer/fall Chinook salmon, and a plan to integrate them into a comprehensive hatchery strategy that is cost-effective and time-efficient, and builds on existing data. Larsen said monitoring would occur in the fall, beginning in the second year of life, and immediately prior to release. Larsen reviewed the different approaches as outlined in Attachment B, and specifically noted the size versus rearing vessel relationship, proposed primarily at Chelan Falls Acclimation Facility. Larsen said lipid levels in the feed would be manipulated in a two-by-two factorial design, and that ideally, the experiment would be conducted over multiple years to control for environmental variability. Larsen proposed monitoring the fish for smolt quality and early maturation rate, with follow-up monitoring for downstream survival and adult return data. Larsen said the results of this study would further inform questions about the future of the Dryden facility and the ability to meet the proposed Wenatchee River phosphorus TMDL. Murauskas said that identifying a biologically-based size target could allow some flexibility in meeting the TMDL. Murauskas said he wanted to gauge the interest of the Hatchery Committees in pursuing this study before developing a detailed study plan. Murauskas also said that, in order to move forward, Chelan PUD wanted some level of assurance that the results would be used to make changes to the hatchery programs.

Bill Gale said he was concerned with the lack of replication. He said that if an infectious disease occurred in one tank, the entire study could be lost. Murauskas and Larsen agreed that replication was a concern. Larsen said that monitoring over multiple years should compensate for the lack of replication to some degree; he added that robust tagging data may also help. Larsen also said that the tanks proposed for testing at Chelan Falls and Eastbank Hatchery will be less subject to variation in flow, which was a problem with earlier studies conducted in the Chelan Falls net pens. Murauskas noted that not all fish may hit a specific size target; however, tagging a high percentage of the fish will enable collection of more accurate data over a broader size range.

Gale said that he is generally okay with the proposed sample sizes. However, conceptually, he is concerned that the study relies too heavily on passive integrated transponder (PIT) tags. Murauskas said Larsen will focus primarily on the biological indicators, and the data derived from PIT tags are secondary measurements. Gale suggested tagging a large number of fish and conducting one mark-recapture analysis, as is currently being done at Leavenworth. Murauskas reiterated that Chelan PUD would first like to gauge the interest of the Hatchery Committees, and then formulate a study plan with specific details. Gale asked to clarify whether the study will control lipid levels at Chelan Falls. Larsen said lipid levels will be altered in the feed, and size will be altered by ration.

Keely Murdoch said she thinks the study is worth consideration. She added that it is important to consider fish size and associated performance; however, she said this study by itself is not likely to resolve all of the questions associated with meeting the phosphorus TMDL. The Hatchery Committees representatives present agreed to move forward with the size targets aspect of this conceptual design. Murauskas said Chelan PUD will develop a draft study plan for investigating size-at-release of summer/fall Chinook salmon released at selected locations, including the Dryden Rearing Facility.

B. Dryden Acclimation Ponds (Josh Murauskas)

Josh Murauskas said that, as requested at the June 20, 2012 Hatchery Committees meeting, Chelan PUD developed a description of actions to ensure that summer Chinook production and infrastructure complies with the Wenatchee River TMDL for phosphorus (Attachment C). Kristi Geris distributed this document to the Hatchery Committees on July 18, 2012, prior to the meeting.

Alene Underwood reviewed Attachment C with the Hatchery Committees and stated that the document has already been discussed with Grant PUD. Underwood said Action No. 1 sets up a baseline dataset with data collection continuing into 2013 and 2014; she said the feed trial outlined in Action No. 2 will commence next year, pending results of the feed study ongoing this year. Todd Pearsons said the type of phosphorus feed has not yet been fully defined. Bill Gale asked if this trial is linked to the larger project at Leavenworth; Underwood responded that it is. Gale asked about the Joint Fisheries Parties' (JFP's) request for chemical analyses of the two different water sources (i.e., irrigation canal versus the Wenatchee River). Underwood said that issue will be addressed separately from the phosphorus TMDL issue.

Underwood said Action No. 3 is a benchmarking exercise where efficacy of removing phosphorus will be tested at Chelan Falls. Effluent sampling was conducted in 2012 and will continue in 2013 and 2014. Underwood reviewed Actions No. 4 and No. 5, and concluded that Chelan PUD could have all the information to make a decision by 2015 on how to meet the 2019 phosphorus TMDL. Tom Scribner asked if there was a detailed monitoring and sampling plan for each of the actions. Underwood said these plans were under development and that she would distribute them to the Hatchery Committees as they become available.

Scribner suggested that the Hatchery Committees engage Ecology regarding what is being done to meet the TMDL and how the fisheries community has been proactive. Underwood said Chelan PUD has already started discussions with Ecology. Scribner expressed the importance that the Hatchery Committees formally and collectively go to Ecology as a unified group. Underwood said Chelan PUD would need to first coordinate internally to ensure the Hatchery Committees' actions are not counteracting other Chelan PUD interactions that are taking place with Ecology. Chelan PUD agreed to meet internally with fisheries and hatcheries staff to discuss the best approach to: 1) engage Ecology with the Committees' efforts to meet the upcoming Wenatchee River phosphorus TMDL at the Dryden Rearing Facility; and 2) share applicable baseline water quality data. Chelan PUD also agreed to the concept of approaching Ecology pending the outcome of the internal meeting; which the Hatchery Committees discussed should involve preparing a presentation of the proposed 2013 and 2014 study design and collectively presenting these items to Ecology.

Scribner requested that the Hatchery Committees discuss the Dryden water source issue. Underwood said Chelan PUD is currently discussing with a consultant a strategy for best addressing this issue. Gale said that he believes this issue is more time-sensitive than the TMDL issue because pushing this issue back puts Grant PUD on hold for a water source, and a lot of work accomplished by the JFP is now on hold. Gale said that the JFP wants to get this water source issue figured out. The decision to go to overwinter acclimation is secondary; however, the JFP has made it clear that this is important and they would like to see a plan or proposal soon. Underwood said that Chelan PUD is budgeting for chemical analysis to occur in early 2013.

Scribner asked Underwood about what Chelan PUD considered to be the risks associated with developing a new water supply at Dryden. Underwood said that Chelan PUD and Grant PUD's water rights have not been reconciled, and Chelan PUD needs to maintain its priority water right at this location. Second, as Sam Dilly explained during the June Hatchery Committees meeting, discharge volume affects the amount of phosphorous discharge and thus the ability to comply with the TMDL. Underwood added that, at this point, Grant PUD has submitted a water right application, but the status of Chelan PUD's existing water right is still under discussion. Underwood also said that Chelan PUD cannot have that discussion with Grant PUD until more is known about the water source. Underwood said next year's budget starts on January 1, 2013, and the irrigation canal opens in March; when the time is most appropriate, Chelan PUD will conduct sampling in the canal.

Scribner said he did not fully understand the relationship between water volume and the TMDL. Underwood said she will ask Sam Dilly to contact Scribner regarding the sizing of a dedicated surface-water intake at the Dryden Rearing Facility.

C. Hatchery M&E Update (Josh Murauskas)

Josh Murauskas said he will finalize meeting logistics for the Hatchery M&E Program working session, and he will distribute this information to the Hatchery Committees.

Murauskas said Chelan PUD is revisiting the M&E objectives and discussing what metrics are needed to meet those objectives. He said Chelan PUD plans to set up targets by fall 2012 and have them finalized by early 2013. Murauskas said he developed a draft timeline for Chelan PUD's 5-year review and updating of the Hatchery M&E Program, and that he will distribute the timeline to the Hatchery Committees. Regarding Chelan PUD's contracting process, Murauskas said there are a lot of moving pieces that need to be sorted through, particularly with the CCT and Grant PUD.

D. Methow Sharing Agreement (Josh Murauskas)

Josh Murauskas said the Douglas PUD and Chelan PUD Sharing Agreement has expired. The agreement expired this year, and on July 17, 2012, termination of the agreement was authorized by letter from Chelan PUD to Douglas PUD. Murauskas said the last release of Chelan PUD spring Chinook from the Methow under contract will be in 2013. Chelan PUD's spring Chinook will be released at Chiwawa in 2014 per an earlier SOA to accommodate delays in additional spring Chinook production in the Wenatchee River. Murauskas added that Chelan PUD is currently discussing a new sharing agreement with Douglas and will consult with the Hatchery Committees as needed. Greg Mackey said that Douglas PUD had already presented a proposed budget to Chelan PUD to extend the agreement and was prepared to rear fish for Chelan PUD if and when needed. Alene

Underwood said Chelan PUD just recently began budget discussions for 2013. Murauskas said there are several issues and entities affected by these sharing arrangements; Bill Gale suggested that this discussion include a larger group (i.e., Grant PUD, as well as Chelan and Douglas PUDs). Gale and Murauskas both said the proposed Chief Joseph Hatchery programs need to be considered as well. Gale said it would be helpful to have an outline of how all of these hatchery programs link to one another. Mike Schiewe said he will contact Kirk Truscott and request a presentation on the CCT's Chief Joseph hatchery programs and their M&E plans.

III. Douglas PUD

A. Hatchery M&E Update (Greg Mackey)

Greg Mackey said Douglas PUD would like to have an updated Hatchery M&E Plan by fall 2012. Mackey said Douglas PUD operates on an annual contract, and if an implementation plan can be developed in the fall in time for budgeting and contract approval by the end of 2012, it can be implemented in 2013. Mackey said Douglas PUD is not considering significant changes to the objectives, and he reminded the Hatchery Committees of the five items Douglas PUD plans to focus on as reviewed with the Hatchery Committees during the June 20, 2012 meeting; these items are reflected in the meeting minutes.

IV. Yakama Nation

A. YN Coho Restoration Program Update (Keely Murdoch)

Keely Murdoch said the YN is in the early stages of discussions with Douglas PUD to rear juvenile coho salmon for the YN Upper Columbia Coho Reintroduction Program at the Wells Hatchery Facility. Murdoch first discussed that the YN was looking for hatchery space to accommodate expansion of numbers in the YN coho program at the May 17, 2012 Hatchery Committees meeting. Tom Scribner said these discussions are somewhat timely, because Wells Hatchery is in the master-planning stage of a rebuild. Scribner said rearing YN coho at Wells hatchery makes sense geographically and that the YN is very interested and are willing to commit capital funds to it.

Murdoch said that in preparing to move forward with the YN Upper Columbia Coho Reintroduction Program, the YN is also looking for potential acclimation sites. Murdoch said the spring Chinook program is being significantly reduced in the Chewuch River, and so one option may be to co-mingle coho and spring Chinook at Douglas PUD's Chewuch Acclimation Pond. Greg Mackey said Douglas PUD has not yet looked into multispecies acclimation with Chinook and coho, and asked about the YN experience with this. Mackey added that co-acclimating the fish may be possible, but this type of arrangement would require an agreement. Tom Kahler asked about duration of acclimation, and Murdoch replied that most acclimation sites would be short term, spring acclimation only. Murdoch added that the YN would, however, consider overwinter acclimation where possible. Murdoch said acclimation could start as early as 2014; however, this date depends on other acclimation sites because, for a given area, all fish need to be ready for release at the same time. Kahler asked how many coho the YN would consider acclimating in the Chewuch Acclimation Pond, and Murdoch said that as other acclimation locations fall into place, the YN will have a better idea, but it could be approximately 100,000 fish. Mackey asked if the YN had considered truck-planting fish and inquired about stray rates for coho planted by truck versus for those receiving a short spring acclimation. Murdoch said the YN coho plan specifies acclimating fish before release and has not tested truck plants versus acclimated plants; however, the YN has experimented with non-acclimated fish plants and there was significantly lower survival (measured as smolt-to-adult-ratio [SAR] back to the basin).

Scribner said that the YN has experience with co-mingled acclimation of spring Chinook and coho in the back-channel at Winthrop. Murdoch said she will distribute to the Hatchery Committees multi-species acclimation data collected from the back-channel at Winthrop. Scribner added that the YN is just in the beginning stages of exploring what is available and they are considering all options.

V. HETT

A. HETT Update (Greg Mackey)

Greg Mackey said that Douglas PUD has completed their NTTOC Risk Model runs. Keely Murdoch said that the YN has more model runs to complete; however, they can be ready to provide results by next month's meeting. Josh Murauskas said Chelan PUD has not yet had time to run the models. Bill Gale said that as these model runs were discussed in the M&E objectives a couple of years ago, it is time to move forward with discussions on the modeling results. Todd Pearsons pointed out that if a person running the models has already viewed the results, this affects their objectivity as a potential Delphi panelist. Mackey added that people who are running the models, however, are likely the best-suited to be a part of the Delphi Panel, but knowledge of model results would influence their assessment under the Delphi Panel.

Mackey said that HETT did not meet this month. Mike Schiewe said if administrative support is needed, Anchor QEA support can be provided. Mackey said that he will notify HETT that the Hatchery Committees would like HETT to resume meeting and to move forward with discussions on the NTTOC Risk modeling results.

VI. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees meetings are on August 15, 2012 (Chelan PUD office); September 19, 2012 (Douglas PUD office); and October 17, 2012 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – Mid-Columbia Chinook Salmon Precocity Studies Conceptual Draft
Attachment C – Chelan PUD – Dryden TMDL Compliance Timeline

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Alene Underwood*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Chas Kyger	Douglas PUD
Todd Pearsons	Grant PUD
Tom Scribner*†	Yakama Nation
Keely Murdoch*	Yakama Nation
Bill Gale*	USFWS
Jayson Wahls	WDFW
Don Larsen††	NMFS

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone

†† Joined by phone for Summer Chinook Growth Modulation Experiment discussion

MID-COLUMBIA CHINOOK SALMON PRECOCITY STUDIES

SUMMARY

Monitoring and evaluation data from mid-Columbia spring- and summer-run Chinook salmon hatcheries indicate that rearing strategies have significant implications in the performance of artificially-produced fish. Growth regimes, influencing size at release, are among the foremost factors affecting survival and population demographics. Rearing approaches therefore provide an opportunity to increase age at maturity, reproductive success, smolt survival, subsequent adult returns, stray rates, impacts to non-target species, and likelihood of reaching genetic management goals. Smolt size further influences the ability to comply with water quality standards (i.e., larger smolts require a greater wasteload allocation). The purpose of this draft study design is put forward conceptual approaches to develop biologically-based growth regimes and size targets for mid-Columbia River hatchery yearling Chinook salmon.

POTENTIAL STUDY CONSTRUCT

The objective of the proposed study would be to assess culture practices to identify techniques that maximize performance of hatchery-origin summer-run yearling Chinook salmon released in the mid-Columbia River. The Dryden and Chelan Falls facilities provide opportunities to evaluate size targets, adiposity, and rearing vessels and their effect on quality and performance of hatchery-origin summer Chinook smolts (Table 1). Smolts reared at Eastbank and spring-acclimated at Dryden can be treated by fish size and rearing vessel (adiposity constant); fish reared at Eastbank and winter-acclimated at Chelan Falls can be treated by fish size and adiposity (rearing vessel constant; Figure 1). Metrics collected will include fish physiological and disease screening, along with smolt and adult in-river behavior (Table 2).

Evaluations will determine if changes in hatchery operations can significantly improve the quality and subsequent performance of hatchery-origin summer Chinook salmon. For example, precocity affects the overall survival of smolts (since precocious males are valued as mortalities in mark-recapture models). With survival held constant between rearing vessels and assumed to increase with size, effective survival decreases at some point with increasing rate of precocity. Optimal strategies can therefore be identified through monitoring physiology, health, and in-river performance of smolts reared under varying circumstances. Results would be used to inform rearing strategies and establish size targets for yearling Chinook salmon programs with the intention of increasing performance. Wasteload allocation toward water quality standards may be subsequently reduced as an ancillary benefit if results warrant a reduced size target.

TABLE 1. POTENTIAL STUDY FACILITIES FOR YEARLING SUMMER CHINOOOK PRECOCITY STUDIES.

Facility	Stock	Potential treatments or replications	Notes
Dryden[1]	Wenatchee	Four	Size [12/20 fpp] × rearing vessel [raceway/circular]. Adiposity held constant.
Chelan Falls	Wells	Four	Size [12/20 fpp] × adiposity [high/low]. Rearing vessel held constant.
Carlton	Wells	Unknown	Potential replication with circular vessels.
Similkameen	Okanogan	Unknown	Potential test with overwinter acclimation.

[1] Dryden is of particular interest given the hatchery limitations presented by wasteload allocation.

TABLE 2. POTENTIAL STUDY METRICS FOR YEARLING SUMMER CHINOOOK PRECOCITY STUDIES.

Metric	Purpose	Hypothesis
Fish screening	Precocity and smolt quality	Feeding regime, size targets, and rearing vessels significantly influence the rate of precocity and quality of yearling summer Chinook.
Disease screening	Smolt quality	
Smolt performance	Travel and survival to McNary	
Adult performance	Age structure, SARs, stray rates	

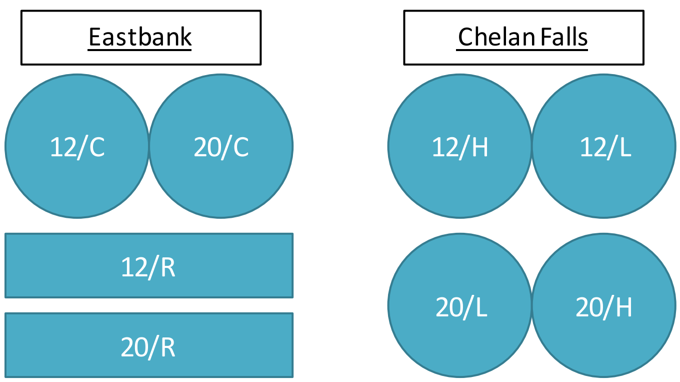

FIGURE 1. POTENTIAL VESSEL AND REARING CONFIGURATION OF SUMMER CHINOOK REARING STRATEGIES EVALUATED AT EASTBANK (DRYDEN) AND CHELAN FALLS, INCLUDING CIRCULAR (C) AND RACEWAY (R) REARING, VARYING SIZES (12/20 FPP), AND ADIPOSITY (HIGH [H] AND LOW [LOW]).

Attachment B

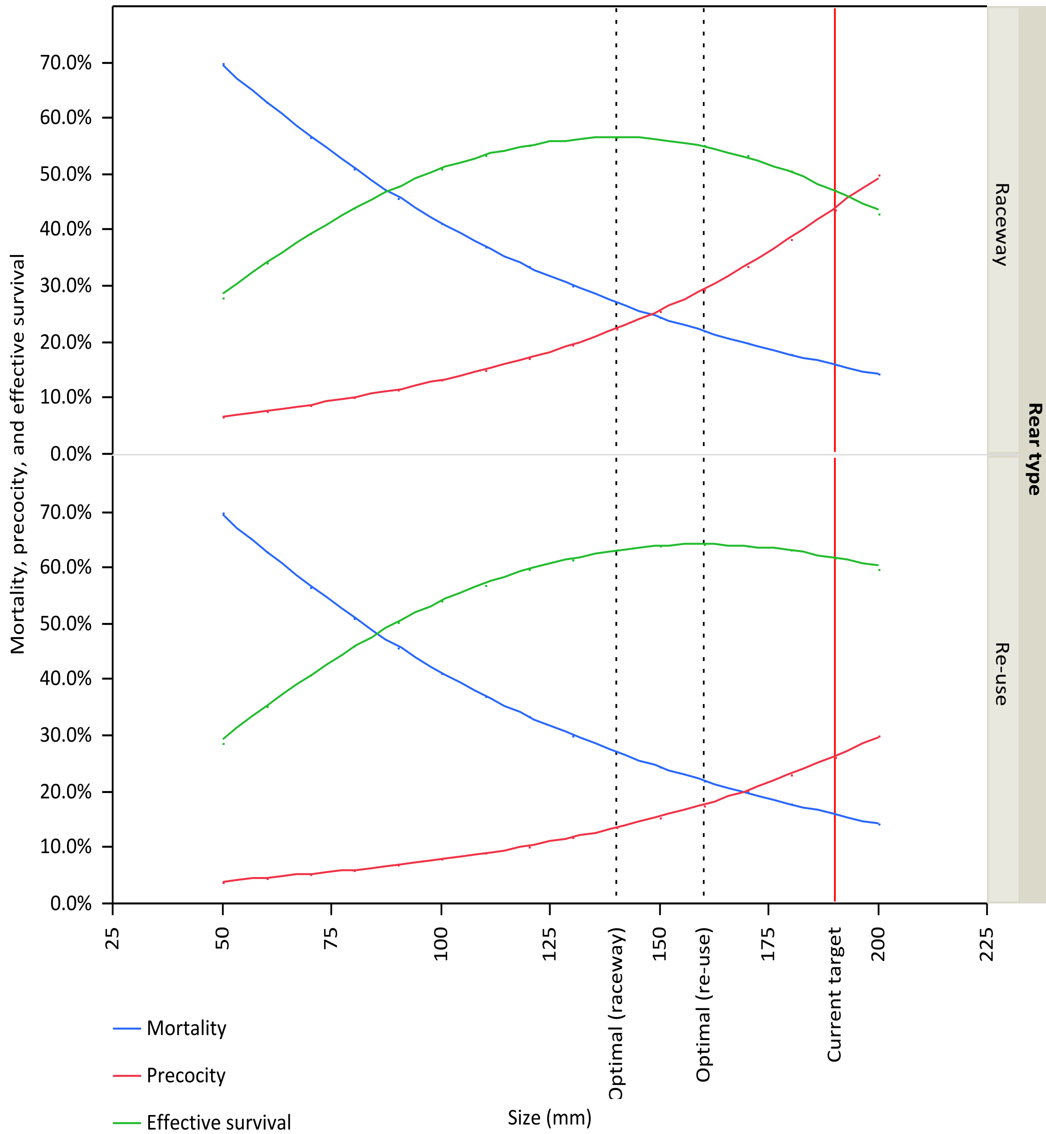

FIGURE 2. CONCEPTUAL MODEL OF MORTALITY, PRECOCITY, AND RESULTING EFFECTIVE JUVENILE SURVIVAL RATE, BY REAR TYPE. CURRENT TARGET (RED), AND OPTIMAL TARGETS (DASHED) FOR RE-USE (~64%) AND RACEWAY (~57%) SHOWN FOR COMPARISON.

Submitted by Chelan PUD for July 18, 2012, HCP HC Meeting

Chelan PUD- Dryden TMDL Compliance

At the June HCP HC meeting, Chelan PUD committed to provide the HC with a description of activities required to ensure that we can meet hatchery production levels and TMDL compliance.

The following actions will be used to ensure that summer Chinook production and infrastructure complies with the Wenatchee River TMDL for phosphorus.

Action	Purpose	Timeline	Decision
1. Measure baseline phosphorus levels in Wenatchee River and at Dryden facility (Chelan PUD) before, during, and after fish on station	Use WQ data to establish baseline phosphorous levels and estimate variability. Then, determine the (1) quantity of phosphorous and (2) the flow "Q" that can be discharged	2013 & 2014 acclimation periods	If background concentration levels exceed wasteload allocation, resize Q to appropriate level or consider other treatment options.
2. Conduct low phosphorous feed trial at Dryden (Grant PUD & Chelan PUD)	Use regular and low phosphorous feeds during acclimation to measure WQ response in effluent and to determine efficacy of future use	2013 acclimation period	If low phosphorous feed reduces effluent phosphorous concentration and meets fish health parameters (evaluated separately at FWS lab), then consider use for TMDL compliance
3. Benchmark Chelan Falls and Leavenworth circulars (Chelan PUD & USFWS).	Determine efficacy of circular tanks and radial flow separators for phosphorous removal by looking at effluent WQ	2013 & 2014 (Chelan Falls is currently operational, Leavenworth would be considered if infrastructure is built)	If circular tanks and waste removal effectively remove phosphorous, consider future application for Dryden. Consider reuse if Q is reduced significantly.
4. Evaluate size of smolts released- use physiological data and PIT tag data to empirically test different smolt sizes (NOAA - Beckman and Larsen & Chelan PUD)	Optimize smolt release size to decrease precocity, increase SARs, and reduce phosphorous input (i.e., less food)	Begins in 2012 and would focus on 2014 & 2015 release years	If a smaller smolt can improve return performance, consider application of smaller size for Dryden production group
5. Evaluate the	Examine reduction in	2014 acclimation period	Program changes are

Attachment C

Submitted by Chelan PUD for July 18, 2012, HCP HC Meeting

Action	Purpose	Timeline	Decision
number of fish released and effects on phosphorous levels (Chelan PUD)	phosphorous discharge associated with 500k smolt production (reduced from 864k)		likely to reduce phosphorous levels (supports decision in Action 1). This is not a proposal for further reductions.
6. Evaluate Actions 1-5 and select best option(s) for Dryden to meet TMDL standard		2015 summer	

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	September 20, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the August 15, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Chelan PUD Headquarters in Wenatchee, Washington, on Wednesday, August 15, 2012, from 9:30 am to 12:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Josh Murauskas will check with fish monitoring staff at Rocky Reach Dam about monitoring passage of Wells Hatchery subyearling summer Chinook beginning in May 2013 (Item II-A).
- Kirk Truscott will coordinate with Keith Wolf to arrange a formal presentation on the Colville Confederated Tribes' (CCT's) Chief Joseph Hatchery Programs for the September 19, 2012 Hatchery Committees meeting (Item III-A).
- Kirk Truscott will provide an electronic copy of CCT's proposed brood year (BY) 2013 Chief Joseph Hatchery spring and summer Chinook production to Kristi Geris for distribution to the Hatchery Committees (Item III-A).
- Josh Murauskas will provide to the Hatchery Committees a more detailed study plan for the Mid-Columbia Chinook Salmon Precocity Studies, including: 1) fish size targets and estimated pond timing, and 2) a section on sample sizes and proposed statistical methods for analyzing and interpreting results. Murauskas also agreed to provide to the Committees monthly updates as the study progresses (Item IV-C).
- Alene Underwood will provide the Dryden Facility 2012 effluent sampling results and Chelan PUD's Draft Water Quality Sampling Report to Kristi Geris for distribution to the Hatchery Committees after internal review (Item V-A).
- The Yakama Nation (YN) will develop suggested steps forward for engaging

Washington State Department of Ecology (Ecology) regarding efforts by fisheries interests to meet the Wenatchee River phosphorus Total Maximum Daily Load (TMDL); this topic will be discussed at the September 19, 2012 Hatchery Committees meeting (Item V-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- No Statements of Agreement (SOAs) were approved at this meeting.

AGREEMENTS

- The Hatchery Committees' representatives present agreed that Chelan PUD and Washington Department of Fish and Wildlife (WDFW) should implement their plan, titled "Chelan River Brood Collection 2012 Pilot Study," to test methods for capturing returning adults to use as broodstock for the Chelan Falls summer/fall Chinook program (Item IV-B).
- The Hatchery Committees representatives present agreed that Chelan PUD could proceed with their proposal, "Mid-Columbia Chinook Salmon Precocity Studies," but requested a more detailed study plan and monthly updates as the study progresses (Item IV-C).
- The Hatchery Committees members present agreed to continue the existing Hatchery Monitoring and Evaluation (M&E) Programs with minor revisions in 2013, and to implement the updated M&E program for 2014 and beyond (Item II-B).

REVIEW ITEMS

- No reports are currently out for review.

FINALIZED REPORTS

- No reports have been finalized since the last Hatchery Committees meeting.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. The following revisions were requested:

- Keely Murdoch asked for an update on the Dryden Rearing Facility studies and efforts to meet the Wenatchee River phosphorus TMDL.
- Kirk Truscott added a presentation on the CCT's Chief Joseph production and M&E plans for fiscal year (FY) 2013.
- Greg Mackey added: 1) a discussion of a draft SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook; and 2) a brief Wells Hatchery modernization update.

The revised draft July 18, 2012 meeting minutes were reviewed. Chelan PUD discussed their revisions already incorporated into the revised minutes. Hatchery Committees' members present approved the July 18, 2012 meeting minutes, as revised. Bill Gale approved the July meeting minutes by email.

II. Douglas PUD

A. SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook (Greg Mackey)

Greg Mackey presented for discussion a draft SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook (Attachment B). The draft SOA was distributed to the Hatchery Committees by Kristi Geris on August 14, 2012. Mackey said that Douglas PUD will be seeking approval of this SOA at the September 19, 2012 Hatchery Committees meeting.

Mackey said that former Wells Hatchery Manager, Jerry Moore, originally expressed concern about the mid-June release time for Wells Hatchery subyearling summer Chinook. He said that, based on Moore's observations and other WDFW staff, a 4-year study beginning in 2004 was conducted to compare smolt to adult returns (SARs) of mid-May versus mid-June release groups of Wells Hatchery subyearlings. The results of this study indicated that the May release group had SARs 2.75 times those of the June release group. Mackey said that, as a result of these findings, in 2008, the HCP Hatchery Committees decided to shift the release time of future Wells Hatchery sub-yearlings to mid-May, starting with the 2009 release group, but did not formalize the decision. Mackey said this SOA is intended to formalize the decision that was made by the HCP Hatchery Committees in 2008. He added that the release time affects water use at Wells Hatchery and needs to be taken into account during ongoing planning for the hatchery's modernization; therefore, Douglas PUD would like to have formal agreement on the release timing.

The Hatchery Committees members expressed continued support for the May release date and draft SOA. Josh Murauskas noted that smolt monitoring at the Rocky Reach Bypass does not begin enumerating subyearling Chinook until June 1. Murauskas agreed to check with the fish monitoring staff at Rocky Reach Dam about shifting the start date of subyearling Chinook monitoring to begin in May in future years.

B. Hatchery M&E Update (Greg Mackey)

Before addressing plans to revise and update the Douglas PUD Hatchery M&E Plan, Greg Mackey updated the Committees on the status of their Hatchery and Genetic Management Plans (HGMP). He said that neither the Wells steelhead nor Methow spring Chinook HGMPs, and associated Endangered Species Act (ESA) permits, have been processed yet by National Marine Fisheries Service (NMFS), and he anticipates that NMFS will incorporate M&E conditions into the new permit. Mackey said Douglas PUD is scheduled to meet with NMFS, WDFW, and U.S. Fish and Wildlife Service (USFWS) staff to discuss HGMP goals. He said these discussions could lead to modifications of the M&E Plan.

With several HGMP and M&E issues still unresolved, Mackey said Douglas PUD is proposing to defer implementation of the fully revised Hatchery M&E Program until 2014; in 2013, they would implement the existing M&E programs with minor updates. Tom Kahler added that in order for Douglas PUD to implement a new M&E program this coming year, the new program would need to be approved by the November 2012 Hatchery Committees meeting; and Douglas PUD will not have their new permits before that time, which will largely shape their M&E programs. Mackey said new permits are due one year from now, which will coincide with the proposed date for the new M&E programs. This revised schedule would allow more time for a thorough review of the existing programs and for development of M&E updates.

Keely Murdoch expressed support for Douglas PUD's proposed timeline to implement a new Hatchery M&E Program in 2014. She added that a lot of thought went into the original M&E Plan, and she does not foresee significant changes in the revised M&E plan. Mackey said Douglas PUD anticipates maintaining most of the original program with only minor revisions.

Josh Murauskas said Chelan PUD plans to complete, in conjunction with the Hatchery Committees, the 5-year review of their Hatchery M&E Program by mid-2013. He said Chelan PUD has discussed their M&E objectives, and plans to review those and verify whether Chelan PUD is meeting the goals of their M&E program.

The Hatchery Committees members present agreed to the new schedule, which includes: 1) continuing to implement the existing Hatchery M&E Programs with minor revisions in 2013; 2) maintaining an aggressive schedule for updating the plan so as to not lose momentum; and 3) implementing the fully revised M&E programs beginning in 2014.

C. Wells Hatchery Modernization Update(Greg Mackey)

Greg Mackey said that Wells Hatchery is currently in Phase I of a modernization process, which largely focuses on the water supply and conveyance system, bio-programming, and the condition of existing facilities. He said Douglas PUD is working with a hydrologist from HDR Engineering, Inc. (HDR), and a report on the well water supply is expected soon. Mackey said HDR is also conducting a facility assessment of the entire Wells Hatchery facility. He said that, in general, the Phase I effort includes an initial assessment of all infrastructure, and identification of needed upgrades.

Mackey said Phase II of the modernization process will continue to focus on bio-programming, which will inform water needs for Wells Hatchery operations. Mackey said rearing vessels needed to accommodate future programs will also be addressed during Phase II.

Mackey said Douglas PUD had met with the YN to discuss the rearing of coho salmon for the YN Upper Columbia Coho Reintroduction Program at Wells Hatchery. However, he said the needed modifications were not within their budget, and the YN has decided to look elsewhere. Mackey did note that Douglas PUD will be able to provide space at Wells Hatchery for the YN Twisp River Steelhead Kelt Reconditioning Program.

Keely Murdoch provided a brief update on the YN Kelt Reconditioning Program. She said they are currently holding kelts at Winthrop National Fish Hatchery (NFH), and will be releasing adults to spawn naturally. She added that, because the kelts have already been spawned once in a hatchery, they do not plan to spawn them in a hatchery again. Murdoch said all fish are passive integrated transponder (PIT)-tagged and tissue sampled for genetic analysis. Mackey suggested that the YN might want to consider a temporary weir to control the migration of reconditioned kelts released into a small stream, such as Little Bridge Creek. This would enable a more controlled assessment of spawning and reproductive success.

III. CCT

A. CCT's Chief Joseph Hatchery Programs and M&E Plans (Kirk Truscott)

Kirk Truscott said that he will coordinate with Keith Wolf to arrange a formal presentation on the CCT's Chief Joseph Hatchery Programs at the September 19, 2012 Hatchery Committees meeting.

Truscott said the CCT submitted a Hatchery M&E Program proposal to the Bonneville Power Administration (BPA) through the PISCES program. He said that the scope of work is based upon work elements that are standardized, and may not correspond to typical M&E program elements. Truscott said that the CCT is developing an additional Hatchery M&E Program that aligns with the HCP and Priest Rapids Coordinating Committee (PRCC) objectives. He added that the CCT will have a contract by October 1, 2012; and an update will be provided at the March 2013 APR workshop.

Truscott said the CCT is no longer operating under multiple-year contracts with BPA; therefore, CCT's Operations and Maintenance (O&M) and M&E plans will be modified annually. Truscott said key components of the CCT Hatchery M&E Program include: 1) in-hatchery monitoring by life stage; 2) tagging plans; 3) deployment of two smolt traps to increase monitoring on the Okanogan River; and 4) fall carcass recovery and redd counts. Truscott said CCT is also developing a pilot weir operation near Monse to facilitate improved accuracy of enumeration of escapement into the Okanogan River.

Truscott said CCT's proposed Hatchery Operations and M&E budgets for FY 2013 are approximately $1.4 million and $960,000, respectively. He said approximately $650,000 of the Hatchery Operations budget is for electricity; and a large amount of the $960,000 for M&E

goes towards database development during the first year, and this figure will decrease in subsequent years.

Truscott said CCT is anticipating a 60 percent of capacity production for BY 2013. He added that spring and summer Chinook production will be adequate to meet the planned PUD Chinook obligations at Chief Joseph Hatchery. Truscott said he will provide an electronic copy of CCT's proposed BY 2013 Chief Joseph Hatchery spring and summer Chinook production to Kristi Geris for distribution to the Hatchery Committees. Truscott said CCT is still expecting to bring BY 2013 spring Chinook on-station by mid-May 2013; he added that the fish will be from broodstock collected at Leavenworth NFH; MetComps will be from Winthrop NFH. Mike Tonseth asked if a plan was in place in case facilities are not ready, and Truscott said that plans are in place. Tonseth also asked about plans for overwinter acclimation. Truscott said that Chief Joseph Hatchery overwinter acclimation preparations are mostly complete, and on track for 2013. He said that CCT plans to operate overwinter acclimation ponds this winter to investigate whether groundwater prevents the ponds from freezing.

IV. Chelan PUD

A. Methow Update (Josh Murauskas)

Josh Murauskas said Chelan PUD sent Douglas PUD a proposal for continuing production at the Methow facility, including associated costs for production of 60,516 Chelan PUD spring Chinook. Mike Tonseth asked when a decision can be expected. Murauskas replied that the sharing agreement would be required for BY 2013, and Greg Mackey said that would require a decision by this winter. Mackey added that Joe Miller and Shane Bickford have been corresponding; however, Mackey said he is unsure of the status as the discussions are ongoing.

B. Chelan Falls Brood Collection (Josh Murauskas)

Josh Murauskas said that Chelan PUD has been coordinating with WDFW on logistics for conducting the Chelan River Brood Collection 2012 Pilot Study (Attachment C). Kristi Geris distributed the study plan to the Hatchery Committees on August 8, 2012. Murauskas said that Chris Moran (WDFW) has been helping with this study plan that is designed to investigate the potential to collect returning Chelan River summer/fall Chinook to use as brood for Chelan Falls Hatchery production. Murauskas said the study includes mark and recapture methods to assess how many fish may be available for production at Chelan Falls Hatchery. Murauskas asked the Hatchery Committees for comments or concerns regarding this study.

Keely Murdoch asked about the rationale for sourcing returning fish for Chelan Falls Hatchery production. She asked why they would not use excess hatchery returns collected at Wells Hatchery. Murauskas said the purpose was to take advantage of the opportunity for local brood collection. Kirk Truscott asked if it was mostly a cost issue, and Murauskas responded that it was, and said if collection at Chelan River turns out to be difficult or expensive, then Chelan PUD will not pursue this option.

Mike Tonseth suggested that there may be the potential for some biological benefit. He said that, unlike at other facilities, there are no rack returns. Truscott added that with Chelan River brood collection, Chelan PUD will not have to rely on Wells production to meet Chelan Falls broodstock. Murdoch added that if Chelan PUD thinks localized brood collection will be more efficient, she is not opposed to the study. She said it will be important to closely observe what fish are collected for the study; it could be a problem if fish are collected that are heading upstream. Tonseth agreed that timing is a major issue. The Hatchery Committees representatives present agreed that Chelan PUD and WDFW should proceed with the Chelan River Brood Collection 2012 Pilot Study for summer Chinook production at Chelan Falls Hatchery.

C. Summer Chinook Size Targets (Don Larsen/Josh Murauskas)

Josh Murauskas said that Chelan PUD, in coordination with Brian Beckman and Don Larsen (NMFS Northwest Fisheries Science Center), recently developed a conceptual draft Mid-Columbia Chinook Salmon Precocity Studies plan (Attachment D). He added that results of this study may contribute information that would help Chelan PUD meet the phosphorus TMDL targets at the Dryden facility. Murauskas said that Chelan and Grant PUDs, the NMFS scientists, and WDFW met with the hatchery staff last week to discuss revisions to the draft study plan. Kristi Geris distributed the revised draft study design to the Hatchery Committees on August 8, 2012.

Larsen said they planned to test a range of fish sizes, and that the study plan was to incorporate replications over years at each site. Larsen said raceway types and fish sizes still need to be determined. He said that the hope was for fish to be sampled next fall to evaluate study progress. Larsen said that results of this study would provide information about differences among rearing vessels, as well as size at release. Murauskas said Chelan PUD was looking for support from the Hatchery Committees to move this study forward.

Mike Schiewe asked about a statistical analysis plan. Murauskas said that PIT tags will be used to analyze smolt survival, performance, and travel time. He added that discussions are still ongoing regarding sample sizes needed for sufficient statistical power. Keely Murdoch asked to clarify what "reduced size" implies as described in Table 1 of Attachment D. Larsen said he is working with fish health staff to determine what size limit would be attainable without impacting fish health. Mike Tonseth asked if they considered increasing the length of chilled incubation to decrease fish size. Alene Underwood said she thinks that option is already being implemented to the extent it can be used without affecting fish health.

Schiewe asked if criteria are being developed to ensure fish health is not being affected. Murauskas said fish will be monitored throughout the study to prevent fish health impacts. He added that fish will also be monitored at the end of spring prior to release. Larsen also said monitoring will include coefficients of variation (CVs) and condition factors of the fish. Brian Beckman said that if monthly monitoring indicates potential issues, culture staff will conduct additional monitoring, and conditions can be adjusted. Beckman said there will be both group and individual monitoring.

Murauskas said that fish will be PIT tagged prior to release in the spring, and fish lengths will be recorded on 100 percent of the fish. Beckman said growth and smolt physiology will also be monitored among the treatments. For adult performance, as described in Table 2 of Attachment D, Kirk Truscott asked if the study plan includes testing for statistical significances in SARs. He suggested that a large number of PIT tags will be needed for this. Murauskas said that for SARs, a large sample size is not needed because of the high probability of detection of returning adults. Murauskas said there can be, however, large variation with tag detection efficiency of smolts.

Truscott asked about the high percentage of overall production that would be involved in the study, and suggested that it was risky to have half of the production manipulated in case something goes wrong. Larsen said they need a large sample size to make a stronger case. He added that considering the potential risk, the reduced ration is planned for the smaller vessels. Beckman added that the general consensus was to use the larger sample size because the overall survival will go up.

Tonseth said that the largest fish size will probably be about 10 fish per pound (fpp), without compromising fish health. Larsen said he agreed with that number and added that it is a good benchmark to aim for. Tonseth said 15 fpp has been targeted, as well; so having half of the program at 10 fpp and the other half at 15 fpp, would not put excessive risk to the program. Larsen clarified that in Table 1 in Attachment D, 10 fpp and 15 fpp should be included as size targets at Chelan Falls to mimic the Dryden control. He said this will be important in identifying issues. Larsen added that both facilities will be adaptively managed.

Schiewe asked if the option had been considered of viewing the 2012 brood as a pilot year, given that there are so many unknowns. Larsen said he originally had in mind a 3-year study. Murauskas noted that, in order for these results to contribute to meeting the Wenatchee phosphorus TMDL, they are needed sooner than 3 years out.

Murauskas added that Table 6.10 in the annual M&E report shows variation with fish size at release up to 22 fpp; so this study appears to be realistic compared to what has happened in the past. Tonseth added that there have been various factors in the past that caused variation.

Tonseth asked if a more detailed study plan will be provided to the Hatchery Committees for review. Murauskas said that the conceptual draft plan (Attachment D) should serve as a good platform; however, if the Committees would like to see something more specific, then Chelan PUD will prepare a more detailed plan. Tonseth said he would like to see a write-up on pond timing and chilled incubation. He said that this information would provide a rough idea of what size at release will be. Murauskas said that within the next month he will provide to the Hatchery Committees a more complete study plan for the Mid-Columbia Chinook Salmon Precocity Studies, including: 1) fish size targets and estimated pond timing, and 2) a section on sample sizes and proposed statistical methods for analyzing and interpreting results. Murauskas also agreed to provide to the Committees monthly updates as the study progresses.

The Hatchery Committees representatives present agreed that Chelan PUD could proceed with the Mid-Columbia Chinook Salmon Precocity Studies, contingent upon receiving a more complete study plan and monthly updates as the study progresses.

V. Yakama Nation

A. Dryden Update as it Pertains to the Wenatchee River Phosphorus TMDL (Keely Murdoch)

Keely Murdoch requested an update on any follow-up to the Hatchery Committees' July meeting discussion on the Dryden facility and plans to comply with Wenatchee River phosphorus TMDL. Murdoch asked if there was a path forward to engage Ecology. She also asked who is working on it, and what the timeline is for the tasks.

Alene Underwood said she thought Tom Scribner was pulling this together, particularly in terms of how and when to engage Ecology. Underwood said Chelan PUD developed a water quality testing plan, which is now being internally reviewed. Underwood said that once that review is complete, she will provide Chelan PUD's Draft Water Quality Sampling Report and the Chelan Falls Hatchery 2012 effluent sampling results to Kristi Geris for distribution to the Hatchery Committees. Murdoch explained that the YN wants to be sure that this issue is not getting dropped, and that someone is taking the lead.

Mike Schiewe explained that Scribner requested that the Hatchery Committees work together on a plan to approach Ecology as a group. Underwood had explained that within Chelan PUD there were multiple units involved in the Wenatchee TMDL issue and that any role of the fisheries staff would have to be reviewed by Chelan PUD management. She added that none of this was an agreement by Chelan PUD to take the lead; in fact, she said Chelan PUD had already been in contact with Ecology on the TMDL issue as summarized by Sam Dilly at the June Hatchery Committees meeting. Murdoch agreed that the YN will develop suggested steps forward on how to engage Ecology regarding what is being done to meet the Wenatchee River phosphorus TMDL, in order to facilitate discussion at the September 19, 2012 Hatchery Committees meeting.

VI. HETT

A. HETT Update (Greg Mackey)

Greg Mackey said that the Hatchery Evaluation Technical Team (HETT) met on August 14, 2012, and discussed the status of the Non-Target Taxa Of Concern (NTTOC) risk modeling. Mackey said that the HETT agreed to send him the model runs completed to date, which Mackey estimated to total approximately 127 runs. Mackey said he will compile the results into a database for analysis, which will then also be used to assess Delphi panel results in comparison the model results. Mackey said the HETT agreed that the Delphi panel will consist, at least initially, of a smaller group of local scientists and that the HETT will produce a report on the NTTOC modeling and Delphi results for the Hatchery Committees, and then potentially engage a broader Delphi panel and ultimately develop a more robust manuscript later. Mackey said the HETT will meet again in one month to discuss data gaps in the modeling. Mackey said a more concrete update will be provided thereafter, once all runs have been received.

VII. HCP Administration

A. Next Meetings

The next scheduled Hatchery Committees meetings are on September 19, 2012 (Douglas PUD office); October 17, 2012 (Chelan PUD office); and November 21, 2012 (Douglas PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – Draft SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook
Attachment C – Chelan River Brood Collection: 2012 Pilot study for summer Chinook production at Chelan Falls Hatchery
Attachment D – Mid-Columbia Chinook salmon precocity studies

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Alene Underwood*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Todd Pearsons	Grant PUD
Kirk Truscott	Colville Confederated Tribes
Keely Murdoch*	Yakama Nation
Mike Tonseth*	WDFW
Brian Beckman†	NMFS
Don Larsen†	NMFS

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone for the Mid-Columbia Chinook salmon precocity studies discussion

Draft 8-13-2012

Wells HCP Hatchery Committee

Statement of Agreement

Timing of release of Wells Hatchery Sub-Yearling Summer Chinook

Approved on XX September 2012

Statement

The Wells HCP Hatchery Committee approves the timing of release for the 484,000 subyearling summer Chinook inundation compensation program that takes place annually from the Wells Hatchery. The new release timing for this program will be on or around May 15th of each calendar year.

Background

The Wells HCP requires Douglas PUD to release 484,000 sub-yearling summer Chinook as Fixed Hatchery Compensation – Inundation (Wells HCP; Section 8.4.6). A recent study tested the management strategy of releasing Wells Hatchery subyearling summer Chinook (sub-yearlings) in mid-May (range May 11-18) instead of in mid-June (range June 13-14) , as had been used at Wells Hatchery for many years.

Beginning in 2004, the Wells Hatchery subyearling release was split into May and June release groups and tracked with CWT and PIT tags. The results of this study found that the May release group arrived at McNary Dam approximately 15 days earlier and had 2.75 times the smolt to adult returns (SAR) as the June release group (2004-2007 release years, each year the early release group had a statistically higher SAR). Based on the results of the first three years of the study, in 2008 the HCP Hatchery Committee decided to shift the release timing of all future Wells Hatchery sub-yearlings to the middle of May starting with the 2009 release group.

This SOA is intended to formalize the decision that was made by the HCP HC in 2008. This change in release timing is expected to more than double the number of adult Chinook returning from this component of the summer Chinook inundation compensation program.

Chelan River Brood Collection

2012 Pilot study for summer Chinook production at Chelan Falls Hatchery

Introduction

Fishery managers often desire localized brood collection for genetic and logistic purposes. The Chelan Falls Hatchery was constructed to provide capacity for a 600,000 yearling summer Chinook segregated program intended for harvest augmentation. Brood has typically been collected at the Wells Hatchery, though increasing returns to the Chelan River may provide an opportunity for a localized collection. As a means to test the efficacy of various methods, we are proposing to conduct a pilot study in 2012. The intent is to identify methods to secure brood in the Chelan River for a 576,000 smolt program based on recalculated production values beginning with brood year 2012 (estimated 318 adults including 154 females).

Materials and Methods

Various methods will be used to target adult summer Chinook returning to the Chelan River. Beach seines will be the primary capture technique, though boat seines, fyke nets, Merwin traps, and hook and line fishing will be considered depending on availability of equipment and expertise. Chelan PUD is currently coordinating with Washington Department of Fish and Wildlife to determine which approaches would be viable options to assess during the 2012 return to the Chelan River. All fish handled will be released following capture since the objective is to assess the efficacy of capture methods. Environmental (temperature, flow), date/time, and biological (length, sex) will be determined to the extent possible and results reported to the Hatchery Committee by December 2012. Additional data collected during Chelan River surveys will serve as further context to consider local brood collection.

Timeline

Fish trapping will occur approximately three weeks prior to peak spawning in October. Capture methods, previous years' data, and technician availability will drive the sampling schedule. Reporting will be provided to the Hatcher Committee in December 2012.

MID-COLUMBIA CHINOOK SALMON PRECOCITY STUDIES

SUMMARY

Monitoring and evaluation data from mid-Columbia spring- and summer-run Chinook salmon hatcheries indicate that rearing strategies have significant implications in the performance of artificially-produced fish. Growth regimes, influencing size at release, are among the foremost factors affecting survival and population demographics. The consequences of rearing approaches therefore provide an opportunity to increase age at maturity, reproductive success, smolt survival, subsequent adult returns, and likelihood of reaching genetic management goals. Positive outcomes could further reduce stray rates, precocity, and potential impacts to non-target species in natal streams. The purpose of this study design is to use physiological and behavioral monitoring techniques to develop biologically-based growth regimes and size targets for mid-Columbia River hatchery summer Chinook reared at Dryden and Chelan Falls acclimation ponds. Outcomes would also be considered as a potential means for improving performance of the Wenatchee River summer Chinook hatchery program. Results would be adopted for use in hatchery programs moving forward.

STUDY CONSTRUCT

The goal of the proposed study would be to assess culture practices to identify techniques that maximize performance of hatchery-origin summer-run yearling Chinook salmon released in the mid-Columbia River. The Dryden and Chelan Falls facilities provide opportunities to evaluate size targets and rearing vessels and their effect on quality and performance of hatchery-origin summer Chinook smolts (Table 1). Smolts reared at Eastbank and spring-acclimated at Dryden can be treated by fish size and rearing vessel; fish reared at Eastbank and winter-acclimated at Chelan Falls can be treated by fish size with comparisons to Eastbank. Metrics collected will include fish physiological and smolt and adult in-river performance based on PIT returns (Table 2). Brood years 2012 and 2013 will be evaluated, with juvenile results concluding in 2015 concurrent with additional studies at Dryden Acclimation Ponds.

The goal of the evaluations described here will be to determine if changes in hatchery operations can significantly improve the quality and subsequent performance of hatchery-origin summer Chinook salmon. For example, precocity affects the overall survival of smolts (since precocious males are valued as mortalities in mark-recapture models). With survival held constant between rearing vessels and assumed to increase with size, effective survival decreases at some point with increasing rate of precocity. Optimal strategies can therefore be identified through monitoring physiology, health, and in-river performance of smolts reared under varying circumstances. The funding of this research would be contingent on acceptance from the hatchery committees that results will be used to adopt biologically-derived rearing strategies and further ascertain if operational approaches can be used to increase performance of the Dryden program to meet management objectives.

TABLE 1. POTENTIAL STUDY FACILITIES FOR YEARLING SUMMER CHINOOOK PRECOCITY STUDIES.

Facility	Stock	Treatments or replications
Dryden	Wenatchee	Control (10 FPP) and test (reduced size) fish reared in re-use (2 vessels), super raceways (2 vessels), and standard raceways (2-4 vessels) for a total of ≥3 groups each of control and test fish. The availability of standard raceways 3 and 4 will be determined by the operators. Super raceways will contain ≥ 150k smolts each, 25k smolts in standard raceways, and 50k smolts in circular vessels for a total of 500k smolts destined for Dryden Ponds.
Chelan Falls	Wells	Four groups representing a range of size targets (e.g., 12, 16, 20, and 24 FPP) depending on capacity of operators to manipulate growth among groups.

TABLE 2. POTENTIAL STUDY METRICS FOR YEARLING SUMMER CHINOOOK PRECOCITY STUDIES.

Metric	Purpose	Hypothesis
Fish screening	Precocity and smolt quality	Feeding regime, size targets, and rearing vessels significantly influence the rate of precocity and quality of yearling summer Chinook.
Smolt performance	Travel and survival to McNary	Feeding regime, size targets, and rearing vessels significantly influence the in-river performance of yearling summer Chinook.
Adult performance	Age structure, SARs, stray rates	Feeding regime, size targets, and rearing vessels significantly influence the subsequent in-river performance of adult summer Chinook returns.

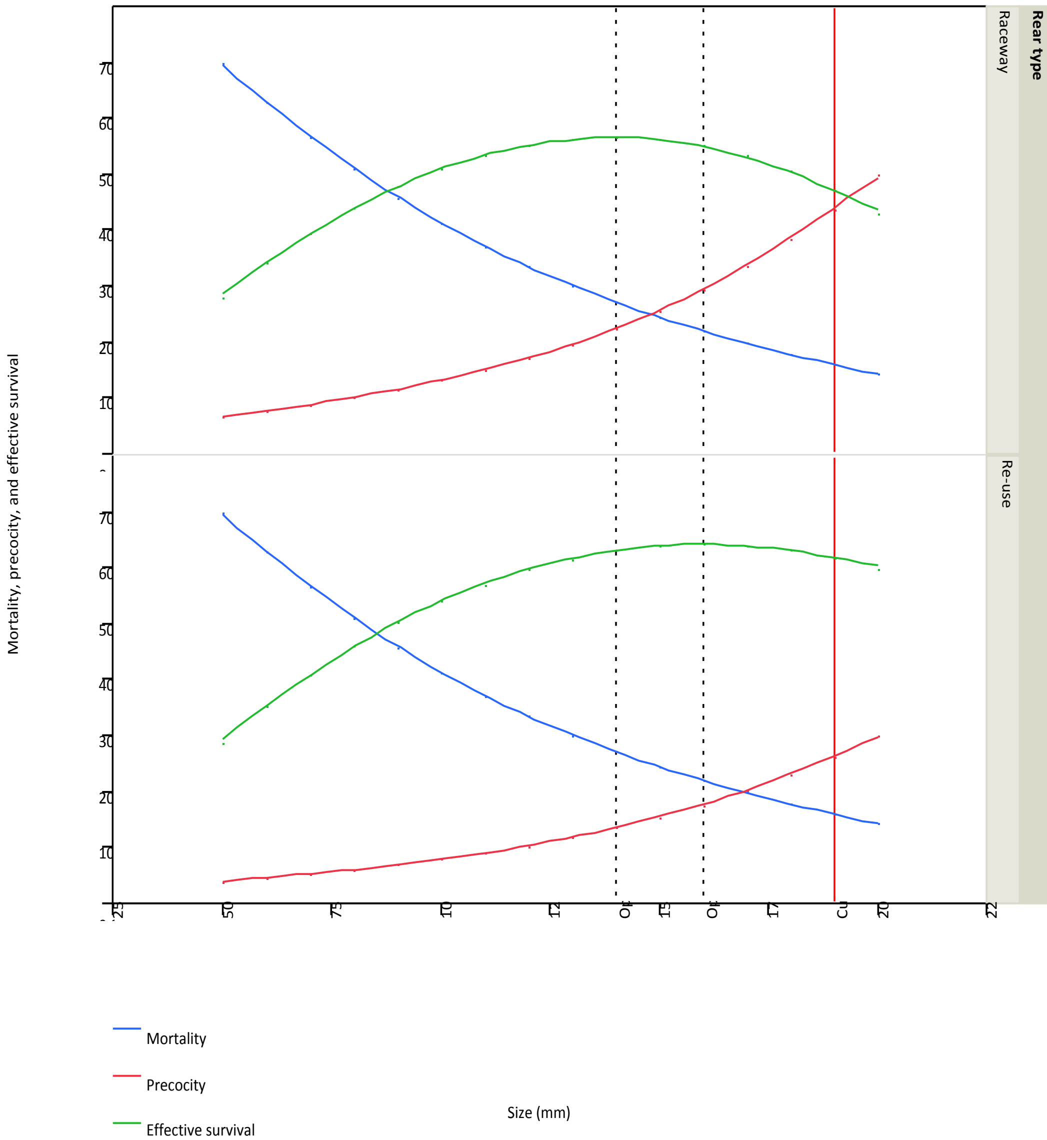

FIGURE 1. CONCEPTUAL MODEL OF MORTALITY, PRECOCITY, AND RESULTING EFFECTIVE JUVENILE SURVIVAL RATE, BY REAR TYPE. CURRENT TARGET (RED), AND OPTIMAL TARGETS (DASHED) FOR RE-USE (~64%) AND RACEWAY (~57%) SHOWN FOR COMPARISON.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	November 15, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the September 19, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Douglas PUD headquarters in East Wenatchee, Washington, on Wednesday, September 19, 2012, from 9:30 am to 12:30 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Kirk Truscott will email Colville Confederated Tribes' (CCT's) revisions to the revised draft August 15, 2012 meeting minutes to Kristi Geris to be incorporated into the final Hatchery Committees August 15, 2012 meeting minutes (Item I).
- Chelan PUD and Douglas PUD will present their draft 2013 Hatchery Monitoring and Evaluation (M&E) Work Plans to the Hatchery Committees no later than the November 21, 2012 Hatchery Committees meeting (Item III-A).
- Chelan PUD will contact Douglas PUD to discuss a limited sharing agreement that supports only selected aspects of Chelan PUD's Methow spring Chinook salmon production (Item III-B).
- Bill Gale will discuss with U.S. Fish and Wildlife Service (USFWS) the potential to use Winthrop National Fish Hatchery (NFH) for Chelan PUD above Rocky Reach spring Chinook salmon mitigation (Item III-B).
- Alene Underwood will provide electronic versions of the draft 2012 Wastewater Quality Analysis for Dryden and Chelan Falls, and the draft 2013 Dryden Acclimation Wastewater Sampling Plan to Kristi Geris for distribution to the Hatchery Committees. Comments on the draft documents are due to Chelan PUD prior to the October 17, 2012 Hatchery Committees meeting (Item III-C).
- Alene Underwood will revise the draft 2013 Dryden Acclimation Wastewater

Sampling Plan prior to distribution to the Hatchery Committees (Item III-C).
- Kristi Geris will coordinate with Tom Scribner to set up an initial call convening a workgroup for engaging Washington State Department of Ecology (Ecology) in discussions regarding efforts to meet the Wenatchee River phosphorus total maximum daily load (TMDL). The workgroup will include Tom Scribner representing the Yakama Nation (YN); Bill Gale and Dave Irving representing USFWS; Alene Underwood representing Chelan PUD; Mike Tonseth representing Washington Department of Fish and Wildlife (WDFW); and Todd Pearsons and Ross Hendrick representing Grant PUD (Item III-C).
- Keely Murdoch, Mike Tonseth, and Bill Gale will develop a draft conceptual plan outlining multi-species acclimation options for Upper Columbia salmon and steelhead mitigation programs. The draft plan will be distributed to the Hatchery Committees for review and discussion no later than December 1, 2012 (Item IV-A).

STATEMENT OF AGREEMENT DECISION SUMMARY

- The Statement of Agreement (SOA) for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook was approved by the Wells Hatchery Committees representatives present (Item II-A).

AGREEMENTS

- The Hatchery Committees representatives present agreed to authorize the YN to release approximately 24,000 excess production coho salmon from Winthrop NFH at the Starr Boat Launch (Item IV-B).
- The Hatchery Committees representatives present agreed to the YN proposal to move forward with negotiations with Douglas PUD to use the Chewuch Acclimation Facility for the YN Upper Columbia Coho Reintroduction Program (Item IV-C).

REVIEW ITEMS

- No reports are currently out for review.

FINALIZED REPORTS

- No reports have been finalized since the last Hatchery Committees meeting.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. Tom Scribner added: 1) authorization for a thinning release of coho salmon at Starr Boat Launch; and 2) discussion on using the Chewuch Acclimation Facility for the YN Upper Columbia Coho Reintroduction Program.

The revised draft August 15, 2012 meeting minutes were reviewed. Kristi Geris said all comments and revisions received on the draft meeting minutes were incorporated and there are no outstanding items remaining to be discussed. Kirk Truscott said the CCT has additional revisions to the revised minutes that he will email to Geris to be incorporated into the final meeting minutes; and Keely Murdoch requested a minor text revision to the YN's action item and discussion on engaging Ecology. The Hatchery Committees' members present approved the August 15, 2012 meeting minutes, with CCT's proposed revisions incorporated.

II. Douglas PUD

A. DECISION: SOA for Wells Hatchery Sub-Yearling Summer Chinook Release Date (Tom Kahler)

Tom Kahler said that Douglas PUD is seeking approval from the Hatchery Committees of a draft SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook (Attachment B), which was introduced at the August 2012 Hatchery Committees meeting and then redistributed to the Hatchery Committees by Kristi Geris on September 4, 2012.

Kahler summarized that, historically, the release time for Wells Hatchery subyearling summer Chinook salmon was mid-June; however, releases in June did not produce good numbers of returning adults. A multi-year passive integrated transponder (PIT) tag study to evaluate the relative survival of June versus May subyearling releases indicated that mid-May release groups have smolt-to-adult returns (SARs) 2.75 times those for mid-June release groups. Kahler said that the HCP Hatchery Committees decided in 2009 to shift the release time of future Wells Hatchery sub-yearlings to mid-May; however, this decision was never formalized. He said that Douglas PUD is now developing plans to modernize Wells Hatchery, and because release timing affects water requirements, Douglas PUD needs formal agreement on the release timing. The SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook was approved by the Wells Hatchery Committees representatives present.

III. Chelan PUD

A. Hatchery M&E Update (Josh Murauskas)

Josh Murauskas said the Hatchery M&E Program working group has convened twice, and a third meeting is being scheduled, as distributed to the Hatchery Committees by Kristi Geris on September 5, 2012. Murauskas said the goal is to hold these meeting as often as practical, and he encouraged Hatchery Committees members to participate as time allows. Murauskas recapped that, during the first meeting, the group discussed the strategy for reviewing and revising the Hatchery M&E Plans; and during the second meeting, the group agreed that the starting point would be evaluation of the current analytical framework and existing objectives to determine what modification may be needed. Murauskas noted that adult management has been a key topic, and in particular, how to incorporate it into M&E objectives.

Mike Schiewe reminded the group that the Hatchery Committees agreed to implement the fully revised M&E programs beginning in 2014, and the existing Hatchery M&E Programs, with minor revisions, in 2013. He added that minor revisions to the existing plans will be reflected in the 2013 Hatchery M&E Work Plans. Chelan PUD and Douglas PUD agreed to present their draft 2013 Hatchery M&E Work Plans to the Hatchery Committees no later than the November 21, 2012 Hatchery Committees meeting.

B. Rocky Reach Spring Chinook Salmon Production (Josh Murauskas)

Josh Murauskas presented a handout outlining several potential options for rearing Rocky Reach no net impact (NNI) spring Chinook salmon mitigation in the Upper Columbia (Attachment C), which Kristi Geris distributed to the Hatchery Committees on September 4, 2012. Alternatives to the existing arrangement are necessary because Chelan PUD terminated the existing sharing agreement between Chelan PUD and Douglas PUD, and a new agreement has not been established. Accordingly, he said Chelan PUD wants to begin obtaining feedback on options from the Hatchery Committees. Murauskas said some of the possibilities mentioned so far included rearing at Winthrop NFH, rearing in distributed acclimation ponds, and rearing at the new Chief Joseph Hatchery. Murauskas added that the last possible date for a decision is April 2013, in order to meet the deadline for the Hatchery Committees to review and for WDFW to submit a broodstock collection plan to the National Marine Fisheries Service (NMFS).

Tom Scribner asked if Chelan PUD has a backup plan while options are explored. Murauskas said one possibility was to rear fish at Chiwawa. Scribner asked if Chelan PUD could rear fish at Eastbank Hatchery. Mike Tonseth said that capacity exists at Eastbank for early rearing and holding adults. Bill Gale reminded the Committees that Chelan PUD has an obligation to produce fish for release above Rocky Reach. He said the two options include release in the Okanogan and Methow rivers, both of which require broodstock collection at Wells Dam or above. Gale said that even if Chelan PUD goes elsewhere for rearing, broodstock will still need to be collected at or above Wells Dam, with current options being Wells Dam or a Methow River facility.

Scribner asked if the PUDs had discussed an arrangement where individual steps in production (i.e., broodstock collection, spawning, early rearing, etc.) could be accomplished at the Methow Hatchery. Alene Underwood said that the discussions so far did not include any such options. Tom Kahler added that Douglas PUD has made offers to Chelan PUD and Grant PUD that would require all three PUDs to pay their proportion of overall hatchery capital, M&E, and operation costs; individual components of the program were not split out, and doing so would complicate an otherwise straightforward offer.

Tonseth noted that even if the spring Chinook salmon were reared at Eastbank, adult collection and overwinter acclimation would need to be resolved. Scribner asked if overwinter acclimation could be accomplished at Carlton, and Underwood said that Chelan PUD's portion at Carlton Facility is not currently suitable for overwinter rearing. Gale suggested that if Chelan PUD and Douglas PUD cannot come to agreement about using the Methow Hatchery, then rearing at Carlton would be Chelan PUD's most viable option. Tonseth did not dismiss the possibility of acclimating Carlton-reared fish in the upper basin YN facilities; however, he said that WDFW will find it difficult to support long-term rearing at Carlton because it is too low in the basin, and there is no way to manage proportion of hatchery-origin spawners (pHOS). Gale said he would prefer Carlton over Eastbank.

Scribner asked when Chelan PUD needs a Hatchery Committees recommendation on broodstock collection and spawning. Murauskas said that, at this point, Chelan PUD needs to look into the question of a limited use agreement at Methow Hatchery. He said that Chelan

PUD will contact Douglas PUD to discuss an agreement that supports only selected aspects of Chelan PUD's Methow spring Chinook salmon production.

Responding to a question about the potential for moving the program to Winthrop NFH, Gale said that he did not consider that a good option as the broodstock would have to be held separately, and there was currently not enough rearing space to take 60,000 to full term. He said more rearing space could become available if one of the existing programs was reduced; however, he doubted that USFWS would reduce a U.S. Bureau of Reclamation-funded program to accommodate Chelan PUD production. Gale said another possibility might be to add rearing space, but he was not sure enough water was available. Gale agreed to discuss these options with USFWS hatchery staff. Tonseth noted that the Committees should also consider the differences in SARs at the Methow and Winthrop NFH facilities; the SARs at the two facilities have been 0.234 and 0.134, respectively.

Kirk Truscott said he had discussed options for production at Chief Joseph Hatchery (CJH) with Chelan PUD staff, but the Biological Opinion (BiOp) issued for CJH did not include rearing Endangered Species Act (ESA)-listed salmon and CCT was not willing to reinitiate consultation. Further, Truscott expressed concern that if Methow spring Chinook were reared at CJH until spring acclimation in the Methow Basin, rearing at CJH would consist of water sources above the confluence of the Methow River and unacceptable straying to areas above the Methow would be likely.

Mike Schiewe said that all parties need to continue exploring options, including interim arrangements that maintain production until a permanent solution can be found. Tonseth said that, at a minimum, Chelan PUD needs to figure out where to get broodstock; and he added that both options appear to be at Douglas PUD facilities.

C. Dryden Update (Alene Underwood)

Alene Underwood distributed to the Hatchery Committees the draft 2012 Wastewater Quality Analysis for Dryden and Chelan Falls (Attachment D), and the draft 2013 Dryden Acclimation Wastewater Sampling Plan (Attachment E). She said she will provide electronic versions of the draft documents to Kristi Geris for distribution to the Hatchery Committees.

Underwood provided a quick summary of the two draft documents. Bill Gale noted that Leavenworth NFH would not be operating the pilot program in 2013 as proposed in Attachment E. Underwood said she will revise Attachment E prior to distribution to the Hatchery Committees. She requested comments on the draft documents prior to the October 17, 2012 Hatchery Committees meeting. Underwood added that sampling is not planned to begin until March 2013, so there will be plenty of time to adjust the sampling plan, if needed.

Tom Scribner asked about the spike in Figure 1 of Attachment D. Mike Tonseth suggested including river discharge in Figure 1, which might suggest that a freshet contributed to the pulse (spike). Scribner asked if the recommendations outlined in Section IV of Attachment D have been modeled to determine if phosphorus concentrations would meet the TMDL. Underwood said that Grant PUD's consultant is running the models, and at this point, Chelan PUD is focusing on collecting the empirical data. Todd Pearsons added that key differences in model results depend on what standards are used for incoming phosphorus. He said Grant PUD's consultant discussed this with Ecology, and determined this is still an assumption.

Gale asked about the status of the Hatchery Committees forming a working group to engage Ecology in discussion to ensure they understand the importance to the fisheries parties of the hatchery programs on the Wenatchee River. Keely Murdoch said that the Committees discussed Scribner taking the lead on this effort. Scribner agreed to this role, and said he could contact Ecology with the data collected so far, and let Ecology know there will be more data to come. Mike Schiewe added that the group should also inquire as to whether there is something additional Ecology needs.

Scribner said he would like to convene an initial meeting in the near future. Gale said he is not directly involved in the TMDL, and that Dave Irving is the USFWS lead. Underwood said that Chelan PUD's wastewater staff likely will also want to be kept in the loop. The Hatchery Committees agreed that Geris will coordinate with Scribner to set up an initial call convening a working group for engaging Ecology in a discussion on efforts to meet the Wenatchee River phosphorus TMDL. The workgroup will include Scribner representing the YN; Gale and Irving representing USFWS; Underwood representing Chelan PUD; Tonseth representing WDFW; and Todd Pearsons and Ross Hendrick representing Grant PUD.

D. Brood Collection Feasibility Update (Josh Murauskas)

Josh Murauskas said that Chris Moran (WDFW) recently had collected several summer Chinook salmon from a holding pool at the Eastbank outfall, some of which were of Dryden origin. On August 28, 2012, he collected 56 Chinook salmon, including 53 with coded wire tags. On September 11, 2012, 74 Chinook salmon were collected and snouts taken; coded wire tags were pulled from 21 of these fish. Moran said he also investigated collecting fish in the area around the Chelan Falls powerhouse, but that area was less ideal. Moran suggested, based on his findings so far, moving forward with developing the Eastbank outfall as a broodstock collection site.

Mike Tonseth suggested the option of constructing a trap at the outfall site, indicating that such an option would make it easier to acquire broodstock for the Chelan Falls Hatchery program, rather than seining or hook and line. He also noted that Eastbank Hatchery had not been constructed with a hatchery return rack because it is a central facility; and he added that there may also be a biological benefit to constructing a trap in the outfall. He suggested that if spring Chinook salmon also gather near the outfall, it might be possible to collect broodstock and manage strays.

Mike Schiewe asked what other methods for capturing broodstock were explored. Tonseth said the necessary equipment and permits still need to be obtained before testing other methods. He added that he had already confirmed with National Oceanic and Atmospheric Administration (NOAA) that their current activities at the outfall are consistent with existing ESA permits. Alene Underwood noted that if Chelan PUD decides to install a trap, it would require discussions with their permitting staff, and Chelan PUD would want to first seek the full Hatchery Committees' input. Murauskas said he will update the Committees as broodstock collection efforts continue.

IV. Yakama Nation

A. Multi-Species/Expanded Acclimation (Tom Scribner)

Tom Scribner said that the YN remains interested in developing a long-term multi-species/ acclimation plan for Upper Columbia salmon mitigation programs. He said that the plan would focus mainly on steelhead and Chinook salmon, but also include coho salmon. He added that the YN has data on juvenile rearing and releases to support the planning process. Scribner proposed that the YN develop a draft conceptual plan to present to the Hatchery Committees. Keely Murdoch suggested also involving WDFW in developing the plan; Bill Gale indicated that he would like to participate as well.

Kirk Truscott said that reluctance on the part of the Hatchery Committees to develop such a plan was not a matter of disinterest; rather, there are differences of opinion on some of the technical aspects and information presented to date. Mike Schiewe added that some Committees members were concerned that, because the size of most hatchery programs has just been reduced, waiting for the smaller programs to operate for a few years before developing a plan would be important. Schiewe said that the Hatchery Committees are open to the concept, but the best path forward needs to be established.

Bill Gale said that USFWS is open to discussion of new acclimation opportunities; however, they are currently in the process of ESA consultations, and are somewhat restricted in what decisions can be made until they know the results of the consultation. Mike Tonseth suggested developing a conceptual plan with mechanisms that indicate alternative options in the event that one option is not viable.

Gale asked if the YN would consider focusing on the Wenatchee River first, and then address the Methow River. Scribner said he would like to develop a conceptual plan for the entire Upper Columbia. Tom Kahler said that Douglas PUD has concerns about their ability to obtain the needed broodstock if fish are dispersed. Scribner said the YN does not have significant capital investments at these sites, so there is flexibility to make changes if problems such as collecting broodstock are encountered. He said the YN would like to have plans for steelhead and spring Chinook salmon completed in time for 2014 releases. Tonseth added that, in terms of marking, planning would need to be finalized by March 2013. Tonseth agreed to work with the YN to development a draft plan and identify data gaps. Murdoch said that it will be challenging to incorporate adult management in a conceptual plan without having certain data.

Murdoch, Tonseth, and Gale agreed to work together to develop a draft conceptual plan outlining multi-species acclimation options for Upper Columbia salmon and steelhead mitigation programs. The draft plan will be distributed to the Hatchery Committees for review and discussion no later than December 1, 2012

B. Authorization for a Thinning Release of Coho Salmon at Starr Boat Launch (Tom Scribner)

Tom Scribner said the YN has drafted a letter requesting authorization from NMFS to release approximately 24,000 excess production coho salmon from Winthrop NFH at Starr Boat Launch, located on the Columbia River upstream of Wells Dam. Scribner said that Craig Busack requested that Scribner share the request with the Hatchery Committees to obtain their concurrence. Scribner added that the proposed release of 24,000 is from a total of 250,000 coho salmon that are currently being reared at Winthrop NFH; all fish are coded wire tagged; and the release would be consistent with the current ESA permit. The Hatchery Committees representatives present concurred with the authorization for the release of excess production coho salmon at Starr Boat Launch.

C. Chewuch Acclimation Facility (Tom Scribner)

Tom Scribner said the YN and Douglas PUD have had initial discussions regarding the use of the Chewuch Acclimation Facility for the YN Upper Columbia Coho Reintroduction Program. He added that the YN now has a record of decision (ROD) from the Bonneville Power Administration to implement their long-term plan. Scribner said that, given the recent NNI recalculation, the size of the spring Chinook salmon program has been significantly reduced in the Chewuch River. This change creates an opportunity to co-mingle and acclimate coho and spring Chinook salmon in the existing Chewuch Facility. Scribner said the YN is proposing to acclimate approximately 100,000 coho salmon at the facility; and he added that the YN is also considering acclimating approximately 150,000 coho salmon at Eightmile Creek Acclimation Ponds. Keely Murdoch said that all 250,000 coho salmon are planned for release in the Chewuch River in 2013.

Mike Tonseth said that, as long as spring Chinook salmon acclimation is not adversely affected, then WDFW had no issues with the proposal. Scribner said that the YN has experience with co-mingled acclimation of spring Chinook and coho salmon in the back-channel at Winthrop NFH, and no negative interactions were observed. Tonseth requested further that there be an agreement to suspend co-acclimation if negative interactions are observed, to which Scribner agreed. The Hatchery Committees representatives present agreed to the YN's proposal to move forward with negotiations with Douglas PUD to use the Chewuch Acclimation Facility for the YN Upper Columbia Coho Reintroduction Program.

V. USFWS

A. Biological Opinion Update (Bill Gale)

Bill Gale said that USFWS and NOAA are close to finalizing the Entiat River BiOp. He added that the Leavenworth BiOp is also very close to being finalized. Mike Tonseth said WDFW expects a draft Wenatchee River BiOp from NMFS by the end of this month. He added that terms and conditions will largely be the same as those in the existing BiOp, with a few new terms and conditions incorporated.

VI. HCP Administration

A. Next Meetings

Mike Schiewe said that the "Future of Our Salmon" Conference scheduled for October conflicts with the Hatchery Committees' October 17, 2012 meeting date, and a request has been made to consider rescheduling the Hatchery Committees meeting to accommodate participation at the conference. The Hatchery Committees representatives did not support rescheduling the October meeting; therefore, the next Hatchery Committees meeting will be held as scheduled.

The next scheduled Hatchery Committees meetings are on October 17, 2012 (Chelan PUD office); November 21, 2012 (Douglas PUD office); and December 19, 2012 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – Draft SOA for the Timing of Release of Wells Hatchery Sub-Yearling Summer Chinook
Attachment C – Options for spring Chinook salmon mitigation above Rocky Reach handout
Attachment D – Draft 2012 Wastewater Quality Analysis for Dryden and Chelan Falls
Attachment E – Draft 2013 Dryden Acclimation Wastewater Sampling Plan

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Alene Underwood*	Chelan PUD
Tom Kahler*	Douglas PUD
Todd Pearsons	Grant PUD
Kirk Truscott*	Colville Confederated Tribes
Tom Scribner*	Yakama Nation
Keely Murdoch*	Yakama Nation
Bill Gale*	U.S. Fish and Wildlife Service
Mike Tonseth*	Washington Department of Fish and Wildlife
Chris Moran†	Washington Department of Fish and Wildlife

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone

Draft 8-13-2012

Wells HCP Hatchery Committee

Statement of Agreement

Timing of release of Wells Hatchery Sub-Yearling Summer Chinook

Approved on XX September 2012

Statement

The Wells HCP Hatchery Committee approves the timing of release for the 484,000 sub-yearling summer Chinook inundation compensation program that takes place annually from the Wells Hatchery. The new release timing for this program will be on or around May 15th of each calendar year.

Background

The Wells HCP requires Douglas PUD to release 484,000 sub-yearling summer Chinook as Fixed Hatchery Compensation – Inundation (Wells HCP; Section 8.4.6). A recent study tested the management strategy of releasing Wells Hatchery subyearling summer Chinook (sub-yearlings) in mid-May (range May 11-18) instead of in mid-June (range June 13-14) , as had been used at Wells Hatchery for many years.

Beginning in 2004, the Wells Hatchery subyearling release was split into May and June release groups and tracked with CWT and PIT tags. The results of this study found that the May release group arrived at McNary Dam approximately 15 days earlier and had 2.75 times the smolt to adult returns (SAR) as the June release group (2004-2007 release years, each year the early release group had a statistically higher SAR). Based on the results of the first three years of the study, in 2008 the HCP Hatchery Committee decided to shift the release timing of all future Wells Hatchery sub-yearlings to the middle of May starting with the 2009 release group.

This SOA is intended to formalize the decision that was made by the HCP HC in 2008. This change in release timing is expected to more than double the number of adult Chinook returning from this component of the summer Chinook inundation compensation program.

Attachment C

DRAFT FOR DISCUSSION PURPOSES ONLY

Spring Chinook Mitigation above Rocky Reach

Discussion Item for the Rocky Reach Hatchery Committee; September 19th, 2012

The Rocky Reach Hatchery Committee must consider options to fulfill the production requirement of 60,516 smolts beginning with the 2015 release [note that a Statement of Agreement is currently in place to fulfill this obligation at Chiwawa Ponds for the 2014 release]. The following options are submitted for discussion at the September 19th meeting. Hatchery Committee members are encouraged to propose additional options.

Table 1. Potential options for spring Chinook production above Rocky Reach Dam, 2015-2023.

Location	Timeline	Notes
Chief Joseph Hatchery	Immediately	Increase funding to include NNI production
Chiwawa Hatchery	Immediately	Continue 2014 arrangement at Chiwawa
Winthrop Hatchery	Immediately	Provide funding to include NNI production
Carlton Pond	> 2016	Facility modifications, permits, and brood collected needed

Wastewater Quality Analysis for Dryden and Chelan Falls 2012 DRAFT

I. Purpose

The purpose of the 2012 water quality analysis was to document the effect summer Chinook rearing and acclimation has on surface water discharges. Two locations, Dryden Pond and Chelan Falls Rearing Ponds, were tested for influent and effluent water quality. The data create information to guide the District and stakeholders to make decisions about ongoing facility use, future management, and infrastructure development. The data also create an understanding how facility operations (specifically feeding and cleaning) affects effluent water quality.

Background

A. Wenatchee Watershed Water Quality

The Washington Department of Ecology (DOE) issued *Addendum to Wenatchee River Watershed dissolved Oxygen and pH Total Maximum Daily Load, WRIA 45* in March 2012. The addendum communicates a Waste Load Allocation (WLA) according to Table 1.

Table 1
Waste Load Allocation
Total Phosphorous Measurement

Dryden Flow	Total Phosphorous Concentration	Total Phosphorous Load	Total Phosphorous Load
CFS	ug/l	grams/day	lbs/day
33	9.2	743	1.638
17	16.1	670	1.477
8	32.0	626	1.380
4	62.3	610	1.345
2	122.8	601	1.325
1	243.6	596	1.314

The Addendum did not state when the WLA would become effective. It is understood the timeframe to implement the Wenatchee Watershed TMDL is 2018.

B. Production Changes and Overwintering

Recent agreements in the Habitat Conservation Plan Hatchery Committee resulted in a reduction to the Wenatchee River summer Chinook program. Old and new facility acclimation criteria are as shown in Table 2. New criteria will become effective for the 2012 brood year. One future change dependent upon multiple parameters is the time fish are reared in the Dryden Pond. Grant

PUD is considering how to modify the facility to rear Chinook from November to May each season while current methods rear fish from late February until release (generally around May 1). In many years fish transfer is limited by water temperature differences and snow and ice in the Dryden Facility. This was the case with the 2009 and 2010 brood year's acclimation periods. Fish were on station each year for five or six weeks (late March to mid April).

Table 2
Dryden Pond Rearing Conditions

Rearing Criteria	Existing Conditions	Future Conditions
Fish Quantity	864,000	500,000
Fish size	10 fish/lb	10 fish/lb
Flow Index	1.0 gpm/lb-inch	
Density Index	0.125 lb/cf-inch	
Peak Flow Required	31.5 cfs	15.3 cfs[1]
Peak Volume Required	113,000 cf	55,000 cf[1]

1 This assumes 13fish/lb (only implemented under overwintering scenarios); flow and volume calculations are also needed for 10 fish/lb

C. GPUD 2011 Sampling

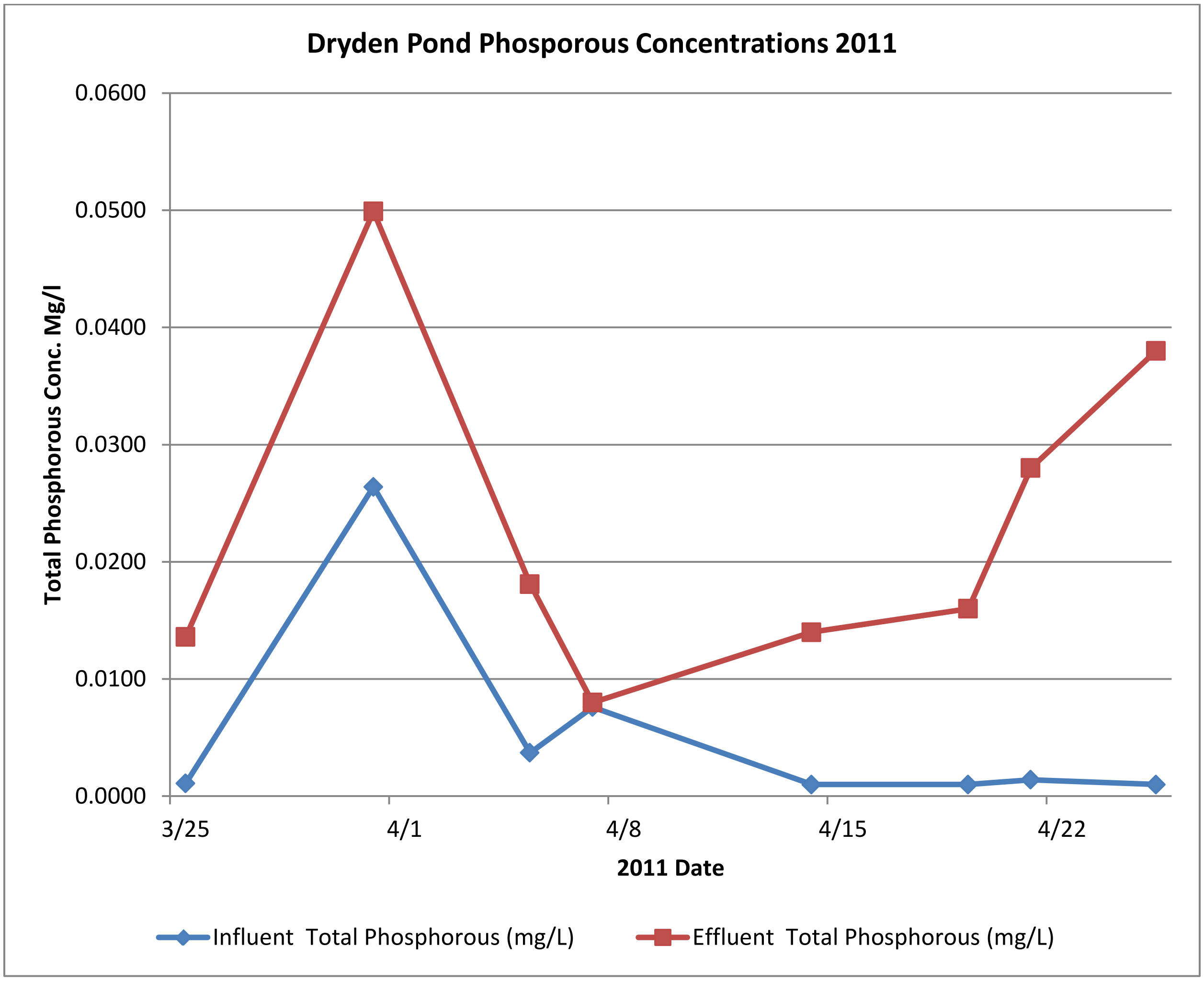
During the 2011 Acclimation Period (2009 brood year) Grant PUD sampled water quality at multiple locations upstream and downstream of the facility. Grant PUD sought to quantify the pond's effect on the river through testing water quality before and after discharge. Also Grant PUD sampled pond influent and effluent to characterize the ponds waste load. Samples were collected once per week during mid day. The sampling included Total and Ortho Phosphorous, inorganic chemicals, and Total Dissolved Solids. Grant PUD data are included in Appendix 2. Influent and effluent Dryden Pond Phosphorous data are summarized in Table 3 and Figure 1.

Table 3
2011 Dryden Influent and Effluent
Phosphorous Concentrations and Discharge Load

Date	Time	Influent		Effluent	
		Total Phosphorous (mg/L)	Ortho Phosphorous (mg/L)	Total Phosphorous (mg/L)	Ortho Phosphorous (mg/L)
3/25/2011	12:00 PM	0.0011	0.002	0.0136	0.003
3/31/2011	3:00 PM	0.0264	0.007	0.0499	0.029
4/5/2011	1:00 PM	0.0037	< 0.001	0.0181	0.015
4/7/2011	10:30 AM	0.0076	0.014	0.0080	0.005
4/14/2011	10:15 AM	0.001[1]	0.006	0.0140	0.006
4/19/2011	12:00 PM	0.001[1]	0.001[1]	0.0160	0.006
4/21/2011	10:00 AM	0.0014	0.001[1]	0.0280	0.013
4/25/2011	1:30 PM	0.0010	0.001	0.0380	0.008

1. Below the 0.001detection limit concentration

Figure 1



II. Water Quality Sampling 2012

A. Dryden

1. Methods

The 2012 (2010 brood year) testing characterized water entering and leaving the pond with correlation to feeding and maintenance operations. Samples were collected once per week while fish were on station. Also, two sets of hourly samples were collected for a 24 hour continuous period. Hourly tests were performed to better understand the effect feeding and maintenance has on effluent water quality.

A number of influences affected Dryden Pond fish rearing during 2012. The acclimation period was again reduced in 2012 due to inclement weather and large water temperature difference between Eastbank and Dryden. Throughout the acclimation period Chinook were at times not fed to allow formalin treatment for Saprolignia. An epidemic evolved among the Chinook causing fish loss. Roughly 793,000 fish were released and 30,000 fish died while in the Dryden pond.

Water samples were tested for TSS, BOD, Total and Dissolved Phosphorous at the pond entrance and exit. The District observed low phosphorous concentrations at times and altered the phosphorous tests to more accurately record dilute concentrations.

2. Sample Data Results

Phosphorous test results and the corresponding daily pounds of phosphorous discharged into the Wenatchee River are recorded in Table 3 and displayed in Figures 2 through 4. Flow into the pond was set by positioning valves and flow control gates. Pond flow the first week was 9,950 gpm. The remaining period flow was set to 15,800 gpm. The lower flow April 3, 3012 may have caused high total phosphorous concentration observed April 3, 2012. Multiple formalin treatments and not feeding fish also may contribute to inconsistent trends among the test results.

Table 4
2012 Dryden Influent and Effluent
Phosphorous Concentrations and Discharge Load

Date	Time	Influent		Effluent		Difference	Load
		TP (mg/L)	DP (mg/L)	TP (mg/L)	OP (mg/L)	TP (mg/l)	lbs/day
4/3/2012	9:40 AM	0.0120	<0.001	0.0300	0.015	0.0180	3.41
4/10/2012	12:00 PM	0.0090	0.003	0.0230	0.010	0.0140	2.65
4/19/2012	12:40 PM	0.0170	0.004	0.0250	0.019	0.0080	1.51
4/24/2012	8:00 AM	0.0410	< 0.001	0.0640	0.005	0.0230	4.36

Figure 2 data shows effects of feeding fish on total phosphorous discharge. In the late morning April 10, 2012 operators broadcast fed 484 pounds of normal concentration phosphorous feed. Testing detected 20 to 30 Ug/I increase in Total Phosphorous discharge concentrations. Data indicated a slug load event with a typical bell curve concentration distribution over time leading to normal background levels. Concentrations doubled as a result of feed and feces in the pond effluent caused by the feeding event.

Figure 3 data show the effects of pond cleaning on phosphorous discharge. Fish sickness lead to mortality among ponded fish. While sampling April 24, 2012 operators began removing dead fish from the pond floor adjacent to the fluent screens (where they accumulate). The dipping and scraping action stirred depositions from the pond floor and entrained material in the effluent. Total Phosphorous concentrations increased from 0.058 mg/l to 0.112 mg/l as a result of the operator activity. Investigators observed particulate materials in the effluent while sampling. The peak discharge concentration was over ten times greater than the proposed discharge limit.

Figure 2

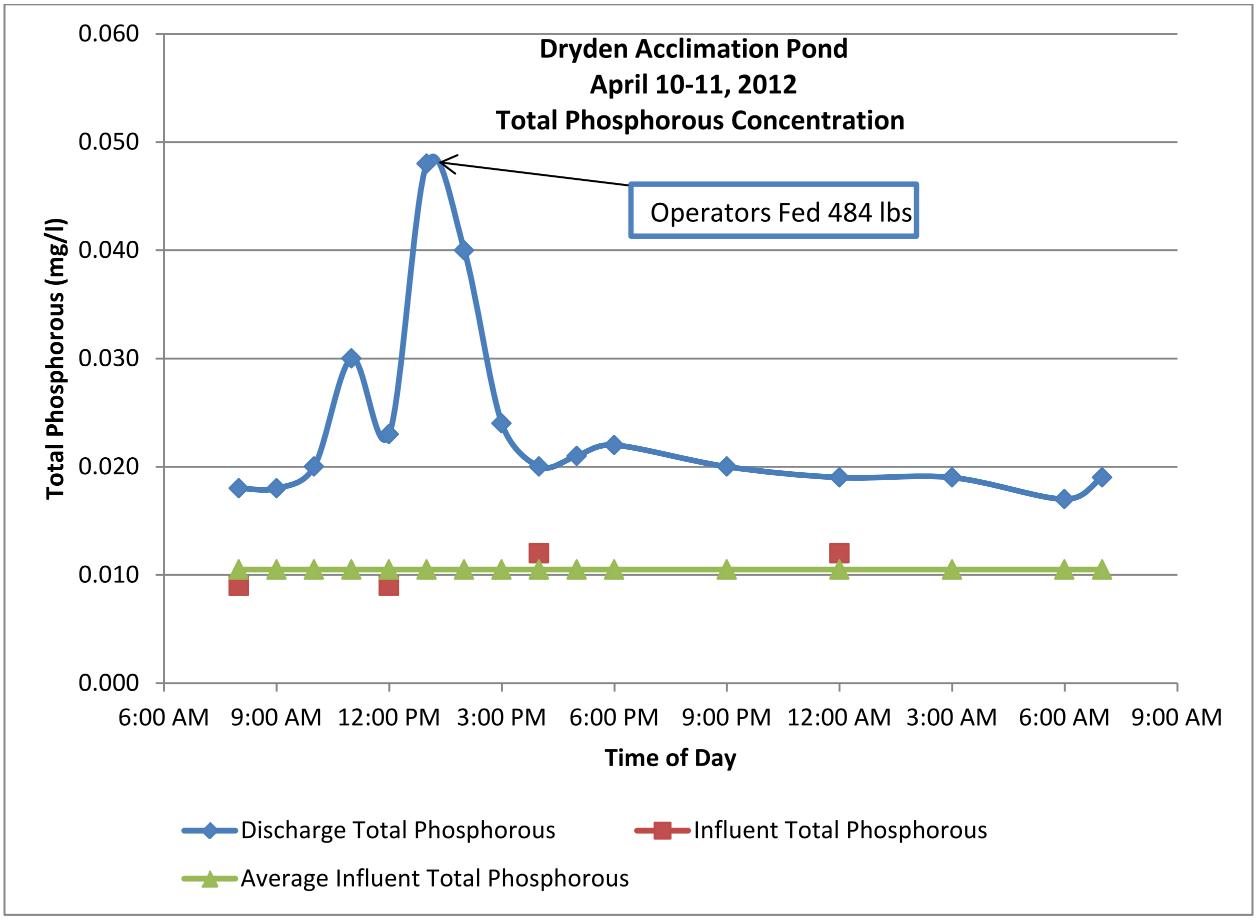

Dryden Acclimation Pond
April 10-11, 2012
Total Phosphorous Concentration
Operators Fed 484 lbs
Total Phosphorous (mg/l)
0.060
0.050
0.040
0.030
0.020
0.010
0.000
6:00 AM
9:00 AM
12:00 PM
3:00 PM
6:00 PM
9:00 PM
12:00 AM
3:00 AM
6:00 AM
9:00 AM
Time of Day
Discharge Total Phosphorous
Influent Total Phosphorous
Average Influent Total Phosphorous

Figure 3

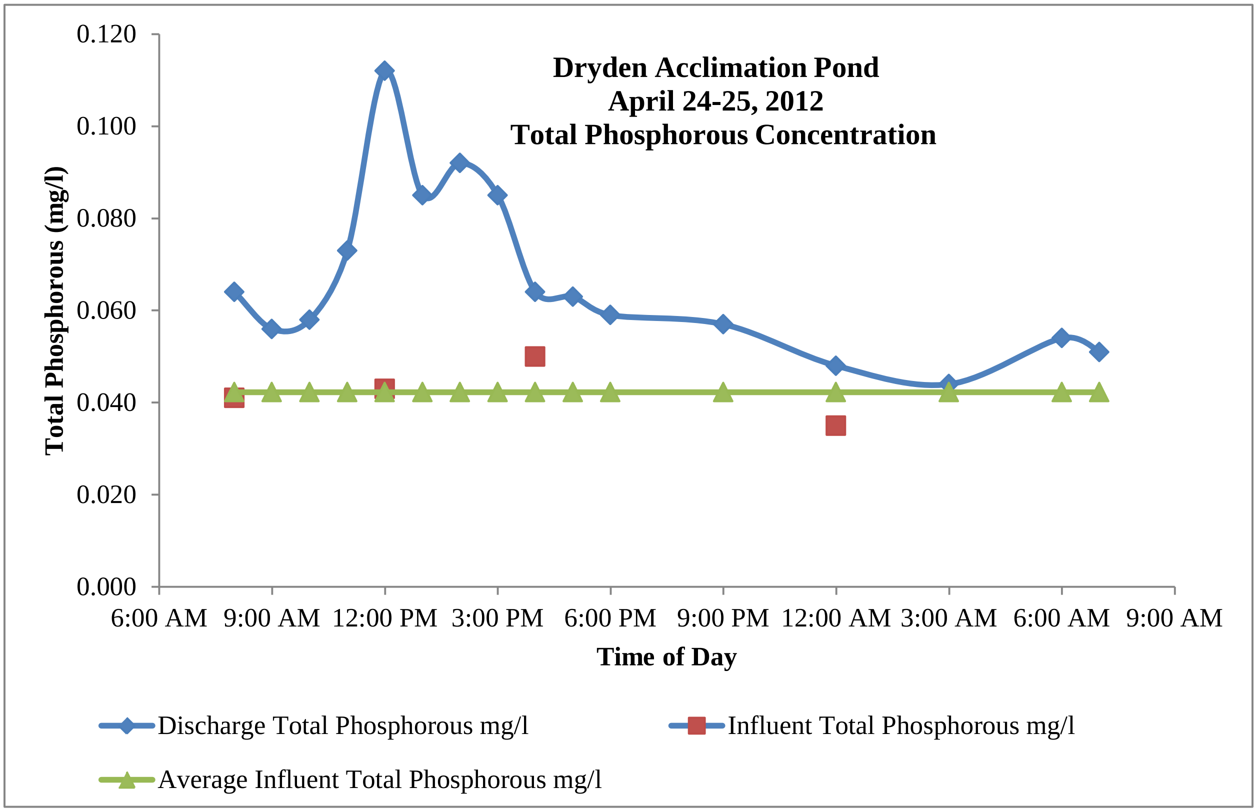
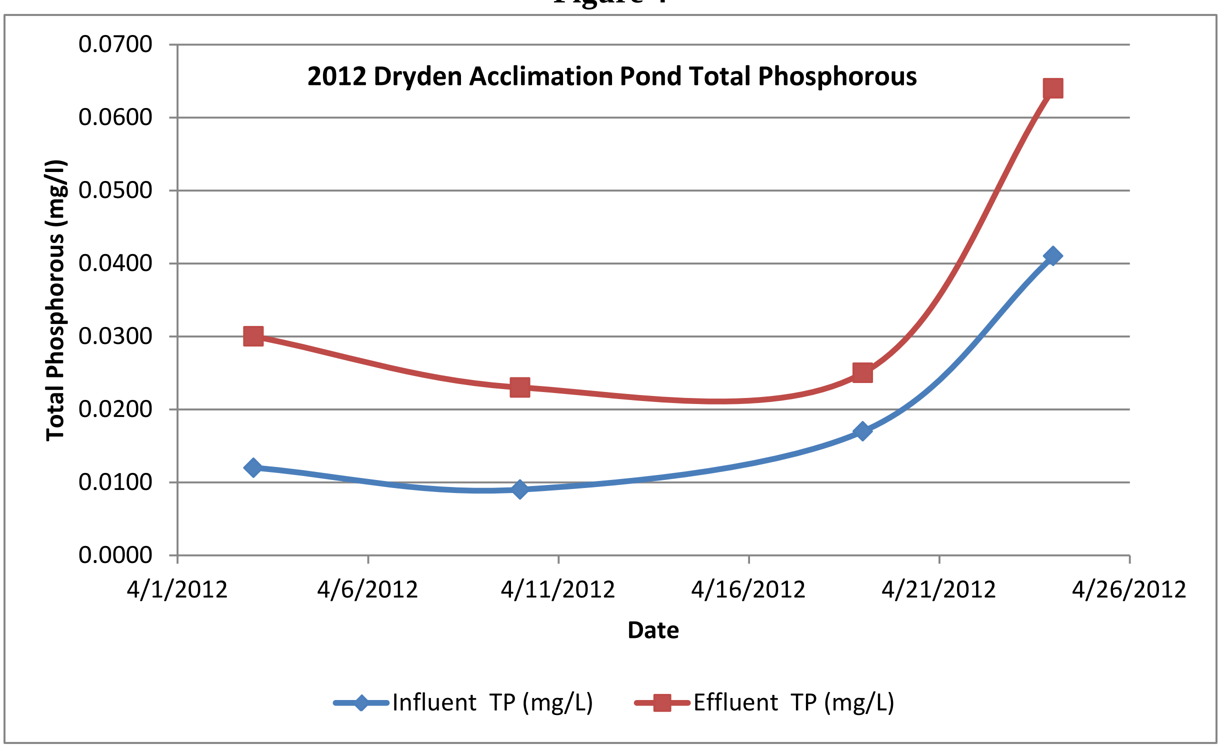


Figure 4



B. Chelan Falls

1. Methods

Chelan Falls Rearing Ponds is a flow through facility that holds summer Chinook from November to late April each year. There are four ponds 45 feet in diameter and 8 feet deep. Tank four held roughly 140,000 summer Chinook during the testing period and received 2,250 gpm of flow. The Cornell dual drain ponds distribute roughly 75 percent of the flow directly to the outfall through a side wall screen. The center drain collects concentrated feces and excess feed into 25 percent of the flow. The center drain flow is routed to a radial flow clarifier (RFC). The clarifier settles solids accumulated at RFC flow are flushed to a waste abatement pond where they are concentrated and hauled off site.

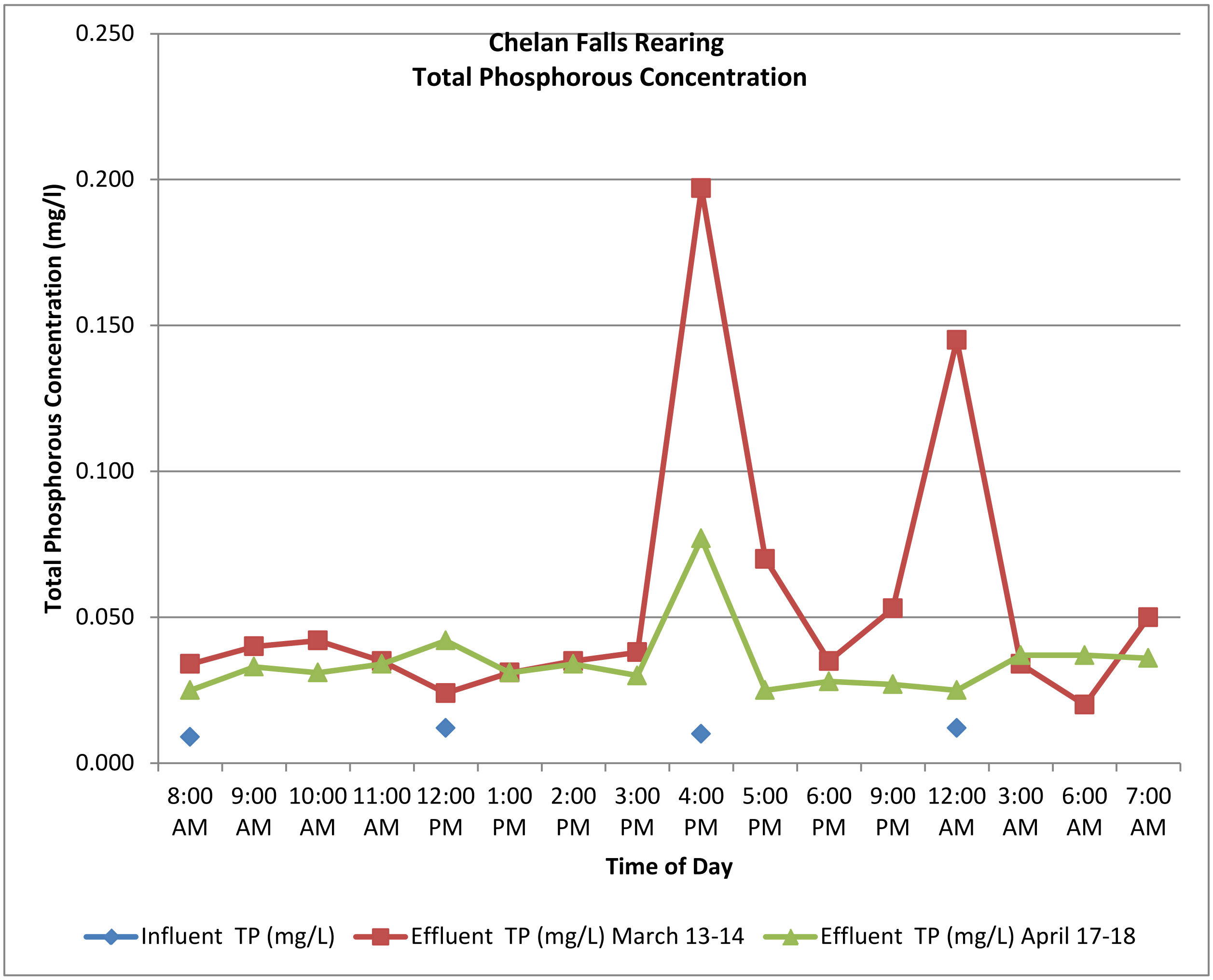
The District sampled water entering pond four and exiting over RFC's weir. The effluent sample is water cleaned by the RFC. The purpose of this sampling is to create data that would help estimate removal capacity of the RFC's.

In designing the Chelan Falls Rearing facility it was estimated that 75 percent of the feces and feed leaves the pond through the center drain and is treated by the FRC. It is estimated 25 percent of the pond waste products leave in the side wall flow.

2. Results

Figure 5 illustrates hourly influent and RFC effluent total phosphorous concentrations in March and April. Data average approximately 20 to 40 ug/l increased phosphorous concentration caused by fish rearing throughout the 24-hour testing with one notable exception. Both sampling events again indicate the effect of fish feed operations. In March fish were fed at 3:45 P.M. and in April fish were fed at 3:20 P.M.

Figure 5



C. Phosphorous Load

Daily load is flow times concentration and as noted above is a DOE TMDL criterion. The influent water contains phosphorous from other anthropogenic sources affecting the watershed. Dryden's influent load was 2 pounds with the exception of the final week when it was 8 pounds. The influent exceeds the 1.6 pound TMDL limit set by DOE for the 33 cfs flow.

Dryden's 779,000 fish rearing activity increases effluent phosphorous load by roughly 2.5 pounds. April 10-11 the effluent load was 4.8 pounds and April 24-25 the load was 12.6 pounds total phosphorous. These loads are three to seven times greater than the TMDL allowable load.

In contrast, roughly 75percent of the waste discharged from Chelan Falls goes through the RFC and amounts to a load ranging from 0.65 to 1.2 pounds total Phosphorous. This load is caused by rearing 560,000 fish. The remaining 25 percent waste load is not treated and was not monitored during 2012. Thus total effluent load cannot be accurately reported or estimated. The 75percent waste capture estimate is based on industry testing of Cornell Dual Drain tanks and is not specific to Chelan Falls.

III. Results

A. Dryden Discharge Compliance with TMDL

Total Phosphorous testing completed in 2011 and 2012 indicate Dryden's load ranges from 2.4 pounds to 12.6 pounds. The future TMDL equates to 1.63 pounds allowable total phosphorous. Dryden fish rearing increases the phosphorous concentration between approximately 0.01 and 0.08 mg/l; considerably greater than the 0.0092 mg/l future TMDL.

Feeding and cleaning affect Dryden's total phosphorous effluent water quality. Large concentrations of phosphorous discharge from the pond after these activities. Similar relationships were observed at Chelan Falls.

IV. Recommendations

A number of alternatives are under consideration to meet future TMDL criteria. It is recommended the most viable of these options be combined and further analyzed. Some alternatives include:

- Rearing fish to a more natural target size
- Feeding fish throughout the week and multiple times per day
- Feeding low phosphorous feed with high settling capabilities
- Continued monitoring of the Dryden Pond water quality to increase the knowledge base
- Compilation of further phosphorous testing data documenting other facility operation using dual drain tanks, automatic feeders, drum filter and abatement pond settling with flow through and water reuse technology

Dryden Acclimation Wastewater Sampling Plan 2013- DRAFT

The goal of 2013 wastewater sampling related to the Dryden Acclimation Facility (Dryden) is twofold. The initial effort is to describe conditions specific to Dryden and are as follows:

1. Create a data set of river water Total Phosphorous at Dryden Acclimation Facility during the period fish may be reared and the TMDL is in effect in the future.
    - Sample upstream of the discharge location weekly from March 1 until fish release
2. Quantify the effects summer Chinook acclimation has on the Wenatchee River Total Phosphorous
    - Sample the canal and pond discharge weekly from March 1 until fish release
3. Quantify the effects feeding and cleaning operations have on Total Phosphorous at Dryden
    - On three occasions, sample each hour for 12 hours followed by samples every 3 hours through the night hour
4. Quantify the effects low phosphorous feed has on discharge Total Phosphorous at Dryden
    - Depending on the biological criteria defined by others, we will sample both weekly and at least one time sample each hour for 12 hours followed by samples every 3 hours through the night hour[1]
5. Quantify the river Total Phosphorous upstream of the acclimation discharge (in the river) and in the canal (current inlet location).
    - This data will be readily available from the above sampling work

The second effort is to refine the District's knowledge of best methods to reduce phosphorous discharge at various rearing facilities/equipment. This work involves testing Chelan Falls Rearing Facility and Eastbank Hatchery. The testing will include the following:

1. Test the effect automatic feeders have on reducing peak total phosphorus discharge from flow-through circular tanks at Chelan Falls. Circular ponds are expected to not result in strong waste discharge caused by cleaning. Automated feeding is thought to lower the amount of uneaten feed left in the tank and to reduce large slug doses of feed and feces in the pond discharge.
    a. Samples will be taken at the influent and radial flow clarifier and sidewall box weekly for the last 12 weeks of rearing at Chelan Falls.
    b. Three times samples will be collected each hour for 12 hours followed by samples every 3 hours through the night hours. These samples will describe the effect automated feeding has on peak discharge concentrations.
2. Test the drum filter at Eastbank Hatchery. The 60 micron drum filter is expected to collect particulate material and dispose it prior to effluent discharge.

[1] This sampling is contingent on low P feed trails at Dryden in 2013.

a. Sampling before and after the drum filter will characterize the drum filters removal capabilities at similar load conditions to the Dryden Acclimation Facility.
b. Samples will be collected before and after the drum filter once per week for 6 weeks.
c. Twice samples will be collected each hour for 12 hours and then every 3 hours through the night to gather information about total removal on a daily basis with intermittent fish feeding operations.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	December 13, 2012
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the November 14, 2012, HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Douglas PUD headquarters in East Wenatchee, Washington, on Wednesday, November 14, 2012, from 9:30 am to 1:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- The Joint Fisheries Parties (JFP) will develop a draft strategy to meet Chelan PUD Methow production goals for discussion at the Hatchery Committees' December meeting. The draft will be distributed to the Hatchery Committees at least 1 week prior to the December meeting (Item IV-D).
- Josh Murauskas will distribute to the Hatchery Committees the draft Chelan PUD 2013 Hatchery Monitoring and Evaluation (M&E) Plan, with changes highlighted from the existing 2012 Chelan PUD M&E Plan (Item V-B).
- Mike Schiewe will coordinate with Kirk Truscott to finalize the Hatchery Committee's December meeting date; which will be scheduled for either December 12, 2012, or for December 19, 2012. The Hatchery Committee's December meeting date will be distributed to the Hatchery Committees once it is finalized (Item VI).

STATEMENT OF AGREEMENT DECISION SUMMARY

- No Statements of Agreement (SOA) were approved at this meeting.

AGREEMENTS

- The Hatchery Committees representatives present agreed to a Chelan PUD request for 3,000 summer/fall Chinook salmon eggs from the Eastbank Hatchery for use in an intra-gravel dissolved oxygen (DO) study at Chelan Falls (Item IV-A).

REVIEW ITEMS

- Kristi Geris sent an email notification to the Hatchery Committees on September 29, 2012, stating that the draft Douglas PUD 2011 Monitoring and Evaluation (M&E) Report is out for a 60-day review period with comments due to Greg Mackey by November 30, 2012.
- Geris sent an email notification to the Hatchery Committees on November 13, 2012, stating that the draft Chelan PUD 2013 M&E Plan, distributed to the Hatchery Committees on November 9, 2012, is out for a 30-day review period with comments due to Josh Murauskas by December 10, 2012.
- Geris sent an email notification to the Hatchery Committees on November 13, 2012, stating that the draft Douglas PUD 2013 M&E Implementation Plan is out for a 30-day review period with comments due to Greg Mackey by December 14, 2012.

FINALIZED REPORTS

- No reports have been finalized since the last Hatchery Committees meeting.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed the Hatchery Committees and reviewed the agenda. The following revisions were requested:

- Josh Murauskas added for Chelan PUD a request for approval of 3,000 summer/fall Chinook salmon eyed eggs for research at Chelan Falls, to be presented by Steve Hays.
- Greg Mackey added for Douglas PUD a notification of a new Wells Hydroelectric Project Federal Energy Regulatory Commission (FERC) License; and he added a brief update on the draft Douglas PUD 2013 M&E Plan.
- Bill Gale added for U.S. Fish and Wildlife Service (USFWS) an update on Methow spring Chinook salmon and steelhead Hatchery and Genetic Management Plans (HGMPs).
- Keely Murdoch added for the Yakama Nation (YN) an update on their steelhead kelt reconditioning program, and requested an update from Chelan PUD on their draft 2013 Hatchery M&E Plan.

The revised draft September 19, 2012, meeting minutes were reviewed. Kristi Geris said there were three edits remaining to be discussed regarding Chelan PUD's agenda item III-B on Rocky Reach spring Chinook salmon production: 1) Tom Kahler suggested incorporating a statement pointing out that the possibility of acclimating Carlton-reared fish in the upper basin YN facilities was not dismissed; 2) Mackey requested that Gale clarify his statement regarding his preference for rearing Chelan PUD Methow spring Chinook salmon production at the Carlton facility rather than Eastbank Hatchery; and 3) Geris noted that she received Kirk Truscott's revisions on November 13, 2012, regarding his concerns about rearing Methow spring Chinook salmon at Chief Joseph Hatchery (CJH). Revisions were discussed and incorporated. Geris said that all other comments and revisions received on the draft meeting minutes were incorporated. The Hatchery Committees' members present approved the September 19, 2012, meeting minutes, as revised. Truscott approved the September 19, 2012, meeting minutes by email.

II. Douglas PUD

A. Wells Hydroelectric Project FERC License (Greg Mackey)

Greg Mackey announced that Douglas PUD had received its new Wells Hydroelectric Project license from FERC. Mackey said that the new license includes numerous terms and conditions that Douglas PUD is currently reviewing. Craig Busack asked if the new license is expected to affect the work of the Hatchery Committees. Steve Hays said that FERC typically is not concerned with the details of an action or plan; rather, they are more interested in tracking compliance. Mackey said that he will keep the Hatchery Committees updated as Douglas PUD learns more.

B. Draft Douglas PUD 2013 M&E Implementation Plan (Greg Mackey)

Greg Mackey said that the draft Douglas PUD 2013 M&E Implementation Plan was distributed to the Hatchery Committees by Kristi Geris on November 13, 2012. He said that the draft plan is out for a 30-day review period with comments requested by December 14, 2012. Mackey said that expedited review was requested because the new contract starts on January 1, 2013. Mike Schiewe reminded the Committees that a 60-day review is the default for all plans, proposals, and studies unless a shorter period is approved by the Committees. Mackey said that the draft Douglas PUD 2013 M&E Plan is essentially the same as last year.

Mackey explained that according to the M&E Conceptual Framework, it was time to begin another round of population genetic analyses. However, he explained that the previously adopted time interval of 5 years is far too short for genetic differentiation to occur, particularly when little-to-no differentiation was detected in the first round of studies with the exception of Twisp spring Chinook. Mackey said that a longer time interval between studies should be considered and that in future years Douglas PUD would recommend that the frequency of genetic stock structure monitoring be reduced to every 10 years, rather than the current 5-year interval. He added that tissue samples are collected each year so that analyses can be run for any given interval. Mackey also noted that the past study reports were difficult to interpret and felt that future reports needed to be written with managers and non-geneticists in mind. Craig Busack agreed that every 10 years would be reasonable. Busack also noted that several previous reports on the genetic structure of upper Columbia salmon populations had been largely driven by software outputs. He said that in the future he would like to see a greater emphasis on explaining the biological significance of the findings.

The Hatchery Committees agreed to an expedited 30-day review.

III. USFWS

A. HGMP Update (Greg Mackey and Bill Gale)

Greg Mackey said that HGMPs have previously been submitted by Douglas PUD and USFWS for Methow steelhead and spring Chinook salmon programs. He said that the National Marine Fisheries Service (NMFS) requested supplemental analyses showing that the programs would meet a proportion hatchery-origin spawners (pHOS) target of 0.25. Mackey said he anticipated that the Douglas PUD analyses for their Wells steelhead and Methow spring salmon programs would be submitted to NMFS by the end of this week (November 16, 2012).

Bill Gale said that revisions are being finalized for the Winthrop steelhead HGMP. He said that a supplemental attachment was developed, and that both will be submitted to NMFS by the end of the week. Gale said that revisions to the spring Chinook salmon HGMP are also being completed, and that a supplemental attachment on adult management will accompany this submittal; NMFS should expect the submittal by the end of next week. Mike Schiewe asked if NMFS will be issuing individual permits or biological opinions (BiOps). Craig Busack said that NMFS would issue individual permits, and only one BiOp for each species. Busack acknowledged that the YN had expressed concern over the proposed pHOS target of 0.25, and that NMFS staff has been working with Steve Parker to resolve concerns. Busack noted that the uncertainty regarding Chelan PUD production of spring Chinook salmon in the Methow would likely delay NMFS issuing a permit for that program.

IV. Chelan PUD

A. Request for summer/fall Chinook salmon eyed eggs for research at Chelan Falls (Steve Hays)

Steve Hays said that last year Chelan PUD requested 2,500 summer/fall Chinook salmon eyed-eggs for egg-to-fry survival studies in the Chelan River. Hays said that the Lake Chelan Hydroelectric Project FERC License requires Chelan PUD to evaluate powerhouse flows needed to maintain intra-gravel DO concentrations in the tailrace to support high egg survival. He summarized that in 2012, Chelan PUD had monitored egg survival in tubes placed in the gravel in selected areas of the tailrace. Preliminary results were 100 percent loss in about 50 percent of the tubes, with most of the mortality occurring just prior to hatch. The timing of this mortality coincided with times when the powerhouse was offline. Hays said that this year, Chelan PUD plans to repeat the intra-gravel DO study again with 3,000 eyed-eggs from Eastbank Hatchery to test a more consistent powerhouse operation. The Hatchery Committees representatives present agreed to the Chelan PUD request for 3,000 summer/fall Chinook salmon eyed eggs from the Eastbank Hatchery, for use in an intra-gravel DO study at Chelan Falls. Hays said that a report on the 2012 studies will be available by the end of February 2013, and a final report will be available by April 2013.

B. 2012 steelhead survival (Josh Murauskas)

Josh Murauskas said that his analyses of the post-release survival rates of Wenatchee steelhead (Attachment B) was distributed to the Hatchery Committees by Kristi Geris on November 14, 2012. Murauskas reviewed recent changes to the Wenatchee steelhead program, including: 1) overwinter acclimation at Chiwawa Ponds; 2) a reduction in program size from 400,000 to 250,000; 3) 100 percent wild-by-wild progeny in 2012; and 4) a volitional release strategy with smaller release groups.

Murauskas reviewed the post-release survival rates of steelhead smolts migrating from the Chiwawa River, Nason Creek, and Wenatchee River in 2006 to 2011, based on passive inductive transponder (PIT)-tag detections at McNary Dam. The results were statistically greater than other steelhead programs in the region. He then compared these results to the performance in 2012 for these same release locations, and noted that the values were unprecedentedly low. Mike Schiewe asked where the release location is on the Wenatchee River, and Murauskas said that the release location is near Leavenworth directly in the Wenatchee River. Bill Gale asked if the survival rates represent all fish, or just those volitionally released. Murauskas said that survival rates represent all fish that were planted, but also noted that the "non-migrants" had comparable survival rates to the "volitional migrants."

Murauskas suggested several potential issues that may be the cause of these low survival rates, including: 1) overwinter acclimation; 2) brood origin; 3) size at release; 4) timing; 5) volitional release; and 6) release number, or number of fish in each release group. Murauskas shared a graph depicting brood origin and survival by year. He noted that the lowest survival was that of wild-by-wild crosses. He noted that these results are confounded by release location; however, they can be sorted by brood origin. Mike Tonseth added that there are also differences in size at release. He said that wild fish tend to spawn later; therefore, they are not at the same size.

Murauskas presented differences in 2012 fish sizes at release: 1) 11 fish per pound (fpp) at Blackbird; 2) 8 fpp at Chiwawa re-use; and 3) 12 fpp at Chiwawa Pond 2. He noted that he did not have data on size at McNary, and that he is unsure how size at McNary would impact results. Gale asked how 2012 sizes compared to past years; and Murauskas said that 2011 sizes were about 7 to 8 fpp. Keely Murdoch added that when the YN received fish for the Rolfing Acclimation Pond, the fish were exceptionally small.

Murauskas reviewed a graph depicting the number of fish per release group and said that when numbers of PIT-tags are plotted against survival to McNary, the results indicate that the more fish per release group, the higher the survival rate. Craig Busack asked if these results could also mean that the study is not accounting properly for detectability. Murauskas said that probability of detection is accounted for in the survival model and he believes these results reflect "safety in numbers," and that proportional predation is the explanation. Greg Mackey observed that the variance in survival was positively correlated with release group size, suggesting that smaller release groups are more limited in their potential for survival, while larger groups have a higher range of potential for survival. Gale asked if transport conditions differed among truckloads, and Tonseth said that if anything, transportation time from rearing to release was reduced in 2012. Tom Kahler asked when the smaller release groups were released. Murauskas said he looked at the timing of release; however, survival was so poor for every release that no statistical significance was found among timing of releases.

Murauskas suggested that the Hatchery Committees reconsider volitional release based on results of this analysis. His analyses of the 2012 releases indicated that there was no survival advantage for the volitionally released fish and suggested that releasing all fish at once appeared to improve survival to McNary Dam. Gale noted that there is limited information on the forced release of steelhead at Chiwawa, and Murdoch noted that the study was limited to 1 year. Tonseth recommended being careful how volitional and forced releases are defined. He added that the poor survival numbers could be due to other factors that have nothing to do with release. Murauskas and Tonseth discussed that it would be informative to also consider 2012 survival of Methow steelhead in the context of their historical average.

Murauskas summarized by saying that Chelan PUD was not seeking the Committees' agreement on the cause of the low post-release survival in 2012; however, they wanted to bring this to the Committees' attention before releasing in 2013. Gale said that a mark and recapture analysis is planned for Winthrop National Fish Hatchery (NFH), which may be executed differently than that in Chelan PUD; Gale said he would coordinate with Murauskas. Tonseth cautioned that there is still key information to be determined, both biotic and abiotic, and added that it needs to be determined whether the problem persists. Murauskas reiterated that the new release approaches implemented in 2012 significantly compromised survival of juvenile steelhead and regardless of the exact cause, the Hatchery Committees should consider reverting back to release techniques with proven success before implementing unproven changes.

C. Summer Chinook salmon brood collection options (Chris Moran)

Chris Moran presented an overview of the Chelan Falls summer Chinook salmon pilot broodstock collection study (Attachment C), that Kristi Geris distributed to the Hatchery Committees on November 15, 2012. He said that the purpose of the study was to: 1) determine if adult summer Chinook salmon could be captured in the vicinity of the Chelan River; 2) determine which stocks are returning to the area; and 3) determine the best methods for capture. Collection methods used included tangle nets, hook and line, and sampling the Eastbank Hatchery outfall (EBO). Moran said that other methods were considered such as beach seines and purse seines; however, logistically, these methods were not feasible.

Moran said that on September 24, 2012, WDFW tested a 60-foot tangle net that was attached to the "no trespassing" float line near the Chelan River powerhouse area, which runs parallel to shore. He said that attaching the net parallel to shore was intended to avoid potentially overloading the net with fish. He said that an additional 100-foot tangle net was set diagonally near the attraction waters of the Chelan Falls Acclimation Facility outfall pipe, from the middle portion of the net pens to a small tree on the opposite bank, on October 3, 2012. On September 21, 2012, hook and line fishing was conducted on the Columbia River between the confluence of the Chelan and Columbia rivers to the Highway 97 Bridge; and the EBO was sampled using pond seines on August 28, 2012; September 11, 2012; and October 3, 2012.

Moran reviewed the results for each sampling method and date. The EBO resulted in the highest number of fish captures, while hook and line and the tangle nets resulted in the lowest captures. Moran said that of the 180 fish captured, 174 were collected from the EBO; and of the 174 fish collected from the EBO, 122 heads were sampled, and 114 coded wire tags (CWTs) were recovered. Fish collected from the EBO were predominantly male and the CWTs indicated that most fish were 4-year-olds from Turtle Rock.

Moran said that, based on these results, recommendations include: 1) discontinue testing collection methods in the vicinity of the Chelan River; and 2) utilize the EBO as a trap location for the Chelan Falls program beginning July 2013. He said that incorporating the EBO as a trap location would also provide added benefits such as: 1) establishing a location to manage returning adults; 2) minimizing stray rates of hatchery fish released from Eastbank

Complex facilities; and 3) enhancing the genetic makeup of a domesticated program by incorporating hatchery strays from programs that utilize wild origin fish for hatchery broodstock.

Josh Murauskas said that Chelan PUD is now looking for feedback regarding long-term use of the EBO as source of broodstock for the Chelan Falls program. He noted that Chelan PUD had also been interested in testing purse seine capture this year; however, Chelan PUD was unable to do testing this year. He also noted that Chelan PUD still needs to internally discuss permitting. Mike Tonseth said that eventually it needs to be determined if it is appropriate to use any type of fish collected at the EBO for Chelan Falls broodstock. Tonseth added that from an Endangered Species Act (ESA) perspective, seining in the mainstem presents potential for take of ESA-listed fish. Keely Murdoch said that she is concerned that so few females were collected from the EBO. She agrees with continuing to move forward; however, she also would like some sort of backup plan to ensure production is met. Tonseth suggested that in 2012, what may have led to high male counts is that females tend to arrive early in the return; therefore, toward the end of the season, there are more males. Tonseth recommended that in 2013, sampling activities be conducted earlier to have the opportunity to intercept females, and that the Wells volunteer channel be used as the "backup plan."

D. Update on Chief Joseph Hatchery and Methow sharing agreements (Josh Murauskas and Joe Miller)

Joe Miller indicated that Chelan PUD had recently met with the Colville Confederated Tribes (CCT) to discuss the terms of a hatchery agreement between the two parties' relating to CJH and Similkameen Acclimation Pond. The meeting was successful and both parties have indicated a desire to complete a final contract in the coming months.

Miller said that executing a new sharing agreement with Douglas PUD for rearing Chelan PUD Methow spring Chinook salmon production did not work out. He added that, regarding concerns about ESA coverage that had been raised earlier in the meeting, coverage is currently provided by Permit 1196 until 2014, as described in the Chelan PUD Methow production update (Attachment D) that was distributed to the Hatchery Committees by Kristi Geris on November 6, 2012. Miller said that the current permit provides adequate time to consider alternative rearing strategies and options, and that when the permit expires in 2014, there should be adequate time to obtain ESA coverage. He reminded the Committees that Chelan PUD's Methow program represents about 10 percent of the overall production of hatchery spring Chinook in the Methow Basin. Miller also suggested that implementing a "conservation" program of this small size should be easier from an ESA perspective than the relatively large USFWS safety-net program simply because conservation fish are ostensibly desirable in the spawning grounds (at some level).

Miller said that Chelan PUD is proposing two options for broodstock collection. Option 1 involves trapping at Rocky Reach Dam and holding at Eastbank Hatchery while Genetic Stock Identification (GSI) is used to determine genetic identity. Miller said that this option will not interfere with the migration of Wenatchee-origin fish, and noted that GSI would eliminate Entiat-origin fish. Option 2 is a parental-based tagging (PBT) approach that involves trapping at Priest Rapids, PIT-tagging, running genetics (GSI via micro-satellite or single nucleotide polymorphism) to determine origin, and then recapture at Rocky Reach. Miller noted that PBT was not successful in the Wenatchee but did show promise for Methow fish because: 1) many of the fish tagged during PBT eventually ascended Wells Dam – suggesting Methow-origin; and 2) during the PBT 'pilot,' ample fish were encountered to meet Chelan PUD's reduced broodstock program (i.e., 35 to 40 broodstock). Miller suggested that the genetic markers needed to differentiate Methow fish were already in use (for sorting spring Chinook at Wells Dam) and did not rely on establishment of a parental genotype baseline, which requires years of sampling. Moreover, the segregation of Entiat-origin fish may be relatively easy because previous work has shown the existence of a strong Carson-stock signal in the population, and this signal makes Entiat-origin fish stand out. Miller suggested that, overall, a geographic based GSI approach would be less complicated than the broodstock identification using PBT, which requires a baseline of parental genotypes. He noted that using Option 2 would eliminate the need to hold the fish while the genetic samples are run. Instead they would be sampled and released at Priest Rapids, and the GSI/tributary assignment would be evaluated while fish are in transit between Priest Rapids and Rocky Reach.

Miller said that the adult holding and rearing option being considered is at Eastbank Hatchery. He said the historical issue at Eastbank Hatchery has been temperature; however, rearing only 65,000 juveniles would not be a problem in the long-term because they would be reared in tributary waters that are cooler (identical to the Chiwawa approach). He said for acclimation, two options are being considered. Option 1 involves spring acclimation at Carlton with early imprinting. Option 2 involves Carlton overwintering plus YN upper basin acclimation. Craig Busack said that he does not like the idea of rearing fish outside of the basin. Bill Gale said he has two concerns: 1) details regarding operations of the Rocky Reach trap, such as how many non-target natural origin fish would be encountered; and 2) details regarding acclimation for release at Carlton. Gale said that USFWS and WDFW have been analyzing Methow production using National Oceanic and Atmospheric Administration (NOAA) guidance of a pHOS target of 0.25; and he said that only works if the program returns a high proportion of the adults to a facility where they can be removed. Gale expressed concern that Chelan PUD would be releasing fish that preclude meeting the 0.25 pHOS target. Keely Murdoch asked if fish can be removed from Wells Dam if needed; Gale responded that Wells Dam removal was possible, but that it was complicated by CJH coming online.

Miller said that he is not aware of any overriding risks posed by these options, and added that Chelan PUD can develop a marking scheme if needed. Gale asked if there is a plan to remove excess adults, and noted that the current Methow HGMP analyses are dependent on the ability to remove excess adults. He added that if marked fish are removed at Wells, it would require an agreement between Douglas PUD and Chelan PUD. Greg Mackey said that it is physically possible to trap as many fish as desired at Wells; however, trapping a large portion of the run would entail handling many non-target fish and would cause passage delays for all species. Therefore, Wells Dam is not suitable as a primary adult management facility.

Tonseth said there are a number of issues that would need to be worked out with what Chelan PUD has proposed, and that he has some additional ideas that he would like to discuss with the JFP. He said the JFP can then evaluate and compare options, and identify any issues before presenting a draft strategy to the Hatchery Committees. The JFP agreed to develop a draft strategy to meet Chelan PUD Methow production goals, for discussion at the Hatchery Committees' December meeting. The JFP will distribute the draft to the Hatchery Committees at least 1 week prior to the December meeting. Gale noted that in terms of consultations, Douglas PUD consultations will have to move forward without the Chelan

PUD Methow production goals piece. Miller agreed, and said that Chelan PUD has no intentions of impeding progress on the HGMP.

V. Yakama Nation

A. Steelhead kelt reconditioning program update (Keely Murdoch)

Keely Murdoch said that last year, the YN built a kelt reconditioning facility on the Methow River at Winthrop National Fish Hatchery. She said that the program started with a small number of fish but now is looking to expand. She said that last week, the YN met with Douglas PUD, USFWS, and WDFW to discuss live spawning Twisp natural origin steelhead. She said that the outcome of the meeting was that they agreed that the only way to move forward is to create an isolation facility for these fish during the Wells modernization. Murdoch said that the YN is pursuing construction of an isolation facility for the progeny of 13 females in order to keep the fish separate until testing for disease can be completed. She said that in moving forward with the design, there will likely be some risks to consider; however, there may not be huge issues with such a small program. Murdoch said that the YN will ultimately need a decision by the Hatchery Committees to move forward, and said that the YN will keep the Hatchery Committees informed as discussions progress.

Greg Mackey added that Douglas PUD asked HDR, Inc., to develop a cost to build an isolation area into the Wells facility for the YN kelt reconditioning program. He said that the fish health staff typically take samples for testing at 30 days after swim up, and it takes an additional 30 days to obtain results; this means that the fish need to be held 60 days in isolation. Mackey noted that Infectious Pancreatic Necrosis Virus (IPNV; among other diseases) is of greatest concern to fish health staff as that disease has been detected in steelhead at Wells Hatchery in the past. Murdoch asked the Hatchery Committees to please share ideas for a temporary isolation location until the Wells Hatchery facility is available.

B. Hatchery M&E Plans update (Keely Murdoch)

Keely Murdoch noted that both Chelan PUD and Douglas PUD draft Hatchery M&E Implementation Plans were distributed, and that comments are due prior to the next Hatchery Committees meeting. She recounted that Douglas PUD already said that there were no changes to their plan from 2012; however, she asked Chelan PUD to highlight changes to their plan from 2012. Josh Murauskas said that he will distribute to the Hatchery Committees the draft Chelan PUD 2013 Hatchery M&E Plan, with changes highlighted from the existing 2012 Chelan PUD M&E Plan.

Murdoch noted that the upper Wenatchee River smolt trap is missing from Chelan PUD's draft plan, and she said that she thought the main purpose for the trap was to obtain sockeye estimates. She added that she thought it was agreed during the recalculation exercise that Chelan PUD would continue to collect sockeye data at that location. She also added that although Chelan PUD does not have that program any longer, the data are still needed. Murauskas said that those activities will continue in 2013; however, he said that the new smolt trap downstream would serve the sockeye purpose as well. Murdoch said that in the past, the new smolt trap downstream had lowered efficiency, and that this outcome justified using the other trap. She added that if the new smolt trap downstream works, it is fine, but that data are needed to confirm that it does. Murauskas said that Chelan PUD is also considering possibly using PIT-tags for long-term data collection for sockeye. Murdoch said that if Chelan PUD is still planning to run the trap in 2013, then this should be included in the 2013 plan. Murauskas agreed and said it would be added. Murauskas pointed out that the analytical framework is still in effect but that it will not be appended to the work plan.

Mike Tonseth said that Chelan PUD's draft 2013 plan is similar to the 2012 plan, with some language changes in terms of sockeye on which the Hatchery Committees will need to come to consensus. He added that there are a few items that are flagged for discussion; however, he did not think they needed to be resolved now.

VI. HCP Administration

A. Next Meetings

Mike Schiewe will coordinate with Kirk Truscott to finalize the Hatchery Committee's December meeting date; and that the date will be scheduled for either December 12, 2012, or December 19, 2012. The Hatchery Committee's December meeting date will be distributed to the Hatchery Committees once it is finalized. **Note: Kristi Geris sent an email notification to the Hatchery Committees on November 16, 2012, stating that the Hatchery Committee's December meeting date has been rescheduled to Wednesday, December 12, 2012.*

The next scheduled Hatchery Committees meetings are on December 12, 2012 (Chelan PUD office), January 16, 2013 (Douglas PUD office), and February 20, 2013 (Chelan PUD office).

List of Attachments

Attachment A – List of Attendees

Attachment B – 2012 Steelhead Survival Presentation

Attachment C – Chelan Falls Summer Chinook Salmon Pilot Study Presentation

Attachment D – Chelan PUD Methow Production Update

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Josh Murauskas*	Chelan PUD
Joe Miller*	Chelan PUD
Steve Hays	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Todd Pearsons	Grant PUD
Keely Murdoch*	Yakama Nation
Craig Busack*†	National Marine Fisheries Service
Bill Gale*	U.S. Fish and Wildlife Service
Mike Tonseth*†	Washington Department of Fish and Wildlife
Chris Moran	Washington Department of Fish and Wildlife
Jayson Wahls	Washington Department of Fish and Wildlife

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone

Survival of Wenatchee River Hatchery Steelhead in 2012

Josh Murauskas

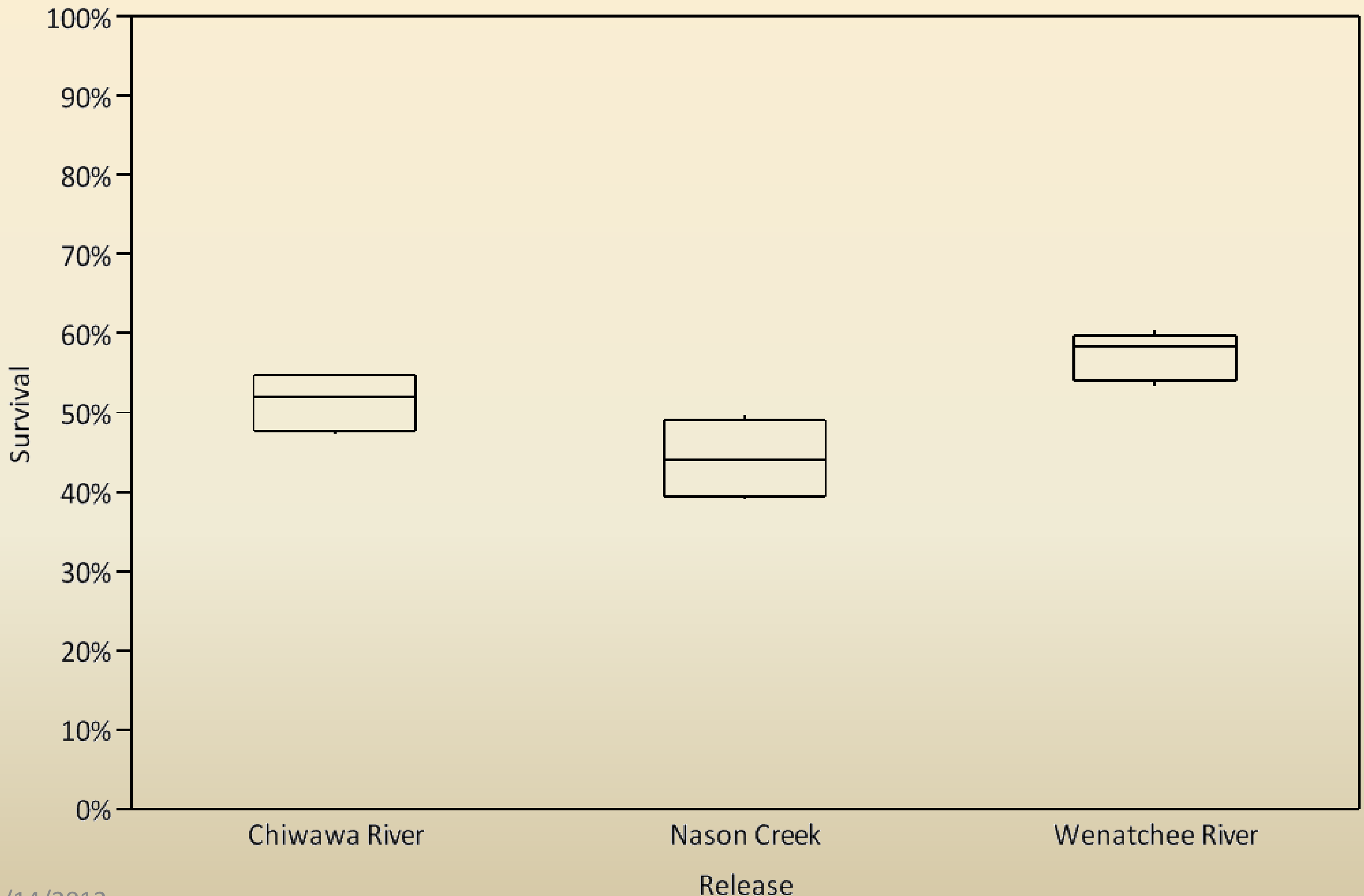
November 14th, 2012

HCP Hatchery Committee

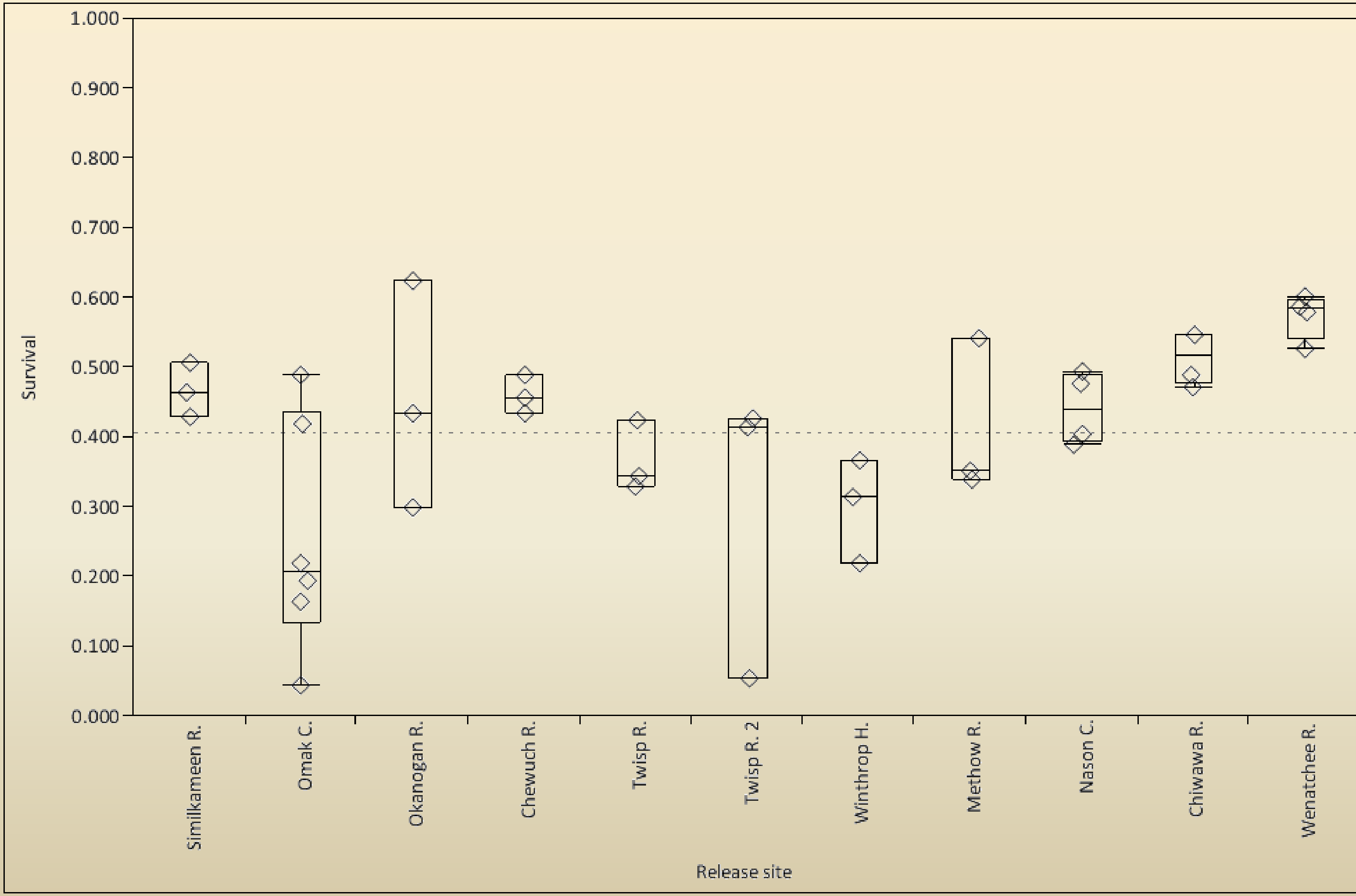
Overview

- Major programmatic changes
  - Overwinter acclimation at Chiwawa Ponds
  - Reduction in program size
  - 100% wild by wild progeny in 2012
  - Volitional release strategy

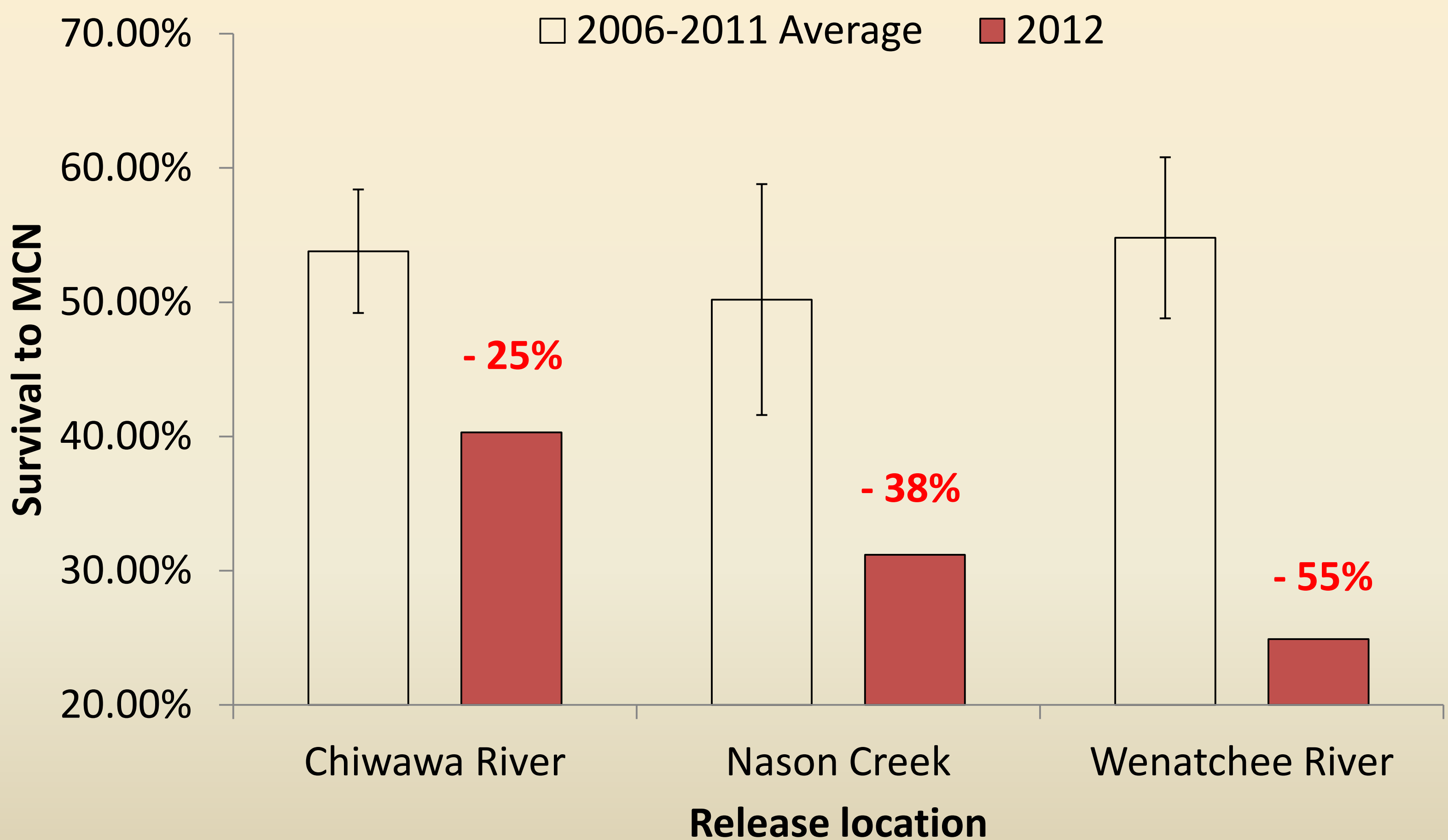
Historical performance



Historical performance



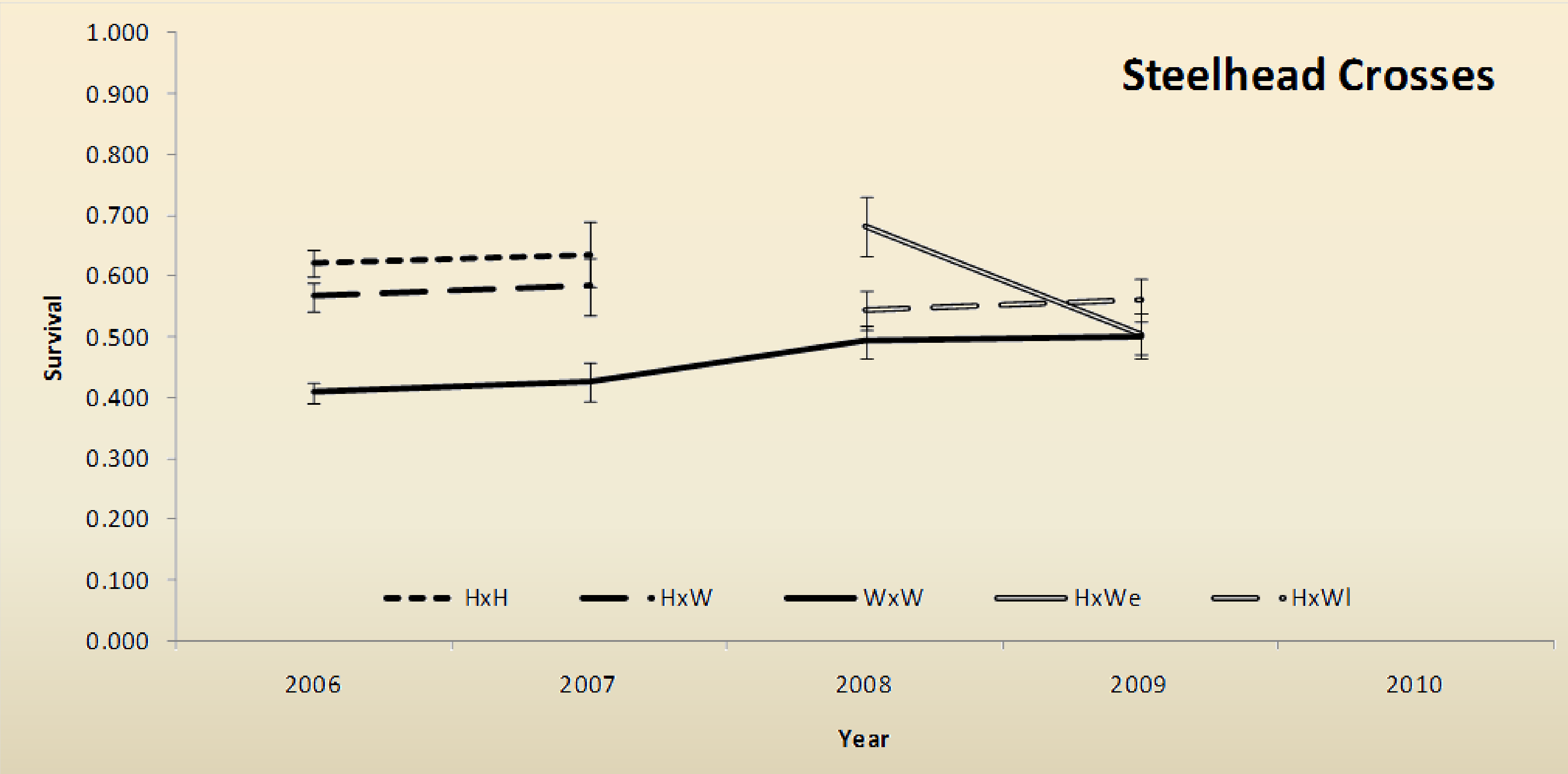
Performance in 2012



Potential issues

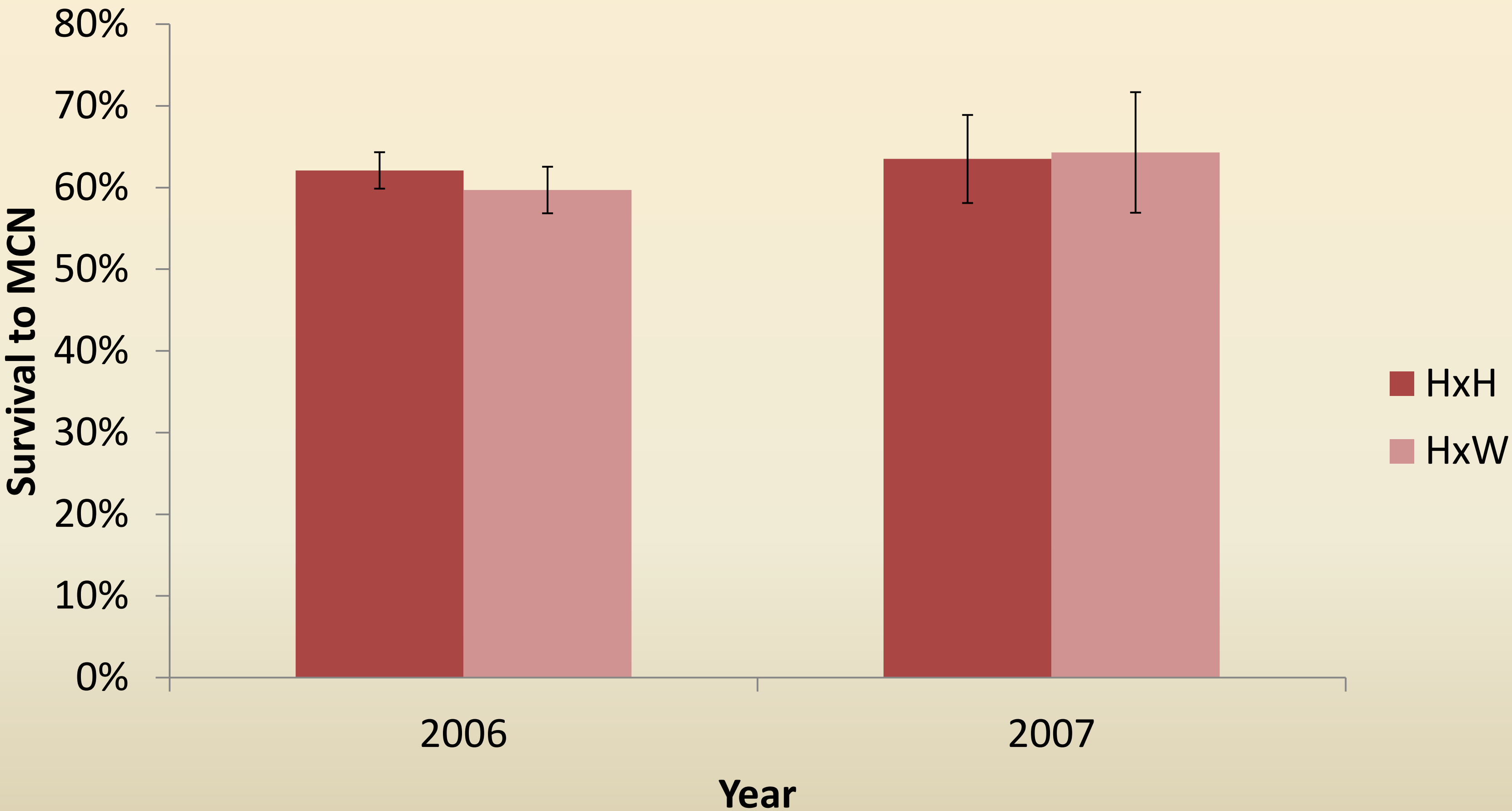
- Overwinter acclimation
- Brood origin
- Size at release
- Timing
- Volitional release
- Release #

Brood origin



** Results confounded by release location*

Brood origin

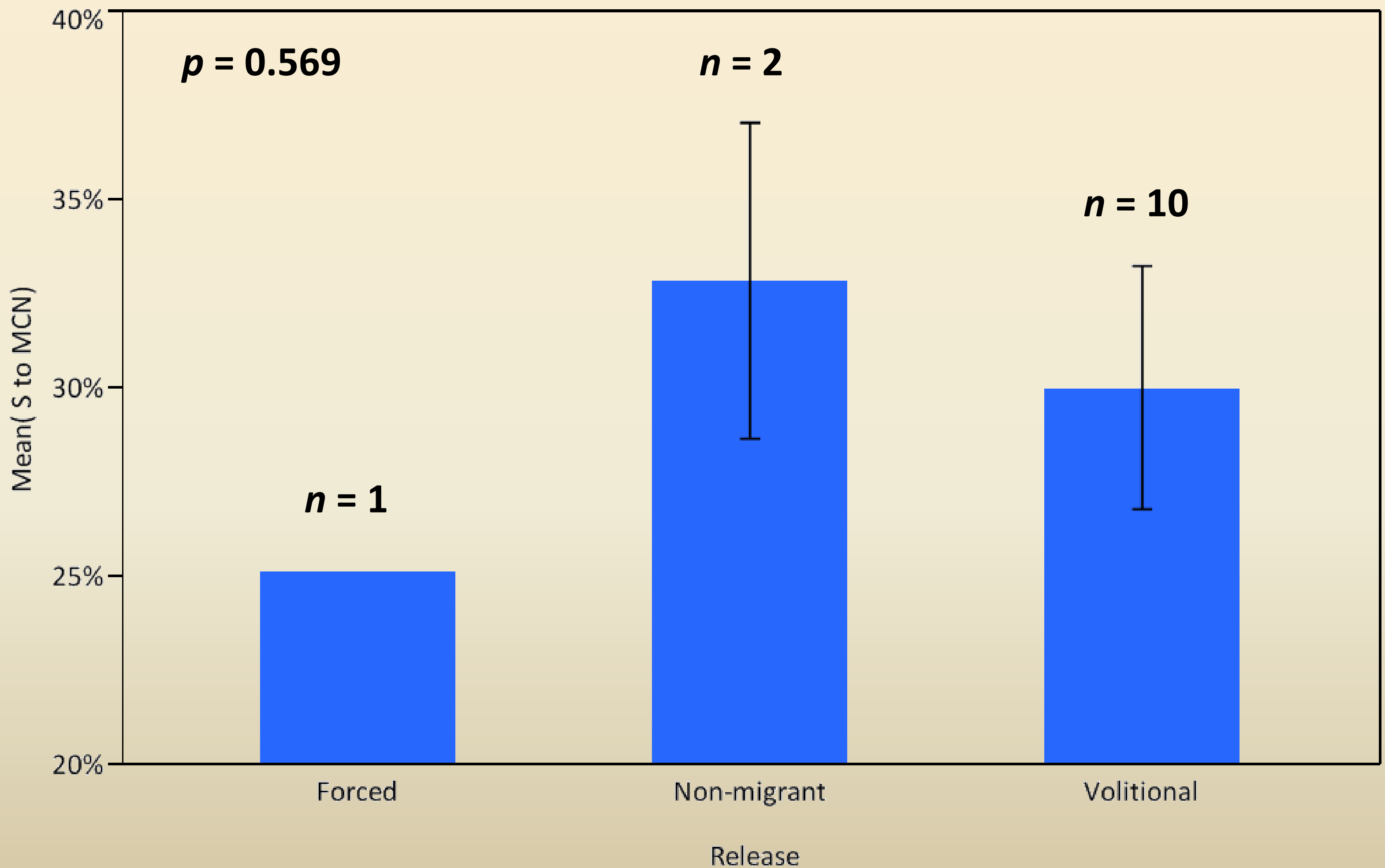


** Wenatchee River Releases only*

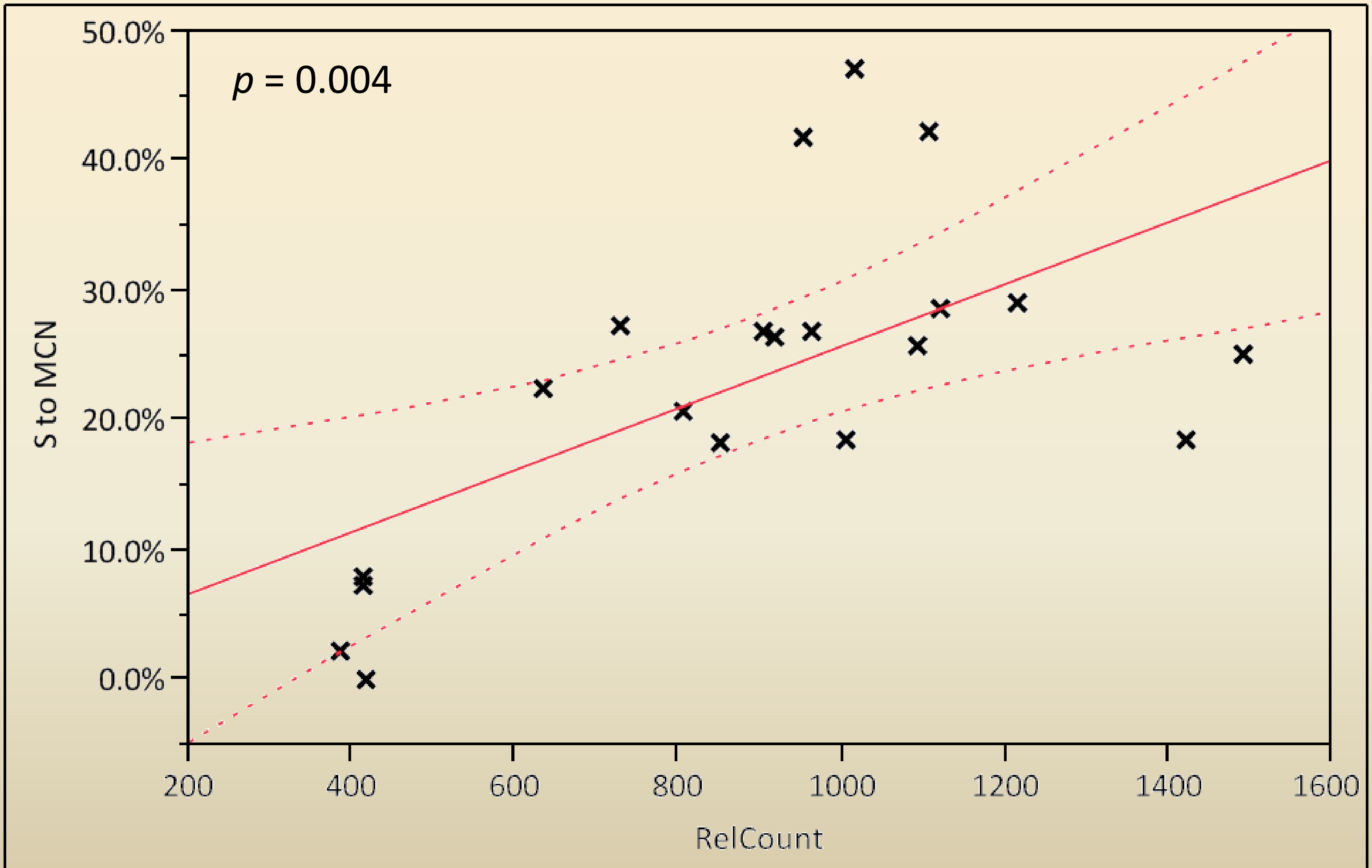
Size at release

- Blackbird = 11 FPP
- Re-use = 8 FPP
- Pond 2 = 12 FPP
- Target = 6 FPP

Volitional release



Number in release group

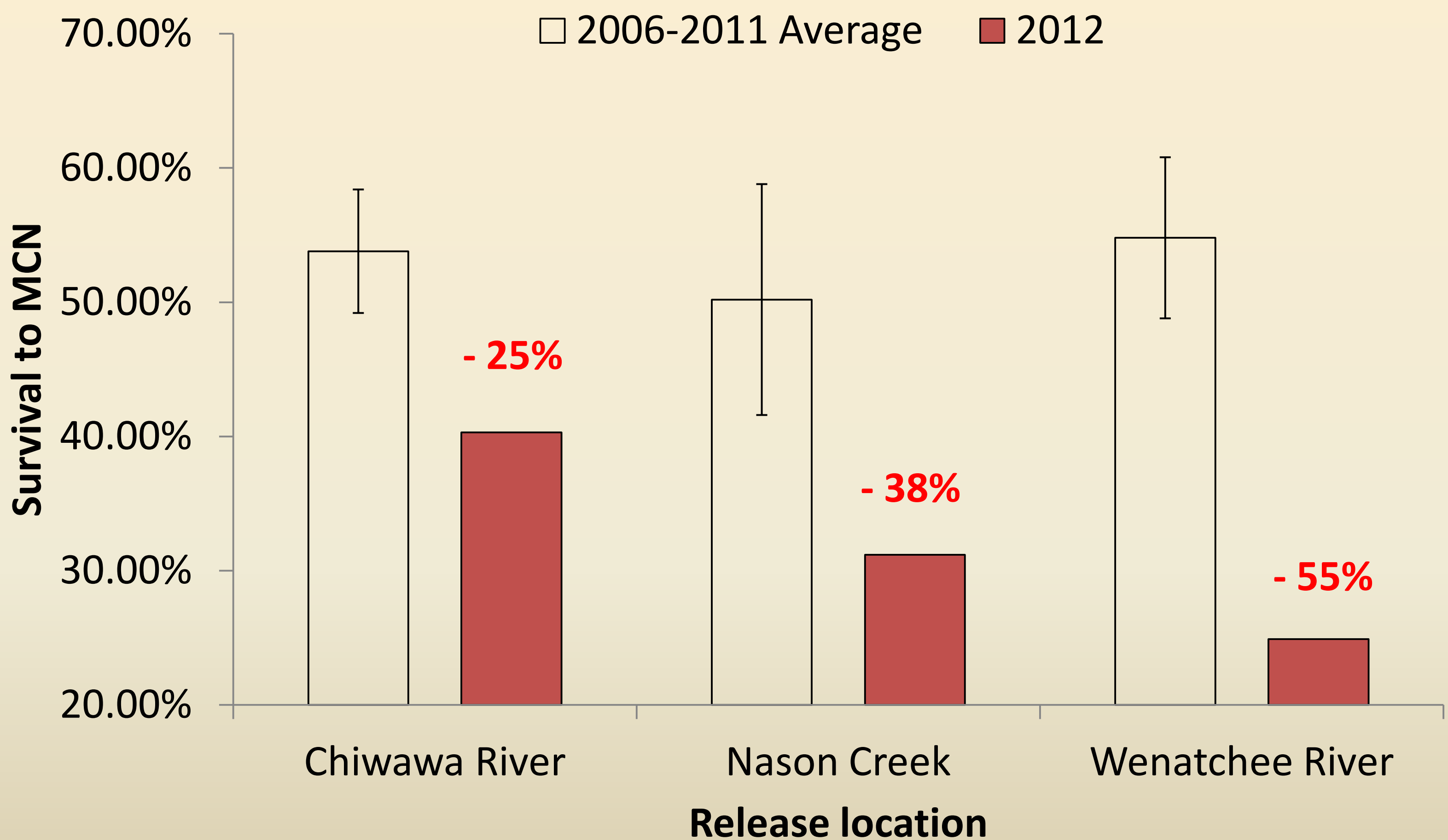


Recommendations

- Revert to original release strategy
  - Force release
  - First week in May
  - Large release groups
- Better investigate residual “problem” before making management decisions

Attachment B

Performance in 2012




Attachment C
Chelan Falls Summer Chinook
Pilot Study

Purpose

- Determine if we could capture adult summer Chinook in the Chelan River area.
- Determine which stocks are returning to the area (hopefully Chelan Falls summers).
- Best methods to utilize.

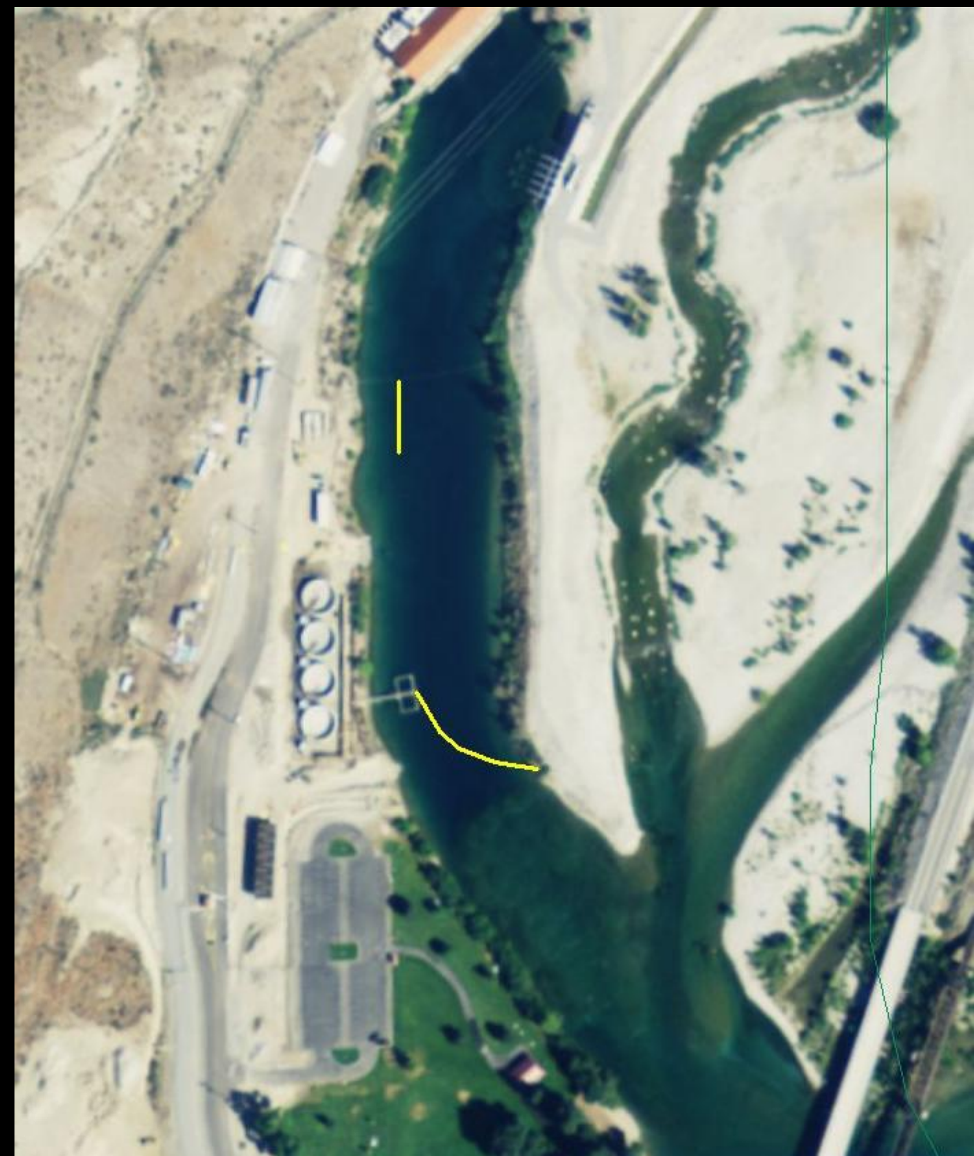
Methods Used

- Tangle Nets
- Hook and Line
- Eastbank Outfall (EBO)

Methods

Tangle Nets:

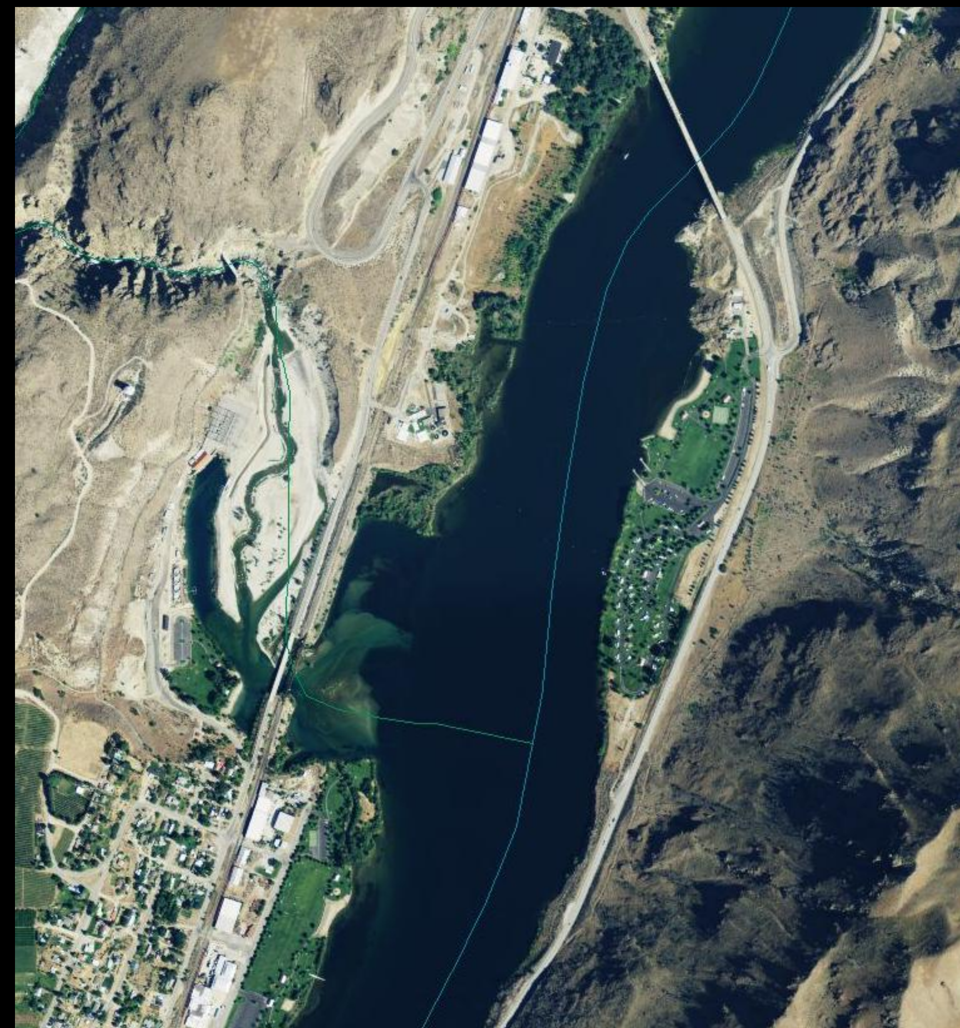
- 60’ x 30’ set parallel to shore from the “No Public” line on September 24th.
- 100’ x 30’ set diagonally from net pens to opposite shore on October 3rd.



Methods

Hook and Line:

- Columbia River just up river of Chelan River confluence on September 21st.



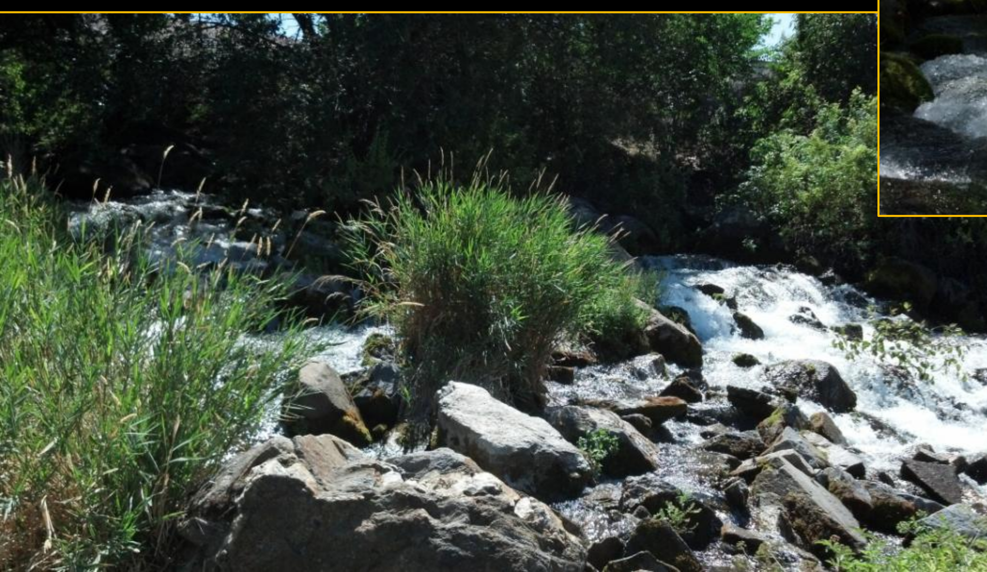
Methods

Eastbank Outfall:

- Used pond seines on 3 occasions:
  - August 28th
  - September 11th
  - October 3rd

Attachment C

Attachment C



Attachment C

Attachment C

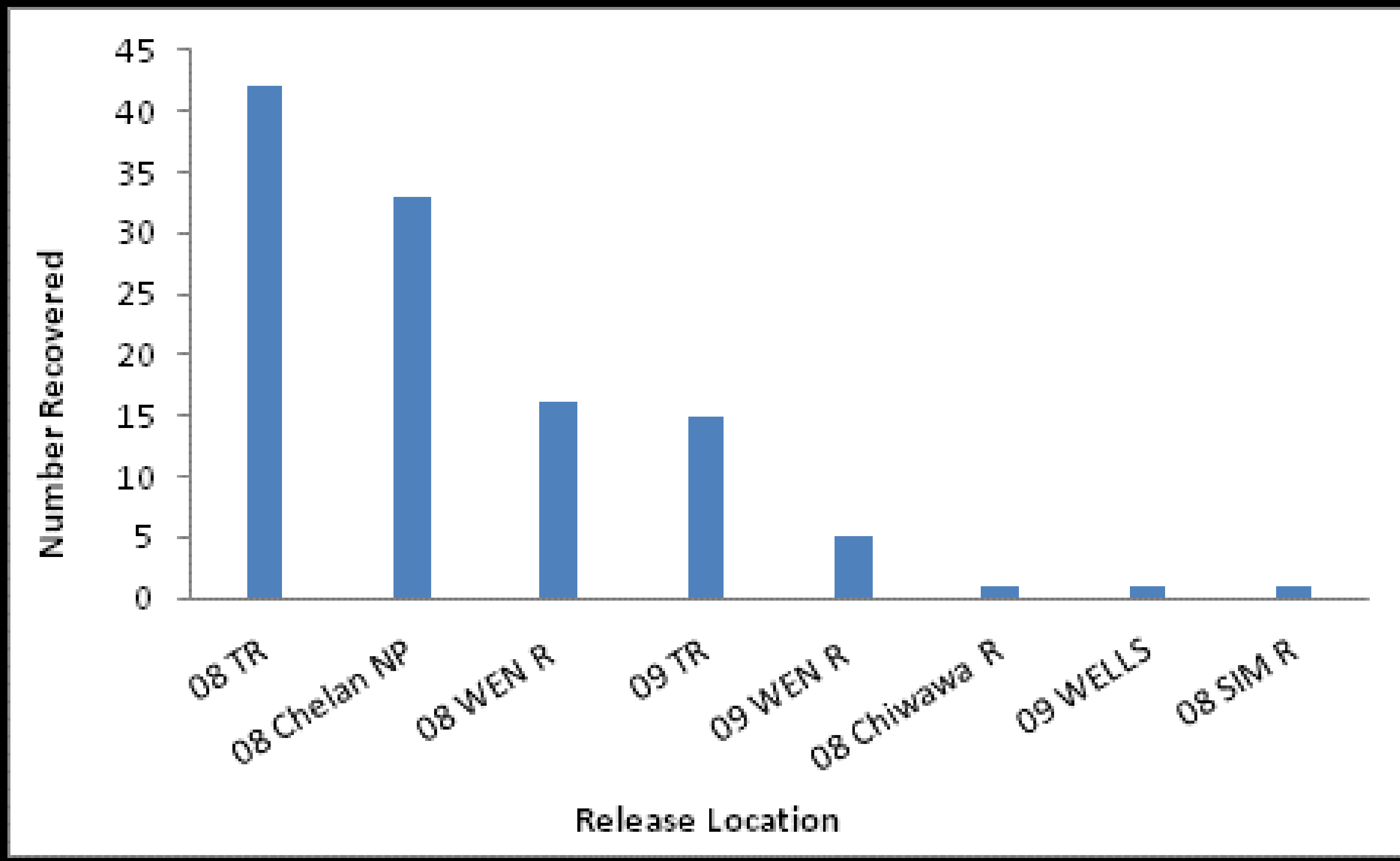
Results

Date	Method	Hours	# Staff	Total Hours	Chinook	Fish/hr
28-Aug	EBO	1.50	8	12.00	56	4.67
11-Sep	EBO	1.00	8	8.00	74	9.25
21-Sep	H+L	3.00	3	9.00	2	0.22
24/25-Sep	Tangle Net	4.00	2	13.00*	0	0.00
03-Oct	EBO	0.75	8	6.00	44	7.33
03/04-Oct	Tangle Net	4.00	3	14.00*	4	0.29

Attachment C

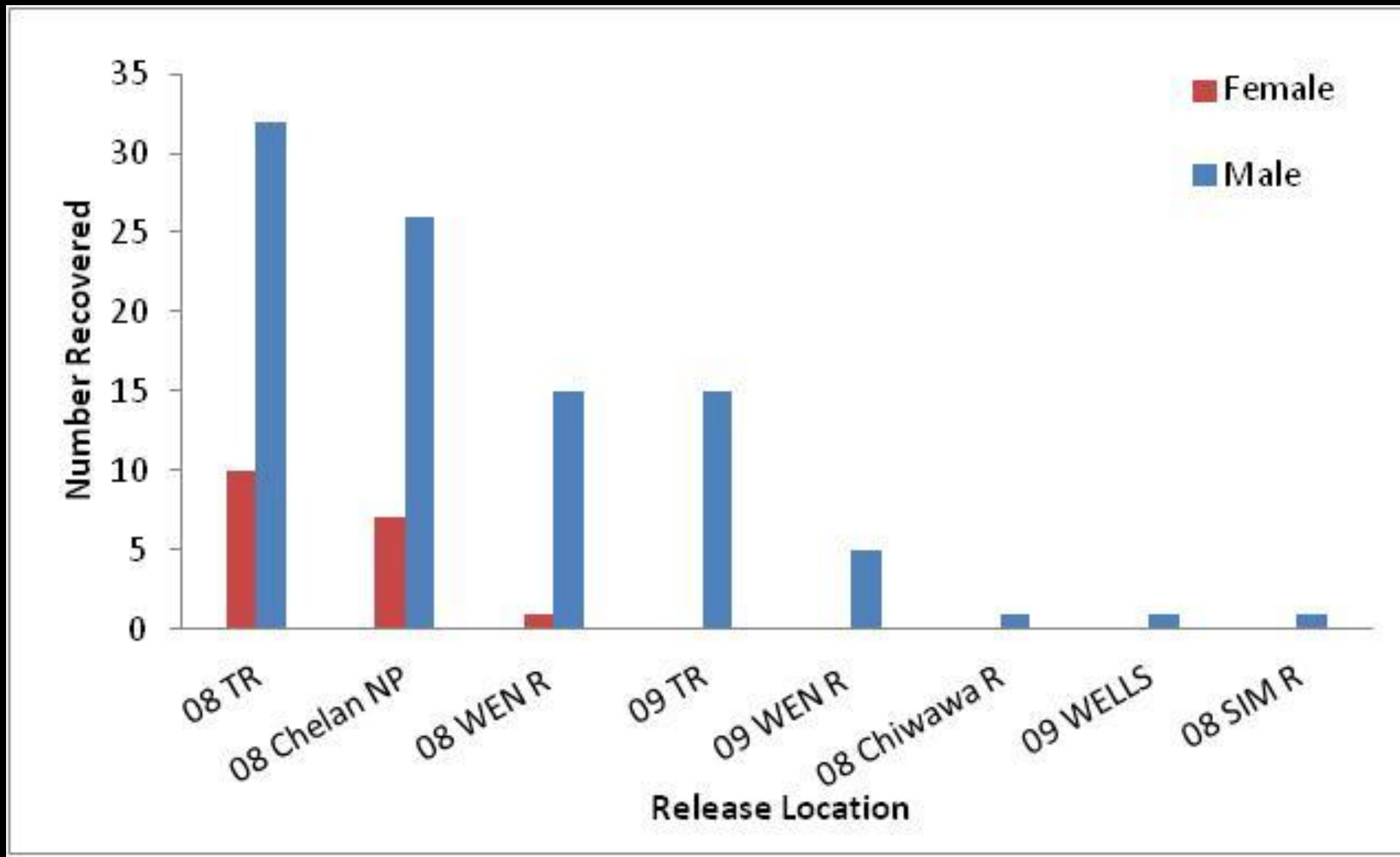
Results

- Release location of fish collected from EBO
  - 122 heads sampled
  - 114 CWT's recovered



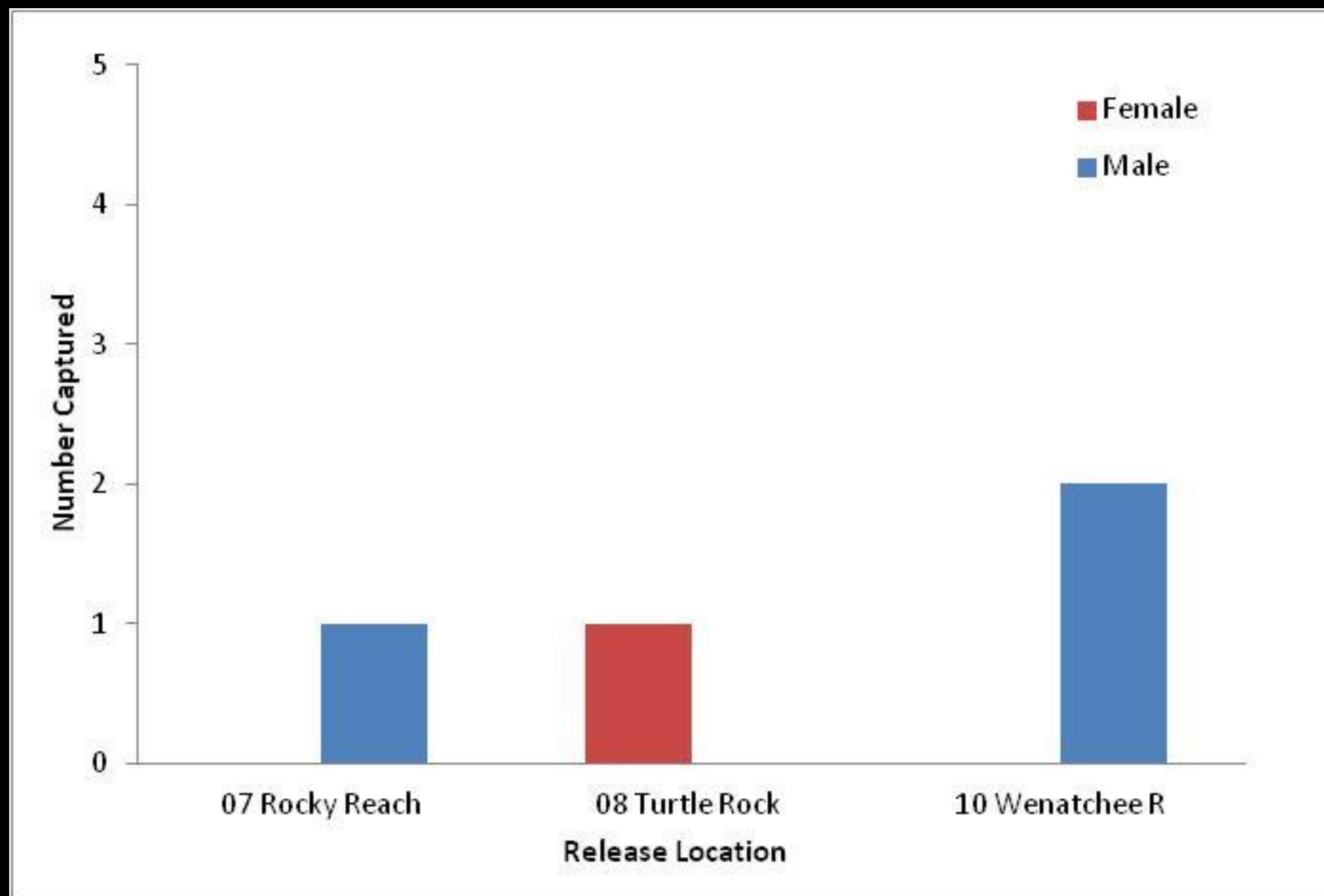
Results

- Female vs. Male collections at EBO.



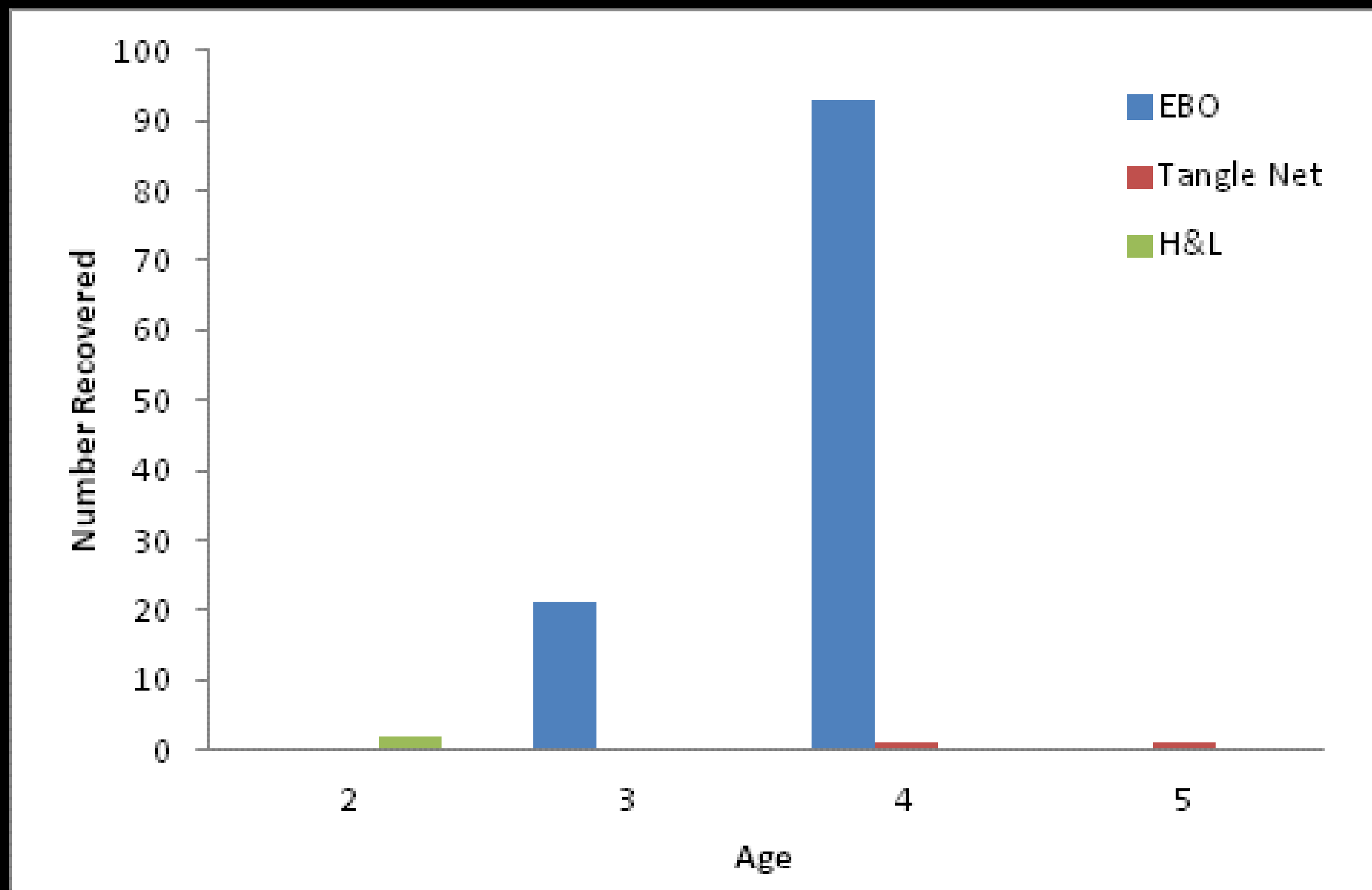
Results

- Origin of Tangle Net and Hook & Line fish.



Results

- Age of collected Chinook based on CWT's



Conclusions/Recommendations

- Not continue testing collection methods in the Chelan River area.

- Incorporate the EBO as a trap location for the Chelan Falls program beginning of July 2013.

- EBO would be:
  - Fish friendly
  - Safe for staff
  - Economical solution
  - Small cost to improve the outfall
    - Potentially capture more females
    - Utilize Volunteer Channel as back up

Conclusions/Recommendations

Added benefits:

- Would establish a location to conduct adult management.
- Can minimize stray rates of hatchery fish released from Eastbank Complex facilities.
- Enhance genetic makeup of this domesticated program by incorporating hatchery strays from programs that utilize wild origin fish for hatchery broodstock (i.e. Wenatchee, Methow, Okanogan, Wells and others?).

Acknowledgements

- Eastbank Hatchery Staff
- Chelan, and Arlington Hatchery staff
- CCPUD
- Wenatchee Food Bank
- Peter Flohr

DRAFT FOR DISCUSSION PURPOSES ONLY

Chelan PUD Methow Production Update

November 6, 2012

Summary: Over the past several months, Chelan PUD has worked with Douglas PUD to reach an agreement on terms and conditions for future production at Douglas' Methow Hatchery. Despite these efforts, no agreement has been reached. In the interest of moving forward, Chelan is proposing to use alternative hatchery infrastructure to meet our production obligations. We recognize the need for regulatory compliance and Hatchery Committee approval and are therefore initiating the discussions and processes necessary for a new program.

Purpose: This document provides a conceptual draft "proposal" for discussion in the Hatchery Committee. The primary goal of the proposal is to identify one or more pathways to meet production goals within our regulatory requirements. The proposal also provides NMFS with some basic documentation that the production of up to 60,516 smolts is reasonably certain to occur for the purposes of existing or ongoing Section 7 consultations related to the Methow River.

Ensuring ESA Compliance: Currently, ESA coverage is provided by Permit 1196, which expires January 20, 2014. Permit 1196 covers production of up to 550,000 spring Chinook smolts in the Methow River and it is expected that Chelan's 60,516 smolt obligation would result in a level of Take that is within or below that anticipated by Permit 1196 (including the additional production by Grant and Douglas PUD). After the expiration of Permit 1196, new ESA coverage will be required. Chelan will work with NMFS and the HC to ensure that any materials required for an application are prepared and delivered. Broodstock collection for 2012 has already been implemented for a 223,765 smolt program at Methow Hatchery and these fish will be released in 2014, after the expiration of the current permit. Therefore it is expected that NMFS would consider the level of take and effect analysis associated with a 223,765 smolt release, regardless of the timing of individual applications (i.e., there is no need to delay the evaluation of current HGMPs based on the number of fish produced at Methow Hatchery).

Attachment D

DRAFT FOR DISCUSSION PURPOSES ONLY

Initial Methow Proposal:

Broodstock Collection	***Why?***	**Adult Holding and Rearing**	**Why?**	**Acclimation**	**Why?**
Option 1. Rocky Reach Trap + GSI at Eastbank	*Trap was successfully used in the past & small future program of 60,516 smolts = 35 broodstock. Very close to Eastbank for adult holding and sorting. Available GSI markers used to sort out Entiat.*	**Option 1.** Eastbank	*Capacity exists and track record is good: spring Chinook originating from Eastbank perform well (i.e., Chiwawa SAR = .540 vs. Methow SAR = .234)*	**Option 1.** Carlton spring acclimation (short term only)+ early imprinting to improve homing fidelity to desired habitat.	*Allows for imprinting on Methow River water and development of new science that could be applicable on larger scale. Work by Andy Dittman at NMFS shows promise.*
Option 2. Rocky Reach Trap + PBT analog (GSI markers)	*PBT didn't work for Wenatchee, but may be easier for Methow. In 2010, 113 of 196 PBT study fish ascended Wells. These could be collected at Rocky Reach instead. Also PBT relied on availability of parental genotypes, where Methow could use existing GSI markers.*			**Option 2.** Carlton overwinter + Yakama Nation upper basin acclimation (e.g., Heath Ranch or Goat Wall or others)	*Overwintering on lower Methow River water and then acclimating at locations higher in the basin provides options for distributing adult returns and meeting manager goals.*

Note- The options depicted here are conceptual and have not been approved by any party.

Attachment D

DRAFT FOR DISCUSSION PURPOSES ONLY

Other Options:

1. Chelan is open to any suggestions/options
2. Additional homing fidelity to specific locations within the Methow could be achieved through early life history imprinting (i.e., Andy Dittman, NMFS Science Center). Chelan would support this
3. If there was a short term benefit to moving the 2013 brood year to Chiwawa, Chelan would support the move. This option does not include any commitments from Grant PUD.

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FINAL MEMORANDUM

To:	Wells, Rocky Reach, and Rock Island HCPs Hatchery Committees	**Date:**	January 18, 2013
From:	Mike Schiewe, Chair		
Cc:	Kristi Geris		
Re:	Final Minutes of the December 12, 2012 HCP Hatchery Committees Meeting		

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans (HCPs) Hatchery Committees meeting was held at Chelan PUD headquarters in Wenatchee, Washington, on Wednesday, December 12, 2012, from 9:30 am to 3:00 pm. Attendees are listed in Attachment A to these meeting minutes.

ACTION ITEM SUMMARY

- Mike Tonseth will send the proposal for broodstock collection at Tumwater Dam for Grant PUD's Nason Creek spring Chinook program to Kristi Geris for distribution to the Hatchery Committees after the proposal has been vetted in the Priest Rapids Coordinating Committee Hatchery Subcommittee (PRCC HSC; Item I).
- Greg Mackey will distribute to the Hatchery Committees updates to the Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs (Item II-B).
- Joe Miller will contact Grant PUD about the potential to overwinter acclimate Chelan PUD Methow spring Chinook production at Grant PUD's Carlton facility in 2013 (Item III-A).
- Joe Miller will contact Craig Busack regarding drafting concurrence letters to authorize collection of Methow spring Chinook broodstock using a modified parental based tagging (PBT) approach, and out-of-basin rearing facilities—both for brood year (BY) 2013 only (Item III-A).
- Chelan PUD will discuss with the Yakama Nation (YN) the potential use of upper Methow basin acclimation sites for Chelan PUD's BY2013 Methow spring Chinook production, to include installation of temporary adult weirs at the remote acclimation locations (Item III-A).
- Chelan PUD will draft a study plan to test Methow spring Chinook broodstock

collection at the Rocky Reach Trap; the study would potentially involve trapping, tagging, and genetic testing at Priest Rapids Dam, and monitoring at the Rocky Reach Dam Fish Trap (Item III-A).

- Bill Gale will discuss with United States Fish and Wildlife Service (USFWS) staff the potential to collect, spawn, incubate, and early rear Chelan PUD's Methow spring Chinook at Winthrop National Fish Hatchery (NFH) in 2013, and he will also propose a meeting for USFWS, Washington Department of Fish and Wildlife (WDFW), and Chelan PUD staff to review opportunities before the January 16, 2013 Hatchery Committees meeting (Item III-A).
- Bill Gale will distribute to the Hatchery Committees the draft terms and conditions that incorporate non-target taxa of concern (NTTOC) analyses as Monitoring and Evaluation (M&E) measures in the Leavenworth NFH Complex draft Biological Opinions (BiOps; Item IV-A).
- Kirk Truscott will coordinate internally to arrange a presentation on the Colville Confederated Tribes' (CCT's) Chief Joseph Hatchery (CJH) M&E Plan for a future Hatchery Committees meeting (Item VI-A).
- Kristi Geris will re-circulate the Conflict of Interest Policy Agreement amongst the Hatchery Committees members (Item VII-B).

STATEMENT OF AGREEMENT DECISION SUMMARY

- No Statements of Agreement (SOAs) were approved at this meeting.

AGREEMENTS

- The Hatchery Committees representatives present agreed that Chelan PUD and Douglas PUD will provide their respective draft M&E Implementation Plans to the Hatchery Committees for review no later than July 1 of the year preceding the proposed M&E activities (Item V-A).

REVIEW ITEMS

- Kristi Geris sent an email notification to the Hatchery Committees on November 13, 2012, stating that the draft Douglas PUD 2013 M&E Implementation Plan is out for a 30-day review period with comments due to Greg Mackey by December 14, 2012.

FINALIZED REPORTS

- The Douglas PUD 2011 M&E Report was finalized and distributed to the Hatchery Committees on December 3, 2012.

I. Welcome, Agenda Review, Meeting Minutes, and Action Items

Mike Schiewe welcomed Lynn Hatcher to the Hatchery Committees, who will be replacing Craig Busack as the National Marine Fisheries Service (NMFS) primary representative to the committees (Busack will become the NMFS alternate representative to the committees). Hatcher works in the Protected Resources Division of the Northwest Regional Office in their Ellensburg, Washington, office. Schiewe said that during the transition, Busack plans to be in touch frequently and will attend Hatchery Committees meetings by conference call for critical agenda items. Schiewe then reviewed the agenda, and the following revisions were requested:

- Joe Miller added an update on Chelan PUD's requirement to issue a request for proposal (RFP) for implementation of their Hatchery M&E Program.
- Kirk Truscott added an update on CJH.
- Bill Gale added: 1) a review of information compiled by Matt Cooper of the Mid-Columbia River Fishery Resource Office (MCRFRO) on the composition of spring Chinook spawning in the Entiat Basin; and 2) a discussion of the potential to incorporate the results of the NTTOC analyses as a term and condition in the new ESA permit for the operation of Leavenworth NFH.

Miller asked about the status of discussions in the PRCC HSC regarding the use of Tumwater Dam for broodstock collection for Grant PUD's Nason Creek spring Chinook program; Tonseth replied that he will send the proposal to Kristi Geris for distribution to the Hatchery Committees after the proposal has been vetted within the PRCC HSC.

The revised draft November 14, 2012 meeting minutes were reviewed. Geris said that there was one edit remaining to be discussed regarding the discussion on CJH and Methow sharing agreements; however, Greg Mackey said that his comment had already been resolved in subsequent edits. Geris said that all other comments and revisions received on the draft meeting minutes were incorporated. The Hatchery Committees members present approved the November 14, 2012 meeting minutes, as revised.

II. Douglas PUD

A. Draft Douglas PUD 2013 M&E Plan (Greg Mackey)

Greg Mackey reminded the Hatchery Committees that the draft Douglas PUD 2013 M&E Implementation Plan is out for a 30-day review period with comments due to him by December 14, 2012. Mackey encouraged discussion on the draft plan now, if needed. Keely Murdoch said that the YN plans to submit comments to Douglas PUD by December 14, 2012. Mackey said that if no significant comments or revisions are received on the draft plan, it will be finalized on December 14, 2012.

B. Updating the PUD M&E Plans (Greg Mackey)

Greg Mackey said that the Hatchery M&E Programs workgroup recently convened to further discuss updating the Hatchery M&E Plans. Mackey said that the workgroup is evaluating what needs to be addressed; and he added that Douglas PUD has edited the existing Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs. Mackey said that he will provide those edits to Kristi Geris for distribution to the Hatchery Committees.

Mike Schiewe recommended developing a schedule to complete the edits well in advance of the January 2014 implementation date. Bill Gale asked how the Hatchery M&E Plans can be revised when consultations are not complete. Mike Tonseth said that approximately 90 percent of the M&E Plans can be completed now and that once the consultations are complete, any new terms and conditions in the permits can be added. Tonseth added that he did not recommend postponing the update of the Hatchery M&E Plans because this will then impact the timing of the annual Implementation Plans.

Tonseth said that Douglas PUD, Grant PUD, USFWS, and WDFW recently met to discuss projected hatchery M&E programs and activities in the Methow basin, including the associated infrastructure needs and identification of stakeholders. Mackey said that the reasoning behind the discussion was to proactively develop a common understanding of individual agency responsibilities. Keely Murdoch asked why only select agencies attended this meeting, and Mackey explained that this meeting was initially intended to facilitate discussions between USFWS, and Douglas PUD and Grant PUD as funding entities; and then WDFW was brought in because they implement the M&E plan. Tonseth said that a draft spreadsheet template was being developed to capture and organize M&E activities in the Methow Basin, and that once it is refined, it will be distributed to all HCP signatories. Murdoch noted that a similar spreadsheet was developed by the Upper Columbia Salmon Recovery Board that identified agencies and their current data collection efforts. She added that the spreadsheet only focused on field efforts, however, and included no in-hatchery M&E activities. Murdoch also noted that as this effort moves forward, all of the Hatchery Committees representatives should be involved. The Hatchery Committees agreed to this, and Gale added that this first meeting was largely to give Douglas PUD and Grant PUD an idea of USFWS M&E activities. Joe Miller asked if USFWS requirements were fundamentally different from Chelan PUD's, and Gale replied that USFWS does not have a binding M&E framework that requires coordination as occurs under the HCPs; and he also added that USFWS is not bound by the Federal Energy Regulatory Commission (FERC). Miller asked if the completeness of USFWS's program depends on Chelan PUD's program, and Gale replied that most USFWS programs operate independently of other programs. Tonseth reiterated that the purpose of the meeting was to determine who has what requirements for what monitoring activities. He added that the group has a meeting scheduled for December 19, 2012; and Mackey suggested that this meeting should be cancelled and the discussions moved into the Hatchery Committees.

III. Chelan PUD

A. Methow Production (Joe Miller)

Joe Miller recapped that at the last Hatchery Committees meeting, Chelan PUD put forward a proposal for meeting their required Methow spring Chinook production. He noted that an action item that came out of that discussion was for the Joint Fisheries Parties (JFP) to meet, consider the merits of the proposal, and provide feedback, including alternatives if needed. Mike Tonseth said that a memo was distributed on December 11, 2012 summarizing the JFP discussion on the Chelan PUD Methow spring Chinook 2013 production obligation

(Attachment B). He said that the JFP reviewed Chelan PUD's proposal in multiple stages: adult collection, adult holding and spawning, incubation, and juvenile rearing and acclimation.

For adult collection in 2013, Tonseth said that there was a JFP consensus that Chelan PUD must meet its Methow production requirement of 60,516 spring Chinook. He said that the JFP also concluded that using the Rocky Reach trap for broodstock collection posed a risk to populations other than the Methow (i.e., Entiat natural origin recruits [NORs]), and that there was also uncertainty that Chelan PUD could capture enough broodstock to meet its production obligation. Miller told the Hatchery Committees members that neither the Wells Dam nor the Methow Hatchery option was possible without a sharing agreement between Douglas PUD and Chelan PUD, and that such an agreement currently did not exist. Keely Murdoch noted that several other agencies are already trapping broodstock at Wells Dam, and suggested that it would be more efficient if Chelan PUD, Grant PUD, and Douglas PUD all utilized broodstock from the same pool of fish. Miller reiterated that spring Chinook broodstock collection at Wells Dam in 2013 was highly unlikely and that the Committees needed to focus on alternatives.

Miller said that Chelan PUD staff had routinely sampled bull trout using the Rocky Reach trap; and if necessary, Chelan PUD can provide additional information regarding trapping at that location. He added that Chelan PUD is also prepared to work with NMFS and USFWS to obtain the necessary permits. Tonseth said that Chelan PUD needs to demonstrate that the Rocky Reach trap is the only option, and also needs to convince the Hatchery Committees that it is worth the risk. Gale said that his major concern is handling Entiat natural origin spring Chinook. Miller said that during the PBT pilot study, the majority of the fish trapped, sampled, and tagged at Priest Rapids Dam converted over Wells Dam. Murdoch noted that a PBT process had been considered in the past but was dismissed due to the elevated risk involved with over-handling the fish. Tonseth noted that the options available for collecting broodstock in 2013 were limited by what can be initiated in six months.

Kahler asked about the numbers of natural origin fish typically seen in the Winthrop NFH volunteer trap, and Gale replied that there are none, and that very few are in the volunteer channel. Gale added that USFWS needs the Methow Hatchery origin fish trapped in the Winthrop NFH volunteer channel for the Winthrop NFH program. He said that the USFWS might consider collecting Chelan PUD's broodstock at Winthrop NFH as an interim measure for 2013. He added that hatchery program staff would likely be reluctant to hold and spawn at Winthrop NFH. Gale said that he would prefer this broodstock collection option over trapping at Rocky Reach due to the potential impacts to Entiat fish. Miller said that Chelan PUD will consider any option except the Wells Dam option.

Tonseth said that because of the poor returns of spring Chinook forecasted for 2013, it is not likely that there will be enough natural origin fish returning to the Methow for all three PUDs to meet program goals, and that incorporation of hatchery returns to meet production goals will be required. He added that if Wells Dam is truly not an option, in order to get around permitting issues, the Rocky Reach trap may be the most effective short-term solution. Tonseth asked Miller if Chelan PUD could employ a sort-by-code approach to minimize handling; Miller said that, currently, Chelan PUD would need to rely on visual identification. Miller said that Chelan PUD does not have enough time to set up a gate system for sort-by-code. Gale asked if Priest Rapids Dam has a sort-by-code function, and Murdoch said that they do not. Tonseth said that a sort-by-code feature could be installed at the top of the fishway; however, this would entail manually picking out the fish. He suggested that, as proposed by Chelan PUD, an option for implementation in 2013 would be replacing PBT with genetic stock identification (GSI), and then passive integrated transponder (PIT) tagging and externally marking the fish to determine the probability of collecting the fish at the Rocky Reach trap. Tonseth suggested reviewing previous studies and conducting a second pilot study in 2013 to evaluate potential impacts. Miller said that he will contact Craig Busack regarding drafting concurrence letters to authorize collection of Methow spring Chinook broodstock using a modified PBT approach, and out-of-basin rearing facilities—both for BY2013 only.

Tonseth said that the JFP accepted Chelan PUD's proposed option to hold and spawn 2013 broodstock at Eastbank Fish Hatchery (FH); and noted that there are several incubation options possible. He said that the JFP preferred using a portable incubation trailer to initially imprint the fish to groundwater at the Carlton Facility. He said that because of the limited summer water right at Carlton, this option would be implemented during early rearing only. Tonseth asked Miller about the logistical feasibility of this option, and Miller said that he did not think it is impossible, but that implementation in the next 6 months might be difficult. Murdoch said that overwinter acclimation at Carlton was also discussed because the water is too warm at Eastbank FH. She said that the YN's Goat Wall and Heath Pond sites were also considered and that they are both mainstem Methow. Miller said that Chelan PUD will discuss with the YN the potential use of upper Methow basin acclimation sites for Chelan PUD's BY2013 Methow spring Chinook production. Murdoch added that Chewuch would have also been considered but no ponds are developed there yet.

Tonseth said that another option considered involved using surface water acclimation and an ultraviolet (UV) treatment system; however, the feasibility of getting the necessary infrastructure in place by 2013 was questionable. Miller said that from a fish health and bio security perspective, Eastbank FH seems like a good option. He added that the incubation method and location may require further discussion. Truscott noted that another option would be to incubate and early rear at Winthrop NFH if space is available; Gale replied that he will discuss this option with USFWS, but that he was unsure whether there would be space available. Gale asked Miller why Chelan PUD is reluctant about the portable incubation trailer option; and added that he thought that was along the lines of what Chelan PUD wanted. Miller replied that Chelan PUD is interested in that idea for 2014 and beyond but is unsure if the infrastructure will be ready to meet 2013 production.

Schiewe summarized that Chelan PUD is suggesting that it would be less risky to utilize Eastbank FH for incubation and early rearing in 2013. Murdoch said that the YN has routinely transported coho gametes among locations and noted that it can work; however, this option may not be a first choice. Lynn Hatcher added that NMFS would prefer doing as much of the rearing as possible in the Methow. Tonseth said that WDFW's first priority, if approved by USFWS, would be to collect broodstock and incubate eggs and early rear at Winthrop NFH. Schiewe said that if that is not an option, then the next option would be to take fish from Winthrop NFH, and hold and spawn at Eastbank FH. Miller mentioned that Grant PUD is developing a facility at Carlton to accommodate overwinter rearing of their Methow summer Chinook, and that it might be possible to use the existing space proposed by Grant PUD if the densities allow, or adding a single circular tank for Chelan PUD's spring Chinook production. Miller said that he will contact Grant PUD about the potential to overwinter acclimate Chelan PUD Methow spring Chinook production at Grant PUD's Carlton facility in 2013.

Tonseth concluded that for 2013 there seems to be a path forward. Greg Mackey reminded the Committees that it is important to consider measures to meet the percent hatchery origin spawners (pHOS) objectives. Hatcher said that he thought NMFS was comfortable with the pHOS analysis Douglas PUD submitted, and Mackey replied that the submittal did not include Chelan PUD fish. Murdoch noted the small size of Chelan PUD's requirement (approximately 61,000 smolts); she suggested marking fish to address any concerns. She also said that there are many uncertainties associated with the proposed pHOS and escapement targets, and that the YN has not had an opportunity to comment to date.

Schiewe asked what can be accomplished in 2013 that will inform 2014 and beyond. He asked if Chelan PUD can do anything in 2013 to improve understanding of the potential to collect broodstock at Rocky Reach in future years. Tonseth noted that permitting options need to be determined. Miller suggested using a pilot study approach similar to the PBT study to determine if sampling and rapid turnaround GSI at Priest Rapids Dam is feasible. Murdoch noted that a 2-week pilot study at Priest Rapids Dam is a fairly short duration for broodstock collection; and she added that it will not represent the entire run. Tonseth said that sampling could be spread out over the run. Miller said that Chelan PUD will draft a study plan to test Methow spring Chinook broodstock collection at the Rocky Reach Trap, potentially involving trapping, tagging, and genetic testing at Priest Rapids Dam, and monitoring at the Rocky Reach Dam Fish Trap. Gale said that once agreement is reached on Chelan PUD production for 2013 that these decisions need to be discussed with NMFS. Gale added that he will discuss with USFWS staff the potential to collect, spawn, incubate, and early rear Chelan PUD's Methow spring Chinook at Winthrop NFH in 2013, and he will propose a meeting for USFWS, WDFW, and Chelan PUD staff to review opportunities before the January 16, 2013 Hatchery Committees meeting.

B. M&E RFP (Joe Miller)

Joe Miller indicated that the Chelan PUD Commission will require an open competition and RFP for awarding new contracts for implementing the revised Hatchery M&E in 2014. Miller said that this would require completing revisions to the plan by April 2013. Mike Schiewe noted that this means the Hatchery M&E workgroup needs to finalize any proposed changes and that all the Hatchery Committees need to approve the revised Hatchery M&E by April 2013.

IV. USFWS

A. Assessing the Ecological Impact of Leavenworth Releases on NTTOC (Bill Gale and Amilee Wilson [National Oceanic and Atmospheric Administration])

Bill Gale said that as USFWS and NMFS were working through the final drafts of the Leavenworth NFH BiOps (which are now with NMFS for their final quality check [QC]), it was noted that ecological interactions were identified in the BiOps as a potential avenue for incidental take; however, nowhere in the terms and conditions was this incidental take measured or addressed. NMFS is primarily concerned with the effects of residualism. He said that as a result USFWS discussed with NMFS the possibility of incorporating into the BiOps the risk modeling that is being conducted by the Hatchery Evaluation Technical Team (HETT), and using that risk assessment to identify the high-risk areas and interactions that could be subject to intensive monitoring. Gale shared with the Hatchery Committees the draft terms and conditions language that he developed for the Leavenworth NFH BiOps.

Amilee Wilson said that National Oceanic and Atmospheric Administration (NOAA) General Counsel, during their legal reviews of recent BiOps, has asked NMFS to incorporate methods to quantify potential take that could occur through ecological interactions as a result of the hatchery program. She said that NMFS would not only like to address this issue for Leavenworth NFH, but was also interested in developing an approach to apply to all hatchery BiOps. Mike Schiewe asked how take would be determined. Craig Busack noted that calculating take is very difficult and typically involves using surrogate variables. He said that the Predation, Competition, and Disease (PCD) Risk Model could be a useful tool to quantify risk. Gale added that all the HCP parties are already conducting PCD risk modeling as part of the NTTOC analysis. Gale said that he will distribute to the Hatchery Committees the draft terms and conditions incorporating NTTOC analyses as M&E measures in the Leavenworth NFH Complex draft BiOps.

Greg Mackey said that when he was running the PCD risk models for Douglas PUD hatchery programs, he encountered problems when hatchery fish are smaller in size than wild fish, which resulted in the program crashing. Mackey said that he thinks this problem is caused by a programming error. Busack said that an issue with the use of the PCD risk model is that it has not had a lot of use under varying circumstances; and he added that it would be beneficial to hear other users' thoughts on the output. Gale asked the Hatchery Committees if they felt it was reasonable to expect NTTOC risk modeling to be complete by 2015. Keely Murdoch said that 2015 seemed reasonable.

Truscott asked what the difficulty was in performing snorkel surveys to assess residuals. Wilson said that the focus of NMFS' concern is to determine impacts from residual fish. She added that those fish will still be around in the summer, and that terms and conditions can be developed which include snorkel surveys; but for now, NMFS approves using NTTOC analyses as long as the Hatchery Committees are comfortable with those data. Wilson said that this is a good tool to identify programs and populations of high and low risks. She said that for low risk programs, terms and conditions may not be required; however, NMFS will want to require further monitoring of identified high risk programs. Therefore, the PCD-Risk model could be used to identify areas of concern that could require additional field work, such as snorkel surveys, to quantify the level of risk associated with a hatchery program, while in cases of low risk, additional field work would not be required.

Schiewe asked the Hatchery Committees if there were concerns regarding NMFS using PCD modeling as a tool in addressing ecological interactions. Joe Miller said that Chelan PUD was addressing residualism directly and it was not clear how additional NTTOC language would improve the current plan. Chelan PUD would like to first see the recommended language and assess how it aligns with Chelan PUD's planning. Murdoch said that she would also like to internally discuss any recommendation prior to agreement. She added that the YN has discussed the NTTOC process as part of their M&E processes; however, as far as incorporating the process as a term and condition, there is uncertainty about relying fully on a model for these processes. Murdoch also noted that using NTTOC risk modeling as a tool was one thing; however, relying on it in a permit is different. Mackey said that Douglas PUD would consider this idea. Tonseth noted that it seems that agreements still need to happen in regards to NTTOC outputs and what they mean. Gale said that this concern arose late in the process, and USFWS already had existing terms and conditions in place. He said that this was a way to address the concern and move the BiOps forward without requiring additional analyses. Tonseth noted that specific conditions on how to address residualism are outlined in the Hatchery and Genetic Management Plans (HGMPs), and asked if modeling will address those conditions. Mackey said that the model does not quantify residuals, but rather estimates the likelihood and magnitude of ecological interactions. Busack said that there is enough skepticism regarding the use of this model, so the terms and conditions language needs to be carefully crafted; and he added that NMFS will discuss this issue further.

B. Entiat Spring Chinook Salmon (Bill Gale)

Bill Gale introduced a summary of information collected by Matt Cooper and his staff at MCRFRO regarding the genetic composition of spring Chinook spawning in the Entiat Basin (Attachment C), which Kristi Geris distributed to the Hatchery committees on December 11, 2012. Gale said that this review may be useful in evaluating Chiwawa stray rates and the discontinuation of the Entiat program. He explained that these data were obtained through the observation of spring and summer Chinook salmon redd surveys and the recovery of fish carcasses; and he noted that, since 2000, there have been significant Chiwawa Hatchery contributions to the Entiat River spring Chinook spawning population, as shown in Figure 1 of Attachment C. Gale briefly reviewed the data described in Attachment C, and said that this review was not intended as a recommendation about Chiwawa. He said to contact Cooper with any questions.

Joe Miller said that in terms of Chiwawa, several modifications to the program would change the potential stray rates in the future, including: 1) significant reduction in program release numbers; 2) adjustment to smolt release size to reduce precocity; and 3) improved trapping protocols at Tumwater. He also suggested that the Chiwawa program was a victim of its own "success" where high SARs translate to more returns and potential strays, compared to lower performing programs. Mike Tonseth noted that this also involves determining entry timing of known Chiwawa-tagged fish into the Entiat River. Gale suggested installing a trap at the Eastbank FH outfall to capture spring Chinook (and other species) that are reared at Eastbank for part of their lives and may return there as a potential approach to reducing straying to the Entiat. Tonseth said that seining at the Eastbank outfall is planned for July 2013 to determine if installing a trap is worthwhile. Lynn Hatcher asked if the planned seining has been permitted, and Tonseth replied that seining will take place in the hatchery discharge channel; not in the river. Tonseth also added that adult management actions are included in the draft permit currently under consultation.

V. Yakama Nation

A. Protocol and Timeline for Developing, Reviewing, and Approving the Annual M&E Implementation Plans (Keely Murdoch)

Keely Murdoch said that she added this discussion to revisit the purpose and timing of the M&E Implementation Plans. She said that it is her understanding that the purpose of the M&E Implementation Plans is to identify what data are being collected and where they are being collected. She added that the Hatchery Committees need to complete a review of these plans prior to implementation and before contracting begins. Murdoch noted that this review is not taking place. She proposed that Hatchery Committees' approval of annual M&E Implementation Plans needs to occur in the summer preceding implementation and also proposed that a timeline be developed to meet key deadlines.

Mike Schiewe agreed with Murdoch and noted that approval of annual M&E Implementation Plans originally occurred in the summer. He said that this deadline has been steadily slipping primarily due to analytical problems and acknowledgement that the programs might change with the 5-year reviews. Schiewe suggested moving the deadline for approval back to the original summer date, particularly in 2013 when there are potentially significant upcoming changes. Greg Mackey said that he believes July 1 has historically been the deadline for approval; and Schiewe said that as far as a timeline, the PUDs need to work backwards from the date when they present the plans to their commissions. Mackey said that, ideally, the implementation plans should remain largely the same year-to-year because if the methods change too drastically, then the data are invalidated. The Hatchery Committees representatives present agreed that Chelan PUD and Douglas PUD will provide their respective draft M&E Implementation Plans to the Hatchery Committees for review no later than July 1 of the year preceding the proposed M&E activities.

B. 40K Steelhead Converted from Lake Wenatchee Sockeye Program (Keely Murdoch)

Keely Murdoch said that at a recent Production Advisory Committee (PAC) meeting, the idea of converting 40,000 Lake Wenatchee sockeye to spring Chinook, instead of steelhead (as specified in the 2011 SOA on the recalculation of hatchery obligations), was discussed. Mike Tonseth said that WDFW is discussing this proposal and has not yet made a decision. Bill Gale said that he prefers converting to steelhead; and Tonseth noted that if conversion to spring Chinook occurs, these fish would be "safety net fish." Gale asked if there would be sufficient numbers of spring Chinook to justify recreational harvest; and Murdoch replied that there may not be, but that converting these 40,000 fish will improve returns. Gale asked if converting 40,000 fish to spring Chinook will increase numbers enough to result in a hatchery benefit. Tonseth said that converting the sockeye program to steelhead would mean maintaining steelhead production at Chiwawa. He added that also, according to the existing agreement, such a change would not require WDFW approval. Tonseth noted that this is a state economics versus tribal issue because steelhead are an economic benefit to the state. Based on preliminary estimates, he said that the benefits from those fish are negligible—approximately 200 to 230 spring Chinook back, versus 500 steelhead.

VI. CCT

A. Chief Joseph Hatchery Update (Kirk Truscott)

Kirk Truscott said that CJH testing, modifications, and upgrades are still in progress, and that the final completion is expected by July 31, 2013. He said that all facilities and equipment essential for receiving fish will be complete by the end of April. He said that the groundwater system, buildings, and raceways are complete, and that all facility components are now being tested. Truscott said that there have been some unanticipated issues with the original design. He said that, for example, the fish ladders are now anticipated to be complete by the end of February. This change is because of a complete redesign of the fish water intake due to riprap that the U.S. Army Corp of Engineers (USACE) would not allow to be moved. Truscott said that CCT is anticipating 60 percent of capacity production for BY2013. Greg Mackey asked if the interim Douglas PUD summer Chinook spawned from Chief Joseph Hatchery brood collection by the CCT in 2012 and currently reared at Wells Hatchery would be able to be accepted at CJH in 2013, and Truscott noted that CCT was considering holding those fish at Wells Hatchery until October acclimation begins, as opposed to moving the fish multiple times. Truscott said that CCT is working with Chelan PUD on developing a cost share agreement similar to the NNI agreements with Douglas PUD and Grant PUD. He also said that he will coordinate internally to arrange a presentation on CCT's CJH M&E Plan for a future Hatchery Committees meeting. Mackey noted that the Hatchery Committees will want assurance that CJH M&E programs meet the PUDs' program objectives. Truscott said that CCT compared the Bonneville Power Administration (BPA) program format to the PUD format to ensure that PUD objectives would be met. Mike Tonseth asked if CCT planned to conduct the run-composition sampling at Wells Dam for summer Chinook above Wells (which by default includes Methow, Okanogan, and Columbia River mainstem spawning aggregates), and Truscott said that it was not included in their current plan. Tonseth said that all three PUDs have obligations in the Okanogan; and noted that if the PUDs are cost sharing M&E activities with the CCT, those data will need to be collected.

VII. HCP Administration

A. Annual Reports (Mike Schiewe)

Mike Schiewe announced that the Rocky Reach Dam, Rock Island Dam, and Wells Dam 2012 Annual Reports are being prepared. He said that there is a brief chapter on Hatchery Committees highlights summarizing 2012 activities. He said the annual reports also compile published reports, SOAs, and other documentation approved throughout the year. Kristi Geris said that the comment period will be from February 8, 2013, to March 6, 2013, for the Wells Dam Annual Report, and from February 21, 2013, to March 19, 2013, for the Rocky Reach Dam and Rock Island Dam Annual Reports.

B. Conflict of Interest Policy (Mike Schiewe)

Mike Schiewe recommended that the Hatchery Committees extend the Conflict of Interest Policy at the January 16, 2013 Hatchery Committees meeting. He explained that the policy was initially reviewed and approved by the Hatchery Committees in late 2010 for implementation on a 2-year trial basis; however, since then, there have been no opportunities to re-evaluate implementation of the policy. Schiewe said that Kristi Geris will re-circulate the Conflict of Interest Policy Agreement amongst the Hatchery Committees members.

C. Next Meetings

The next scheduled Hatchery Committees meetings are on January 16, 2013 (Douglas PUD office); February 20, 2013 (Chelan PUD office); and March 20, 2013 (Douglas PUD office).

List of Attachments

Attachment A – List of Attendees
Attachment B – JFP discussion on Chelan PUD Methow spring Chinook production obligation
Attachment C – Review of Entiat Basin spring Chinook spawning population, 2000 – 2012

Attachment A
List of Attendees

Name	Organization
Mike Schiewe	Anchor QEA, LLC
Kristi Geris	Anchor QEA, LLC
Joe Miller*	Chelan PUD
Greg Mackey*	Douglas PUD
Tom Kahler*	Douglas PUD
Keely Murdoch*	Yakama Nation
Kirk Truscott*	Colville Confederated Tribes
Lynn Hatcher*	National Marine Fisheries Service
Craig Busack*†	National Marine Fisheries Service
Amilee Wilson†	National Marine Fisheries Service
Bill Gale*	U.S. Fish and Wildlife Service
Mike Tonseth*	Washington Department of Fish and Wildlife
Chris Moran	Washington Department of Fish and Wildlife
Todd Miller†	Washington Department of Fish and Wildlife
Charlie Snow	Washington Department of Fish and Wildlife
Jayson Wahls	Washington Department of Fish and Wildlife

Notes:

* Denotes Hatchery Committees member or alternate

† Joined by phone

December 11 2012

To: HCP-Hatchery Committee

From: Joint Fisheries Parties

Re: JFP Discussion on Chelan PUD Methow Spring Chinook Production Obligation

Introduction

During recalculation of the Upper Columbia PUD's No Net Impact (NNI), Chelan PUD realized a drop in their NNI production obligation for Methow spring Chinook to 60,516 fish. It was assumed by the Joint Fisheries Parties (JFP) that adult collection, spawning, incubation, early, rearing, and release would remain consistent with past practices for the collective conservation program out of Methow Hatchery. Subsequent to recalculation, the JFP were informed of the termination of hatchery sharing agreements between Chelan PUD and Douglas PUD (owners of the facility) and that the two parties have been unable to reach a mutual agreement for continuation of Chelan PUD's production at the Methow FH facilities. At the November HCP-HC meeting, Chelan PUD provided a draft proposal to meeting their Methow spring Chinook production obligation of 60,516 fish beginning with the 2013 brood. This document is a JFP response to that proposal. Under consideration is how to meet the production obligation in the most efficient manner in 2013. Parallel to this is how to best implement this program for the duration of the recalculation period (9 years) without compromising recovery of spring Chinook in the Methow Basin. JFP preferences have been discussed for each of the four major production elements (e.g. adult collection, adult holding/spawning, incubation, and juvenile rearing/acclimation) with other options discussed (no hierarchy provided) following the preferred option.

Adult Collection

Presently the JFP are of the position that adult collection for the Methow spring Chinook conservation program (comprised of GPUD, DPUD, and CPUD production obligations of 134,216, 60,516, and 29,123 respectively) needs to occur at Wells Dam following past prescribed methodology(GSI). Because the Rocky Reach adult collector is relatively unknown, the JFP are in agreement that based upon present knowledge, to use the Rocky Reach trap poses an excessive risk to other populations other than the Methow, and poses risk to not meeting Chelan PUD's production obligation.

Concerns about impacts to the Entiat NOR spring Chinook population combined with the uncertainty of effectiveness to collect the appropriate broodstock (Methow/Chewuch) in the correct proportions (H:W) based upon run size such that extraction of 1/3 of the NOR's is not exceeded, makes any other proposal unsupportable in the near term. Additionally NMFS has expressed concerns about supporting/permitting broodstock collection at locations below Wells Dam.

Adult Holding/Spawning

The JFP agree that adult holding and spawning of broodstock at Eastbank FH for the 61K obligation poses little threat or risk to meeting the production obligation or performance of progeny.

Incubation

For incubation there are a number of possible iterations ranging from traditional incubation practices currently used for the Chiwawa program to less than conventional (or more accurately described as experimental) methods using egg imprinting on natal water sources. The current short term preference is to incubate eggs on ground water at Carlton Ponds using a portable incubation trailer complete with chilled water capacity and using either ISO buckets (as have been used historically at Methow Hatchery) or conventional Heath Trays. At eye-up or more preferably at swim-up, progeny would be transferred to Eastbank FH for early rearing.

Additional incubation alternatives considered:

1.) Eastbank FH using existing well water.
2.) Eastbank FH using experimental egg imprinting on natal surface water
    a.) Requires additional infrastructure to isolate eggs and treat (most probable UV) surface water used for the imprinting/incubation.
3.) Carlton Pond surface water on site
    a.) Requires additional infrastructure including permanent or portable incubation trailer, chiller, and disinfection unit (UV?) to treat surface water.
4.) Carlton Pond using surface water trucked from higher in the Methow Basin for use for experimental egg imprinting/incubation on natal surface water.

Juvenile Rearing/acclimation

As with incubation, there are a number of options available to consider. To address the 2013 brood, acclimating fish at Carlton Pond on surface water from October through March or until fish can be transferred to spring acclimation locations (YN multispecies have been suggested however specific sites and appropriate numbers have not yet outlined), seems the logistically likely action that can be taken. There are significant concerns that acclimation of spring Chinook this low in the Methow Basin poses risk to significantly change the spawner distribution of spring Chinook, and more importantly spawner distribution of hatchery spring Chinook into reaches of the Methow where they haven't been historically observed. Additionally, conducting adult management on returning on excess hatchery adults could be problematic given the absence of structure for fish to return to (such as can occur with Methow Station releases and the Twisp Weir). Strong consideration should be given to implement a robust PIT tagging program such that returning adults can be evaluated to look at spawner distribution of these releases.

Additional juvenile rearing/acclimation alternatives considered:

1.) Eastbank FH on well water until spring transfer to acclimation sites/ponds. This is not an option for serious consideration at this time. Given peak ground water temperatures at Eastbank FH occur in winter. The probability of being able to keep fish within a reasonable size limit would be impossible. In addition, the long term rearing on ground water would likely produce a smolt similar to the WR captive brood program produced at Aquaseed.

2.) Eastbank FH on well water and direct planted into upper reaches of the Methow at the earliest possible time in the spring – assumes no acclimation pond/site is available.

3.) Eastbank FH on well water then direct planted as sub-yearlings (pre-smolt) into upper reaches of the Methow Basin. This option may require adjustment of production level to ensure the smolt equivalents are met. Additionally, release of sub-yearling hatchery fish pose an ecological risk to their natural cohorts due to the length of time they would remain in fresh water in direct competition with wild fish. This type of an approach would be counter to conventional protocol which was previously permitted through the Section 10 permits requiring spring Chinook to be released as actively migrating yearling smolts. Additional information would be needed before this type of approach could be considered. Before the full 61K could be released as sub-yearlings, this approach would need to be piloted to measure/monitor effectiveness and effects. A major benefit of this approach would be overwinter acclimation facilities are not required.

Attachment C

United States Department of the Interior
Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Road
Leavenworth, WA 98826
Phone: (509) 548-7573
Fax: (509) 548-5743

MEMORANDUM December 11, 2012

To: William Gale

From: Matt Cooper

RE: Review of Entiat Basin spring Chinook spawning population, 2000 – 2012.

This review summarizes the spring Chinook spawning population of the Entiat River Basin from 2000 to 2012. It is hoped that this information will provide insight into the ability of fisheries co-managers to achieve program and population specific goals. The following background and methods of hatchery releases and spawning ground surveys were taken as excerpts from the 2011 annual spawning ground report by Hamstreet in 2012.

BACKGROUND

Spring Chinook Salmon

In the initial years after Grand Coulee Dam was built, little effort was made to re-establish wild spring Chinook salmon runs in the Entiat River. From 1942 to 1944, Entiat NFH released a total of 1.3 million sub-yearlings and fewer than 50,000 yearling spring Chinook salmon that were offspring of the upriver stocks collected at Rock Island Dam (Mullan 1987). No spring Chinook salmon were released from Entiat NFH from 1945 to 1975. As early as 1956 and 1957, a wild spring Chinook salmon run was observed spawning in the area above Stormy Creek (rm 18.4) (French and Wahle 1960). Since 1962, spring Chinook salmon redds have been counted in an *index* area between river miles 28.1 and 21.3 where an established spring Chinook salmon run had been documented. MCRFRO has conducted surveys in the upper river (rm 28.1-16.2) and on the Mad River (rm 3.5-1.5) by foot since 1994. Entiat NFH resumed spring Chinook salmon production in 1974. Egg sources have included Cowlitz River (1974), Carson NFH (1975 to 1982), Little White Salmon NFH (1976, 1978, 1979, 1981), Leavenworth NFH (1979-1981, 1994), and Winthrop NFH (1988). Adults that voluntarily returned to the hatchery were the primary brood stock in 1980 and from 1983 to 2006, the last spring Chinook release into the Entiat River was in 2007, after which the program was terminated (Table 1). The last returning age-class of Entiat NFH origin spring Chinook was completed in 2010.

Summer Chinook Salmon

Although summer Chinook salmon are not believed to be endemic to the Entiat River (Craig and Suomela 1941), several efforts were made to establish summer Chinook salmon in the Entiat River following completion of Grand Coulee Dam. In 1939 and 1940, a total of 3,015 adult summer Chinook salmon, collected at Rock Island Dam from the commingled upriver stocks, were placed in upper Entiat River spawning areas. Only an estimated 1,308 of these survived to spawn (Fish and

Hanavan 1948). Entiat NFH reared and released juvenile summer Chinook salmon into the Entiat River from 1941-1964, and 1976 (Mullan 1987). After cessation of spring Chinook program in 2006 a summer Chinook program was reinitiated in 2009 with the first release occurring in 2011. Entiat NFH summer Chinook egg sources have included commingled upriver stocks intercepted at Rock Island Dam (1939-1943), Methow River (1944), Carson NFH (1944), Entiat River (1946-1964), Spring Creek NFH (1964), and Wells Dam (1974, 2009-2010). Historically summer Chinook salmon spawning was monitored by aerial surveys in the lower 10.4 river miles from 1957 to 1991. Positive redd identification from the air is difficult at best; therefore aerial surveys likely underestimated actual redd numbers. Spawning numbers were never high, with a maximum of 55 redds in 1967. For years 1972-1991, aerial redd counts averaged about five per year. MCRFRO has conducted surveys in the upper river (rm 28.1-16.2) by foot since 1994 and on the lower River (rm 6.8-0.3) by raft since 2006.

METHODS

Spring and Summer Chinook Salmon Redd Surveys

Redd surveys consisted of dividing the survey area into several reaches which were surveyed multiple times by walking or rafting downstream. Each encountered redd of both runs were numbered sequentially, number of live fish were recorded and redds were marked with colored flagging hung on nearby vegetation. Hand held Global Positioning System (GPS) units recorded latitude and longitude positions for each redd. Recovered carcasses were measured from snout tip to fork in tail (fork length) and post orbital to hypural plate (POH), gender identified, females were dissected and visually ranked (complete/partial/incomplete or unknown) for egg voidance and scale samples were collected when possible. Scales were viewed using a microfiche reader to determine age and origin (wild or hatchery). Carcasses were examined for external tags or marks and scanned for the presence of coded-wire tags (CWT) and passive integrated transponder (PIT) tags. Snouts were removed from carcasses with detected CWT's. The tags were later retrieved, de-coded and uploaded to the Regional Mark Processing Center with accessory information. The number of CWT potentially available for recovery were estimated by dividing the observed number of CWT's by the estimated carcass recovery rate based on a redd expansion of 2.4 fish/redd. Detected PIT tags were loaded into a portable transceiver and uploaded with accessory information to PTAGIS. Tissue samples were taken for future DNA analysis and the tail was removed to prevent re-counting. The estimated spawning population is determined by expanding the number of redds by 2.4 fish/redd. The subsequent population is then broken by the percentage of carcasses determined to be of hatchery or wild origin using both scales and CWT's. These percentages are then utilized to apportion the estimated spawning escapement by rearing origin. The hatchery population is then further broken by release facility by expanding the estimated number of each CWT group by the percentage of the release that was tagged. The sum total of all expanded CWT's are then utilized to apportion the estimated hatchery spawning escapement by release facility. The FWS currently conducts Chinook salmon redd surveys in the Entiat River Basin from mid-August to November annually. The collection of post-spawn adults (carcasses) and determining their identity/origin is a key component of the surveys.

RESULTS

Data obtained from spring Chinook carcass recoveries for years 2000 to 2011 in the Entiat River Basin shows the following:

- An average of 54% (31% - 75%) natural origin return (NOR) and 46% (25% - 69%) hatchery origin return (HOR) comprised the spawning population (see Figure 1).
- Average number of redds = 138 (73 – 248).
- Average spawning escapement = 340 (175 – 595) for adults expanded by an estimated 2.4 spawners/redd.
- Average estimated carcass recovery rate = 20% (14% - 29%).
- Average NOR spawning escapement = 192 (54 – 367).
- Average HOR spawning escapement = 149 (84 – 276).
- Average NOR age structure = 4% age 3, 68% age 4, and 28% age 5.
- Average HOR age structure = 18% age 3, 74% age 4, and 8% age 5.
- Average within basin (ENFH) contribution rate to spawning population = 23% (0% - 49%).
- Average out of basin contribution rate to spawning population also = 23% (4% - 51%).
- Average Chiwawa Rearing pond contribution rate to spawning population = 12% (0% - 37%).
- Of the hatchery spawning population ENFH = 50% (0% - 92%)
  CRP = 26% (0% - 79%) (see Table 2)
  Other UCR = 14% (0% - 37%)
  Non-UCR = 10% (0% - 47%) (see Figure 2).

Table 1. Entiat NFH spring Chinook releases with marking and tagging rates, 1997-2008.

Brood Year	Release Year	Yearlings	Sub-Yearlings	Total Release	CWT # Tagged	% CWT	% Ad. Clip	# PIT Tagged
1995	1997	200,486		200,486	197,071	98%	98%	1,199
1996	1998	350,784		350,784	124,536	36%	36%	
1997	1998		154,053	154,053	154,053	100%	100%	
1997	1999	354,238		354,238	118,058	33%	33%	
1998	2000	359,667		359,667	109,394	30%	30%	
1999	2000		421,126	421,126	99,963	24%	24%	
1999	2001	397,855		397,855	394,411	99%	99%	
2000	2002	533,720		533,720	159,363	30%	100%	59,401
2001	2003	395,689		395,689	199,248	50%	100%	59,879
2002	2004	386,833		386,833	193,630	50%	100%	58,625
2003	2005	401,240		401,240	199,127	50%	100%	3,732
2004	2006	322,516		322,516	147,991	46%	100%	3,001
2005	2007	362,854		362,854	159,098	44%	100%	999
2006	2008	Entiat spring Chinook program terminated 683,789 transferred off station.						
	AVE	369,626	287,590	357,005	173,534	53%	78%	26,691
	MAX	533,720	421,126	533,720	394,411	100%	100%	59,879
	MIN	200,486	154,053	154,053	99,963	24%	24%	999

Table 2. Age composition for Chiwawa Rearing Pond observed CWT recoveries, 2011-2012.

# Chiwawa Rearing Pond/Year	2011	2012
Age-2	1	0
Age-3	31	4
Age-4	17	23
Age-5	0	1
Totals	**49**	**28**

# Chiwawa Rearing Pond/Year	2011	2012
Age-2	2%	0%
Age-3	63%	14%
Age-4	35%	82%
Age-5	0%	4%
Totals	**100%**	**100%**

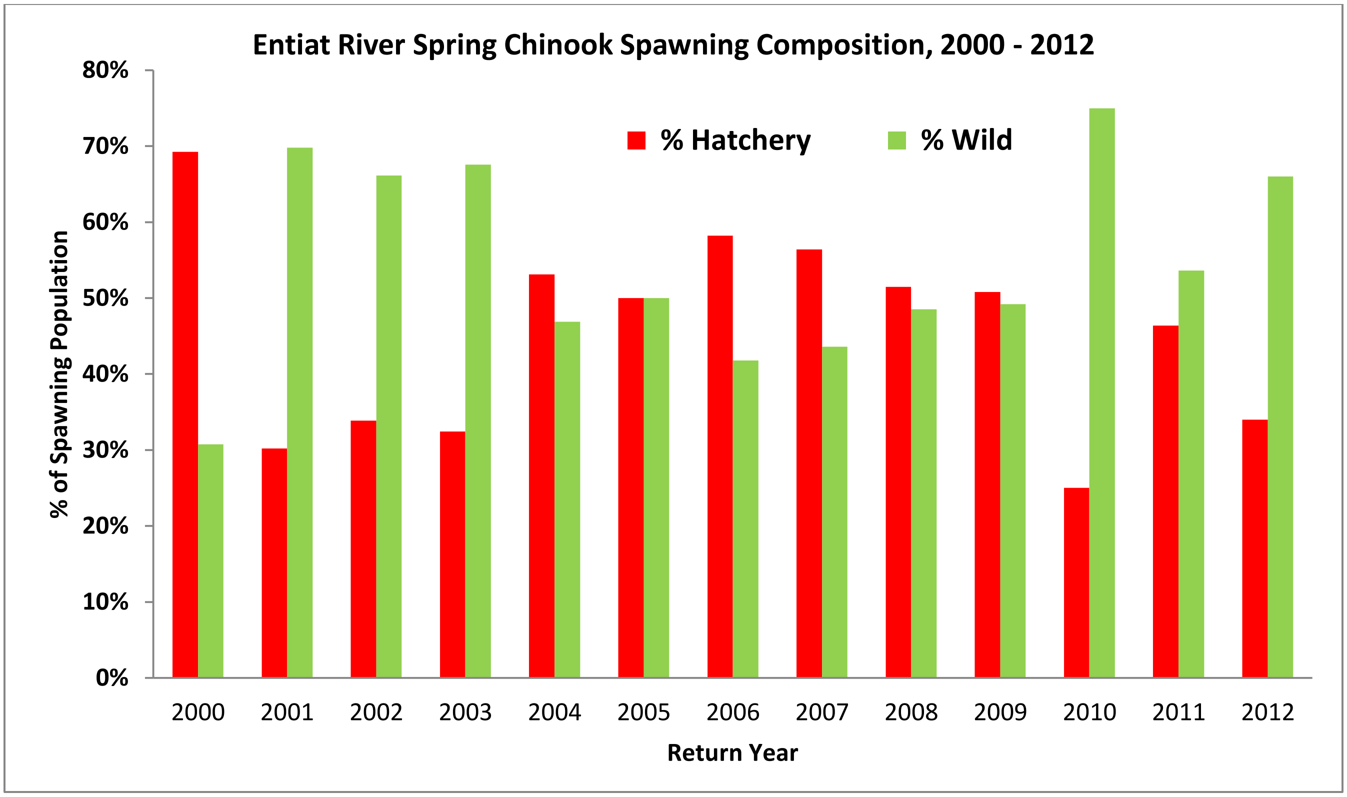


Figure 1. Entiat River spring Chinook spawning composition by rearing origin from 2000 – 2012.

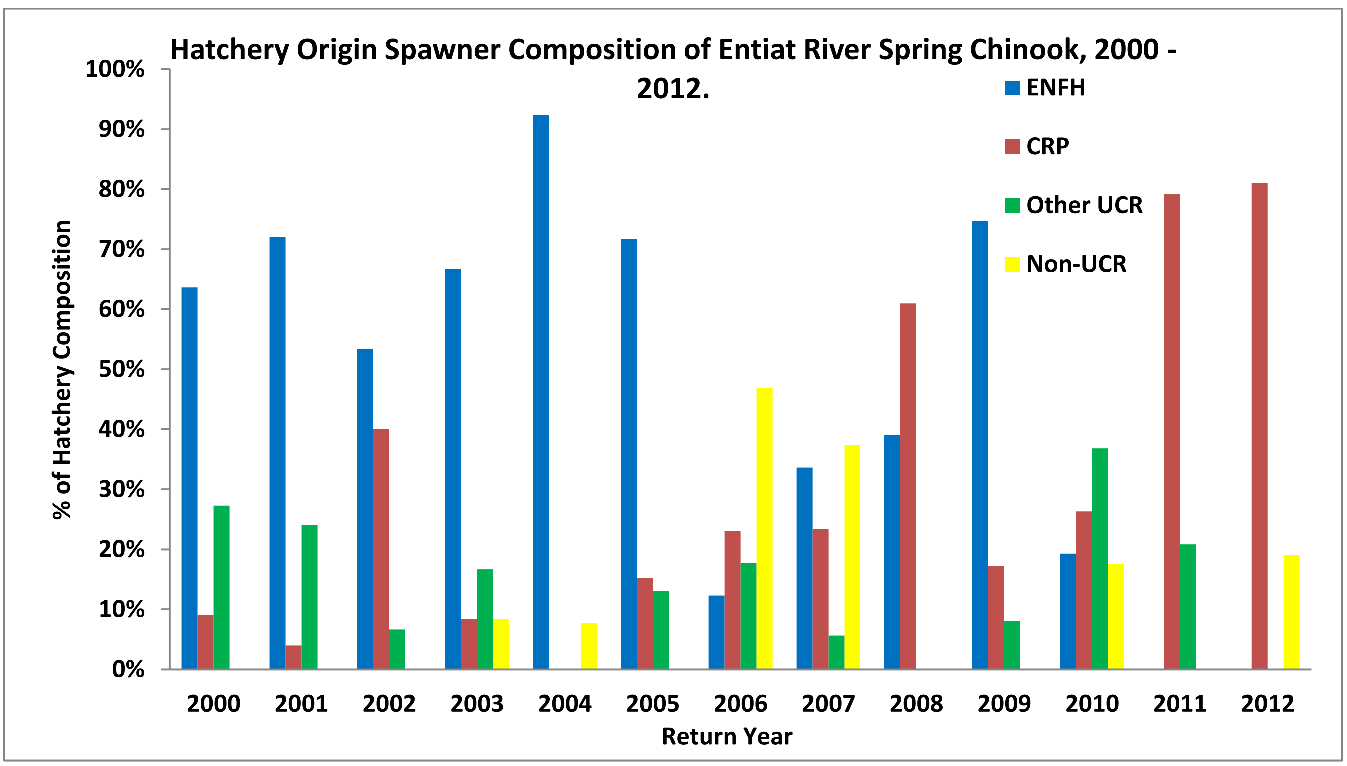


Figure 2. Entiat River hatchery origin spring Chinook spawning composition from 2000 – 2012.

Attachment C

Table 3. Detailed breakdown of the Entiat River spring Chinook spawning population, 2000 – 2012.

Var/Year	1994	1995	1996	1997*	1998	1999	2000	2001	2002	2003	2004**	2005	2006	2007	2008	2009	2010	2011	2012	AVE 00'-11'
Total Counted # Redds	34	13	20	37	24	27	73	202	112	108	126	146	107	102	116	115	204	248	229	138
Index Area # Redds	24	1	8	20	15	6	28	144	72	70	65	81	65	70	77	76	125	180	172	88
Index % of total redds	71%	8%	40%	54%	63%	22%	38%	71%	64%	65%	52%	55%	61%	69%	66%	66%	61%	73%	75%	62%
Spawning Population Exp'd by 3.5	84	4	28	70	53	21	98	504	252	245	228	284	228	357	406	403	714	868	802	382
Spawning Population Exp'd by 2.4	82	31	48	89	58	65	175	485	370	259	302	350	257	245	278	276	490	595	550	340
# Hatchery Spawners	NA	NA	10	NA	0	0	121	146	125	84	161	175	149	138	143	140	122	276	186	149
# Wild Spawners	NA	NA	38	NA	58	65	54	338	245	175	142	175	107	107	135	136	367	319	363	192
ENFH Return	80	121	175	275	216	724	1,919	2,666	1,834	872	759	763	812	627	623	532	15	0	0	952
ENFH Basin Return	80	121	175	275	216	724	1,996	2,771	1,901	928	907	889	830	673	679	597	26	0	0	1,017
#ENFH Strays on the Upriver Pop.	NA	NA	NA	NA	NA	NA	77	105	67	56	148	126	18	46	56	65	11	0	0	65
ENFH Upper River Stray Rate	NA	NA	NA	NA	NA	NA	3.9%	3.8%	3.5%	6.0%	16.3%	14.1%	2.2%	6.9%	8.2%	17.6%	90.9%	0.0%	0.0%	14%
ENFH % Influence on Spawn Pop.	NA	NA	NA	NA	NA	NA	44.1%	21.7%	18.1%	21.6%	49.0%	35.9%	7.2%	19.0%	20.1%	23.6%	4.8%	0.0%	0.0%	22%
# Useable Carcasses	5	0	6	7	7	4	31	128	68	42	43	52	73	40	80	61	84	151	117	71
% of Est. Pop Sampled	6.1%	0.0%	12.5%	7.9%	12.2%	6.2%	17.7%	26.4%	18.4%	16.2%	14.2%	14.8%	28.4%	16.3%	28.7%	22.1%	17.2%	25.4%	21.3%	20%
# Wild	0	0	4	3	7	4	8	74	41	25	15	21	28	17	33	30	63	81	78	36
# Hatchery	0	0	1	0	0	0	18	32	21	12	17	21	39	22	35	31	21	70	40	28
# Unknown	5	0	1	4	0	0	5	22	6	4	11	10	6	1	12	17	9	22	7	10
# Hatchery Age-3	NA	NA	1	0	0	0	3	0	2	2	2	4	1	6	7	6	3	41	7	6
# Hatchery Age -4	NA	NA	0	0	0	0	15	31	18	7	13	16	34	13	26	22	15	26	32	20
# Hatchery Age - 5	NA	NA	0	0	0	0	0	1	1	3	1	1	2	2	2	3	3	2	1	2
# Wild Age-3	NA	NA	0	0	0	0	0	0	0	1	0	1	2	3	1	2	2	6	2	2
# Wild Age -4	NA	NA	4	3	3	4	7	59	18	2	14	17	21	9	28	22	50	45	52	24
# Wild Age - 5	NA	NA	0	0	4	0	1	15	23	22	1	3	5	5	4	6	11	30	23	11
% Hatchery Age-3	NA	NA	100%	0%	0%	0%	17%	0%	10%	17%	13%	19%	3%	29%	20%	19%	14%	59%	18%	18%
% Hatchery Age -4	NA	NA	0%	0%	0%	0%	83%	97%	86%	58%	81%	76%	92%	62%	74%	71%	71%	38%	80%	74%
% Hatchery Age - 5	NA	NA	0%	0%	0%	0%	0%	3%	5%	25%	6%	5%	5%	10%	6%	10%	14%	3%	3%	8%
% Wild Age-3	NA	NA	0%	0%	0%	0%	0%	0%	0%	4%	0%	5%	7%	18%	3%	7%	3%	7%	3%	4%
% Wild Age -4	NA	NA	100%	100%	43%	100%	88%	80%	44%	8%	93%	81%	75%	53%	85%	73%	79%	56%	68%	68%
% Wild Age - 5	NA	NA	0%	0%	57%	0%	13%	20%	56%	88%	7%	14%	18%	29%	12%	20%	17%	37%	30%	28%
			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
% Hatchery	NA	NA	20%	NA	0%	0%	69%	30%	34%	32%	53%	50%	58%	56%	51%	51%	25%	46%	34%	46%
% Wild	NA	NA	80%	NA	100%	100%	31%	70%	66%	68%	47%	50%	42%	44%	49%	49%	75%	54%	66%	54%

Table 3 (con't). Detailed breakdown of the Entiat River spring Chinook spawning population, 2000 – 2012.

Var/Year	1994	1995	1996	1997*	1998	1999	2000	2001	2002	2003	2004**	2005	2006	2007	2008	2009	2010	2011	2012	AVE 00'-11'
ENFH Spawners	NA	NA	NA	NA	NA	NA	77	105	67	56	148	126	18	46	56	105	24	0	0	69
LNFH Spawners	NA	NA	NA	NA	NA	NA	0	0	0	0	0	23	13	0	0	11	0	57	0	9
WNFH Spawners	NA	NA	NA	NA	NA	NA	22	29	0	7	0	0	9	0	0	0	24	0	0	8
MSFH Spawners	NA	NA	NA	NA	NA	NA	11	6	8	7	0	0	5	8	0	0	21	0	0	6
CRP Spawners	NA	NA	NA	NA	NA	NA	11	6	50	7	0	27	34	32	87	24	32	218	151	44
ODFW Spawners	NA	NA	NA	NA	NA	NA	0	0	0	7	12	0	0	0	0	0	0	0	0	2
Sawtooth Spawners	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	5	0	0	0	0	0	6	0
Dworshak/Kooskia NFH Spawners	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	66	52	0	0	11	0	30	11
Nez Perce Spawners	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	11	0	0	1
							121	146	125	84	161	175	149	138	143	140	122	276	186	149
ENFH % of Spawning Population	NA	NA	NA	NA	NA	NA	44%	22%	18%	22%	49%	36%	7%	19%	20%	38%	5%	0%	0%	23%
LNFH % of Spawning Population	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	7%	5%	0%	0%	4%	0%	10%	0%	2%
WNFH % of Spawning Population	NA	NA	NA	NA	NA	NA	13%	6%	0%	3%	0%	0%	4%	0%	0%	0%	5%	0%	0%	2%
MSFH % of Spawning Population	NA	NA	NA	NA	NA	NA	6%	1%	2%	3%	0%	0%	2%	3%	0%	0%	4%	0%	0%	2%
CRP % of Spawning Population	NA	NA	NA	NA	NA	NA	6%	1%	14%	3%	0%	8%	13%	13%	31%	9%	7%	37%	27%	12%
ODFW % of Spawning Population	NA	NA	NA	NA	NA	NA	0%	0%	0%	3%	4%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Sawtooth/Clearwater % of Spawning Population	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	1%	0%
Dworshak/kooskia NFH % of Spawning Population	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	26%	21%	0%	0%	2%	0%	5%	4%
Nez Perce % of Spawning Population	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
							69%	30%	34%	32%	53%	50%	58%	56%	51%	51%	25%	46%	34%	46%
ENFH % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	64%	72%	53%	67%	92%	72%	12%	34%	39%	75%	19%	0%	0%	50%
LNFH % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	13%	8%	0%	0%	8%	0%	21%	0%	4%
WNFH % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	18%	20%	0%	8%	0%	0%	6%	0%	0%	0%	19%	0%	0%	6%
MSFH % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	9%	4%	7%	8%	0%	0%	3%	6%	0%	0%	18%	0%	0%	5%
CRP % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	9%	4%	40%	8%	0%	15%	23%	23%	61%	17%	26%	79%	81%	26%
ODFW % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	0%	0%	0%	8%	8%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Sawtooth Clearwater % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	3%	0%
Dworshak/kooskia NFH % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	44%	37%	0%	0%	9%	0%	16%	8%
Nez Perce % of Hatchery Origin Spawners	NA	NA	NA	NA	NA	NA	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	9%	0%	0%	1%
							100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Estimated CWT's																				
ENFH Exp'd CWT's	NA	NA	NA	NA	NA	NA	7	18	8	8	12	66	16	36	39	65	11	0	0	24
LNFH Exp'd CWT's	NA	NA	NA	NA	NA	NA	0	0	0	0	0	12	11	0	0	7	0	50	0	7
WNFH Exp'd CWT's	NA	NA	NA	NA	NA	NA	2	5	0	1	0	0	8	0	0	0	11	0	0	2
MSFH Exp'd CWT's	NA	NA	NA	NA	NA	NA	1	1	1	1	0	0	4	6	0	0	10	0	0	2
CRP Exp'd CWT's	NA	NA	NA	NA	NA	NA	1	1	6	1	0	14	30	25	61	15	15	190	133	30
ODFW Exp'd CWT's	NA	NA	NA	NA	NA	NA	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Sawtooth SFH/Clearwater Exp'd CWT's	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	4	0	0	0	0	0	5	0
Dworshak/Kooskia NFH Exp'd CWT's	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	57	40	0	0	5	0	26	9
Nez Perce Tribal Hat Exp'd CWT's	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Total Est. CWT's	NA	NA	NA	NA	NA	NA	11	25	15	12	13	92	130	107	100	87	57	240	164	74
Observed CWT's																				
ENFH Obs. CWT's	NA	NA	NA	NA	NA	NA	2	6	4	5	6	5	2	3	5	8	1	0	0	4
LNFH Obs. CWT's	NA	NA	NA	NA	NA	NA	0	0	0	0	0	1	2	0	0	1	0	2	0	1
WNFH Obs. CWT's	NA	NA	NA	NA	NA	NA	2	5	0	1	0	0	2	0	0	0	2	0	0	1
MSFH Obs. CWT's	NA	NA	NA	NA	NA	NA	1	1	1	1	0	0	1	1	0	0	2	0	0	1
CRP Obs. CWT's	NA	NA	NA	NA	NA	NA	1	1	6	1	0	2	8	4	17	4	3	49	28	8
ODFW Obs. CWT's	NA	NA	NA	NA	NA	NA	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Sawtooth SFH/Clearwater	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	1	0	0	0	0	3	1	0
Dworshak/Kooskia NFH	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	2	1	0	0	1	0	1	0
Nez Perce Tribal Hat	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Total Obs. CWT's	NA	NA	NA	NA	NA	NA	6	13	11	9	7	8	18	9	22	13	10	54	30	15

APPENDIX C
HABITAT CONSERVATION PLAN TRIBUTARY COMMITTEES 2012 MEETING MINUTES

Note: The Tributary Committees did not meet in April, August, September, or December of 2012.

Wells, Rocky Reach, and Rock Island HCP
Tributary Committees Notes
12 January 2012

Members Present: Dale Bambrick (NOAA Fisheries), Dennis Beich (WDFW), Lee Carlson (Yakama Nation), Tom Kahler (Douglas PUD), Steve Hays (Chelan PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Members Absent: Chris Fisher (Colville Tribes).[1]

Others Present: Becky Gallaher (Tributary Project Coordinator).

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met at the Chelan PUD Auditorium in Wenatchee, Washington, on Wednesday, 12 January 2012 from 10:00 am to 12:10 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 8 December 2011 meeting notes with edits from Tom Kahler.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Washington Rivers Conservancy-Trout Unlimited has continued work with other sponsors on coordinating the Lower Wenatchee Instream Flow Enhancement Project. As part of the coordination, TU, PWUA, and Chelan PUD signed an agreement to allow the project to continue on PUD property. After investigating potential diversion sites, it was determined that the Pioneer Property west of the highway bridge was the best diversion site. The sponsor also worked with the Washington Department of Transportation to identify easement issues associated with the project. Two public meetings were held to inform shareholders of progress and to allow for feedback. The sponsor worked with the Conservation Commission and the local conservation district to garner support for a funding request from the Irrigation Efficiency Program. The JARPA has been modified, based on the selection of the diversion site, and will be submitted in January. A Cultural Resources review has been conducted. Construction is planned for fall 2012.
- The Boat Launch Off-Channel Pond Reconnection project is complete. The sponsor (Chelan County NRD) submitted a final report.
- The Methow River (Bird) Acquisition is expected to close at the end of January.

[1] Chris Fisher voted on decision items following the meeting.

IV. Small Projects Program Application: Mission Creek Fish Passage Project

The Committees reviewed a Small Projects Program application from Cascadia Conservation District titled *Mission Creek Fish Passage Project*.

Mission Creek Fish Passage Project

The purpose of this project is to improve juvenile steelhead and Chinook salmon rearing habitat and passage, stream flows, and riparian habitat and function at four sites (between RM 2.9 and 4.5) on Mission Creek. This will be accomplished by installing four log weirs to provide primary pool habitat that will increase habitat complexity and eliminate season fish passage barriers. In addition, the sponsor will re-vegetate the stream banks to control bank erosion and improve shade in the channelized section of Mission Creek. The total cost of the project is $50,000. The sponsor requested $50,000 from HCP Tributary Funds. After careful consideration of the proposal, ***the Rock Island Committee approved funding for this project***.

The Committee voiced a concern that there is no long-term monitoring of the structures. It is possible that after 90 days a landowner could remove the structure or modify it so that it no longer allows fish passage. Dennis Beich suggested that the Committees address this issue in the future. The Committee also requested that the sponsor demonstrate that the landowners have valid water rights. Finally, the Committee would like to visit these structures sometime in the future.

V. Additional Funding Request for the White River Nason View Acquisition Project

The Chelan-Douglas Land Trust asked the Rock Island Tributary Committee for additional funds for the White River Nason View Acquisition project. Recall that this project will purchase and protect about 117 acres of unconfined floodplain and undisturbed riparian habitat along the White River (between RM 4.3 and 5.4). The property contains about 6,200 feet of riverbank. This land is surrounded by property owned by the Forest Service, WDFW, and the Chelan-Douglas Land Trust. The estimated value of the property in 2009 was $545,000. The Rock Island Tributary Committee agreed to contribute $76,635 to the project. A recent appraisal of the property identified the value of the property at $639,000. Thus, the sponsor is requesting an additional $123,365 from the Rock Island Tributary Committee.

The Rock Island Tributary Committee elected not to contribute additional funds and recommended that the sponsor seek the additional funds from the PRCC Habitat Subcommittee.

VI. SOW Change for the Chewuch Canal Instream Flow Project

The Rocky Reach Tributary Committee received a request from Washington Water Project – Trout Unlimited (WWP-TU) to change the scope-of-work on the Chewuch River Permanent Instream Flow Project. Recall that the purpose of this project is to reduce the Chewuch Canal Company's (CCC) maximum diversion from 34 cfs to 24 cfs when the Chewuch flow levels reach 100 cfs. This will result in a 10% increase in instream flow for the Chewuch River. The basis of the project is a contract between Trout Unlimited and CCC under which CCC agrees to reduce its diversions in exchange for compensation. In part, the request from WWP-TU states:

> *Our original estimate for the saved water quantity for this project was 428 ac/ft annually, 42,372 ac/ft over 99 years. WWP-TU obtained and analyzed additional historic data including hydrographic records and irrigation records to estimate the acre-foot water quantities that will remain instream. Because this agreement is triggered by river flows, the actual amount of water returned for instream flows will change from year to year.* ***Annual diversion reductions during the irrigation season resulting from this***

> ***agreement are on average about 640.8 ac/ft per season based on historical CCC average diversions for the past 20 years and USGS records for flows in the Chewuch River.*** *Climate change modeling specific to the Methow subbasin indicates that climate change will result in an earlier and higher peak flows and earlier and loser base flows in the Methow River. We believe that under this agreement the average annual amount of water returned instream is likely to significantly increase if climate change models are accurate.. This additional water available instream under the terms of this agreement will provide additional protection for aquatic habitat as the Methow River hydrograph shifts, making this project important as a climate change adaption project. In addition, as stated above while working with NOAA Fisheries and others on this project WWP-TU was asked to look at options to help CCC stop filling their reservoir from the Chewuch River in October and November after irrigation ceased annually on October 1. These additional diversions outside the irrigation season under their existing reservoir permit while the river had reached base flows were adversely affecting spring Chinook spawning and rearing and steelhead and bull trout rearing. In the event of climate change and thus increased shareholder demand for water at the same time as the hydrograph shifts unfavorably for irrigation, it is very likely that without this project, CCC would be required to divert 1000 ac/ft annually in October and November.* ***The total saved water on an annual basis is estimated at 1640.8 ac/ft per year. Over the lifetime of the project (99 years) the cost is estimated at around $10.00 per af/ft.***
>
> *When we submitted the proposal to the Trib fund in 2010 we estimated the cost of the project at $1.2 million. Cost estimates based on the current design are estimated at closet to $1.65 million. The increase in cost is largely based on the changes required to the current infrastructure at the Lake Creek location to allow spring fill of the reservoir. This was not anticipated in the original proposal.*
>
> *This project was anticipated to get off the ground late 2010, early 2011 so we would have the water instream in 2012. We are a year behind at this point so we are not entirely clear (depends on the permitting and water right change) how much construction we can get completed in 2012. It is likely some construction will take place in 2013.*

After carefully reviewing the information contained in the request, the Rocky Reach Tributary Committee concluded that they could not determine exactly what the sponsor was requesting. It was not clear if the sponsor was requesting a change in scope-of-work, an increase in funding, a time extension, or some combination of these. Therefore, the Committee directed Tracy Hillman and Becky Gallaher to seek additional information from the sponsor. Specifically, the sponsor needs to identify what was originally proposed, what they are now proposing, and exactly what the sponsor is requesting from the Committee.

VII. Review of Policies and Procedures Documents

Tracy Hillman asked if the Committees had any changes or edits to the Policies and Procedures for Funding Projects and the Tributary Committee Operating Procedures documents. In the Policies and Procedures document under Section 3.6, The Small Projects Program, the Committees agreed to increase the maximum contract allowance from $50,000 to $75,000. Thus, the total cost of a small projects proposal cannot exceed $75,000 (including matches). In the same document under Section 4.3, Ineligible Projects and Elements, the Committees agreed to remove the bullet stating, “Purchase of equipment necessary to implement or monitor a restoration or protection project funded by the Committees.” The Committees will approve the purchase of equipment on a case-by-case basis (e.g., purchase of gloves and pliers may be OK, but the purchase of total stations and excavators would not). ***The Committees directed Tracy to make the edits to the Policies and Procedures document.***

VIII. Tributary Assessment Programs

The Committees discussed how they could implement the Tributary Assessment Programs. According to the HCPs, the purpose of the Tributary Assessment Program is to monitor and evaluate the relative performance of the tributary enhancement projects approved by the Committees. It is not the purpose of the program to measure whether the Plan Species Accounts have provided a 2% increase in survival for Plan Species. Rather, the program will ensure that Plan Species Account dollars are used in an effective and efficient manner. Funding for the Assessment Program is separate from the Plan Species Accounts and shall not exceed $200,000 per account. Currently, some funds from the Wells Tributary Assessment Program are used to help evaluate a large enhancement project in Canada (ORRI project).

The Committees discussed using some of the Tributary Assessment Program funds to evaluate appraisals. About 52% of Plan Species Account funds have been spent on protection projects (acquisitions and conservation easements). The costs of acquisitions and easements have continually increased even though the market has struggled during the last several years. Thus, the Committees see a need to evaluate the appraisals received from project sponsors. In short, funds from the Tributary Assessment Programs could be used to conduct independent appraisals of appraisals. The Committees would like to think about this and discuss it again in the future.

Tracy asked if the Committees would like a spreadsheet that shows the total cost of each acquisition/conservation easement funded through the Plan Species Account. The spreadsheet would include the name of the project, name of the sponsor, total acres of the acquisition/easement, total cost of the acquisition/easement, cost per acre, amount funded by the Committees, and the Plan Species Account. The Committees directed Tracy and Becky to build the spreadsheet.

IX. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in December and January:

   Rock Island Plan Species Account:

   - $29,793.35 to Chelan County Treasurer for work on the Boat Launch Off-Channel Pond Reconnection project. This project is now complete.
   - $16,094.25 to Cascade Columbia Fisheries Enhancement Group for the Assessing Nutrient Enhancement Logistics project. This project is now complete.
   - $679.43 to Chelan County PUD for project coordination during the fourth quarter of 2011.
   - $190.00 to Larson Allen for fourth-quarter financial management and reporting.

   Rocky Reach Plan Species Account:

   - $623.07 to Cascadia Conservation District for administration and riparian plantings for the Below the Bridge project.
   - $329.43 to Chelan County PUD for project coordination during the fourth quarter of 2011.
   - $190.00 to Larson Allen for fourth-quarter financial management and reporting.

   Wells Plan Species Account:

- $108,436.21 to Baines Title Company for the Methow River Acquisition 2010 MR 48.7 (Bird) project.
- $329.47 to Chelan County PUD for project coordination during the fourth quarter of 2011.

2. Becky Gallaher reported that she declined a payment request of $144.00 to Cascadia Conservation District for administration on the Roaring Creek Flow Enhancement project. Recall that this project was pulled in June 2011 because of a significant change in the scope-of-work.
3. Tracy Hillman reported that Chelan and Douglas PUDs will be submitting their Draft 2012 Action Plans to the Coordinating Committees in February. Tom Kahler provided the Committees with the Draft Wells HCP Tributary Committee Action Plan for 2012. The 2012 Draft Action Plan for the Wells Tributary Committee is as follows:

Plan Species Account Annual Contribution

- $176,178 in 1998 dollars: January 2012

Annual Report – Plan Species Account Status

- Draft to Committee: February 2012
- Approval Deadline: March 2012
- Period Covered: January to December 2012

2012 Funding-Round: General Salmon Habitat Program

- Request for Project Pre-proposals *To be determined* (March)
- Pre-proposal to TC *To be determined* (early May)
- Tours of Proposed Projects *To be determined* (late May)
- Project Sponsor Presentations to TC *To be determined* (early June)
- Final Project Proposals to TC *To be determined* (early July)
- RTT Project Rating Decision *To be determined* (July)
- Supplemental Sponsor Presentations *To be determined* (September)
- TC Final Funding Decisions *To be determined* (before Dec.)

Small Projects Program

- Project Review and Funding Decision Applications accepted anytime

Tributary Assessment Program

- Proposals for year-5 of 5 for ORRI March 2012
- Develop plan for remaining funds March 2012
- Implement monitoring plan *To be determined* (2012)
- Monitoring plan final product December 2012

The Wells Tributary Committee accepted the Wells Action Plan for 2012. The Committees will review the Rocky Reach and Rock Island 2012 Draft Action Plans in February.

4. Tracy Hillman reported that he and Becky Gallaher have completed Section 2.6 (Tributary Committees and Plan Species Accounts) for the Annual Report of Activities under the Anadromous Fish Agreement and Habitat Conservation Plan for each hydroelectric project. Members of the Committees should soon receive the draft reports for their reviews. The final reports will be submitted to the Federal Energy Regulatory Commission in April. Financial activities in 2011 for each of the Plan Species Accounts are appended as Attachment 1.

5. Tracy Hillman shared with the Committees the draft schedule for proposal development, submission, and review of SRFB/GSHP/BPA projects (see Attachment 2). Currently, pre-proposals would be delivered to the Tributary Committees on 7 May and the Committees would review the pre-proposals during their May and June meetings (10 May and 14 June). Project tours are scheduled for 21-24 May and pre-proposal presentations would occur on 13 June. Final proposals would be delivered to the Tributary Committees on 29 June. The Committees would conduct an initial review of the final proposals during their July meeting (12 July) and determine if supplemental tours of selected projects are necessary. Supplemental tours would occur in September and, if necessary, sponsors would be invited to present their projects to the Committees in October. The Committees would make final funding decisions in November or December.

   The Committees voiced some concern with the proposed dates for the project tours. Because of conflicts with the HCP Coordinating Committees meeting, it would be better to tour Wenatchee/Entiat projects early in the week and Methow/Okanogan projects later in the week. Tracy will share this concern with Derek Van Marter.

6. Tracy Hillman reported that funds will be deposited into each of the Plan Species Accounts at the end of January. The amounts deposited will be about $656,000 into the Rock Island Account, $311,000 into the Rocky Reach Account, and $238,000 into the Wells. Exact amounts deposited into each account will be provided during the February meeting.

X. Next Steps

The next meeting of the Tributary Committees will be on Thursday, 9 February 2012 at Chelan PUD in Wenatchee.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Attachment 1
Plan Species Account Financial Statements for 2011

Chelan County PUD
Rock Island Hydroelectric Project
Habitat Conservation Plan
Plan Species Cash Account Activity
Annual Financial Report Per Section 7.4.3
Reporting Period: 1/1/2011 - 12/31/2011

Beginning Balance:	**1/1/2011**		**$ 2,997,035.74**
Transfers In:			
Rock Island Funding		655,882.00	
Interest Earnings		13,834.63	
Total Transfers In			669,716.63
Transfers Out:			
Payments		(236,061.20)	
Bank Service Fees		(95.30)	
Total Transfers Out			(236,156.50)
Ending Balance:	**12/31/2011**		**$ 3,430,595.87**

The Plan Species Account was established per the Rock Island Habitat Conservation Plan, Section 7.4. Interest earnings shall remain in the Account in accordance with Appendix E, Section 7.4.1.

Chelan County PUD
Rocky Reach Hydroelectric Project
Habitat Conservation Plan
Plan Species Cash Account Activity
Annual Financial Report Per Section 7.4.3
Reporting Period: 1/1/2011 - 12/31/2011

Beginning Balance:	**1/1/2011**		**$ 1,761,278.01**
Transfers In:			
Rocky Reach Funding		310,638.00	
Interest Earnings		7,455.55	
Total Transfers In			318,093.55
Transfers Out:			
Payments		(174,224.94)	
Bank Service Fees		(94.80)	
Total Transfers Out			(174,319.74)
Ending Balance:	**12/31/2011**		**$ 1,905,051.82**

The Plan Species Account was established per the Rocky Reach Habitat Conservation Plan, Section 7.4. Interest earnings shall remain in the Account in accordance with Appendix E, Section 7.4.1.

Annual Report of Wells Plan Species Account Financial Activity
For the Year Ended December 31, 2011
As required by Section 7.3.7.2 of the Wells Hydroelectric Project HCP

Beginning cash and investment balance 01/01/2011			$ 739,492.33
Sources:			
Annual payment from Douglas PUD per Section 7.4 of HCP		$ 238,153.00	
Interest earnings		3,481.71	
	Total Sources		241,634.71
Uses:			
Project #	Description		
1101	Methow River Acquisition - Bird	2,008.14	
1102	Methow River Acquisition - Hoffman	4,373.02	
1103	Methow River Acquisition - Risley	26,407.24	
	Total for Projects	32,788.40	
0699	Chelan PUD	3,501.69	
0699	Douglas PUD	2,128.00	
	Total for Administration	$ 5,629.69	
	Total Uses		38,418.09
Ending cash and investment balance 12/31/2011			$ 942,708.95

Wyatt W. Scheibner, Treasurer
PUD No. 1 of Douglas County

Attachment 2
Proposed 2012 SRFB/GSHP/BPA Schedule

2012 UPPER COLUMBIA PROCESS SCHEDULE

SRFB/TRIB/BPA

Project Proposal Development, Submittal, and Review

DATE	ACTIVITY/MILESTONE (MEETING/DEADLINE)
FEBRUARY	
9 February	SRFB/TRIB Debrief of 2011 (afternoon)
28 February	IT Funding Coordination Meeting (all day)
MARCH	
March	SRFB/Tributary Fund cycles announced; SRFB Policy Manual available; Regional Process Guide Revisions
APRIL	
5 April	SRFB/TRIB/BPA Kickoff Meeting for the Region; RCO presentation; RTT Technical criteria presentation; CAC criteria presentation
April	Project Sponsors develop projects and pre-proposal (materials available from http://www.ucsrb.com)
MAY	
7 May	**Pre-proposals due to LE Coordinators –** delivered to RTT, TRIB (via TRIB ftp site) and SRFB Panel Members (via PRISM)
14 May	Conference Call to discuss project tour logistics (RTT, LEs, Trib and UCSRB)
21-24 May	SRFB/TRIB/BPA project tours (*subject to change pending final pre-proposals*) • 21st – Okanogan • 22nd – Methow • 23rd – Wenatchee • 24th – Entiat
JUNE	
13 June	Pre-proposal Presentation Workshop: review pre-proposals with RTT, TRIB and CAC's
14 June	TRIB internal review of pre-proposals
June	Proposal refinement based on technical feedback. Two weeks after visiting projects, the State Technical Review Panel will post comments in SharePoint for lead entities and grant applicants. Grant applicants should update their applications to address any Review Panel concerns and attach their responses to Review Panel comments in PRISM with their application. The Review Panel will "flag" projects that it believes would benefit from additional review at the regional area project meeting.

29 June	**Final project proposals due to LE Coordinators –** delivered to RTT, TRIB (via TRIB ftp site) and RCO (via PRISM)
JULY	
6 July	**Grant applicants update applications in PRISM to address Review Panel concerns from initial site visit and review.**
11 July	RTT Meeting: formal project reviews and technical ranking
12 July	Review Panel discusses “flagged” projects and updates the review forms. Panel will meet either in person or via conference call to provide full panel feedback on “flagged” projects.
12 July	TRIB final review of proposals
23 July	Final comments from TRIB will be via e-mail to LE for distribution to project sponsors
AUGUST	
August (TBD)	Okanogan and Chelan CAC project rankings
10 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (early optional date)**
22 August	Regional joint CAC approves final combined ranked list
24 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (final due date)**
SEPTEMBER	
September	TRIB supplemental tours of selected projects (project sponsors will be notified in advance of visit). TRIB makes initial internal decisions.
14 September	**Regional organizations submit their recommendations for funding and responses to the information questionnaire**
26-29 September	Regional presentations to State Technical Review Panel
OCTOBER	
October	Project Presentations to TRIB (*if needed*)
6 October	Comment forms available from State Technical Review Panel
18 October	Comments due on State Technical Review Panel draft report
NOVEMBER	
16 November	**Final 2011 funding report delivered to SRFB**
DECEMBER	
12-13 December	SRFB makes funding decisions
December (TBA)	TRIB makes supplemental decisions

Acronyms

CAC Citizen's Advisory Committee
BPA Bonneville Power Administration
IT Implementation Team
LE Lead Entity
RCO Recreation and Conservation Office
SRP State Review Panel
SRFB Salmon Recovery Funding Board
TRIB HCP Tributary Committee

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 9 February 2012

Members Present: Dale Bambrick (NOAA Fisheries), Dennis Beich (WDFW), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Members Absent: Tom Kahler (Douglas PUD).[1]

Others Present: Becky Gallaher (Tributary Project Coordinator).

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met at the Chelan PUD First Floor Conference Room in Wenatchee, Washington, on Wednesday, 9 February 2012 from 10:30 am to 12:00 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 12 January 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher stated that there are no updates on funded projects.

IV. Review of Policies and Procedures Documents

The Committees revisited the maximum allowance for small projects described under Section 3.6 in the Policies and Procedures for Funding Projects document. Last month the Committees agreed to increase the maximum contract allowance for small projects from $50,000 to $75,000. Chris Fisher suggested that the maximum allowance for small projects should be increased to $100,000. He offered the following reasons: (1) there is less likelihood that a small project proposal will be part of a larger project; (2) funding would be more responsive and timely as opposed to the proponent waiting to submit a General Salmon Habitat Proposal and then waiting for the lengthy review process; and (3) there may be more opportunities to fund small-scale projects. After discussion, the Committees agreed to increase the maximum contract allowance from $75,000 to $100,000. Thus, the total cost of a small projects proposal cannot exceed $100,000 (including matches). ***The Committees directed Tracy to make the appropriate changes in the Policies and Procedures document.***

The Committees also reviewed Section VII, Full Disclosure, in the Operating Procedures document. The last sentence in Section VII states, “Committee members should recuse themselves from voting on a particular project if they represent an entity that may benefit from

[1] Tom Kahler provided his votes on decision items before the meeting.

that project." The Committees recommended that the sentence be changed to, "Committee members who represent an entity that submitted a project proposal will not vote on that particular project." ***The Committees directed Tracy to make the edits in track changes. The Committees will review the edits during the next meeting.***

V. Review of 2012 Draft HCP Action Plans

Tracy Hillman reported that Chelan and Douglas PUDs asked the Tributary Committees to review and approve their 2012 Draft HCP Action Plans. The 2012 Action Plan for both Rocky Reach and Rock Island Tributary Committees is as follows:

- Plan Species Account Deposit: January 2012
- Project solicitation: To be determined
- Project approval deadline: To be determined
- Project implementation: Ongoing

The Rocky Reach and Rock Island Tributary Committees approved the Rocky Reach and Rock Island Action Plan for 2012.

The 2012 Draft Action Plan for the Wells Tributary Committee is as follows:

Plan Species Account Annual Contribution

- $176,178 in 1998 dollars: January 2012

Annual Report – Plan Species Account Status

- Draft to Committee: February 2012
- Approval Deadline: March 2012
- Period Covered: January to December 2012

2012 Funding-Round: General Salmon Habitat Program

- Request for Project Pre-proposals *To be determined* (March)
- Pre-proposal to TC *To be determined* (early May)
- Tours of Proposed Projects *To be determined* (late May)
- Project Sponsor Presentations to TC *To be determined* (early June)
- Final Project Proposals to TC *To be determined* (early July)
- RTT Project Rating Decision *To be determined* (July)
- Supplemental Sponsor Presentations *To be determined*
- TC Final Funding Decisions *To be determined* (before Dec.)

Small Projects Program

- Project Review and Funding Decision Applications accepted anytime

Tributary Assessment Program

- Proposals for year-5 of 5 for ORRI March 2012
- Develop plan for remaining funds March 2012

- Implement monitoring plan — *To be determined* (2012)
- Monitoring plan final product — December 2012
- TC delivers final product to CC — January 2013

The Wells Tributary Committee approved the Wells Action Plan for 2012.

VI. Mission Creek Fish Passage Project

Last month the Rock Island Tributary Committee approved funding for the Mission Creek Fish Passage Project. The purpose of the project was to install four log weirs, which should improve stream flows and enhance juvenile steelhead and Chinook salmon rearing habitat and passage in Mission Creek. The total cost of the project was $50,000.

During review of the proposal, the Rock Island Committee noted that there was no long-term requirement to maintain the structures. The Committee also requested that the sponsor verify that the landowners have valid water rights. Finally, the Committee would like to visit these structures sometime in the future. In his letter to the sponsor, Tracy asked the sponsor to respond to these concerns.

In a recent email to Becky Gallaher, Kurt Hosman, Cascadia Conservation District, indicated that he will modify the language in the agreements to include an extended period of maintenance (he will try to extend the period out 10 years). Kurt also provided the Committee with copies of the water rights for each landowner. The Committee reviewed the water rights and determined that they were valid. Finally, Kurt indicated that he will write into the access clause of the agreements that the Committee will be allowed to visit these structures within two years of post-construction.

VII. SOW Change for the Chewuch Canal Instream Flow Project

Last month the Rocky Reach Tributary Committee received a request from Washington Water Project – Trout Unlimited (WWP-TU) asking for a change in the scope-of-work on the Chewuch River Permanent Instream Flow Project. After carefully reviewing the information contained in the request, the Rocky Reach Tributary Committee concluded that they could not determine exactly what the sponsor was requesting. It was not clear if the sponsor was asking for a change in scope-of-work, an increase in funding, a time extension, or some combination of these. Therefore, Becky Gallaher contacted Lisa Pelly, WWP-TU, and asked if she would provide the Committee with a proposal describing exactly what WWP-TU was requesting from the Committee. Lisa indicated that they were simply seeking a change in the schedule. Because the schedule change they were requesting does not require approval from the Committee, the sponsor withdrew their request.

VIII. Silver Protection Project

Last year the Washington Department of Fish and Wildlife (WDFW) submitted a proposal under the General Salmon Habitat Program titled *Silver Protection*. The purpose of the project was to protect about 45 acres along the Methow River downstream from the Town of Twisp. The conservation easement/acquisition would include about 3,500 feet of spring-fed, perennial channel. The total cost of the project was $660,000. The Wells and Rocky Reach Committees elected to contribute $250,000 to the project ($125,000 from each account).

Because the Committees found the proposal lacking in several areas, they made funding contingent on receiving more information. Specifically, the Committees asked for the following information:

1. An example of the management plan for the acquisition and easement.

2. A description of conditions in the easement and of the landowner's intended use of the easement.
3. Indication that the management plan for the property will include language that the property may receive habitat restoration activities if deemed appropriate. Additionally, as a condition of this funding, the Committees must approve any restoration actions on this property.
4. A more detailed and itemized land-management budget (the proposal indicates that only $15,000 is needed for land management, which includes weeds, fencing, etc.). In addition, the sponsor must indicate where and how much fencing is proposed.

The Committees recently received a letter from Ken Bevis, WDFW, responding to the information request from the Committees (see Attachment 1). Ken also provided an example of WDFW's management plan.

After reviewing the letter, the Committees were mostly satisfied with the responses from WDFW. Lee Carlson questioned the major restoration work that WDFW proposes to do on the property. Specifically, Lee was concerned about the possibility that other entities (e.g., the Yakama Nation) would not be allowed to implement restoration actions on the property. Dennis Beich indicated that WDFW has plans to conduct restoration work and would likely work with others intending to do restoration work on the property. ***Each Committee agreed to contribute $125,000 to the project.***

IX. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in January and February:

   Rock Island Plan Species Account:

   - $220.00 to Trout Unlimited for legal services on the Lower Wenatchee Instream Flow Enhancement Project.

   Rocky Reach Plan Species Account:

   - $92.27 to Cascadia Conservation District for project materials on the Entiat National Fish Hatchery Habitat Improvement Project.

   Wells Plan Species Account:

   - $1,531.40 to the Methow Salmon Recovery Foundation for surveying and project administration on the Methow River Acquisition 2010 (Hoffman) Project.
2. Becky Gallaher reported that the PUDs deposited funds into each of the Plan Species Accounts at the end of January. Chelan PUD deposited $673,450 into the Rock Island Account and $318,959 into the Rocky Reach Account. Following the meeting, Tom Kahler reported that Douglas PUD deposited $244,533 into the Wells Account.
3. Tracy Hillman indicated that he will attend the SRFB/TC Debrief Meeting on 22 February in Wenatchee. The purpose of the meeting is to: (1) review what worked well during the 12th round and what needs improvement; and (2) establish plans, expectations, and a timeline for the SRFB 13th round. Tracy will also announce during the debrief meeting that the Tributary Committees have increased the cap on Small Projects from $50,000 to $100,000.

4. Becky Gallaher shared with the Committees a draft spreadsheet that shows project name, sponsor, total acres, total cost, cost/acre, and property information for all acquisitions and conservation easements funded by the Tributary Committees. The Committees reviewed the draft spreadsheet and recommended additional columns showing the closing date for each project and whether the project was a conservation easement or acquisition. Becky and Tracy will update the spreadsheet and share it with the Committees during the next meeting.

X. Next Steps

If necessary, the next meeting of the Tributary Committees will be on Thursday, 8 March 2012 at Chelan PUD in Wenatchee.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Attachment 1
Letter from Ken Bevis, WDFW, Regarding Silver Protection

State of Washington

Department of Fish and Wildlife

Winthrop Field Office: 350 Bear Creek Rd, Winthrop WA, 98862

February 1, 2012

To: Wells and Rocky Reach Tributary Committee

From: Ken Bevis, WDFW Watershed Steward

Re: Answers to questions in regard to Silver Protection Project grant

Dear Tributary Committee:

Thank you for supporting WDFW's request for funds on the Silver Protection Project. This note is in response to your request for additional information. I will answer the questions to the best of my ability herein.

First, the lands will be managed as a block of the Methow Wildlife Area, on the west side of the Methow River, adjacent to the Golden Doe Unit. Land management will follow the guidelines and stewardship standards utilized on all of the Methow Wildlife Area. This plan is referenced here.

Specific Questions in letter from Tributary Committee:

1. *Please provide an example of the management plan for the acquisition and easement*.

   Methow Wildlife Area Plan – The WDFW Management Plans for our wildlife areas address many issues associated with long term, holistic land management. First and foremost, our key objectives is to provide habitat for healthy and diverse fish and wildlife populations, through sound stewardship, monitoring and management. The plan can be accessed via WDFW's web site, in the Conservation Tab. The citation is:

Washington Department of Fish and Wildlife. 2006. Methow Creek Wildlife Area Management Plan. Wildlife Management Program, Washington Department of Fish and Wildlife, Olympia. 97 pp.

Easement Example: WDFW's real estate program manages the terms and negotiations for easements held in our name. The specific terms of each easement can be negotiated on a case by case basis, but the attached example contains our general terms.

2. *What are the conditions in the easement? What does the landowner intend to do on the easement?*

Specific terms for any easement can be negotiated. In the specific case of the Silver Protection project, a minority portion of the lands would be placed in a conservation easement, adjacent to the homesites maintained by the landowner, and the waterway. Normal agricultural activities could continue there, particularly continuance of an existing hay field. Specific exclosure distances, likely a minimum of 100 feet, from the edge of the water would be established to protect riparian plantings and vegetation. Fencing would be required to prevent future livestock from being near the water.

3. *Please indicate that the management plan for the property will include language that the property may receive habitat restoration activities if deemed appropriate. Additionally, the Committees must approve any restoration actions on this property.*

The acquisition by WDFW and subsequent management planning will include provisions for the restoration project. The easement will also contain conditions that allow access for a restoration project to occur here. The project itself would largely be on either WDFW lands, or within waters of the state in the channel itself.

The Silver Side Channel has been degraded into a wide shallow channel, likely from many years of intensive grazing, and is in need of restoration. Restoration work will include plantings and instream installation of wood and (possibly) other materials that would narrow and deepen these flows. The ability to do this work has been agreed to with the landowner, and will be formalized in the easement agreement.

The major restoration project anticipated is not funded at this time, and will require significant planning and potentially fund raising. As the project develops we will keep the Tributary Committee fully informed as to the developments. It will also undoubtedly undergo the significant scrutiny of the Upper Columbia Salmon Recovery Board, Regional Technical Team, many members of which are closely associated with the Tributary committee.

4. The proposal indicates that $15,000 will be needed for land management, which includes weeds, fencing, etc. Please provide a more detailed and itemized

> *land management budget. In addition, indicate where and how much fencing is needed.*

At this time, I do not have detailed information as to the necessary level of weed control intended for the property. Fencing is already present on the adjacent WDFW lands along the west side of the channel in the lower half of the project. We anticipate a need to mirror this fencing on the east side, with approximately 1/2 mile of wire fencing required. Estimated numbers from Methow Wildlife Area staff appear below.

Weed control – equipment, chemicals, staff - $5,000
Fence construction – materials and staff - $10,000

I hope that this memorandum adequately answers the questions posed by the Tributary Committee.

Thank you for accepting our grant application for the Silver Protection Project.

Sincerely,

Kenneth R. Bevis
WDFW Upper Columbia Watershed Steward

Attachment:
Example of WDFW Easement Agreement.

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 8 March 2012

Members Present: Dale Bambrick (NOAA Fisheries), Dennis Beich (WDFW), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Others Present: Becky Gallaher (Tributary Project Coordinator).

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met at the Chelan PUD Auditorium in Wenatchee, Washington, on Thursday, 8 March 2012 from 10:00 am to 12:00 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda with additional discussion items from Dale Bambrick, Kate Terrell, and Tracy Hillman.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 9 February 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Wenatchee River Instream Flow Enhancement – The project is set to begin construction in the fall of 2012. All cultural resource work has been completed, including the new point-of-diversion site, and the sponsor (Trout Unlimited – WWP) expects to have the Department of Archaeology and Historic Preservation concurrence by the end of March. The Army Corps of Engineers permit is being reviewed and approval from the USFWS and NOAA is anticipated. Currently, the outstanding issue is the water right change. The sponsor is working closely with Washington Department of Ecology (WDOE) to identify certainty of expedience on the process.
- Upper White Pine CPUD Power Line Alternatives Analysis - The contractor (HDR Engineering) has completed two drafts of the alternatives analysis memo and has received comments from both the sponsor (CCNRD) and Chelan PUD. The Sponsor will send Becky the draft memo by mid-March.
- Mission Creek Fish Passage Project – The sponsor (Cascadia Conservation District) asked the Rock Island Tributary Committee for an additional $10,000 for the fish passage improvement project on Mission Creek. The additional money would be used for contingencies. The Rock Island Committee rejected the additional funding request.
- White River Van Dusen Conservation Easement – The project is complete and a final report will be submitted to the Rock Island Tributary Committee.

- White River Nason View Acquisition – This project is expected to close at the end of March.
- Chewuch River Instream Flow Project – This project is moving forward quickly on several fronts. The sponsor (Trout Unlimited – WWP) has completed all documents to allow for the change in water right with WDOE. The sponsor has also started significant outreach with local landowners along the ditch. Project engineers are working to finalize the drawings for the Lake Creek part of the project. Final drafting of all of the JARPA documents are close to completion.
- Nutrient Enhancement Assessment – The project contractor (Water Quality Engineers) has started compiling information for the development of a Quality Assurance Project Plan (QAPP) for WDOE. Over the next several months, the sponsor (Cascade Columbia Fisheries Enhancement Group), TU, and Water Quality Engineers will be focusing on data collection protocols and the QAPP.
- Large Wood Atonement Project – To date, the sponsor (Cascade Columbia Fisheries Enhancement Group) has (1) completed cultural resources consultation with the USFWS; (2) conducted initial outreach meetings; (3) coordinated topo and geotech surveys; (4) coordinated with the Sheriff's office to allow motorized use on the White River; and (5) completed and received a temporary use permit from WDFW.

IV. Review of Policies and Procedures Documents

During the last meeting, the Committees reviewed Section VII, Full Disclosure, in the Operating Procedures document. The last sentence in Section VII states, "Committee members should recuse themselves from voting on a particular project if they represent an entity that may benefit from that project." The Committees recommended that the sentence be changed to, "Committee members who represent an entity that submitted a project proposal will not vote on that particular project." ***The Committees approved the change to the Operating Procedures document.***

The Methow Conservancy contacted Tracy Hillman and asked for clarification on the Committees' policy on public access on protection projects. After reviewing Section 3.8 in the Policies and Procedures document, the Committees directed Tracy to add draft language that states, "The Tributary Committees reserve the right to require public access on conservation easements or lands acquired with Plan Species Account funds." Note that this statement does not require public access on all easements or acquisitions. However, if the Committees believe that a given protection project should have public access, they will make it a requirement for that specific project. Thus, the Committees will evaluate public access on a case-by-case basis. If a project sponsor believes that a particular protection project should have no public access, the sponsor will need to demonstrate why this is so in their proposal to the Committees. The Committees will review the draft language during their next meeting.

V. Review of Landowner Agreement for Restoration Projects

Cascadia Conservation District asked the Rock Island Tributary Committee to review their Landowner Agreement for Restoration Projects. This is the agreement that will be signed by the Landowner and Grantee. The Committee reviewed the agreement in detail and requested that the sponsor add the following language to the section titled, The Grantee agrees to:

- ***For the duration of this agreement, the Grantee will annually monitor the structures using photo points to make sure the structures are functioning as designed.***

Tracy Hillman will add this language in track changes to the Landowner Agreement and send it to Cascadia Conservation District.

VI. Nutrient Enhancement Design Subcontract Agreement

The Cascade Columbia Fisheries Enhancement Group (CCFEG) asked the Rock Island Tributary Committee to review their subcontract agreement with Water Quality Engineering, Inc. CCFEG is requesting that Water Quality Engineering assist CCFEG with the Wenatchee Nutrient Enhancement Design Project that was in part funded by the Rock Island Committee. ***The Committee reviewed all sections of the agreement for consulting services, including the scope of work, and approved the subcontract agreement.***

VII. Evaluation of Appraisals

During the January meeting, the Committees discussed how they could implement the Tributary Assessment Programs. According to the HCPs, the purpose of the Tributary Assessment Program is to monitor and evaluate the relative performance of the tributary enhancement projects approved by the Committees. During the January meeting, the Committees discussed using some of the Tributary Assessment Program funds to evaluate appraisals. About 52% of Plan Species Account funds have been spent on protection projects (acquisitions and conservation easements). The costs of acquisitions and easements have continually increased even though the market has struggled during the last several years. Thus, the Committees would like to use some of the funds from the Tributary Assessment Programs to conduct an independent appraisal of appraisals.

The Committees identified two primary questions:

1. Are the appraisals properly capturing the value of the market?
2. Are the costs of acquisitions and conservation easements appropriate?

As a first step in addressing these primary questions, the Committees would like a description of the training that is required to conduct appraisals. Secondly, the Committees would like input from economists at local universities. They directed Tracy and Becky to contact economists at local universities to see what it would cost to conduct an independent evaluation of the appraisals. At the same time, Dale Bambrick will speak with Peter Dykstra about evaluation of appraisals. Finally, the Committees would like a time series plot showing the relationship between costs of protection projects in the Upper Columbia (costs/acre) and indices of property values nationwide, statewide, and countywide.

VIII. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in February and March:

   Rock Island Plan Species Account:

   - $66,000.00 to North Meridian Title for the White River Nason View Acquisition.
   - $1,354.00 to Chelan-Douglas Land Trust for administration of the White River Nason View Acquisition Project.
   - $6,651.50 to Cascade Columbia Fisheries Enhancement Group for WQE work, QAPP development, and organization of files on nutrient enhancement for the Wenatchee Nutrient Enhancement Design Project.

   Rocky Reach Plan Species Account:

   - $49,000.00 to North Meridian Title for the Entiat Stormy Reach Phase 2 Acquisition.

2. Tracy Hillman reported that he and Kate Terrell attended the SRFB/TC Debrief Meeting on 22 February in Wenatchee. The purpose of the meeting was to: (1) review what worked well during the 12th round and what needs improvement; and (2) establish plans, expectations, and a timeline for the SRFB 13th round. Tracy and Kate provided the following summary from the meeting:

    - The Methow Conservancy requested that the Tributary Committees clearly describe their policy on public access on protection projects (see Section IV above).
    - The SRFB is requiring a pre-proposal from all project sponsors in 2012. Becky Gallaher will work with Jennifer Goodridge on what the Committees require in the pre-proposal.
    - Project sponsors will be allowed more time to present their proposal during the pre-proposal workshop.
    - Pre-proposals are due on 7 May. Project tours will be on 21-24 May and the pre-proposal presentation workshop will be on 13 June. The Tributary Committees will review pre-proposals on 14 June and provide feedback to sponsors on 15 June. Final proposals are due on 29 June. The RTT will review and score final proposals on 11 July and the Tributary Committees will evaluate final proposals on 12 July. The Final Schedule is appended to these notes as Attachment 1.
    - Sponsors would like a final funding decision from the Tributary Committees by the end of July. However, this can create some funding coordination problems for the Committees, who hold funding coordination meetings in August. Therefore, the Committees decided that they will provide final decisions to the sponsors in late August following their funding coordination meetings.
    - The State of Washington Recreation and Conservation Office asked that the Upper Columbia Salmon Recovery Board integrate the Okanogan and Chelan County lead entities into the Upper Columbia Salmon Recovery Board Regional Organization. The reason for the change is to improve efficiencies resulting from reductions in salmon recovery funding sources. The 2012 Federal Pacific Coast Salmon Recovery Fund has been reduced from $80 million to $65 million. Additionally, the state has reduced funding for the lead entity program over the past four years by a total of $615,000. Kate indicated that the Board recently approved the integration of the lead entities into the Upper Columbia Salmon Recovery Board Regional Organization. This means that the Counties will no longer be lead entities.

3. Becky Gallaher said that she was approached by Jason Lundgren (CCFEG) and Ken Bevis (WDFW) about the possibility of the Tributary Committees funding the construction and placement of river safety signs in the Methow and Wenatchee basins. The signs would be placed at put-ins and take-outs along the rivers. The signs would warn about the potential hazards of habitat restoration structures in the rivers. The Committees agreed that the signs are important, but believed that funding should come from statewide sources (e.g., Salmon Recovery Funding Board). The Committees recommended that CCFEG and WDFW talk with Bud Hover, SRFB Chair.

4. On behalf of CCFEG, Kate Terrell asked if the Committees would be interested in covering the costs of transporting large wood collected at the mainstem dams to floodplain habitat in tributaries. The Committees indicated that a wood relocation project would probably not get funding from the Tributary Committees.

5. Tracy Hillman shared with the Committees that he received a Small Projects Application from the Methow Conservancy requesting $96,000 for beaver restoration in the Lower Chewuch. The Conservancy requested an additional $101,000 from the PRCC Habitat Subcommittee. Thus, the total cost of the project exceeded the maximum allowed under the Small Projects Program. Lee Carlson indicated that the Yakama Nation could no longer help fund the project because of BPA and funding issues. Therefore, the US Forest Service and the Methow Conservancy are seeking funds from other sources. The Committees recommended that the sponsor request the funds from the PRCC Habitat Subcommittee.

6. Dale Bambrick provided the following updates.

    - Dale talked about some of the discussions regarding the MVID diversion. He stated that they are currently examining the potential for a pump plant, which would take MVID out of the Twisp River. Converting to a surface pump would cost about $3-4 million.

    - Dale indicated that modifications to the Barkley Irrigation Diversion on the Methow may be a potential project in the future.

    - Finally, Dale said that there are potential breakthroughs regarding diverting water from Icicle Creek. That is, the proposal to divert water out of Icicle Creek may not happen.

7. Finally, Becky Gallaher shared with the Committees a draft spreadsheet that shows project name, type of protection project, sponsor, total acres, total cost, cost/acre, and property information for all acquisitions and conservation easements funded by the Tributary Committees. The Committees reviewed the draft spreadsheet and recommended the addition of cost per feet of shoreline. They would also like a time series plot showing the relationship between costs of protection projects in the Upper Columbia (costs/acre) and indices of property values nationwide, statewide, and countywide (see Section VII above). Becky and Tracy will update the spreadsheet, develop a time series plot, and share them with the Committees during the next meeting.

IX. Next Steps

The Tributary Committees will not meet in April. Their next meeting will be on Thursday, 10 May 2012 at Chelan PUD in Wenatchee.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Attachment 1

2012 UPPER COLUMBIA PROCESS SCHEDULE

SRFB/TRIB/BPA

Project Proposal Development, Submittal, and Review

DATE	ACTIVITY/MILESTONE (MEETING/DEADLINE)
FEBRUARY	
22 February	SRFB/TRIB Debrief of 2011 (afternoon)
28 February	IT Funding Coordination Meeting (all day)
MARCH	
March	SRFB/Tributary Fund cycles announced; SRFB Policy Manual available; Regional Process Guide Revisions
29 March	SRFB/TRIB/BPA Kickoff Meeting for the Region; RCO presentation; RTT Technical criteria presentation; CAC criteria presentation
APRIL	
13 April	
April	Project Sponsors develop projects and pre-proposal (materials available from http://www.ucsrb.com)
MAY	
7 May	**Pre-proposals due to LE Coordinators –** delivered to RTT, TRIB (via TRIB ftp site) and SRFB Panel Members (via PRISM)
14 May	Conference Call to discuss project tour logistics (RTT, LEs, Trib and UCSRB)
21-24 May	SRFB/TRIB/BPA project tours (*subject to change pending final pre-proposals*) • 21st – Wenatchee • 22nd – Entiat • 23rd – Methow • 24th – Okanogan
JUNE	
13 June	Pre-proposal Presentation Workshop: review pre-proposals with RTT, TRIB and CAC's
14 June	TRIB internal review of pre-proposals
June	Proposal refinement based on technical feedback. Two weeks after visiting projects, the State Technical Review Panel will post comments in SharePoint for lead entities and grant applicants. Grant applicants should update their applications to address any Review Panel concerns and attach their responses to Review Panel comments in PRISM with their application. The Review Panel will "flag" projects that it believes would benefit from additional review at the regional area project meeting.
29 June	**Final project proposals due to LE Coordinators –** delivered to RTT,

	TRIB (via TRIB ftp site) and RCO (via PRISM)
JULY	
6 July	**Grant applicants update applications in PRISM to address Review Panel concerns from initial site visit and review.**
11 July	RTT Meeting: formal project reviews and technical ranking
12 July	Review Panel discusses "flagged" projects and updates the review forms. Panel will meet either in person or via conference call to provide full panel feedback on "flagged" projects.
12 July	TRIB final review of proposals
23 July	Final comments from TRIB will be via e-mail to LE for distribution to project sponsors
AUGUST	
August (TBD)	Okanogan and Chelan CAC project rankings
10 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (early optional date)**
22 August	Regional joint CAC approves final combined ranked list
24 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (final due date)**
SEPTEMBER	
September	TRIB supplemental tours of selected projects (project sponsors will be notified in advance of visit). TRIB makes initial internal decisions.
14 September	**Regional organizations submit their recommendations for funding and responses to the information questionnaire**
26-29 September	Regional presentations to State Technical Review Panel
OCTOBER	
October	Project Presentations to TRIB (*if needed*)
6 October	Comment forms available from State Technical Review Panel
18 October	Comments due on State Technical Review Panel draft report
NOVEMBER	
16 November	**Final 2011 funding report delivered to SRFB**
DECEMBER	
12-13 December	SRFB makes funding decisions
December (TBA)	TRIB makes supplemental decisions

Acronyms

CAC Citizen's Advisory Committee
BPA Bonneville Power Administration
IT Implementation Team
LE Lead Entity
RCO Recreation and Conservation Office
SRP State Review Panel
SRFB Salmon Recovery Funding Board
TRIB HCP Tributary Committee

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 10 May 2012

Members Present: Dale Bambrick (NOAA Fisheries), Dennis Beich (WDFW), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Others Present: Becky Gallaher (Tributary Project Coordinator). Denny Rohr (PRCC Habitat Subcommittee Facilitator), Dave Duvall (Grant PUD), Terrie Preston (WDFW), Dan Budd (WDFW), Shawn Kyes (WDFW), Sheryl Dotson (Grant PUD Lands Department), and Blair Fuglie (Grant PUD Lands Department) joined the meeting at 10:00 am for the Appraisal Presentation and Discussion.

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met at the Chelan PUD Auditorium in Wenatchee, Washington, on Thursday, 10 May 2012 from 9:00 am to 12:30 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda with additional discussion items from Tom Kahler and Tracy Hillman.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 8 March 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Lower Wenatchee River Instream Flow Enhancement – All permits have been submitted and the sponsor (Trout Unlimited – WWP) continues to prepare design documents for the pump station, water intake, fish screen, and site grading. Their consultant has prepared a cross-section design for multiple pipe locations, prepared pipe casing design for multiple right-of-way pipe crossings, and developed the initial structure and obstruction inventory. The sponsor received concurrence from the Washington Department of Ecology (WDOE) to initiate the water right change process with the Chelan County Conservancy Board. The application was submitted and presented to the Board in early April. A decision on the water right will be made in June.
- Upper White Pine CPUD Power Line Alternatives Analysis - The contractor (HDR Engineering) has completed two drafts of the alternatives analysis memo and has received comments from the U.S. Forest Service, Bonneville Power Administration, and Chelan PUD. The Committees provided no comments on the alternatives analysis.

- Mission Creek Fish Passage Project – The project engineer is developing site plans and designs. Becky will request a signed copy of the landowner agreement form from the sponsor (Cascadia Conservation District).
- White River Van Dusen Conservation Easement – The project is complete and a final report will be submitted to the Rock Island Tributary Committee.
- Nason View Acquisition – The project is complete and a final report will be submitted to the Rock Island Tributary Committee.
- Chewuch River Instream Flow Project – The sponsor (Trout Unlimited – WWP) has conducted landowner coordination, permitting, project planning and design, and construction management.
- Nutrient Enhancement Assessment – The sponsor (Cascade Columbia Fisheries Enhancement Group) and their contractor (Water Quality Engineers) has completed a draft Quality Assurance Project Plan, which will serve as the scientific foundation for the project. The sponsor convened a Nutrient Enhancement Technical Group on 2 May. The purpose of the group is to make sure that the QAPP is sound scientifically, that the work takes into account temporal and spatial distribution of salmonids, and that the ultimate goal of understanding the need for nutrient enhancement is met.
- Large Wood Atonement Project – The sponsor (Cascade Columbia Fisheries Enhancement Group) has held two meetings with residents and posted a fact sheet on the Lake Wenatchee Info Website. This process has generated more interest and the sponsor plans to hold another community meeting soon. The sponsor has submitted the JARPA and SEPA Checklist for the geotechnical exploration within the channel of the White River.
- Entiat National Fish Hatchery Habitat Improvement Project – The sponsor (Cascadia Conservation District) planted, weed-matted, and mulched 725 bare-root ponderosa pines at the upstream end of the removed levee and installed temporary irrigation. They also planted, weed-matted, and mulched an additional 209 large potted native trees and shrubs in the relict channel area and seeded the relict channel with native grass. The sponsor installed upgrades to the existing irrigation on the upper floodplain area adjacent to the new abatement/fishing pond. They seeded the upper floodplain area with naturalized turf-blend grasses. Finally, they reconditioned the hatchery access roads, which trucks used during the removal of the levee.

IV. Preliminary Review of General Salmon Habitat Program Pre-Proposals

The Committees received 27 General Salmon Habitat Program pre-proposals. The Committees conducted a preliminary review of the pre-proposals with the intent of identifying which projects the Committees would like to visit in the field. During the July meeting, the Committees will identify which pre-proposals will have no chance or a low likelihood of receiving funding from the Tributary Committees. The following table summarizes which projects the Committees would like to visit.

Project Title	Sponsor	Request Site Visit
Lower Chiwawa Project Development	Cascade Columbia Fisheries Enhancement Group	No
Lower White River Floodplain Rehabilitation	Cascade Columbia Fisheries Enhancement Group	No

Project Title	Sponsor	Request Site Visit
Methow River Riparian Planting	Cascade Columbia Fisheries Enhancement Group	Yes
Entiat PUD Canal system conversion project	Cascadia Conservation District	No
Tyee Ranch Conservation Easement	Cascadia Conservation District	No
Tall Timber Ranch Conservation Easement Phase 2	Chelan-Douglas Land Trust	No
Lower Sleepy Hollow Floodplain Conservation Easements	Chelan-Douglas Land Trust	Yes
Peshastin RM 8.8 Side Channel Reconnection Design	Chelan County Natural Resources Department	Yes
Lower Nason Creek RM 3.5-4.7 Reach Based Restoration	Chelan County Natural Resources Department	No
Cottonwood Flats Bridge Removal	Chelan County Natural Resources Department	Yes
Skinney Creek Restoration Design (USFS)	Chelan County Natural Resources Department	No
Lower Entiat RM 1.9 Channel Design	Chelan County Natural Resources Department	Yes
Upper Peshastin Roads Inventory (USFS)	Chelan County Natural Resources Department	No
Mill Creek/Mountain Home Ranch Road Fish Passage (USFWS)	Chelan County Natural Resources Department	No
Upper Peshastin Tributary Assessment (WFC)	Chelan County Natural Resources Department	No
Providing Fish Passage at Shingle Creek Irrigation Dam (ONA)	Colville Confederated Tribes	No
Lower Foster Creek Steelhead Habitat Enhancement	Foster Creek Conservation District	Yes
Chewuch Campground Bank Restoration (WDFW)	Methow Salmon Recovery Foundation	No
Middle Methow (M2) Wetland Conservation Easement RM 45.75	Methow Salmon Recovery Foundation	No
Twisp River Poorman Creek Wetland Habitat Acquisition RM 4.75	Methow Salmon Recovery Foundation	No
Twisp River Elbow Coulee Phase II Bank Restoration RM 6.5	Methow Salmon Recovery Foundation	Yes
Upper Beaver Habitat Improvement Channel Restoration RM 7	Methow Salmon Recovery Foundation	No
Wenatchee and Entiat Beaver Reintroduction Project	Trout Unlimited	No

Project Title	Sponsor	Request Site Visit
Twisp River Riparian Protection III	Methow Conservancy	Yes
Big Valley Riparian Protection (WDFW)	Methow Conservancy	No
Lower Chewuch Beaver Restoration	Methow Conservancy	No
Lower Entiat RM 26.-3.5 projects (BOR Reach 1B)	Yakama Nation	Yes

Project tours are scheduled for the week of 21 May (see Attachment 1). Becky Gallaher and Tracy Hillman will participate on the conference call on Monday, 14 May, to coordinate the project tours. Sponsors will give presentations to the Tributary Committees and RTT on Wednesday, 13 June. The Committees will then meet on Thursday, 14 June to conduct their final evaluation of pre-proposals.

V. Okanagan River Restoration Initiative Monitoring

Karilyn Alex, Okanagan Nation Alliance (ONA) Project Biologist, submitted a monitoring report titled, "Aquatic Monitoring of the Okanagan River Restoration Initiative—Post Construction 2011" to the Wells Committee. The Committee reviewed the report and the monitoring proposal/budget and concluded that the fifth and final year of monitoring should continue as planned. ***Thus, the Wells Committee directed Douglas PUD to fund via the Tributary Assessment Program (Wells HCP Section 7.5) the following components: (1) Fish Holding and Rearing for $3,802, (2) Channel Morphometry and Hydraulics for $9,566, and (3) Substrate Composition for $5,617. Thus, the total amount approved by the Committee is $18,984.*** At the end of the project, the Committee would like to see a report that summarizes the results of the five-year study. The Committee requested that the final report include a "lessons learned" section.

VI. Methow River RM 48.9 (Peters) Conservation Easement

Last year, the Methow Salmon Recovery Foundation submitted a proposal to the General Salmon Habitat Program titled "Methow River Acquisition 2011 RM 48.9 (Peters) Project." The purpose of the project was to acquire about one acre of riparian and alcove habitat adjacent to the middle Methow River near RM 48.9. The total cost of the project was $37,325. The sponsor requested $6,310 from HCP Tributary Funds. The Committees elected not to fund the project, because they believed the potential benefits of the acquisition did not justify the cost.

Recently, the Methow Salmon Recovery Foundation appraised the property for a conservation easement. Because the cost of the easement is less than half the amount request last year (the sponsor would request about $2,000 from the Committees), the sponsor asked the Committees if they would be interested in reevaluating the proposal and cost estimate. ***The Committees elected not to reevaluate the proposal.***

VII. Appraisal Presentation and Discussion

Since January, the Committees have been discussing how they can use some of the Tributary Assessment Program funds to evaluate appraisals. The costs of acquisitions and easements have continually increased even though the market has struggled during the last several years. Thus, the Committees identified two primary questions that they wanted to explore:

1. Are the appraisals properly capturing the value of the market?
2. Are the costs of acquisitions and conservation easements appropriate?

During the March meeting, the Committees directed Tracy and Becky to begin the process of addressing the two questions. As a first step, the Committees asked for a description of the training that is required to conduct appraisals. Secondly, the Committees wanted input from experts on how to evaluate appraisals. Finally, the Committees asked for time series plots showing the costs of protection projects in the Upper Columbia (costs/acre and cost/river bank) over time.

To this end, Becky and Tracy compiled information on the cost of protection projects funded by the Committees over time. They summarized the information in a table and generated time series plots of the information contained in the table (see Attachment 2). In addition, based on a recommendation from Teresa Scott, WDFW representative to the HCP Coordinating Committees, Becky and Tracy contacted Dan Budd, Manager of Real Estate Services for WDFW, and asked if he would be willing to address the following questions for the Tributary Committees.

- What are the qualifications and training for an appraiser?
- What information does an appraiser need (or use) to appraise property value?
- Why are there large differences in appraised values of a given property among different appraisers?
- How would one evaluate the validity of an appraisal?
- Are there people who appraise appraisals? If so, who?
- What qualifications or criteria should one consider in selecting an appraiser?

Dan indicated that he and Shawn Kyes, WDFW Chief Appraiser, would give a presentation to the Committees and answer any questions the Committees may have. The presentation is appended to these notes as Attachment 3.

Dan Budd provided a brief overview of the WDFW appraisal process. He indicated that because their funding comes from taxpayers and ratepayers, they use very strict criteria in appraising property. He noted that their appraisals are usually contested, and the sellers are very passionate about the outcome, while the buyer is much less passionate. Thus, WDFW must be very thorough in their evaluation of properties. The following notes capture most of the discussion during and after the presentation by Shawn Kyes.

Question (Q): Are there specific assumptions associated with appraisals?
Answer (A): The appraiser must label and be clear on all hypothetical conditions and assumptions (see slide 10 in the presentation).

Q: Should appraisals include the cost of, say, a bridge if access is assumed and there is currently no bridge?
A: The appraisal should identify the bridge as a hypothetical condition and include assumptions.

Q: Does the Yellow Book include a cost/acre threshold value?
A: No. If an appraiser intends to use Yellow Book, the appraiser must have training in Yellow Book.

Q: Is there any reason not to request a Yellow Book appraisal?
A: Yellow Book is not needed unless federal funds are to be used in the purchase of the property. The use of Yellow Book does not give a better appraisal. Yellow Book does require a larger amount of effort, and the appraiser must be trained in Yellow Book.

Q: What do you do if the only comparables are pre-2009?

A: Even though the marked has been slow, there should be comparables available after 2009. If the appraiser does not include recent comparables, he/she must build an argument as to why they did not include recent comparables.

Q: Is there a way to walk away from comparables and start over in the appraisal process?
A: Value is an expectation between the buyer and seller and may be based on sale of related properties. The appraiser must verify the value of the property.

Q: Appraisals are too high and our willingness to fund protection projects may be driving the cost of protection projects. Can you provide advice to a bunch of "ologists," who must decide whether to fund protection projects?
A: The Committees need to take control of the appraisal process. That is, they need to have appraisals conducted by firms hired by the Committees. If this is not possible, at a minimum, they need to have appraisals reviewed, perhaps by PUD evaluators. Keep in mind that appraisals of habitat will be expensive. This is because the seller is in a "take-it-or-leave-it" position. The bottom line is that the Committees need to take control of the appraisal process.

Q: Can the Committees contract with the State to review appraisals?
A: The State is very busy with WDFW evaluations and therefore it is unlikely that they would have time to evaluate Committees' appraisals. The Committees should establish a relationship with appraisers or firms in the area. The Committees could have one firm conduct the appraisal and another evaluate the appraisal. It is important that the appraiser and reviewer know the area.

Q: How would the Committees reconcile differences in appraised values between the Committees' appraiser and the landowner's appraiser?
A: Make sure you select a firm or appraiser you trust. Also, have the appraisals reviewed by trusted firms. Be very skeptical of reviews that cost around $400. Most should cost around $3,500.

Q: Is there a cost rule-of-thumb for conservation easements versus acquisitions?
A: There is no rule-of-thumb. Both conservation easements and acquisitions are negotiations. Make sure you evaluate the terms in a conservation easement.

The Committees found the information provided by Dan and Shawn very useful. They will consider the recommendations by Dan and Shawn and plan their next steps during May and June.

VIII. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in April and May:

   Rock Island Plan Species Account:

   - $1,151.77 to Chelan PUD for Rock Island project administration/coordination during the first quarter, 2012.
   - $14,253.61 to Trout Unlimited – Washington Water Project for the Lower Wenatchee Instream Flow Project.

   Rocky Reach Plan Species Account:

   - $1,007.41 to Chelan PUD for Rocky Reach project administration/coordination during the first quarter, 2012.

- $42,730.25 to Trout Unlimited – Washington Water Project for the Chewuch Instream Flow Project.
- $15,800.00 to Chelan-Douglas Land Trust for the Entiat Stormy Reach Phase 2 Acquisition Project.

Wells Plan Species Account:

- $863.23 to Chelan PUD for Wells project administration/coordination during the first quarter, 2012.

2. Dennis Beach reported that Carmen Andonaegui would serve as his alternate on the Tributary Committees. Tracy Hillman asked Dennis to provide him and Mike Schiewe with a letter stating that WDFW has identified Carmen as their alternate on the Tributary Committees. Dennis agreed to provide the letter as soon as possible.
3. Tom Kahler indicated that Douglas PUD has requested that the Department of Fisheries and Oceans Canada (DFO) develop a proposal that Douglas PUD will likely submit as a Small Projects Proposal to the Committees for review. Tom explained that they have been very successful in using the Okanogan Fish and Water Management Tool funded by Douglas PUD to reduce density-independent mortality of sockeye salmon eggs and alevins in the Okanogan River, and pre-smolts in Lake Osoyoos. Since its initiation in 2004, the tool has resulted in a 5-10 fold increase in sockeye smolt production from Lake Osoyoos. The Colville Tribes have advocated expanding the model to include summer Chinook downstream from Lake Osoyoos. The purpose would be to use the tool to increase egg-fry survival of summer Chinook spawning within the Okanogan River on the east side of Driscoll Island. The current model could be expanded to include a summer Chinook component with decision rules for Lake Osoyoos. Douglas PUD will likely submit a Small Projects Proposal within two months seeking funding to add a summer Chinook sub-model and a Lake Osoyoos water-level sub-model to the Fish and Water Management Tool.
4. Dennis Beach asked about possible funding options for improving fish passage at Zosel Dam on the Okanogan River. Dennis thought that this would be a good year to evaluate passage issues because of the projected large return of sockeye to the Okanogan Basin. If there is an issue with passage at Zosel Dam, Dennis thought that it may be possible to add another opening with a gate in the dam.

IX. Next Steps

The next meeting of the Tributary Committees will be on Thursday, 14 June 2012 at Chelan PUD in Wenatchee. At that time, the Committees will evaluate General Salmon Habitat Program Pre-Proposals, discuss a Policy for Stewardship Plans, and continue their evaluation of appraisals and the appraisal process.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Attachment 1

2012 UPPER COLUMBIA PROCESS SCHEDULE

SRFB/TRIB/BPA

Project Proposal Development, Submittal, and Review

DATE	ACTIVITY/MILESTONE (MEETING/DEADLINE)
FEBRUARY	
22 February	SRFB/TRIB Debrief of 2011 (afternoon)
28 February	IT Funding Coordination Meeting (all day)
MARCH	
March	SRFB/Tributary Fund cycles announced; SRFB Policy Manual available; Regional Process Guide Revisions
29 March	SRFB/TRIB/BPA Kickoff Meeting for the Region; RCO presentation; RTT Technical criteria presentation; CAC criteria presentation
APRIL	
13 April	
April	Project Sponsors develop projects and pre-proposal (materials available from http://www.ucsrb.com)
MAY	
7 May	**Pre-proposals due to LE Coordinators –** delivered to RTT, TRIB (via TRIB ftp site) and SRFB Panel Members (via PRISM)
14 May	Conference Call to discuss project tour logistics (RTT, LEs, Trib and UCSRB)
21-24 May	SRFB/TRIB/BPA project tours (*subject to change pending final pre-proposals*) • 21st – Wenatchee • 22nd – Entiat • 23rd – Methow • 24th – Okanogan
JUNE	
13 June	Pre-proposal Presentation Workshop: review pre-proposals with RTT, TRIB and CAC's
14 June	TRIB internal review of pre-proposals
June	Proposal refinement based on technical feedback. Two weeks after visiting projects, the State Technical Review Panel will post comments in SharePoint for lead entities and grant applicants. Grant applicants should update their applications to address any Review Panel concerns and attach their responses to Review Panel comments in PRISM with their application. The Review Panel will "flag" projects that it believes would benefit from additional review at the regional area project meeting.
29 June	**Final project proposals due to LE Coordinators –** delivered to RTT,

	TRIB (via TRIB ftp site) and RCO (via PRISM)
JULY	
6 July	**Grant applicants update applications in PRISM to address Review Panel concerns from initial site visit and review.**
11 July	RTT Meeting: formal project reviews and technical ranking
12 July	Review Panel discusses "flagged" projects and updates the review forms. Panel will meet either in person or via conference call to provide full panel feedback on "flagged" projects.
12 July	TRIB final review of proposals
23 July	Final comments from TRIB will be via e-mail to LE for distribution to project sponsors
AUGUST	
August (TBD)	Okanogan and Chelan CAC project rankings
10 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (early optional date)**
22 August	Regional joint CAC approves final combined ranked list
24 August	**LE submits final project applications and deliverables to RCO/SRFB in PRISM (final due date)**
SEPTEMBER	
September	TRIB supplemental tours of selected projects (project sponsors will be notified in advance of visit). TRIB makes initial internal decisions.
14 September	**Regional organizations submit their recommendations for funding and responses to the information questionnaire**
26-29 September	Regional presentations to State Technical Review Panel
OCTOBER	
October	Project Presentations to TRIB (*if needed*)
6 October	Comment forms available from State Technical Review Panel
18 October	Comments due on State Technical Review Panel draft report
NOVEMBER	
16 November	**Final 2011 funding report delivered to SRFB**
DECEMBER	
12-13 December	SRFB makes funding decisions
December (TBA)	TRIB makes supplemental decisions

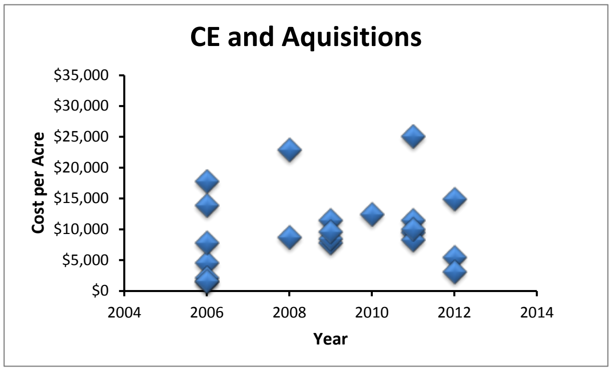
Acronyms

CAC Citizen's Advisory Committee
BPA Bonneville Power Administration
IT Implementation Team
LE Lead Entity
RCO Recreation and Conservation Office
SRP State Review Panel
SRFB Salmon Recovery Funding Board
TRIB HCP Tributary Committee

Attachment 2

Land Acquisition/Conservation Easement Cost per Acre

Upper Columbia Basin							
Basin	**CE/Acquisition**	**Year**	**Total Cost**	**Total Acres**	**Linear ft of bank**	**Cost per Acre**	**Cost per ft of bank**
Wenatchee	A	2006	$574,000	127	3802	$4,520	$151
Wenatchee	A	2006	$300,000	38.4	422	$7,813	$710
Wenatchee	A	2008	$190,000	8.3		$22,892	
Wenatchee	A	2006	$30,000	20	2957	$1,500	$10
Wenatchee	A	2006	$112,408	53	3907	$2,121	$29
Wenatchee	A	2006	$96,331	60	2640	$1,606	$36
Wenatchee	A	2012	$639,000	117	6200	$5,462	$103
Wenatchee	CE	2010	$170,000	13.7	1050	$12,409	$162
Wenatchee	CE	2011	$380,000	40	5000	$9,500	$76
Wenatchee	A		$294,700	18	2500	$16,372	$118
Entiat	A	2012	$165,000	53	3380	$3,113	$49
Methow	CE	2006	$1,950,000	140.5	7920	$13,879	$246
Methow	CE	2007	Donation	22.3	1742		
Methow	CE	2008	$600,000	69	3960	$8,696	$152
Methow	CE	2009	$160,000	14	1560	$11,429	$103
Methow	CE	2009	$205,000	26.32		$7,789	
Methow	CE	2009	$90,000	10.6	839	$8,491	$107
Methow	A		$195,048	15	2100	$13,003	$93
Methow	A	2012	$253,000	17		$14,882	
Methow	A	2011	$112,000	13.5	1500	$8,296	$75
Methow	A		$125,000	4.3		$29,070	
Methow	A		$376,000	13.3	1000	$30,150	$401
Methow			$349,988	71	5400	$4,929	$65
Methow	CE	2011	$420,000	36.6	2000	$11,475	$210
Methow	A	2006	$184,000	10.36		$17,761	
Methow	A	2011	$340,000	13.56	723	$25,074	$470
Methow	CE/A		$660,000	45	3500	$14,667	$189
Methow	A	2011	$15,000	1.5		$10,000	
Okanogan	CE	2009	$48,000	5		$9,600	


CE and Aquisitions
Cost per Acre
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2004
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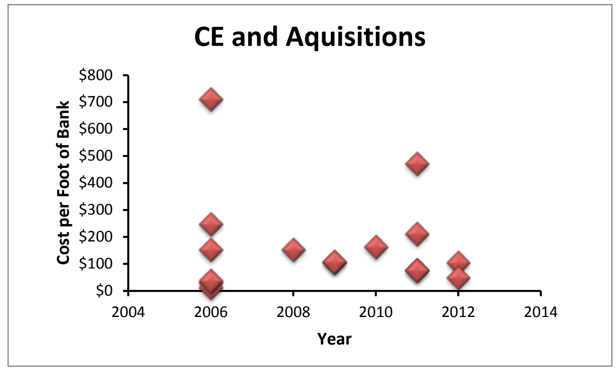
CE and Aquisitions
Cost per Foot of Bank
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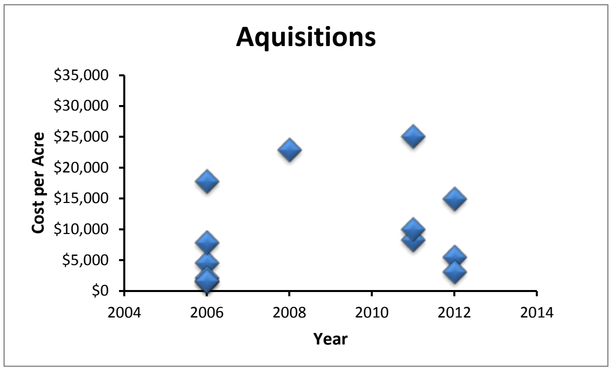
Aquisitions
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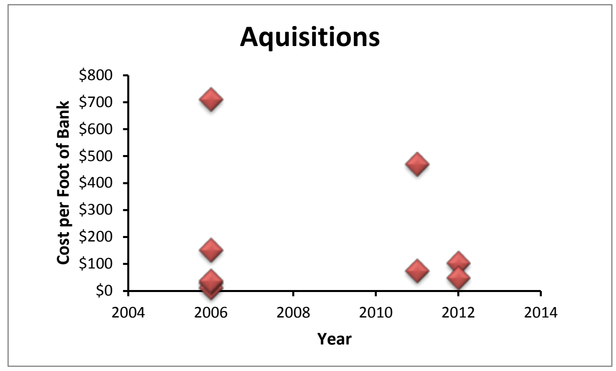
Aquisitions
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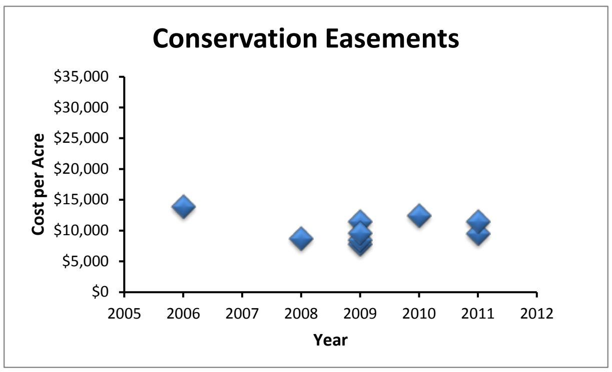
Conservation Easements
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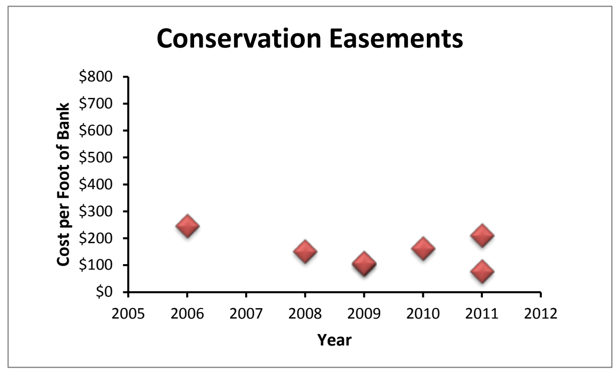
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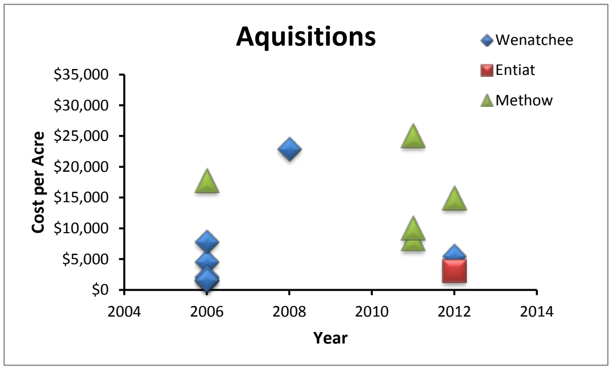
Aquisitions
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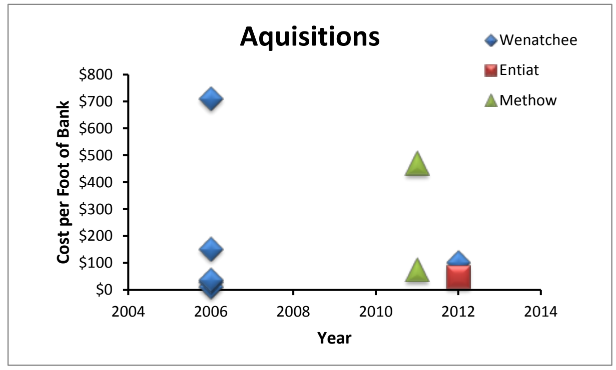
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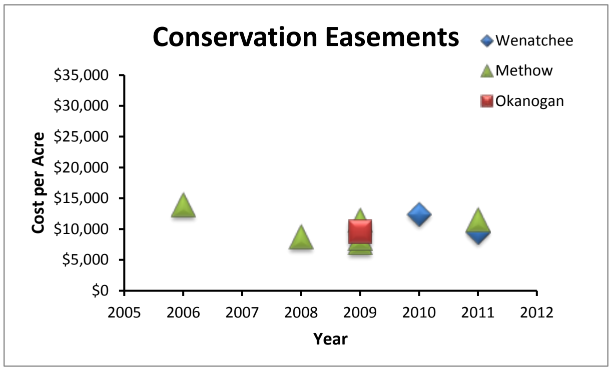
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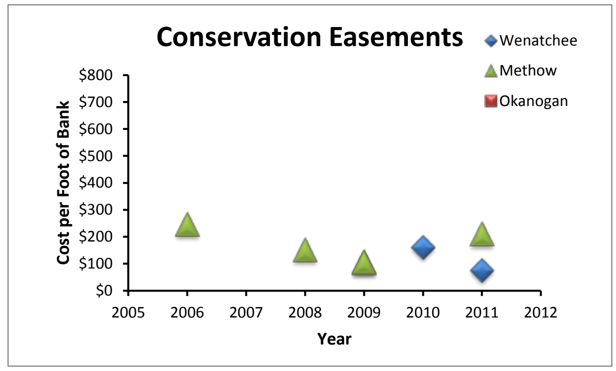
Conservation Easements
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Cost per Foot of Bank
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Year

Attachment 3

Presentation by Shawn Kyes (WDFW) on Protection Project Real Estate Appraisals

Chelan/Douglas PUD Tributary Presentation

Protection Project Real Estate Appraisals

- *Shawn Kyes, MAI*
  Chief Appraiser, WDFW

Washington Department of FISH and WILDLIFE

1

WDFW Real Estate Services

- Acquisitions/Dispositions/Exchanges
- Property Management
- Environmental Site Assessments
- Conservation Easement Baselines
- *Real Property Appraisals & Reviews*
  - *43 Appraisal Firms Statewide under contract*
  - *Funding sources typically require UASFLA (aka "Yellow Book") compliant appraisals*
  - *Independent contractors solicited for appraisals, with typically internal review*

2

Appraiser Qualifications

- Certified General Appraiser License
  - Bachelors or 30 semester hours in specified
  - 300 hours of RE Appraisal coursework
  - 2.5 years supervised appraisal experience
  - Comprehensive Exam

3

Appraiser Qualifications (continued)

- Experience & Recent Coursework in Uniform Appraisal Standards for Federal Land Acquisitions ("Yellow Book")
- *Valuation of Conservation Easements Course,* jointly presented by Appraisal Institute & American Society of Farm Managers and Rural Appraisers, in conjunction with the Land Trust Alliance.
- Preferably Affiliated or Designation with AI, ASA, ASFMRA, IRWA

4

Scoping the Appraisal Assignment

- Purpose of Appraisal (idea of value, negotiation of sale, secure funding) >> Summary report vs. Self-Contained
- Intended Uses & Users of Appraisal (internal, external also, IRS donation) >> USPAP vs. USPAP & Yellow Book
- Acquisition Scenarios (Total, Partial, Life Estate to be acquired) >> One Fee appraisal vs. "Before & After" Valuation(s).

5

Scoping the Appraisal Assignment
(continued)

- Encumbrances/Conditions
  - Title Report encumbrances
  - Easements, access, water & mineral rights
  - Entitlements/Allowed Uses
  - Landowner Reserved Rights
- History of Ownership & Use
  - Other adjacent lands identified for Larger Parcel analysis
  - Recent Sales/Offerings have to be analyzed by the appraiser
  - Recent Water Usage or Lack of is important for significant Water Right Claims

6

Appraiser Solicitation & Selection

- Cost & Timing
- Geographical Familiarity
- Property Type Familiarity
- Experience
  - Geographic and Property Specific Knowledge
  - Before/After Appraisals
  - Conservation Easements

7

Review Appraiser Consideration & Involvement

- The act or process of developing and communicating an opinion about the quality of another appraiser's work that was performed as part of an appraisal.*
  - Desk Review
  - Field Review

**2012-2013 USPAP*

8

Common Issues/Deficiencies found under Review

- Appraised as if Fee Simple when properties are subject to encumbrances:
  - encumbrances in the Title Report need to be addressed; (easements, access, mineral estates, etc.)
  - Does the Estate appraised equal the Estate to be acquired?

9

Common Issues
(continued)

- The appraiser should not independently create Hypothetical Conditions and Extraordinary Assumptions.
  - Access, water rights, mineral rights, development rights, restrictions of proposed Conservation Easement
  - Must be predominantly stated and be realistic. Client and/or Agency should be consulted prior to their inclusion.

10

Common Issues
(continued)

- Larger parcel (“Yellow Book”)
  - No discussion of the three tests, or no larger parcel determination at all.
  - Unity of ownership(title)
  - Unity of Use (Highest and Best Use)
  - Contiguity
- Differences in Larger Parcel Conclusion can have significant effects in conclusions of value from one appraisal to another.

11

Highest and Best Use

- Lack of comprehensive highest and best use analysis using the 4 tests.
  - Legally Permissible
  - Physically Possible
  - Financially Feasible
  - Maximally Profitable (Productive)
- Separate, complete Highest and Best Use analysis is also required in "After" Valuations.

12

Sales Comparables & Analysis

- Dated sales (pre-2009)....are these reflective of post-recession conditions?
- Are the sales truly comparable...."Are the purchasers of the comparables the same people that would be buyers of the subject?"

13

Sales analysis

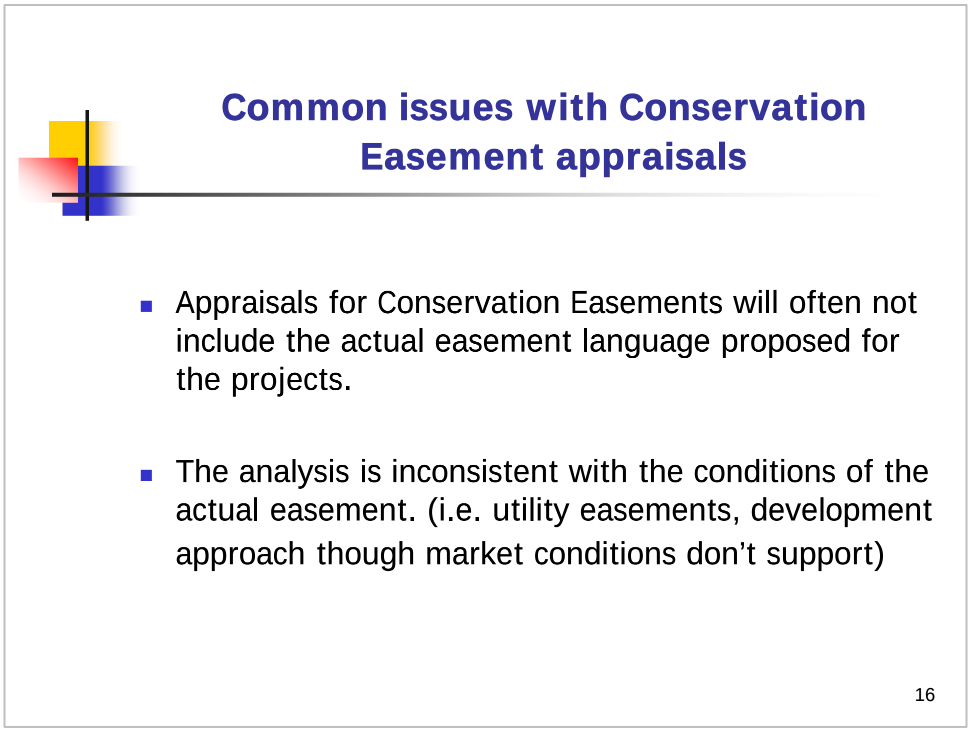
- All Elements of Comparison examined?
  - Conditions of the sale
  - Market Conditions
  - Location
  - Size/Shape
  - Access
  - Frontage
  - Topography/Views
  - Soils
  - Irrigated Acres/Orchard (Type/Amount)
  - Utilities
  - Zoning/Entitlements

14

Sales analysis

- Are all applicable sales presented or just a select few?
- Are adjustments to sales based on market evidence? Are they reasonable?

15


Common issues with Conservation Easement appraisals
Appraisals for Conservation Easements will often not include the actual easement language proposed for the projects.
The analysis is inconsistent with the conditions of the actual easement. (i.e. utility easements, development approach though market conditions don’t support)
16

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 14 June 2012

Members Present: Carmen Andonaegui (WDFW), Dale Bambrick (NOAA Fisheries), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Others Present: Becky Gallaher (Tributary Project Coordinator). Denny Rohr (PRCC Habitat Subcommittee Facilitator) and Dave Duvall (Grant PUD) joined the meeting during the afternoon.

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met at the Chelan PUD Auditorium in Wenatchee, Washington, on Thursday, 14 June 2012 from 9:00 am to 2:00 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda with additional discussion items from Dale Bambrick and Tracy Hillman.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 10 May 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Upper White Pine CPUD Power Line Alternatives Analysis – The contractor (HDR Engineering) has completed a draft report on alternatives analysis. They received comments from the U.S. Forest Service, Bonneville Power Administration, and Chelan PUD.
- Mission Creek Fish Passage Project – The Natural Resources Conservation Service (NRCS) has produced 95% design plans for the four sites on Mission Creek. In addition, the sponsor (Cascadia Conservation District) met with the landowners on 5 June. The sponsor will submit revised permit applications to the Corp of Engineers on 11 June. Resubmittal is necessary because the permits expired this spring. Construction is scheduled for late September 2012.
- White River Van Dusen Conservation Easement – The project is complete and the Rock Island Tributary Committee received the final report.
- Nason View Acquisition – The project is complete and the Rock Island Tributary Committee received the final report.

- Entiat Stormy Reach Phase 2 Acquisition – The project is complete and a final report will be submitted to the Rocky Reach Tributary Committee.
- Entiat National Fish Hatchery Project – The project is complete and a final report will be submitted to the Rocky Reach Tributary Committee.
- Chewuch River Instream Flow Project – The sponsor (Trout Unlimited – WWP) has conducted landowner coordination, permitting, project planning and design, and construction management.
- Nutrient Enhancement Assessment – The sponsor (Cascade Columbia Fisheries Enhancement Group) and their contractor (Water Quality Engineers) had a conference call with Washington Department of Ecology on 29 May to discuss the draft Quality Assurance Project Plan (QAPP). The sponsor has incorporated comments into the QAPP and they plan to start sampling for water quality and macroinvertebrates soon.

IV. Small Projects Program Application: Wenatchee Levee Removal and Riparian Restoration Project

The Committees reviewed a Small Projects Program application from Chelan County Natural Resource Department titled *Wenatchee Levee Removal and Riparian Restoration Project*.

<u>Wenatchee Levee Removal and Riparian Restoration Project</u>

The purpose of this project is to restore natural processes to the Wenatchee River by removing a 300-foot long levee, restoring the riparian zone, and eliminating a surface-water irrigation diversion. The project is located at RM 13.5. The sponsor will replace the surface-water diversion with a well, restore a 35 x 265 foot riparian zone, and install a floodplain fence to help capture woody debris. The fence will also protect the adjacent orchard without limiting the river from accessing the floodplain. The total cost of the project is $67,450. The sponsor requested $56,700 from HCP Tributary Funds. After careful consideration of the proposal, ***the Rock Island Tributary Committee approved funding for this project***.

V. Appraisal Discussion

Since January, the Committees have been discussing how they can better evaluate appraisals. The costs of acquisitions and easements have continually increased even though the market has struggled during the last several years. Last month, the Committees listened to a presentation by Dan Budd, Manager of Real Estate Services for WDFW, and Shawn Kyes, WDFW Chief Appraiser. They advised the Committees to take control of the appraisal process. That is, the Committees need to hire a firm to conduct appraisals, or, if that is not possible, the Committees need to hire a firm to review the appraisals. The best approach would be to hire both the appraiser and the reviewer.

Following the May meeting, Dan Budd and Shawn Kyes provided Tracy and Becky with a list of recommended appraisers. Becky shared the list with an appraiser at Chelan PUD. He identified four individuals from the list who he said are well-respected appraisers. They included:

- Michael Gentry with Auble, Jolicoeur and Gentry, Spokane, WA.
- Larry Rees with Cascade Chelan Appraisal, Inc., Chelan, WA.
- Peter Shorett with GVA Kidder Mathews Valuation Advisory SVS, Seattle, WA.
- Fred Strickland with Strickland Heischman and Hoss, Inc., Tacoma, WA.

After reviewing the list of appraisers, the Committees decided that they would use one of the appraisers (e.g., Larry Rees) to do the appraisal and one of the other three to review appraisals. Thus, the Committees will hire both the appraiser and reviewer. The Committees directed Tracy to inform Marc Duboiski (Recreation and Conservation Office) that the Committees will use their own appraisers and reviewers to evaluate the value of future acquisitions and conservation easements.

VI. Review of General Salmon Habitat Program Pre-Proposals

The Committees received 27 General Salmon Habitat Program pre-proposals. The Committees reviewed each pre-proposal and selected those that they believe warranted a full proposal. Projects that the Committees dismissed were either inconsistent with the intent of the Tributary Fund or did not have strong technical merit. The Committees assigned pre-proposals to one of two categories: Fundable and Not Fundable. It is important to note that these are ratings of pre-proposals and do not reflect ratings of full proposals. The Committees directed Tracy to notify sponsors with appropriate projects to submit a full proposal, with a discussion of the questions/comments identified for each pre-proposal listed below. Tracy will also notify sponsors with projects that have no chance or a low likelihood of receiving funding from the Tributary Committees.

Tall Timber Ranch Conservation Easement Phase 2 (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan-Douglas Land Trust, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- It is unlikely that this property will be developed in the future. Thus, the Committees do not see the need for a conservation easement on this property at this time.

Lower Wenatchee Sleepy Hollow Floodplain Conservation Easement (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan-Douglas Land Trust, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- It is unlikely that this property will be developed in the future. Thus, the Committees do not see the need for a conservation easement on this property at this time.

Mill Creek/Mountain Home Ranch Road Fish Passage Project (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan County Natural Resource Department, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- Although the Committees believe that fish passage is important in Mill Creek, they also believe that there are sufficient funds available to complete the work without having to use Tributary Funds.

Upper Peshastin Creek Tributary Assessment Project (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan County Natural Resource Department, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- There is no need to conduct an expensive assessment in an area where threats and limiting factors are already known. The Committees would be willing to review proposals that identify specific habitat actions within this area of Peshastin Creek.

Peshastin Creek – Blewett Rock and Gravel Side Channel Reconnection Design Project (Fundable)

The Committees recommend that the sponsor (Chelan County Natural Resource Department) consider the following comments/suggestions as they develop the full proposal:

- Reduce the scope of the final proposal to two alternatives (i.e., alternatives 2 and 3).
- Significantly reduce the cost of the proposal. The Committees believe that ~$200,000 is excessive for design work.

Lower Nason Creek Reach Based Restoration (RM 3.5-4.7) Project (Fundable)

The Committees recommend that the sponsor (Chelan County Natural Resource Department) consider the following comments/suggestions as they develop the full proposal:

- Remove restoration actions 2 (Floodplain Reconnection) and 4 (Oxbow Enhancement). The proposal should focus only on abutment and parking area removal, and engineered logjam structures.
- Significantly reduce the cost of the proposal by combining efforts across the different actions. For example, ~$30,000 for wetland and cultural surveys is excessive for this project, and may not be necessary with the reduced scope of the project as per the above bullet.

Lower Entiat River – RM 1.9 Side Channel Design (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan County Natural Resource Department, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- This project is too expensive and can be completed without conducting an expensive analysis of different design alternatives.
- The sponsor should simply modifying the upstream openings to the channels to allow high flows to restructure the side channels.

Skinney Creek Restoration Design (originally identified as Not Fundable, but after communicating with the sponsor it was changed to Fundable)

The Committees recommend that the sponsor (Chelan County Natural Resource Department) submit a full proposal.

Upper Peshastin Creek Road Inventory and Analysis Project (Not Fundable)

The Committees recommend that this project, sponsored by the Chelan County Natural Resource Department, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees are not interested in funding an inventory and analysis of forest roads. On the other hand, they would consider funding actions that intend to improve roads that are linked directly to the degradation of fish spawning and rearing habitat.

Wenatchee and Entiat Beaver Reintroduction Project (Fundable)

The Committees recommend that the sponsor (Trout Unlimited-Washington Water Project) consider the following comments/suggestions as they develop the full proposal:

- The sponsor needs to describe how they intend to use the lessons learned from the reintroduction work in the Methow.

- The cost of the project is excessive. The sponsor needs to reduce the cost of the final proposal.

Lower Chiwawa Project Development Project (Not Fundable)

The Committees recommend that this project, sponsored by the Cascade Columbia Fisheries Enhancement Group, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees do not see the need to conduct an expensive assessment in an area where threats and limiting factors are already known. They would be interested in reviewing proposals that identify specific habitat actions within the Chiwawa Basin.

Lower White River Floodplain Rehabilitation Project (Fundable)

The Committees recommend that the sponsor (Cascade Columbia Fisheries Enhancement Group) consider the following comments/suggestions as they develop the full proposal:

- In the final proposal the sponsor needs to focus on project development and identify costs of project implementation.
- Members of the Committees were ambivalent about the utility of various components of the proposal, but several believed that the hydrologic analysis may have the most relevance for the development of future projects.

Methow River Riparian Planting 2012 Project (Not Fundable)

The Committees recommend that this project, sponsored by the Cascade Columbia Fisheries Enhancement Group, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees see a problem with sequencing and recommend that the sponsor plant wider buffers in areas where riparian restoration is appropriate. For example, the Committees believe that the lower terrace on or adjacent to the Silver Property may be a suitable site for the proposed action, but also felt that the sponsor should not proceed with planting that terrace before a plan is developed for the restoration of the combined WDFW holdings in that reach of the Methow. To that end, the Committees would entertain a Small Projects Application that addresses restoration in that area, upon completion of such planning and necessary vetting of the resultant plan. Additionally, the sponsor would need to demonstrate that the rate of erosion along the lower terrace would not remove plantings.

Providing Fish Passage at Shingle Creek Irrigation Dam (Fundable)

The Committees recommend that the sponsor (Okanagan Nation Alliance and the Colville Confederated Tribes) consider the following comments/suggestions as they develop the full proposal:

- Reduce the cost of the proposal. Cost savings may be realized by considering other methods for passing fish.
- Describe the condition of the habitat upstream from the irrigation dam.
- Also, if available, provide information on stream flows and water temperatures.

Lower Foster Creek Steelhead Habitat Enhancement Project (Fundable)

The Committees recommend that the sponsor (Foster Creek Conservation District) consider the following comments/suggestions as they develop the full proposal:

- Consider moving the return water upstream.
- Describe the structural integrity of the dam on Foster Creek.
- Try to secure additional funds from the Army Corps of Engineers.
- Reduce the cost of the project. The sponsor should be able to complete the proposed work with substantially less funding.

Lower Chewuch Beaver Restoration Project (Fundable)

The Committees recommend that the sponsor (Methow Conservancy) consider the following comments/suggestions as they develop the full proposal:

- Reduce the cost of the project. The sponsor should be able to complete the proposed work with less funding.

Big Valley Riparian Protection Project (Fundable)

The Committees recommend that the sponsor (WDFW) consider the following comments/suggestions as they develop the full proposal:

- Remove the 1.5 acre parcel (downstream parcel) from the final proposal. The Committees believe there is no threat of development on this parcel.

Chewuch Campground Bank Restoration Project (Not Fundable)

The Committees recommend that this project, sponsored by WDFW, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- Although the Committees believe that restoring native riparian vegetation is an important component of stream restoration, they do not believe the benefits associated with this project justify the costs. Because the riparian zone is already fenced, they would like the site to restore itself naturally.

Middle Methow (M2) Wetland Conservation Easement 2012 RM 45.75 (Not Fundable)

The Committees recommend that this project, sponsored by the Methow Salmon Recovery Foundation, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees believe that there is a low likelihood that this property will be developed in the future. Therefore, they do not see the need for a conservation easement on this property at this time.

Twisp River-Poorman Creek Wetland Habitat Acquisition 2012 RM 4.75 (Fundable)

The Committees recommend that the sponsor (Methow Salmon Recovery Foundation) consider the following comments/suggestions as they develop the full proposal:

- Reduce the cost of the project. The cost of the acquisition appears excessive.

Twisp River Elbow Coulee Phase II Rt/Lt Bank Restoration 2012 RM 6.5 Project (Fundable)

The Committees recommend that the sponsor (Methow Salmon Recovery Foundation) submit a full proposal.

<u>Upper Beaver Habitat Improvement Channel Restoration 2012 RM 7 Project (Fundable)</u>

The Committees recommend that the sponsor (Methow Salmon Recovery Foundation) submit a full proposal.

<u>Twisp River Riparian Protection III Project (Not Fundable)</u>

The Committees recommend that this project, sponsored by the Methow Conservancy, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees believe that it is unlikely that the floodplain/riparian portion of this property will be developed in the future. Therefore, they do not see the need for a conservation easement on this property at this time.
- The cost per acre is excessive and the public benefit is low relative to that cost.

<u>Entiat PUD Canal System Conversion Project – Phase 2 Project (Not Fundable)</u>

The Committees recommend that this project, sponsored by Cascadia Conservation District, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The project is too expensive and should be funded by Chelan PUD.

<u>Tyee Ranch Conservation Easement (Not Fundable)</u>

The Committees recommend that this project, sponsored by Cascadia Conservation District, should not be submitted as a full proposal to the Tributary Committees for the following reasons:

- The Committees cannot contribute funds beyond the appraised value of the conservation easement.

<u>Cottonwood Flats Phase 1: Bridge Removal Project (Fundable)</u>

The Committees recommend that the sponsor (Chelan County Natural Resource Department) consider the following comments/suggestions as they develop the full proposal:

- Following the presentation, the Committees understand that the sponsor will change the grant application from a restoration proposal to an acquisition proposal. To that end, the Committees are willing to review the final proposal.
- The Committees are not interested in reviewing the final proposal if it includes Phase II (Bridge Removal) or III (Floodplain Restoration) work.

<u>Lower Entiat RM 2.6-3.5 Projects (BOR Reach 1B) Project (Fundable)</u>

The Committees recommend that the sponsor (Yakama Nation) consider the following comments/suggestions as they develop the full proposal:

- The sponsor needs to make sure that the landowners are committed to the project. There is some concern that Mr. Asher may not be committed to the project.

Tracy will share this information with project sponsors on Friday, 15 June. The Committees hope this feedback will help sponsors develop full proposals, which are due on 29 June. The Committees will evaluate final proposals on Thursday, 12 July.

VII. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in May and June:

Rock Island Plan Species Account:

- $16,066.90 to Cascade Columbia Fisheries Enhancement Group for the Wenatchee Nutrient Enhancement Project.
- $883.00 to Chelan-Douglas Land Trust for the White River Van Dusen Conservation Easement. This is the final payment for this project.

Rocky Reach Plan Species Account:

- $24,711.82 to Trout Unlimited–Washington Water Project for the Chewuch River Instream Flow Project.

2. Becky Gallaher reported that currently there is $1,437,319.80 in the Rock Island Plan Species Account, $1,057,743.67 in the Rocky Reach Plan Species Account, and $978,751.48 in the Wells Plan Species Account.
3. Tracy Hillman reported that Carmen Andonaegui will serve as the WDFW representative on the Tributary Committees and Dennis Beich will serve as the alternate.
4. Tracy Hillman stated that The Seminar Group will be hosting an Easements Seminar on 10 October at the Washington State Convention Center in Seattle. For more information see the following link: http://theseminargroup.net/seminar.lasso?seminar=12.EASWA
5. Trout Unlimited–Washington Water Project asked the Committees if they would be interested in reviewing a Small Projects Proposal that would fund the drilling and testing of a well, which would remove Greg Port from the Redshirt Ditch on Beaver Creek, a tributary to the Methow River. The cost of the project would not exceed $20,000. The Committees said that they would review the Small Projects Proposal.
6. Dale Bambrick described a Small Projects Proposal that the Committees may receive in the near future. Dale indicated that there are plans to replace the Barkley Irrigation Diversion (push-up dam) on the Methow River with a more fish-friendly project. In the meantime, a short-term fix that does not require a push-up dam is being considered. Dale indicated that the Committees may receive a Small Projects Proposal requesting about $20,000 for poly bags and gravel.
7. Tracy Hillman shared with the Committees an e-mail he received from Julie Grialou with the Methow Conservancy. Julie asked that the Committees address the following questions regarding public access on conservation easements and acquisitions funded by the Tributary Committees:
    - What form of public access will be required/considered (e.g., from river or from road)?
    - On what frequency must public access be allowed (e.g., one day per year vs daylight hours only vs all the time)?
    - Can you describe to us how other project sponsors are meeting this public access requirement in their proposals?
    - Could this access come in the form of organized field trips coordinated by our organization?
    - Is there a standard to which the access must be maintained (surface type/ parking requirements)?
    - Must the access provide access to the river/riparian area?

- Is there any limit to the infrastructure a landowner can provide to accommodate the public use?
- Does the distance of the site from other existing public access points affect the public access that would be required on the easement?
- Must the access be designed in accordance with ADA standards?

The Committees did not have time to address these questions; however, they noted that easements and acquisitions funded by the Committees should have a 10-12 foot wide easement that allows public access to the river, and allows for bird watching and fishing. The Committees will address these questions during the July or August meeting.

VIII. Next Steps

The next meeting of the Tributary Committees will be on Thursday, 12 July 2012 at Chelan PUD in Wenatchee. At that time, the Committees will evaluate General Salmon Habitat Program Proposals, discuss a policy for Stewardship Plans and public access on protected properties, and continue their discussions on appraisals and the appraisal process.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 12 July 2012

Members Present: Dale Bambrick (NOAA Fisheries), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Members Absent: Carmen Andonaegui (WDFW)[1].

Others Present: Becky Gallaher (Tributary Project Coordinator). Joe Connor and Peter Lofy (Bonneville Power Administration) joined the meeting for the review of General Salmon Habitat Program Proposals.

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met in the Chelan PUD Second Floor Conference Room in Wenatchee, Washington, on Thursday, 12 July 2012 from 9:00 am to 12:20 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 14 June 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Lower Wenatchee Instream Flow Enhancement Project – The sponsor (Washington Rivers Conservancy) has been working through the permitting process. They have completed the NEPA, SEPA, Cultural Resources, Shoreline Exemption, and Wetland Variance reports. The NPDES, Corp of Engineers, and WDFW permits are pending. In addition, the sponsor is working with Chelan PUD on submitting the application for the FERC permit.
- Entiat National Fish Hatchery Project – The project is complete and a final report has been submitted to the Rocky Reach Tributary Committee.
- Mission Creek Fish Passage Project – The sponsor (Cascadia Conservation District) has submitted revised permit applications to the Corp of Engineers. Construction is scheduled for late September 2012.

[1] Carmen provided her votes on decision items before the meeting.

- Chewuch River Instream Flow Project – The sponsor (Trout Unlimited – WWP) has conducted landowner coordination, permitting, project planning and design, and construction management.
- Nutrient Enhancement Assessment – The sponsor (Cascade Columbia Fisheries Enhancement Group) had a conference call with Washington Department of Ecology on 2 July to discuss the draft Quality Assurance Project Plan (QAPP). The QAPP is final and Ecology has been involved and supportive of the project. Ecology sees this project as laying the groundwork for nutrient enhancement work statewide.

  Water Quality Engineers began water quality and macroinvertebrate sampling on 24-25 June. This involved preparation, ordering and calibration of field equipment, reconnaissance of sites, location of riffle zones, photographs, field coordinates, and collection of field samples and field measurements.
- Large Wood Atonement Project – The sponsor (Cascade Columbia Fisheries Enhancement Group) is working with Chelan County and WDFW on permitting the geotechnical phase of the project. The sponsor will collect geotech data in July and continue to conduct landowner outreach.
- Entiat Stormy Reach Phase 2 Acquisition – The project is complete and a final report will be submitted to the Rocky Reach Tributary Committee.

IV. Review of General Salmon Habitat Program Proposals

The Committees received 16 General Salmon Habitat Program proposals. Before reviewing the proposals, Becky Gallaher reported that currently there is $1,437,319.80 in the Rock Island Plan Species Account, $1,057,743.67 in the Rocky Reach Plan Species Account, and $978,751.48 in the Wells Plan Species Account. In addition, and consistent with the Committees' Operating Procedures, members of the Committees identified potential conflicts of interest. Kate Terrell recused herself from voting on the Lower White River Floodplain Rehabilitation project, the Upper Beaver Habitat Improvement Channel Restoration project, and the Lower Foster Creek Steelhead Habitat Enhancement project. Lee Carlson recused himself from voting on the YN Lower Entiat RM 2.6-3.5 Habitat project, Steve Hays recused himself from voting on the Entiat PUD Canal System Conversion project, and Chris Fisher recused himself from voting on the Fish Passage at Shingle Creek Dam project.

Lower Wenatchee Sleepy Hollow Floodplain Conservation Easements

Chelan-Douglas Land Trust is the sponsor of the Lower Wenatchee Sleepy Hollow Floodplain Conservation Easement Project. The purpose of this project is to protect riparian/floodplain habitat along the Wenatchee River between RM 2.5 and 3.1. The easement will protect about 40 acres (all of which is in the 100-year floodplain), including about 3,400 feet of riverbank. The total cost of the project is $545,000. The sponsor requested $136,250 from HCP Tributary Funds. ***The Tributary Committees elected not to fund this project,*** because the risk of development on the properties is low.

Lower White River Floodplain Rehabilitation Project

Cascade Columbia Fisheries Enhancement Group is the sponsor of the Lower White River Floodplain Rehabilitation Project. The purpose of this project is to assess historic, current, and target riparian and floodplain conditions on a reach scale, and to develop a restoration strategy that improves the health and function of the lower White River area for native salmonids. The total cost of the project is $125,000. The sponsor requested $25,000 from HCP Tributary Funds.

The Committees believe that this project is out of sequence. They believe that the sponsor should first develop alternatives and share those with the landowners to find out which ones the landowners approve. The sponsor should then resubmit the application with the alternatives agreed to by the landowners. The Committees also noted that the proposal did not link the hydraulic assessment with potential actions to improve floodplain connectivity and function. Therefore, ***the Tributary Committees elected not to fund this project***.

Lower Nason Creek RM 3.7-4.7 Restoration Project

Chelan County Natural Resource Department is the sponsor of the Lower Nason Creek RM 3.7-4.7 Restoration Project. The purpose of this project is to restore stream and floodplain function by removing 0.64 acres of floodplain fill and adding large wood structures, brush bundles, and vegetation. The total cost of the project is $398,233. The sponsor requested $60,000 from HCP Tributary Funds.

The Committees recognize that fish would benefit from the placement of large wood and removing the bridge abutment; however, they were unable to recognize a benefit associated with removing the parking area. It was not clear what the intended outcome would be from removing the parking area. Is the removal of fill material intended to create a wetland, side channel, high-flow channel, or simply allow high flows to flood the area? Without knowing the intended outcome of the action, the Committees were unable to assess its biological benefit. Based on these concerns, ***the Tributary Committees elected not to fund this project***.

Skinney Creek Floodplain Restoration Design Project

Chelan County Natural Resource Department is the sponsor of the Skinney Creek Floodplain Restoration Design Project. The purpose of this project is to design a restoration action that will restore natural channel processes such as channel migration and floodplain inundation in lower Skinney Creek and to improve spawning and rearing habitat for spring Chinook and steelhead. This would be accomplished by removing 3,430 feet of levee, increasing floodplain area from 0 to 4-13 acres, increasing juvenile rearing habitat by 50%, and creating 0.1 miles of spawning habitat. The total cost of the design project is $60,000. The sponsor requested $4,000 from HCP Tributary Funds.

The Committees believe that the proposed work is out of sequence and should be reconsidered after the Department of Transportation (DOT) completes their work. It is unclear at this time what specific conditions will result from the actions to be implemented by DOT. This project should be reevaluated after the completion of the DOT work. Therefore, ***the Tributary Committees elected not to fund this project***.

Wenatchee and Entiat Beaver Reintroduction Project

Trout Unlimited – Washington Water Project is the sponsor of the Wenatchee and Entiat Beaver Reintroduction Project. The purpose of this project is to enhance salmon and steelhead rearing conditions within the Peshastin, Mission, Mad, and upper Entiat watersheds by reintroducing beaver. This action should improve stream habitat complexity, flows, riparian conditions, and sedimentation while helping to ameliorate the effects of climate change. The total cost of the project is $199,000. The sponsor requested $70,000 from HCP Tributary Funds.

Although the Committees support the concept of reintroducing beaver into Wenatchee and Entiat watersheds, they believe the project is too expensive. In addition, they believe that before the sponsor seeks funding for the entire project, they should first run the model to identify if suitable introduction sites exist in the watersheds. To that end, the Committees would be willing to review a Small Projects Program Application requesting funds to support model runs. Based on these concerns, ***the Tributary Committees elected not to fund this project***.

Entiat PUD Canal System Conversion Project – Phase 2 Project

Cascadia Conservation District is the sponsor of the Entiat PUD Canal System Conversion Project. The purpose of this project is to complete the conversion of water source from a river-intake canal system to wells on four of seven users of the PUD canal system on the lower Entiat. This project will create water savings (about 4 cfs), enhance off-channel habitat conditions for Chinook and steelhead, and prevent juvenile entrainment. The total cost of the project is $240,000. The sponsor requested $36,000 from HCP Tributary Funds.

Although the Committees support the concept of saving water, they did not believe that the savings of about 4 cfs in the lower Entiat would result in a significant biological benefit. In addition, they believe that the Bureau of Reclamation should address the Milne intake structure. Based on these concerns, ***the Tributary Committees elected not to fund this project***. On the other hand, the Committees would review a Small Projects Program application requesting funding to outfit the test wells so they can be converted to full production.

YN Lower Entiat RM 2.6-3.5 Habitat Projects

The Yakama Nation is the sponsor of the Lower Entiat RM 2.6-3.5 Habitat Project. The purpose of this project is to design a project that will increase habitat diversity and complexity in the lower Entiat. This will be accomplished by adding large wood along the stream margins and boulder clusters within the channel. The total cost of the project is $98,000. The sponsor requested $98,000 from HCP Tributary Funds.

Although the Committees support the proposed project, ***the Tributary Committees elected not to fund this project*** because BPA has agreed to fund the project.

Cottonwood Flats Phase 1: Acquisition

Chelan County Natural Resource Department is the sponsor of the Cottonwood Flats Phase 1: Acquisition Project. The purpose of this project is to acquire about 25.02 acres of riparian and upland habitat (including about 2,475 feet of stream bank) adjacent to the middle Entiat River between RM 17.8-18.1. The total cost of the project is $402,000. The sponsor requested $60,300 from HCP Tributary Funds.

Given that 80% of the acquisition consists of uplands, the Committees found little biological benefit to the proposed project. In addition, the Committees believe that the sponsor should discuss this project with the Chelan-Douglas Land Trust and make sure that the Land Trust agrees with the acquisition and all proposed phases of this project. Based on these concerns, ***the Tributary Committees elected not to fund this project***.

Methow River Riparian Planting Project

Cascade Columbia Fisheries Enhancement Group is the sponsor of the Methow River Riparian Planting Project. The purpose of this project is to restore riparian habitat along the mainstem Methow River between the towns of Carlton and Twisp. Degraded areas will be replanted with native vegetation. The total cost of the project is $95,000. The sponsor requested $15,000 from HCP Tributary Funds.

Although the Committees generally support riparian restoration projects, they see this project as having little biological benefit. In addition, the project seems to be out of sequence with the restoration of the Silver Reach. Riparian restoration should be reevaluated after completion of work in the Silver Reach. Based on these concerns, ***the Tributary Committees elected not to fund this project***.

Twisp River Elbow Coulee Phase II Rt/Lt Bank Restoration 2012 RM 6.5 Project

The Methow Salmon Recovery Foundation is the sponsor of the Twisp River Elbow Coulee Phase II Rt/Lt Bank Restoration Project. The purpose of this project is to improve access, increase rearing habitat, and reduce stranding of fish in two side channels of the Twisp River. This will be accomplished by enlarging a previously constructed levee breach, and breaching an existing levee to reconnect an 800-foot long groundwater-fed channel. The total cost of the project is $77,000. The sponsor requested $14,580 from HCP Tributary Funds. ***The Wells Committee approved funding for this project.***

BPA is currently considering funding the Committee's portion of this project. If they elect to fund this project, funding from the Wells Committee would be unnecessary and the Committee would withdrawal their financial support for this project. If BPA decides not to fund the project, the Wells Committee will contribute up to $14,580 to this project.

Twisp River-Poorman Creek Wetland Habitat Acquisition 2012 RM 4.75

The Methow Salmon Recovery Foundation is the sponsor of the Twisp River-Poorman Creek Wetland Habitat Acquisition Project. The purpose of this project is to acquire about 24 acres of riparian habitat adjacent to the Twisp River at RM 4.75 (mouth of Poorman Creek). The acquisition includes about 2,300 feet of Twisp River frontage and 960 feet of Poorman Creek. The project will also decommission two irrigation diversions on Poorman Creek and an irrigation pump station within a wetland. The total cost of the project is $423,000. The sponsor requested $63,450 from HCP Tributary Funds. ***The Wells Committee approved funding for this project.***

As part of the Wells Committee's contribution to this project, they will use their own appraiser and reviewer to assess the value of the property. This is a new policy of the Committees. All acquisitions and conservation easements funded by the Committees will be evaluated by the Committees' appraiser and reviewer, and the Committees will deduct the costs for the appraisal and appraisal review from the total cost of each project. Finally, the Committee recommended that the management/conservation plan for the property includes language that the property may receive habitat restoration activities if deemed appropriate.

Upper Beaver Habitat Improvement Channel Restoration 2012 RM 7 Project

The Methow Salmon Recovery Foundation is the sponsor of the Upper Beaver Habitat Improvement Channel Restoration Project. The purpose of this project is to increase habitat complexity, which will support rearing, spawning, and migration of steelhead in Beaver Creek. This will be accomplished by reconnecting 600 feet of historic channel and constructing 1,700 feet of new meandering stream to replace a 1,160-foot long straightened channel. In addition, the project will reconnect the stream with the floodplain and add large wood to create complexity. Finally, the Batie diversion will be replaced with a diversion that meets all state and federal criteria. The total cost of the project is $674,300. The sponsor requested $205,225 from HCP Tributary Funds. ***The Wells and Rocky Reach Committees each elected to contribute $102,612.50 to this project.***

Lower Chewuch Beaver Restoration Project

The Methow Conservancy is the sponsor of the Lower Chewuch Beaver Restoration Project. The purpose of this project is to enhance salmon and steelhead rearing conditions within the lower Chewuch watershed by reintroducing beaver. This action should improve stream habitat complexity, flows, riparian conditions, and sedimentation while helping to ameliorate the effects of climate change. The total cost of the project is $231,000. The sponsor requested $27,000 from HCP Tributary Funds. ***The Wells Committee approved funding for this project.***

Big Valley Riparian Protection Project

The Washington Department of Fish and Wildlife is the sponsor of the Big Valley Riparian Protection Project. The purpose of this project is to acquire about 30 acres of riparian and floodplain habitat along the upper Methow River. The total cost of the project is $404,000. The sponsor requested $200,000 from HCP Tributary Funds.

Although the Committees support protecting important habitat, they believe that these parcels have a low probability of being developed. In addition, over half of the proposed acquisition consists of uplands. Finally, the proposal lacked a detailed budget and signed landowner agreement forms. Based on these concerns, ***the Tributary Committees elected not to fund this project***.

Fish Passage at Shingle Creek Irrigation Dam

The Okanagan Nation Alliance and the Colville Confederated Tribes are the sponsors of the Fish Passage at Shingle Creek Irrigation Dam Project. The purpose of this project is to provide fish passage at an irrigation dam, which prevents access to 22 miles of spawning and rearing habitat in Shingle Creek and Shatford Creek. The dam will be modified and/or replaced with a series of riffles that will maintain the stability of the streambed while allowing access to upstream habitat. The total cost of the project is $180,950. The sponsor requested $118,450 from HCP Tributary Funds. ***The Wells and Rocky Reach Committees each elected to contribute $59,225 to this project.***

Lower Foster Creek Steelhead Habitat Enhancement Project

The Foster Creek Conservation District is the sponsor of the Lower Foster Creek Steelhead Habitat Enhancement Project. The purpose of this project is to increase channel complexity, provide cover, capture sediment, create pools, increase water availability, and increase spawning gravels. This will be accomplished by adding large wood and spawning gravels to lower Foster Creek. In addition, the project will assess the feasibility of relocating the discharge point for Chief Joseph toe-water further upstream. The total cost of the project is $85,500. The sponsor requested $57,500 from HCP Tributary Funds. ***The Wells Committee approved funding for this project.***

Funding for this project is contingent on the Committee's review and approval of the restoration design. The Committee questioned the need for 100 cubic yards of spawning gravels. This amount seems excessive for such a small treatment area.

Summary of Review of 2012 General Salmon Habitat Program Projects.

Project Name	Sponsor[1]	Total Cost	Request from T.C.	T.C. Contribution[2]
Lower Wenatchee Sleepy Hollow Easement	CDLT	$545,000	$136,250	$0
Lower White Floodplain Rehabilitation	CCFEG	$125,000	$25,000	$0
Nason Creek RM 3.7-4.7 Restoration	CCNRD	$398,233	$60,000	$0
Skinney Creek Floodplain Restoration Design	CCNRD	$60,000	$4,000	$0
Wenatchee and Entiat Beaver Reintroduction	TU-WWP	$199,000	$70,000	$0
Entiat PUD Canal System Conversion	CCD	$240,000	$36,000	$0
YN Lower Entiat RM 2.6-3.5 Habitat	YN	$98,000	$98,000	$0
Cottonwood Flats Phase 1 Acquisition	CCNRD	$402,000	$60,300	$0
Methow Riparian Planting	CCFEG	$95,000	$15,000	$0
Twisp River Elbow Coulee Phase II Restoration	MSRF	$77,000	$14,580	W: $14,580[3]
Twisp River-Poorman Wetland Habitat Acquisition	MSRF	$423,000	$63,450	W: $63,450

Project Name	Sponsor[1]	Total Cost	Request from T.C.	T.C. Contribution[2]
Upper Beaver Creek Habitat Improvement	MSRF	$674,300	$205,225	W/RR: $205,225
Lower Chewuch Beaver Restoration	MC	$231,000	$27,000	W: $27,000
Big Valley Riparian Protection	WDFW	$404,000	$200,000	$0
Fish Passage at Shingle Creek Dam	ONA/CCT	$180,950	$118,450	W/RR: $118,450
Lower Foster Creek Habitat Enhancement	FCCD	$85,500	$57,500	W: $57,500
Total:		**$4,237,983**	**$1,190,755**	**$486,205**

[1] CCD = Cascadia Conservation District; CCFEG = Cascade Columbia Fisheries Enhancement Group; CCNRD = Chelan County Natural Resource Department; CDLT = Chelan-Douglas Land Trust; FCCD = Foster Creek Conservation District; MC = Methow Conservancy; MSRF = Methow Salmon Recovery Foundation, ONA/CCT = Okanagan Nation Alliance and Colville Confederated Tribes; TU-WWP = Trout Unlimited – Washington Water Project; and WDFW = Washington Department of Fish and Wildlife.

[2] RI = Rock Island Plan Species Account; RR = Rocky Reach Plan Species Account; W = Wells Plan Species Account.

[3] If BPA elects to fund this project, funding by the Wells Committee will be unnecessary.

V. Small Projects Program Applications

The Committees reviewed three Small Projects Program applications from Cascadia Conservation District.

Wenatchee River RM 20-23 Riparian Restoration Project

The purpose of this project is to improve and restore riparian areas along a section of the Wenatchee River between RM 20.0 and 23.0. The total cost of the project is $95,424. The sponsor requested $80,424 from HCP Tributary Funds. After careful consideration of the proposal, ***the Tributary Committees elected not to fund this project***.

Peshastin Creek Riparian Restoration Project

The purpose of this project is to improve and restore riparian areas along a contiguous section of Peshastin Creek from RM 0.6 to 1.4. The total cost of the project is $76,257. The sponsor requested $51,257 from HCP Tributary Funds. After careful consideration of the proposal, ***the Tributary Committees elected not to fund this project***.

Entiat 1G/2A Reach Riparian Restoration Project

The purpose of this project is to improve and restore riparian areas along a nearly contiguous section of the Entiat River from RM 11.5 to 17.0. The total cost of the project is $100,000. The sponsor requested $85,000 from HCP Tributary Funds. After careful consideration of the proposal, ***the Tributary Committees elected not to fund this project***.

Although the Committees believe that riparian restoration is important, they found that the applications lacked enough information to evaluate the success of the proposed actions. For example, there was no information on what species would be planted, nor was there information on the age/size, number, density, and width of plantings. In addition, it was not clear if irrigation would be required to sustain the plantings. Finally, the Committees questioned why the three projects differed in cost per linear foot.

The Committees indicated that they would reevaluate proposals for the Wenatchee River and Peshastin Creek if the sponsor provided more detailed information on the proposed action (Section E in the application). The Committees noted that they were not interested in funding the proposed riparian restoration work in the Entiat. The area proposed for restoration on the Entiat falls within a reference reach for the IMW. In addition, it looks like the vegetation is recovering in that area.

VI. Appraisal Discussion

As noted during the June meeting, the Committees will use Larry Rees as their primary appraiser and Michael Gentry, Peter Shorett, and Fred Strickland as reviewers. The Committees directed Tracy Hillman and Becky Gallaher to contact the appraisers and ask them for rates and qualifications.

The Committees also talked about the possibility of purchasing acquisitions. At this time, it is unclear if the PUDs would be willing to hold the titles to the properties or if they would donate them to another entity such as WDFW, Land Trust, or Methow Conservancy. Because the PUDs do not pay property taxes for land held in fee title, local committees tend to complain about the PUDs acquiring property as a tool to mitigate for their effects on fish and wildlife. Tom Kahler and Steve Hays will check with their respective PUDs to see if the PUDs would be willing to hold the titles or donate them to another entity.

Finally, Tracy informed Marc Duboiski (Recreation and Conservation Office) that the Committees will use their own appraisers and reviewers to evaluate the value of future acquisitions and conservation easements. Marc supported the use of the Committees appraisers.

VII. Methow Conservancy Questions

Last month Tracy Hillman received an e-mail from Julie Grialou with the Methow Conservancy asking the Committees to address several questions regarding public access on conservation easements and acquisitions funded by the Tributary Committees. The Committees provided the following answers to Julie's questions:

- What form of public access will be required/considered (e.g., from river or from road)? Pedestrian access from the road.
- On what frequency must public access be allowed (e.g., one day per year vs daylight hours only vs all the time)? Access will be provided at all times.
- Can you describe to us how other project sponsors are meeting this public access requirement in their proposals? All sponsors awarded funding from the Tributary Committees for protection projects will be required to provide pedestrian access to the river.
- Could this access come in the form of organized field trips coordinated by our organization? No.
- Is there a standard to which the access must be maintained (surface type/ parking requirements)? There will be no impediments to foot access (e.g., fences).
- Must the access provide access to the river/riparian area? Yes.
- Is there any limit to the infrastructure a landowner can provide to accommodate the public use? Infrastructure cannot devalue the habitat being protected.
- Does the distance of the site from other existing public access points affect the public access that would be required on the easement? No. Access must be provided on all protection projects funded by the Committees.
- Must the access be designed in accordance with ADA standards? No.

The Committees directed Tracy to provide these responses to Julie.

VIII. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in June and July:

   Rock Island Plan Species Account:

   - $2,066.89 to Chelan PUD for Rock Island project administration/coordination during the second quarter, 2012.
   - $276.50 to Clifton Larson Allen for second-quarter financial management and reporting.
   - $10,830.08 to Cascade Columbia Fisheries Enhancement Group for the Wenatchee Nutrient Enhancement Project.

   Rocky Reach Plan Species Account:

   - $1,816.44 to Chelan PUD for Rock Rocky project administration/coordination during the second quarter, 2012.
   - $276.50 to Clifton Larson Allen for second-quarter financial management and reporting.
   - $15,353.49 to Trout Unlimited–Washington Water Project for the Chewuch River Instream Flow Project.
   - $26,691.92 to Cascadia Conservation District for the Entiat National Fish Hatchery Improvement Project. This is the final bill for this project.

   Wells Plan Species Account:

   - $898.62 to Chelan PUD for Wells project administration/coordination during the second quarter, 2012.

IX. Next Steps

The next meeting of the Tributary Committees will be on Thursday, 13 September 2012 at Chelan PUD in Wenatchee. There will be no meeting in August.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 11 October 2012

Members Present: Dale Bambrick (NOAA Fisheries), Dennis Beich (WDFW), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), and Tracy Hillman (Committees Chair).

Members Absent: Kate Terrell (USFWS)[1].

Others Present: Becky Gallaher (Tributary Project Coordinator). Brandon Rogers, Yakama Nation, joined the last 20 minutes of the meeting.

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met in the Chelan PUD Auditorium in Wenatchee, Washington, on Thursday, 11 October 2012 from 10:00 am to 12:20 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda with the following changes:

- Drop the Wenatchee Riparian Restoration Project proposal.
- Add discussion on outreach and coordination.
- Add discussion on Okanogan Fish and Water Management Tool.
- Add discussion on Assessment Funds (The Committees did not have time to discuss this item; therefore, it will be added to the November Agenda).

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 12 July 2012 meeting notes with edits from Tom Kahler and Kate Terrell.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Lower Wenatchee Instream Flow Enhancement Project – The sponsor (Washington Rivers Conservancy) received FERC approval, but recently received notice that the Department of Natural Resources would like to review and comment on the project. The final design was modified slightly and an addendum will be sent to the contractors this week. Becky will check with the sponsor on the modifications to the final design. Installation of the fish screens will begin in late October or early November. The sponsor

[1] Kate provided her votes on decision items following the meeting.

will then begin construction on the pump facility, prep the pipeline transgress, and start laying pipe. The sponsor anticipates completion of the project in early March. They will test the system in early April.

- Twisp River Riparian Protection (Zinn) – The sponsor (Methow Conservancy) is currently drafting the easement and the appraisal is in progress. The Forest Service is behind schedule in completing the land exchange, which is the precursor to the easement. The sponsor and the SRFB have extended the contract to accommodate the Forest Service schedule.
- Nason Creek Upper White Pine Reconnection – Chelan PUD Powerline Reconnection Alternatives Analysis – The alternative analysis was completed in July 2012. The sponsor (Chelan County Natural Resources Department) asked the Rock Island Tributary Committee for a time extension on the project. The contract amendment would extend the current deadline from 31 July 2012 to 31 December 2013. The purpose of the extension is to allow time to select an alternative for relocating the Chelan PUD powerlines. The sponsor also asked if they could use the remaining funds in the project (~$26,000) to hire a mediator with utility experience to facilitate discussions between the Forest Service and Chelan PUD. ***The Rock Island Tributary Committee agreed to extend the period of the project to 31 December 2013. The Committee also approved the use of remaining funds to hire a mediator to facilitate discussions between the Forest Service and Chelan PUD.***
- Mission Creek Fish Passage Project – The sponsor (Cascadia Conservation District) has not yet received the Army Corps of Engineers (ACOE) permit. This is because of internal staffing and workload priorities within the ACOE. If the permit is received this fall, it will be too late to begin construction as planned. In addition, the Bureau of Reclamation and the Natural Resources Conservation Service have expressed concerns that the recent fires may affect flow conditions and sediment dynamics within Mission Creek. The current design may not survive the expected flow conditions and sediment transport. Thus, the sponsor asked the Rock Island Committee for a time extension on the project. The contract amendment would extend the deadline to 31 December 2013. ***The Rock Island Tributary Committee agreed to extend the period of the project to 31 December 2013.***
- Chewuch River Instream Flow Project – Project construction was scheduled to begin this fall; however, the sponsor (Trout Unlimited – WWP) decided to postpone construction until early 2013. This is because (1) the Report of Examination for the change in water right is still in draft form, (2) the bids for the Bear Creek-to-Winthrop portion of the project were all higher than the Bureau of Reclamation’s estimated costs, and (3) project costs. The sponsor will “ground-truth” all costs for the project. If the costs are above the original estimate, the sponsor will seek additional funding.
- Twisp River Acquisition (Hovee) – After the initiation of the acquisition process, the owners of the property separated. This killed the project. The sponsor (Methow Salmon Recovery Foundation) is asking the RCO about substituting the Twisp River Acquisition project for two other adjacent properties. If the RCO approves the substitution, the sponsor will submit a similar request to the Wells Tributary Committee.
- Nutrient Enhancement Assessment – The sponsor (Cascade Columbia Fisheries Enhancement Group) and their contractor have been sampling water quality and macroinvertebrates monthly since June. They are also sampling periphyton and have installed sondes for continuous measurement of pH, dissolved oxygen, temperature, and

conductivity. Preliminary findings will be presented to the CCFEG Board in November. The sponsor is planning to hold another stakeholder meeting in December.

- Large Wood Atonement Project – Gravity Environmental, the U.S. Fish and Wildlife Service, and Tetra Tech have collected topographic and geotechnical information. This information is needed to inform the feasibility and refinement of the design, which the USFWS is currently developing. The sponsor (Cascade Columbia Fisheries Enhancement Group) will schedule a meeting with Chelan County, Chelan-Douglas Land Trust, WDFW, and the Army Corps of Engineers to discuss permitting and logistics.
- Silver Protection Project – The sponsor (WDFW) is still negotiating with the landowner. The sponsor agreement is in the WDFW contracting process.
- Coulter Creek Barrier Replacement Project – Funding for this project is contingent upon the successful implementation of the railroad reconnection project, which has not yet happened.
- Entiat Stormy Reach Phase 2 Acquisition – The project is complete and a final report will be submitted to the Rocky Reach Tributary Committee in November.
- Wenatchee Levee Removal and Riparian Restoration Project – In September, the sponsor (Chelan County Natural Resources Department) asked the Rock Island Tributary Committee for a time extension on the project. This is because there have been some water-right issues that have complicated the process. The sponsor is currently working with the Water Conservancy Board, but it is unlikely the project will be completed by the end of October 2012. Thus, the sponsor asked the Rock Island Tributary Committee for a contract amendment that would extend the deadline to 30 June 2013. ***The Rock Island Tributary Committee agreed to extend the period of the project to 30 June 2013.***

IV. Okanagan Field Trip

Tracy Hillman, with much help from Chris Fisher, Tom Kahler, and Dennis Beich, provided a briefing on their trip to the Okanagan River in Canada (notes from the trip are appended as Attachment A). The Okanagan Nation Alliance (ONA) conducted the site tours. During the first day of the fieldtrip (12 September), members visited the lower portion of Shuttleworth Creek. The lower portion of Shuttleworth Creek was designed to act as a sediment trap. During our visit in October 2010, the lower portion of the stream was wide, shallow, and heavily embedded with fine sediments. The banks were laid-back and there was limited channel structure and riparian vegetation. This year, the Ministry of Environment cleaned the sediment from the channel. This resulted in what looked like a bombing range (see before and after photos below). A rock dam located just upstream from the mouth of the stream maintains the sediment trap. Restoration actions under consideration include removing the barrier, reconfiguring the channel, and restoring riparian vegetation. Reconfiguration would result in a step-pool sequence, which would allow the Ministry of Environment to clean annually the first few pools in the sequence. Restoration would open about 31 km of tributary habitat. This stream is an important spawning and rearing area for steelhead/rainbow.

Before (October 2010)

After (September 2012)

Members then visited the Shuttleworth Creek diversion, which is located at Rkm 3.5. Surface water is diverted through an unscreened intake into a 300-m long open ditch that feeds into Hody Lake. The water is then piped to the Water Users' Community (WUC) properties. The system significantly reduces stream flows and habitat conditions in Shuttleworth Creek, and strands rainbow/steelhead in pools. The goal of the restoration project is to transfer the WUC from surface water to groundwater, and decommission the existing intake and diversion. The PRCC Habitat Subcommittee has approved funding for the conversion to groundwater.

Following the site visit on Shuttleworth Creek, members visited the irrigation dam on Shingle Creek. The dam is located at Rkm 2.3 and blocks access to 35.4 km of spawning and rearing habitat for steelhead and Chinook (once passage is provided at Okanagan Falls Dam). ONA is considering three options: (1) remove the dam, (2) backwater the dam with a series of riffles, and (3) notch the dam and backwater with a series of riffles. The latter is currently the preferred alternative; however, hydraulic analysis and modeling work will determine the best approach.

The ONA discussed restoration options for the Penticton Channel (Okanagan River upstream from Okanagan Falls Dam), which was channelized in the 1950s. About 100 meters of spawning gravels were added to the channel in the mid-1970s. Kokanee spawn extensively in these gravels. The ONA intends to add about four spawning gravel ramps to the Penticton Channel that will be used by sockeye after passage is provided at Okanagan Falls Dam. Because of controlled flows, the gravels should remain stable in the channel.

On the second day (13 September), members visited McIntyre Dam. During the visit in 2009, members noted that fish were temporarily trapped in a cavity along the outer edge of the horizontal lift gates. Engineers have since placed metal plates over the outer edge of the lift gates. ONA continues to test different combinations of passage scenarios (e.g., opening various gates, testing different flows over gates, etc.). As in 2010, it appeared that most fish were attempting to pass along the end wall on the left bank.

Lastly, members visited the Okanagan River Restoration Initiative (ORRI) Project, which is located just upstream from the Town of Oliver. The first phase of implementation, which is complete, was to rebuild the setback dike in the lower portion of the project area. Members observed the completed side channel and instream rock structures, and noted the gravel bar forming in the main channel upstream of the side channels. They also visited the location of the second phase of the project, which will reconnect a 300-m long side channel with the main channel. This will be accomplished by placing bottomless, box culverts at the upstream and downstream ends of the side channel. ONA also intends to modify Vertical Drop Structure (VDS)

13 by removing four V-shaped concrete components within the two middle bays of the structure. This should improve fish passage at the structure and enhance fish habitat (velocities and substrates) upstream from the structure. ONA will monitor the effects of the modification on incubating sockeye eggs.

V. Small Projects Program Application

The Committees reviewed a Small Projects Program application from Cascadia Conservation District.

Peshastin Creek Riparian Restoration Project

The purpose of this project is to improve and restore riparian areas along a contiguous section of Peshastin Creek from RM 0.6 to 1.4. The total cost of the project is $76,257. The sponsor requested $51,257 from HCP Tributary Funds. After careful review of the proposal, ***the Tributary Committees were unable to make a funding decision.*** The Committees questioned why the sponsor was seeking funds from the Plan Species Accounts when it appears that the proposed project fits better with Farm Bill Programs such as the Conservation Reserve Enhancement Program (CREP). The Committees asked that the sponsor please explain why CREP, or other similar funding sources, are not appropriate for this project.

VI. Acquisitions

During the July meeting, the Committees talked about the possibility of purchasing acquisitions. At that time, it was unclear if the PUDs would be willing to hold the titles to the properties or if they would donate them to another entity such as WDFW, Land Trust, or Methow Conservancy. Both Steve Hays and Tom Kahler consulted with their managers and reported that the PUDs have no interest in holding the titles to the properties. Because the PUDs do not pay property taxes for land held in fee title, the local committees would likely complain about the PUDs acquiring property as a tool to mitigate for their effects on fish and wildlife. In addition, the PUDs do not want stewardship responsibilities. Therefore, the Committees decided that they will not pursue purchasing acquisitions.

VII. Information Updates

The following information updates were provided during the meeting.

1. Approved Payment Requests in September and October:

   Rock Island Plan Species Account:

   - $2,108.87 to Chelan PUD for Rock Island project administration/coordination during the third quarter, 2012.
   - $97.50 to Clifton Larson Allen for third-quarter financial management and reporting.
   - $890.21 to Trout Unlimited – Washington Water Project for the Lower Wenatchee Instream Flow Project.
   - $28,703.97 to Chelan County Treasurer for the Nason Creek Upper White Pine Reconnection – Chelan PUD Powerline Alternatives Analysis Project.

   Rocky Reach Plan Species Account:

   - $963.13 to Chelan PUD for Rock Rocky project administration/coordination during the third quarter, 2012.

- $97.50 to Clifton Larson Allen for third-quarter financial management and reporting.

Wells Plan Species Account:

- $941.97 to Chelan PUD for Wells project administration/coordination during the third quarter, 2012.

2. Lee Carlson and Becky Gallaher reported that Cascadia Conservation District, Chelan County, Upper Columbia Salmon Recovery Board (UCSRB), and other entities have identified the need for funding to assist with outreach and coordination in the Upper Columbia. Dale Bambrick indicated that coordination and outreach was supposed to be the job of the UCSRB. He noted, however, that there is a need for messaging. This effort should be an all agency exercise. Dale indicated that he would help with messaging. Becky said that she will see if Derek Van Marter (UCSRB) and Susan Dretke (Cascadia Conservation District) will be able to attend the next meeting to talk briefly about messaging and funding needs.
3. During the May meeting, Tom Kahler indicated that Douglas PUD had asked the Department of Fisheries and Oceans Canada (DFO) to develop a proposal that would expand the Okanogan Fish and Water Management Tool to include summer Chinook downstream from Lake Osoyoos. The purpose would be to use the tool to increase egg-fry survival of summer Chinook spawning within the Okanogan River on the east side of Driscoll Island. During the Okanagan field trip, Tom discussed the expansion of the tool with Chris Fisher and Dennis Beich. Based on advice from Chris and Dennis, Douglas PUD has decided to wait for the new rule curves for Lake Osoyoos before expanding the tool. Thus, Douglas PUD will not be submitting within the next few months a Small Projects Proposal seeking funds to add a summer Chinook sub-model and a Lake Osoyoos water-level sub-model to the Fish and Water Management Tool.

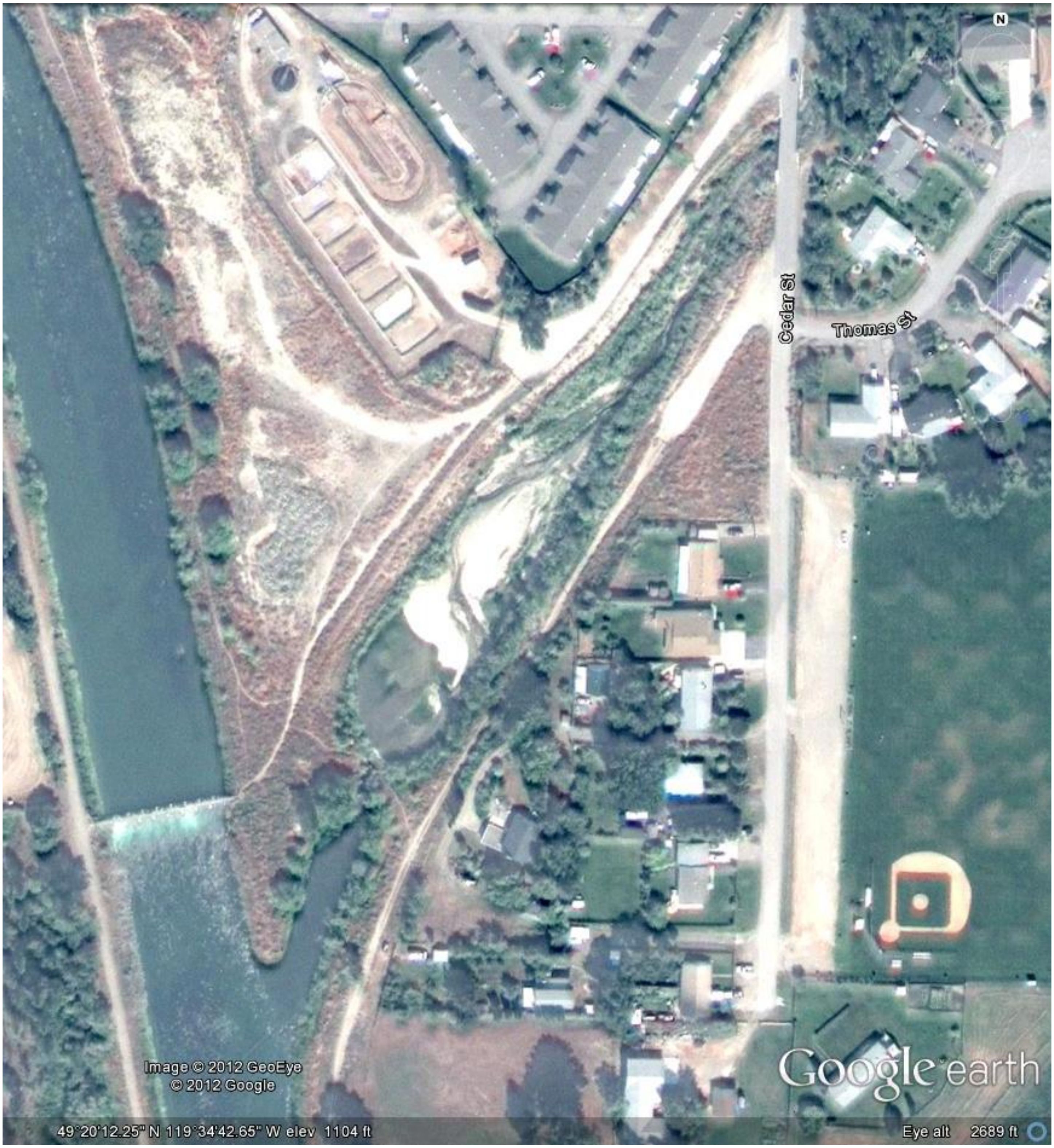
VIII. Next Steps

The next meeting of the Tributary Committees will be on Thursday, 8 November 2012 at Chelan PUD in Wenatchee.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

Attachment 1
Okanagan Field Trip Handouts

Shuttleworth Creek – Sediment basin



Sediment basin - Prior sediment extraction

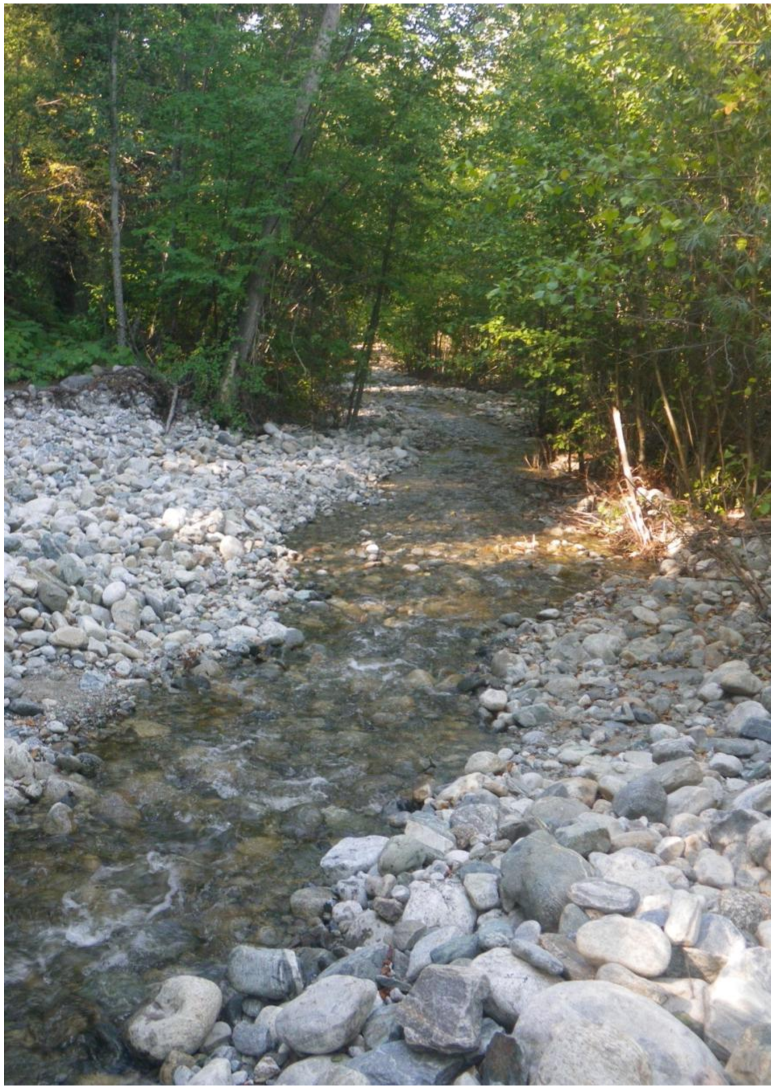
Looking downstream from Cedar Street bridge.

Looking upstream from weir. Note full sediment basin.

Shuttleworth Creek – Habitat upstream of sediment catching basin

Lower Reach (looking upstream)

Middle Braided Reach (looking upstream)



Upper Reach (looking downstream)

Rainbow Trout/Steelhead

Shuttleworth Creek – Sediment basin

Project History:

- The sediment catching basin was constructed by the BC Ministry of Forests, Land and Natural Resource Operations (MoFLNRO) in the 1950's at the mouth of Shuttleworth Creek along with the Okanagan River channelization.
- MoFLNRO has been extracting the accumulated sediment in the basin approximately every 5-10 years since its implementation. The last extraction took place August 2012.
- This sediment basin is a partial fish barrier.
- The upstream section of Shuttleworth Creek contains good quality habitat for Steelhead (listed as endangered in the U.S.).

Project Goal:

- To provide fish passage at the sediment basin while maintaining the BC MoFLNRO criteria for the maintenance of Okanagan River's channel capacity.

Project Location:

- Shuttleworth Creek (mouth)
- Okanagan Falls, BC

Project Progress:

- Currently modeling the basin before and after the sediment extraction in order to provide a foundation for a conceptual design for a re-designed sediment basin.
- Design criteria under discussion through a steering committee involving ONA, MoFLNRO, and Hydraulic Engineers.
- Expect a funding request proposal

Shuttleworth Creek – Intake and Diversion

Legend

- Open diversion (yellow)
- Mainline irrigation (blue)
- Water Users' Community properties (red)

Intake (looking downstream) **Intake (looking upstream)**

Just downstream from intake

~2km downstream from intake

Rainbow Trout/Steelhead fry trapped in pool

Shuttleworth Creek – Intake and Diversion

Project History:

- The existing diversion and intake was implemented in the 1930's.
- Intake controls the amount and timing of downstream flow.
- Water is diverted through the unscreened intake into the ~300m long open ditch diversion to Hody Lake. The water is then diverted via pipeline to the Water Users' Community (WUC) properties for irrigation.
- This system greatly reduces fish flows, habitat and passage leaving Rainbow Trout/Steelhead stranded in pools.

Project Goal:

- To transfer the WUC from surface water to groundwater and decommissioning the existing intake and diversion by removing all anthropogenic materials from the creek.
- To restore natural flows within the creek improving fish passage and habitat for Rainbow Trout/Steelhead.

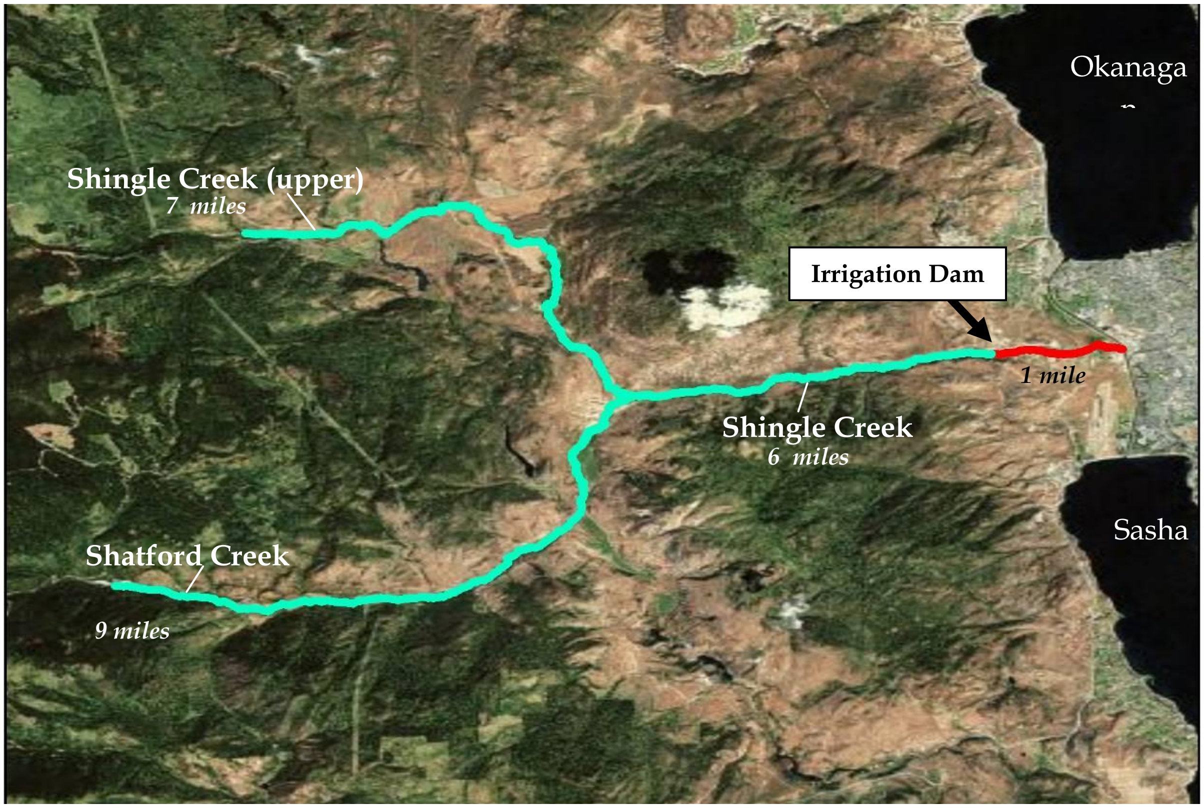
Project Location:

- Shuttleworth Creek (~3.5km upstream from mouth)
- Okanagan Falls, BC

Project Progress:

- Draft design complete from irrigation specialists.
- Awaiting approval from Nature Trust in regards to construction on their land.
- September – discussion with landowners and option to be selected.
- October 1st – start of design implementation.

Fish Passage at Shingle Creek Dam



Ortho Photo of Project Location and Accessible Creeks (22 miles)

Current Shingle Creek Dam

Riffles Concept Diagram

Conceptual Diagram of Projected Project Design Option

Fish Passage at Shingle Creek Dam

Project History:

- Both Shingle and Shatford creeks (tributary of Shingle) are underutilized by anadromous salmonids, due to limited access.
- An irrigation dam located 1.4 miles from the mouth of Shingle Creek prevents upstream fish migration. The dam contains a fish ladder that has not been operational at low flows and even during its operation has been regularly obstructed with debris.
- The irrigation dam was built in 1952 for water withdrawal purposes (irrigation and domestic). Today, water withdrawals are discontinued. The dam and adjacent lands are owned by the Penticton Indian Band (PIB).

Project Goal:

- This project will modify the concrete irrigation dam and install backwatering riffles in order to:
    - Provide access to 22 miles of upstream spawning and rearing habitat for Steelhead and spring Chinook.
    - Increase the creek habitat complexity (pools/riffles).

Projected Fish Passage Design Option:

- The current projected option is backwatering the irrigation dam with a series of riffles. The final project design will be selected depending on the hydraulic analysis and modeling outputs. The number of riffles, the location of the riffles and the size of material will be determined during this process.

Project Location:

- Shingle Creek (1.4 miles from creek mouth)
- Penticton, BC

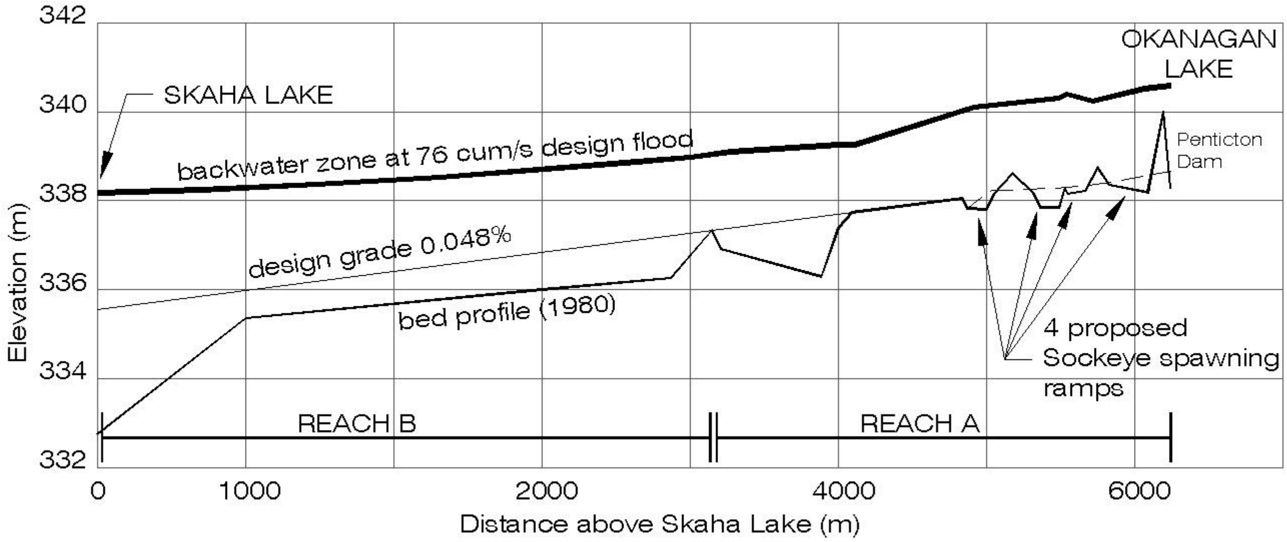
Project Progress:

- Documentation collection and site surveys are completed.
- Funding research is in progress (the majority of funds are secured).
- Hydraulic analysis and modeling of potential design options are in progress (expected for fall 2012).
- Design option selection and design criteria are expected for winter 2012.
- Engineering design and approvals are expected for spring 2013.
- Construction works are expected for summer 2013.
- Post construction site re-vegetation is expected for fall 2013.
- Implementation monitoring (salmon utilization) will be done 2013-2015 within OBMEP monitoring program.

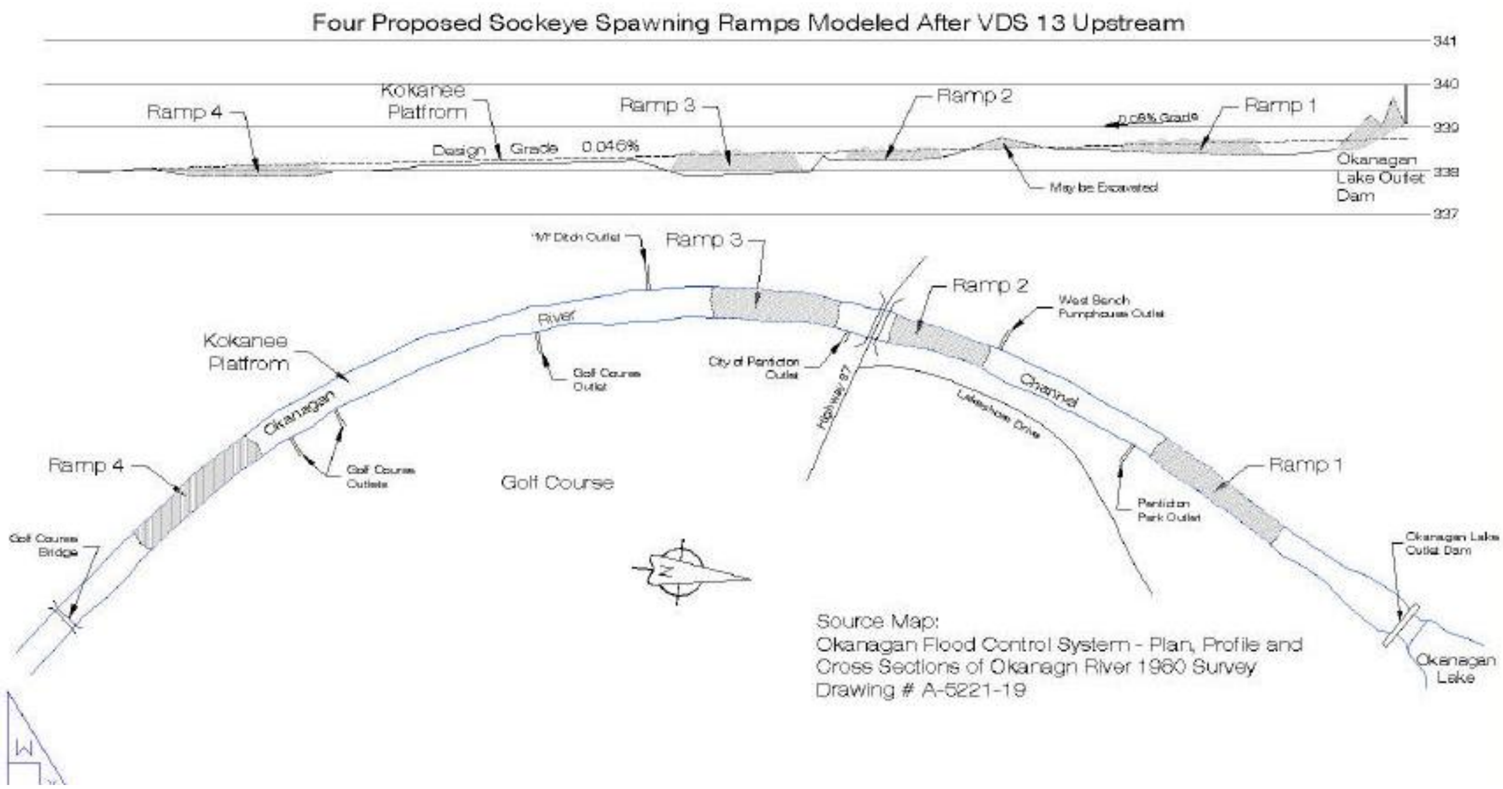
Penticton Channel – River Restoration

Penticton Channel prior channelization, 1930’s.

Penticton Channel after channelization, 2012.



Profiles of river bed, design grade and design flood water level.



Profile and plan of proposed spawning ramps.

Penticton Channel – River Restoration

Project History:

- Okanagan River was channelized in the 1950's and few suitable areas remain for salmon to spawn.

Project Goal:

- Restore ecological function where opportunities arise along the entire river reach and its tributaries.
- Create native fish habitat areas where opportunities exist for:
  - Spawning Sockeye (*Oncorhynchus nerka*), Kokanee (*O. nerka)*, Chinook (*O. tshawytscha)*, Steelhead (*O. mykiss)* and Rainbow Trout (*O. mykiss*).
  - Rearing areas for fry and parr of Chinook, Steelhead and Rainbow Trout.
  - Residence areas for adult Rainbow Trout.
- Reduce picivorous exotic fish habitat where opportunities exist.

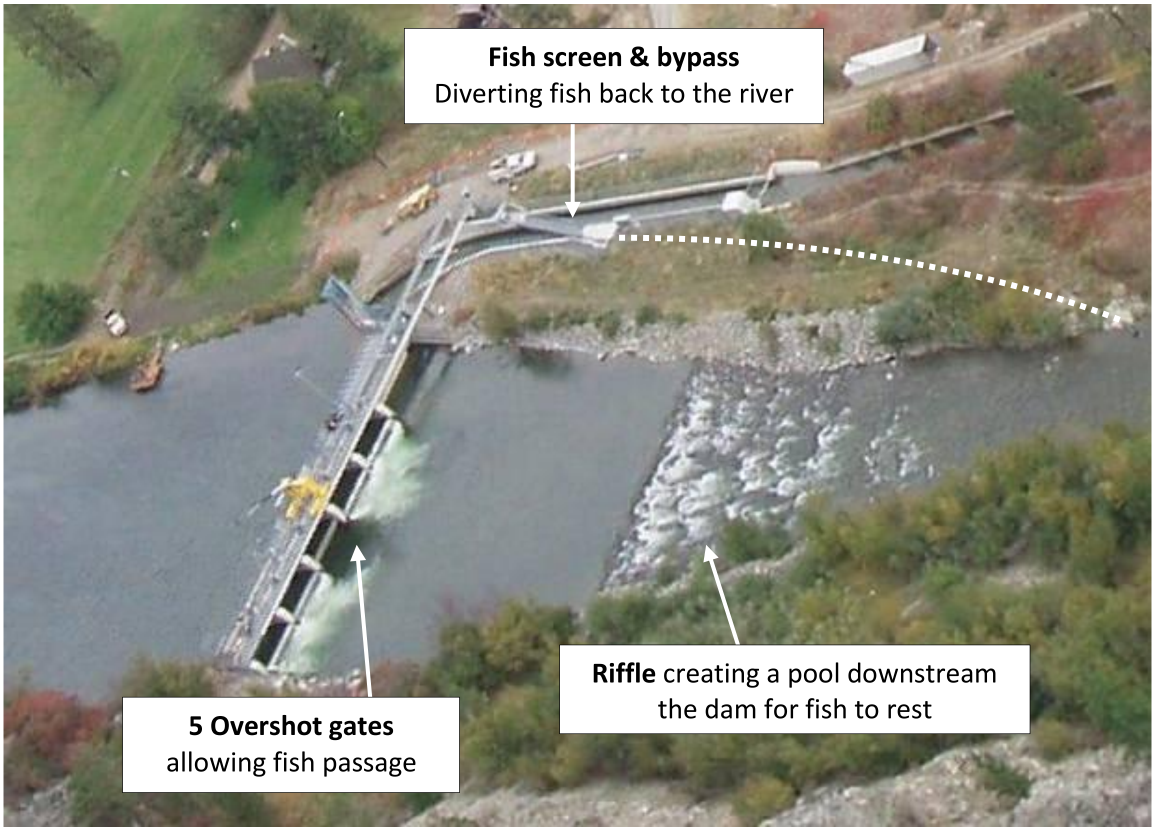
Project Location:

- Penticton Channel (Okanagan River)
- Penticton, BC

Project Progress:

- Scoping of project complete regarding river restoration design options and design criteria.
- Hydraulic analysis for conceptual design options is in progress.

Fish Passage at McIntyre Dam



Conceptual Design of Providing Fish Passage at McIntyre Dam

BEFORE (2008)

AFTER (2011)

McIntyre Dam Before and After the Modifications

Fish Passage at McIntyre Dam

Project History:

- McIntyre Dam was built in 1954 in order to control water levels in the Okanagan River between Vaseux and Osoyoos lakes and in order to provide irrigation water for agriculture and municipality purposes. MoFLNRO operates the dam.
- When this dam was constructed, no upstream fish passage provisions were included. The dam had been the upstream migration barrier for anadromous salmonids in the Okanagan River.

Project Goal:

- The project provided adult salmon passage and improved juvenile salmon downstream migration by:
    1. Replacing the existing 5 undershot gates with 5 overshot gates;
    2. Building a backwater riffle downstream of the dam;
    3. Monitoring the impacts on sockeye salmon migration (juvenile and adults);
    4. Installing a fish screen preventing fish entrainment in irrigation canal (Town of Oliver).
- The completion of this project provided an additional 11 km of spawning and rearing habitat in the Okanagan River and Vaseux Lake, historic habitat which has not been utilized by anadromous fish within the last six decades.

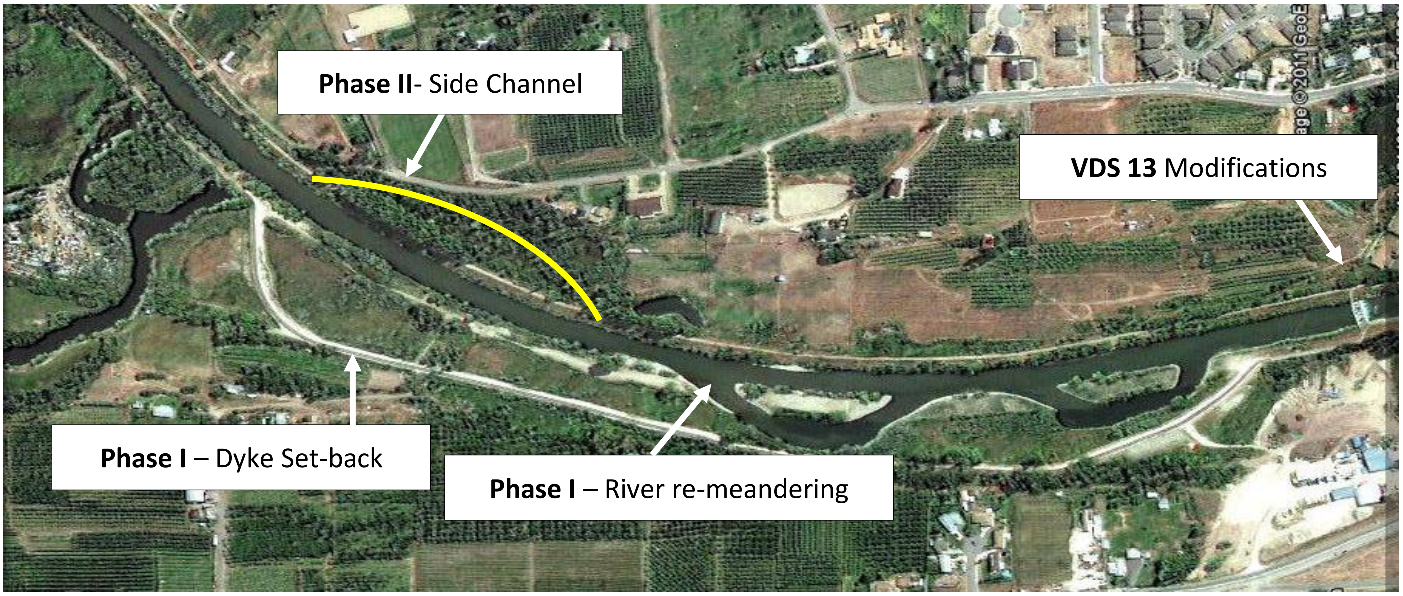
Project Location:

- Okanagan River (1 mile downstream of Vaseux Lake)
- Oliver, BC

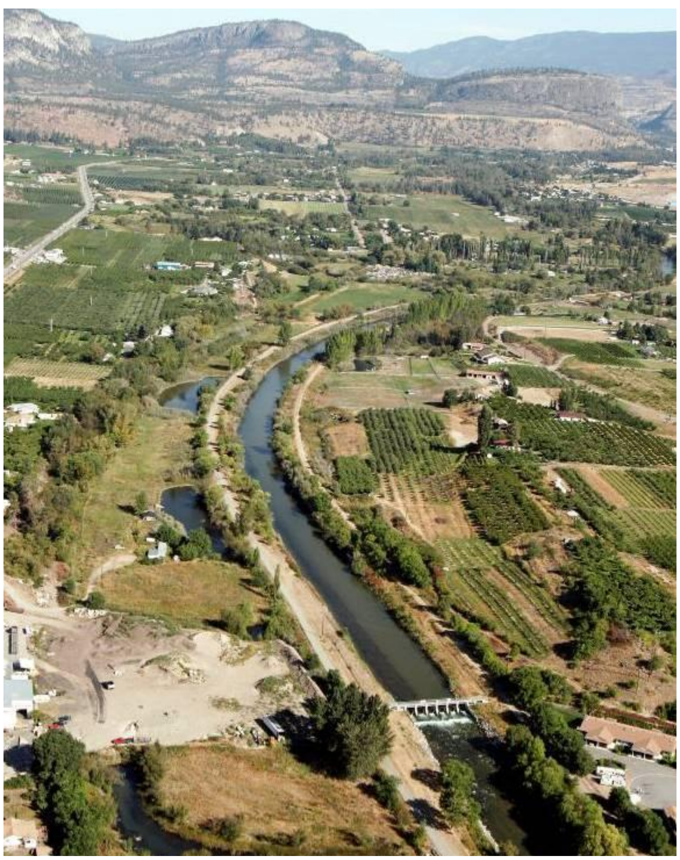
Project Progress:

- McIntyre Dam was refitted for fish passage in 2009.
- In 2010-2012, ONA has been monitoring sockeye utilization of upstream habitat and fish jumping efficiency over the dam.
- The new gates allow passage for sockeye of all sizes, but the fish jumping efficiency is low.
- ONA is working in collaboration with MoFLNRO (the manager of the dam) to find ways to optimize fish passage through the new gates, by producing (expected for winter 2012):
    - Guidelines for gate operation settings.
    - Guidelines for upstream water levels (Vaseux Lake).

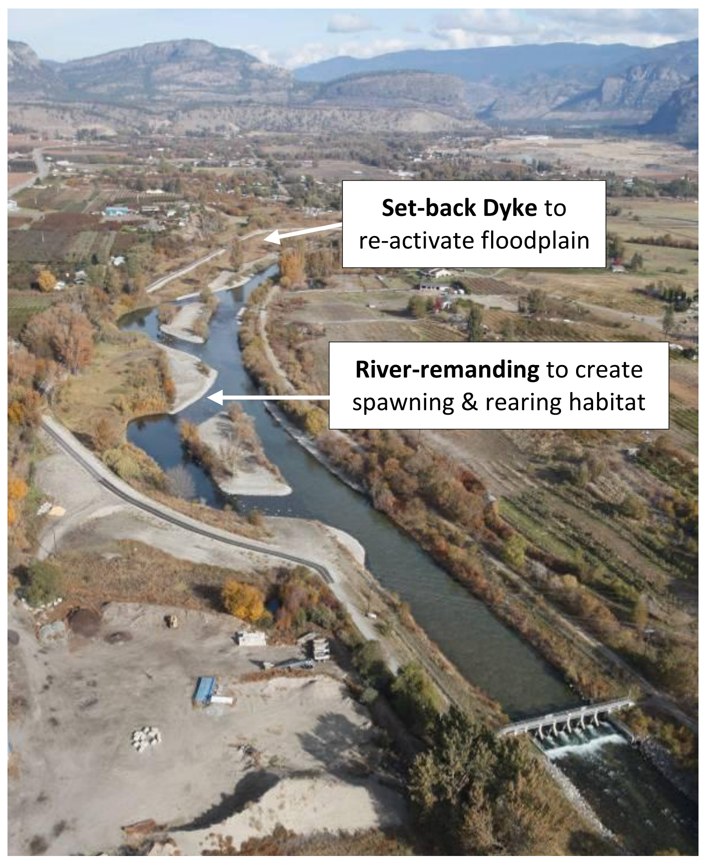
Okanagan River Restoration Initiative - ORRI



ORRI Phases (Phase I, Phase II and VDS 13)

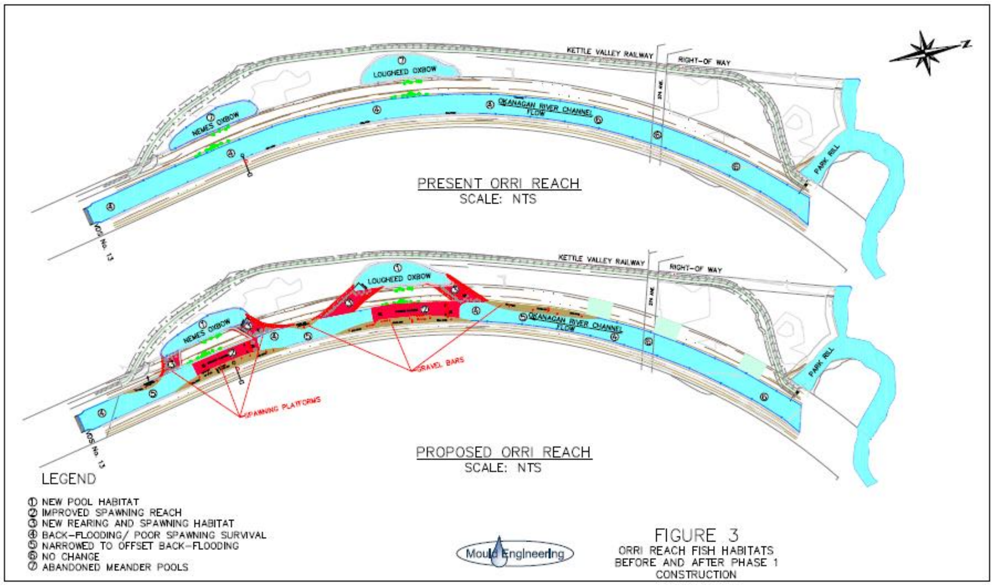


BEFORE (2005)

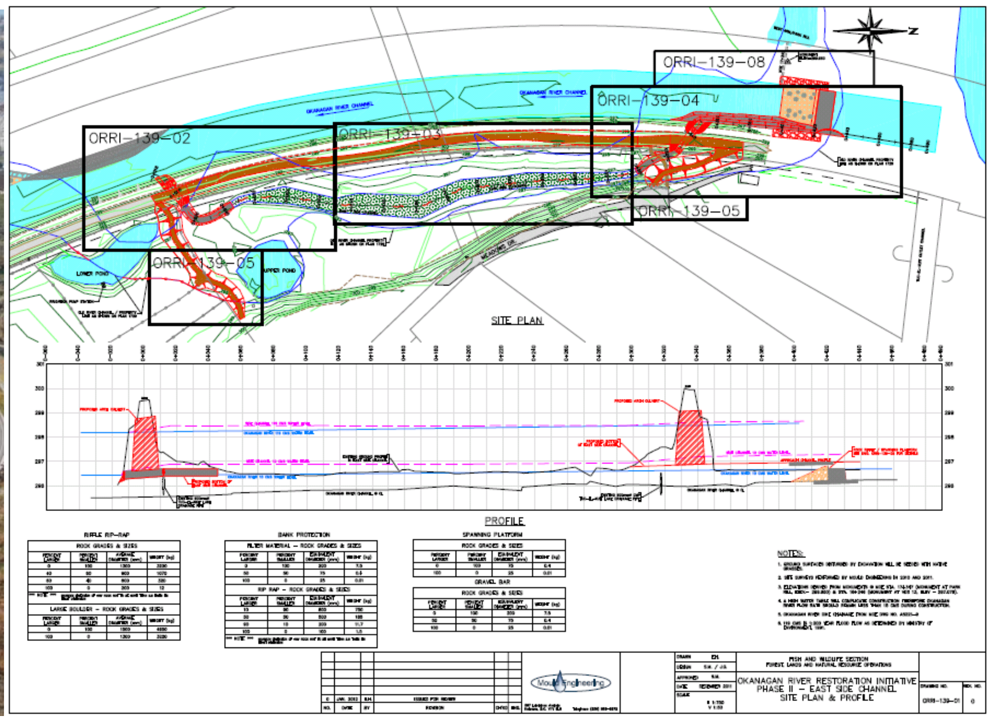


AFTER (2009)

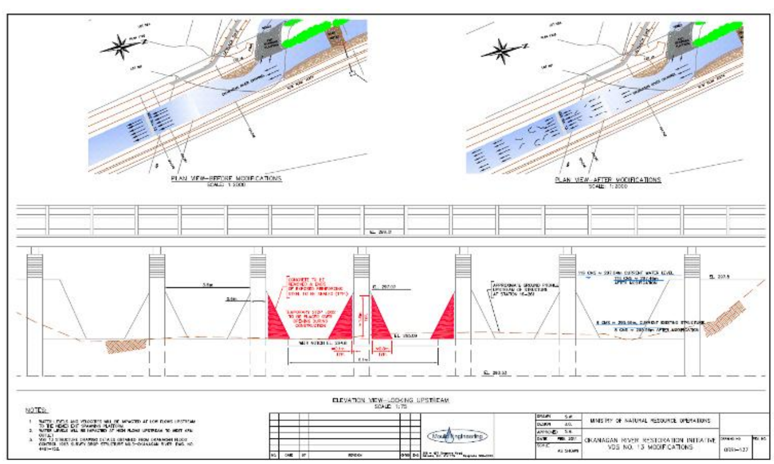
Conceptual Design of Phase I – Reconnection of two old oxbows



Engineering Design of Phase I



Conceptual and Engineering Designs of Phase II



Conceptual and Engineering Designs of VDS 13 Modifications

Okanagan River Restoration Initiative - ORRI

Project History:

- The health of the Okanagan River has been severely impacted by the channelization works that occurred in the mid-1950's. Only 16% (4.9 km) of the river remains in a natural (2.8 km) or semi-natural state (2.1 km). 84% (30.4 km) of the river has been channelized, straightened, narrowed and dyked.
- In an effort to regain the habitat quality and quantity that has been lost, the ORRI concept was conceived in 2000.
- ORRI is an ecosystem based collaborative approach assembling provincial (MoFLNRO), federal (DFO, EC), First Nations (ONA, CCT, OIB) and various local authorities and project funders.
- The ORRI site was specifically chosen based on channel gradient and connection to upstream productive habitats.

Project Goal:

- The goal of the ORRI restoration work is to return portions of the channelized river back to more natural conditions.
- This work involves relocating the dikes, lengthening the river channel, re-establishing meanders and pool/riffle sequences, reconnecting the river to contiguous floodplains, creating side channels, and replanting riparian vegetation.
- The long term purpose of this initiative is to create more complex and diverse habitat for fish and wildlife.

Project Location:

- Okanagan River (10 miles upstream of Osoyoos Lake)
- Oliver, BC

ORRI – Phase I (creation of a dual river channel):

- Phase I Construction works completed in 2009:
    - 1.2 km of dyke was set back reconnecting the river to 15,0000 m^2 of historic floodplain.
    - 0.5 km of river was re-meandered (dual channel) reconnecting 2 oxbows & creating pool/riffle sequences.
    - 5 spawning platforms, 2 riffles and 5 gravel bars were created enhancing fish spawning habitat.
    - 112 boulders clusters and 4 large woody debris were placed creating habitat features for fish & wildlife.
    - Riparian vegetation was re-planted re-establishing the floodplain functions.
- Effectiveness monitoring occurred in 2008-2012. Results to date include:
    - Increased number of Sockeye & Chinook spawners (live + dead) counted in Phase I (relative to total run).
    - Increased density of sockeye redds in the spawning platforms.
    - Increased sockeye egg survival in the spawning platforms.

ORRI – Phase II (creation of a side channel):

- The project involves the creation of a 300m long side channel on the East side of the river immediately upstream ORRI-Phase I. This side channel will provide rearing habitat for Steelhead and Rainbow Trout and spawning habitat for Sockeye salmon.
- Design elements include:
  - A V-shape riffle and an approach channel in the river mainstem diverting flow to the side channel.
  - A culvert crossing the dyke at both the entrance and the exit excavated channels.
  - A 5m wide natural vegetated meandering side channel.
  - Spawning material placed upstream the riffle, at approach channel, at entrance and exit channels.
  - Re-profiled dyke along the side channel and two new small dyke portions.
- Engineering designs, approvals and funding research are near completion. Construction works are expected for summer 2013.

ORRI – VDS 13 (Modifications of VDS 13):

- The project involves the removal of the 4 V-shaped concrete components within the 2 middles bays of the vertical drop structure #13 (VDS 13).
- Engineering designs, approvals and funding research are completed. Construction works are expected for summer 2013 (project delayed by the high flows occurring in summers 2011 and 2012).
- The modifications are expected to improve fish passage through the drop structure and enhance fish habitat (velocities, substrate, Froude numbers) for 0.4 km of river upstream.
- ONA will monitor the effectiveness of the modifications on incubating Sockeye eggs.

Wells, Rocky Reach, and Rock Island HCP Tributary Committees Notes 8 November 2012

Members Present: Carmen Andonaegui (WDFW), Dale Bambrick (NOAA Fisheries), Lee Carlson (Yakama Nation), Chris Fisher (Colville Tribes), Steve Hays (Chelan PUD), Tom Kahler (Douglas PUD), Kate Terrell (USFWS), and Tracy Hillman (Committees Chair).

Others Present: Becky Gallaher (Tributary Project Coordinator) and Jeremy Cram (WDFW).

The Wells, Rocky Reach, and Rock Island Hydroelectric Projects Habitat Conservation Plans Tributary Committees met in the Chelan PUD Auditorium in Wenatchee, Washington, on Thursday, 8 November 2012 from 10:00 am to 12:15 pm.

I. Review and Adopt Agenda

Tracy Hillman welcomed everyone to the meeting and the Committees adopted the proposed agenda with the following additions:

- Review of Peshastin Creek Riparian Restoration Project.
- RTT field trip to the Entiat.
- Discussion on flow management in Icicle Creek.

Carmen Andonaegui introduced Jeremy Cram to the Tributary Committees. WDFW recently hired Jeremy to fill the position vacated by Casey Baldwin. The Committees approved the inclusion of Jeremy on the Tributary Committees distribution list.

II. Review and Approval of Meeting Minutes

The Committees reviewed and approved the 11 October 2012 meeting notes.

III. Monthly Update on Ongoing Projects

Becky Gallaher gave an update on funded projects. Most are progressing well or had no salient activity in the past month.

- Lower Wenatchee Instream Flow Enhancement Project – The sponsor (Washington Rivers Conservancy) has selected a contractor (P.O.W. Contracting from Pasco, WA). A pre-construction meeting is scheduled for 6 November and mobilization will follow thereafter. Efforts planned for November include work on the pump station and fish screen construction.
- Nason Creek Upper White Pine Reconnection – Chelan PUD Powerline Reconnection Alternatives Analysis – The sponsor (Chelan County Natural Resources Department) is currently interviewing firms to facilitate discussions between the Forest Service and Chelan PUD. So far, they have interviewed two firms; they will interview a third soon.

- Chewuch River Instream Flow Project – The sponsor (Trout Unlimited – WWP) revised landowner agreements based on the modified work schedule. In addition, they continue coordination with Ecology on the Record of Examination (agreement should be finalized by mid-November), tracking expenditures and progress on tasks, and refining the project plan and strategy based on the changing nature of permitting reviews. The Washington Parks easement is waiting on fee calculation.

  The sponsor also submitted a budget amendment for consideration by the Rocky Reach Tributary Committee. The sponsor indicated that it has taken longer than planned to secure permits and that the costs to complete those permits were higher than anticipated. Therefore, they proposed to move money from salaries/benefits and excavation/heavy equipment work to contract labor and permitting. After careful consideration, ***the Rocky Reach Tributary Committee approved the budget modification.*** The Committee understands that the total budget amount will not change as a result of this request.

- Nutrient Enhancement Assessment – The sponsor (Cascade Columbia Fisheries Enhancement Group) and their contractor recently completed nutrient sampling. They collected one set of samples from ten sites each month from June through October. In addition, they collected water samples two other times in October to determine if decomposition of sockeye carcasses would affect nitrogen and phosphorus concentrations in the White River. They retrieved periphyton accrual plates and data loggers. Currently, they are analyzing data and organizing water quality and periphyton samples for processing. Preliminary findings will be presented to the CCFEG Board in November. The sponsor is planning to hold another stakeholder meeting in December.

- Large Wood Atonement Project – Gravity Environmental, the U.S. Fish and Wildlife Service, and Tetra Tech have collected topographic and geotechnical information and provided the Rock Island Tributary Committee with maps of the layout of wood treatments.

- Silver Protection Project – The landowner has signed an option agreement with the sponsor (WDFW). This will begin the appraisal process and fee simple purchase of the property. WDFW will hold an internal meeting to discuss the details of the process.

- Coulter Creek Barrier Replacement Project – Funding for this project is contingent upon the successful implementation of the railroad reconnection project, which has not yet happened.

- Entiat Stormy Reach Phase 2 Acquisition – The project is complete and a final report will be submitted to the Rocky Reach Tributary Committee in November or December.

IV. Tributary Assessment Programs

The Committees discussed how they could implement the Tributary Assessment Programs. According to the HCPs, the purpose of the Tributary Assessment Program is to monitor and evaluate the relative performance of the tributary enhancement projects approved by the Committees. It is not the purpose of the program to measure whether the Plan Species Accounts have provided a 2% increase in survival for Plan Species. Rather, the program will ensure that Plan Species Account dollars are used in an effective and efficient manner. Funding for the Assessment Program is separate from the Plan Species Accounts and shall not exceed $200,000 per account. Some funds (~$70,000) from the Wells Tributary Assessment Program were used to help evaluate a large enhancement project in Canada (ORRI project).

Tom Kahler suggested that some of the funds could be used to: (1) evaluate different project types and determine which ones work well and/or (2) fund graduate students to assess colonization of habitat in Shingle Creek. BPA is currently funding Tetra Tech and ISEMP to evaluate which habitat project types work best. The funding of a graduate student gained some traction; however, the Committees also recognized that a graduate study would include evaluations that may not be very useful to the Committees in selecting future projects. Steve Hays recommended that some of the funds be used to synthesize monitoring information. The Upper Columbia Salmon Recovery Board (UCSRB) and the Upper Columbia Regional Technical Team (UCRTT) are supposed to prepare a synthesis report every three years. This report should evaluate monitoring results at different spatial and temporal scales.

Tom Kahler asked the Committees what kind of information they want from an assessment and how the Committees would use the information. Members indicated that they would like information that would allow them to make informed decisions on selection of future projects. That is, which projects will provide the largest benefit:cost ratio. The BPA-funded monitoring programs in the Upper Columbia are designed to answer this question. However, BPA has cut ISEMP funds about 10-15%, which means there may be opportunities to use Tributary Assessment Program funds to help support ISEMP. In addition, because BPA does not fund monitoring projects in Canada, the Committees see possible opportunities to fund monitoring there (e.g., colonization of Shingle Creek). Dale Bambrick recommended that the Committees hold the money until opportunities arise in Canada or elsewhere. The Committees agreed to wait for unique future monitoring opportunities.

Lee Carlson will check with Bob Rose on the data and results from the LIDAR work that was funded by the PRCC Habitat Subcommittee.

V. Small Projects Program Applications

The Committees reviewed three Small Projects Program applications.

Twisp River Well Conversion

The Committees received a Small Projects Program proposal from the Washington Water Project of Trout Unlimited titled, Twisp River Well Conversion. The purpose of this project is to improve habitat and remove an irrigation diversion that kills juvenile steelhead and Chinook salmon. The sponsor will replace the existing diversion, located at RM 6.5 on the Twisp River, with a well and efficient irrigation system. The conversion will result in a 4.5 cfs increase in stream flows. The total cost of the project is $87,738.87. The sponsor requested $43,550.27 from HCP Tributary Funds. After careful review of the proposal, ***the Wells Tributary Committee approved funding for this project.***

Beaver Creek Late Season Well Test

The Committees received a Small Projects Program proposal from the Washington Water Project of Trout Unlimited titled, Beaver Creek Late Season Well Test. The purpose of this project is to determine the feasibility of removing a landowner from a surface diversion on Beaver Creek during the period 1 August to 15 September. The sponsor will conduct a pump test to assess the production of an existing well. If the conversion from surface water to well water is feasible, a total of about 0.3 cfs could be saved permanently in trust. The total cost of the project is $1,500. The sponsor requested $1,500 from HCP Tributary Funds. After careful review of the proposal, ***the Tributary Committees were unable to make a funding decision,*** because additional information is needed from the sponsor. For example, the Committees need information on the depth of the existing well, whether or not the landowner has a valid water right (it has not been surrendered), and what the expected cost would be if the conversion from surface water to well water is feasible. The latter is needed to estimate if the total cost of the project justifies the savings of about 0.3 cfs.

Peshastin Creek Riparian Restoration Project

In October, the Committees received a Small Projects Proposal from Cascadia Conservation District titled, Peshastin Creek Riparian Restoration. The purpose of the project was to improve and restore riparian areas along a contiguous section of Peshastin Creek from RM 0.6 to 1.4. The total cost of the project was $76,257. The sponsor requested $51,257 from HCP Tributary Funds. After carefully reviewing the proposal in October, the Committees were unable to make a funding decision. The Committees questioned why the sponsor was seeking funds from the Plan Species Accounts when it appeared that the proposed project fit better with Farm Bill Programs such as the Conservation Reserve Enhancement Program (CREP). The Committees asked that the sponsor explain why CREP, or other similar funding sources, were not appropriate for this project.

In November, the sponsor submitted a letter to the Committees describing why they did not seek funding from CREP. After reviewing the letter and the proposal, ***the Tributary Committees elected not to fund the project***. Although the Committees believe that riparian restoration is important, they believe the proposed restoration approach will have questionable success. They believe that the sponsor should use smaller plants (plugs) and plant them deep so they can tap into groundwater. This would minimize the need for irrigation.

VI. Okanogan Fish and Water Management Tool

During the October meeting, the Committees talked briefly about expanding the Okanogan Fish and Water Management Tool (FWMT) to include summer Chinook and steelhead downstream from Lake Osoyoos. The purpose would be to use the tool to increase egg-fry survival of summer Chinook and steelhead spawning within the Okanogan River on the east side of Driscoll Island. The Committees agreed that it would be best to wait for the new rule curves for Lake Osoyoos before expanding the tool. However, Dennis Beich said that he and Chris Fisher should talk with John Arterburn, Colville Tribes, to get John's input on expanding the FWMT, since John promoted the expansion to the Osoyoos Fisheries Advisory Council.

Chris Fisher reported that he spoke with John, and John simply wanted to be involved in the process. John agreed that at this time it is not necessary to expand the FWMT (Tom Kahler provided the Committees with the proposal to expand the FWMT). This addressed the question posed by Dennis and therefore Grant PUD will not seek funding at this time to expand the FWMT. They will wait for the new rule curves for Lake Osoyoos.

VII. Information Updates

The following information updates were provided during the meeting.

1. There were no payment requests in October and November.
2. Dale Bambrick reported that Mike Kaputa, Chelan County Natural Resources Department, will convene a meeting on 4 and 5 December to discuss flow issues on Icicle Creek. Additional information on the meeting will be available soon.
3. Tracy Hillman reported that the UCRTT will visit restoration projects (Dillwater, Tyee, and 3-D projects) on the Entiat River on Monday, 26 November. Kate Terrell indicated that members of the Tributary Committees and the PRCC Habitat Subcommittee are welcome to attend the field trip with the UCRTT. Those interested can meet at the Forest Service Supervisor's Office at 9:00 am to carpool to the Entiat.
4. Chis Fisher asked the Committees which of three fish passage options they preferred for Shingle Creek Dam. The options are (1) backwater the dam with a series of riffles, (2)

notch the dam and backwater with a series of riffles, and (3) remove the dam. The Committees agreed that the preferred approach would be to remove the dam. If that option is not feasible, the next preferred option would be to notch the dam and backwater with a series of riffles.

VIII. Next Steps

If necessary, the next meeting of the Tributary Committees will be on Thursday, 13 December 2012 at Chelan PUD in Wenatchee.

Meeting notes submitted by Tracy Hillman (tracy.hillman@bioanalysts.net).

APPENDIX D
LIST OF ROCKY REACH HCP COMMITTEE MEMBERS

Rocky Reach Mid-Columbia HCP Committees, 2012

Coordinating Committees

Name	Organization
Michael Schiewe (Chair)	Anchor QEA, LLC
Jerry Marco	Colville Confederated Tribes
Steve Hemstrom	Chelan PUD
Bryan Nordlund	NMFS
Jim Craig	USFWS
Teresa Scott	WDFW
Bob Rose	Yakama Nation

Hatchery Committees

Name	Organization
Michael Schiewe (Chair)	Anchor QEA, LLC
Kirk Truscott	Colville Confederated Tribes
Josh Murauskas	Chelan PUD
Craig Busack (Jan-Dec) Lynn Hatcher (Dec)	NMFS
Bill Gale	USFWS
Mike Tonseth	WDFW
Tom Scribner	Yakama Nation

Tributary Committees

Name	Organization
Tracy Hillman (Chair)	BioAnalysts
Chris Fisher	Colville Confederated Tribes
Tom Kahler	Douglas PUD
Steve Hays	Chelan PUD
Dale Bambrick	NMFS
Kate Terrell	USFWS
Carmen Andonaegui	WDFW
Lee Carlson	Yakama Nation

Policy Committees

Name	Organization
Michael Schiewe (Facilitator)	Anchor QEA, LLC
Joe Peone (Jan-Dec) Randy Friedlander (Dec)	Colville Confederated Tribes
Kirk Hudson	Chelan PUD
Keith Kirkendall	NMFS
Jessica Gonzales	USFWS
Bill Tweit	WDFW
Steve Parker	Yakama Nation

APPENDIX E
2012 STATEMENTS OF AGREEMENT FOR COORDINATING COMMITTEES

STATEMENTS OF AGREEMENT

There were no Statements of Agreement in 2012.

APPENDIX F
2012 STATEMENTS OF AGREEMENT FOR HATCHERY COMMITTEES

Rock Island and Rocky Reach HCP Hatchery Committees

Statement of Agreement

Chelan PUD Spring Chinook Compensation, Release Year 2014

Approved January 19, 2012

Statement

The Rock Island and Rocky Reach Habitat Conservation Plans' (HCP) Hatchery Committees (HC) approve Chelan PUD meeting its 2014 spring Chinook mitigation obligation through production of 204,542 smolts at the Chiwawa Acclimation Ponds in lieu of production requirements in the Methow River, contingent on the Methow River production (60,516) being produced by another entity (i.e., "backfilled"). This represents No Net Impact obligations for both the Wenatchee (144,026) and Methow (60,516) rivers, per the December 14, 2011 recalculation SOA.

Background

Potential delays to the Grant PUD-funded Nason Creek facility may preclude the full Wenatchee River Basin spring Chinook production scheduled for release in 2014. In order to maintain production targets, Grant PUD has proposed to backfill the Methow Program. This arrangement will allow Chelan PUD to reallocate it's Methow River spring Chinook production requirement to the Chiwawa Hatchery for release year 2014 to maintain the total production target for the Wenatchee River Basin.

Rock Island and Rocky Reach HCP Hatchery Committees

Statement of Agreement

Chelan PUD Chiwawa Spring Chinook Size Targets

Approved February 15, 2012

Statement

The Rock Island and Rocky Reach HCP Hatchery Committee agrees to adjusting the size at release target for the Chiwawa Spring Chinook program from 12 fish/pound (~176 mm) to 18 fish/pound (~126 mm) beginning with the 2012 brood year. The intention of the programmatic adjustment is to more closely resemble wild-origin smolt populations and the unique length-weight relationship of Chiwawa spring Chinook, and increase age at maturity for hatchery-origin adults. The size at release targets may be further adjusted based on continued monitoring and evaluation data, consistent with the Rock Island and Rocky Reach HCPs.

Background

Analyses on age structure of spring Chinook returns from the Chiwawa hatchery program (Appendix 1) indicate that large hatchery smolts do not provide an overall survival benefit and further increase the rate of Age 2 and 3 returns (i.e., mini-jack and jack rates). Further analyses suggest that increased age at maturation will reduce stray rates, and are not likely to negatively influence female returns (Appendix 2). Larger smolts have not contributed favorably to female returns, and small smolts have shown to result in a greater proportion of 3-salt (e.g., 11% of females identified at Tumwater were 3-salt fish, compared to 1% of males; Appendix 2). This agreement is consistent with recommendations from monitoring and evaluation results, the program intention of conserving wild-origin populations, and NOAA recommendations. Chelan PUD will continue monitoring and evaluation efforts to ensure that program adjustments are meeting the intended goals.

APPENDIX G
FINAL SURVIVAL, DIEL PASSAGE, AND MIGRATION DYNAMICS OF YEARLING CHINOOK SALMON SMOLTS AT ROCKY REACH DAM IN 2011

Final
Survival, Diel Passage, and Migration Dynamics of Yearling Chinook Salmon Smolts at Rocky Reach Dam in 2011

Prepared for:
Public Utility District No. 1 of Chelan County
P.O. Box 1231
327 North Wenatchee Avenue
Wenatchee, Washington 98801

Prepared by:
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715 N.E. Northlake Way
Seattle, Washington 98105

30 January 2012

Executive Summary

Study Objective

The overall objective of the 2011 yearling Chinook salmon smolt studies at Rocky Reach Dam was to estimate and compare project passage survival using daytime and nighttime releases. The standard powerhouse operation "Waterview" (i.e., no spill) was the focus of the evaluation, but high river flows required spill during the last two weeks of the study.

Methods

Yearling Chinook salmon smolts were tagged with HTI *Model 795Lm Acoustic Tags*. Paired release-recapture methods were used to estimate project passage survival pooled across the study, and separately for day and nighttime releases. Overall project passage survival was estimated using the pooled value over the day and nighttime releases.

Results

Project passage survival at Rocky Reach was estimated to be $\hat{S}_{\text{RR-Day}} = 0.9289$ ($\widehat{\text{SE}} = 0.0135$) for daytime releases and $\hat{S}_{\text{RR-Night}} = 0.9299$ ($\widehat{\text{SE}} = 0.0135$) for nighttime releases. An overall pooled estimate of project passage survival was calculated to be $\hat{S}_{\text{RR}} = 0.9294$ ($\widehat{\text{SE}} = 0.0097$).

Dam passage survival for yearling Chinook salmon smolts arriving at Rocky Reach during the day was estimated to be $\hat{S}_{\text{Dam-Day}} = 0.9715$ ($\widehat{\text{SE}} = 0.0103$). For yearling Chinook salmon smolts arriving during the night, dam passage survival was estimated to be $\hat{S}_{\text{Dam-Night}} = 0.9614$ ($\widehat{\text{SE}} = 0.0137$). A weighted average of the dam passage survivals based on the diel passage distribution for run of river yearling Chinook at Rocky Reach Dam produced an overall estimate of dam passage survival of $\hat{S}_{\text{Dam}} = 0.9655$ ($\widehat{\text{SE}} = 0.0091$).

This report conforms to the guidelines of the Peven et al. (2005) recommendations for survival studies.

Survival Study Summary

Year: 2011	Start date: 25 April 2011	Stop date: 9 June 2011

Study site(s): Rocky Reach project

Objective(s) of study: Estimate project survival

State hypothesis, if applicable: N/A

Fish
- Species-race: Yearling Chinook salmon smolts
- Source: Run-of-river from Rocky Reach juvenile sampling facility

Size (median & range)
- Weight: Median – 44.1 g, range – 28.1 – 126.4 g
- Length: Median – 164 mm, range – 108 – 223 mm

Tag
- Type/model: HTI *Model 795Lm Acoustic Tag*
- Weight (g): 0.65 g in air

Implant procedure
- Surgical: Acoustic tag

Type (project, etc.): Project survival	Rocky Reach
• Project – Day Releases	0.9289 (0.0135)
• Project – Night Releases	0.9299 (0.0135)
• Project – Day/Night Pooled	0.9294 (0.0097)

- Sample size/replicate: 28 /replicate (Wells & Rocky Reach, day & night)
- # replicates: 15 replicates (Wells & Rocky Reach, day & night RR SC, day)
- Analytical model: Paired release-recapture model

Hypothesis test and results (if applicable): N/A

Characteristics of estimate
- Effects reflected (direct, total, etc.): Total project
- Absolute or relative: Absolute

Environmental/operating conditions
- Discharge: Rocky Reach, median: 205.2 kcfs, range: 114.5 –312.6kcfs
- Temperature: Rocky Reach, median: 9.1^{o}C, range: 7.1– 11.8^{o}C
- TDG: Rocky Reach, median: 115.9%, range: 105.9– 134.2 %
- Treatment(s): Day and nighttime releases

Unique study characteristics: None

Table of Contents

Table of Figures

Table of Tables

1. Introduction

The purpose of the 2011 acoustic-tag investigations of yearling Chinook salmon smolts at Rocky Reach Dam (Figure 1.1) was to estimate project passage survival and route-specific survival of daytime and nighttime releases. Information from these release-recapture studies was combined with information on the diel passage of smolts at the dam to better understand migration dynamics and dam passage survival at the project. Specific objectives of the study were as follows:

1. Estimate Rocky Reach project passage survival using daytime and nighttime releases.
2. Estimate dam passage survival at Rocky Reach and partition project passage survival into dam and pool components for daytime releases.
3. Compare route-specific passage proportions and relative survivals between daytime and nighttime releases at Rocky Reach Dam.
4. Characterize arrival timing of daytime and nighttime releases from Wells tailrace to Rocky Reach Dam.
5. Compare arrival distributions of tagged fish at Rocky Reach Dam to the diel passage distribution of ROR fish at the juvenile sampling facility.

The intent of the release-recapture study was to estimate project passage survivals under the standard powerhouse operation condition, "Waterview" with no voluntary spill. However, due to high river flows during spring 2011, spill was mandatory during the latter half of the study. Additional analyses were performed to assess how influential spill conditions may have been in the overall estimate of passage survival for yearling Chinook salmons in 2011.

Figure 1.1. Map of the study area showing Wells, Rocky Reach, and Rock Island dams and the locations of the acoustic detection arrays used in the 2011 Rocky Reach Project passage survival study.

2. Release-Recapture Design

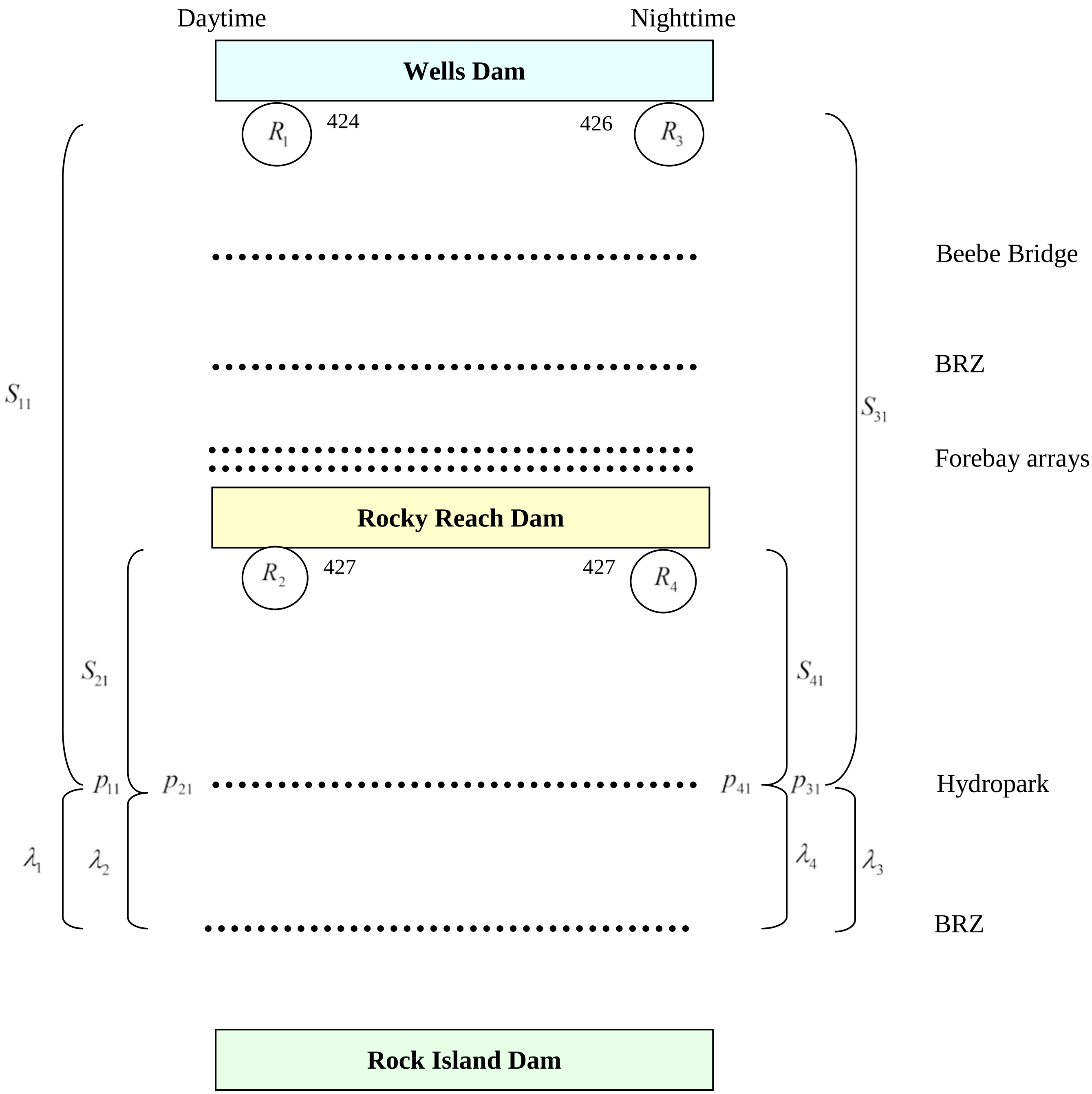
The objectives of the 2011 yearling Chinook salmon smolt survival study at Rocky Reach were accomplished using a total of five different release groups. Some release groups were used for more than one study objective.

2.1 Paired Releases

A standard paired release-recapture design was used to estimate project passage survival based on releases in the Wells and Rocky Reach tailraces (Figure 2.1). Separate paired releases were performed during day (approximately 1 pm PDT) and night (approximately 12 midnight PDT) times. The purpose was to provide separate estimates of project passage survival for the day and nighttime releases. At Wells tailrace, release sizes ranged from 424–426 smolts for the day and nighttime releases. At Rocky Reach tailrace, the daytime releases and nighttime releases were 427 each (Figure 2.1). The day and night releases were performed in 15 replicates, each over the period 25 April to 27 May 2011.

2.2 Triple-Release Design

An additional set of daytime releases totaling 425 yearling Chinook salmon smolts were performed at the entrance of the surface collector at Rocky Reach to estimate route-specific passage proportions, survivals, and dam passage survival during daytime hours (Figure 2.2). No nighttime surface collector release was performed. Instead, the estimate of surface collector passage survival calculated during daytime hours was assumed the same at nighttime in order to estimate route-specific survivals at night.



Rocky Reach passage survival: $\hat{S}_{\text{RR-Day}} = \frac{\hat{S}_{11}}{\hat{S}_{21}}$ and $\hat{S}_{\text{RR-Night}} = \frac{\hat{S}_{31}}{\hat{S}_{41}}$

Figure 2.1. Schematic of the paired-release design for daytime and nighttime releases used to estimate dam passage survival at Rocky Reach.

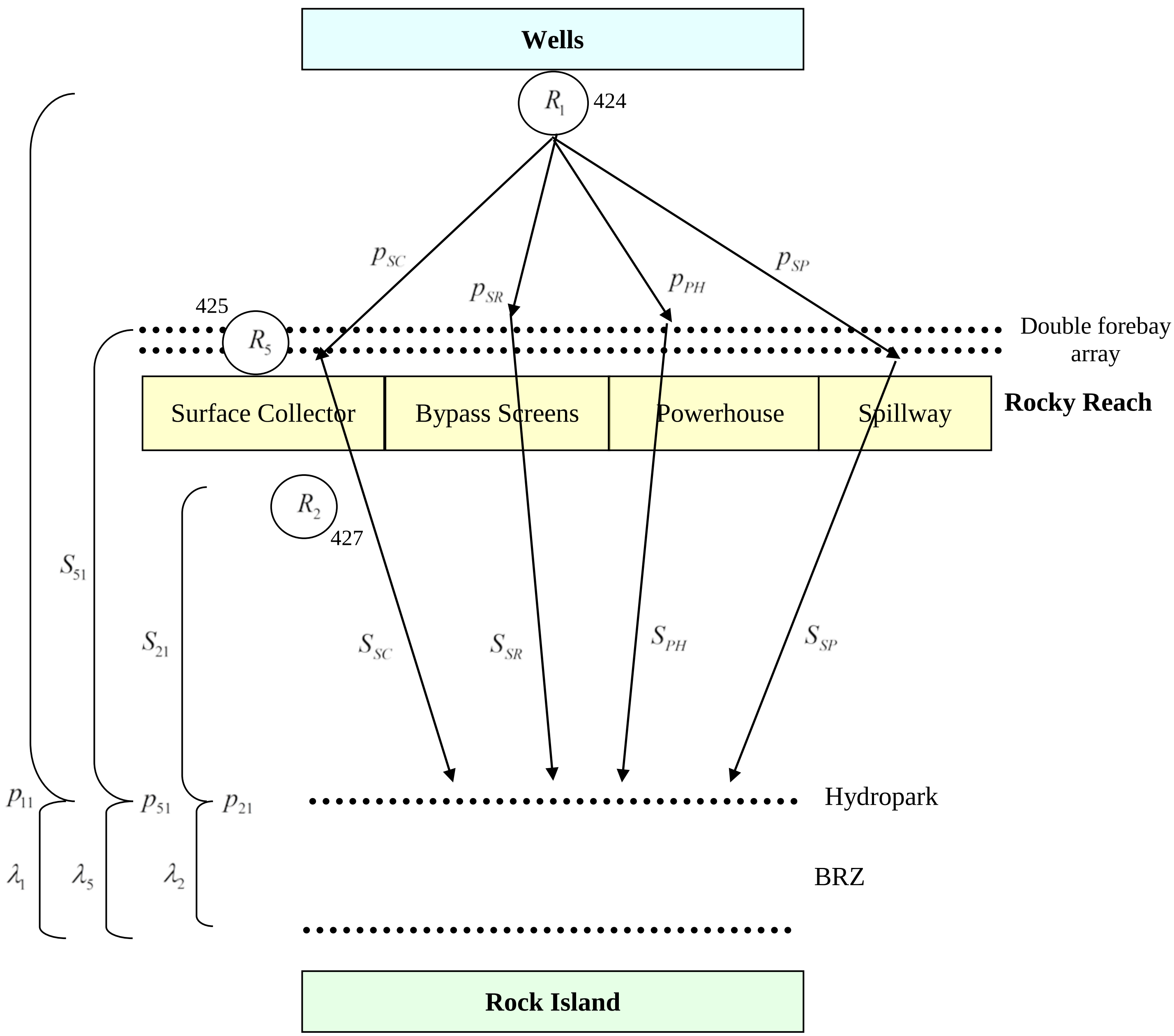


Figure 2.2. Schematic of the triple-release design used to estimate dam, project, and route-specific passage survivals and proportions. Only daytime releases were used in this design.

3. Statistical Analysis

3.1 Paired-Release Design

Statistical methods of estimating project passage survival using the paired release-recapture methods of Burnham et al. (1987) were used to provide separate day and nighttime survivals based on respective release groups. Project passage survival was estimated as the quotient of the tag-life-adjusted estimate of survival from Wells tailrace to Rock Island Hydroproject to the estimate of survival from Rocky Reach to the Rock Island Hydroproject, i.e.,

$$\hat{S}_{RR} = \frac{\left(\hat{S}_{11}/L_{11}\right)}{\left(\hat{S}_{21}/L_{21}\right)} \tag{1}$$

where

S_{i1} = estimate of perceived reach survival using Cormack-Jolly-Seber (CJS) model for the *i*th release $(i = 1, 2)$ in the first reach,

L_{i1} = probability of a tag being active for the *i*th release group $(i = 1, 2)$ at the first downstream detection site.

The daytime and nighttime estimates of project passage survival were calculated analogously. The reach survival estimates were adjusted for the possibility of tag failure using the method in Townsend et al. (2006).

3.2 Tag-Life Study

An independent tag-life study was performed in order to model the failure time/survivorship curve for the acoustic tags used in the survival study. A total of 50 acoustic tags were systematically sampled over the course of the spring survival study and monitored in ambient river water to record failure time for each tag. The tag-life data were fit to the four-parameter vitality model of Li and Anderson (2009). The capture and tag-life data were analyzed using the software program ATLAS 2.0 (Active Tag-Life-Adjusted Survival), publicly available at http://www.cbr.washington.edu/paramest/atlas/.

3.3 Examination for Tagger and Tag-Lot Effects

Reach survival estimates for various tag groups were calculated and compared to identify any tag-lot or tagger-related effects that could bias the estimates of dam passage survival. Tests of homogeneous survival across tag lots or taggers were based on the asymptotic *F*-test

$$F_{n-1,\infty} = \frac{s^2_{\hat{S}_i}}{\frac{1}{n}\sum_{i=1}^{n}\widehat{\text{Var}}\left(\hat{S}_i \middle| S_i\right)} \qquad (2)$$

for *n* groups of survival estimates.

3.4 Route-Specific Survivals and Passage Proportions

Route-specific survivals and passage proportions were calculated for yearling Chinook salmon smolts that arrived at Rocky Reach Dam during day and nighttime periods. Separate estimates of passage proportions and survivals were calculated for each temporal group. These values were used, in turn, to estimate dam passage survivals for each temporal group.

At each passage route within Rocky Reach Dam, a double hydroacoustic array was deployed to detect acoustic-tagged smolt during dam passage. The double-detection data was used to estimate the absolute abundance (N) of tagged smolts through the routes. Define for any particular passage route the following variables:

n_{10} = number of tagged smolt detected at the 1st array but not the 2nd,

n_{01} = number of tagged smolt detected at the 2nd array but not the 1st,

n_{11} = number of tagged smolt detected at both the 1st and 2nd arrays.

From these counts of smolt with various route-specific detections histories, absolute passage abundance $(\hat{N})$ of tagged smolts can be estimated as

$$\hat{N} = \frac{(n_{10}+n_{11}+1)(n_{01}+n_{11}+1)}{(n_{11}+1)} - 1$$

or

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(n_{11}+1)} - 1 \qquad (3)$$

where $n_1 = n_{10} + n_{11}$ and $n_2 = n_{01} + n_{11}$ with associated variance estimate (Seber 1982:60)

$$\widehat{\text{Var}}(\hat{N}) = \frac{(n_1+1)(n_2+1)(n_1-n_{11})(n_2-n_{11})}{(n_{11}+1)^2(n_{11}+2)}. \qquad (4)$$

The estimated probability of detection (p_1) in the first array was calculated as

$$\hat{p}_1 = \frac{n_{11}}{n_2},$$

and the probability of detection $\left(p_2\right)$ at the second array as

$$\hat{p}_2 = \frac{n_{11}}{n_1}.$$

The overall probability of a smolt being detected in the double array system was

$$\hat{p} = 1 - \left(1 - \hat{p}_1\right)\left(1 - \hat{p}_2\right) = \frac{n_{11}\left(n_1 + n_2 - n_{11}\right)}{n_1 n_2}$$

Passage abundance was estimated for the surface collector $\left(\hat{N}_{SC}\right)$, bypass screens $\left(\hat{N}_{BY}\right)$, powerhouse $\left(\hat{N}_{PH}\right)$ and spillway $\left(\hat{N}_{SP}\right)$.

The proportion of the acoustic-tagged smolt passing through the surface collector $\left(\hat{P}_{SC}\right)$ was estimated by

$$\hat{P}_{SC} = \frac{\hat{N}_{SC}}{\hat{N}_{SC} + \hat{N}_{BY} + \hat{N}_{PH} + \hat{N}_{SP}}. \tag{5}$$

Using the delta method (Seber 1982:7–9), the variance of $\hat{P}_{SC}$ was approximated by

$$\widehat{\text{Var}}\left(\hat{P}_{SC}\right) = \hat{P}_{SC}^2\left(1 - \hat{P}_{SC}\right)^2\left[\frac{\widehat{\text{Var}}\left(\hat{N}_{SC}\right)}{\hat{N}_{SC}^2} + \frac{\widehat{\text{Var}}\left(\hat{N}_{BY}\right) + \widehat{\text{Var}}\left(\hat{N}_{PH}\right) + \widehat{\text{Var}}\left(\hat{N}_{SP}\right)}{(\hat{N}_{BY} + \hat{N}_{PH} + \hat{N}_{SP})^2}\right]. \tag{6}$$

Values of $\hat{P}_{BY}$, $\hat{P}_{PH}$ and $\hat{P}_{SP}$ and associated variances were estimated analogously to Eq. (5) and Eq. (6), respectively.

The paired-releases above $\left(R_5\right)$ and below $\left(R_2\right)$ the surface collector were used to estimate yearling Chinook salmon survival through the surface collector (Figure 2.2). Survival through the surface collector was estimated by the quotient

$$\hat{S}_{SC} = \frac{\left(\dfrac{t}{R_5}\right)}{\left(\dfrac{c}{R_2}\right)} \tag{7}$$

where

t = number of R_5 smolts detected downstream,

c = number of R_2 smolts detected downstream.

The variance of $\hat{S}_{SC}$ was estimated as

$$\widehat{\text{Var}}\left(\hat{S}_{SC}\right) = \hat{S}_{SC}^{2}\left[\frac{1}{t} - \frac{1}{R_5} + \frac{1}{c} - \frac{1}{R_2}\right]. \tag{9}$$

Smolts known to have passed through the various routes at Rocky Reach Dam (Figure 2.2) were monitored downriver to obtain their capture histories. Define the following variables:

N_{SC} = number of smolts known to have passed through surface collector,

n_{SC} = number of smolts among N_{SC} detected downriver,

N_{BY} = number of smolts known to have passed through bypass system,

n_{BY} = number of smolts among N_{BY} detected downriver,

N_{U1-2} = number of smolts known to have passed through turbine units 1–2,

n_{U1-2} = number of smolts among N_{U1-2} detected downriver,

N_{U3-11} = number of smolts known to have passed through turbine units 3–11,

n_{U3-11} = number of smolts among N_{U3-11} detected downriver,

N_{SP} = number of smolts known to have passed through the spillway,

n_{SP} = number of smolts among N_{SP} detected downriver.

Using the relative recoveries of smolt through the various routes compared to the surface collector, route-specific survival probabilities were estimated. For example, at the bypass, i.e.,

$$\hat{S}_{BY} = \hat{S}_{SC} \cdot \frac{\left(\frac{n_{BY}}{N_{BY}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)}, \tag{10}$$

and at turbine units 1–2,

$$\hat{S}_{U1-2} = \hat{S}_{SC} \cdot \frac{\left(\frac{n_{U1-2}}{N_{U1-2}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)}, \tag{11}$$

turbine units 3–11,

$$\hat{S}_{U3-11} = \hat{S}_{SC} \cdot \frac{\left(\frac{n_{U3-11}}{N_{U3-11}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)}, \tag{12}$$

and the spillway,

$$\hat{S}_{SP} = \hat{S}_{SC} \cdot \frac{\left(\frac{n_{SP}}{N_{SP}}\right)}{\left(\frac{n_{SC}}{N_{SC}}\right)}. \tag{13}$$

The variance of $\hat{S}_{BY}$, for example, was estimated by

$$\begin{aligned}\widehat{\mathrm{Var}}\left(\hat{S}_{BY}\right) &= \widehat{\mathrm{Var}}\left(\hat{R}_{BY/SC}\right) \cdot \hat{S}_{SC}^2 + \widehat{\mathrm{Var}}\left(\hat{S}_{SC}\right) \cdot \hat{R}_{BY/SC}^2 \\ &\quad - \widehat{\mathrm{Var}}\left(\hat{R}_{BY/SC}\right) \cdot \widehat{\mathrm{Var}}\left(\hat{S}_{SC}\right),\end{aligned} \tag{14}$$

where

$$\widehat{\mathrm{Var}}\left(\hat{R}_{BY/SC}\right) = \hat{R}_{BY/SC}^2 \left[\frac{1}{n_{BY}} - \frac{1}{N_{BY}} + \frac{1}{n_{SC}} - \frac{1}{N_{SC}}\right]. \tag{15}$$

The variances of $\hat{S}_{U1-2}$, $\hat{S}_{U3-11}$, and $\hat{S}_{SP}$ were expressed analogously.

Using the estimates of route-specific survival and passage proportions, dam passage survival at Rocky Reach Dam (i.e., in the case of no spill) was estimated by the expression

$$\begin{aligned}\hat{S}_{\mathrm{Dam}} &= \hat{P}_{SC} \cdot \hat{S}_{SC} + \hat{P}_{BY} \cdot \hat{S}_{BY} + \hat{P}_{U1-2} \cdot \hat{S}_{U1-2} + \hat{P}_{U3-11} \cdot \hat{S}_{U3-11} \\ &= \hat{P}_{SC} \cdot \hat{S}_{SC} + \hat{P}_{BY} \cdot \hat{S}_{SC} \cdot \hat{R}_{BY/SC} + \hat{P}_{U1-2} \cdot \hat{S}_{SC} \cdot \hat{R}_{U1-2/SC} \\ &\quad + \hat{P}_{U3-11} \cdot \hat{S}_{SC} \cdot \hat{R}_{U3-11/SC} \\ &= \hat{S}_{SC}\left[\hat{P}_{SC} + \hat{P}_{BY} \cdot \hat{R}_{BY/SC} + \hat{P}_{U1-2} \cdot \hat{R}_{U1-2/SC} + \hat{P}_{U3-11} \cdot \hat{R}_{U3-11/SC}\right].\end{aligned} \tag{16}$$

Dam passage survival was estimated for day and night periods, and compared using an asymptotic Z-test.

4. Results

4.1 Examination of Tagger Effects

Four taggers were used to tag all the fish in the 2011 Rocky Reach survival study. Tagger effort was homogeneously distributed between upstream and downstream release locations for both the daytime $\left(P\left(\chi_3^2 \geq 0.0216\right) = 0.9992\right)$ and nighttime $\left(P\left(\chi_3^2 \geq 0.0441\right) = 0.9976\right)$ releases (Table 4.1).

The same tagger was used to tag all the fish within one replicate at both upstream and downstream locations for both the day and night releases (Table 4.2). One tagger was used for three replicate releases, and the remaining three taggers were used for four replicates each. Inspection of the tagging schedule also indicated tagger effort was fairly evenly distributed over the course of the study.

Reach survival estimates were calculated using the CJS model, uncorrected for tag life, for fish tagged by the different taggers. The Wells tailrace, Rocky Reach tailrace, and Rocky Reach surface collector releases were all examined for tagger effects (Table 4.3). Of the nine different tests of homogeneous survival performed, none were significant $(P \geq 0.1045)$ (Table 4.3). Therefore, there was no evidence that differential tagger effect might bias the survival results and noreason to exclude any of the fish tagged by different staff members. Furthermore, any small effects left unnoticed should have been evenly distributed across release locations as the result of the homogeneous tagger effort.

4.2 Examination of Tag-Lot Effects

Three different manufacturing tag lots were used in the 2011 yearling Chinook salmon survival study at Rocky Reach (i.e., lot numbers 11204, 11205, and 11206). These three tag lots were evenly distributed between release locations and day/night releases $\left(P\left(\chi_6^2 \geq 0.0266\right) = 0.9999\right)$ (Table 4.4).

Reach survival estimates were calculated for the different release locations and times of day by tag lot (Table 4.5). In all case, survival estimates across tag lots were found to be homogeneous $(P \geq 0.1235)$ (Table 4.5). Any smolt heterogeneity that may have gone undetected should be accounted for by the balanced tag-lot allocation scheme (Table 4.4). Therefore, all tag lots were used in the subsequent survival analyses.

Table 4.1. Number of acoustic-tagged fish tagged by each staff member by release location and time of day during the 2011 Rocky Reach yearling Chinook salmon survival study. Chi-square tests of homogeneous tagger effort reported.

	Tagger			
Release location	#1	#2	#3	#4
Wells tailrace (day)	114	114	113	83
Rocky Reach tailrace (day)	116	115	112	84
	$P\left(\chi_3^2 \geq 0.0216\right) = 0.9992$			
Wells tailrace (night)	114	116	112	84
Rocky Reach tailrace (night)	115	114	112	86
	$P\left(\chi_3^2 \geq 0.04441\right) = 0.9976$			

Table 4.2. Numbers of acoustic-tagged fish tagged by each staff member, by replicate release, and by location (i.e., RR = Rocky Reach tailrace, W = Wells tailrace) for the 2011 yearling Chinook salmon survival study at Rocky Reach.

Day						Night					
		Tagger						Tagger			
Replicate	Location	#1	#2	#3	#4	Replicate	Location	#1	#2	#3	#4
1	W			28		1	W			28	
	RR			28			RR			28	
2	W		28			2	W		28		
	RR		28				RR		27		
3	W	29				3	W	29			
	RR	28					RR	29			
4	W				28	4	W				27
	RR				27		RR				28
5	W			28		5	W			28	
	RR			28			RR			27	
6	W		29			6	W		30		
	RR		31				RR		30		
7	W	27				7	W	28			
	RR	29					RR	28			
8	W				27	8	W				28
	RR				28		RR				29
9	W			29		9	W			29	
	RR			29			RR			29	
10	W		29			10	W		28		
	RR		28				RR		29		
11	W	28				11	W	27			
	RR	28					RR	28			
12	W				28	12	W				29
	RR				29		RR				29
13	W			28		13	W			27	
	RR			27			RR			28	
14	W		28			14	W		30		
	RR		28				RR		28		
15	W	30				15	W	30			
	RR	31					RR	30			

Table 4.3. Reach survival estimates (not tag-life-corrected) for fish tagged by different staff members by location, time of day, and associated results of *F*-tests of homogeneous survivals (*P*-values).

Release site	Release	Tagger	CJS Survival: Release to Beebe Bridge	CJS Survival: Beebe Bridge to RR Boat R. Zone	CJS Survival: RR Boat R. Zone to RI Hydropark
Wells tailrace	Day	#1	0.9825 (0.0123)	0.9643 (0.0175)	0.9630 (0.0182)
		#2	0.9825 (0.0123)	1.0000 (< 0.0001)	0.9732 (0.0153)
		#3	0.9912 (0.0088)	0.9732 (0.0153)	0.9450 (0.0218)
		#4	0.9639 (0.0205)	0.9875 (0.0124)	0.9494 (0.0247)
		P(F-test)	***0.5755***	***0.2327***	***0.7511***
	Night	#1	0.9912 (0.0087)	0.9735 (0.0151)	0.9545 (0.0199)
		#2	1.0000 (< 0.0001)	0.9741 (0.0147)	0.9204 (0.0255)
		#3	0.9911 (0.0089)	0.9820 (0.0126)	0.9541 (0.0200)
		#4	1.0000 (< 0.0001)	0.9881 (0.0118)	0.9639 (0.0205)
		P(F-test)	***0.5677***	***0.8534***	***0.5041***
Rocky Reach SC	Day	#1			1.0000 (< 0.0001)
		#2			1.0000 (< 0.0001)
		#3			0.9821 (0.0125)
		#4			0.9884 (0.0116)
		P(F-test)			***0.3525***
Rocky Reach tailrace	Day	#1			1.0000 (< 0.0001)
		#2			1.0000 (< 0.0001)
		#3			0.9821 (0.0125)
		#4			1.0000 (< 0.0001)
		P(F-test)			***0.1045***
	Night	#1			1.0000 (< 0.0001)
		#2			0.9912 (0.0087)
		#3			1.0000 (< 0.0001)
		#4			0.9884 (0.0116)
		P(F-test)			***0.5613***

Table 4.4. Numbers of tags by manufacturing tag lot used in each of the release groups by location and time of day during the 2011 yearling Chinook salmon survival study at Rocky Reach. Test of homogeneous distribution was not rejected $\left(P\left(\chi_6^2 \geq 0.0266\right) = 0.9999\right)$.

	Mfg. Lot Number		
Release	11204	11205	11206
Wells Tailrace (day)	163	168	93
Wells Tailrace (night)	164	168	94
Rocky Reach Tailrace (day)	164	170	93
Rocky Reach Tailrace (night)	165	168	94

Table 4.5. Reach survival estimates (uncorrected for tag life) by release location and time of release for the three different tag lots used in the 2011 yearling Chinook salmon survival study at Rocky Reach. *P*-values for the *F*-tests of homogeneous survival reported.

Tag Lot	Well Tailrace (day)	Well Tailrace (night)	Rocky Reach Tailrace (day)	Rocky Reach Tailrace (night)
11204	0.9571 (0.0159)	0.9451 (0.0178)	0.9939 (0.0060)	0.9939 (0.0060)
11205	0.8929 (0.0239)	0.9048 (0.0226)	0.9941 (0.0059)	0.9940 (0.0059)
11206	0.9140 (0.0291)	0.9149 (0.0288)	1.0000 (<0.0001)	1.0000 (<0.0001)
P(F-test)	***0.1235***	***0.4958***	***0.6821***	***0.6705***

4.3 Tag-Life Curve

A four-parameter vitality curve was fit to the tag-life data (Figure 4.2). The fitted curve nicely tracked the data from the 50 tags used in the tag-life study. The maximum likelihood estimates of the model parameters for the fitted vitality curve were $r = 0.0300403$, $s = 0.0116277$, $k = 0.000879903$, and $u = 0.0508766$. Average tag life was estimated to be 32.7 days during the 2011 survival study. This tag-life curve was used for both subsequent daytime and nighttime survival analyses (Figure 4.1).

4.4 Project Survival Estimate

Project passage survival was separately estimated for daytime and nighttime paired releases at Rocky Reach. Overall project passage survival was estimated by pooling the daytime and nighttime release groups.

4.4.1 Tag-Life Corrections

Plotting the cumulative arrival distributions of the Wells and Rocky Reach tailrace releases superimposed upon the tag-life curve indicates the tagged fish arrived at the downstream detection sites before tag failure became a problem (Figure 4.2). In all cases, the probability an acoustic tag was active at a downstream detection site was estimated to be ≥ 0.9935 (Table 4.6). Consequently, tag-life adjustments to the estimated survival from the CJS model will be small.

4.4.2 Downstream Mixing

Adequacy of downstream mixing of Wells tailrace and Rocky Reach tailrace releases was evaluated using graphs of arrival time plots.

The Rocky Reach tailrace releases were released 72 hours after the corresponding Wells tailrace releases within a replicate to facilitate downstream mixing. Plots of the arrival timing at Rock Island Hydropark indicate the Rocky Reach tailrace fish arrive approximately in the center of the arrival distributions for the Wells tailrace fish (Figure 4.3). However, as seen in past years, the arrival distribution of the Rocky Reach tailrace fish was abrupt, with a pronounced peak, while the Wells tailrace released fish had a flatter, more protracted arrival distribution.

4.4.3 Survival Estimate

The capture histories for the Wells and Rocky Reach tailrace releases to Rock Island Hydropark and Rock Island Boat Restricted Zone (BRZ) were used to estimate the reach survivals in the paired release-recapture design (Table 4.7). Very small adjustments for tag failure were used because the probability of a tag being active when the fish passed the detection arrays was ≥ 0.9935 (Table 4.6). The estimates of project passage survival were calculated using the ratio of the tag-life adjusted survivals from release to Rock Island Hydropark (Table 4.8).

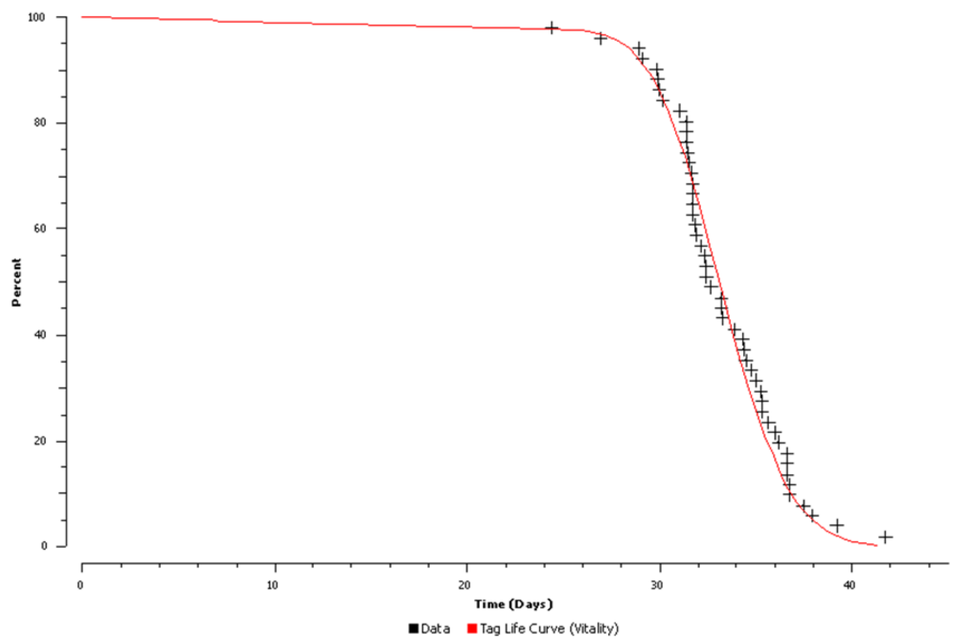
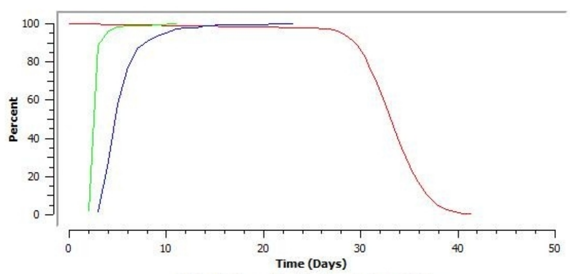
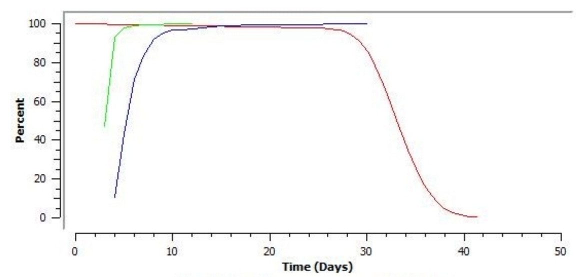


Figure 4.1. Observed times to failure and the fitted vitality curve for tag-life data used in the 2011 Rocky Reach survival study (*n* = 50).

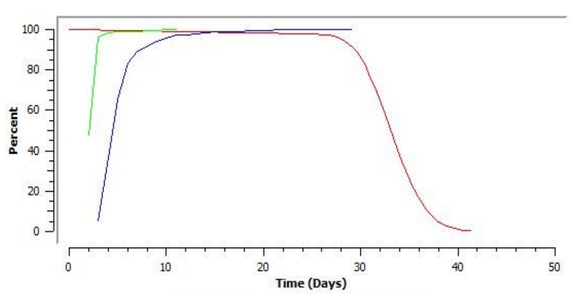
a. Rock Island Hydropark – Daytime releases



b. Rock Island Hydropark – Nighttime releases



c. Rock Island BRZ – Daytime releases



d. Rock Island BRZ – Nighttime releases

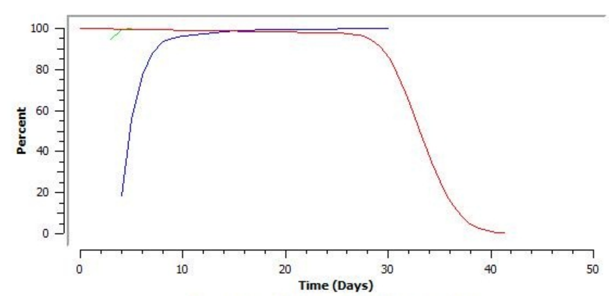
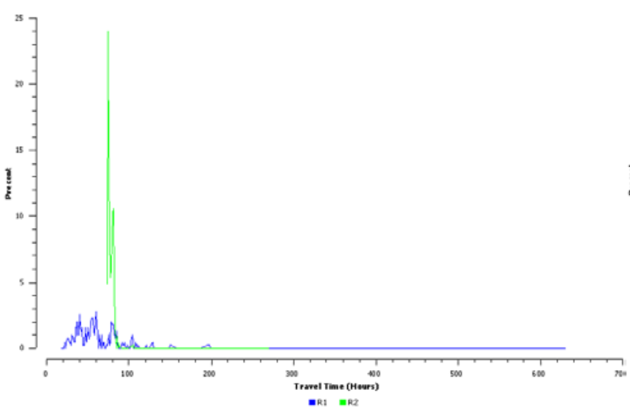


Figure 4.2. Tag-life survivorship curve vs. timing of downstream detections of yearling Chinook salmon smolts tagged with HTI *Model 795Lm Acoustic Tags* at (a) Rock Island Hydropark – daytime releases, (b) Rock Island Hydropark – nighttime releases, (c) Rock Island Boat Restricted Zone (BRZ) – daytime releases, and (d) Rock Island BRZ – nighttime releases.

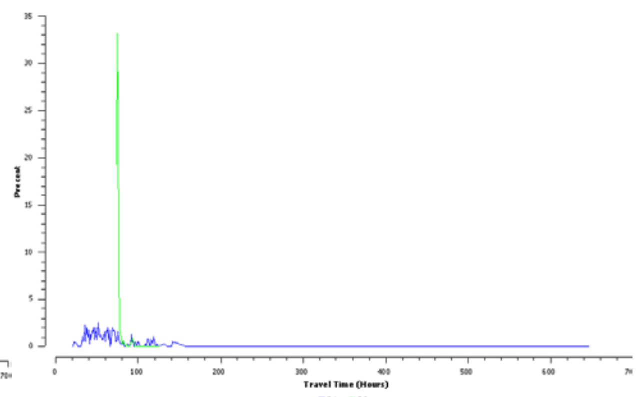
Table 4.6. Estimated probabilities an acoustic tag was operational at a detection site as a function of release location and release time for yearling Chinook salmon smolts in the Rocky Reach survival study. Standard errors in parentheses.

		Detection site	
Release time	Release site	Rock Island Hydropark	Rock Island BRZ
Daytime	Wells tailrace	0.9946 (0.0046)	0.9946 (0.0047)
	Rocky Reach tailrace	0.9972 (0.0024)	0.9970 (0.0027)
Nighttime	Wells tailrace	0.9938 (0.0034)	0.9935 (0.0035)
	Rocky Reach tailrace	0.9970 (0.0018)	0.9965 (0.0021)

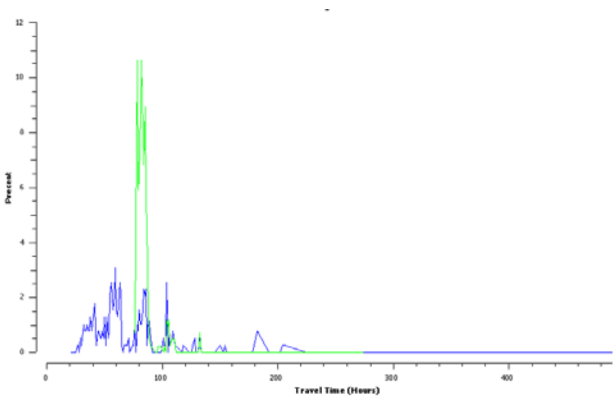
a. Rock Island Hydropark – Daytime releases



b. Rock Island Hydropark – Nighttime releases



c. Rock Island BRZ – Daytime releases



d. Rock Island BRZ – Nighttime releases

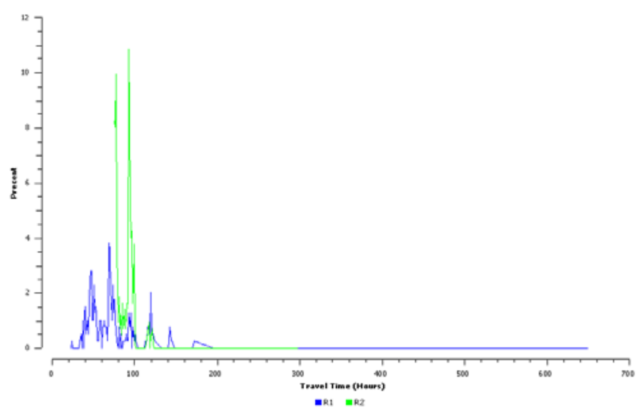


Figure 4.3. Arrival distributions of Wells and Rocky Reach tailrace releases at Rock Island Hydropark and BRZ detection locations for (a) daytime and (b) nighttime releases.

Table 4.7. Capture histories for the Wells and Rocky Reach day and nighttime releases of yearling Chinook salmon smolts at Rock Island Hydropark and Boat Restricted Zone (BRZ) used in estimating project passage survivals in 2011. The 1 denotes detection; 0, nondetection.

	Detection history				
Release	11	01	10	00	Total
Wells tailrace (day)	389	0	2	33	424
Wells tailrace (night)	392	0	1	33	426
Rocky Reach tailrace (day)	424	0	1	2	427
Rocky Reach tailrace (night)	423	0	2	2	427

Table 4.8. Results of the paired release-recapture analyses used in estimating project passage survival at Rocky Reach using daytime and nighttime releases for yearling Chinook salmon smolts in 2011. Survival estimates are adjusted for acoustic-tag failures. Standards errors in parentheses.

Release site	Release to RI Hydropark $(\hat{S})$	λ	$\hat{S}_{RR}$
Wells tailrace (day)	0.9272 (0.0036)	0.9949 (0.0036)	0.9289 (0.0135)
Rocky Reach tailrace (day)	0.9981 (0.0037)	0.9979 (0.0024)	
Wells tailrace (night)	0.9283 (0.0135)	0.9977 (0.0025)	0.9299 (0.0135)
Rocky Reach tailrace (night)	0.9983 (0.0038)	0.9958 (0.0033)	
Wells tailrace (day & night)	0.9277 (0.0099)	0.9962 (0.0022)	0.9294 (0.0097)
Rocky Reach tailrace (day & night)	0.9982 (0.0031)	0.9965 (0.0020	
	Detection probability at RI Hydropark		
Wells tailrace (day)	1.0000 (<0.0001)		
Rocky Reach tailrace (day)	1.0000 (<0.0001)		
Wells tailrace (night)	1.0000 (<0.0001)		
Rocky Reach tailrace (night)	1.0000 (<0.0001)		
Wells tailrace (day & night)	1.0000 (<0.0001)		
Rocky Reach tailrace (day & night)	1.0000 (<0.0001)		

Project passage survival for yearling Chinook salmon using daytime releases was estimated to be $\hat{S}_{\text{RR-Day}}$ = 0.9289 ($\widehat{\text{SE}}$ = 0.0135). For nighttime releases, project passage survival at Rocky Reach was estimated to be $\hat{S}_{\text{RR-Night}}$ = 0.9299 ($\widehat{\text{SE}}$ = 0.0135) (Table 4.8). The estimates of project passage survival for day and nighttime releases were not significantly different (P = 0.9582, two-tailed). Pooling the day and nighttime release-recapture data, overall project passage survival at Rocky Reach for yearling Chinook salmon smolts in 2011 is estimated to be $\hat{S}_{\text{RR}}$ = 0.9294 ($\widehat{\text{SE}}$ = 0.0097). Averaging the separate day and nighttime estimates produces the same point estimate of $\hat{S}_{\text{RR}}$ = 0.9294, as might be expected, because release numbers were almost equal between day and nighttime releases (Table 4.7).

4.4.4 Robustness of Project Survival Estimate

The high flows in 2011 had three potential effects on the performance of the Rocky Reach survival study. First, because of the high river flows, the Wells tailrace releases could not always occur 1,000 feet below the dam, as planned. Wells Dam flows peaked at more than 293,000 cfs during the later part of the release period. For reasons of safety of the release crew in the boat, the Wells tailrace releases ranged from 1,000 to 4,000 feet below the dam in 2011. In 18 of the 30 Wells tailrace releases (15 day and 15 night), the release location was used as planned. The other 12 releases occurred beyond the traditional 1000-ft release location, 2 of which were also shoreline releases. The shorter reaches could result in a positive bias, while the shoreline releases are anticipated to have a negative effect on survival.

The second consequence of high river flows in 2011 was Rocky Reach Dam was forced to use spillways during part of the study, thereby affecting the evaluation of dam passage survival characterized by no spill. However, because spill was both the result of and concurrent with high flows, survival benefits of spill and flow were interrelated. Nonetheless, if spill affected smolt survival estimates, then this event could bias the evaluation of the no-spill operation at Rocky Reach. Spill occurred the first time between the hours 0200–1100 on 16 May 2011. Starting at hour 0100 on 18 May 2011, unavoidable spill occurred continuously until the end of the study. This period was coincident with replicate releases 12–15 and the highest flows of the study period.

The third consequence of the high river flows was that some of the hydrophones at the downstream detection sites were lost toward the very end of the study. The first hydrophone losses occurred on 28 May 2011, with additional losses occurring through 5 June 2011. May 28 was after the last release event (i.e., 24 May 2011), but some of the fish from that and earlier releases were still passing through the detection sites. A reduction in detection probabilities during part of the study could have positive or negative ramifications to the estimates of project passage survival.

The purpose of this section is to evaluate whether the survival estimates reported for the Rocky Reach project (see Section 4.4.3) are robust to the high flow events and their effects on study performance. First, with regard to the relationship between release distance below Wells Dam and the estimate of project passage survival, the furthest release distance below Wells Dam was 4,000 feet, which occurred during the nighttime release for replicate 14 only. That nighttime release replicate produced an estimate of project passage survival of $\hat{S}_{\text{RR}}$ = 0.9352 ($\widehat{\text{SE}}$ = 0.0465), which is not significantly different from the overall survival estimate of $\hat{S}_{\text{RR}}$ = 0.9294 $\left(\widehat{\text{SE}} = 0.0097\right)$. There was no obvious positive correlation between the estimates of project passage survival on a per-replicate basis and distance below Wells Dam for the tailrace releases for either daytime (r = 0.3776, P = 0.0827, one-tailed) or nighttime (r = 0.1015, P = 0.3594) releases (Figure 4.4). There was also no obvious correlation found between the reach survival estimates from Wells tailrace to Rock Island Hydropark and the distance of the releases below Wells Dam (daytime, r = 0.3574, P = 0.0954; nighttime, r = 0.1109, P = 0.3470). Consequently, no discernible bias was found in the estimate of Rocky Reach project survival as the result of some Wells tailrace releases occurring below the 1,000-foot location.

The possible effect of spill on the estimate of Rocky Reach project passage survival was examined in two ways. First, the effect of spill was examined on a temporal basis comparing the period before and during spill. The period before spill included replicates 1-10 and during spill included replicates 11–15. Data were pooled for day and nighttime releases. In addition, by using only replicates 1–10, the issue of equipment loss at the end of the study is eliminated as well as replicate 14, which released fish 4,000 feet below Wells Dam.

During the period before spill (i.e., replicates 1–10), river flows were lower and estimated project passage survival was $\tilde{S}_{\text{RR}}$ = 0.9161 ($\widehat{\text{SE}}$ = 0.0125) (Table 4.9). During the spill period (i.e., replicate 11–15), flows were higher and estimated project passage survival for all fish was $\tilde{S}_{\text{RR}}$ = 0.9560 ($\widehat{\text{SE}}$ = 0.0143) (Table 4.9). However, the benefits of spill and high flows were both represented in this estimate. Therefore, to further partition the effect of spill and flow, fish that passed through the spillway during replicates 11–15 were omitted and project survival was reestimated at $\tilde{S}_{\text{RR}}$ = 0.9474 ($\widehat{\text{SE}}$ = 0.0162) (Table 4.9).

The second evaluation of robustness was performed by omitting all fish known to have gone through the spillway during the entire study. In so doing, any direct survival advantage of spillway passage is eliminated from the estimate of project passage survival. However, any indirect effects of changes in the tailrace environment, either positive or negative, would not be excluded. A total of 17 smolts from the daytime and 24 smolts from the nighttime releases were omitted from the release data to account for spillway passed fish. Thus, the paired release for daytime releases estimated project passage survival at $\tilde{S}_{\text{RR}}$ = 0.9257 ($\widehat{\text{SE}}$ = 0.0140). For the nighttime releases, project passage survival was then estimated to be $\tilde{S}_{RR}$ = 0.9253 ($\widehat{\text{SE}}$ =

0.0143). Pooling the day and nighttime releases with spillway fish removed resulted in an estimate of project passage survival of $\tilde{S}_{RR}$ = 0.9255 ($\widehat{\text{SE}}$ = 0.0101). This value compares favorably with the original estimate using all the data of $\hat{S}_{RR}$ = 0.9294 ($\widehat{\text{SE}}$ = 0.0097).

a. Daytime releases

b. Nighttime releases

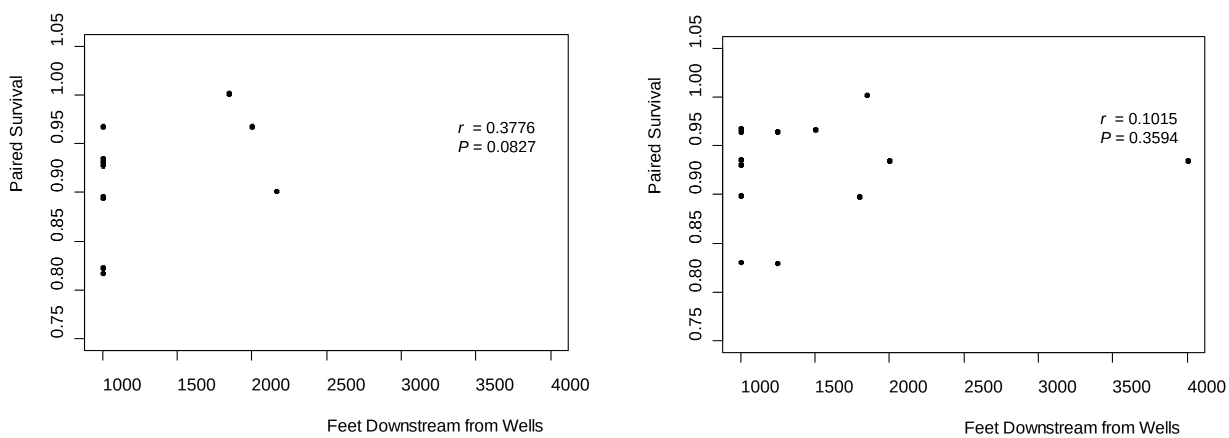


Figure 4.4. Scatterplots of estimates of project passage survival at Rocky Reach vs. distance of treatment releases below Wells Dam on a per-replicate basis for (a) daytime and (b) nighttime releases.

Table 4.9. Alternative estimates of Rocky Reach project passage survival for yearling Chinook salmon for the early (i.e., replicates 1–10) and later (i.e., replicates 11–15) periods of study corresponding to lower and higher river flows and with and without spillway-passed fish.

Period	All fish	Spillway-detected fish removed	River flow @ RR
Replicates 1-10	0.9161 ($\widehat{\text{SE}}$ = 0.0125)	0.9161 ($\widehat{\text{SE}}$ = 0.0125)	150.0 kcfs
Replicates 11-15	0.9560 ($\widehat{\text{SE}}$ = 0.0143)	0.9474 ($\widehat{\text{SE}}$ = 0.0162)	266.7 kcfs

4.5 Diel Passage Distributions

Using the hourly sampling data from the Juvenile Sampling Facility at Rocky Reach, 25 April to 27 May, 2011, the diel passage of yearling Chinook salmon smolts was estimated. Inspection of the diel pattern indicates the majority of the yearling Chinook salmon smolts passed through the dam during nighttime hours in 2011 (Figure 4.6). Of all run-of-river yearling Chinook passing through the surface collector in 2011, an estimated 40.9% passed during the day. The remaining 59.1% passed during the night. In the previous two years, daytime passage was 39.1% and 52.0% in 2009 and 2010, respectively, for yearling Chinook salmon smolts. Examination of Figure 4.6 indicates the various salmonid smolts had very different diel distributions. Steelhead, subyearling Chinook, coho, and sockeye salmon passage was predominantly during daytime.

The diel passage distribution of acoustic-tagged yearling Chinook salmon smolts at Rocky Reach Dam was also examined for the day and nighttime releases of these fish from Wells Dam. Regardless of release times at Wells, diel arrival passage patterns at Rocky Reach were quite similar (Figure 4.5b, c). However, the acoustic-tagged yearling Chinook salmon had a much stronger daytime passage component than the run-of-river yearling Chinook salmon (Figure 4.5a**,** Table 4.10).

4.6 Reach Survivals

The day and nighttime releases permitted comparison of survival estimates over common reaches. For the Wells tailrace releases, reach survival estimates for the day and nighttime releases generally tracked one another as the fish progressed downriver (Table 4.11). In the first reach between release and Beebe Bridge, reach survivals were significantly different (P = 0.0668) . Nighttime releases had a survival of $\hat{S}$ = 0.9984 ($\widehat{\mathrm{SE}}$ = 0.0038), while daytime releases had a survival of $\hat{S}$ = 0.9838 ($\widehat{\mathrm{SE}}$ = 0.0070). For the Rocky Reach tailrace releases, reach survival estimates for the day and nighttime releases tracked one another as the fish progressed downriver (Table 4.12). The reach survival estimates were not significantly different between the Rocky Reach day and nighttime releases ($P \geq 0.9699$) (Table 4.12).

4.7 Route-Specific Passage Proportions and Survivals

Not to be confused with the project passage survival estimates based on times of release, route-specific passage proportions and route survivals were based on times of arrival at Rocky Reach Dam. Acoustic-tagged yearling Chinook salmon smolts arriving at Rocky Reach Dam were classified according to whether they arrived during the day or nighttime hours. For each of the time periods, separate estimates of dam passage proportions and route-specific survivals were calculated.

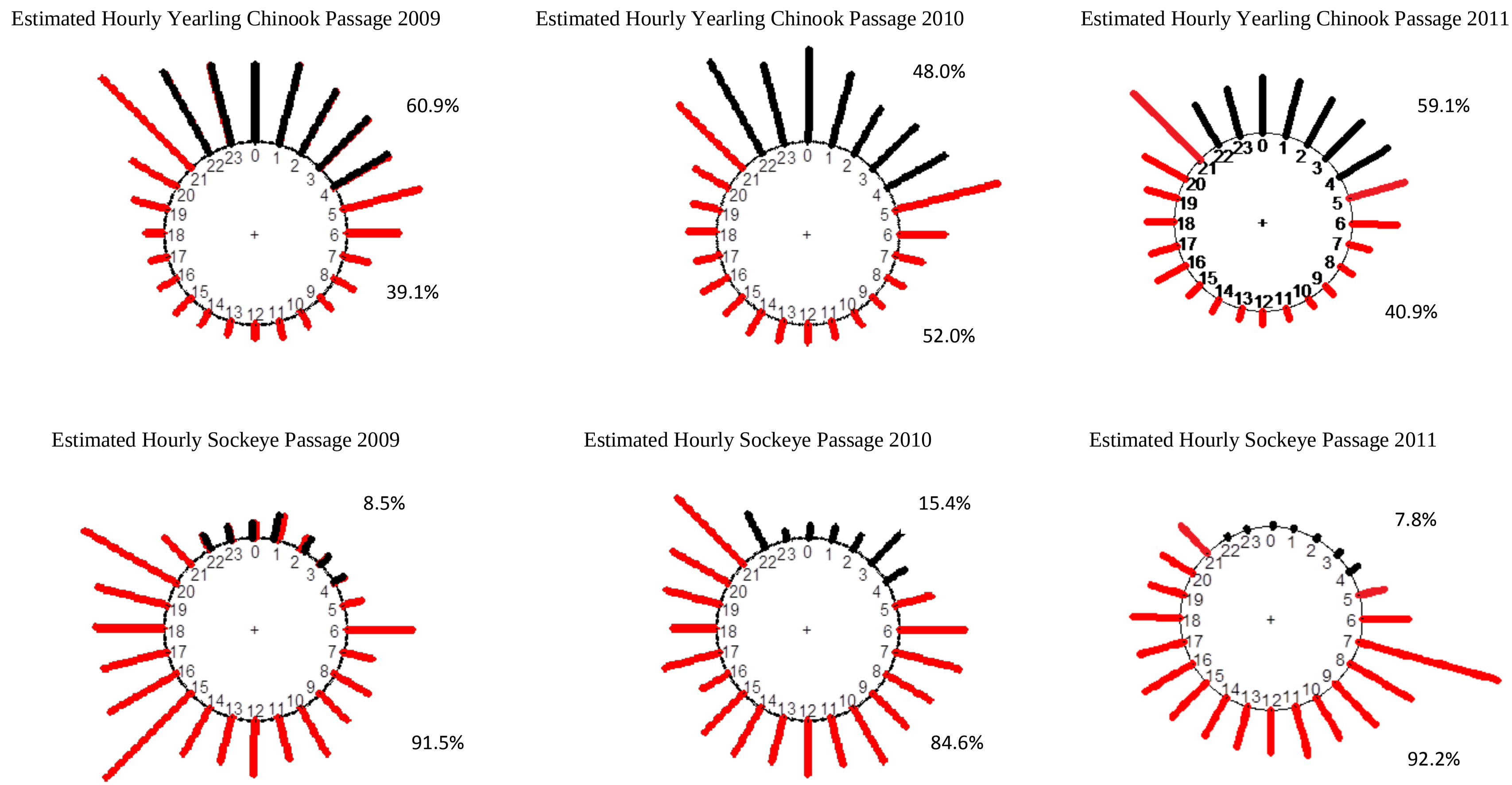


Figure 4.5. Diel relative frequencies of fish passage plotted on a 24-hour clock by fish stock with comparisons of results for 2009–2011. Approximate hours of day and night denoted by red and black bars, respectively (see Table A1). Percent passage during day and night indicated.

Figure 4.5. (Continued) Diel relative frequencies of fish passage plotted on a 24-hour clock by fish stock with comparisons of results for 2009–2011. Approximate hours of day and night denoted by red and black bars, respectively (see Table A1). Percent passage during day and night indicated.

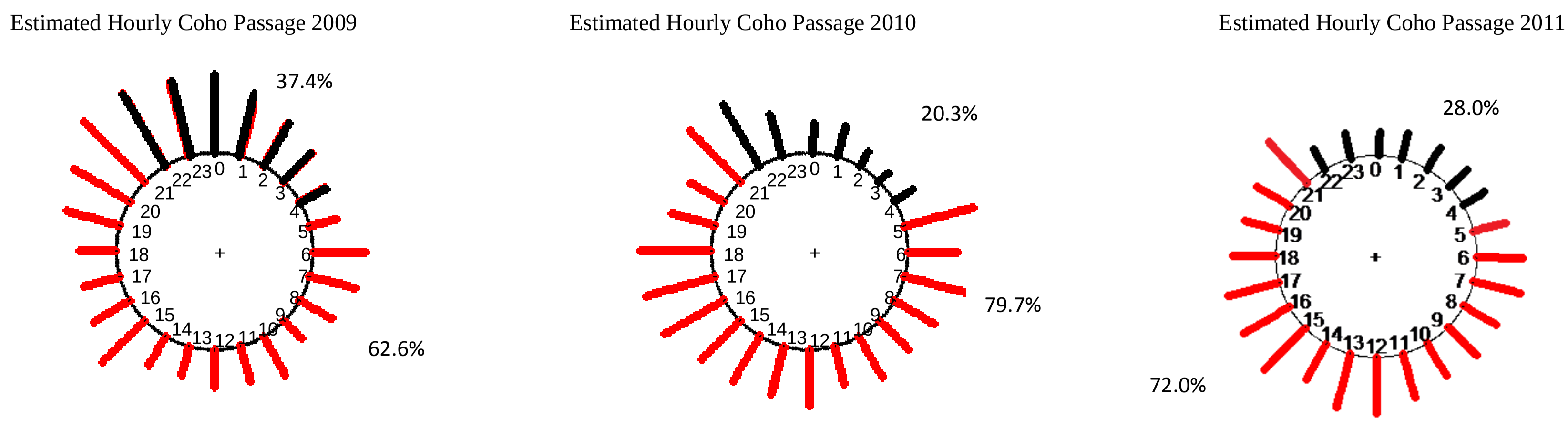


Figure 4.5. (Continued) Diel relative frequencies of fish passage plotted on a 24-hour clock by fish stock with comparisons of results for 2009–2011. Approximate hours of day and night denoted by red and black bars, respectively (see Table A1). Percent passage during day and night indicated.

Table 4.10. Estimates of proportions of acoustic-tagged yearling Chinook salmon smolts released from Wells tailrace in 2011 and detected at Rocky Reach Dam during day and night periods.

Wells tailrace releases	Total released	Proportion of Rocky Reach yearling Chinook salmon passage: Day	Proportion of Rocky Reach yearling Chinook salmon passage: Night
Day releases	408	0.5368	0.4632
Night releases	415	0.6145	0.3855
Pooled releases	823	0.5759	0.4241
ROR estimated at Juvenile Sampling Facility		0.4092	0.5908

a. Juvenile sampling facility b. Day releases c. Night releases

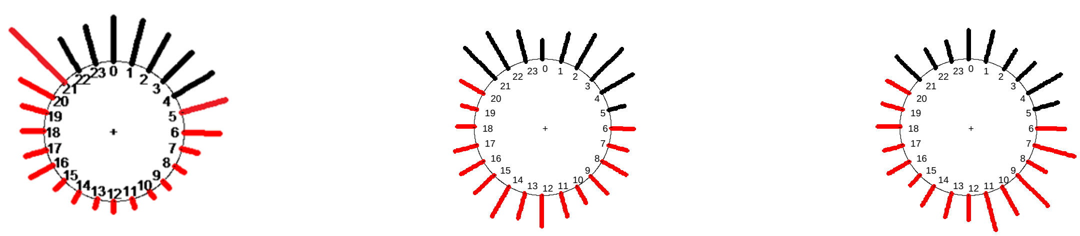


Figure 4.6. Diel relative frequencies of Rocky Reach passage at the (a) Rocky Reach juvenile sampling facility for run-of-river yearling Chinook salmon, and the (b) daytime- released and (c) nighttime- released, acoustic-tagged yearling Chinook salmon smolts from Wells tailrace in 2011, plotted on a 24-hour clock. Each clock is normalized to 100%.

Table 4.11. Reach survivals, adjusted for tag life, for yearling Chinook salmon smolts released from Wells tailrace for day and night releases. Standard errors in parentheses.

Reach	Day releases	Night releases	*P*-value (2-tailed)
Release to Beebe Bridge	0.9838 (0.0070)	0.9984 (0.0038)	0.0668
Beebe Bridge to RR BRZ	0.9830 (0.0093)	0.9812 (0.0086)	0.8870
RR BRZ to RI Hydropark	0.9588 (0.0112)	0.9477 (0.0115)	0.4893

Table 4.12. Reach survivals, adjusted for tag life, for yearling Chinook salmon smolts released from Rocky Reach tailrace for day and night releases. Standard errors in parentheses.

Reach	Day releases	Night releases	*P*-value (2-tailed)
Release to RI Hydropark	0.9981 (0.0037)	0.9983 (0.0038)	0.9699

Using the double-acoustic arrays at the face of Rocky Reach Dam, the abundance of acoustic-tagged yearling Chinook salmon smolts passing through the various routes was estimated (Table 4.13). Abundance was estimated using the Lincoln/Petersen closed population model (Seber 1982:59). From the estimates of passage abundances, estimates of passage proportions for day and nighttime arriving yearling Chinook salmon smolts were calculated (Table 4.14). Passage proportions were significantly different at two of the five routes at Rocky Reach Dam between day and nighttime. Fewer yearling Chinook salmon used the surface collector at night compared to day (night: 22.3% vs. day: 38.0%), with the majority going into Units 3–11 (night: 58.6% vs. day: 47.8%) instead. The remaining 4.9% of the difference was evenly split between the bypass screens (+1.5%), Units 1-2 (+1.7%), and the spillway (+1.7%), but none were signicantly different than their daytime passage proportions. (Table 4.14).

For those smolts known to have passed through routes at Rocky Reach Dam, downstream detection histories were obtained (Table 4.15) in order to estimate relative route-specific survivals (Table 4.16). Survival through the surface collector for the daytime releases was estimated to be $\hat{S}_{SC}$ = 0.9976 ($\widehat{\text{SE}}$ = 0.0053). This estimate of absolute survival through the surface collector was used to convert the relative survival estimates (Table 4.16) to estimate route-specific absolute survivals (Table 4.17).

There were no significant differences in the survival estimates, day and night, through any of the four other passage routes. All passage survivals were lower at night than day, with Units 1–2 having the largest (0.9264 vs. 0.8788, P = 0.6128, two-tailed) but not significant difference, likely due to the small numbers of fish that went through this route (Table 4.13). Survival through the screens (1.0146 vs. 1.0106, P = 0.8248, two-tailed) and Units 3-11 (0.9469 vs. 0.9464, P = 0.9864, two-tailed), and spillway (1.0146 vs. 1.0106, P = 0.8248, two-tailed) were very similar (Table 4.17).

4.8 Dam Passage Survival

Combining the route-specific passage proportions (Table 4.14) with the information on route-specific survival estimates (Table 4.17) produced an estimate of $\hat{S}_{\text{Dam-Day}}$ = 0.9715 ($\widehat{\text{SE}}$ = 0.0103) for tagged yearling Chinook salmon smolts that arrived at Rocky Reach Dam during the day. For yearling Chinook salmon arriving at Rocky Reach Dam during the night, the estimate of dam passage survival was calculated to be $\hat{S}_{\text{Dam-Night}}$ = 0.9614 ($\widehat{\text{SE}}$ = 0.0137). These two estimates of dam passage survival are not significantly different (P = 0.5557, two-tailed).

An overall estimate of dam passage survival was calculated by weighting day and nighttime survival estimates by the proportions of run-of-river yearling Chinook salmon passing through the surface collector during day (0.4092) and nighttime (0.5908) hours. The overall estimate across day and night was calculated to be $\hat{S}_{\text{Dam}}$ = 0.9655 ($\widehat{\text{SE}}$ = 0.0091). If the route-specific survival estimates > 1.0 in Table 4.16 are set to 1.0, overall dam passage survival is estimated to be $\tilde{S}_{\text{Dam}}$ = 0.9642 ($\widehat{\text{SE}}$ = 0.0091). Using the overall estimate of project survival of $\hat{S}_{\text{RR}}$ = 0.9294 ($\widehat{\text{SE}}$ = 0.0097), pool passage survival is then estimated to be $\hat{S}_{\text{Pool}}$ = 0.9639 ($\widehat{\text{SE}}$ = 0.0135).

In an attempt to estimate dam passage survival had there been no spill, the passage proportions (Table 4.14) were recalculated conditionally on non-spill passage routes only (e.g., surface collector at day (0.3800/(1 – 0.0425) = 0.3969). Using these conditional passage proportions and the same route-specific survivals reported in Table 4.17, daytime passage survival through the dam was estimated to be 0.9688 (0.0107) and nighttime passage at 0.9576 (0.0146). Overall dam passage survival conditional on non-spill routes was then estimated to be 0.9621 ($\widehat{\text{SE}}$ = 0.0097) when weighting by diel passage proportions compared to 0.9642 ($\widehat{\text{SE}}$ = 0.0091) when all routes of passage are considered.

Table 4.13. Capture histories at Rocky Reach forebay double-arrays for acoustic-tagged yearling Chinook salmon smolts released from Wells tailrace in 2011 and associated estimated passage abundance. Standard errors are in parentheses. The 1 denotes detection; 0 denotes not detected at the Rocky Reach primary and secondary forebay arrays.

	Day				Night			
	Detection history				Detection history			
Route	11	10	01	Est. total	11	10	01	Est. total
Surface collector	179	0	0	179 (0)	78	0	0	78 (0)
Bypass screens	24	0	0	24 (0)	23	0	0	23 (0)
Units 1–2	23	0	0	23 (0)	23	0	0	23 (0)
Units 3–11	222	0	3	225 (0)	204	1	0	205 (0)
Spillway	20	0	0	20 (0)	21	0	0	21 (0)

Table 4.14. Estimates of acoustic-tagged yearling Chinook salmon passage proportions at Rocky Reach Dam during day and night periods in 2011. Standard errors in parentheses. Two-tailed *P*-values for a difference in passage proportions.

Route	Passage proportions: Day	Passage proportions: Night	*P*-value (2-tailed)
Surface collector	0.3800 (0.0224)	0.2229 (0.0222)	< 0.0001
Bypass screens	0.0510 (0.0101)	0.0657 (0.0132)	0.3765
Units 1–2	0.0488 (0.0099)	0.0657 (0.0132)	0.3057
Units 3–11	0.4777 (0.0230)	0.5857 (0.0263)	0.0020
Spillway	0.0425 (0.0093)	0.0600 (0.0127)	0.2662

Table 4.15. Downstream histories of acoustic-tagged yearling Chinook salmon smolts detected during either day or nighttime passage at Rocky Reach Dam in 2011. The capture histories denote detections by “1” and nondetections by “0” at Rock Island Hydropark and Rock Island BRZ, respectively.

	Day					Night				
	Detection history					Detection history				
Release site	11	10	01	00	Passage	11	10	01	00	Passage
Rocky Reach Dam										
Surface collector	176	0	0	3	179	76	1	0	1	78
Bypass screens	24	0	0	0	24	23	0	0	0	23
Units 1–2	21	0	0	2	23	20	0	0	3	23
Units 3–11	209	1	0	15	225	191	1	0	13	205
Spillway	20	0	0	0	20	21	0	0	0	21
Release above surface collector	418	3	1	3	425					
Release below surface collector	424	1	0	2	427					

Table 4.16. Estimates of route-specific relative survival for yearling Chinook salmon compared to surface collector at Rocky Reach during day and night passage in 2011. Standard errors in parentheses.

	Relative survival to the surface collector		
Parameter	Day	Night	*P*-value (2-tailed)
$S_{\text{Bypass screens}}$	1.0170 (0.0099)	1.0130 (0.0131)	0.8075
$S_{\text{Units 1-2}}$	0.9286 (0.0604)	0.8809 (0.0720)	0.6118
$S_{\text{Units 3-11}}$	0.9492 (0.0193)	0.9487 (0.0211)	0.9860
S_{Spillway}	1.0170 (0.0099)	1.0130 (0.0131)	0.8075

Table 4.17. Estimates of route-specific survival at Rocky Reach for yearling Chinook salmon during day and night periods in 2011. Standard errors in parentheses. Two-tailed *P*-values for a difference in survival.

	Absolute survival		
Parameter	Day	Night	*P*-value (2-tailed)
$S_{\text{Surface collector}}$	0.9976 (0.0053)		
$S_{\text{Bypass screens}}$	1.0146 (0.0113)	1.0106 (0.0141)	0.8248
$S_{\text{Units 1-2}}$	0.9264 (0.0605)	0.8788 (0.0720)	0.6128
$S_{\text{Units 3-11}}$	0.9469 (0.0199)	0.9464 (0.0216)	0.9864
S_{Spillway}	1.0146 (0.0113)	1.0106 (0.0141)	0.8248

5. Discussion

Implementation of the 2011 yearling Chinook salmon survival study at Rocky Reach was performed with only minor incidents that did not affect study objectives. Statistical analyses identified no tag-lot or tagger effects that could have biased study results. Tag life was long enough for study fish to traverse the study areas before tag failure became a problem in estimating smolt survival. There was some loss of detection equipment due to high river flows at the very end of the study that might have affected one or two replicate releases. However, statistical analyses found no adverse effects on the survival estimates. All indications are that the survival estimates are precise and reliable.

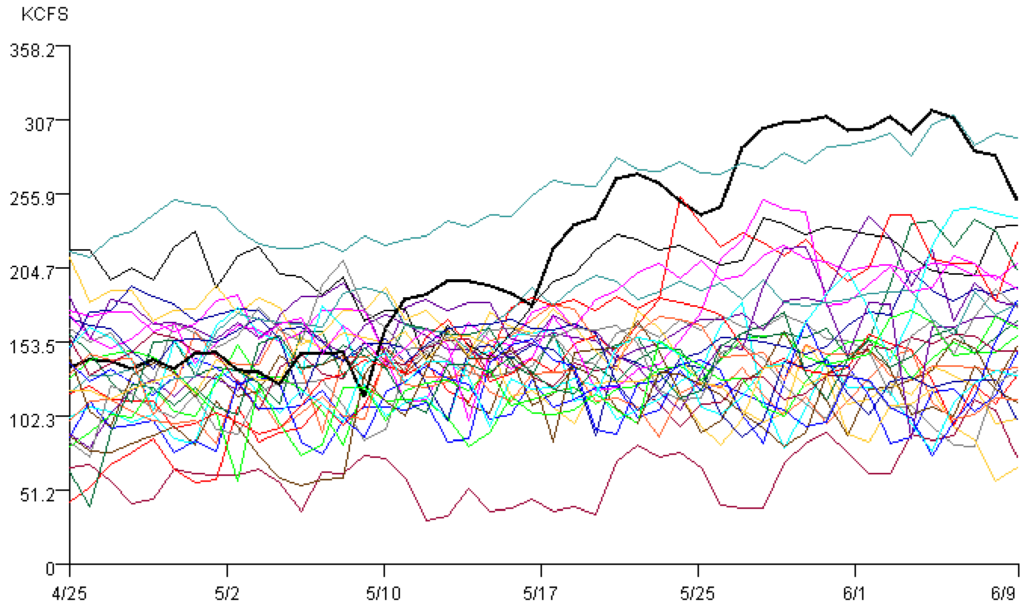
The season-wide estimate of project passage survival for yearling Chinook salmon through the Rocky Reach project in 2011 of $\hat{S}_{\text{RR}}$ = 0.9294 ($\widehat{\text{SE}}$ = 0.0097) did not achieve the juvenile HCP survival requirement of $S \geq 0.93$. While the precision requirement was achieved (i.e., $\widehat{\text{SE}} \leq 0.025$), the point estimate just missed its threshold. The four-year average (years 2004, 2005, 2010, 2011) survival for yearling Chinook salmon smolts at Rocky Reach Hydroproject is 0.9237 (Table 5.1).

River flows in 2011 were much higher than average. Average total discharge during the study period (e.g., 25 April – 9 June 2011) at Rocky Reach was 214.9 kcfs (Figure 5.1). The year 2011 had the second highest average discharge in the last 30 years. Spill occurred beginning on the 22nd day of the 46-day study (Figure 5.1). Average spill volume during during the period once spill began was 78.4 kcfs. This spill volume was equivalent to an average percent spill of 27.5% during the last half of the study. Analysis of the 2011 tagging data could not identify a significant increase in survival of the yearling Chinook salmon smolts during those days of spill. Two alternative analysis attempts to account or adjust for spill produced estimates of 0.9161 ($\widehat{\text{SE}}$ = 0.0125) and 0.9255 ($\widehat{\text{SE}}$ = 0.0101).

Table 5.1. Summary of annual HCP compliance testing at Rocky Reach Project by species with years tested, technique, fish source, dam operation tested, and estimate of project passage survival with associated standard error. Status of compliance testing and Habit Conservation Plan listed.

Species	Year	Technique	Fish source	Dam operations	$\hat{S}$	$\widehat{SE}$	Status
Sockeye	2006	Acoustic tag	Run-of-river	Waterview	0.9331	0.0121	
	2008	Acoustic tag	Run-of-river	Waterview	0.9209	0.0212	
	2009	Acoustic tag	Run-of-river	Waterview	0.9545	0.0118	
				Average	0.9362		HCP compliance achieved
Steelhead	2004	Acoustic tag	Run-of-river	Waterview	0.9833	0.0184	
	2005	Acoustic tag	Run-of-river	Waterview	0.9303	0.0134	
	2006	Acoustic tag	Run-of-river	Waterview	0.9598	0.0100	
				Average	0.9578		HCP compliance achieved
Yearling Chinook	2004	Acoustic tag	Run-of-river	Waterview	0.9293	0.0196	
	2005	Acoustic tag	Run-of-river	Waterview	0.9109	0.0179	HCP compliance achieved in conjunction with adult survival of 0.9990.
	2010	Acoustic tag	Run-of-river	Waterview	0.9250	0.0142	
	2011	Acoustic tag	Run-of-river	Waterview	0.9294	0.0097	
				Average	0.9237		

a. Flow (Kcfs)



b. Spill (%)

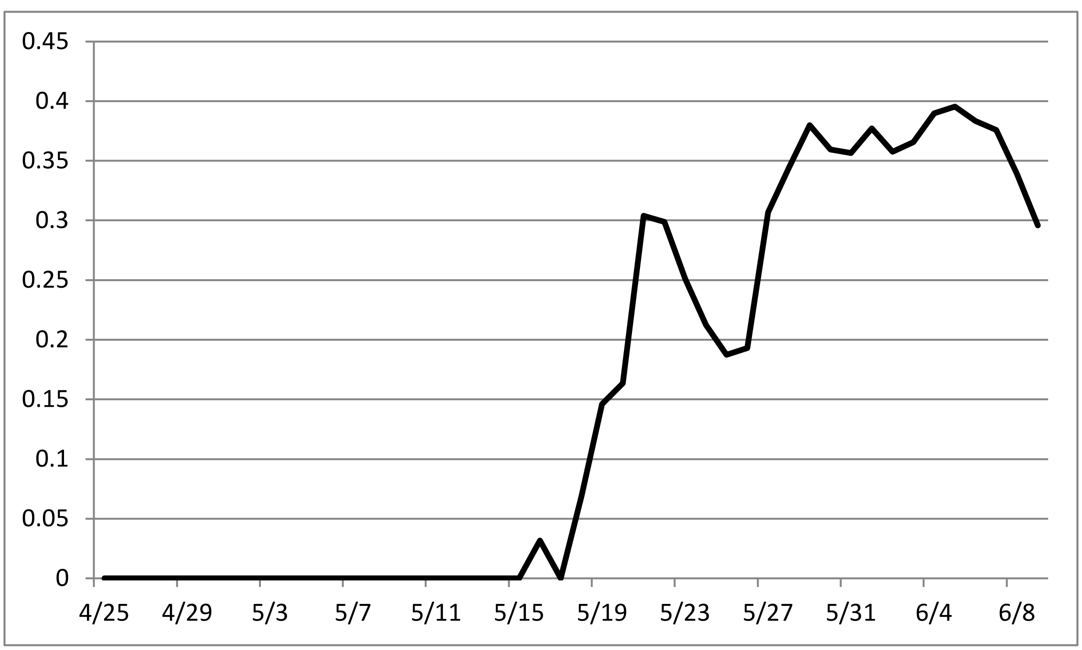


Figure 5.1. Daily rate of (a) total discharge at Rocky Reach Dam (25 April – 9 June) for the years 1982–2011 with 2011 in bold and (b) daily percent spill during the 2011 yearling Chinook salmon study at Rocky Reach.

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Appendix A

Table A1. Sunrise and sunset times during the 2011 smolt survival studies at Rocky Reach Dam (PDT).

Date	Sunrise (Day)	Sunset (Night)
4/25/11	5:55	20:04
4/26/11	5:53	20:06
4/27/11	5:52	20:07
4/28/11	5:50	20:09
4/29/11	5:48	20:10
4/30/11	5:47	20:11
5/1/11	5:45	20:13
5/2/11	5:43	20:14
5/3/11	5:42	20:15
5/4/11	5:40	20:17
5/5/11	5:39	20:18
5/6/11	5:37	20:20
5/7/11	5:36	20:21
5/8/11	5:34	20:22
5/9/11	5:33	20:24
5/10/11	5:31	20:25
5/11/11	5:30	20:26
5/12/11	5:29	20:27
5/13/11	5:27	20:29
5/14/11	5:26	20:30
5/15/11	5:25	20:31
5/16/11	5:24	20:33
5/17/11	5:22	20:34
5/18/11	5:21	20:35
5/19/11	5:20	20:36
5/20/11	5:19	20:37
5/21/11	5:18	20:39
5/22/11	5:17	20:40
5/23/11	5:16	20:41
5/24/11	5:15	20:42
5/25/11	5:14	20:43
5/26/11	5:13	20:44
5/27/11	5:12	20:45
5/28/11	5:11	20:46
5/29/11	5:11	20:47
5/30/11	5:10	20:48
5/31/11	5:09	20:49
6/01/11	5:09	20:50
6/02/11	5:08	20:51
6/03/11	5:07	20:52
6/04/11	5:07	20:53
6/05/11	5:06	20:54
6/06/11	5:06	20:54
6/07/11	5:06	20:55
6/08/11	5:05	20:56
6/09/11	5:05	20:57

"Sunrise and sunset conventionally refer to the times when the upper edge of the disk of the Sun is on the horizon. Atmospheric conditions are assumed to be average, and the location is in a level region on the Earth's surface . . . . sunrise or sunset is defined to occur when the geometric zenith distance of center of the Sun is 90.8333 degrees. That is, the center of the Sun is geometrically 50 arcminutes below a horizontal plane." (U.S. Naval Observatory, http://aa.usno.navy.mil/faq/docs/RST_defs.php#riseset).

APPENDIX H
WELLS PROJECT SUBYEARLING CHINOOK LIFE-HISTORY STUDY 2011 INTERIM REPORT

WELLS PROJECT SUBYEARLING CHINOOK LIFE-HISTORY STUDY
2011 INTERIM REPORT

WELLS HYDROELECTRIC PROJECT

FERC NO. 2149

December 2012

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Table of Contents

List of Tables

List of Figures

List of Appendices Examples

ABSTRACT

The Public Utility District No. 1 of Douglas County (Douglas PUD) initiated a study in 2011 to better characterize the behavior and ecology of subyearling Chinook found within the Wells Project. Our goal was to investigate the behavior and life-history strategies of subyearling Chinook in the Wells Reservoir to provide data necessary to determine how best to study their survival through the Wells Hydroelectric Project.

Together nearly 18,500 wild subyearling Chinook salmon were handled during scoping, tagging, and growth monitoring efforts and over 13,200 were Passive Integrated Transponder (PIT)-tagged and released during the 2011 study. Fish were available for capture by beach seine from our first seining efforts in late May to the end of July, with availability declining dramatically by mid-July. Over the course of the study, the proportion of taggable fish captured in seine sets increased from 4% in late May to 100% in late July. During the three-week tagging period the proportion of taggable fish (>57 mm) captured increased from just under 48% to greater than 96%. Estimated growth in the Wells Reservoir was 0.77 mm/day based on the change in mean length of fish captured over the study period, late-May to the end of July. Growth may have been underestimated since larger fish may have moved offshore and newly arrived smaller fish may have replaced them throughout the study. Measured growth rates of tagged fish recaptured at lower-river projects were in excess of 1 mm/d. In contrast, the mean of measured growth rates of 415 tagged fish recaptured in Wells Reservoir within 2 to 11 days of release was only 0.34 mm/d, suggesting a short-term energetic cost to capture, tagging, and handling. Handling and tagging caused an observed mortality of 2.3 %. Delayed mortality from handling was not evaluated.

Prior to mid-November when juvenile bypass systems (JBSs) shut down at McNary, John Day, and Bonneville dams, 2,314 unique fish of 13,223 (17.5%) tagged and released were detected at downstream arrays. The majority of detections occurred at Rocky Reach Dam. Travel rates increased with increasing distance from release location: the mean of travel rates from Wells to Rocky Reach was 4.8 km/d, but was 44.6 km/d from John Day to Bonneville.

In the analysis of our data we compared our results with the set of six “life-history” hypotheses and two “tagging and fish size” hypotheses that we selected to assist us in understanding the degree to which the assumptions of the single- and paired-release experimental models match the behavior of the population of subyearling Chinook in Wells Reservoir. Our results are as follows:

1. Juvenile summer/fall Chinook in the Wells Reservoir clearly exhibit a continuum of migration timing, with passage at downstream projects occurring from spring at least until termination of bypass operations in mid-November.

2. In 2011 the 86-mm fish length was a size threshold beyond which fish began the transition to occupying habitat beyond the reach of our beach-seining efforts, and many of them commenced active migrations.

3. The residence time of for at least 30%of the subyearling Chinook tagged in Wells Reservoir in 2011, and in particular, those less than 87 mm in length, exceeds the battery life of the smallest currently available acoustic tags.

4. A portion of the study-fish population migrates during periods when downstream PIT-tag detection arrays are not operational.

5. Because of differences in migration timing and migration rates of individuals of varying sizes tagged during the same or different time period(s), subyearling Chinook released above and below Wells Dam would experience different river conditions, and different survival probabilities when migrating through the control reach and other downstream reaches.

6. Nearly all fish captured in May in 2011 were too small to PIT-tag, and the proportion of the combined weekly catches that was too small to tag declined in a curvilinear fashion until mid-July when all fish captured were large enough to tag. Unfortunately for study purposes, by the date when all captured fish were large enough to tag few fish were available for capture by beach seining.

7. Nearly all of the subyearling Chinook available for capture by beach seining in the Wells Reservoir were of insufficient size for tagging with an acoustic transmitter.

9. The process of capturing, holding, and tagging incurs a biological cost on subyearling Chinook that affects short-term growth, and may affect both short- and long-term survival.

We conclude that our inability to tag a representative sample of the study population, and the differential probability of detection and survival within the sample population present substantial obstacles to conducting a study of project survival using either active or passive tags. Additional years of study will be required to verify what appears to be a size threshold for a behavioral shift from near-shore rearing to an off-shore migration phase. Further, other environmental variables such as flow and temperature might be important in triggering the transition of fish from a rearing into a migratory phase. Analysis of data from several years of study may reveal the influence of such factors on fish behavior.

1.0 INTRODUCTION

Douglas PUD's Wells Hydroelectric Project (Wells Project or Project) Anadromous Fish Agreement and Habitat Conservation Plan (Wells HCP) establishes requirements for determining the rates of survival through the Wells Project (comprising the reservoir, dam, and tailrace) for all species and races of anadromous salmonids that pass the Project. Studies to measure the passage survival of migrating juvenile salmonids rely on marking or tagging of study subjects and subsequent "recapture" (i.e., tag detection) of those subjects at downstream locations. The "single release" and "paired release" experimental designs rely on conformance of both the study protocols and study subjects to a set of assumptions, the violation of which affects (to varying degrees) the accuracy and/or precision of the resultant survival estimates. Yearling spring migrants (e.g., yearling Chinook and steelhead) and the protocols used to study them adhere neatly to the assumptions of the paired-release study design. In contrast, subyearling Chinook apparently do not conform well to those assumptions (Anchor QEA 2010); and yet, their behavior, both in Wells Reservoir and during their migration, remains poorly understood, as does the degree to which they do not conform to the paired-release survival-study assumptions.

In November 2009 the combined HCP Coordinating Committees (HCP CC) for the Wells, Rocky Reach, and Rock Island hydroelectric projects convened a "Subyearling Workshop" to learn the state of the science regarding juvenile subyearling Chinook and consider means for studying their survival through hydroelectric projects (Anchor QEA 2010). In February 2010, the HCP CC discussed the findings of the Subyearling Workshop and contemplated an appropriate path forward to achieving the HCP requirements regarding determinations of project survival estimates for subyearling Chinook. Douglas and Chelan PUDs (PUDs) agreed to prepare a summary of feasible actions for HCP CC consideration. In June of 2010, the PUDs presented a proposal to monitor detections of Passive Integrated Transponder (PIT)-tagged subyearling Chinook originating upstream of Rocky Reach Dam. The PUD's expected that relatively small numbers of PIT-tagged subyearling Chinook originated above Rocky Reach Dam, but a new PIT-tag detection system installed in the Rocky Reach Juvenile Fish Bypass System would dramatically improve detection probability. By monitoring PIT-tag detections the PUDs hoped to determine the distribution of migration timing of subyearling Chinook.

In December of 2010, Douglas PUD proposed to increase the number of PIT-tagged subyearling Chinook above Rocky Reach Dam by implementing a pilot study to tag up to 20,000 subyearling Chinook in the Wells Reservoir. Besides enhancing the number of PIT-tagged fish available for downstream detection, the pilot study would also more systematically investigate life-history strategies of subyearling Chinook toward an understanding of the population behavior as a foundation for progress toward obtaining a valid passage-survival estimate at the Wells Project. Douglas PUD presented a subyearling pilot-study proposal to the HCP CC in March 2011, and implemented the study in May 2011. This report presents background information on subyearling Chinook in the Columbia River Basin, and the methods, results, discussion, and conclusions from Douglas PUD's 2011 subyearling Chinook life-history study.

2.0 BACKGROUND

2.1 Spring, Summer, and Fall Chinook

The Columbia and Snake r ivers support large populations of spring, summer/fall, and fall Chinook salmon (*Oncorhynchus tshawytscha*) that exhibit a diverse array of downstream passage and life-history strategies (Brannon et al. 2004; Connor et al. 2003; Chapman et al. 1994). Spring Chinook above Wells Dam return to spawning tributaries in the spring, and spawn in August and early September in the upper reaches of major tributaries. Spring Chinook juveniles emigrate as yearlings, following the classic "stream-type" life-history strategy. "Ocean-type" adult Chinook salmon, also referred to as summer/fall Chinook, return to fresh water in the summer and fall (July through November). Spawning occurs in the late fall in the lower reaches of large tributaries and the mainstem Snake and Columbia rivers (Dauble et al. 1999; Groves and Chandler 1999). Above Wells, these fish spawn in the Methow, Okanogan, and Similkameen Rivers, and in the mainstem of the Columbia River within the delta of Foster Creek in the tailrace of Chief Joseph Dam (Mann et al. 2012). Fry rear in fresh water for several weeks to several months, and subsequently move seaward as subyearlings (Lister and Genoe 1970; Healey 1991; Brannon et al. 2004).

The emigration behavior of juvenile summer/fall Chinook above Wells Dam does not fit neatly into the classic "ocean-type" classification, with some emigrants delaying migration or apparently exhibiting a "reservoir-type" life-history strategy (Chapman et al. 1994). "Reservoir-type" summer/fall Chinook salmon juveniles remain in the reservoirs of hydroelectric dams longer than typical ocean-type subyearlings. These fish usually emerge later in the spring and may migrate more slowly to the Pacific Ocean arriving in the late fall. Others may overwinter, or "residualize" (Connor et al. 1996), in reservoirs and migrate seaward as yearlings during the following spring (Connor et al. 2005). The prevalence of ocean-type and reservoir-type life-histories varies dramatically from year to year within the summer/fall Chinook population upstream of Wells Dam (Chapman et al. 1994).

2.2 Subyearlings above Wells

Above Wells Dam, summer/fall Chinook fry are thought to emerge between mid-February and the end of April in the Okanogan and Methow rivers (Chapman et al. 1994; Chapman 2007). Similar emergence dates were recorded in the Wells Hatchery spawning channel from 1968-1971 (Allen 1970; Allen et al. 1971). Following emergence, mid-Columbia subyearlings appear to preferentially select shallow littoral habitats (< 100 cm deep), low velocities (< 1cm/s), and often share small-substrate habitats with small resident fishes (McGee et al. 1983; Chapman et al. 1994; Chapman 2007).

Wells Project subyearlings are suspected to move offshore as they grow and may migrate up- or downstream to seek forage and cover. In addition, subyearlings are reported to return to the nearshore and remain inactive during the night, moving off shore each day to forage (Hillman et al. 1989). This diel movement pattern diminishes with increased growth, since larger subyearlings may participate in nighttime emigration (Chapman 2007). Rondorf and Gray (1987) observed such onshore-offshore movements in the upstream reaches of the McNary

Reservoir (Hanford Reach) from May to mid-July, with 80 mm as a critical fish length that determined the initiation of offshore migration behaviors. Size thresholds for ontogenetic foraging behaviors have not been evaluated above Wells Dam. Our expectations based on available information were that we could capture subyearlings in the Wells Project using seine nets in shallow littoral habitats during spring and early summer. We also considered that it may be easier to capture subyearling Chinook during nighttime hours, when they are docile in shallow-water habitats, up until they reach a critical size and commence offshore movements or emigration behavior.

2.3 Migration Timing and Behavior in the mid-Columbia

Migration-timing disparities between subyearling and yearling Chinook are illustrated in historic PIT tag data. In 2009, 10-90% (run percentile) of out-migrating yearling Chinook passed Rock Island Dam over a 36-day period, highlighting the predictability of yearling migration. However, 10-90% (run percentile) of subyearling Chinook passed Rock Island over a 64 day period (May 30-Aug 2), indicating variable or protracted migration rates relative to yearling Chinook. Comparatively, at Lower Granite Dam, 10-90% (run percentile) of the subyearlings passed the project during a 47 day window (June 5 to July 22; FPC 2009). These results may highlight an increased diversity in run timing in the mid-Columbia compared to the Snake River subyearlings.

In the Snake River, the protracted migration periods exhibited by some subyearling Chinook can be explained by the observation that subyearlings exhibit at least four different migration phases (Connor et al. 2003):

1. Discontinuous downstream dispersal along the shorelines of the free-flowing river,
2. Abrupt and mostly continuous downstream dispersal off shore in the free-flowing river,
3. Passive, discontinuous downstream dispersal offshore in the first reservoir encountered en route to the sea, and
4. Active and mostly continuous seaward migration.

Although scales from returning adults provide evidence of reservoir-type summer/fall Chinook in the mid-Columbia, the expression of the four migration phases described by Conner et al. (2003) has not been empirically identified in the mid-Columbia. That is, we know that reservoir-type fish exist, but the details of their emigration behavior remain undefined. Assuming that subyearling Chinook in the mid-Columbia behave similarly to those in the Snake River, it is unclear which stocks (tributary populations, mainstem spawners) and what proportions of each stock manifest these behaviors. One could reasonably conclude that the percentages of fish exhibiting these behaviors fluctuate with annual variability in flow, water temperature (natal area and migration corridor), and population size; but this information is absent in the mid-Columbia (see Connor et al. 2003; Buchanan et al. 2009).

3.0 STUDY OBJECTIVES, ASSUMPTIONS, AND HYPOTHESES

The goal of the 2011 subyearling Chinook life-history study was to investigate the behavior and life-history strategies of subyearling Chinook in the Wells Reservoir to provide data necessary to determine how best to study their survival through the Wells Project. In particular, Douglas PUD sought to understand the degree to which the assumptions of the single- and paired-release experimental models match the behavior of the population of subyearling Chinook in Wells Reservoir. Those assumptions are as follows:

1. Study fish are representative of the study population and not just a subset of fish that can tolerate the tag
2. The study tag does not affect survival and detection probabilities
3. Mortality does not occur during detection
4. Survival and detection probabilities of individuals are independent of each other
5. All individuals from a release group have the same probability of survival to the end of the reach
6. All individuals alive at detection location have the same probability of detection
7. All tags are correctly identified and status as either alive or dead is accurately assessed
8. Survival below the control release site must be conditionally independent of survival upstream of the control release site
9. Survival in common river segments downstream of the control release site is equal for both the treatment and control release groups

3.1 Objectives

Within the goal stated above, Douglas PUD considered specific assumptions in the design of a pilot study, and, based upon those assumptions, identified primary objectives for the study that considered logistical and practical issues of study implementation within the context of the overall goal. The primary objectives of the 2011 subyearling study were as follows:

1. Using various capture methods (e.g., beach seine, purse seine, screw traps), and gleaning from historical fyke net and bypass data from the Upper Columbia River, and in coordination with annual trapping schedules, begin to identify the size distributions of subyearlings in the Wells Reservoir at given time intervals.
2. Determine the size of fish that are actively migrating past Wells Dam, or begin to identify the critical size at which subyearling fish begin to actively migrate.
3. If appropriate, identify and categorize differences in migration timing between observed variations in subyearling life histories.
4. Determine the presence of taggable fish in the Wells Reservoir, and whether these fish are representative of a migratory subyearling Chinook salmon.
5. Use study results to evaluate the feasibility of/limitations to conducting subyearling survival studies at the Wells Project.

3.2 Life History Assumptions

The assumptions that formed the basis for the objectives stated above and the hypotheses listed below are as follows:

1. Subyearling Chinook present in the Wells Reservoir comprise rearing or passive migrants in addition to active, seaward migrants.
2. Fish migrate past detection points when the tags are still active, detection arrays are operational and active, and detection efficiencies are uniform.
3. Migration occurs during the life of the tag used in the study.
4. Travel times for subyearlings in general are similar for all subyearlings released.
5. Migrating fish are large enough to be tagged and there is no “biological cost” to tagging (biological cost is defined as a decrease in growth or impairment in function, or otherwise increased probability of mortality from any cause).

3.3 Study Hypotheses

Study hypotheses were adapted from Douglas PUD’s 2011 Study Plan reviewed by the Wells HCP CC in March of 2011, and included both life-history hypotheses and tagging and fish-size hypotheses.

3.3.1 Life-history Hypotheses

$H1_{alt}$: Ocean-type Chinook in Wells Reservoir represent multiple life-history strategies with variable migration timing including spring and summer subyearling, spring yearling, reservoir rearing, and intermediate migration types.
$H1_{o}$: Ocean-type Chinook in Wells Reservoir represent a single life-history strategy with discrete and predictable migration timing.

$H2_{alt}$: Subyearling Chinook tagged into the Wells Reservoir, of the size observed migrating through Wells Dam, do not actively migrate through the Wells Project.
$H2_{o}$: Subyearling Chinook tagged into the Wells Reservoir, of the size observed migrating through Wells Dam, are actively migrating through the Wells Project.

$H3_{alt}$: Residence time in Wells Reservoir exceeds the battery life of current acoustic tags.
$H3_{o}$: Residence time in Wells Reservoir does not exceed the battery life of current acoustic tags.

$H4_{alt}$: A portion of the study-fish population migrates during periods when downstream PIT-tag detection arrays are not operational.
$H4_{o}$: The study-fish population migrates only during periods when downstream PIT-tag detection arrays are operational.

$H5_{alt}$: Subyearling Chinook released above and below Wells Dam experience different river conditions, and different survival probabilities when migrating through the control reach (Rocky Reach Reservoir).

$H5_o$: Subyearling Chinook released above and below Wells Dam experience similar river conditions and have similar survival probabilities when migrating through the control reach (Rocky Reach Reservoir).

3.3.2 Tagging and Fish Size Hypotheses

$H6_{alt}$: The fish available for capture in the Wells Project at time t_1 are not of sufficient size for tagging with 12.5 mm tags.
$H6_o$: The fish available for capture in the Wells Project (reservoir, dam and tailrace) at time t_1 are of sufficient size for tagging with a 12.5-mm PIT tag.

$H7_{alt}$: The fish available for capture in the Wells Project are not of sufficient size for tagging with an acoustic transmitter.
$H7_o$: The fish available for capture in the Wells Project are of sufficient size for tagging with an acoustic transmitter.

Hypothesis H8 from the 2011 Study Plan would require a lab component to the study, and we did not include a lab component. Following the finalization of the 2011 Study Plan we added the following hypothesis:

$H9_{alt}$: The process of capture, holding, and tagging incurs a biological cost on subyearling Chinook.
$H9_o$: The process of capture, holding, and tagging does not incur a biological cost to subyearling Chinook.

4.0 METHODOLOGY

4.1 Study Area

The Wells Project is located at river kilometer (RK) 830 on the Columbia River in the State of Washington. Wells Dam is located approximately 50 river kilometers downstream from the Chief Joseph Hydroelectric Project, owned and operated by the United States Army Corps of Engineers (COE), and 70 kilometers upstream from the Rocky Reach Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan County (Chelan PUD). The nearest town is Pateros, Washington, located approximately 13 kilometers upstream from the Wells Project at the confluence of the Methow River.

The Wells Project is the chief generating resource for Douglas PUD. It includes 10 generating units with a nameplate rating of 774,300 kW and a peaking capacity of approximately 840,000 kW. The design of the Wells Project is unique in that the generating units, spillways, switchyard, and fish passage facilities were combined into a single structure referred to as the hydrocombine. Fish passage facilities reside on both sides of the hydrocombine, which is 1,130 feet long, 168 feet wide, with a crest elevation of 795 feet mean sea level (msl) in height.

The Wells Reservoir is approximately 50 kilometers long. The Methow and Okanogan rivers are tributaries of the Columbia River within the Wells Reservoir. The Wells Project boundary extends approximately 2.5 kilometers up the Methow River and approximately 26 kilometers up the Okanogan River. The normal maximum surface area of the reservoir is 9,740 acres with a gross storage capacity of 331,200 acre-feet and usable storage of 97,985 acre-feet at elevation of 781 feet msl. The normal maximum water surface elevation of the reservoir is 781 feet msl.

4.2 Fish Capture Details

Fish were captured with beach-seine nets throughout a two month period of 2011. Capture efforts for tagging began on June 20th, and that date was selected based on mean sizes of fish and growth data collected during scoping activities earlier in the season. Seining dates were as follows: May 27th, June 10th, and June 15th for scoping (captured fish were enumerated, measured, and released without tagging); June 20-23rd, June 27th-30th and July 5th-8th for tagging, and July 19th and 27th for fish-growth monitoring and to determine continued susceptibility of the fish to capture by beach seining.

Scoping efforts prior to the first day of capture allowed Douglas PUD biologists to identify locations for effective beach seining, and to gather location-specific growth information. During the first week of collecting fish for tagging, two crews of 4-5 staff deployed to multiple capture locations. Three beach seines were used to capture fish; one 15.24-m long x 1.83-m deep, another 15.24-m long x 1.22-m deep, and a third 30.49-m long and 3.05-m deep, with a 28.32-cubic-meter "bag" in the center (Figure 1). Seines were made by Memphis Net and Twine (Memphis, Tennessee) and were Delta woven 4.8-mm mesh with "fish-green" treatment. During the second week the two smaller seines were mended together into a single net to increase fishing distance offshore. By the last week of June only the large net was used and one fishing crew was deployed, since a highly productive fishing area was located on the north shore of the Columbia River downstream from the mouth of the Okanogan River.

Figure 1. Operating the large 100-foot seine at Gebber's Landing in 2011.

To operate the large net, two people would anchor the net on shore, while the other end was affixed to the bow of a tow boat. The boat would back away from the beach perpendicular to the shoreline to deploy the net. Once the net was fully extended, the boat would turn to parallel the shoreline and begin pulling the net upstream. Those on shore would pull the other end of the net up the shoreline, matching the speed of the boat as it slowly reversed parallel to and approximately 50 feet from shore (see Figure 1). The operator on shore holding the lead-line would lead the walk along the shoreline, and attempt to direct fish along the wing of the net towards the center or bag (see Figure 1). Once a suitable distance had been covered (250-2000 feet) the boat would reverse toward the shore where the net could be closed off and the "set" could be completed. From the beach, the lines and net on either side would be pulled in to remove the slack and concentrate fish in the center of the seine. When the bag was the only part of the net remaining in the water, the contents of the bag would be emptied with dip nets. All captured fish were put directly into buckets containing ambient river water. Fish remained in buckets for up to 1 hour (usually much shorter duration), and water was changed out regularly to maintain suitable temperatures and dissolved oxygen. All non-target fish were returned to the water immediately. At regular intervals, subyearlings held in buckets were transported by boat to floating net pens. These net pens were anchored in the river, within one mile of the seining locations. Net pens were approximately 5 square meters and were covered with 4.8-mm mesh; maximizing water exchange, preventing escape, and entrance of predators (Figure 2A). Fish were held in the net pens overnight to recover from capture stress and to evacuate their digestive tracts, prior to tagging on the following day (Figure 2B).

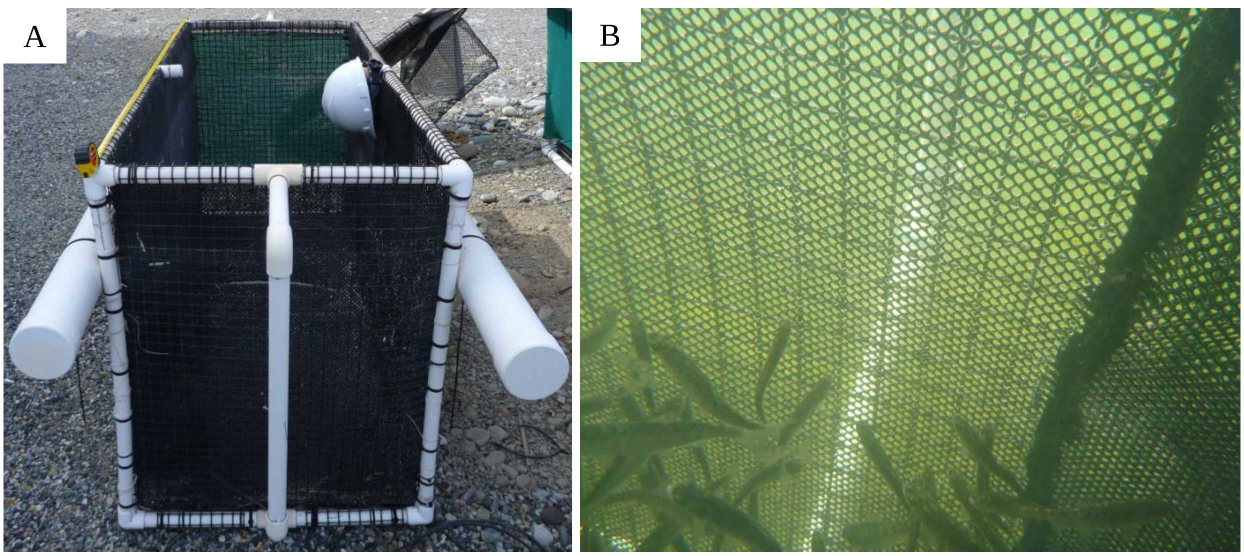


Figure 2. A) An empty net pen with the lid removed, and B) tagged subyearling fish swim within the in-river net pen.

Fishing effort was focused in areas that contained large numbers of subyearling Chinook that could be fished without snagging the seine net thereby yielding high catch per unit effort. Areas fished in the Wells Projects are provided in Figures 3 and 4, with the bulk of the fish captured coming from seining locations in Figure 3. Capture locations were given the following names for reference purposes: Dead Beaver, Smuggler's Cove, Gebber's Landing, Okanogan Mouth/River, Washburn Island and Starr (Figures 3 and 4).

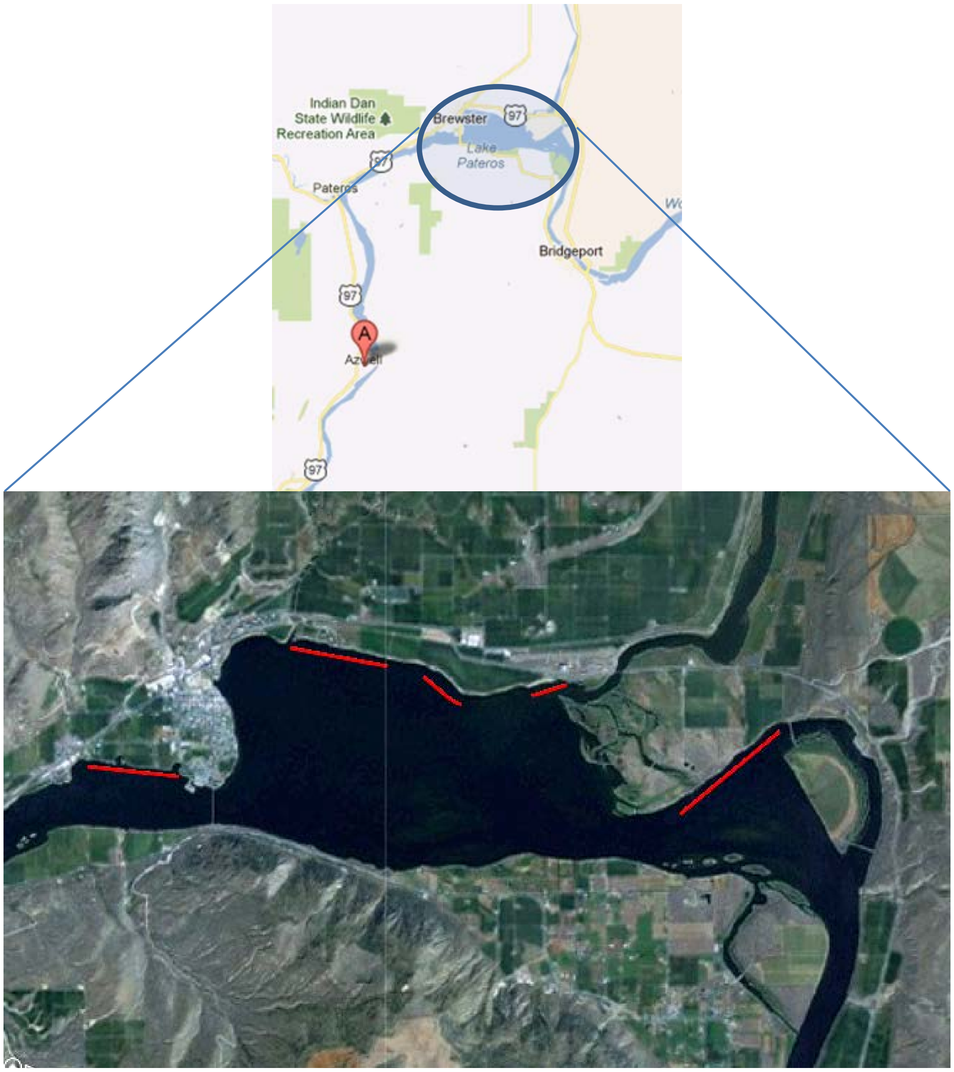


Figure 3. Seining locations in the Wells Project (red lines) in 2011. From left to right: Dead Beaver, Smuggler's Cove, Gebber's Landing, Okanogan Mouth/River, and Washburn Island.

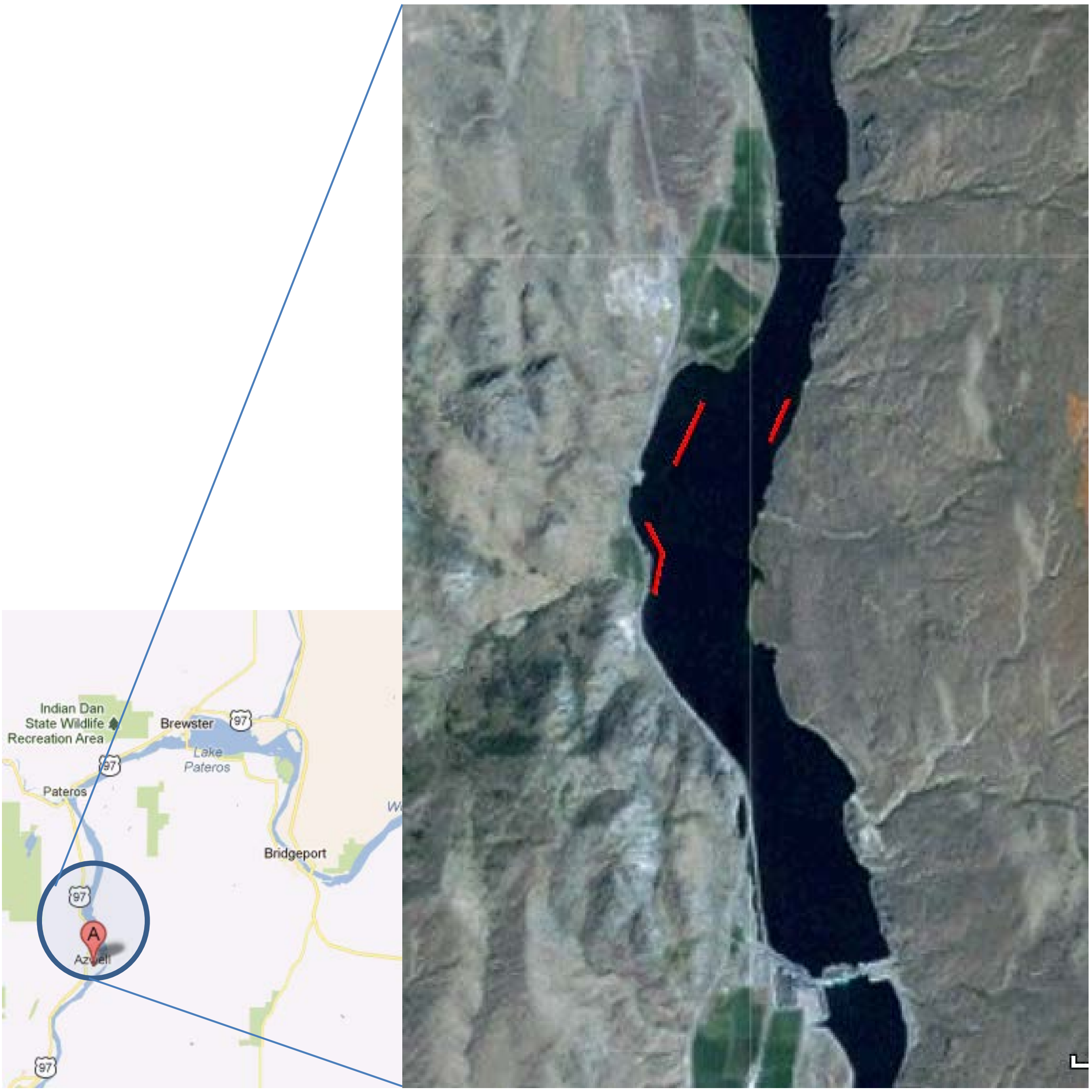


Figure 4. Seining locations in the Starr boat launch area in 2011. Wells Dam extends across the river in the lower portion of the figure.

4.3 Tagging Procedures

4.3.1 General Protocol

All tagging was conducted by Biomark using a Biomark mobile tagging station modified for this project. The tagging station consisted of an approximately one-meter-square aluminum work surface with built in sinks and a trough for holding fish during the tagging process. The station also housed the necessary electronics (computer, digitizer board, tag reader, and antenna) needed for tagging. Water was taken from the Wells Pool via 18.9 liter (5 gallon) buckets to supply the 45 liters needed to fill the sinks and trough of the tagging station. An anesthetic solution consisting of 100 grams tricane methanosulfonate (MS-222) mixed in one liter of water was used to sedate the fish prior to tagging. Approximately 12 milliliters of anesthetic solution was added to the 45 liters of water in the sinks and troughs. Water in the tagging station was changed every 5-10 minutes to maintain the water temperature within 1.0^{o}C of ambient water temperature. The concentration of MS-222 used would bring the fish to the desired level of stage-2 anesthesia in approximately 3 to 4 minutes. All fish were tagged within 10 minutes of the initial exposure. Recovery time was approximately 1 to 2 minutes.

Because of the dispersed nature of the tagging locations (see Figures 3 and 4), the mobile tagging station was set up on a barge that was moved between net pens rather than transporting large numbers of fish to and from a central tagging location. Each day following seining, the barge would move to the net pen containing the fish captured the previous day. Each tagging location had two net pens: one containing the fish to be tagged, and an empty pen for receiving the tagged fish. Fish to be tagged were collected from the respective net pens using a dipnet and placed into an 18.9-liter bucket of water. Up to 40 fish at a time were collected from the bucket using a small dipnet and placed in one of the tagging-station sinks containing anesthetic solution.

Fish were tagged with 12.5 mm 134.2 kHz ISO PIT tags using pre-loaded, single-use, 12-gauge hypodermic needles (BIO12.BPLT) fitted onto injection devices (MK-25). We opted to use the 12.5 mm PIT tags to maximize detection at downstream locations, and, in particular, at Rocky Reach Dam and the Bonneville Dam corner collector. Detection efficiencies at both of these sites would dramatically suffer when using the smaller PIT tags available in June 2011. All fish were tagged with a single-use needle to reduce the chance of disease transmission or injuries caused by dull needles. The two-person Biomark tagging crew consisted of one tagger and one tagger/data collector (data collector interrogates the tag in each tagged fish, records their fork length with an electronic wand on a digitizer board, and notes any anomalies). After the data were collected on a tagged fish, the fish was placed into an 18.9-liter bucket of water, and the fish in the bucket were then placed into the receiving net pen for tagged fish after all the fish in the tag-station sink had been tagged and recorded.

Data collected during tagging were stored using PITTAG3 software (Pacific States Marine Fisheries Commission). After completion of the tagging events, tag files were consolidated, uploaded to PTAGIS, and submitted to Douglas PUD.

4.3.2 Fish Releases

Tagged fish were released the morning after they had been tagged. The net pen was opened and all observed mortalities and moribund fish were removed. Once the mortalities were removed the net pen was tilted to allow the fish to volitionally exit. PIT tags were recovered from mortalities and moribund fish and the associated tag codes were marked as “Mortalities” in the tag files and the tag codes were deleted. No shed tags were recovered since the mesh used on the bottom of the net pens was such that any tags that were shed would fall through the mesh.

4.3.3 Post-tagging Sampling

After the completion of tagging, we sought to monitor growth by attempting to capture, measure, and release fish in locations where they were captured earlier in the season. The same locations were sampled on a semi-weekly basis until fish were no longer available via beach seining. To confirm the absence of subyearling Chinook in these littoral habitats, snorkel surveys were conducted in these locations late into the summer.

4.3.4 Statistical Methods

Comparisons of growth rates, run timing, distribution of passage, and all statistical methods were performed in JMP 7.0 (SAS) or MS excel. Linear regressions were used to assess growth of fish recaptured in the Wells Project; fish captured during scoping, tagging, and growth monitoring; and recaptures at lower-river projects. An analysis of variance (ANOVA) and non-parametric equivalents were used to test for relationships between detection frequency and tagging location. Linear regressions were used to analyze the data for relationships between the observed growth of fish recaptured at Rocky Reach and Rock Island dams and the number of days between release and recapture. Frequency distributions were used to show the distribution of detections at lower-river projects. Travel times of all tagged subyearlings, smaller subyearlings (<87 mm), and large subyearlings (>86 mm) were analyzed using the University of Washington's online travel-time analysis (http://www.cbr.washington.edu/dart/pit_sum_tagfiles.html). A non-parametric Mann-Whitney U test was used to examine differences between travel times to Rocky Reach Dam of smaller and larger fish, in an effort to examine size thresholds that may influence migratory behavior. To examine whether there was a biological cost to capture, handling, tagging, and holding, a linear regression was used to examine growth rates of fish that were recaptured in the Wells Project within 11 days of tagging.

Statistical significance for all tests was assessed to $\alpha = 0.05$. All means were reported with standard errors where appropriate and are indicated in the results. Non-parametric analyses were performed when sample sizes were unequal or when data with unequal variances could not be transformed to meet parametric assumptions.

5.0 RESULTS

5.1 Total Fish Sampled and Fish Size by Location

Fish sampling first occurred on May 27 as a "scoping" effort to locate suitable seining sites with concentrations of subyearling Chinook. During the initial sampling efforts a large number of Chinook fry were observed at several locations including Dead Beaver, Brewster Park, Smuggler's Cove, and lower Washburn Island. Gear deployed in these areas resulted in the capture of hundreds of small Chinook fry (averaging 45.2-47.4 mm in FL). The numbers encountered were too large to easily count and, at many sites, the seine sets were cut short or simply not retrieved because the numbers were too large to safely handle. Bycatch of resident stickleback, chub, and pikeminnow fry were also very high.

River conditions during the second scoping trip on June 10 were very different but the results were similar in terms of the numbers of fish observed. Flows in the Columbia River were above normal, and the Okanogan, and Methow rivers were at or near flood stage. The water-surface elevation of the Wells Reservoir was lowered to prevent damage to shoreline and adjacent properties. Rather than finding juvenile Chinook within the riparian vegetation, as was observed during the prior week of sampling, juvenile Chinook fry were observed in most small bays or backwater areas. Sampling included several sites along the Douglas County shoreline between the Brewster Bridge and Park Islands. The sites closer to the bridge produced large number of Chinook fry (mean 56.4-56.7 mm). Bycatch of resident fish was exceedingly high along this section of river and in particular adjacent to the Wells Wildlife Area. The sites sampled closer to Park Island did not produce any fish even though fishing occurred within the channels between the Park Islands where it was believed that habitat conditions were ideal for juvenile Chinook.

Sampling efforts on the third scoping trip on June 15 captured larger fish than the first two scoping periods. The reservoir remained very low during this period (approximate elevation 773' msl). Fish were collected along Dead Beaver and Smuggler's Cove and the mean fish lengths from the combined seine sets at each location were 60.6 mm and 60.3 mm fork length, respectively. With 65 mm as the target minimum fish length for tagging (this was reduced to 58 mm after the first day of tagging), the decision was made to commence tagging efforts during the following week on June 20.

During the implementation of the study (including scoping efforts) a total of 18,487 subyearling Chinook were handled and greater than 92% of those were measured. Growth regressions were plotted by sampling location and for all sampled fish in the Wells Project combined (Figure 5A and B). P-values were not generated for location-specific regressions since repeated samples at each location were too few. Despite the few location-specific samples, fish size was positively correlated with date except at Gebber's Landing. The mean size of subyearling Chinook at Gebber's Landing reached a maximum of around 80 mm on July 8, but fish captured on July 19 had a smaller mean length and no fish were captured during subsequent sampling. During the growth-monitoring phase of the study (post tagging) fish became increasingly difficult to locate. Only two fish were captured at Washburn Island on July 27th (see figure 5A); no fish were encountered at the two other locations sampled (Dead Beaver and Gebber's Landing).

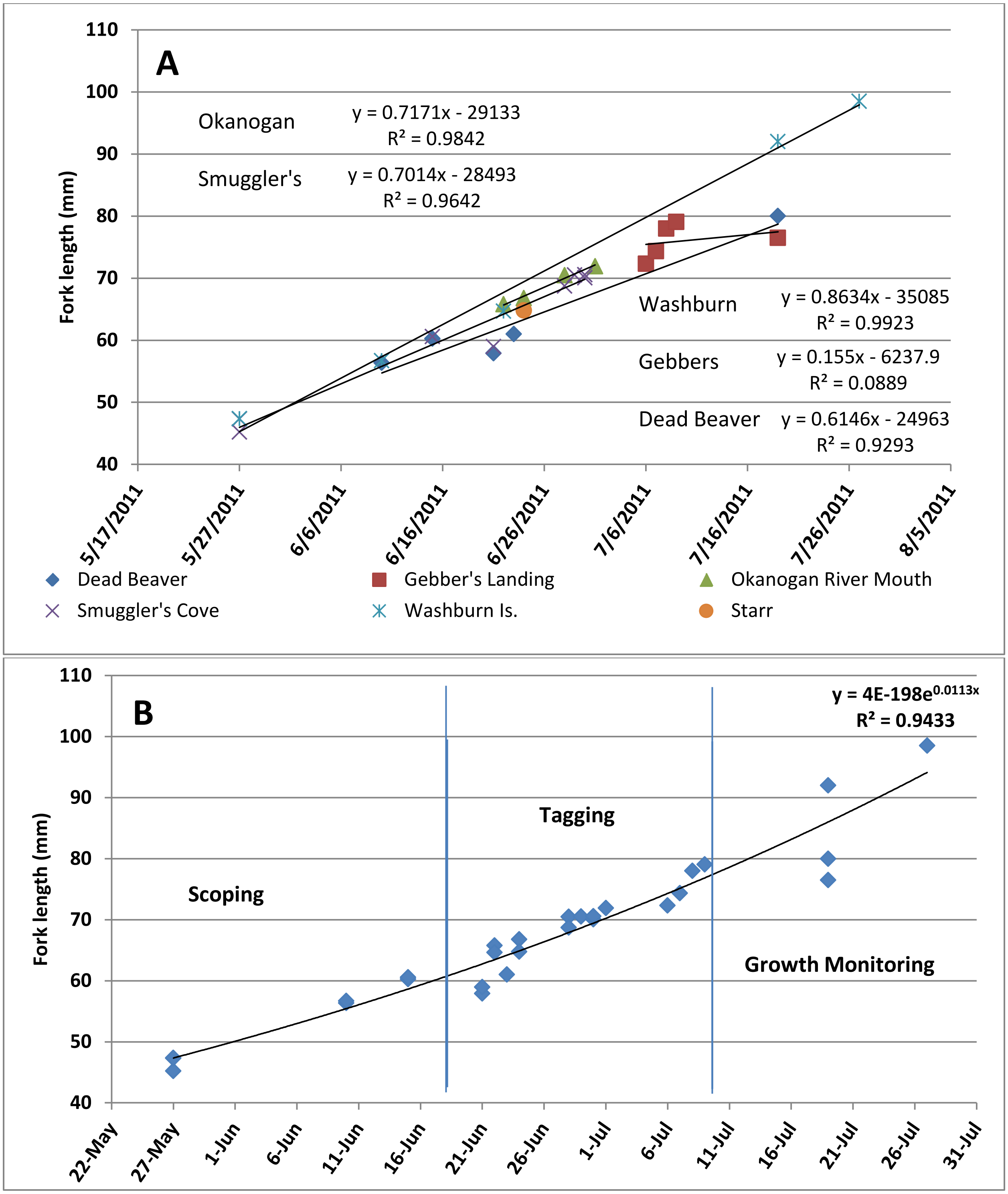


Figure 5. Subyearling Chinook size by A) location, and B) combined sampling from throughout the study ($p<0.0001$). Vertical lines in (B) separate between the three phases of subyearling sampling in 2011: scoping, tagging, and post-tagging growth monitoring.

5.2 Tagging Results

5.2.1 Total Tagged and Handled

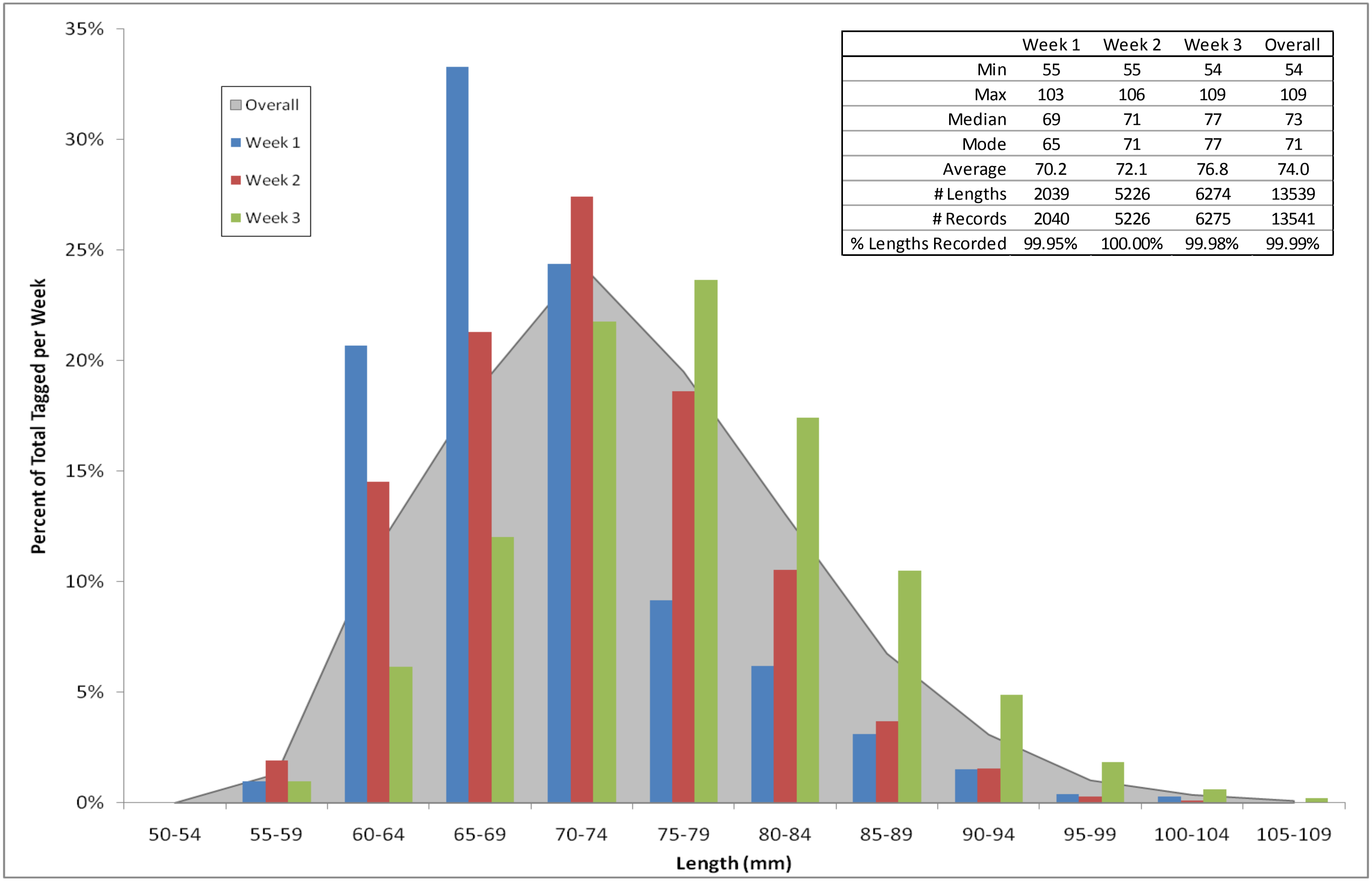
Biomark implanted PIT tags into 13,955 wild subyearling Chinook salmon captured in Wells Reservoir between 21 June and 9 July 2011 (Table 1). A total of 3,170 subyearling Chinook were rejected prior to tagging because they were less than the minimum fork length for tagging (n=3,111) or they had obvious signs of disease or injuries (n=59). Together, 17,125 subyearling Chinook were handled during the three-week tagging phase of the study. Fork lengths (mm) were recorded for 13,539 (99.99%) of the fish tagged (Figure 6). Fish were collected, tagged, and released at six different locations in the Wells Reservoir (see Table 1 and Figures 3 and 4). The site with the most fish tagged was Gebber’s Landing (river km 856) with 6,272 tagged fish. The site with the fewest fish tagged was Starr Boat Launch (river km 834) with 132 tagged fish.

A total of 415 PIT-tagged fish were recaptured during the project, and most of those were recaptured only once (n = 402). One of the recaptured fish died prior to release the second time. Thirteen of 415 recaptured fish were recaptured twice. More specific recapture information is provided in Appendix C.

Table 1. **Summary of subyearling Chinook salmon PIT tagged in Wells Reservoir in 2011, by week. “Recaps” = recaptured fish; “Rejected Fish” refers to fish handled but not tagged. “Short” indicates fish too small (fork length) to tag.**

Tag File	Tag Date	Tag/Release Site	# Records	# Pre-Release Mortalities	% Mortality	Recaps	% Recaps	# New Tagged Fish Released	Rejected Fish			Total # Fish Handled
									Short	(% Shorts)	Diseased/ Injured	
CSM11172.WP1	6/21/2011	Dead Beaver	68	4	5.9%	0	0.0%	64	418	86.0%	0	486
CSM11172.WP2	6/21/2011	Smuggler's Cove	65	0	0.0%	0	0.0%	65	467	87.8%	1	533
CSM11173.WP1	6/22/2011	Okanogan River	489	71	14.5%	0	0.0%	418	199	28.9%	4	692
CSM11173.WP2	6/22/2011	Near Washburn Is.	334	54	16.2%	0	0.0%	280	177	34.6%	6	517
CSM11174.WP1	6/23/2011	Dead Beaver	340	7	2.1%	5	1.5%	328	605	64.0%	4	949
CSM11175.WP1	6/24/2011	Okanogan River	622	22	3.5%	5	0.8%	595	239	27.8%	8	869
CSM11175.WP2	6/24/2011	Starr Boat Launch	132	4	3.0%	0	0.0%	128	156	54.2%	0	288
		Week 1 Total	***2050***	***162***	***7.9%***	***10***	***0.5%***	***1878***	***2261***	***52.4%***	***23***	***4334***
CSM11179.WP1	6/28/2011	Okanogan River	243	4	1.6%	4	1.6%	235	22	8.3%	3	268
CSM11179.WP2	6/28/2011	Smuggler's Cove	845	20	2.4%	4	0.5%	821	93	9.9%	0	938
CSM11180.WP1	6/29/2011	Smuggler's Cove	1475	27	1.8%	2	0.1%	1446	194	11.6%	8	1677
CSM11181.WP1*	6/30/2011	Smuggler's Cove	271	0	0.0%	1	0.4%	270	40	12.9%	1	312
CSM11181.WP2	6/30/2011	Smuggler's Cove	1244	28	2.3%	20	1.6%	1196	143	10.3%	9	1396
CSM11182.WP1	7/1/2011	Okanogan River	1207	16	1.3%	28	2.3%	1163	106	8.1%	5	1318
		Week 2 Total	***5285***	***95***	***1.8%***	***59***	***1.1%***	***5131***	***598***	***10.2%***	***26***	***5909***
CSM11187.WP1	7/6/2011	Gebber's Landing	1574	17	1.1%	94	6.0%	1463	145	8.4%	5	1724
CSM11188.WP1	7/7/2011	Gebber's Landing	1464	33	2.3%	53	3.6%	1378	62	4.1%	0	1526
CSM11189.WP1	7/8/2011	Gebber's Landing	1659	1	0.1%	100	6.0%	1558	23	1.4%	3	1685
CSM11190.WP1	7/9/2011	Gebber's Landing	1923	10**	0.5%	99**	5.1%	1815**	22	1.1%	2	1947
		Week 3 Total	***6620***	***61****	***0.9%***	***346****	***5.2%***	***6214****	***252***	***3.7%***	***10***	***6882***
		Project Total	**13955**	**318****	**2.3%**	**415****	**3.0%**	**13223**	**3111**	**18.2%**	**59**	**17125**

*Fish in CSM11181.WP1 were remaining fish that were captured on 179 (Julian date) and not tagged on 180 due to high winds during tagging. **One fish in file CSM11190.WP1 was a recaptured fish that died prior to release the second time. This fish is counted in both the mortality and recapture columns, but it is subtracted only once from the "# Records" so that the "# New Tagged Fish Release" remains accurate.



	Week 1	Week 2	Week 3	Overall
Min	55	55	54	54
Max	103	106	109	109
Median	69	71	77	73
Mode	65	71	77	71
Average	70.2	72.1	76.8	74.0
# Lengths	2039	5226	6274	13539
# Records	2040	5226	6275	13541
% Lengths Recorded	99.95%	100.00%	99.98%	99.99%

Figure 6. **Length Frequency (by week) of PIT-tagged subyearling Chinook in Wells Reservior in 2011. Week 1 was June 21-24; Week 2 was June 28-July 1; Week 3 was July 6-9.**

5.2.2 Minimum Size Criteria

Tagging began on 21 June at the "Dead Beaver" site (river km 852) and the "Smuggler's Cove" site (river km 855) based upon information collected during the prior weekly sample indicating that subyearling Chinook at those two sites were approaching a minimum fork length of 65mm, which was considered a minimum taggable size. A total of 885 fish in that first group were rejected for having a fork length less than 65mm (86.9% of the 1,019 fish handled the first day of tagging). On subsequent days the target minimum fork length for tagging was reduced to 58 mm. The average fork length of tagged fish increased from about 70.2 mm the first week to 76.8 mm for the third week, which further reduced the rate of fish rejection due to insufficient length. That rejection rate decreased from 52.4% for the first week to 3.7% for the final week, as the size of fish available to our seining gear increased over the three-week tagging period.

5.2.3 Inclement Weather

During tagging on 29 June, high winds resulted in unfavorable tagging conditions. Thus, after tagging 1,475 fish, tagging was suspended for the day (tagging file CSM11180.WP1) with 271 untagged fish left in the net pen. The following day Biomark released the fish from CSM1180.WP1 and recovered 27 mortalities (1.8%) prior to release. Biomark then tagged the remaining 271 fish in the net pen (captured on 28 June) and stored those data in a separate file (CSM11181.WP1). Thus, those 271 fish were held in a net pen for two days prior to tagging and one day post tagging while the rest of the tagged fish in the study were held in net pens for only one day prior to tagging and one day post tagging. No post-tagging mortality was observed in the group held two days.

5.2.4 Fish Releases and Mortalities

Releases occurred between 0800 and 1015 PDT each morning following tagging. A total of 13,223 tagged fish were released during this project, and 318 mortalities and moribund fish were collected prior to releases, for an overall mortality rate of 2.3% (see Table 1). High mortality rates resulting from seining activities on 21 June (tagged on 22 June) pushed the overall mortality rate above 2% (see Table 1). On 21 June, seining crews worked the mouth of the Okanogan River, which had turbid water and a mud substrate that sometimes collected in large mud balls in the bag of the seine. During retrieval of captured fish from the seine when mud balls were present, the fish displayed obvious signs of distress, and the decision was made to avoid those areas where the seine collected mud balls. Nevertheless, 71 (14.5%) of the 489 Chinook tagged at that location did not survive the collection/tagging process. Likewise, at the Washburn Island site, seine sets often enclosed a large amount of filamentous algae, which entangled and distressed the fish, and greatly extended the fish-retrieval time. Fifty-four (16.2%) of the 334 Chinook tagged at that location did not survive the collection/tagging process.

5.3 Post-tagging Sampling

After the completion of tagging, periodic sampling for growth monitoring occurred by attempting to capture, measure and release fish in locations where fish had been captured earlier in the season. On July 19th we captured 144 fish from three locations: Gebber's Landing, Dead Beaver, and Washburn Island. Fish were large in all locations but mean fish length was largest at Washburn Island at 92 mm, followed by 80 mm at Dead Beaver and 76.5 mm at Gebber's Landing. Sample sizes were quite small at Dead Beaver (n = 11) and Washburn (n = 24) compared to Gebber's Landing (n = 109), which may have been a product of larger fish sizes (see discussion below on fish size threshold and behavior).

On July 27 the same three locations were sampled; however, only two subyearling fish were captured, both at Washburn Island. No fish were captured at Gebber's Landing and only non-target taxa were captured at Dead Beaver. The lengths of the two fish captured at Washburn Island were 98 and 99 mm, respectively.

On August 3 the Dead Beaver, Gebber's Landing, and Washburn Island locations were again seined, but no fish were captured during this period. On August 12 Douglas PUD biologists snorkeled Washburn Island, Gebber's Landing, and Starr to locate subyearling Chinook, but found none. Fish observed included resident, non-salmonid taxa and triploid rainbow trout.

5.4 Biological Results

5.4.1 General Detection Results

Together, 2,314 unique fish of 13,223 (17.5%) tagged and released were detected at downstream arrays by mid-November when juvenile bypass systems (JBSs) shut down at McNary, John Day, and Bonneville dams. One percent (n = 135) of these detections occurred at non-JBS facilities (e.g. Wells, Rocky Reach, or Rock Island dams adult fishways, or the corner collector at Bonneville Dam[1]). Total detections at Rocky Reach, McNary, John Day, and Bonneville dams, including fish detected at more than one of these projects, was 1,200, 920,435 and 71 respectively. However, detections at McNary, John Day, and Bonneville dams might be inflated relative to detections at Rocky Reach since the JBSs at lower Columbia River Projects operate into November and thus have two-and-a-half months more time during which to obtain detections. Detections at McNary, John Day and Bonneville dams through August 31st (equivalent to Rocky Reach) were 732, 363 and 59, respectively. Therefore, 20%, 17%, and 17%, respectively, of the total detections at McNary, John Day, and Bonneville dams occurred after August 31st.

The percentage of PIT-tagged fish detected at downstream recapture locations remained consistent between tagging days and release sites (Figure 7A and B respectively). Detection probability for each tag file ranged between 17.2-25.8%. No analysis was performed to confirm trends in detection efficiency. Both an ANOVA and non-parameteric equivalents of mean detection probability by location showed no significant differences in detection probability between fish tagged at Okanogan, and Smuggler's Cove or Gebber's Landing (P = 0.9 and P = 0.8 respectively; other locations were left out of the analysis since the number of times they were sampled was insufficient for analysis). Overall, weighted mean detection probability including detections of fish at multiple projects was 20.9% (weighted by number of fish released per day). Mean detection probability, regardless of daily release numbers was 20.4%.

[1] Although the Bonneville corner collector could be considered part of the JBS system at Bonneville, PTAGIS separates the corner collector and the JBS PIT detection locations and therefore we retained this consistency.

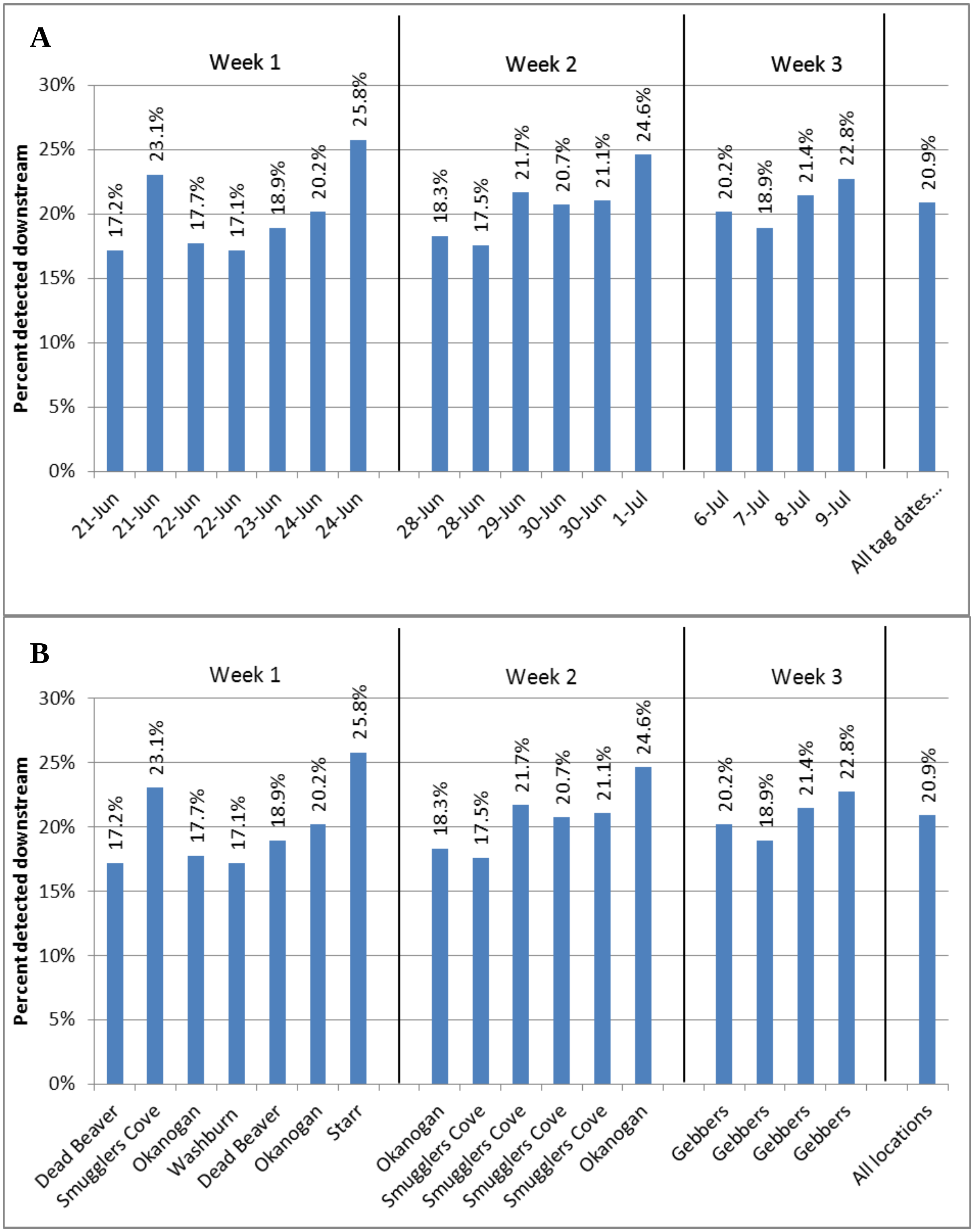


Figure 7. Percent by week of fish tagged A) on a given day, or B) at a location, that were subsequently detected on a PIT-tag detection array at a downstream project in 2011.

Table 2. Detection of released fish by tag file as of November 15th 2011. Note that detections at Rocky Reach Dam are through August 31st only.

				Rocky Reach		McNary		John Day		Bonneville		BCC, BO1, MC1, MC2, RIA, RRF, WEA		
Tag Week	Tag Location	Date	Number tagged and released	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Detected	Percent Detected	Cumulative Percent
1	Dead Beaver	21-Jun	64	8	12.5%	1	1.6%	1	1.6%	0	0.0%	1	1.6%	17.2%
	Smuggler's Cove	21-Jun	65	7	10.8%	3	4.6%	3	4.6%	1	1.5%	1	1.5%	23.1%
	Okanogan	22-Jun	418	33	7.9%	21	5.0%	10	2.4%	1	0.2%	9	2.2%	17.7%
	Washburn	22-Jun	280	19	6.8%	16	5.7%	9	3.2%	1	0.4%	3	1.1%	17.1%
	Dead Beaver	23-Jun	328	26	7.9%	20	6.1%	12	3.7%	0	0.0%	4	1.2%	18.9%
	Okanogan	24-Jun	595	52	8.7%	36	6.1%	22	3.7%	2	0.3%	8	1.3%	20.2%
	Starr	24-Jun	128	17	13.3%	10	7.8%	3	2.3%	2	1.6%	1	0.8%	25.8%
2	Okanogan	28-Jun	235	15	6.4%	14	6.0%	11	4.7%	1	0.4%	2	0.9%	18.3%
	Smuggler's Cove	28-Jun	821	65	7.9%	47	5.7%	21	2.6%	5	0.6%	6	0.7%	17.5%
	Smuggler's Cove	29-Jun	1446	145	10.0%	94	6.5%	54	3.7%	9	0.6%	12	0.8%	21.7%
	Smuggler's Cove	30-Jun	270	21	7.8%	22	8.1%	9	3.3%	1	0.4%	3	1.1%	20.7%
	Smuggler's Cove	30-Jun	1196	112	9.4%	76	6.4%	44	3.7%	9	0.8%	11	0.9%	21.1%
	Okanogan	1-Jul	1163	117	10.1%	102	8.8%	43	3.7%	9	0.8%	15	1.3%	24.6%
3	Gebber's	6-Jul	1463	135	9.2%	100	6.8%	47	3.2%	5	0.3%	8	0.5%	20.2%
	Gebber's	7-Jul	1378	120	8.7%	80	5.8%	37	2.7%	6	0.4%	18	1.3%	18.9%
	Gebber's	8-Jul	1558	144	9.2%	114	7.3%	49	3.1%	12	0.8%	15	1.0%	21.4%
	Gebber's	9-Jul	1815	164	9.0%	164	9.0%	60	3.3%	7	0.4%	18	1.0%	22.8%
Total	All locations	All tag dates	13223	1200	9.1%	920	7.0%	435	3.3%	71	0.5%	135	1.0%	20.9%

5.4.2 Fish Length and Availability in the Reservoir

During the scoping period from late May to mid-June, the means of fish sizes at each sampling location were between 45.2-60.6 mm fork lengths, irrespective of location (see Figure 5A). During tagging, the mean sizes of fish captured at each location each day ranged between 57.9-79.1 mm. The weekly means of sizes of those fish tagged were 69, 71, and 77 mm for all locations combined, during the three respective weeks (see Figures 5 and 6). Following the conclusion of the tagging phase of the study, we attempted to collect fish on a weekly or biweekly schedule to monitor lengths of captured fish in the reservoir over time, to determine growth of tagged fish through recaptures, and to assess the availability of subyearlings in the Wells Project. During this post-tagging period, fish availability decreased quickly such that, by the end of July, fish availability approached zero. The means of the lengths of subyearlings captured on each collection date increased over time (see Figure 5B). July 27 was the latest date on which we captured subyearlings, and at that time the lengths of the two fish captured at Washburn Island were nearly 100 mm. During the growth-monitoring period (post tagging) some site-specific size differences appeared that were not apparent during the earlier periods of the study. However, these differences were not statistically evaluated since fish were hard to find during the growth-monitoring period and sample sizes were low in most locations. Collectively, fish available during daylight hours in shoreline areas of the Wells Project appeared to follow a curvilinear growth plot throughout the entire study (see Figure 5B; linear regression $p < 0.0001$). Estimated mean increase in the length of captured fish in the Wells Reservoir based on this curve was 0.77 mm/day. This does not represent site-specific growth rates of individuals within the reservoir, but rather the increase over time of the mean sizes of fish available for capture by beach seine at the locations sampled.

5.4.3 Recapture at Downstream Projects and Growth of Recaptured Fish

Twelve hundred of 13,223 tagged fish were detected at Rocky Reach Dam traveling though the JBS before Aug 31st 2011, the last day of Rocky Reach JBS operation. Twenty-six of these fish were captured during smolt-index sampling conducted by Chelan PUD smolt-monitoring staff. The PIT-tag codes and size data for these recaptures were uploaded to PTAGIS by Chelan PUD biologists. Twenty-two of these fish were recaptured at Rocky Reach Dam in June or July, and four in August. Growth data (change in fork length divided by the number days between tagging and recapture) for these recaptures are depicted in Figure 8, which illustrates a positive correlation between growth and days after tagging, especially after 20 or more days following tagging. Fish recaptured in July at Rocky Reach Dam had been 10 mm larger (mean of sampled lengths) at the time of tagging than those recaptured in August (79 ± 5.62 mm vs. 69 ± 8.12 mm when tagged respectively; Kruskal-Wallis $p = 0.03$). However, fish recaptured in June and July had slower and more variable growth rates than those recaptured in August (0.54 ± 0.56 mm/day vs. 1.18 ± 0.08 mm/day; Kruskal-Wallis $p = 0.01$). Means of recapture lengths were 86.77 ± 9.67 mm (n = 22) and 123.75 ± 9.91 mm (n = 4) for fish recaptured at Rocky Reach Dam in June/July and August, respectively and were significantly dissimilar (Kruskal-Wallis $p = 0.001$).

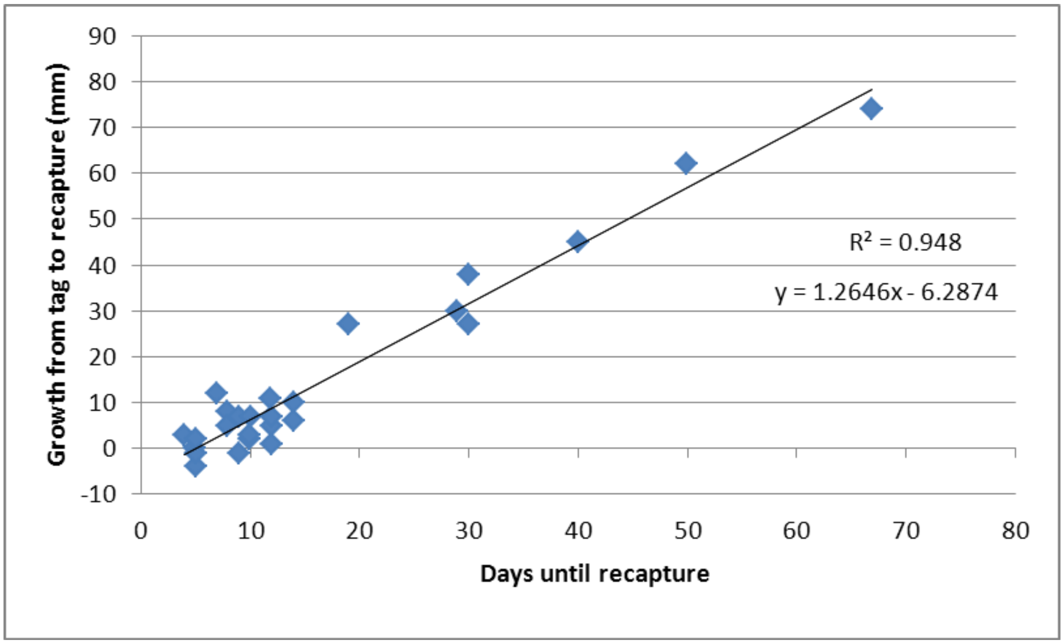


Figure 8. Growth as the increase in fork length (mm) divided by the number of days between tagging and recapture for tagged subyearlings recaptured during index sampling at Rocky Reach Dam (linear regression $p < 0.0001$)

In addition to those fish recaptured at Rocky Reach Dam, 14 tagged fish were recaptured at Rock Island Dam and similarly measured, allowing determination of growth. These data were also uploaded to PTAGIS. Growth of fish recaptured at Rock Island Dam was more variable than for those recaptured at Rocky Reach Dam. Variability coupled with a smaller sample size at Rock Island Dam reduced the fit of the regression equation describing the growth rate of fish recaptured at Rock Island Dam (Figure 9). Average growth was similar to that of fish recaptured at Rocky Reach Dam in June and July at 0.58 ± 0.38 mm/day. Only one of the 14 fish recaptured at Rock Island Dam was captured in August and was 77 mm at tagging, 108 mm at recapture, and had a growth rate of 1.07 mm/day.

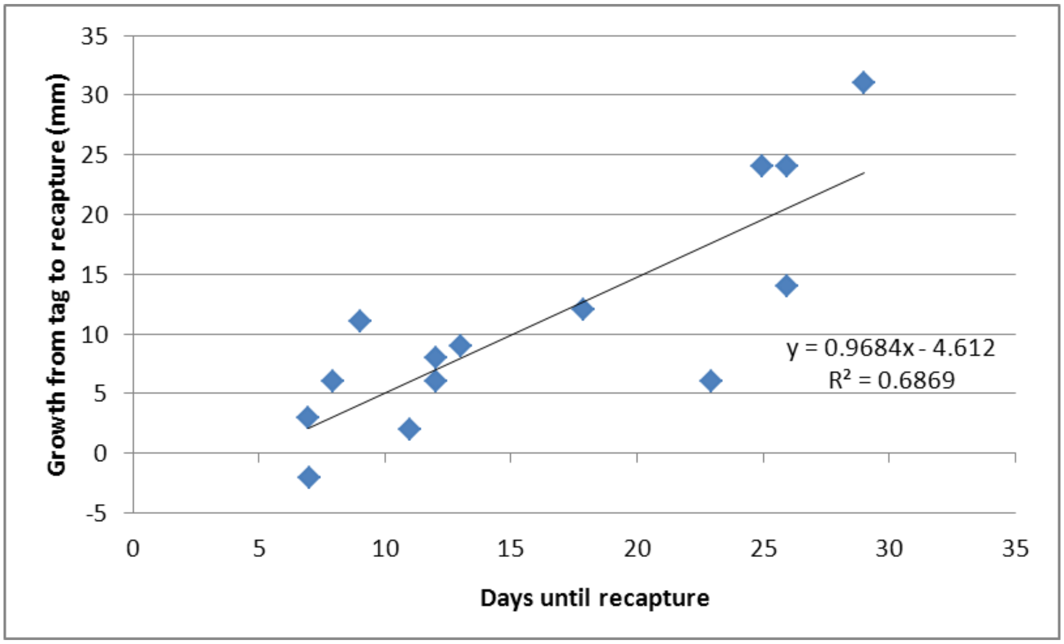


Figure 9. Growth as the increase in fork length (mm) divided by the number of days between tagging and recapture for tagged subyearlings recaptured during index sampling at Rock Island Dam (linear regression $p < 0.0002$)

5.4.4 Run Timing and Travel Time

The majority of the fish detected passing Rocky Reach Dam did so during the month of July (67%) with fewer (30%) passing in August (Figure 10). As the number of PIT-tagged fish released above Wells Dam increased, so did the number of detections at Rocky Reach Dam. The first two detections occurred on June 25th (Figure 11) and were fish released on the 23rd and 24th of June. The last fish detected at Rocky Reach Dam in 2011 had been released in the Wells Reservoir on July 10th, the last release day. The greatest number of detections at Rocky Reach Dam occurred during the first four days following the last release (July 11-14; see Figure 10). Detections decreased dramatically following this peak and subsequently oscillated between 3-22 fish a day through August, with a small peak in detections between August 8th and August 20th (see Figure 11). With the termination of bypass operations at Rocky Reach Dam at midnight on August 31st 2011, we could no longer rely on detections at that location for tracking movements of study fish.

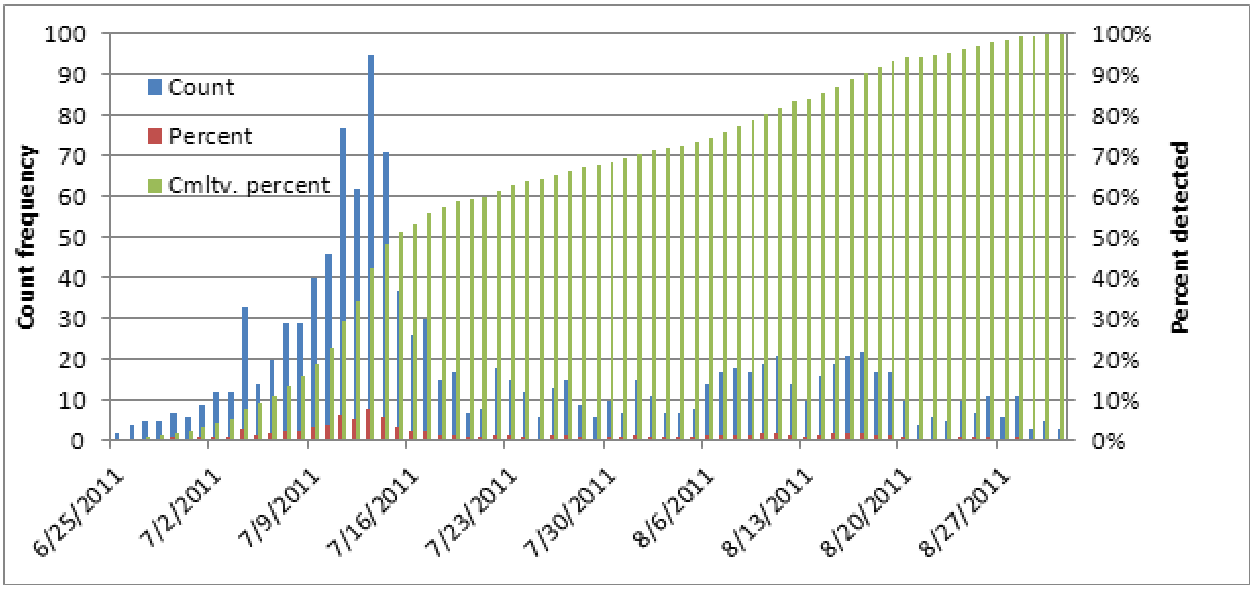


Figure 10. Daily distribution frequency and cumulative percent of PIT-tagged subyearling Chinook passage at Rocky Reach Dam before bypass shutdown on Aug 31st 2011.

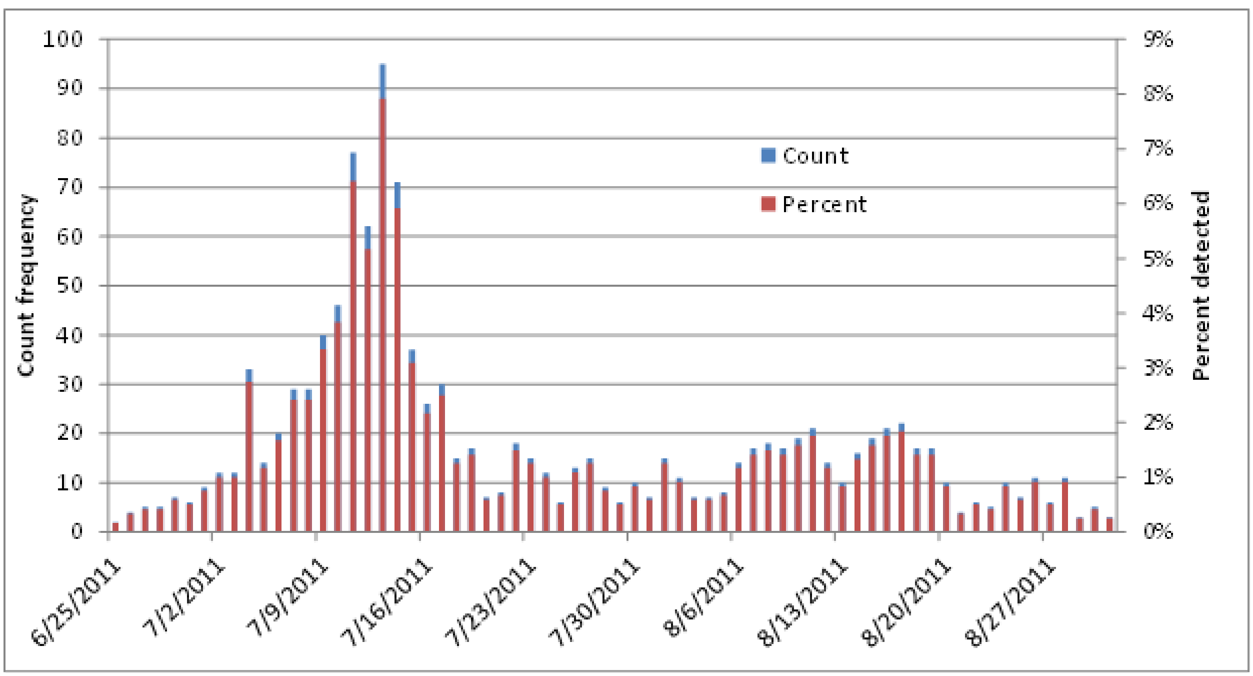


Figure 11. Daily distribution frequency of PIT-tagged subyearling Chinook passage and daily percent passage at Rocky Reach Dam prior to bypass shutdown at midnight on Aug 31st 2011.

At McNary, John Day, and Bonneville dams detections appeared to peak around the same time (Figure 12), with 17-20% of those detections occurring in September through Nov 15th. It is unclear, however, how many tagged fish continued to pass projects after the bypass systems were turned off at the respective projects.

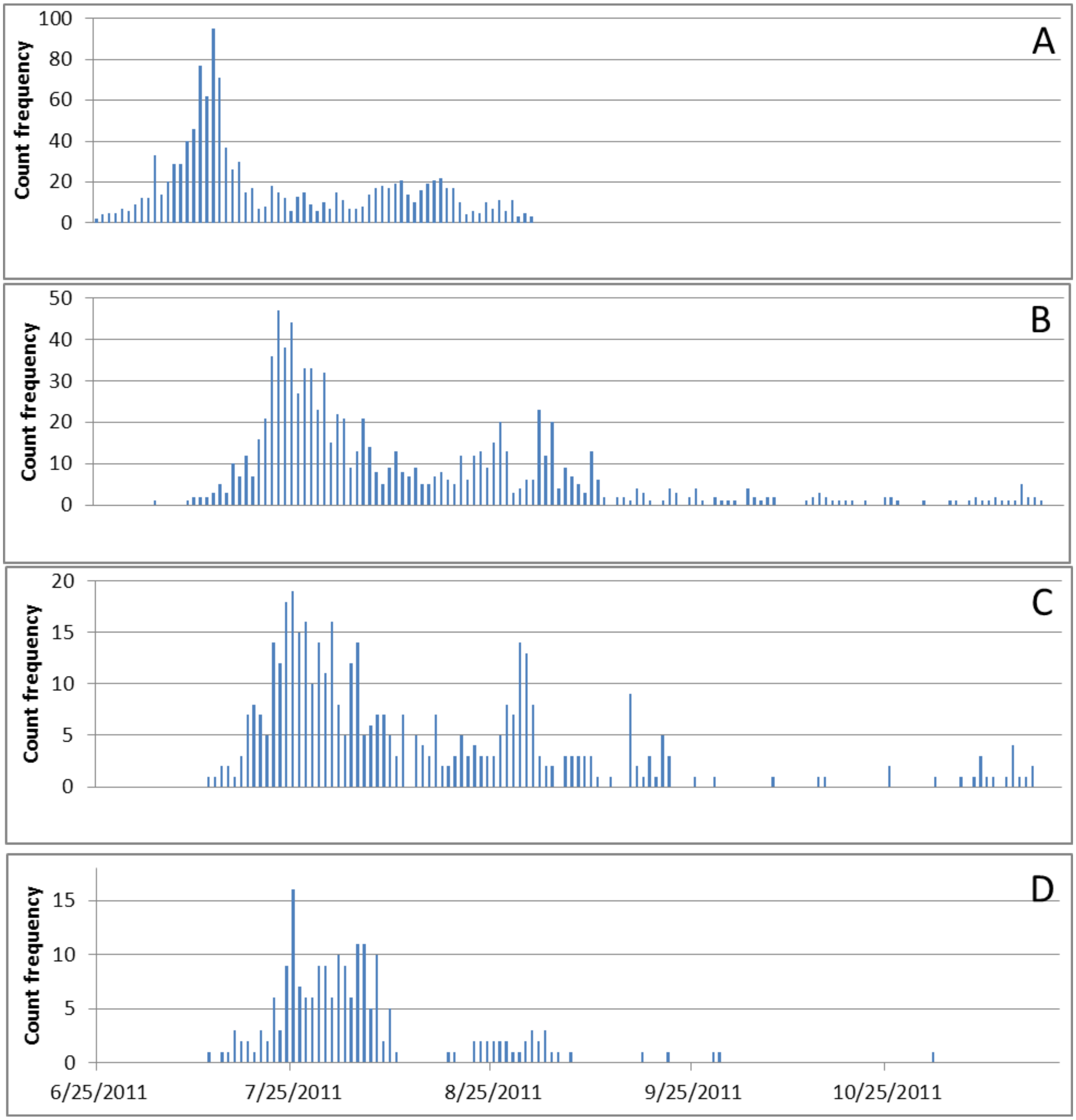


Figure 12. Daily distribution frequency of PIT-tagged subyearling Chinook passage at A) Rocky Reach, B) McNary, C) John Day, and D) Bonneville dams prior to bypass shutdown at each project. Note differences in vertical scales.

5.4.5 Travel Time

Travel time decreased as fish moved down river, and the largest fish at the time of tagging traveled faster than smaller fish. Travel times were protracted through the upper Columbia and decreased as fish moved into the middle and lower Columbia. Migration rates from release to Rocky Reach Dam were the slowest of all reaches (Table 3), with fish moving an average of 4.8 km a day for a mean of 20 days to travel to Rocky Reach Dam. In contrast, the mean of travel times from John Day Dam to Bonneville Dam was only 2.5 days for a rate of 44.6 kilometers per day (km/d).

Table 3. Mean reach-specific travel time (d) and rate (km/d) for all PIT tagged subyearling Chinook released in the Wells Reservoir in 2011 and subsequently detected at downstream hydroprojects. RRH = Rocky Reach Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam.

	RRH (762)		**MCN (470)**		**JDA (347)**		**BON (235)**	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	**19.7** (±0.48; n = 1185)	**4.8**						
RRH (762)			**20.1** (±0.98; n = 188)	**14.5**				
MCN (470)					**7.6** (±0.99; n = 99)	**16.2**		
JDA (347)							**2.5** (±0.29; n = 33)	**44.6**

Note. Smolt index recaptures removed.

Fish greater than 86 mm at tagging traveled through all reaches faster than fish smaller than 87 mm at tagging (Tables 4 and 5). From release to Rocky Reach Dam fish greater than 86 mm at tagging traveled at rates nearly five times faster than smaller conspecifics. Even in the lower river between McNary and John Day dams, larger fish (at tagging) traveled at nearly double the rate of smaller subyearlings.

Table 4. Mean reach-specific travel time (d) and rate (km/d) for PIT-tagged subyearling Chinook that were greater than 86 mm at the time of tagging in the Wells Reservoir in 2011 and subsequently detected at downstream hydroprojects. RRH = Rocky Reach Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam.

	RRH (762)		MCN (470)		JDA (347)		BON (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	**4.7** (±0.41; n = 121)	**20**						
RRH (762)			**15.78** (±3.08; n = 17)	**18.5**				
MCN (470)					**3.23** (±0.33; n = 6)	**38.1**		
JDA (347)							**1.92** (±0.17; n = 7)	**58.3**

Note. Smolt index recaptures removed.

Table 5. Mean reach-specific travel time (d) and rate (km/d) for PIT-tagged subyearling Chinook that were less than 87 mm at the time of tagging in the Wells Reservoir in 2011 and subsequently detected at downstream hydroprojects. RRH = Rocky Reach Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam.

	RRH (762)		MCN (470)		JDA (347)		BON (235)	
Location (River KM)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)	Travel Time (d)	Rate (km/d)
Release (856)	**21.17** (±0.5; n = 1080)	**4.4**						
RRH (762)			**20.52** (±1.02; n = 173)	**14.2**				
MCN (470)					**7.86** (±1.05; n = 93)	**15.6**		
JDA (347)							**2.67** (±0.37; n = 26)	**41.9**

Note. Smolt index recaptures removed.

Comparisons between subyearling Chinook counts at Rocky Reach Dam and river discharge or temperature revealed no biologically meaningful relationships (Figure 13) even though two regressions comparing flow and temperature at Wells Dam with subyearling Chinook counts at Rocky Reach Dam indicated significant positive (Flow: r^2= 0.18; p = 0.003) and negative (Temperature: r^2= 0.07; p = 0.024) relationships, respectively. Notably, the population of subyearling Chinook PIT tagged in Wells Reservoir represented only a portion of the seasonal migration past Rocky Reach and Rock Island dams (Figure 14); counts at Rock Island Dam include fish originating from the Wenatchee and Entiat rivers, and also include fry. The subyearling Chinook migration through Rocky Reach Dam also includes fry from the Entiat, Methow, Okanogan, and mainstem Columbia rivers, and thus, by including only PIT-tagged study fish, Figure 13 depicts a truncated distribution of the total migration through Rocky Reach Dam. Therefore, any apparent relationship between flow or temperature and the counts of tagged subyearlings at Rocky Reach Dam are likely artifacts of incomplete data, as the actual run distribution more likely resembles that observed at Rock Island Dam.

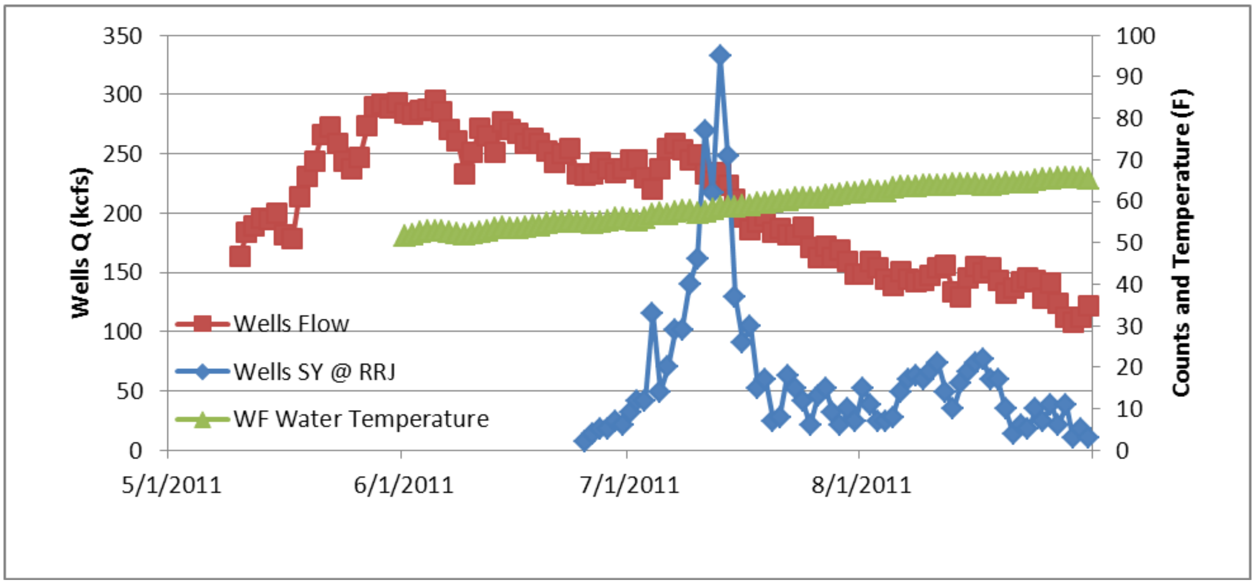


Figure 13. Distribution of PIT tag subyearling Chinook arrival at Rocky Reach Dam and total water flow past Wells Dam in 2011.

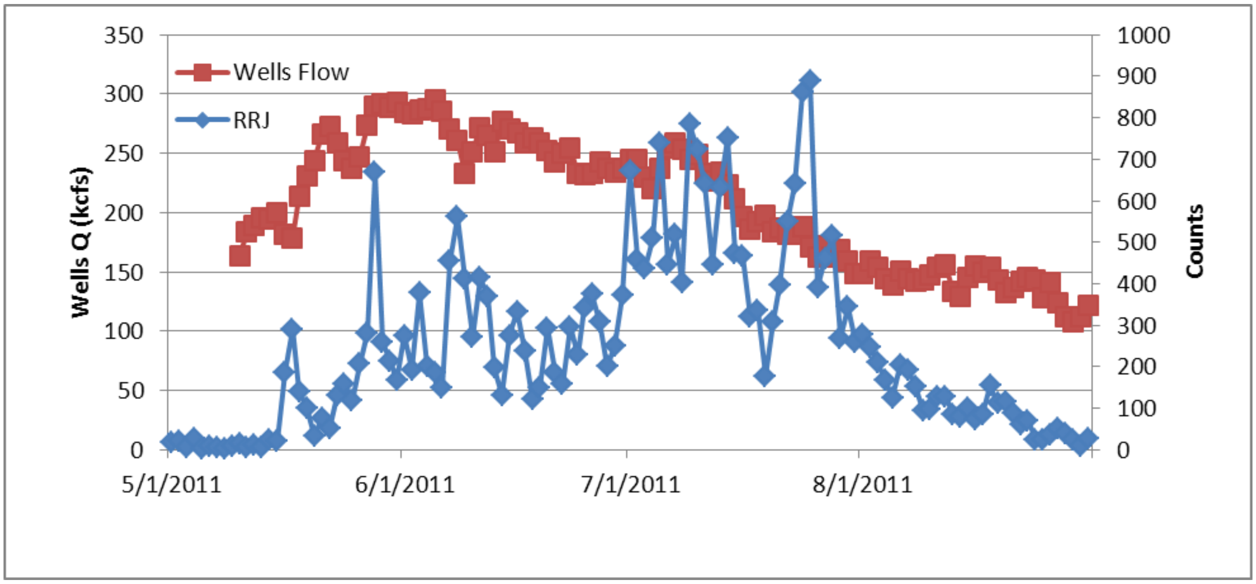


Figure 14. Distribution of subyearling Chinook arrival timing at Rocky Island Dam and total water flow past Wells Dam in 2011.

5.4.6 Size Threshold for Migration

Migration travel time for tagged subyearlings from release to Rocky Reach Dam was highly variable, especially for fish smaller than 87 mm at tagging. As a general rule, larger fish migrated faster (linear regression $P<0.05$; $r^2= 0.29$; Figures 15 and 16), though fork length was a poor predictor of travel time within any size class, and significance was due more to a large sample size than to a strong relationship. In contrast with the large numbers of fish smaller than 87 mm, sample sizes were small for fish equal to or greater than 87 mm long. Nevertheless, the migration behavior of those larger fish was comparatively active with less variable travel times than their smaller counterparts.

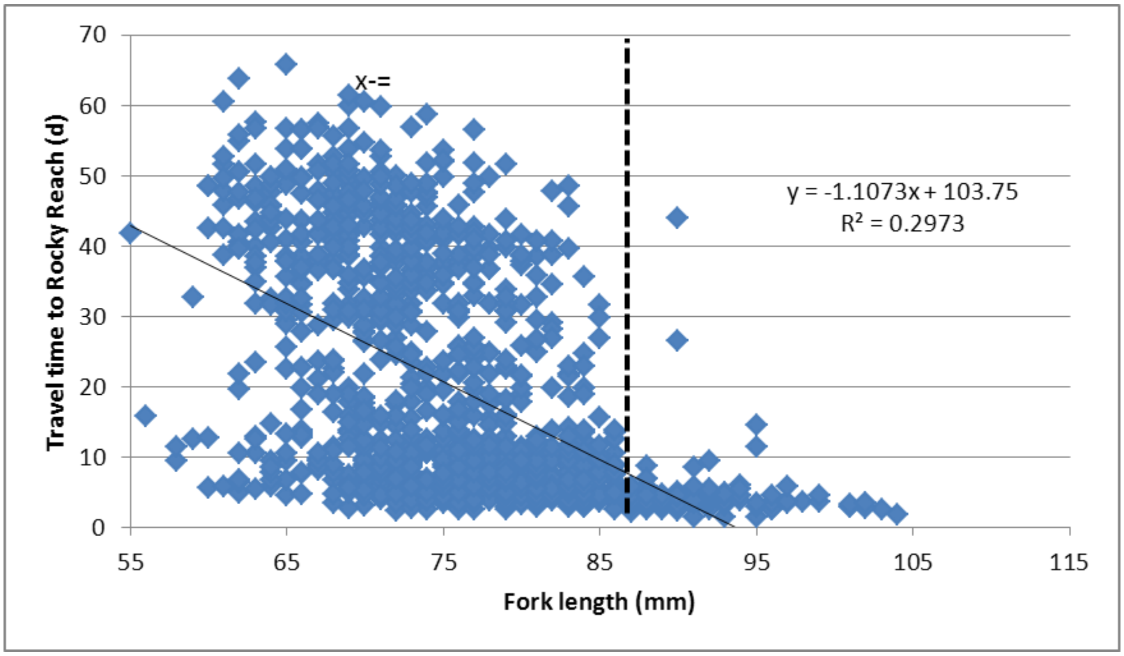


Figure 15. Scatter plot of fish size (fork length) at tagging as a predictor of travel time to Rocky Reach Dam. Although the negative relationship is statistically significant (linear regression P<0.05), it is highly variable below 87 mm. The vertical dashed line represents an apparent shift in migration behavior at 86 mm, with fish ≥ 87 mm exhibiting faster migration rates and less variability in travel time.

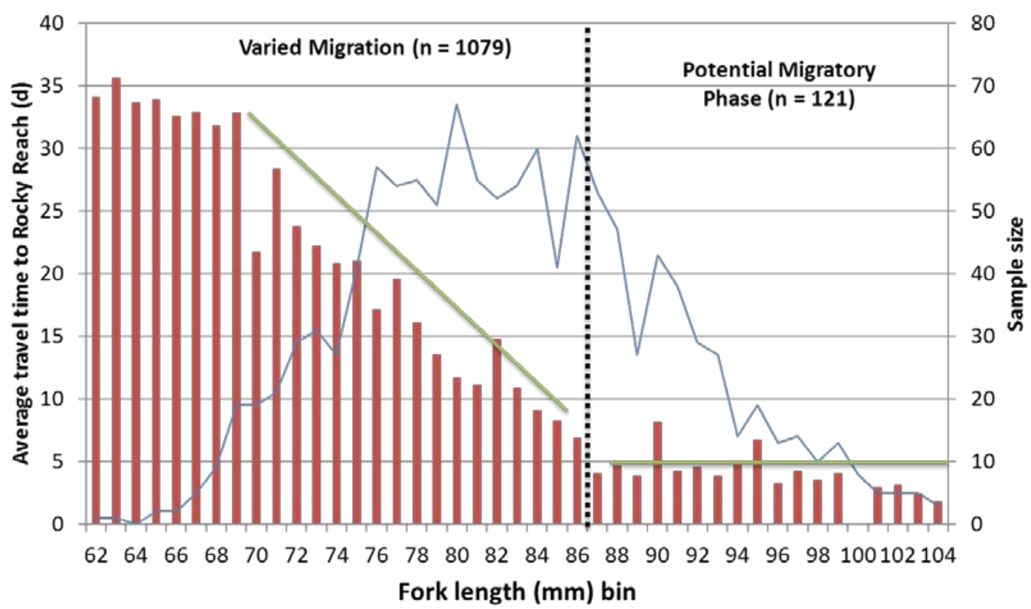


Figure 16. Mean travel time to Rocky Reach Dam for each fork-length size–bin. Travel time increased with decreasing fish length for fish equal to or less than 86 mm, whereas fish 87 mm or greater exhibited no such relationship.

A non-parametric Mann-Whitney U test determined that fish over 86 mm long migrated much faster than fish under this size threshold ($P<0.0001$; see Figure 16), predictably migrating to Rocky Reach Dam within five days of tagging (Table 6). This 86-mm threshold may be important for differentiating the size of actively migrating subyearling Chinook from passively migrating or non-migratory subyearling Chinook. The standard deviations between these groups are quite different, highlighting the increased variability in migration rate to Rocky Reach Dam in those smaller tagged fish. Specifically, the standard deviation in the smaller size class was almost four times greater than that of the larger size class. In addition the median and means for the large size class of subyearlings were almost equal, but for the smaller fish these two metrics were drastically different.

Table 6. Comparison of summary data on travel times from release in the Wells Reservoir to detection at Rocky Reach Dam for two size (fork length) classes of PIT-tagged fish in 2011.

Size range (mm)	*Number tagged*	*Number detected*	***% of size class detected at RRD***	***Mean travel time to RRD***	*Std Dev*
<87	12192	1079	**8.9%**	**21.2**	16.6
>86	1028	121	**11.8%**	**4.7**	4.5

Fish greater than 86 mm represented 10% (121 fish) of the 1,200 PIT-tagged fish that were detected at Rocky Reach Dam. Larger fish were also more likely to be detected at Rocky Reach Dam by the end of August than were smaller conspecifics (see Table 6; 11.8% detected vs. 8.9%). Differences in detectability became even stronger when we used all downstream detection locations. Table 7 illustrates that fish larger than 86 mm had a 30% chance of detection on any downstream array compared to only 20% for their smaller counterparts.

Table 7. Proportion of tagged fish of a give size range detected at any downstream project during 2011 (prior to Nov 15th shutdown of federal JBS systems).

Size range (mm)	*Number tagged*	*Number detected*	***Proportion detected (%)***
<87	12192	2448	**20.1**
>86	1028	313	**30.4**

5.4.7 Biological Cost to Tagging Procedure

Although we did not intend to specifically evaluate the biological cost of the tagging procedure during 2011, evidence from recaptured fish in Wells Reservoir suggests potential costs associated with the capture/handling/tagging experience. The mean of growth rates (0.34 mm/day) was reduced over the first 11 days after tagging (Figure 17) compared to the mean of growth rates of fish recaptured at Rocky Reach Dam (June/July recaps 0.56 mm/day, August recaps 1.18 mm/day). This phenomenon was independent of size at tagging (Figure 18). The apparently negative growth rates in Figures 17 and 18 result from human error in measuring fish on the digitizing board. We did not attempt to quantify the magnitude of nor correct for the measurement error, but assume tagging staff made both positive and negative errors in measurement. Irrespective of measurement errors, the data plots depict a generally flat growth rate during the 11 days post tagging, regardless of fish size at tagging.

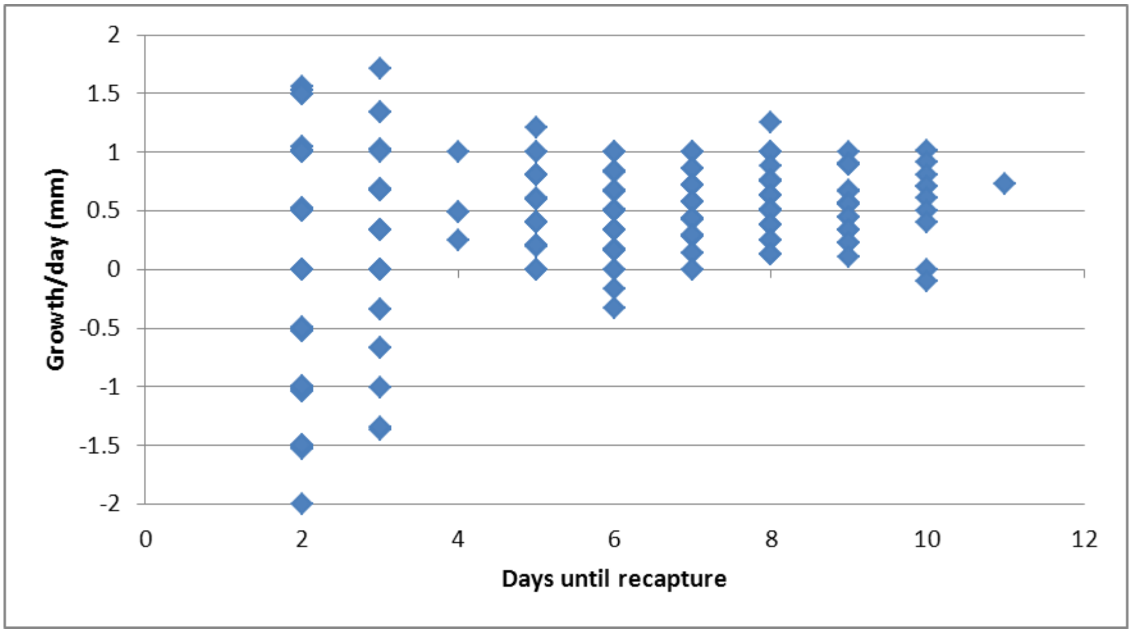


Figure 17. Growth rates (mm/day) by the number of days from tagging to recapture, for fish that were PIT tagged, released and recaptured in the Wells Project during 2011.

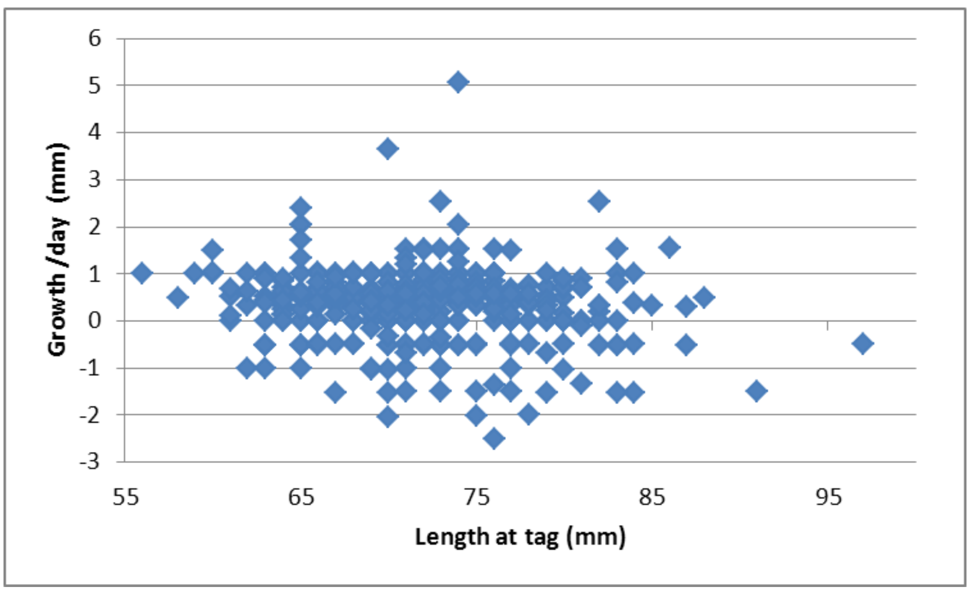


Figure 18. The relationship of fish size at tagging to growth in the subsequent 11 days after tagging.

6.0 DISCUSSION

6.1 Fish Availability and Size

Duing the 2011 pilot study we captured more than 18,500 subyearling Chinook from the Wells Project over a three-month period. Of these fish, we PIT tagged and released 13,223 back to the Wells Reservoir during a three-week period in June and early July. Prior to 2011, limited information existed on the migration behavior, growth and general life-history diversity of subyearling Chinook found within the Wells Project; results from the 2011 study improve our understanding. Subyeraling Chinook were available in May in the Wells Project but most of these fish were too small to tag. Not until the third week in June did weekly test seining yield taggable-sized fish in sufficient numbers to warrant the mobilization of the tagging crew.

Subyearling Chinook were available in most areas that we fished; however, some areas, such as Gebber's Landing, produced consistently more fish than at other sites and minimal bycatch and encounters with debris. The capture of Chinook fry at the Washburn Island site 4.5 kilometers upstream from the mouth of the Okanogan River indicates that subyearling Chinook in the Wells Project originate from not only spawners in the Okanogan and Methow rivers but also from Chinook that spawned in the Columbia River. River flows during May when these fry were captured exceeded 200 kcfs at the Washburn sampling location. The fish sampled in May were too small to swim upstream against the currents observed in this section of the Wells Project. Mann et al. (2012) documented Chinook spawning in the upper reaches of the Wells Reservoir downstream of Chief Joseph Dam, which is the probable spawning location from which the fry we captured originated.

Overall, mortality estimates related to capture, handling and tagging were low (2.3%) and would have been below 2% if areas of high sediment load and debris had been avoided on June 21st. Seining crews learned quickly where to seine to avoid mud balls, debris, and abundant filamentous algae, and how to safely retrieve fish from seine sets with excessive filamentious algae, dramatically reducing mortality rates during the second and third weeks of tagging (see Table 1).

Fish were easier to capture on days when wind pushed debris and waves—and likely food—inshore towards our capture locations. Wave action also caused local turbidity, which may have reduced the ability of the fish to see the net, thus improving capture efficiency. Other authors report this phenomenon, noting postive correations between fish capture abundance and wave action in shoreline surf (Romer 1990; Clark et al. 1996).

Nearly half the number of fish tagged were captured in the third week of fishing. Three factors contributed to a successful third week. First, the relative number of taggable fish was much higher in the third week as the average size of fish in seining locations had increased. For example, only 3% of the captured fish in the third week were too small to tag, compared to 52% and 10% in the first and second weeks, respectively. Secondly, we were able to handle more fish in the third week by focusing seining efforts at Gebber's Landing, which yielded a large number of fish, with limited debris, bycatch, and snagging. Third, the Wells Reservoir was filled to within 2 feet of its maximum operating level 781 msl. This allowed crews to fish over the top of macrophyte beds rather than fishing through the vegetation as was the case during the first two weeks of seining when the water level in the Wells Reservoir was below elevation 776 (msl) for flood control and sediment-flushing purposes on the lower Methow River.

Once released we detected 17.5% of the 13,223 tagged subyearlings before late fall when PIT-tag detectors at downstream hydroprojects were no longer operational. There were no obvious increases in detections related to tagging date or release site, suggesting that the handling of these fish was relatively consistent across the tagging period and tagging sites.

The mean lengths of fish captured within the Wells Project on sequential sampling dates increased in a curvilinear manner. The lengths of fish captured in late May averaged approximately 45 mm, and 43 days later on the last day of tagging, fish length averaged 78 mm. These observed fish-length means are comparable to those reported by McMichael et al. (2003) at Wanapum Dam, where the daily mean sizes of subyearling Chinook were not above 55 mm until after May 26 for the years 2000-2002. In addition, mean length was not above 75 mm until after June 30th for the 2000-2002 sample years (McMichael et al. 2003). Subyearling Chinook in the Wenatchee River had a mean fork length of 48 mm in June and 84 mm in August (Hillman and Chapman 1989), which would be a slightly slower rate of change in fish size over time than we obseved in the Wells Reservoir. We would expect subyearling Chinook rearing in or migrating through the Wenatchee River to grow more slowly than those originating from the Okanogan River (primary source of subyearling Chinook at most of our seining locations) because the Wenatchee River is colder in the spring than the Okanogan River. Our measured and estimated growth rates of subyearlings in the Wells Project were consistent with growth rates observed or estimated in other systems.

6.2 H1: Do Subyearling Chinook in Wells Reservoir Represent Multiple Life-history Strategies?

In our alternate hypothesis H1, we hypothesized that ocean-type Chinook in Wells Reservoir represent multiple life-history strategies with variable migration timing including spring and summer subyearling, spring yearling, reservoir rearing, and intermediate migration types. In 2011 we observed the majority of detected Chinook exhibiting migration behavior that represents the summer-migrating subyearling life-history strategy. Most tagged fish detected during emigration passed Rocky Reach Dam in July, and July and August for downstream projects. Besides the summer migrants, in our scoping sampling in late May and through mid-June we found abundant subyearling Chinook too small to tag and track. The coincidental collection of subyearling Chinook of similar size at the juvenile sampling facility at Rocky Island Dam proves the existence of a spring-migrating component to the subyearling population in the upper Columbia (see Figure 14), but it is debatable whether those fish are true migrants or merely entrained in the flow. Besides those fish that were too small to tag in the spring, we also did not tag beyond July 9, even though we were able to capture fish (albeit at diminished rates) by beach seining through July 27. Of course, we do not know the migration behaviors of those fish that we observed but did not tag during the spring (pre-tagging) or summer (post-tagging).

We did not detect any spring *yearling* migrants among our tagged fish, and must wait for the results of scale analyses to determine whether any migrated as yearlings or as winter parr. Tag detections at lower-river projects demonstrated a small (relative to summer migrants) proportion of tagged subyearlings migrating in the fall right up to the date of bypass shutdown on November 15, and we have no reason to believe that migrants ceased passing those projects on that date. From this body of evidence, we must reject our null hypothesis H1: "Ocean-type Chinook in Wells Reservoir represent a single life-history strategy with discrete and predictable migration timing"; although, from our data so far, we cannot yet fully accept the alternate Hypothesis H1 that includes the yearling spring migrants. Nevertheless, juvenile summer/fall Chinook in the Wells Reservoir clearly exhibit a continuum of migration timing, with passage of downstream projects occurring from spring at least until termination of bypass operations in mid-November. Focusing survival studies on any one segment of that continuum would fail to represent a substantial portion of the entire run.

6.3 H2: Do Subyearling Chinook Tagged in Wells Reservoir Actively Migrate Through the Wells Project?

We hypothesized that subyearling Chinook tagged into the Wells Reservoir, of the size observed migrating through Wells Dam, either actively migrate ($H2_0$) through the Wells Project, or do not actively migrate ($H2_{alt}$) but rather do so passively with the flow through the project. In these hypotheses, the clause "of the size observed migrating through Wells Dam," refers to subyearlings captured in fyke nets at turbine intakes and spill bays at Wells Dam during hydroacoustic studies in the 1980s and 1990s. Mean lengths of fish captured during those studies exceeded 100 mm (Douglas PUD, unpublished data). In contrast, only sixty-two fish captured during the 2011 PIT-tagging effort exceeded 100 mm, and most of those were captured during the last two seining days of the tagging effort. Thus, we cannot directly examine the migration behavior of the size class of fish considered in the drafting of the study hypotheses. Nevertheless, our data from 2011 reveal relationships between fish length and migration behavior that may prove useful for indirectly addressing this hypothesis.

Subyearlings tagged at a size less than 87 mm had highly variable migration rates from release in the Wells Reservoir to detection at Rocky Reach Dam. However, fish that were tagged in the Wells Reservoir when at a length greater than or equal to 87 mm exhibited relatively rapid migration behavior arriving at Rocky Reach Dam in less than 5 days, with a median of less than 4 days (n=121 of 1,200 detected at Rocky Reach Dam), which exceeds travel times for yearling Chinook used in survival studies (Skalski and Townsend 2011; Bickford et al. 2011). Median migration rates between release and Rocky Reach Dam for these fish were 23.8 km/day with some fish migrating at the rate of 47.5 km/day (equating to a travel time of 2 days to Rocky Reach Dam). Emigrating fish could not achieve such rates if passively migrating. Conversely, the mean travel time to Rocky Reach Dam for fish of lengths less than 87 mm was greater than 20 days, or five times longer than larger conspecifics. This travel time would be even longer if we could include fish passing Rocky Reach Dam after August 31st. Thus, 86 mm fork length at tagging appeared to represent a migration threshold above which fish actively migrated and below which fish delayed migration or migrated relatively slowly. This threshold hypothesis is consistent with post-tagging growth-monitoring results conducted on July 27th. The estimated mean size of fish captured in the Wells Project on July 27th should have been above 90 mm according to projections based upon regression analysis (see Figure 7), but no subyearlings were caught in seining attempts in capture locations that yielded large numbers of fish earlier in the season. Again, on subsequent sample days that included shoreline snorkel surveys, no fish were captured or observed. From these observations we might hypothesize that fish were either offshore in deeper habitats or were largely in a migratory phase and had exited the Wells Project.

Although little data exist, large subyearlings have been observed passing Wells later in the year and at larger mean sizes than we observed in our beach-seine sampling. Weekly mean lengths of subyearlings collected in turbine fyke nets were 105, 111, 115, and 121 mm for the consecutive weeks of July 22, July 29, Aug 5th, and Aug 12th, respectively (Douglas PUD unpublished data). Similar subyearling mean lengths were reported by McGee (1984) in purse-seine sampling in the forebay of Wells from mid-June to the end of July (corresponding to our tagging and post-tagging periods). These estimated mean sizes are much larger than fish we were able to capture, indicating that the larger fish are generally not susceptible to our sampling methods because either their swimming capabilities allow them to avoid the net, or their distribution is offshore, beyond the reach of our seines, at least during daylight hours or, they have initiated their seaward migration, thereby vacating the sampling area. Dauble et al. (1989) demonstrated that subyearling Chinook captured in nets positioned off shore in the Columbia River were larger than conspecifics captured along the shoreline. Our mean fish sizes were relatively small compared to those collected by McGee (1984) indicating that McGee captured few fish in the size range of those that we captured in the nearshore, and as described above, we captured few in in the size range of those McGee captured in the forebay. The predominance of large fish and paucity of small fish in catches targeting active migrants, and the scarcity of large fish and predominance of small fish in shoreline-oriented sampling provides evidence of ontogenetic shifts in foraging and migratory behaviors with increasing fish size.

The timing of subyearling Chinook migration past Wells Dam may be a function of fish size at a certain day of the year as recently suggested by Perkins and Jager (2011), who showed that juveniles that become yearling or resident-reared migrants do so soon after emergence if they are too far behind a typical growth schedule given temperature and photoperiod cues. Critical sizes for migration have been identified by other researchers investigating subyearling Chinook. Within an enclosed section of the Wenatchee River, Chinook larger than 80 mm were usually captured in emigrant traps, whereas fish smaller than this size usually remained within the enclosures (Spaulding et al 1989). In addition, few Chinook larger than 80 mm were observed in August in the Methow River by Griffith and Hillman (1986). Similarly, fall Chinook salmon in tributaries of the Columbia River, downstream of Bonneville Dam, migrated when they reached 80-100 mm (Reimers and Loeffel 1967). Onshore-offshore movements have been observed in the Hanford Reach as fish moved into the McNary Reservoir from May to mid-July, where researchers identified 80 mm as a critical size that determined the initiation of offshore migration behaviors (Rondorf and Gray 1987). More recently Connor et al. (2003) noted that mean fork lengths of subyearling Chinook salmon captured in beach seines were 86 and 92 mm in two locations at the end of a given capture season (July) in the Snake River. Beach-seined fish in the Snake River were available from May to July but less than 2%of the total catch was captured in the month of July, suggesting that growing fish move offshore. Finally, Connor et al. (2003) showed increases in travel rates as fish moved down the Snake River comparable to our results in the mid-Columbia.

In summary, a fork length of approximately 87 mm apparently represented a threshold for subyearlings in Wells Reservoir in 2011, with fish 87 mm or larger exhibiting rapid migration rates and declining availability for capture by beach seine relative to their smaller conspecifics. With the data from only one year, we have no estimate of the variability around that apparent threshold. Additionally, without data from multiple years representing a range in environmental variables such as water temperature and the hydrograph, we cannot describe the degree to which those variables influence ontogenetic shifts in foraging or migratory behavior of subyearlings in Wells Reservoir. If size thresholds define a migrant in the Wells Project these findings would be similar to those of other studies that report behavior shifts in subyearling Chinook when they reach a critical size. At the present, we cannot definitively state whether fish of the sizes observed migrating through Wells Dam during fyke netting in the 1980s and 1990s were actively or passively migrating. However, the fact that the lengths of the fyke-netted fish exceeded the lengths of nearly all those available to our sampling gear in 2011 supports the null hypothesis (that they are active migrants), because fish greater than 86 mm in our study displayed consistently faster and less variable migration rates than smaller fish and, in some cases, traveled at rates exceeding those of yearling, active migrants.

6.4 H3: Does Residence time in Wells Reservoir Exceed the Battery Life of Current Acoustic Tags?

The distribution of arrival times of PIT-tagged subyearlings at Rocky Reach Dam in 2011 raises important concerns regarding the use of acoustic tags in studies of the survival of subyearling Chinook through the Wells Project. Currently, the smallest acoustic tag is the JSATS-AMT (Juvenile Salmonid Acoustic Telemetry System) tag from Lotek Wireless (0.3 g in air; New Market, Ontario). These tags typically have a higher detection probability than PIT tags, allowing researchers to use fewer fish to obtain acceptable confidence intervals in survival models. Although the JSATS tag has been used by many researchers for survival studies at federal hydroelectric projects in the Snake and lower Columbia rivers (see McMichael et al. 2010 for examples) tag life remains an important concern for fish tagged above Wells Dam. Currently, the JSATS tag with a 5-second PRI (pulse rate interval) has an expected life of 27 days (Lotek Wireless JSTATS-AMT product sheet 2012). Our results from 2011 show that the travel times from release in Wells Reservoir to detection at Rocky Reach Dam exceeded 27 days for approximately 30% of the detected fish. Furthermore, this percentage may increase if we assume fish continued to pass Rocky Reach after August 31 when the JBS shut down, and once we include any “reservoir-type” fish that migrate as yearlings. Observed counts at projects in the lower river through September to mid-November (17-20% of the detections at McNary, John Day, and Bonneville dams occurred during these months), and the known “reservoir-type” life-history in the Snake River (Connor et al. 2005) support the assumption that fish continued to pass Rocky Reach well outside the expected tag life of the current acoustic tags. Thus, with a minimum 30% of the tagged population passing the nearest downstream detection site after the expiration of the published battery life of the smallest available acoustic tag, the evidence supports the alternate Hypothesis H3: residence time in Wells Reservoir exceeds the battery life of current acoustic tags.

6.5 H4: Do Subyearling Chinook from Wells Reservoir Migrate While PIT-tag Detection Arrays are Operational?

Our null Hypothesis $H4_0$, states that the study-fish population migrates only during periods when downstream PIT-tag detection arrays are operational. Although we were not able to determine passage timing at Wells Dam, detections at Rocky Reach Dam were highly variable with the largest proportion of detected fish migrating through Rocky Reach Dam in July, but fish detections continuing through August 31 when the JBS was turned off. Seventeen to twenty percent of the detections at lower Columbia River projects occurred between September and mid-November, which could indicate that fish migrated past Rocky Reach Dam after the bypass system was turned off. These detections at lower-river projects occurred right up until bypass facilities were turned off in November. Incidences of overwintering fish or residuals will be explored in the spring of 2012 when PIT-tag arrays are once again operational. Based on slow but steady detections at projects immediately prior to JBS shutdowns, it is reasonable to assume that an unknown quantity of subyearlings passed lower river projects at periods when they could not be detected, and thus, tagged fish do not have equal detectability. How many subyearling Chinook pass projects after November 15th and for how long after remains unknown. Proving the assumption that fish pass during a period when JBS systems are shut down will require tracking the fates of tagged fish through to their return as adults.

We have no reason to believe that passage of downstream projects stopped abruptly when the respective bypass systems were shut down. Thus, we have no basis for rejecting the alternate Hypothesis H4: A portion of the study-fish population migrates during periods when downstream PIT tag detection arrays are not operational. This is a concern since fish traveling through projects with non-operational detection arrays violates the assumption of equal detectability. Such fish would be treated as mortalities in current survival models, thereby negatively biasing survival statistics.

6.6 H5: Different River Conditions and Survival Probabilities When Migrating Through the Control Reach.

In Hypothesis H5, we anticipated that subyearling Chinook released to the Wells Reservoir or below Wells Dam would experience different river conditions and survival probabilities while migrating through the control reach (Rocky Reach Reservoir) if they manifested multiple life-history strategies. Thus, Hypothesis H5 is directly related to Hypothesis H1. The differences in river conditions and survival probabilities contemplated in H5 would dramatically exceed the typical variability in River conditions and survival probabilities between release groups that generally occur in a survival study spanning several weeks.

In our 2011 study we observed a range of migration timing among tagged fish that would undoubtedly result in a failure of treatment and control releases from a survival study to mix homogeneously in the control reach or reaches below Rocky Reach Dam. The range of detection dates at Rocky Reach Dam and downstream detection locations spanned more than four months, and we have no reason to believe that passage at detection sites abruptly ceased with the termination of bypass operations at those projects. To an individual fish, the biological importance of that interval between tagging and detection is a function of the span of changes in physical and dependent biological conditions experienced during that interval. Depending upon the length of that time span, temperatures will increase, or may increase and then decease; river discharge will decline, and, if the span is long enough will decline from near the highest to near the lowest extent of the annual hydrograph; photoperiod will decline from near the annual maximum to beyond the autumnal equinox. Wargo-Rub et al. (2011) reported that survival among replicates of both PIT- and acoustic-tagged Chinook in the Snake River changed with discharge and travel time (covariate). Smith et al. (2003) observed for PIT-tagged subyearling Chinook in the Snake River that the probability of survival decreased with increasing (i.e., later) release date. They noted three environmental variables with which survival probability was correlated: survival decreased with declining discharge, increasing temperature, and increasing water clarity, all three of which were highly correlated with each other and predictably tracked with increasing Julian Day. Haeseker et al. (2012) also reported positive correlations between water transit time and both freshwater and marine survival for Snake River yearling Chinook and steelhead. In addition to the variability in environmental parameters over time, predation rates may increase, decrease, or cycle through increasing and decreasing trends over time as the predators respond to the changing environmental parameters and their own reproductive cycles (e.g., Peterson and Ward 1999; Gray and Dauble 2001; Vigg and Burley 1991 Roby et al. 2008).

Combined, all of the changing factors described above influence the survival probabilities of subyearling Chinook in ways both complex and interacting, resulting in inequalities in river conditions and probabilities of survival for study fish exhibiting such variability in both migration behavior and timing of recruitment to taggable size. As an example, we found that larger fish (at tagging) were detected at higher rates than smaller fish. The relationship between fish size at tagging and the probability of subsequent detection at downstream projects likely reflects (among other things such as size-mediated susceptibility to predators) an interaction between migration rate and/or timing, and the physical and biological conditions that individual fish face during their emigration. Thus, the evidence supports the alternate Hypothesis H5, that subyearling Chinook released above and below Wells Dam experience different river conditions, and different survival probabilities when migrating through the control reach (Rocky Reach Reservoir).

6.7 H6: Are the Fish Available for Capture Large Enough to Tag with a 12.5 mm PIT Tag?

As discussed above, we, in consultation with our tagging contractor, Biomark, Inc., decided that we would only tag fish greater than 57 mm fork length. Fish captured on May 27 during the first of three sampling (scoping) efforts prior to tagging were nearly all (96%) too small to PIT tag with the standard 12.5 mm PIT tag, and in the second scoping event on June 10, more than half (52%) of the fish were too small. By the third scoping event on June 15, less than one-third (29%) were too small, and we elected to begin tagging efforts the following week. The size of fish captured in seining efforts varied by sampling site, and several of the sites where we directed much of our efforts during the first week of tagging (week of June 19) yielded catches of relatively small fish (see Table 1). As such, the resultant mean number of undersized fish for that week jumped up to approximately 52%. At the same time, the mean length of the combined catches for the week increased in a linear manner over that of the previous week (Figure 19). During the next two weeks of tagging the proportion of the catch that was too small to tag declined dramatically and the mean lengths of the combined weekly catches continued along the same increasing trajectory as in previous weeks. By the first week of our post-tagging sampling, none of the fish captured were too small to tag. However, by that date catch numbers had declined to the extent that beach seining was no longer a viable method for obtaining sufficient numbers of fish to warrant mobilizing a tagging crew.

From this data we conclude that from the perspective of the logistics of study implementation, during the period when fish were available for capture by beach seining, we conditionally accept the alternate Hypothesis H6: the fish available for capture in the Wells Project at time t_1 are not of sufficient size for tagging with 12.5 mm tags. Assumption 1 of the assumptions from the single- and paired-release survival-study models requires that we tag fish that represent the study population. To fulfill that requirement necessarily forces the rejection of our null Hypothesis H6, that the fish available for capture are of sufficient size for tagging.

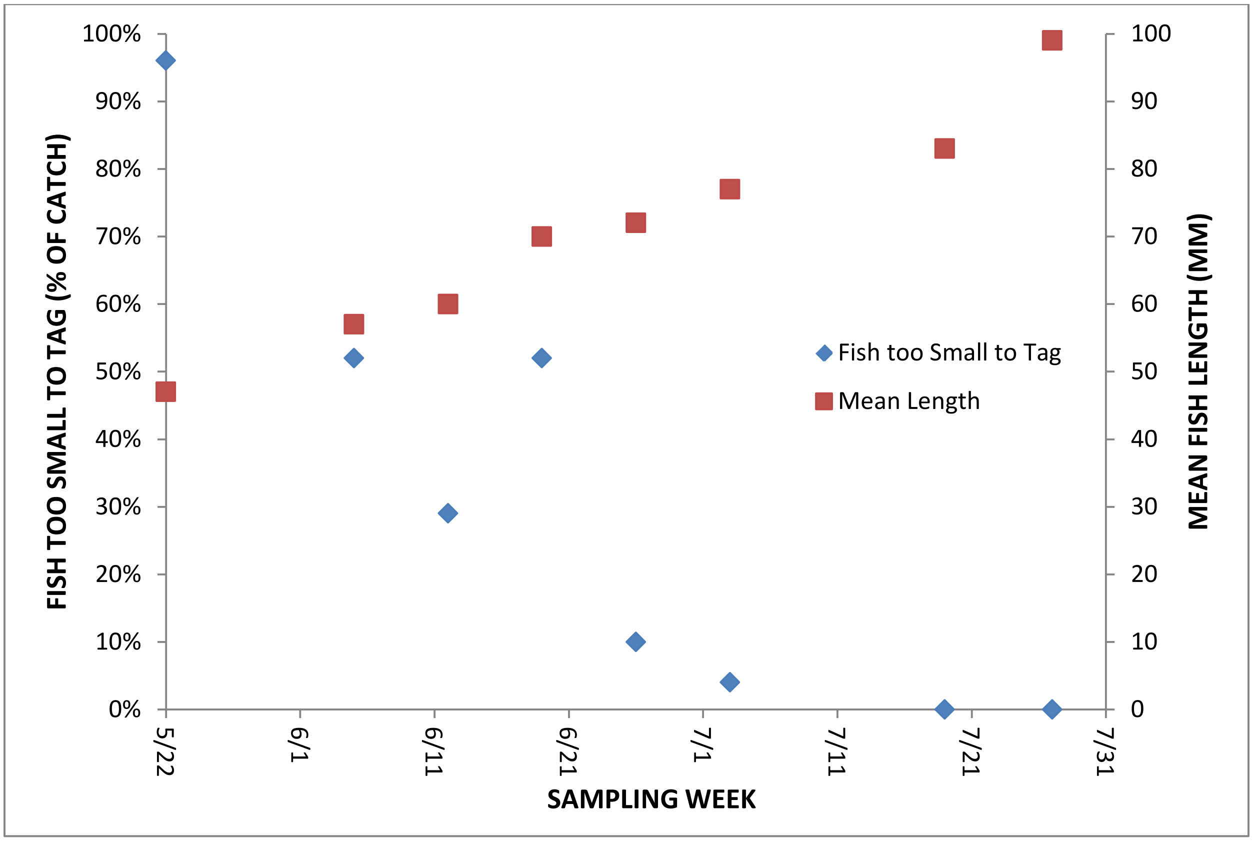


Figure 19. Percentage of fish captured each sampling week that were too small to PIT tag (primary y-axis), and mean length (mm) of combined weekly catch (secondary y-axis), by sampling week. The PIT-tagging size threshold was fork length greater than 57 mm.

6.8 H7: Are the Fish Available for Capture Large Enough to Tag with an Acoustic Transmitter?

$H7_{alt}$: The fish available for capture in the Wells Project are not of sufficient size for tagging with an acoustic transmitter.
$H7_{o}$: The fish available for capture in the Wells Project (reservoir, dam and tailrace) are of sufficient size for tagging with an acoustic transmitter.

The currently accepted fish-size criterion for acoustic-tag studies in the Columbia hydrosystem limits the use of acoustic tags to study fish 95 mm or greater in length (Carlson and Myjak 2010). This length corresponds with the minimum length at which fish tagged with a surgically implanted acoustic tag and PIT tag did not experience reduced survival in a laboratory study conducted in 2006 by Brown et al. (2007). The fish-length threshold stems from concerns that fish growth, behavior, and ultimately, survival could suffer if the weight of the tag exceeds a threshold ratio relative to fish weight. This ratio, referred to as "tag burden," has been the subject of much study and debate, but all agree with the desirability of minimizing tag burden in biotelemetry studies. Laboratory results do not necessarily translate to field settings, and indeed, in field studies conducted in 2007 to accompany the 2006 laboratory studies, detection probabilities and survival of subyearling Chinook with acoustic tags were so poor that the researchers did not repeat the second year of field trials on subyearling Chinook. Laboratory studies in 2008 demonstrated that even with smaller tags (reduced tag burden; mean 3.3%), acoustic-tagged subyearling Chinook survived at significantly lower rates than PIT-tagged subyearlings (Wargo-Rub et al. 2011). These findings are concerning if studies using tagged fish are assumed to represent the population of untagged conspecifics.

With the 95-mm length limit, only 199 (1.5%) of the 13,223 fish we PIT tagged in 2011 could also have carried an acoustic tag. Improvements in acoustic-tag design have reduced tag burden in study fish, but even the smallest acoustic tags still represent a much greater burden than a standard PIT tag. For example, an 85 mm fish that is approximately 8 g, carrying a 0.3 g JSATS (most current version) acoustic tag would have a tag burden approaching 4%, thus limiting the proportion of the run that could be tagged even further than the approximately 57 mm threshold we used for PIT tags in the 2011 study. Additionally, with our HCP requirement to "consider direct, indirect, and delayed mortality" in our survival studies, we must include a PIT tag (0.1 g) along with any other tag to allow us to monitor delayed mortality via adult returns. This would increase the tag burden to 5%. Brown et al. (2010) reported reduced survival and growth for subyearling Chinook less than 90 mm tagged with both acoustic and PIT tags with a combined weight in air of 0.46 g. Nevertheless, adopting the 90-mm threshold would still have precluded the tagging of nearly 96% of the subyearling Chinook that we PIT tagged in 2011.

Carlson and Myjak (2010) presented curves (Figure 20) to estimate the response of juvenile Chinook to rapid decompression events (such as may occur during turbine passage) in terms of "probability of mortal injury," which is the probability of an injury occurring that laboratory studies show leads to mortality. From these curves one can determine that the estimate of probability of mortal injury for a 60 mm Chinook carrying a PIT tag (weight ~0.1 g) would be just under 20% at given ratio of pressure change, and a fish with a 0.45 g tag burden (~that of the current JSATS tag plus a 12.5 mm PIT tag) would have to be nearly 96 mm in length to experience the same probability of mortal injury as the 60 mm PIT-tagged fish at the same ratio or pressure change.

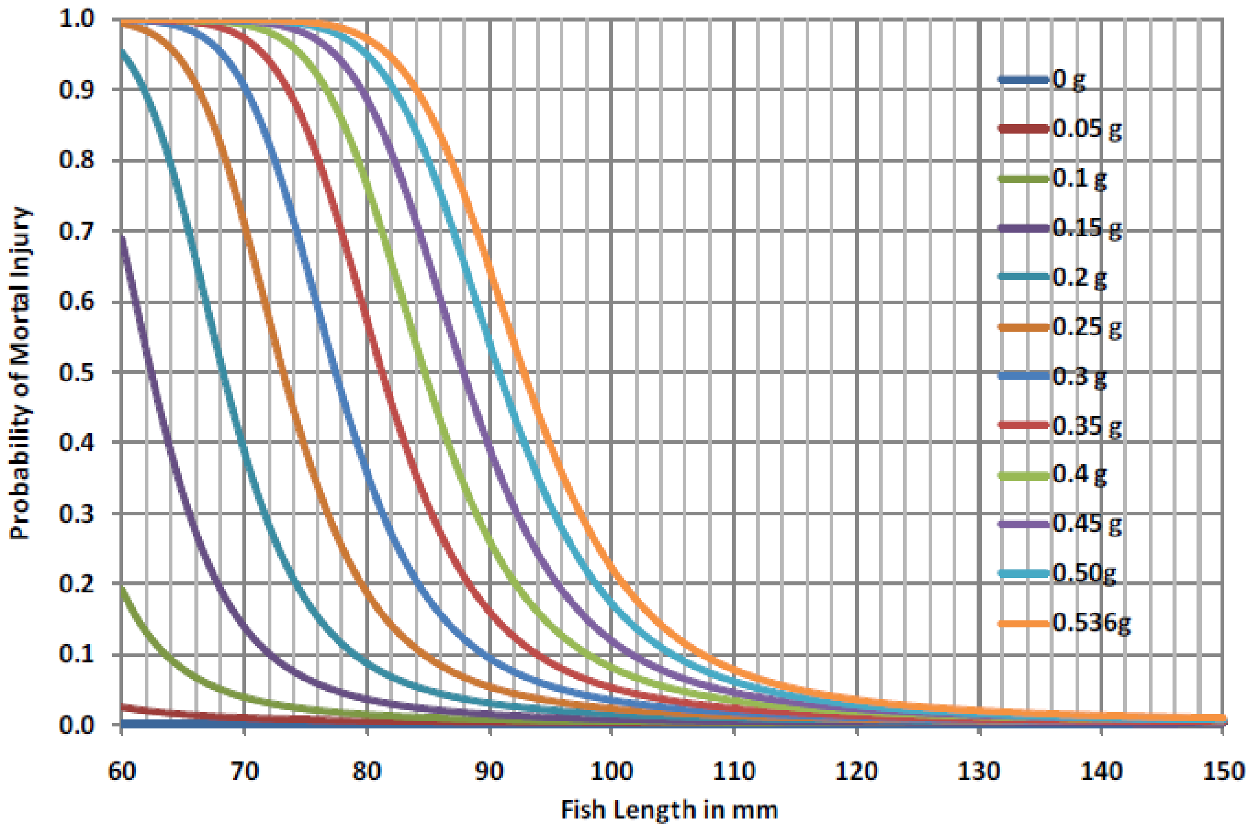


Figure 20. Mortal injury index for transmitter dry weights from 0 g to 0.536 g for fish between 60 mm and 150 mm in length passing a dam via a turbine or otherwise experiencing pressure changes of a similar magnitude as turbine passage (From Carlson and Myjak 2010).

Thus, because greater than 95% to greater than 98% (depending upon threshold accepted) of the subyearlings captured for tagging in the Wells Reservoir in 2011 were too small to tag with the currently available acoustic tags, and from the curves from Carlson and Myjak (2010; see Figure 20) that predict substantial biological consequences to small fish of the tag burden of the current acoustic tags, we accept alternate Hypothesis H7. That is, the fish available for capture in the Wells Project are not of sufficient size for tagging with an acoustic transmitter. A more troubling implication of Figure 20 (above) is that fish smaller than approximately 75 mm will experience a greater probability of mortal injury than larger fish when carrying even a PIT tag weighing approximately 0.1 g and subjected to the same ratio of pressure change. Clearly, for fish within the size range that we tagged in 2011, survival and detection probabilities were affected by the tag, and not all individuals from a release group had the same probability of detection or survival, because of the disproportionate tag burden experienced by the smallest individuals. These probability and detection differences would most specifically apply for those small fish passing a project through a turbine route where pressure changes are more likely, and could possibly explain why fish greater than 86 mm in length had a higher probability of detection than those 86 mm or smaller. Of course, other biases may exist for tagged fish some of which are discussed in H9.

6.9 H9: Are there Biological Costs of the Tagging Process and Carrying a Tag?

We hypothesized ($H9_0$) that the process of capture, holding, and tagging does not incur a biological cost on subyearling Chinook. Tag burden and the effect of a tag or tagging procedures on study fish is the focus of debate and continued research within the fisheries community, and a subject of interest in our study. Although, this topic was not a primary objective of 2011 efforts, we observed growth rates (calculated for recaptured fish) within the Wells Project that suggest some biological cost associated with capture, tagging, and handling. We recaptured 414 fish in the Wells Project 2 to 11 days after release. Although growth rates of these fish from release to recapture varied, in general, fish experienced relatively low growth rates (mean 0.34 mm/day) for up to ten days following release. In contrast, 0.77 mm/day was the growth rate we estimated for run-at-large fish in the Wells Reservoir, and the mean of growth rates calculated from fish recaptured at Rocky Reach Dam greater than 11 days post-release was 1.18 mm/day. Neither of these two measures is a perfect estimate of the rate at which fish grew in the reservoir because the run-at-large growth rate included new fish arriving over time and excluded fish that had moved offshore, thus negatively biasing the actual growth rate that an individual fish experienced in the project. Secondly, the estimated growth rate for fish recaptured at Rocky Reach Dam includes fish sampled later in the year when water temperatures were much warmer and growth might have been faster, thus positively biasing growth. Therefore, we hypothesize that actual growth in the reservoir should have been approximately in between 0.77 and 1.18 mm/d; much higher than the 0.34 mm/d observed in the 414 PIT-tagged recaptures. Importantly, we observed no clear relationship between the size of fish at tagging and growth rates within the 10 days post-tagging. Recaptured fish apparently experienced reduced growth over the first eleven days following tagging, irrespective of fish size at tagging.

We conclude that the reduced growth resulted from the tagging process (capture, holding, and tagging procedure), and not from tag burden, as a cost from tag burden would manifest as a lower growth rate for the smallest fish. Besides any effects from the stress of the capture/tagging process, one aspect of that process should almost certainly reduce the growth rates of tagged individuals—loss of foraging during the process. In our tagging procedure, we held fish overnight prior to tagging to allow them to recover from the capture process and to evacuate their stomachs. Following tagging, we held fish overnight to provide time for them to recover prior to release. Thus, the fish were starved for up to 48 hours post tagging, prior to release. The results of the food deprivation should manifest initially as reduced growth, and could differentially affect larger fish because of their higher metabolic demands (e.g., Clarke and Johnston 1999; Brett and Glass 1973; Wieser 1985), but because of the short duration of the process and the narrow size range of the fish, we do not anticipate a statistically significant difference in response due to fish size (and the occurrences of negative “growth” in our samples reveals the lack of precision in our measurements). Beyond the short-term consequences, the loss of two days of foraging may not result in longer term differences in size between study and run-at-large fish because of the phenomenon of compensatory growth (Nicieza and Metcalfe 1997); although

Johnsson and Bohlin (2006) reported a period of over five months was necessary for brown trout to fully compensate for reduced body length that resulted from temporary restrictions in food consumption. Since all of our study fish experienced the same tagging procedure, we do not expect to observe differential survival or growth in any release group resulting from the tagging process. Nevertheless, long-term fitness consequences may accrue from the tagging process and subsequent compensatory growth. Several researchers have documented such costs, including reduced swimming endurance (Royle at al. 2006) and burst swimming speed (Alvarez and Metcalfe 2007), and delayed mortality (Johnsson and Bohlin 2006). Without a laboratory component to our study we have no means to determine the occurrence or magnitude of such consequences.

From the observed data on reduced growth within the initial days post release, we accept alternate Hypothesis H9: that is, the process of capture, holding, and tagging incurs a biological cost on subyearling Chinook.

7.0 CONCLUSIONS

With data from only the first of a multi-year study available, we have already identified or confirmed challenges to studying the survival of subyearling Chinook originating above Wells Dam. We believe that an accurate and precise study of the survival of subyearling Chinook through the Wells Project is not possible unless we overcome the following logistical obstacles or violations of model assumptions (see Section 4 for the list of model assumptions):

1. Study fish are not representative of the population at large because we can only tag a subset of the population (violation of Model Assumption #1). Current versions of both PIT and acoustic tags are too large to tag the smallest fish (PIT) or most fish (acoustic), and the largest fish are not susceptible to our sampling gear.
2. Survival and detection probabilities are affected by the tags that we could use to study the survival of subyearling Chinook (violation of Model Assumption #2). Currently, tag sizes of both PIT and acoustic tags represent a tag burden that should disproportionately affect the survival and growth of smaller fish. The paired-release model may provide correction of “tag effects” if the other assumptions regarding detectability and survival probabilities were not also violated. However, see below…
3. Not all individuals from a release group have the same probability of survival, nor do they have the same probability of detection (violation of Model Assumptions #5, 6, and 9). We observed variation in migration timing and rates among fish captured and tagged from the same seine set, with passage of downstream projects occurring from within hours after release to at least until termination of bypass operations in mid-November. As described above, survival probability declines with increasing date, and environmental and biological conditions that influence survival probability are not uniform over the migration continuum of subyearling Chinook. Additionally, some fish migrated following shut-down of bypass operations, and long after the batteries of the currently available acoustic tags would have expired. Finally, detection probabilities were higher

for fish that were greater than 86 mm fork length at tagging, than for fish that were less than 87 mm at tagging.

We anticipate that data from additional years of study will refine our characterization of the behavior of subyearling Chinook in the Wells Reservoir, and reveal variations in their manifestation of life-history strategies over time and with changing environmental conditions. We also expect that continued advances in tag technology will enhance our ability to tag a more representative portion of the emigration. Nevertheless, considering the substantial reduction in tag mass necessary to both allow tagging of a broader range of sizes and to eliminate discrepancies in survival and detection probabilities between very large and very small individuals, we are not optimistic that technology will soon overcome these violations of model assumptions.

7.1 Recommendations

We intend the following recommendations to guide continued or future research into the life-history and behavior of subyearling Chinook in the mid-Columbia.

- Repeat the study for several years to allow comparison of year-to-year findings, and to evaluate behavior under different environmental conditions. Increase sample size with specific emphasis on locating fish from the Methow River. In 2011 we focused on fish from the Okanogan River since these fish were highly available and could be captured in a location where target fish were concentrated, by-catch was low, debris and snags were few, and that lacked mud and algae (that clog the net). Connor et al. (2002) reported that subyearling Chinook originating in the Clearwater River have higher propensity to residualize than Snake River Fall Chinook, and attributed this finding to water temperature differences between the two rivers. Since the Methow is colder than the Okanogan in the spring, we might expect Methow subyearlings to have a different proportion of the population manifesting the various life-history alternatives relative to Okanogan subyearlings.
- Refine our study hypotheses in response to the results of our analysis of the 2011 data.
- Sample fish from the mainstem Columbia River upstream of the mouth of the Okanogan River because these fish may have different growth and behavioral profiles than the fish originating from the Okanogan and Methow rivers.
- Continue to track tagged fish from 2011 through adult returns to quantify the incidence of winter emigration.
- Examine tag retention in a subset of tagged subyearlings, and modify net pens to allow collection of shed tags. Ombredane et al. (1998) reported no significant deficit in growth and survival for brown trout tagged when as small as 55 mm using an 11 mm PIT tag. However, these researchers also reported tag shedding greater than 3%, which was not evaluated in our 2011 study.
- Continue to explore the effects of tagging and tag bias.
- Analyze and assess the repeatability of behavioral size thresholds.
- Explore diel movements of subyearling fish in the Wells Project including depth preference of different sizes of fish. For example, in mid-July 1986 night snorkeling in Rock Island Reservoir revealed subyearling Chinook resting on sand and silt less than

one meter in depth and in slow-moving, backwater currents of less than 1cm/s (Chapman et al. 1994).

- Aim to reduce mortalities from capture, tagging, and handling stress to below 2%.

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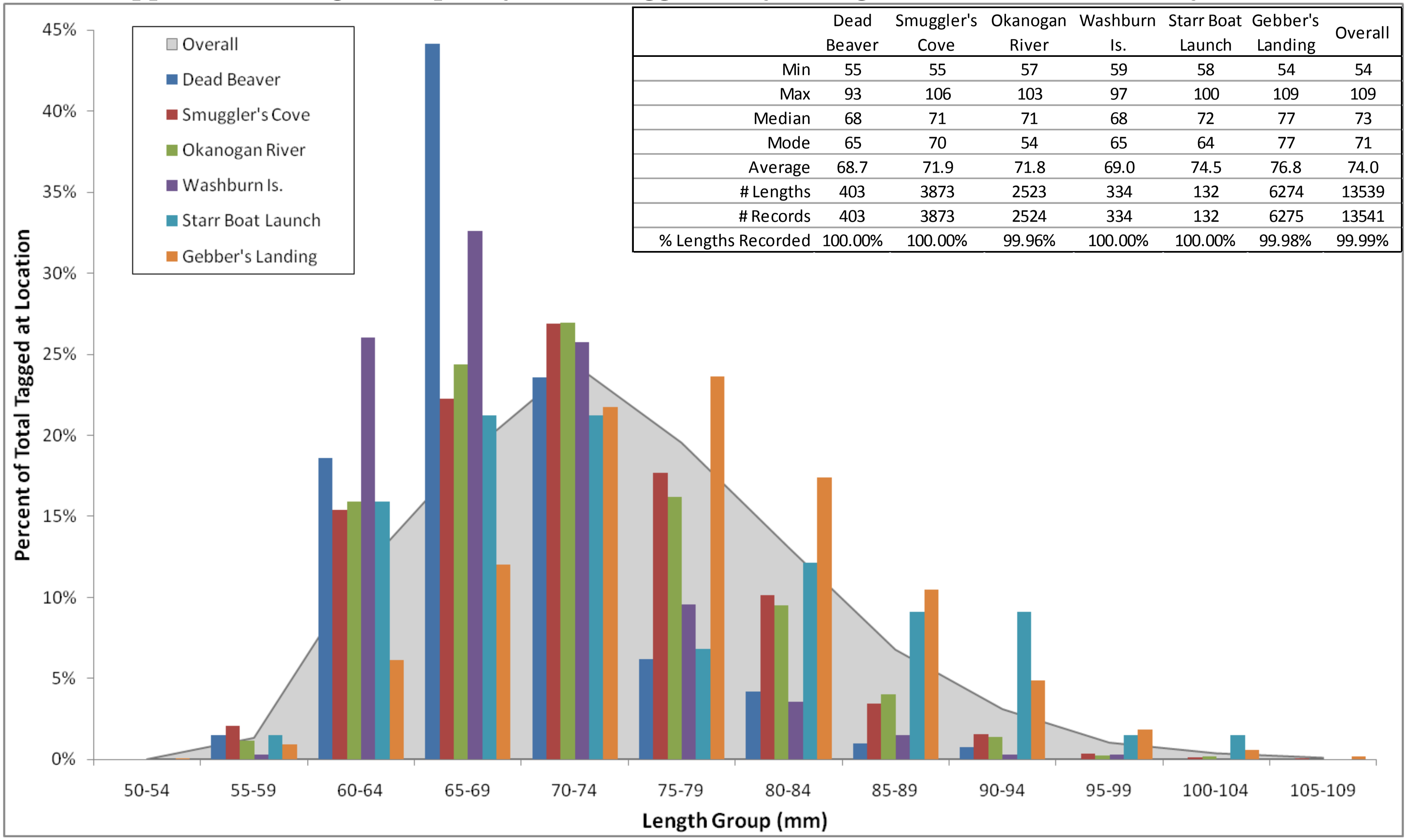
Appendix A. Estimate of bycatch during three weeks of beach seining in the Wells Project. Counts over 15 were estimates. ***Greater than 90% of the sockeye were fry <50 mm.**

Date	Sockeye*	Stickleback	Triploid Rainbow Trout	Common Carp	Sculpin	Sucker sp	Tench	Pikeminnow	Smallmouth bass	Chiselmouth	Bluegill	Redside Shiners
6/20/2011	100	500										
6/21/2011			2	4								
6/22/2011	250	500	1		20	20						
6/23/2011	100	250		4			2					
6/24/2011	No fishing											
6/25/2011	No fishing											
6/26/2011	No fishing											
6/27/2011								150				
6/28/2011				3		4	1	150	10	25		
6/29/2011				2		2		50	3		4	
6/30/2011			3	3		15	1	100	20			
7/1/2011	No fishing											
7/2/2011	No fishing											
7/3/2011	No fishing											
7/4/2011	No fishing											
7/5/2011								50				3
7/6/2011								25	25			
7/7/2011	No bycatch											
7/8/2011	No bycatch											
Species Total	450	1250	6	16	20	41	4	525	58	25	4	3
Grand Total	2402											
Species Total (%)	18.7%	52.0%	0.2%	0.7%	0.8%	1.7%	0.2%	21.9%	2.4%	1.0%	0.2%	0.1%

Appendix B. Length Frequency of PIT tagged sub yearling Chinook in Wells Pool by Week.



	Dead Beaver	Smuggler's Cove	Okanogan River	Washburn Is.	Starr Boat Launch	Gebber's Landing	Overall
Min	55	55	57	59	58	54	54
Max	93	106	103	97	100	109	109
Median	68	71	71	68	72	77	73
Mode	65	70	54	65	64	77	71
Average	68.7	71.9	71.8	69.0	74.5	76.8	74.0
# Lengths	403	3873	2523	334	132	6274	13539
# Records	403	3873	2524	334	132	6275	13541
% Lengths Recorded	100.00%	100.00%	99.96%	100.00%	100.00%	99.98%	99.99%

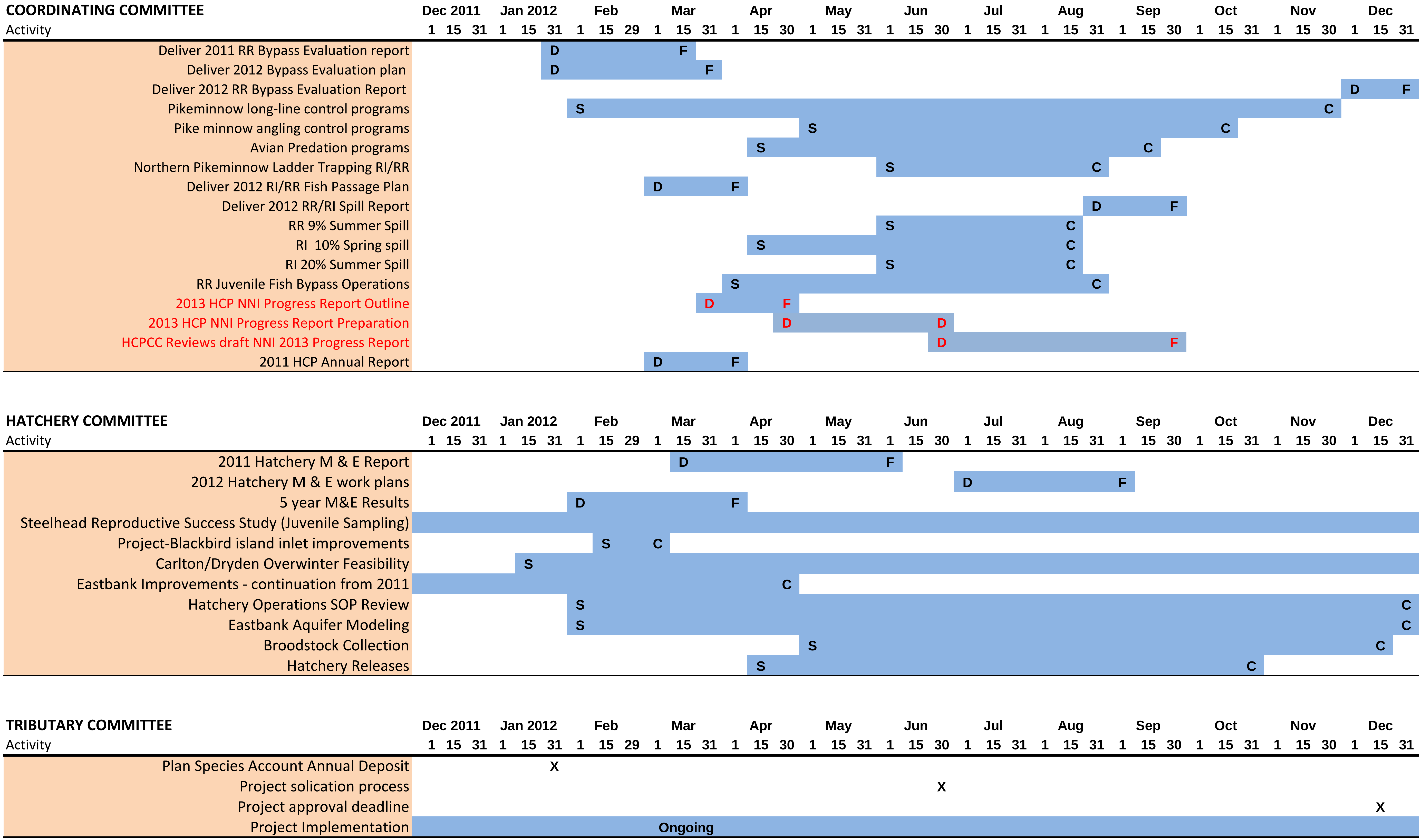
Appendix C. Recapture Summary by Location – Single Recaptures

Tag Location	Release Date	Recapture Site	Recap Date	# Recaps	Days After Release
Dead Beaver	22-Jun	Dead Beaver	22-Jun	5	0
	24-Jun	Dead Beaver	27-Jun	1	3
Smuggler's Cove	29-Jun	Smuggler's Cove	29-Jun	17	0
	29-Jun	Okanogan River	30-Jun	18	1
	29-Jun	Gebber's Landing	5-Jul	16	6
	29-Jun	Gebber's Landing	6-Jul	9	7
	29-Jun	Gebber's Landing	7-Jul	6	8
	29-Jun	Gebber's Landing	8-Jul	1	9
	30-Jun	Okanogan River	30-Jun	7	0
	30-Jun	Gebber's Landing	5-Jul	25	5
	30-Jun	Gebber's Landing	6-Jul	14	6
	30-Jun	Gebber's Landing	7-Jul	8	7
	1-Jul	Gebber's Landing	5-Jul	15	4
	1-Jul	Gebber's Landing	6-Jul	8	5
	1-Jul	Gebber's Landing	7-Jul	1	6
	1-Jul	Gebber's Landing	8-Jul	3	7
Gebber's Landing	7-Jul	Gebber's Landing	7-Jul	74	0
	7-Jul	Gebber's Landing	8-Jul	26	1
	8-Jul	Gebber's Landing	8-Jul	59	0
Okanogan River	23-Jun	Okanogan River	23-Jun	5	0
	23-Jun	Okanogan River	27-Jun	3	4
	23-Jun	Smuggler's Cove	28-Jun	1	5
	23-Jun	Smuggler's Cove	29-Jun	2	6
	23-Jun	Okanogan River	30-Jun	3	7
	25-Jun	Smuggler's Cove	27-Jun	3	2
	25-Jun	Okanogan River	27-Jun	1	2
	25-Jun	Smuggler's Cove	28-Jun	1	3
	25-Jun	Smuggler's Cove	29-Jun	2	4
	29-Jun	Gebber's Landing	5-Jul	1	6
	29-Jun	Gebber's Landing	6-Jul	1	7
	2-Jul	Gebber's Landing	5-Jul	36	3
	2-Jul	Gebber's Landing	6-Jul	20	4
	2-Jul	Gebber's Landing	7-Jul	6	5
	2-Jul	Gebber's Landing	8-Jul	4	6

Appendix C. Recapture Summary by Location – Double Recaptures

Tag Location	Release Date	Recapture 1		Recapture 2	
		Location	Date	Location	Date
Smuggler's Cove	6/29	Okanogan River	6/30	Gebber's Landing	7/5
Smuggler's Cove	6/29	Okanogan River	6/30	Gebber's Landing	7/6
Smuggler's Cove	6/29	Gebber's Landing	7/5	Gebber's Landing	7/7
Smuggler's Cove	6/30	Gebber's Landing	7/5	Gebber's Landing	7/7
Smuggler's Cove	6/30	Gebber's Landing	7/5	Gebber's Landing	7/7
Smuggler's Cove	6/30	Gebber's Landing	7/5	Gebber's Landing	7/8
Smuggler's Cove	6/30	Gebber's Landing	7/5	Gebber's Landing	7/8
Smuggler's Cove	6/30	Gebber's Landing	7/6	Gebber's Landing	7/8
Smuggler's Cove	7/1	Gebber's Landing	7/6	Gebber's Landing	7/8
Okanogan River	7/2	Gebber's Landing	7/5	Gebber's Landing	7/7
Okanogan River	7/2	Gebber's Landing	7/5	Gebber's Landing	7/7
Okanogan River	7/2	Gebber's Landing	7/5	Gebber's Landing	7/8
Okanogan River	7/2	Gebber's Landing	7/6	Gebber's Landing	7/8

APPENDIX I
2012 CHELAN PUD
HCP ACTION PLAN



D = Draft Document
F = Final Document
S = Start Project
C = Complete Project

APPENDIX J
2012 ROCKY REACH JUVENILE FISH BYPASS OPERATIONS PLAN

2012 Rocky Reach Juvenile Fish Bypass Operations Plan

Prepared By:

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P.O. Box 1231
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Wenatchee, Washington 98801

February 2012

Introduction

The Public Utility District of Chelan County (District) constructed and installed a permanent fish bypass system (FBS) in 2002/2003. The bypass system is designed to guide juvenile salmon and steelhead away from turbine intakes at Rocky Reach Dam. The system consists of one surface collector entrance (SC) and the intake screen (IS) system in turbine units 1 and 2. Please refer to Mosey (2004) for a detailed description of the bypass production system.

Studies and data collection at the Rocky Reach FBS fall under one of two general categories “Standard Operations” or “Special Operations” for bypass evaluations. Activities and data collection under standard operations include day to day sampling of run-of-river (ROR) fish to evaluate run timing, species composition, and fish condition after passage. Special operations may include additional sampling time to supply fish for marked fish releases.

2012 Evaluation Requirements

Run-of-river fish collected at the Juvenile Sampling Facility (JSF) to evaluate and provide fish for the following:

1. Run timing of target species:
    a. Provide standardized juvenile capture rate data to supplement Program RealTime (UW) run-timing predictions
    b. Guide decisions about initiating summer fish spill

2. Fish species composition:
    a. Guide decisions about starting or stopping spill
        i. Currently summer fish spill occurs at Rocky Reach. Chelan PUD

3. Origin of fish stocks and identification of marked individuals:
    a. PIT tags
    b. Fin clips

4. Fish condition:
    a. Ensure that the bypass system remains safe for migrating juvenile salmon and steelhead by evaluating:
        i. Descale: 20% or more scale loss on either side
        ii. Injury: Scratches, bruises, or hemorrhages
        iii. Mortality: Any fish dead on arrival to sampling facility

2012 Study Methods

For more information about the study methods please refer to Mosey (2004).

Standard Operations:

1. Sampling Periods (1 April to 31 August):
    a. Monday through Sunday
    b. Collections Times
        i. 30 minute maximum **(or)**

        i. 0800-0830
        ii. 0900-0930
        iii. 1000-1030
        iv. 1100-1130
    ii. Target number of fish
        i. 350 spring species
        ii. 125 summer species

2. Fish Condition:
    a. First 100 fish of each species are examined for condition:
        i. Descale
        ii. Injury
        iii. Mortality

3. Species Composition:
    a. ROR fish collected are enumerated by species
    b. Collect data for Program RealTime to determine start and end of spill
    c. Currently summer fish spill occurs at Rocky Reach.

4. Origin of fish stocks and identification of marked individuals:
    a. PIT tags
    b. Fin clips

Special Operations:

1. Marked Fish Releases (Prior 1 April):
    a. Prior to the 1 April system start-up, hatchery yearling Chinook will be used for marked fish releases to determine if the JFBS is causing descale, injury, or mortality.
        i. Releases will be conducted with hatchery summer chinook prior to the 1 April start date to determine if the JFBS is working properly and to help isolate potential sources of descale, injury, and mortality.
        ii. Fish (n = 100/release) of varying sizes will be randomly selected from hatchery chinook. Only those with no scale loss or injury will be marked.
        iii. Marked fish will be systematically released at locations upstream of the sampling screen in the bypass system and into both intake screens in units C1 and C2.
        iv. If potential problems are identified, resolve problems by 1 April system start-up.

2. Marked Fish Releases (1 April-31 August):
    a. A phased approach will be used to evaluate the descaling rate, injury rate, and mortality rate of fish passing through the bypass system. We developed a sampling protocol and threshold percentages (Table 1) for descale, injury and mortality that will trigger study phases.

b. Identify "ambient" rates of descale, injury and mortality.
c. Once the ambient rate is estimated and if further sampling shows descale problems continuing at 5%, (3% for injury, 2% for mortality) *above* ambient level for three consecutive samples.
   i. If variable rates of descale, injury or mortality do occur between species, then collection of yearling chinook, sockeye, or steelhead may be necessary for marked releases.
   ii. Fish (n = 100/release) of varying sizes will be randomly selected at the juvenile facility and only those migrants with no scale loss or injury will be marked.
   iii. Marked fish will be systematically released at locations upstream of the sampling screen in the bypass system until the problem area is isolated.
d. Identify circumstances when we would refer to the HCP Coordinating Committee.
e. The District will consult with the Coordinating Committee if any abnormal fish conditions (within values outlined in Table 1) are observed in the sample population.

Table 1. Flow diagram of phased approach and threshold values for conducting marked-fish releases in the *juvenile bypass system at Rocky Reach Dam (Skalski and Townsend 2003)*

	Phase 1		Phase 2		Phase 3		Phase 4
Threshold		**5% initl**		**A*+5%**		**A*+15%**	
Descale	Index sampling for for descale rate	→	Mark-releases to est. ambient descale	→	In-system mark-releases to isolate descale problem	→	refer to HCP Coord. Comm.
Threshold		**3% initl**		**A*+3%**		**A*+10%**	
Injury	Index sampling for for inury rate	→	Mark-releases to est. ambient injury	→	In-system mark-releases to isolate injury problem	→	Temp. bypass shutdown refer to HCP Coord. Comm.
Threshold		**2% initl**		**A*+2%**		**A*+4%**	
Mortality	Index sampling for for mortality rate	→	Mark-releases to est ambient mortality	→	In-system mark-releases to isolate mortality problem	→	Temp. bypass shutdown refer to HCP Coord. Comm.

A* = Ambient percentage

3. Collection of Bull Trout:
   a. Document:
      i. Fork Length and weight measurements
      ii. Condition (descale, injury, or mortality)
   b. Allow to recover, then release

Daily Protocol for Fish Collection

Standard Operations:

1. Deploy sampling screen at beginning of each hour (0800, 0900, 1000, 1100 hours).
2. Using direct enumeration to count fish entering the sampling facility
3. Collect for 30 minutes **or** until approximately 350 spring migrants/125 summer migrants have been collected, whichever comes first. RETRACT SCREEN IF 200 TO 300 FISH ARE COLLECTED IN FIRST TWO MINUTES.
4. Retract screen when time period or target number of fish has been reached.
5. Determine species composition of all collected fish in the hourly sample.
6. Scan/examine each fish for PIT tags, fin clips, and acoustic tags.
7. Evaluate fish condition (first 100 fish per species).
8. If needed, collect and hold fish for marked releases (Special Operations).
9. Return to step 1 for next sample period. After the 1100 hour sample, go to step 11.
10. See Special Operations
11. Allow anesthetized fish (examined for species composition and fish condition) to recover in the facility's holding tank for at least 1.5 hours.

Special Operations:

1. If fish are collected for marked fish releases, verify that the required number of target species has been set aside from the four sample periods.
2. If the required number of fish are not collected by the 1100 hour sample period, deploy the sampling screen and repeat steps 2 and 4 under standard operations.
3. Scan/check all anesthetized fish for PIT and acoustic tags.
4. Collect and hold the fish at the facility for transport and/or marking (marked fish releases).
5. Determine species composition for any remaining anesthetized fish and scan for PIT tags.
6. After fish have been collected to meet study needs, estimate the number of fish remaining in the raceway (by species to the extent practical), record the number, and immediately release the fish back into the bypass pipe.
7. Return to step 11 under Standard Operations.

Contingencies:

1. If, after start-up of the bypass system, we encounter any unforeseen problem(s) with fish collection, we will immediately consult with the HCP Coordinating Committee on how to correct the problem(s).
2. If we accumulate many fish during a collection period (e.g. just after a hatchery release), we will only handle/sample the number of fish needed to satisfy the study requirements and then immediately release the remaining fish back into the bypass pipe.
3. If we accumulate many fish during each "index" sample period, we will only evaluate species composition in the first three periods. In the final period, we will evaluate descale and injury, regardless of the number of fish. However, we will

be attentive to any injury or descale that may be present among the fish in each of the first three periods. We need to allow enough time (between samples) to gather all species composition information, so that we have representative information on daily passage.

Diversion Screen and Trashrack Cleaning (Units 1 and 2):
During the last week of March, the trashracks in front of Units 1 and 2 (six intakes total) will be cleaned by divers and clammed to remove any dislodged debris. The trash rack cleaning will be repeated as differentials increase across the racks due to debris load. A mid-season cleaning will be scheduled in June. Starting 1 April, the vertical barrier and diversion screens (IS system) will be cleaned one to two times per week or as needed with an automated screen cleaner. Careful observation of trash build up will also be monitored and the screens will be cleaned on a more regular basis if warranted. Frequency of the cleanings may increase depending on debris load during spring run-off and aquatic plant load in the summer. The District will log each screen cleaning, and in the event of high descaling/injury in a single sample, the vertical barrier and diversion screens will be inspected prior to releasing marked fish.

Discussion

The 2012 biological studies at Rocky Reach will encompass the following: 1) a continuing evaluation of the juvenile bypass system, and 2) a daily sampling program to monitor fish passage for run timing and diel passage. Representatives of various research agencies and the HCP Coordinating Committee will be consulted about the development of detailed study plans and protocols. A time line showing important activities and deadlines for these activities has been developed and is presented in Table 2.

Table 2. Tasks and deadlines for the Rocky Reach 2012 biological evaluations.

Task	Deadline
Present 2012 study plan to Committee	**Winter 2011-2012**
Committee discussion/comments on study plan	**Feb. 21, 2012-Mar. 20, 2012**
Pre-season JFB operations testing (marked fish releases prior to 1 April)	March 15, 2012-March 31, 2012
Begin biological evaluation of JFB	April 1, 2012
Complete 2012 biological evaluation	August 31, 2012
Present 2012 evaluation report to Committee	**December 31, 2012**
Committee comments on 2012 report	**February 1, 2013**
Present 2012 final report to Committee	March 1, 2013

****Tasks printed in bold text require action by the HCP Coordinating Committee.**

References

Mosey, T. R., S. L. Hemstrom, and J. R. Skalski. 2004. Study Plan for the Biological Evaluation for the Rocky Reach Fish Bypass System-2004. Chelan County Public Utility District, Wenatchee, Washington.

APPENDIX K
2012 FISH SPILL PLAN ROCK ISLAND AND ROCKY REACH DAMS

2012 Fish Spill Plan

Rock Island and Rocky Reach Dams

Public Utility District No. 1 of Chelan County

Prepared By:

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Public Utility District No. 1 of Chelan County
Wenatchee, Washington

Final
March 28, 2012

Introduction and Summary

In 2012, spill operations for fish passage at the Rock Island and Rocky Reach and projects will be implemented by Public Utility No. 1 of Chelan County (Chelan PUD) as specified by the respective Habitat Conservation Plan (HCP) for each project, and agreements (SOAs) made by the HCPs' Coordinating Committees following achievement of survival standards using certain Project and spill operations. The Rock Island Project completed eight years of HCP survival testing in 2010 for spring migrating Plan Species (Steelhead, yearling Chinook, sockeye) with a 10 percent spill levels that will be adhered to through 2020. Rocky Reach completed its suite of HCP spring survival studies for Plan Species in 2011, under no-spill operation at the dam. Spring and summer spill levels at each Project are summarized in table 3 of this plan. Chelan PUD holds valid Incidental Take Statements (ITS) from NOAA Fisheries (NOAA) and the United States Fish and Wildlife Service (USFWS) for HCP fish spill operations at the Projects.

For the 2012 juvenile outmigration, Chelan PUD will operate the Rocky Reach juvenile fish bypass system (JFBS) starting 1-April for the spring juvenile outmigration of yearling Chinook, steelhead, and sockeye. Spring spill is not required at Rocky Reach Dam in addition to juvenile bypass operations because of high bypass efficiency and HCP Project survival standards achieved with bypass-only operations. During the subyearling Chinook outmigration in 2012, Rocky Reach will spill 9 percent of day average river flow for a duration covering 95 percent of subyearling outmigration past the dam.

At Rock Island Dam in 2012, Chelan PUD will operate the Project with a 10 percent day-average spill level for the spring outmigration period. Rock Island has completed HCP spring survival testing for all HCP Plan species with a 10 percent spill level at the dam, achieving juvenile survival standards for steelhead and sockeye and combined adult-juvenile survival for spring Chinook.

During the summer period, Rock Island will spill 20 percent of the day-average river flow for the outmigration of sub-yearling Chinook. Spill is the primary means of juvenile salmon and steelhead passage at Rock Island per Section 5.4.1(a) of the Rock Island HCP. Spring and summer spill will cover 95 percent of the juvenile outmigration for yearling Chinook, steelhead, sockeye, and subyearling Chinook in 2012.

Rocky Reach Spring Juvenile Bypass Operations

Rocky Reach will operate its JFBS continuously through the spring outmigration period, beginning 1-April, 2012. Index counts for steelhead, yearling Chinook, and sockeye will be performed at the bypass each day to estimate the outmigration percentiles for each species through the spring period. During “index sample hours” (0800-1130) a 30-minute sample will be taken at the juvenile sampling facility at the start of each hour. Spring spill for fish passage is not required at Rocky Reach in addition to the JFBS operation, but periods of forced spill under high river flows may occur. Forced spill (river flow above 201 kcfs turbine capacity) has occurred at Rocky Reach 26 percent of all hours in April, May, and June, 1992-2011.

Sampling protocols at the JFBS in 2012 will remain consistent with those used in 2004-2011. Smolts will be sub-sampled daily (Monday through Sunday) from the bypass for four 30-minute “index periods” at 0800, 0900, 1000, and 1100 hours (Table 1). The sample target for each 30-minute sampling replicate will be 350 smolts during the spring period (yearling Chinook, steelhead, and sockeye combined), and 125 smolts for summer period (subyearling Chinook). If the number of fish in the bypass sampling raceway is estimated to reach the target number any time prior to completion of the 30-minute sample, the sampling screen will be retracted from the bypass flume and the number of fish collected in the shortened sample period will be proportionately expanded to the entire 30-minute period.

Table 1. Index sampling times and number of smolts per sample at the Rocky Reach juvenile fish bypass system in 2012.

Time	Sample Duration	Number of Smolts	Day of Week
0800-0830	30 minutes*	350 (spring) 125 (summer)	Monday-Sunday
0900-0930	30 minutes*	350 (spring) 125 (summer)	Monday-Sunday
1000-1030	30 minutes*	350 (spring) 125 (summer)	Monday-Sunday
1100-1130	30 minutes*	350 (spring) 125 (summer)	Monday-Sunday

*Sample duration may be less than 30 minutes if smolt numbers are met prior to full 30 minute sample time

Rocky Reach Summer Spill Operations

The summer spill rate at Rocky Reach for subyearling Chinook will be 9 percent of day average river flow, and will commence in early June upon arrival of subyearling Chinook smolts in the Rocky JFBS samples. Juvenile run-timing information at Rocky Reach will be used to determine subyearling Chinook passage percentiles and spill duration to cover 95 percent of the summer outmigration. Daily subyearling counts from index samples at the bypass juvenile collection facility, in combination with the University of Washington's Program RealTime run forecaster, will be used to determine spill start and stop times for summer spill program.

The HCP guidelines for starting and ending summer spill at Rocky Reach are as follows:

1. Summer spill will start at midnight on the day that the estimated 1-percentile passage point, as indicated by Program RealTime run-forecast model, has been reached. S*ubyearling* Chinook will be defined as any Chinook having a fork length from 75 mm to 150 mm.

2. Summer spill season will generally end no later than 15-August, or when subyearling index counts from the juvenile bypass sampling facility are 0.3 percent or less of the cumulative run for three out of any five consecutive days (same protocol used 2004-2011) and Program RealTime is estimating that the 96 percentile passage point has been reached.

Diel Spill Shaping at Rocky Reach and Rock Island

Daily spill volumes will be shaped within each 24-hour period at Rocky Reach during the summer, and the same at Rock Island during both spring and summer spill periods (Table 2). The purpose of diel spill shaping is to vary spill rates within the day to coincide with higher or lower periods of juvenile fish passage. Spill shaping is based on observed diel (24-hour) passage distributions of smolts at each project during spring and summer (Steig et al. 2009, Steig et al. 2010, Skalski et al. 2009, Skalski et al. 2010, Skalski et al. 2011). The different spill percentages and time blocks are shaped such that the summation of water volume from all time blocks within the day equals the volume of water that would have been spilled under a constant, unshaped spill level (for instance 9 percent day-average spill at Rocky Reach with no shaping). This spill strategy attempts to optimize spill water volume to maximize spill passage effectiveness for smolts. Hourly spill shaping in 2012 will be consistent with previous years, 2004-2011.

Table 2. Spill percentages and spill shape for the Rocky Reach spill program, 2012.

Project	Season	Spill Percent	Spill Shape	Hour Block	Time	Percent of River
Rocky Reach	Spring	none	none	--	--	--
Rocky Reach	Summer*	9%	Med	1	00:00-01:00	9.0%
			Low	6	01:00-07:00	6.0%
			Med	2	07:00-09:00	9.0%
			High	6	09:00-15:00	12.0%
			Med	9	15:00-00:00	9.0%

*Spill for subyearling Chinook

2012 Run-Timing Predictions

Chelan PUD contracts with the University of Washington to provide run-timing predictions and year-end observed values for spring and summer out-migrating percentiles for salmon and steelhead. The Program RealTime run-time forecasting model is used for this purpose. Program Real-Time provides daily forecasts and cumulative passage percentiles for steelhead, yearling Chinook, sockeye, and subyearling Chinook at both Rocky Reach and Rock Island. The program enables Chelan PUD to better predict the time when a selected percentage of these species will arrive, and when a given percentage of any stock has passed (for example, the 5 percent passage point for spring species at Rock Island to trigger spring spill). The program utilizes daily fish counts from the Rocky Reach JFBS sampling facility and the juvenile bypass trap at Rock Island. Estimates of passage percentiles are generated with the model's forecast error are displayed with the daily predictions at:

http://www.cbr.washington.edu/crisprt/

Historic Run Timing

Estimated mean dam passage dates (first percentile to the 95th percentile) for each species at Rocky Reach and Rock Island are summarized in Table 3. Run-timing dates are estimated from daily index sample counts at the Rocky Reach JFBS, 2004-2011, and from the Rock Island Dam smolt bypass trap, 2000-2011 (Table 3). At Rocky Reach, the subyearling Chinook run generally begins the first week of June, with the one percentile passage date on 3-June (mean date for years 2004-2011). Rocky Reach subyearling passage reaches the 95th percentile, on average, around 11-August (2004-20l1, range: 27-July to 24-August).

Rock Island Dam juvenile salmon and steelhead sampling from the Smolt Monitoring Program (SMP), 2000-2011, indicates that the fifth percentile (5 percent) mean passage date for combined spring migrants (yearling Chinook, steelhead, and sockeye) occurs on 18-April (Table 3). The latest spring spill start date for Rock Island per the HCP is 17-April. The summer outmigration of subyearling Chinook smolts at Rock Island generally begins in early June (although fry are encountered earlier), and on average, reaches the 95th percentile on 9-August (range: 1-August to 18-August, 2000-2011).

Table 3. Spill percentages and the mean passage durations between the 1st and 95th percentile passage points for spring and summer outmigrations, bypass operation dates, and spill percentages for each HCP Plan species at Rocky Reach and Rock Island dams.

Rocky Reach	**steelhead**	**yearling Chinook**	**sockeye**	**subyearling Chinook**
Percent Spill	0% Spring	0% Spring	0% Spring	9% Summer
95 percentile passage duration	4/16 – 5/31	4/22 – 6/1	5/7 - 5/28	6/3 - 8/11
RR JFBS Operating?	Yes 4/1 – 8/31	Yes 4/1 – 8/31	Yes 4/1 – 8/31	Yes 4/1 – 8/31
Rock Island	**steelhead**	**yearling Chinook**	**sockeye**	**subyearling Chinook**
Percent Spill	10% Spring	10% Spring	10% Spring	20% Summer
95 percentile passage duration	4/22 - 6/10	4/14 - 6/6	4/19 - 6/20	6/3 - 8/9
RI Bypass Trap SMPS Site	4/1 - 8/31	4/1 - 8/31	4/1 - 8/31	4/1 - 8/31

Source Rock Island: http://www.cbr.washington.edu/crisprt/index_midcol2_pi.html
Source Rocky Reach: http://www.cbr.washington.edu/crisprt/index_midcol2_che.html

Rock Island 2012 Spring Spill

In 2012, Rock Island Dam will spill 10 percent of the day average river flow spill beginning no later than 17-April, and end spill after 95 percent of spring outmigrants have passed the dam (usually the first week of June). Spill volume will be shaped to maximize spill efficiency (Table 4). Chelan PUD personnel will operate the Rock Island bypass trap, an upper Columbia Smolt Monitoring Program (SMP) site, continuously from 1-April through 31-August, seven days per week to provide daily smolt counts. Index counts will provide the basis to determine the start and end the spring and summer outmigration periods. HCP SOA guidelines to start and end the spring spill program at Rock Island are as follows:

1. The Rock Island spring spill program will begin when the Rock Island daily passage index (expanded counts) exceeds 400 fish for more than 3 days (this corresponds to the historic 5 percent passage date), or no later than 17-April, as outlined in Section 5.4.1. (a) of the Rock Island HCP. Smolt counts from the lower Wenatchee River smolt trap will also be used (trap is anticipated to be installed in 2012 by WDFW, near Cashmere, WA.) as an indicator of fish movement.

2. Rock Island spring spill will end following completion of the spring outmigration (95 percent passage point), and subyearling Chinook have arrived at the Project.

Rock Island 2012 Summer Spill

Rock Island will spill 20 percent of the daily average river flow for a duration covering 95 percent of the summer out migration of subyearling Chinook. Daily counts from the Rock Island bypass trap will provide the basis for decisions to the start and stop spill at Rock Island Dam. The HCPCC SOA guidelines to start and stop the summer spill at Rock Island are outlined as follows:

1. Rock Island summer spill in 2012 will begin immediately after completion of the spring spill. The summer spill level will be 20 percent of day average flow, shaped to increase spill efficiency, and continue for a duration covering 95 percent of the subyearling outmigration.

2. Summer spill will generally end no later than 15-August, or when subyearling counts from the Rock Island trap are 0.3 percent or less of the cumulative run total for any three out of five consecutive day period, and Program RealTime is estimating 95 percent run completion (same protocol used in 2004-2011).

Table 4. Spill percentages and hourly spill shape for the Rock Island spring and summer fish spill program, 2012.

Project/Season	Daily Spill Average	Spill Levels	Duration (# of hours)	Time of Day	Spill Shape %
Rock Island Spring*	10%	High	4	0000-0400	12.5
		Med	3	0400-0700	10.0
		Low	5	0700-1200	6.0
		Med	8	1200-2000	10.0
		High	4	2000-2400	12.5
Rock Island Summer**	20%	High	1	0000-0100	23.0
		Med	1	0100-0200	19.0
		low	8	0200-1000	15.0
		Med	1	1000-1100	19.0
		High	13	1100-2400	23.0

*Spring spill for yearling Chinook, steelhead, and sockeye

**Summer spill for subyearling Chinook

Spill Program Communication

Chelan PUD's fish spill coordinator will notify the HCP Coordinating Committee (HCPCC) not less than once per week when fish passage numbers indicate that specific triggers for starting or stopping spill are likely to occur in the immediate future. Chelan PUD will also contact the HCPCC regarding any unforeseen issues that pertain to the spill program as the season progresses. Communications with the HCPCC on spill information will generally be made by email and pre-scheduled conference calls.

Literature Cited

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APPENDIX L
FINAL 2012 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
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August 13, 2012

To: NMFS and HCP-HC and PRCC-HSC committee members

From: Mike Tonseth, WDFW

Subject: **FINAL 2012 UPPER COLUMBIA RIVER SALMON AND STEELHEAD BROODSTOCK OBJECTIVES AND SITE-BASED BROODSTOCK COLLECTION PROTOCOLS**

The attached protocol was developed for hatchery programs rearing spring Chinook salmon, sockeye salmon, summer Chinook salmon and summer steelhead associated with the mid-Columbia HCPs, spring Chinook salmon and steelhead programs associated with the 2008 Biological Opinion for the Priest Rapids Hydroelectric Project (FERC No. 2114) and fall Chinook consistent with Grant County Public Utility District and Federal mitigation obligations associated with Priest Rapids and John Day dams (ACOE funded), respectively. These programs are funded by Chelan, Douglas, and Grant County Public Utility Districts (PUDs) and are operated by the Washington Department of Fish and Wildlife (WDFW). Additionally, the Yakama Nation's (YN) Coho Reintroduction Program broodstock collection protocol, when provided by the YN, will be included in this protocol due to the overlap in trapping dates and locations.

This protocol is intended to be a guide for 2012 collection of salmon and steelhead broodstocks in the Methow, Okanogan, Wenatchee, and Columbia River basins. It is consistent with previously defined program objectives such as program operational intent (i.e., conservation and/or harvest augmentation), mitigation production levels (HCPs, Priest Rapids Dam 2008 Biological Opinion), changes to programs as approved by the HCP-HC, and to comply with ESA permit provisions.

Notable in this years protocols are:

- No sockeye in 2012.
- No age-3 males will be incorporated into spring or summer Chinook programs
- All NNI programs will have reductions in adult collection requirements due to re-calculation of NNI impacts per HCP's and Settlement Agreements.
- Implementation of the draft Production Management Plan (Appendix B), for all programs where possible, to ensure mitigation production levels are met and that the permitted production ceiling is not exceeded at release.

- Utilization of genetic sampling/assessment to differentiate Twisp River and non-Twisp River natural-origin spring Chinook adults collected at Wells Dam, and CWT interrogation during spawning of hatchery spring Chinook collected at the Twisp Weir, Methow FH and Winthrop NFH to differentiate Twisp and Methow Composite hatchery fish for discrete management of Twisp and Methow Composite production components.

- The collection of hatchery-origin spring Chinook for the Methow River Basin program in excess of production requirements, for BKD management.

- A smolt production target for the Chiwawa program in 2012 (2014 release) of 204,452 smolts (144,026 for Wenatchee basin mitigation and a one year agreement to produce CPUD's Methow obligation of 60,516 smolts).

- Targeted collection of 100% of the Wenatchee summer Chinook and Wenatchee hatchery origin steelhead broodstock at Dryden Dam to reduce the number of activities that may contribute to delays in fish passage at Tumwater Dam (some adult collections at Tumwater may be necessary if sufficient adults cannot be acquired at Dryden Dam).

- Targeted collection of 100% of the natural origin steelhead broodstock at Tumwater Dam

- Collection of summer Chinook broodstock from the Wells Hatchery volunteer channel, sufficient to meet a 576K yearling juvenile Chelan Falls program. For 2012 the adults will be transferred to Eastbank FH.

  Collection of 24-natural origin steelhead at the Twisp Weir in the spring of 2013. Adults will be transferred to Methow Hatchery for spawning and biosecure, isolated incubation through the eyed-egg stage after which they will be moved to Wells FH for the remainder of rearing.

- Collection of surplus hatchery origin steelhead from the Twisp Weir (up to 25% of the required broodstock) to produce the 100K Methow on-station-released smolts (up to 13 adults). The remainder of the broodstock (37) will be WNFH returns collected at WNFH and surplus to the WNFH program needs. The collection of adults will occur in spring of 2013.

- The collection of natural-origin summer Chinook adults for the 2012 BY Okanogan summer Chinook program in the Wells Reservoir via purse seine (approximately 112 fish). Adults collected for the DC portion of the Okanogan summer Chinook mitigation (26 adults) will be transferred, spawned, incubated, and early reared at Wells FH.

- The collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the USFWS, Entiat NFH summer Chinook programs (requires agreement of the HCP Hatchery Committee [HC]).

- The collection from the Wells Hatchery volunteer channel of Wells summer Chinook to support the Yakama Nation (YN) summer Chinook re-introduction program in the Yakima River Basin (requires agreement of the HCP HC). Transfer will occur as gametes.

These protocols may be adjusted in-season, based on actual run monitoring at mainstem dams and/or other sampling locations. Additional adaptive management actions as they relate to broodstock objectives may be implemented as determined by the HCP-HC or PRCC-HSC and within the boundaries of applicable permits.

Above Wells Dam

Spring Chinook

Inclusion of natural-origin fish in the broodstock will be a priority, with natural-origin fish specifically being targeted. Collections of natural-origin fish will not exceed 33% of the MetComp and Twisp natural-origin run escapement to maximize natural origin fish on the spawning grounds.

To facilitate BKD management, comply with ESA Section 10 permit take provisions, and to meet programmed production, hatchery-origin spring Chinook will be collected in numbers excess to program production requirements. Based on historical Methow FH spring Chinook ELISA levels above 0.12, the hatchery origin spring Chinook broodstock collection will include hatchery origin spring Chinook in excess to broodstock requirements by approximately 19.4% (based upon the most recent 5-year mean ELISA results for the program). For purposes of BKD management and to comply with maximum production levels and other take provisions specified in ESA Section 10 permit 1196, culling will include the destruction of eggs from hatchery-origin females with ELISA levels greater than 0.12 and/or that number of hatchery origin eggs required to maintain production at 223,765 yearling smolts. Culling of eggs from natural-origin females will not occur unless their ELISA levels are determined by WDFW Fish Health to be a substantial risk to the program. Progeny of natural-origin females, with ELISA levels greater than 0.12, will be differentially tagged for evaluation purposes. Annual monitoring and evaluation of the prevalence and level of BKD and the efficacy of culling in returning hatchery- and natural-origin spring Chinook will continue and will be reported in the annual monitoring and evaluation report for this program.

Recent WDFW genetic assessment of natural-origin Methow spring Chinook (Small et al. 2007) indicated that Twisp natural-origin spring Chinook can be distinguished, via genetic analysis, from non-Twisp spring Chinook with a high degree of certainty. The Wells HCP Hatchery Committee accepted that Twisp-origin fish could be genetically assigned with sufficient confidence that natural origin collections can occur at Wells Dam. Scale samples and non-lethal tissue samples (fin clips) for genetic analysis will be obtained from adipose-present, non-CWT, non-ventral-clipped spring Chinook (suspected natural-origin spring Chinook) collected at Wells Dam, and origins assigned based on that analysis. Natural-origin fish retained for broodstock will be PIT tagged (dorsal sinus) for cross-referencing tissue samples/genetic analyses. Tissue samples will be preserved and sent to WDFW genetics lab in Olympia Washington for genetic/stock analysis. The spring Chinook sampled will be retained at Methow FH and will be sorted as Twisp or non-Twisp natural-origin fish prior to spawning. The number of natural-origin Twisp and Methow Composite (non-Twisp) spring Chinook retained will be dependent upon the number of natural-origin adults returning and the collection objective limiting extraction to no greater than 33% of the natural-origin spring Chinook return to the Methow Basin. Based on the broodstock-collection schedule (3-day/week, 16 hours/day), extraction of natural-origin spring Chinook is expected to be approximately 33% or less.

Weekly estimates of the passage of Wells Dam by natural-origin spring Chinook will be provided through stock-assessment and broodstock-collection activities. This information will facilitate in-season adjustments to collection composition so that extraction of natural-origin spring Chinook remains less than 33%. Twisp and Methow Composite hatchery-origin spring Chinook will be captured at the Twisp Weir, and Methow FH outfall. Trapping at the Winthrop NFH will be included if needed because of broodstock shortfalls.

Pre-season run-escapement of Methow-origin spring Chinook above Wells Dam during 2012 are estimated at 3,090 spring Chinook, including 2,609 hatchery and 481 natural origin spring Chinook (Table 1 and Table 2). In-season estimates of natural-origin spring Chinook will be adjusted proportional to the estimated returns to Wells Dam at weekly intervals and may result in adjustments to the broodstock collection targets presented in this document.

The following broodstock collection protocol was developed based on the re-calculated program production levels (223,765 smolts), BKD management strategies, projected return for BY 2012 Methow Basin spring Chinook at Wells Dam (Table 1 and Table 2), and assumptions listed in Table 3.

The 2012 Methow spring Chinook broodstock collection will target up to 166 adult spring Chinook (24 Twisp, 142 Methow). Based on the pre-season run forecast, Twisp fish are expected to represent 6% of the adipose present, CWT tagged hatchery adults and 16% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution and a collection objective of no less than 50% NOR's and to limit extraction to no greater than 33% of the natural-origin spawning escapement to the Twisp, the 2012 Twisp origin broodstock collection will total 24 fish (at least 12 wild and the remainder, maximum = 12, hatchery origin, or 1:1 wild:hatchery if wild broodstock are less than 12), representing 100% of the broodstock necessary to meet Twisp program production of 40,000 smolts. Methow Composite fish are expected to represent 43% of the adipose present CWT tagged hatchery adults and 84% of the natural origin spring Chinook passing above Wells Dam (Tables 1 and 2). Based on this proportional contribution and a collection objective to limit extraction to no greater than 33% of the natural-origin recruits, the 2012 Methow broodstock collection will be predominantly natural origin and total 142 spring Chinook (133 wild and 9 Hatchery [alternative if estimated pHOS > 0.5: 71 wild + 71 hatchery]). The broodstock collected for the Methow program represents 100% of the broodstock necessary to meet Methow program production of 183,765 smolts. The Twisp River releases will be limited to releasing progeny of broodstock identified as wild Twisp and or known Twisp hatchery origin fish, per

ESA Permit 1196. The Methow FH releases will include progeny of broodstock identified as wild non-Twisp origin and known Methow Composite hatchery origin fish. Age-3 males ("jacks") will not be collected for broodstock.

Table 1. Brood year 2007-2009 age class-at-return projection for wild spring Chinook above Wells Dam, 2012.

Brood year	**Smolt Estimate**		**Age-at-return**								
			Twisp Basin				**Methow Basin**				
	Twisp[1/]	Methow Basin[2/]	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total	SAR[3/]
2007	9,715	99,417	2	35	**17**	54	27	361	**167**	555	0.005581
2008	11,932	56,337	8	**50**	9	67	7	**227**	80	314	0.005581
2009	5,124	31,212	**9**	17	3	29	**11**	142	21	174	0.005581
Estimated 2011 Return			**9**	**50**	**17**	**76**	**11**	**227**	**167**	**405**	

[1/]-Smolt estimate is based on sub-yearling and yearling emigration (Charlie Snow, personal communication).
[2/]-Estimated Methow Basin smolt emigration based on Twisp Basin smolt emigration, proportional redd deposition in the Twisp River and Twisp Basin smolt production estimate.
[3/]- Mean Chiwawa NOR spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 2. Brood year 2007-2009 age class and origin run escapement projection for UCR spring Chinook at Wells Dam, 2012.

	Projected Escapement											
	Origin								**Total**			
	Hatchery				**Wild**				**Methow Basin**			
Stock	**Age-3**	**Age-4**	**Age-5**	**Total**	**Age-3**	**Age-4**	**Age-5**	**Total**	**Age-3**	**Age-4**	**Age-5**	**Total**
MetComp	184	898	42	**1,124**	11	227	167	**405**	195	1,125	209	**1,529**
%Total				43%				84%				49%
Twisp	29	123	5	**157**	9	50	17	**76**	38	173	22	**233**
%Total				6%				16%				8%
Winthrop (MetComp)	113	967	248	**1,328**					113	967	248	**1,328**
%Total				51%								43%
Total	326	1,988	295	**2,609**	20	277	184	**481**	346	2,265	479	**3,090**

Table 3. Assumptions and calculations to determine the number of broodstock needed for BY 2012 production of 223,765 smolts.

Program Assumptions	Twisp standard	Twisp program	Methow standard	Methow program	Total program
Smolt Release		40,000		183,765	**223,765**
Fertilization-to-release survival	*88%*		*85%*		
Total egg take target		45,455		216,194	**261,649**
Egg take (production)					
Cull allowance[1/]		45,455	*19.4*	268,231	**313,686**
Fecundity[2/]	*3,952*		*3,851*		
Female Target					
Female to male ratio	*1:1*		*1:1*		
Broodstock target					
Pre-spawn survival	*96%*		*98%*		
Total broodstock collection		**24**		**142**	

[1/]-Hatchery origin MetComp. component only, and is based on the projected natural origin collection and assumption that all Twisp (hatchery and wild) and wild MetComp. fish will be retained for production.
[2/]-Based on historical age-4 fecundities and expected 2012 return age structure (Table 1).

Trapping at Wells Dam will occur at the East and West ladder traps beginning on 01 May, or at such time as the first spring Chinook are observed passing Wells Dam, and continue through 22 June 2012. The trapping schedule will consist of 3-day/week (Monday-Wednesday), up to 16-hours/day. Two of the three trapping days will be concurrent with the stock assessment sampling activities authorized through the 2012 Douglas PUD Hatchery M&E Implementation Plan. Natural origin spring Chinook will be retained from the run, consistent with spring Chinook run timing at Wells Dam (weekly collection quota). Once the weekly quota target is reached, broodstock collection will cease until the beginning of the next week. If a shortfall occurs in the weekly trapping quota, the shortfall will carry forward to the following week. All natural origin spring Chinook collected at Wells Dam for broodstock will be held at the Methow FH.

To meet Methow FH broodstock collection for hatchery origin Methow Composite and Twisp River stocks, adipose-present coded-wire tagged hatchery fish will be collected at Methow FH, Winthrop NFH and the Twisp Weir beginning 01May or at such time as spring Chinook are observed passing Wells Dam and continuing through 24 August 2012. Natural origin spring Chinook will be retained at the Twisp Weir as necessary to bolster the Twisp program production so long as the aggregate collection at Wells Dam and Twisp River weir does not exceed 33% of the estimated Twisp River natural origin spawners to maximize pNOS in the Twisp. All hatchery and natural origin fish collected at Methow FH, Twisp Weir and Winthrop NFH for broodstock will be held at the Methow FH.

Steelhead

Steelhead programs located upstream of Wells Dam and at Wells Hatchery are presented in Table 4.

Table 4. 2013 brood year Steelhead Programs at Wells Hatchery and Upstream of Wells Dam

Program	Hatchery	Owner	Release Location	Release Target	Broodstock Collection Location
Twisp Conservation	Methow Hatchery (incubation); Wells Hatchery (rearing)	Douglas PUD	Twisp Acclimation Pond	48,000	Twisp WxW
Methow Safety-Net	Wells Hatchery	Douglas PUD	Methow Hatchery	100,000	HxH: Twisp Hatchery (25%) + WNFH Hatchery (75%)
Mainstem Columbia Safety-Net	Wells Hatchery	Douglas PUD	Wells Hatchery	160,000	HxH: Methow Hatchery returns (1st option); Wells Stock (2nd option)
WNFH Conservation Program	WNFH	USFWS	WNFH	100,000	Up to 25 collected at Wells Dam/Hatchery; remaining 25 collected by USFWS
Omak Creek	Wells Hatchery	Grant PUD	Omak Creek	Up to 50,000[1]	Omak Creek returns (up to 25 wild or hatchery)
Okanogan	Wells Hatchery	Grant PUD	Okanogan Basin	Up to 100,000[1]	Wells Stock collected at Wells Dam/Hatchery

1/ The Grant PUD programs will total 100,000, with Omak Creek taking precedence, and the Okanogan program = 100,000 – Omak production.

Steelhead mitigation programs above Wells Dam (including the USFWS steelhead program at Winthrop NFH) utilize adult broodstock collections at Wells Dam, Twisp Weir, Methow Hatchery volunteer trap, and WNFH volunteer trap (Table xxx) and incubation/rearing at Wells Fish Hatchery (FH) and incubation at Methow Hatchery (Twisp program). The Wells Steelhead Program has provided eggs for UCR steelhead reared at Ringold FH, not as a mitigation requirement, but rather an opportunity to reduce the prevalence of early spawn hatchery steelhead in the mitigation component above Wells Dam. However, the Methow steelhead program is shifting to locally collected Twisp wild broodstock (Twisp conservation program), and hatchery origin broodstock representative of the Twisp and WNFH conservation programs (Methow safety-net program). Therefore, surplus broodstock will not be collected for the Methow steelhead programs to address the spawn-timing issue of the Wells stock. The Wells Hatchery Columbia River releases will use returns to the Methow Hatchery volunteer trap to the extent possible, and will be augmented with Wells stock as required to fulfill the program. Therefore, surplus broodstock collection to address spawn timing will not occur. However, the local collections of broodstock in the Methow Basin will occur in the spring, 2013. To ensure the safety-net programs have broodstock, some broodstock will be collected at Wells Dam in the autumn, 2012, and held at Wells Hatchery. These autumn-collected Wells stock fish will be considered surplus to the spring-collected Methow and Okanogan broodstock, and eggs from these surplus broodstock may be transferred to Ringold Hatchery. In addition, Wells Hatchery may be used for adult management and steelhead removed for adult management may be retained for the Ringold program (Table 5).

Table 5. Broodstock collection locations, number, and origin by program

Program	**Wells Dam or Hatchery**		**Twisp Weir**		**WNFH**		**Methow Hatchery**		**Omak Creek**	
	H	W	H	W	H	W	H	W	H	W
Twisp Conservation			0	24						
Methow Safety-Net			Up to 50	0	Up to 50 (backup)	0				
Mainstem Columbia Safety-Net	82 (backup)	0					82	0		
WNFH Conservation Program	8					17[1]				
Omak Creek									Up to 25[2]	
Okanogan	Up to 33	Up to 17								
Ringold[3]	Up to 103	0								
Total	226	17	50	24	50	17	82	0	25	

1/ Wild origin fish for WNFH program will be collected through USFWS hook and line angling efforts in the Methow in the spring of 2013.
2/ Wild origin preferred, but hatchery origin broodstock will also be collected to meet target.
3/ Broodstock derived from adult management at Wells Hatchery and surplus brood collected as backup for Methow and Okanogan programs

The following broodstock collection protocol was developed based on mitigation program production objectives (Table 6), program assumptions (Table 7), and the probability that sufficient adult steelhead will return in 2012/2013 to meet production objectives absent a preseason forecast at the present time.

Trapping at Wells Dam will selectively retain 243 steelhead (east and west ladder collection) and will comprise up to 17 natural origin fish and 226 hatchery origin fish. Ringold FH production component will comprise 100% hatchery origin returns collected at Wells Dam and Hatchery volunteer channel. In the spring of 2013, 24 wild steelhead will be targeted at the Twisp Weir and transferred to the Methow Hatchery for spawning and incubation to the eyed-egg stage after which they will be moved to Wells Hatchery for the balance of rearing. In addition, up to 50 surplus hatchery-origin steelhead (to meet the 100K Methow Safety-Net release) will be targeted at the Twisp Weir and moved to Wells Hatchery for spawning. Surplus WNFH hatchery returns will be used to augment the Twisp hatchery-origin collection if needed. Should there be inadequate surplus steelhead from these two sources, steelhead captured at the Methow Hatchery volunteer trap will be used to fulfill the program, and then Wells stock held at the Wells Hatchery will be used as a final option. Approximately, 16 (up to 25) adult steelhead will be targeted in Omak Creek for a 20K (up to 50K) endemic program operated by the CCT and funded by GCPUD as part of their 100K UCR steelhead mitigation obligation. Overall collection for the programs will be 340 fish and limited to no more than 33% of the entire run or

33% of the natural origin return (NOR composition in the broodstock, is estimated at 18%). Hatchery and natural origin collections will be consistent with run-timing of hatchery and natural origin steelhead at Wells Dam. Ladder trapping at Wells Dam will begin on 01 August and terminate by 31 October, three days per week, up to 16 hours per day, if required to meet broodstock objectives. Trapping will be concurrent with summer Chinook broodstocking efforts through 15 September on the west ladder. If insufficient steelhead adults are encountered on the west ladder, the east ladder trap may be considered. Adult return composition including number, origin, age structure, and sex ratio will be assessed in-season at Priest Rapids and Wells dams. Broodstock collection adjustments may be made based on in-season monitoring and evaluation. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.

Table 6. Adult steelhead collection objectives for programs supported through 2012 return year adult steelhead broodstock collected at Wells Dam, Twisp Weir, and Omak Creek (CCT endemic program).

Program	**# Smolts**	**# Green eggs**	**% Wild**	**# Wild**	**# Hatchery**	**Total Adults**
DCPUD[1/]	160,000	226,629	0%		82	82
DCPUD[2/]	100,000	141,643	0%		50	50
DCPUD Twisp	48,000	67,989	100%	24		24
GCPUD[3/]	80,000	113,315	33%	13	27	40
GCPUD Omak	20,000	40,000		16		16[4/]
USFWS	50,000	70,821	33%	8	17	25
Sub-total	**458,000**	**660,397**	26%	**61**	**176**	**237**
Ringold	180,000	285,714	0%	0	103	103
Sub-total	**180,000**	**285,714**	**0%**	**0**	**103**	**103**
Grand Total[5/]	**638,000**	**946,111**	**18%**	**61**	**279**	**340**

[1/]-Mainstem Columbia releases at Wells Dam. Target HxH parental adults as the hatchery component.
[2/]- Methow hatchery release of HxH fish produced from either adults returning from the Winthrop conservation program and/or surplus hatchery adults from the Twisp weir.
[3/]- Okanogan Basin releases as part of GCPUD's 100K summer steelhead obligation. Broodstock need is dependent on the Omak collection to achieve 100,000 smolts total.
[4/]- Broodstock targeted is 16 total (8 male/8 female) of mixed origin composition based upon what is trapped. Collection could range up to 25 broodstock (50,000 smolt program maximum)
[5/]- Based on steelhead production consistent with Mid-Columbia HCP's, GCPUD BiOp and Section 10 permit 1395.

Table 7. Program assumptions used to determine the number of adults required to meet steelhead production objectives for programs above Wells Dam and at Ringold Springs Fish Hatchery.

	Standard	
Program assumptions	**Hatchery**	**Wild**
Pre-spawn survival	95.4%	97.6%
Female : Male ratio	1.0:1.0	1.0:1.0
Fecundity	5,822	5,800
Fertilization-to-yearling release	70.6%[1/]	70.6%[1/]

[1/]*-Not applicable to Ringold Springs Fish hatchery.*

<u>*Summer/fall Chinook*</u>

Summer/fall Chinook mitigation programs above Wells Dam utilize adult broodstock collections at Wells Dam and incubation/rearing at Eastbank Fish Hatchery. The total production level target is 414,669 summer/fall Chinook smolts for two acclimation/release sites on the Methow and Similkameen rivers (Carlton Pond and Similkameen Pond, respectively).

The TAC 2012 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2007, 2008 and 2009 spawn escapement to tributaries above Wells Dam indicate sufficient summer Chinook will return past Wells Dam to achieve full broodstock collection for supplementation programs above Wells Dam. The following broodstock collection protocol was developed based on initial run expectations of summer Chinook to the Columbia River, program objectives and program assumptions (Table 8).

For 2012, WDFW will retain up to 107 natural-origin summer/fall Chinook at Wells Dam east and/or west ladders, including 52 females for the Methow summer Chinook program (this total does not include the balance of the Similkameen program that may not be achieved through the CCT purse seine efforts). Collection will be proportional to return timing between 01 July and 15 September. Trapping may occur up to 3-days/week, 16 hours/day. Age-3 males ("jacks") will not be collected for broodstock.

Additionally, in collaboration with the Colville Tribes, in 2012 attempts will be made to collect up to 100% (N=112; 56 females) of the natural origin adults needed to meet the Okanogan summer Chinook obligation through the CCT purse seine efforts. If logistics or capture efficiency become prohibitive to achieving broodstock goals with this collection activity this season, broodstock collection for the balance will revert back to Wells Dam. In addition, if broodstock collection through the CCT's purse seining efforts falls behind by more than 25%, the difference between the fish collected to date and what should have been collected, will be made up at Wells Dam west ladder trap. Fish collected through the CCT trapping effort will be uniquely tagged from fish collected at Wells Dam to evaluate relative differences in disease, mortality, spawn timing, among other metrics.

For the 2012 brood year, 48,540 summer/fall Chinook will be reared at Wells Hatchery from broodstock collected by the CCT through purse seining in the Wells Reservoir. The fish will be reared to a point at which they can be transferred to the Chief Joseph Hatchery, Omak Riverside

Acclimation Facility for further grow-out in 2013 and release in 2014.

To better assure achieving the appropriate females for program production, the collection will utilize ultrasonography to determine the sex of each fish retained for broodstock.
If the probability of achieving the broodstock goal is reduced based on passage at the west ladder or actual natural-origin escapement levels, broodstock collections may be expanded to the east ladder trap and/or origin composition will be adjusted to meet the broodstock collection objective. If collection of adults from the east ladder trap is necessary, access will be coordinated with staff at Wells Dam due to the rotor rewind project.

Table 8. Assumptions and calculations to determine the number of broodstock needed for summer/fall Chinook production goals in the Methow and Okanogan river basins.

Program Assumptions	**Standard**	**Carlton Pond**	**Similkameen Pond**	**Wells FH/CCT**	**Total**
Smolt release		**200,000**	**166,569**	**48,540**	**414,669**
Fertilization-to-release survival	81.2				
Eggtake target		**246,305**	**205,134**	**59,236**	**510,675**
Fecundity	4,990				
Female target		**49**	**41**	**12**	**102**
Female:male ratio	1:1				
Broodstock target		**99**	**82**	**24**	**205**
Pre-spawn survival	95.5				
Total collection target		**104**	**86**	**26**	**216**

Columbia River Mainstem below Wells Dam

Summer/fall Chinook

Summer/fall Chinook mitigation programs that release juveniles directly into the Columbia River between Wells and Rocky Reach dams are supported through adult broodstock collections at the Wells Hatchery volunteer channel. The total production level supported by this collection is 896,000 yearling (320K Wells and 576K Chelan Falls programs) and 484,000 sub-yearling Chinook (Wells Hatchery). Upon agreement in the HCP-HC, the 2012, summer Chinook broodstock collections at Wells FH may also include 345,000 green eggs to support the Yakama Nation (YN) reintroduction of summer Chinook to the Yakima River Basin and up to 266 adults or 509,009 green eggs for the USFWS Entiat program pending agreements between USFWS and DCPUD. If approved by the HCP Hatchery Committee, YN eggs will be the last eggs taken and will be the responsibility of staff associated with the YN program. Adults for the Entiat program will be transferred to Entiat NFH by either WDFW or USFWS staff (arrangements between USFWS and DCPUD will have been made prior to implementation).

Adults returning from the Wells and Chelan Falls programs are to support harvest opportunities and are not intended to increase natural production and have been termed segregated harvest programs. These programs have contributed to harvest opportunities; however, adults from these programs have been documented contributing to the adult spawning escapement in tributaries upstream and downstream from their release locations. Because of CCT concerns about sufficient natural origin fish reaching spawning grounds, incorporation of natural origin fish for the Wells program will be limited to fish collected in the Wells volunteer channel. The following broodstock collection protocol was developed based on mitigation objectives and program assumptions (Table 9).

WDFW will collect about 1,287 run-at-large summer Chinook from the volunteer ladder trap at Wells Fish Hatchery outfall. Overall extraction of natural-origin fish to Wells Dam (Wells program and above Wells Dam summer/fall Chinook programs) will not exceed 33 percent. Due to fish health concerns associated with the volunteer collection site (warming Columbia River water during late August), the volunteer collection will begin 11 July and terminate by 31 August. Age-3 males ("jacks") will not be collected for broodstock.

Table 9. Assumptions and calculations to determine the number of broodstock needed for summer/fall Chinook production goals for programs relying on adult collection at Wells Dam or Wells Hatchery in 2012.

Program Assumptions	**Standard**		**Wells FH**		**Chelan Falls FH**	**YN**[1/]	**USFWS**[2/]	
	Sub-yearling	**Yearling**	**Sub-yearling**	**Yearling**	**Yearling**	**Green eggs**	**Green eggs**	**Total**
Smolt release			**484,000**	**320,000**	**576,000**		**400,000**	**NA**
Green egg-to-release survival	76.1%[4/]	83.6%						NA
Eggtake target			**636,005**	**382,775**	**688,995**	**345,000**	**509,009**	**2,561,784**
Fecundity	4,487	4,487						
Female target			**142**	**86**	**154**	**77**	**129**	**588**
Female:Male ratio	1:1	1:1						
Broodstock target			**284**	**242**[3/]	**308**	**154**	**258**	**1,246**
Pre-spawn survival	96.8%	96.8%						
Total collection target			**294**	**250**	**318**	**159**	**266**	**1,287**

[1/]-Green eggs for YN reintroduction program in the Yakima River Basin.
[2/]-Adults for USFWS summer Chinook program in the Entiat River Basin.
[3/]- Includes 70 adults collected for the Lake Chelan triploid Chinook program.

Wenatchee River Basin

Spring Chinook

The Eastbank Fish Hatchery (FH) rears spring Chinook salmon for the Chiwawa River acclimation pond located on the Chiwawa River. The HCP HC approved program production level target for 2012 is 204,452 smolts, requiring a total broodstock collection of 114 spring Chinook (78 natural and 36 hatchery origin; Table 10). The production level for 2012 represents agreements made early in 2012 by the Chelan PUD HCP HC to allow CPUD's spring Chinook obligation for the Methow basin (60,516 smolts) to be produced in the Wenatchee basin (CPUD's post 2013 release re-calculated production obligation for the Chiwawa is 144,026 smolts). The gap in production in the Methow is being compensated for by allowing the difference in Grant PUD's Wenatchee spring Chinook at the White River and Nason Creek to be met at Methow Hatchery. This is a one year agreement.

Table 10. Assumptions and calculations to determine the number of broodstock needed in an anticipated 2012 Chiwawa program release of 204,452 smolts.

Program Assumptions	**Standard**	**Conservation**	**Safety Net**	**Full program**
Smolt Release		**150,000**	**54,452**	**204,452**
Fertilization-to-release survival	*84.5%*			
Total egg take target		177,515	64,440	**241,955**
Egg take (production)			74,154	**251,669**
Cull allowance	*13.1%*			**9,714**
Fecundity	*4,711 W* *4,279 H*			
Female Target		38	17	**55**
Female to male ratio	*1:1*			
Broodstock target		76W	34H	**110**
Pre-spawn survival	*98.0%W/98.5H*			
Total broodstock collection		**78W**	**36H**	**114**

Inclusion of natural origin fish into the broodstock will continue to be a priority, with natural origin fish specifically being targeted. Consistent with ESA Section 10 Permit 1196, natural origin fish collections will not exceed 33 percent of the return to the Chiwawa River and will provide, at a minimum, 33 percent of the total broodstock retained.

In addition to production levels and ESA permit provisions, the 2012 broodstock collection, will target both hatchery and natural origin Chiwawa spring Chinook at the Chiwawa Weir.

Pre-season estimates project 3,819 spring Chinook are destined for the Chiwawa River, of which 481 (12.6%) and 3,338 fish (87.4%) are expected to be natural and hatchery origin spring Chinook, respectively (Tables 11 and 12). These protocols target approximately 114 spring Chinook (78 natural origin and 36 hatchery origin) for broodstock purposes, representing 100% of the program production objectives. In-season assessment of the magnitude and origin composition of the spring Chinook return above Tumwater Dam will be used to provide in-season adjustments to hatchery/wild composition and total broodstock collection, consistent with ESA Section 10 Permit 1196.

Table 11. BY 2007-2009 age class return projection for wild spring Chinook above Tumwater Dam during 2012.

Brood year	Smolt Estimate[1/]		Chiwawa Basin[2/]				Wenatchee Basin above Tumwater Dam[2/]				
	Chiwawa	Wen. Basin	Age-3	Age-4	Age-5	Total	Age-3	Age-4	Age-5	Total	SAR[3/]
2007	65,539	103,460	24	271	**71**	366	38	427	**112**	577	0.005581
2008	91,229	168,630	35	**384**	85	504	65	**718**	159	942	0.005581
2009	51,417	88,650	**26**	249	13	287	**8**	387	100	495	0.005581
Estimated 2012 Return			**26**	**384**	**71**	**481**	**8**	**718**	**112**	**838**	

[1/]-Smolt production estimate for Chiwawa River derived from juvenile smolt data (Hillman et al. 2010); smolt production estimate for Wenatchee Basin is based upon proportional redd disposition between Chiwawa River and Wenatchee River basin and the Chiwawa smolt production estimate.
[2/]-Based upon average age-at-return (return year 2007-2011), for natural origin spring Chinook above Tumwater Dam (WDFW unpublished data).
[3/]-Mean Chiwawa spring Chinook SAR to the Wenatchee Basin (BY 1998-2003; WDFW unpublished data).

Table 12. BY 2007-2009 age class return projection for Chiwawa hatchery spring Chinook above Tumwater Dam during 2012.

Brood	**Smolt Estimate**	**Adult Returns**				
Year	Chiwawa[1/]	Age-3[2/]	Age-4[2/]	Age-5[2/]	Total	SAR
2007	305,542	780	1,760	**88**	2,628	0.0086[3/]
2008	609,789	1,229	**2,839**[4/]	139	4,208	0.0069[5/]
2009	438,651	**411**	1,827	88	2,326	0.0053[6/]
Estimated 2012 Return		**411**	**2,839**	**88**	**3,338**	

[1/]-Chiwawa smolt release (Hillman et. al. 2009).
[2/]-Based on average age-at-return for hatchery origin spring Chinook above Tumwater Dam, 2005-2009 (WDFW, unpublished data) and total estimated BY return.
[3/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 1997-2002).
[4/]-Age-4 returns in 2012 may be significantly underestimated due to age-3 returns in 2011 being in excess of 260% of the 2011 forecast.
[5/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 1998-2003).
[6/]-Mean Chiwawa hatchery spring Chinook SAR to the Wenatchee Basin (BY 2000-2004).

Collection at the Chiwawa Weir will be based on weekly quotas, consistent with average run timing at Tumwater Dam. If the weekly quota is attained prior to the end of the week, retention of spring Chinook for broodstock will cease. If the weekly quota is not attained, the shortfall will carry forward to the next week. The number of hatchery origin fish retained for broodstock will be adjusted in-season, based on estimated Chiwawa River natural-origin returns provided through extrapolation of returns past Tumwater Dam. If hatchery origin Chinook are retained in excess to that required to maintain a minimum 33% natural origin composition in the broodstock, excess fish will be sampled, killed and either used for nutrient enhancement or disposed of in a landfill depending upon fish health staff recommendations.

Broodstock collection at the Chiwawa Weir will begin 01 June and terminate no later than 11 September. Spring Chinook trapping at the Chiwawa Weir will follow a 4-days up and 3-days down schedule, consistent with weekly broodstock collection quotas that approximate the historical run timing and a maximum 33 percent retention of the projected natural-origin escapement to the Chiwawa River. If the weekly quota is attained prior to the end of the 4-day trapping period, trapping will cease. If the weekly quota cannot be accomplished with a 4-days up and 3-days down schedule, a 7-day per week schedule may be implemented to facilitate reaching the collection objectives. Under the 7-day per week schedule, no more than 33% (1 in 3) of the fish collected will be retained for broodstock. If the weekly quota is not attained within the trapping period, the shortfall will carry forward to the next week.

All spring Chinook in excess of broodstock needs and all bull trout trapped at the Chiwawa weir will be transported by tank truck and released into a resting/recovery pool at least 16.0 km upstream from the Chiwawa River Weir. Age-3 males ("jacks") will not be collected for broodstock.

Steelhead

The steelhead mitigation program in the Wenatchee Basin use broodstock collected at Dryden and Tumwater dams located on the Wenatchee River. Per ESA section 10 Permit 1395 provisions, broodstock collection will target adults necessary to meet a 50% natural origin – conservation oriented program and a 50% hatchery origin – safety net program, not to exceed 33% of the natural origin steelhead return to the Wenatchee Basin. Based on these limitations and the assumptions listed below (Table 13), the following broodstock collection protocol was developed.

WDFW will retain a total of 130 mixed origin steelhead for broodstock for a smolt release objective of 247,300 smolts (Table 12). The 66 hatchery origin adults will be targeted at Dryden Dam and if necessary Tumwater dam. The 64 natural origin adults will be targeted for collection at Tumwater Dam. Collection will be proportional to return timing between 01 July and 12 November. Collection may also occur between 13 November and 3 December at both traps, concurrent with the Yakama Nation coho broodstock collection activities. Hatchery x wild and hatchery x hatchery parental cross and unknown hatchery parental cross adults will be excluded from the broodstock collection. Hatchery steelhead parental origins will be determined through evaluation of VIE tags, adipose/cwt presence/absence, and PIT tag interrogation during collection. Adult return composition including number, origin, age structure, and sex ratio will be assessed in-season at Priest Rapids and at Dryden Dam. In-season Broodstock collection adjustments may be made based on this monitoring and evaluation. To better assure achieving the appropriate females equivalents for program production, the collection will implement the draft Production Management Plan, including ultrasonography to determine the sex of each fish retained for broodstock.

In the event steelhead collections fall substantially behind schedule, WDFW may initiate/coordinated adult steelhead collection in the mainstem Wenatchee River by hook and line. In addition to trapping and hook and line collection efforts, Tumwater and Dryden dams may be operated between February and early April the subsequent spring to supplement broodstock numbers if the fall trapping effort provides fewer than the required number of adults.

Table 13. Assumptions and calculations to determine the number and origin of Wenatchee summer steelhead broodstock needed for Wenatchee Basin program release of 247,300 smolts.

Program Assumptions	Standard	Wenatchee program
Smolt Release		**123,650 Conservation** **123,650 Safety net**
Fertilization-to-release survival	*68.6%*	
Egg take target		**360,496**
Fecundity	*5,749 H* *5,893 W*	
Female Target		**32 H** **31 W**
Female to male ratio	*1:1*	
Broodstock target		**126**
Pre-spawn survival	*96.9%H/97.9%W*	
Total broodstock collection		**130**
Natural:Hatchery ratio	1:1	
Natural origin collection total		**64**
Hatchery origin collection total		**66**

<u>*Summer/fall Chinook*</u>

Summer/fall Chinook mitigation programs in the Wenatchee River Basin utilize adult broodstock collections at Dryden and Tumwater dams, incubation/rearing at Eastbank Fish Hatchery (FH) and acclimation/release from the Dryden Acclimation Pond. The total production level target for BY 2012 is 500,001 smolts (181,816 GCPUD mitigation and 318,185 CCPUD mitigation).

The TAC 2012 Columbia River UCR summer Chinook return projection to the Columbia River (Appendix A) and BY 2007, 2008 and 2009 spawn escapement to the Wenatchee River indicate sufficient summer Chinook will return to the Wenatchee River to achieve full broodstock collection for the Wenatchee River summer Chinook supplementation program. Review of recent summer/fall Chinook run-timing past Dryden and Tumwater dam indicates that previous broodstock collection activities have omitted the early returning summer/fall Chinook, primarily due to limitations imposed by ESA Section 10 Permit 1347 to minimize impacts to listed spring Chinook. In an effort to incorporate broodstock that better represent the summer/fall Chinook run timing in the Wenatchee Basin, the broodstock collection will front-load the collection to account for the disproportionate collection timing. Approximately 43% of the summer/fall Chinook destined for the upper Basin (above Tumwater Dam) occurs prior to the end of the first week of July; therefore, the collection will provide 43% of the objective by the end of the first week of July. Weekly collection after the first week of July will be consistent with run timing of summer/fall Chinook during the remainder of the trapping period. With concurrence from NMFS, summer Chinook collections at Dryden Dam may begin up to one week earlier. Collections will be limited to a 33% extraction of the estimated natural-origin escapement to the Wenatchee Basin. Based on these limitations and the assumptions listed below (Table 14), the following broodstock collection protocol was developed.

WDFW will retain up to 274 natural-origin, summer Chinook at Dryden and/or Tumwater dams, including 137 females. To better assure achieving the appropriate females equivalents for program production, the collection will implement the draft Production Management Plan, including ultrasonography to determine the sex of each fish retained for broodstock. Trapping at Dryden Dam may begin 01 July and terminate no later than 15 September and operate up to 7-days/week, 24-hours/day. Trapping at Tumwater Dam if needed may begin 15 July and terminate no later than 15 September and operate up to 48 hours per week.

Table 14. Assumptions and calculations to determine the number of Wenatchee summer Chinook salmon broodstock needed for Wenatchee Basin program release of 500,001 smolts.

Program Assumptions	**Standard**	**Grant PUD**	**Chelan PUD**	**Total Wenatchee Program**
Smolt Release		**181,816**	**318,185**	**500,001**
Fertilization-to-release survival	*75.6%*			
Egg take target		**240,497**	**420,880**	**661,377**
Fecundity	*5,135*			
Female Target		**47**	**82**	**129**
Female to male ratio	*1:1*			
Broodstock target		**94**	**164**	**258**
Pre-spawn survival	*94.1%*			
Total broodstock collection		**100**	**174**	**274**

White River Spring Chinook Captive Brood

Smolt production associated with the White River Captive Broodstock Program (150,000 smolts) will be separate from the smolt production objective associated with the Chiwawa River adult supplementation program. Spawning, incubation, rearing acclimation and release will be consistent with provisions of (expired) ESA Permit 1592.

Nason Creek Spring Chinook

Consistent with agreements made in 2012 in both the HCP-HC and PRCC-HSC, Grant PUDs spring Chinook obligation will be met with primarily production from the White River captive brood program with the balance of the obligation being met with spring Chinook at Methow FH. These agreements allow for Chelan PUD to move their Methow spring Chinook obligation to the Chiwawa to maintain the total Wenatchee Basin spring Chinook production at the recalculated level of 367,696 smolts. Total Methow Basin spring Chinook production will be maintained at the re-calculated level of 223,765 smolts. This agreement is only in place for the 2012 brood.

Priest Rapids Fall Chinook

Collection of fall Chinook broodstock at Priest Rapids Hatchery will generally begin in early September and continue through mid November. Smolt release objectives specific to Grant PUD

(5,000,000 sub-yearlings), Federal (1,700,000 sub-yearlings + 3,500,000 eggs – collection of broodstock for the federal programs are conditional upon having contracts in place with the ACOE), mitigation commitments. Biological assumptions are detailed in Table 15. Smolt release objectives for Ringold Springs occur as green eggs collected at Priest Rapids FH and incubated at Bonneville prior to eyed-egg transfers to Ringold Springs. After the new Priest Rapids FH rebuild there will no longer be incubation capacity for programs above GCPUD mitigation obligations.

For 2012, some portion of the broodstock will be collected at the OLAFT as part of the third year of OLAFT studies to determine the composition of natural origin fish that may be attainable in future years to increase the NOR component of the broodstock. Close coordination between broodstock collections at the volunteer channel and the OLAFT will need to occur so over collection is minimized. OLAFT collected and spawned fish will be prioritized for PRH programs (i.e. OLAFT fish will be held in a separate raceway from volunteer collected fish and spawned first each week).

Based upon the biological assumptions in Table 15, an estimated 2,727 females will need to be spawned to meet the 11,724,138 eggs required to meet the current three up-river bright (URB) programs which rely on adults collected at the Priest Rapids Hatchery volunteer channel trap and/or the Priest Rapids Dam off ladder trap (OLAFT).

To increase the probability of incorporating a higher percentage of NOR's from the volunteer channel, only adipose present, non-CWT males and females will be retained.

Implementation Assumptions

1) Broodstock will be collected at both the PRD off ladder trap (OLAFT – two days per week) and the Priest Rapids Hatchery volunteer channel trap.

2) Assumptions used to determine egg/adult needs is based upon current program performance metrics and is consistent with the draft 2012 Broodstock Collection protocols.

3) Broodstock retained from the volunteer channel will exclude age-2 and 3 males (using length at age) to address genetic risks/concerns of younger age-at-maturity males producing offspring which return at a younger age (decreased age-at-maturity).

4) Only adipose present males and females will be retained for broodstock from volunteer channel collected broodstock unless a shortage is expected.

5) Only adipose present, non-wired fish encountered at the OLAFT will be retained for broodstock.

6) All gametes of fish spawned from the OLAFT collections will be incorporated into the URB programs.

Table 15. Assumptions and calculations to determine the number of fall Chinook salmon broodstock needed for non-actively integrated Priest Rapids program release of 6,700,000 sub-yearling fall Chinook in addition to 3,500,000 for Ringold, in 2012.

Program Assumptions	Standard	Program objective
Juvenile Production Level		
Grant PUD Mitigation-PUD Funded		**5,000,000**
John Day Mitigation-Federally Funded		**1,700,000**
John Day Mitigation [1]-Ringold Springs-ACOE funding.		**3,500,000**
Total Program Objectives		**10,200,000**
Fertilization-to-release survival	*87%*	
Egg take target		**11,724,138**
Fecundity	*4,300*	
Female Target		**2,727**
Female to male ratio	*2:1*	
Pre-spawn survival	*88%*	
Broodstock target		
Females		**3,098**
Males		**1,549**
Total broodstock collection		**4,647**

[1] As of brood year 2009, Priest Rapids Hatchery is taking 3,500,000 eggs for release at Ringold-Meseberg Hatchery funded by the ACOE – incubation of this program occurs at Bonneville.

Appendix A

Columbia River Mouth Fish Returns Actual and Forecasts[a/]			
	2011 Forecast	**2011 Return**	**2012 Forecast**
Spring Chinook Upriver Total	**198,400**	**221,200**	**314,200**[b/]
Upper Columbia (total)	22,400	16,500	32,600
Upper Columbia (wild	2,000	2,200	2,800
Snake River Spring/Summer (total)	91,100	127,500	168,000
Snake River (wild	24,700	31,600	39,000
Summer Chinook	**91,100**	**80,600**	**91,200**
Sockeye	**161,900**	**187,300**	**462,000**
Wenatchee	33,000	41,800	28,800
Okanogan	126,800	143,500	431,300
Snake River	2,100	1,900	1,900

a/ Numbers may not sum due to rounding

b/ TAC used a log-normal sibling regression model to forecast the 2012 4-year old returns from the 2011 Bonneville Dam jack count. Log-normal models appear to work relatively well when jack counts are large, and the 2011 jack count at Bonneville Dam was the second highest on record.

Appendix B

DRAFT
Hatchery Production Management Plan

The following management plan is intended to provide life-stage-appropriate management options for Upper Columbia River (UCR) PUD salmon and steelhead mitigation programs. Consistent, significant over-production or under-production risks the PUD's not meeting the production objectives required by FERC and overages in excess of 110% of program release goals violates the terms and conditions set forth for the implementation of programs under ESA and poses potentially significant ecological risks to natural origin salmon communities.
Under RCW 77.95.210 (Appendix A) as established by House Bill 1286, the Washington Department of Fish and Wildlife has limited latitude in disposing of salmon and steelhead eggs/fry/fish. While this RCW speaks more specifically to the sale of fish and/or eggs WDFW takes a broader application of this statute to include any surplus fish and/or eggs irrespective of being sold or transferred.
We propose implementing specific measures during the different life-history stages to both improve the accuracy of production levels and make adjustments if over-production occurs. These measures include (1) Improved Fecundity Estimates, (2) Adult Collection Adjustments, (3) Within-Hatchery Program Adjustments, and (4) Culling.

<u>Improved Fecundity Estimates</u>

A) Develop broodstock collection protocols based upon the most recent 5-year mean in-hatchery performance values for female to spawn, fecundity, Green egg to eye, and green egg to release.

B) Use portable ultrasound units to confirm gender of broodstock collected (broodstock collection protocols assume a 1:1 male-to-female ratio). Ultrsonography, when used by properly trained staff will ensure the 1:1 assumption is met (or that the female equivalents needed to meet production objective are collected). Spawning matrices can be developed such that if broodstock for any given program are male limited sufficient gametes are available to spawn with the females.

<u>Adult Collection Adjustments</u>

C) Make in-season adjustments to adult collections based upon a fecundity-at-length regression model for each population/program and origin composition needs (hatchery/wild). This method is intended to make in-season allowances for the age structure of the return (i.e. age-5 fish are larger and therefore more fecund than age-4 fish), but will also make allowances for age-4 fish that experienced more growth through better ocean conditions compared to an age-5 fish that reared in poorer ocean conditions.

Within-Hatchery Program Adjustments

D) At the eyed egg inventory (first trued inventory), after adjustments have been made for culling to meet BKD management objectives, the over production will be managed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;
- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;
- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;
- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and
- Governmental hatcheries in Washington, Oregon, and Idaho; or
- Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or
- Distribution to approved organizations/projects for research.

E) At tagging (second inventory correction) fish will be tagged up to 110% of production level at that life stage. If the balance of the population combined with the tagged population amounts to more than 110% of the total release number allowed by Section 10 permits then the excess will be distributed in one or more of the following actions as approved by the HCP-HC:

- Voluntary cooperative salmon culture programs under the supervision of the department under chapter 77.100 RCW;
- Regional fisheries enhancement group salmon culture programs under the supervision of the department under this chapter;
- Salmon culture programs requested by lead entities and approved by the salmon funding recovery board under chapter 77.85 RCW;

- Hatcheries of federally approved tribes in Washington to whom eggs are moved, not sold, under the interlocal cooperation act, chapter 39.34 RCW; and
- Transfer to another resource manager program such as CCT, YN, or USFWS program;
- Governmental hatcheries in Washington, Oregon, and Idaho;
- Placement of fish into a resident fishery (lake) zone, provided disease risks are within acceptable guidelines; or
- Culling for diseases such as BKD and IHN, consistent with the Salmonid Disease Control Policy of the Fisheries Co-managers of Washington State; or
- Distribution to approved organizations/projects for research.

F) In the event that a production overage occurs after the above actions have been implemented or considered, and deemed non viable for fish health reasons in accordance with agency aquaculture disease control regulations (i.e. either a pathogen is detected in a population that may pose jeopardy to the remaining population or other programs if retained or could introduce a pathogen to a watershed where it had not previously been detected) then culling of those fish may be considered.

All, provisions, distributions, or transfers shall be consistent with the department's egg transfer and aquaculture disease control regulations as now existing or hereafter amended. Prior to department determination that eggs of a salmon stock are surplus and available for sale, the department shall assess the productivity of each watershed that is suitable for receiving eggs.

APPENDIX M
MONITORING AND EVALUATION OF THE CHELAN COUNTY PUD HATCHERY PROGRAMS, FIVE-YEAR (2006-2010) REPORT

MONITORING AND EVALUATION OF THE CHELAN COUNTY PUD HATCHERY PROGRAMS

FIVE-YEAR (2006-2010) REPORT

May 1, 2012

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TABLE OF CONTENTS

PREFACE

This five-year report is the result of coordinated field efforts conducted by Washington Department of Fish and Wildlife (WDFW), the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), Chelan County Public Utility District (Chelan PUD), and BioAnalysts, Inc. An extensive amount of work has been conducted to collect the data needed to evaluate the effectiveness of the Chelan County PUD Hatchery Programs. This work was directed and coordinated by the Habitat Conservation Plan (HCP) Hatchery Committee, consisting of the following members: Bill Gale, U.S. Fish and Wildlife Service (USFWS); Rob Jones and Craig Busack, National Marine Fisheries Service (NMFS); Joe Miller, Josh Murauskas, and Alene Underwood, Chelan County PUD; Tom Scribner and Keely Murdoch, the Yakama Nation; Mike Tonseth, WDFW; Kirk Truscott, Confederated Tribes of the Colville Reservation (Colville Tribes), and Mike Schiewe, Anchor QEA (Chair).

The approach to monitoring the hatchery programs was guided by the "*Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Programs*" (Murdoch and Peven 2005). Technical aspects of the monitoring and evaluation program were developed by the Hatchery Evaluation Technical Team (HETT), which consists of the following scientists: Carmen Andonaegui, Anchor Environmental; Matt Cooper, USFWS; Steve Hays, Chelan PUD; Tracy Hillman, BioAnalysts; Tom Kahler, Douglas PUD; Russell Langshaw, Grant PUD; Greg Mackey, Douglas PUD; Joe Miller, Chelan PUD; Josh Murauskas, Chelan PUD; Andrew Murdoch, WDFW; Keely Murdoch, Yakama Nation; Todd Pearsons, Grant PUD; and Ali Wick, Anchor Environmental. The HETT developed an "*Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs*" (Hays et al. 2006), which directs the analyses of hypotheses developed under the conceptual approach. The analytical framework provides the foundation for this report.

Most of the work reported in this paper was funded by Chelan PUD. Bonneville Power Administration purchased the Passive Integrated Transponder (PIT) tags that were used to mark juvenile Chinook and steelhead captured in tributaries. This is the first, five-year report written under the direction of the HCP.

"I often say that when you can measure something and express it in numbers, you know something about it. When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science, whatever it may be."

Lord Kelvin

SECTION 1: INTRODUCTION

Chelan PUD implements hatchery programs as part of two Habitat Conservation Plan (HCP) agreements related to the operation of Rocky Reach and Rock Island Hydroelectric Projects. The HCPs define the goal of achieving no net impact to spring Chinook, summer/fall Chinook, sockeye salmon, steelhead, and coho salmon affected by the operation of these projects. The two HCPs identify general program objectives as "*contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest*." The fish resource management agencies initially developed the following general goal statements for each hatchery program, which were adopted by the Hatchery Committee:

(1) Support the recovery of ESA listed species by increasing the abundance of natural adult populations, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.

Includes the Wenatchee spring Chinook, Wenatchee summer steelhead, and Methow spring Chinook programs.

(2) Increase the abundance of the natural adult population of unlisted plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest.

Includes the Wenatchee sockeye, Wenatchee summer/fall Chinook, Methow summer/fall Chinook, Okanogan summer/fall Chinook, and Okanogan sockeye programs.

(3) Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations.

Includes the Turtle Rock summer/fall Chinook program.

Thus, there are two different types of artificial propagation strategies that address the different goals of the program: supplementation and harvest augmentation. The supplementation programs primarily focus on increasing the natural production of fish in tributaries. A fundamental assumption of this strategy is that hatchery fish returning to the spawning grounds are "reproductively similar" to naturally produced fish. The second program type, harvest augmentation, focuses on increasing harvest opportunities. This is accomplished by releasing hatchery fish directly into the Columbia River with the intent that returning adults remain segregated from the naturally spawning populations in tributaries.

Monitoring is needed to determine if the programs are performing properly. The HCP Hatchery Committee adopted a monitoring and evaluation (M&E) approach that guides the assessment of the hatchery programs. The approach, developed by Murdoch and Peven (2005), identified the following objectives:

(1) Determine if supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference population) and the changes in the natural

replacement rate (NRR) of the supplemented population is similar to that of the reference population.

(2) Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

(3) Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

(4) Determine if the hatchery replacement rate (HRR) is greater than the natural replacement rate (NRR) and equal to or greater than the program-specific HRR expected value based on estimated survival rates listed in Appendix D in Murdoch and Peven (2005).

(5) Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

(6) Determine if hatchery fish were released at the programmed size and number.

(7) Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams.

(8) Determine if harvest opportunities have been provided using hatchery returning adults where appropriate (e.g., Turtle Rock program).

Two additional objectives that were not explicit in the goals specified above but were included in the M&E approach because they relate to goals and concerns of all artificial production programs include:

(9) Determine whether bacterial kidney disease (BKD) management actions lower the prevalence of disease in hatchery fish and subsequently in the naturally spawning population. In addition, when feasible, assess the transfer of *Renibacterium salmoninarum* (Rs) infection at various life stages from hatchery fish to naturally produced fish.

(10) Determine if the release of hatchery fish affect non-target taxa of concern (NTTOC) within acceptable limits.

These latter two objectives are not addressed in this five-year report. The HCP Hatchery Committee has put a hold on evaluating the BKD objective. This objective will be evaluated sometime in the future. The NTTOC objective is currently being evaluated by the Hatchery Evaluation Technical Team (HETT) using both a modeling approach and a Delphi approach (Pearsons et al. 2011). Results from these efforts should be available in 2012.

The purpose of this report is to present the first, five-year set of analyses. It is important to point out that the analyses include all available data, not just data collected within the last five years. The report is divided into several sections, each representing a different species or stock (i.e., steelhead, sockeye salmon, spring Chinook, and summer Chinook). For each stock, we provide results from analyzing each of the eight objectives identified above. For some stocks, we were unable to address all the objectives because of a lack of data. For example, some of the objectives could not be evaluated for steelhead, because sufficient numbers of Passive Integrated Transponder (PIT) tagged fish have not yet been detected or recaptured. The tagging of wild and hatchery steelhead began about five years ago and most of those fish have not returned. In addition, spawning tributaries were only wired recently for PIT-tag interrogation. The next five-year report should have sufficient data to completely evaluate each objective for each stock. As a final note, in this report we also provide some scientifically based recommendations to help guide management decisions. The intent is to ensure that the Chelan PUD hatchery programs are meeting their intended goals.

SECTION 2: SUMMARY OF METHODS

The data used to evaluate each of the eight objectives are reported in annual reports (see Hillman et al. 2011). The reports include information on broodstock collection, collection of life-history information, within hatchery spawning and rearing activities, juvenile monitoring within streams, and redd and carcass surveys. Data from reference areas are not included in the annual reports. Those data are presented in this report. The methods used to collect monitoring data are summarized in the annual reports and described in detail in Murdoch and Peven (2005).

In this section we briefly describe the data and methods used to address each objective. Detailed descriptions of methods can be found in Murdoch and Peven (2005), Hays et al. (2006), and in appendices to this report.

2.1 Abundance, Recruitment, and Productivity

One of the most important goals of a supplementation program is to increase the total spawning abundance and natural-origin recruitment (NORs) of the supplemented population, and not reduce the productivity of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and NORs to levels above those that would have occurred without supplementation. Therefore, the first objective is to *determine if supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference population) and the changes in the natural replacement rate (NRR) of the supplemented population is similar to that of the reference population.* This objective requires information on the number of adult spawners (both hatchery and natural-origin adults), NORs, and recruits per spawner (adult productivity or NRR) in both supplemented and reference populations. Here, recruitment is the sum of the number of naturally produced adults harvested and the number of naturally produced adults that spawned.

Because the metrics analyzed under this objective are not measured directly in the field, we needed to use data collected in the field (e.g., redd counts, scale collections, marks and tags, etc.) to derive total spawning abundance, NORs, and adult productivity. The data and methods used to derive these metrics are described in detail in Appendix A and B. In addition, the objective calls for comparing the three derived metric from the supplemented population with those in reference population. Therefore, we needed to identify suitable reference populations for each supplemented population. Our selection process included identification of reference populations with similar life-history characteristics, few or no hatchery spawners, a long time series of accurate abundance and productivity estimates, and similar freshwater habitat characteristics and out-of-basin effects. Those populations that met most of these criteria (no population met all the criteria) were then examined for their relationship with the supplemented population during the period prior to supplementation. Several methods were used, including graphic analysis, correlation, trend analysis, and power analysis. These methods are described in detail in Appendix C. We assume that the supplemented and reference populations that tracked each other before supplementation would continue to track each other in the absence of supplementation.

In some cases, suitable reference populations were not found. Under this scenario, we develop methods for analyzing the objective without reference populations. These included before-after comparisons, correlation analyses, and comparisons to standards. These methods are described in detail in Appendix C.

To address the first objective, we evaluated the following questions and null hypotheses (see Appendix C for more details):

1. Has the supplementation program increased the total number of spawners within the supplemented population?

   Ho: Slope in total spawner abundance before supplementation ≥ slope in total spawner abundance after supplementation.
   Ho: Differences in slopes in total spawner abundance between supplemented and reference populations before supplementation ≥ differences in slopes in total spawner abundance between supplemented and reference populations after supplementation.
   Ho: Mean total spawner abundance before supplementation ≥ mean total spawner abundance after supplementation.
   Ho: Mean ratio scores in total spawner abundance before supplementation ≥ Mean ratio scores in total spawner abundance during supplementation.

2. Is the number of hatchery fish that spawn naturally greater than the number of hatchery and naturally-produced fish taken for broodstock?

   Ho: Number of hatchery fish spawning naturally ≤ number of hatchery and naturally produced fish taken for broodstock.

3. Has the supplementation program increased NORs within the supplemented population?

   Ho: Slope in NORs before supplementation ≥ slope in NORs after supplementation.
   Ho: Differences in slopes in NORs between supplemented and reference populations before supplementation ≥ differences in slopes in NORs between supplemented and reference populations after supplementation.
   Ho: Mean NORs before supplementation ≥ mean NORs after supplementation.
   Ho: Mean ratio scores in NORs before supplementation ≥ Mean ratio scores in NORs during supplementation.
   Ho: Mean ratio scores in NORs/Maximum Recruitment before supplementation ≥ Mean ratio scores in NORs/Maximum Recruitment during supplementation. [This hypothesis adjusts NORs for the capacity of the habitat; it tests the fraction of the habitat saturated with NORs (see Appendix C for details).]
   Ho: There is no association between the proportion of hatchery-origin spawners (pHOS) and NORs; rho = 0. [If there is a significant negative association between pHOS and NORs, then hatchery fish may be reducing the reproductive success of the wild population.]

4. Has the supplementation program increased the adult productivity (NRRs) of the supplemented population?[1]

[1] Because adult productivity is affected by the abundance of the population (i.e., productivity decreases with increasing abundance), the goal of supplementation is to increase or maintain productivity, but not decrease it.

Ho: Slope in NRRs before supplementation ≤ slope in NORs after supplementation.

Ho: Differences in slopes in NRRs between supplemented and reference populations before supplementation ≤ differences in slopes in NRRs between supplemented and reference populations after supplementation.

Ho: Mean NRRs before supplementation ≤ mean NRRs after supplementation.

Ho: Mean ratio scores in NRRs before supplementation ≤ Mean ratio scores in NRRs during supplementation.

Ho: Mean ratio scores in NRRs (adjusted for density dependence) before supplementation ≤ Mean ratio scores in NRRs (adjusted for density dependence) during supplementation. [This hypothesis adjusts NRRs for density-dependent effects; see Appendix C for details.]

Ho: There is no association between the proportion of hatchery-origin spawners (pHOS) and the residuals from the smooth hockey stick stock-recruitment curve; rho = 0. [If there is a significant negative association between pHOS and the residuals, then hatchery fish may be reducing the productivity of the wild population.]

We used graphic analyses, trend analyses, t-tests, Aspin-Welch tests, and randomization tests to evaluate the statistical hypotheses. Detailed descriptions of the statistical procedures are presented in Appendix C.

2.2 Migration and Spawning Characteristics

Another goal of supplementation is to produce hatchery fish that spawn with natural-origin fish (i.e., hatchery and wild fish should be fully integrated). Thus, hatchery and natural-origin fish should have similar migration and spawn timing, and they should spawn in the same locations. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. In addition, hatchery adults that spawn at different times or locations than natural-origin fish would not be integrated into the naturally produced spawning population. Therefore, the second objective is to *determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar*.

The metrics used to analyze this objective are presented in the annual reports (see Hillman et al. 2011). For migration timings of hatchery and natural-origin fish, we estimated the cumulative frequency, 10th percentile, 50th percentile (mode), 90th percentile, and mean Julian date of passage at the most upstream sampling location. That is, we estimated steelhead and sockeye migration timing at Tumwater Dam, spring Chinook at Tumwater Dam and at PIT-tag interrogation sites in the Chiwawa, Wenatchee summer Chinook at Dryden Dam, and Methow and Okanogan summer Chinook at Wells Dam. We also estimated migration timing at lower stations (e.g., Bonneville Dam or Priest Rapids Dam) if PIT-tag recapture data were available. Hays et al. (2006) suggest that these comparisons should use hatchery and natural-origin fish of the same age. In this report, we do not conduct a separate analysis on each age group, because in several cases we rely on video counts, which do not provide age data.

For spawn timing, we used the Julian day when female carcasses were observed in the field. Because steelhead generally do not die after spawning, we were unable to compare the spawn timing of hatchery and natural-origin steelhead. As more PIT-tag data become available, we should be able to compare hatchery and natural-origin steelhead spawn timing. For comparing the distribution of redds, we used the locations where hatchery and natural-origin spawners were observed in the field. Again, because there are no steelhead carcass data, we could not compare hatchery and natural-origin steelhead spawning distributions. As more PIT-tag data become available, we should be able to assess differences at larger (tributary) scales.

To address the second objective, we evaluated the following questions and null hypotheses:

1. Is the migration timing of hatchery and natural-origin fish similar?

   Ho: The cumulative frequency of migration timing of hatchery-origin fish = the cumulative frequency of migration timing of natural-origin fish.

   Ho: The mean migration timing of hatchery-origin fish = the mean migration timing of natural-origin fish. [Here, we test if the 10^{th} percentile, 50^{th} percentile (mode), 90^{th} percentile, and mean Julian dates differ between hatchery and natural-origin fish.]

2. Is the timing of spawning similar for hatchery and natural-origin fish (measured at the time female carcasses were recovered on the spawning grounds)?

   Ho: The cumulative frequency of spawn timing of hatchery-origin fish = the cumulative frequency of spawn timing of natural-origin fish.

   Ho: The mean spawn timing of hatchery-origin fish = the mean spawn timing of natural-origin fish. [Here, we test if the 10^{th} percentile, 50^{th} percentile (mode), 90^{th} percentile, and mean Julian dates differ between hatchery and natural-origin fish.]

3. Is the distribution of redds similar for hatchery and natural-origin fish (measured at the location that female carcasses were recovered on the spawning grounds)?

   Ho: The distribution of hatchery-origin redds (hatchery females) = the distribution of natural-origin redds (natural-origin females). [Distribution will be assessed at the reach scale (using historical sampling reaches) and at the 0.01 km scale.]

We used graphic analyses (cumulative frequency polygons), t-tests, Aspin-Welch tests, and randomization tests to evaluate the statistical hypotheses.

2.3 Genetic and Phenotypic Characteristics

Supplementation programs should not affect the long-term fitness of the supplemented populations. Fitness, or the ability of individuals to survive and pass on their genes to the next generation in a given environment, includes genetic and phenotypic components. Maintaining the long-term fitness of supplemented populations requires a comprehensive evaluation of genetic and phenotypic characteristics. Thus, the third objective is to *(a) determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program and (b) determine if hatchery programs have caused changes in phenotypic characteristics of natural populations*. Other phenotypic traits such as run timing, spawn timing, spawning location, and stray rates are evaluated under other objectives.

The metrics used to analyze this objective are presented in the annual reports and in appendices to the annual reports (see Hillman et al. 2011). Allele frequencies generated from samples of hatchery and natural-origin adults and the donor stocks were used to assess genetic diversity, population structure, and effective population size. Data collected from returning adults were used to estimate age-at-maturity and size-at-maturity. Scales (used to age fish) and lengths (post-orbital to hypural length in cm) were collected from carcasses, broodstock, and fish sampled at stock assessment stations (e.g., Dryden, Tumwater, and Wells dams). Ages were reported as total age and saltwater age.

To address the third objective, we evaluated the following questions and null hypotheses:

1. Is the allele frequency of hatchery fish similar to the allele frequency of natural-origin and donor fish?

   Ho: The allele frequency of hatchery fish = allele frequency of natural-origin fish = allele frequency of donor fish.

2. Does the genetic distance among subpopulations within a supplemented population remain the same over time?

   Ho: The genetic distance between subpopulations in year x = the genetic distance between subpopulations in year x+1.

3. Is the ratio of effective population size (N_e) to spawning population size (N) constant over time?

   Ho: The ratio of N_e/N at time x = the ratio of N_e/N at time x+1.

4. Is the age-at-maturity of hatchery and natural-origin fish similar?

   Ho: The age-at-maturity of hatchery female fish = the age-at-maturity of natural-origin female fish.
   Ho: The age-at-maturity of hatchery male fish = the age-at-maturity of natural-origin male fish.

5. Is the length-at-age of hatchery and natural-origin fish similar?

   Ho: The length-at-age of hatchery female fish = the length-at-age of natural-origin female fish.
   Ho: The length-at-age of hatchery male fish = the length-at-age of natural-origin male fish.

We used graphic analyses, two-way Yates' Chi-square tests, and three-way ANOVA to evaluate the statistical hypotheses.

2.4 Hatchery Fish Survival Rates

The survival advantage from the hatchery (i.e., egg-to-smolt) must be sufficient to produce a greater number of returning adults than if broodstock were left to spawn naturally. If a hatchery program cannot produce a greater number of adults than naturally spawning fish, then the program should be modified or discontinued. Thus, the fourth objective is to *determine if the hatchery replacement rate (HRR) is greater than the natural replacement rate (NRR) and equal to or greater than the program-specific HRR expected value based on estimated survival rates listed in Appendix D in Murdoch and Peven (2005)*. Production levels were initially developed using historical run sizes and smolt-to-adult survival rates (BAMP 1998). Using the stock-specific NRR and the values listed in BAMP, comparisons to actual survival rates will be made to ensure the expected level of survival has been achieved.

Data required to address this objective are presented in the annual reports (see Hillman et al. 2011). HRRs were derived based on the release, recovery, and expansion of coded wire tagged (CWT) hatchery fish. We calculated two different return estimates; (1) marked hatchery fish that returned to the spawning stream (includes hatchery fish that spawned naturally and those taken for broodstock) and (2) marked hatchery fish that returned to the spawning stream and those harvested. Methods for estimating HRRs are detailed in Appendix D.

To address the fourth objective, we evaluated the following questions and null hypotheses:

1. Does the hatchery replacement rate (HRR) exceed the natural replacement rate?

   Ho: The HRR ≥ NRR.

2. Does the hatchery replacement rate (HRR) exceed the target value in Murdoch and Peven (2005)?

   Ho: The HRR ≥ Target Value[2].

We used graphic analyses and/or quantile (sign) tests to evaluate the statistical hypotheses.

2.5 Stray Rates

Maintaining locally adapted traits of fish populations requires that returning hatchery fish have a high rate of site fidelity to the target stream. Hatchery practices (e.g., rearing and acclimation water sources, release methodology, and location) are the main variables thought to affect stray rates. Regardless of the adult returns, if adult hatchery fish do not contribute to the donor population, the program will not meet the basic condition of a supplementation program. Thus, the fifth objective is to *determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks*. Hatchery fish that stray to non-target, independent populations should not comprise more than 5% of the non-target spawning population. Likewise, hatchery fish that stray to non-target spawning areas within an independent population should not comprise greater than 10% of the spawning aggregate within the non-target spawning area.

Data required to address this objective are presented in the annual reports (see Hillman et al. 2011). Stray rates were estimated based on the recovery and expansion of coded wire tagged hatchery fish captured in different hatcheries, spawning areas, and populations. CWTs recovered in different locations were expanded by sampling rates, and then adjusted for tagging rates. Where available, PIT tags were also used to estimate stray rates. Methods for estimating stray rates are described in Appendix E.

To address this objective, we evaluated the following questions and null hypotheses:

1. Is the stray rate of hatchery fish less than 5% for the total brood return?

   Ho: The stray rate of hatchery fish ≥ 5% of total brood return.

2. Do hatchery strays make up less than 5% of the spawning escapement within other independent populations?

[2] There are questions as to the origin of the target values. The target values are presented in Murdoch and Peven (2005), which references the BAMP. However, there are no estimates or target values presented in BAMP.

Ho: Hatchery strays make up ≥ 5% of the spawning escapement within other independent populations.

3. Do hatchery strays make up less than 10% of the spawning aggregate within non-target spawning areas within the target population?

   Ho: Hatchery strays make up ≥ 10% of the spawning aggregate within non-target spawning areas within the target population.

We used graphic analyses and/or quantile (sign) tests to evaluate the statistical hypotheses.

2.6 Hatchery Release Characteristics

The Habitat Conservation Plan (HCP) identifies the number and size of fish that are to be released from each hatchery program to meet the compensation levels identified in the HCP. Therefore, the sixth objective is to *determine if hatchery fish were released at the programmed size and number*. Although many factors can influence both the size and number of fish released, past hatchery cultural experience with these stocks should assist in meeting program production levels.

Data required to address this objective are presented in the annual reports (see Hillman et al. 2011). Numbers, fork lengths (mm), and weights (0.1 g) of fish released from each hatchery program are estimated annually and reported in the annual reports.

To address this objective, we evaluated the following questions and null hypotheses:

1. Is the fork length (1.0 mm) and weight (0.1 g) of hatchery fish released equal to the program goal?

   Ho: The length of hatchery fish released = program length goals.

   Ho: The weight of hatchery fish released = program weight goals.

2. Is the number of hatchery fish released equal to the program goal?

   Ho: The number of hatchery fish released = program number release goals.

We used graphic analyses and/or quantile (sign) tests to evaluate the statistical hypotheses.

2.7 Freshwater Productivity

Out-of-basin effects influence the survival of smolts after they migrate from the tributaries. These effects introduce substantial variability into NRRs and HRRs and may mask in-basin effects (e.g., habitat quality, density-dependent mortality, and differential reproductive success of hatchery and natural-origin fish). Therefore, the seventh objective is to *determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams*. Data from long-term smolt monitoring programs can be used to estimate egg-to-smolt or egg-to-juvenile survival of target stocks. Smolt production models generated from the information obtained from these programs will provide a level of predictability with greater sensitivity to in-basin effects than spawner-recruitment models that take into account all effects.

Data required to address this objective are presented in the annual reports (see Hillman et al. 2011). Smolt traps, adjusted for capture efficiency, were used to estimate smolt numbers. Snorkel surveys, adjusted for detection probabilities, were used to estimate Chiwawa spring

Chinook parr numbers. Parr abundance was not estimated for any other program. Adult spawning escapement and pHOS were estimated from data collected during redd and carcass surveys.

The objective calls for comparing freshwater productivity from the supplemented population with those in reference population. Using the same criteria outlined under objective 1 and described in Appendix C, we were unsuccessful in finding any suitable reference populations for comparing freshwater productivities. This is primarily because un-supplemented populations are not usually monitored for freshwater productivity. In addition, there are no pre-supplementation, freshwater productivity data available for the Chelan PUD hatchery programs. Therefore, we cannot assess before-after effects. Thus, in this report, we use stock-recruitment models and correlation analyses to assess the effects of supplementation on freshwater productivity.

To address this objective, we evaluated the following question and null hypotheses:

1. Does the number of juveniles per redd decrease as the proportion of hatchery spawners (pHOS) increases?

   Ho: There is no association between pHOS and the number of smolts produced; rho = 0. [If there is a significant negative association between pHOS and the number of smolts produced, then hatchery fish may be reducing the freshwater productivity of the wild population.]

   Ho: There is no association between pHOS and the number of Chiwawa spring Chinook parr produced; rho = 0.

   Ho: There is no association between pHOS and the residuals from the smooth hockey stick stock-recruitment curve; rho = 0. [If there is a significant negative association between pHOS and the residuals, then hatchery fish may be reducing the productivity of juvenile fish within the population.]

We used stock-recruitment analyses and correlations to evaluate the statistical hypotheses.

2.8 Harvest

In years when the expected returns of hatchery adults are greater than the numbers required to meet program goals (i.e., supplementation of spawning populations and/or brood stock requirements), surplus hatchery fish may be available for harvest. Thus, the eighth objective is to *determine if harvest opportunities have been provided using hatchery returning adults where appropriate*. It should be noted that if hatchery fish are found to affect the productivity or survival of NORs, harvest or removal of surplus hatchery fish from the spawning grounds could be used to reduce potential adverse effects to naturally produced populations.

Data required to address this objective are presented in the annual reports (see Hillman et al. 2011). Methods used to estimate the number of fish captured in ocean and freshwater (includes tribal, commercial, and recreational) fisheries are described in Appendices A and B.

To address this objective, we evaluated the following questions and null hypotheses:

1. Is the harvest on hatchery fish produced in the Turtle Rock Summer Chinook Program high enough to manage natural spawning but low enough to sustain the hatchery program?

Ho: The harvest on Turtle Rock summer Chinook ≤ the maximum level needed to meet the program goals.

2. Is the escapement of hatchery fish from supplementation programs in excess of broodstock and natural production needs to provide opportunities for terminal harvest?

    Ho: The escapement of hatchery fish from supplementation programs ≤ the maximum level needed to meet supplementation goals.

We used graphic analyses and/or quantile (sign) tests to evaluate the statistical hypotheses.

SECTION 3: WENATCHEE STEELHEAD

The goal of summer steelhead supplementation in the Wenatchee Basin is to use artificial production to replace adult production lost because of mortality at Rock Island and Rocky Reach dams, as well as inundation compensation for Rocky Reach Dam, while not reducing the natural production or long-term fitness of steelhead in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Prior to 1998, steelhead eggs were received from Wells Hatchery (adult broodstock were collected at Wells Dam), fish were reared at Eastbank Fish Hatchery and then released into the Wenatchee River. Beginning in 1998, the program changed to collecting broodstock within the Wenatchee Basin. Currently, adult steelhead are collected from the run-at-large at the right and left-bank traps at Dryden Dam, and at Tumwater Dam if the weekly quotas cannot be achieved at Dryden Dam. The current goal is to collect 130 adult steelhead (64 natural-origin and 66 hatchery-origin fish) for a 247,300 smolt program, but the number of broodstock collected cannot exceed 33% of the natural Wenatchee steelhead population. Broodstock collection occurs from about 7 July through 12 November with trapping occurring up to 24 hours per day, five days a week, at Dryden Dam left and right-bank traps. The intent of the current program is to target adults necessary to meet a 50% natural-origin, conservation-oriented program and a 50% hatchery-origin safety-net program.

Because of unsuitable adult holding temperatures at Eastbank Fish Hatchery, adult steelhead are held and spawned at Wells Fish Hatchery. Beginning with the 2012 brood year, spawning will occur at Eastbank Fish Hatchery. Juvenile steelhead are reared at a combination of facilities including Eastbank, Chelan, Turtle Rock, Rocky Reach Annex, and Chiwawa facilities. Juvenile steelhead reared in these facilities are trucked to release locations on the Wenatchee River, Chiwawa River, and Nason Creek. A percentage of the fish have also been released volitionally from Blackbird Pond and Rolfing Pond. Beginning in the fall of 2012, the entire Wenatchee steelhead program will overwinter at Chiwawa Ponds. Some of these fish may be transferred to short-term remote acclimation sites, while others will be planted from trucks throughout the Wenatchee, Nason, and Chiwawa basins.

The production goal for the Wenatchee steelhead supplementation program has been to release 400,000 yearling smolts into the Wenatchee Basin at six fish per pound. The current production goal is to release 247,300 smolts (123,650 for conservation and 123,650 for safety net). Targets for fork length and weight are 198 mm (CV = 9.0) and 75.6 g, respectively. Over 90% of these fish are marked with color-coded elastomer tags. In addition, since 2006, about 10,000 juvenile steelhead from different parental-cross groups (e.g., WxW, HxW, and HxH) have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

3.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the steelhead supplementation program is to increase the total number of spawners in the Wenatchee Basin. This is difficult to test because hatchery steelhead have been released into the Wenatchee Basin since the early 1900s (Chapman et al. 1994). Thus, adult returns prior to the implementation of the Chelan PUD supplementation program consisted of both hatchery and natural-origin steelhead (Figure 3.1). In addition there are no suitable reference populations for comparison. As a result, we were left with analyzing trends and mean abundances before and after the current Chelan PUD steelhead program was implemented.

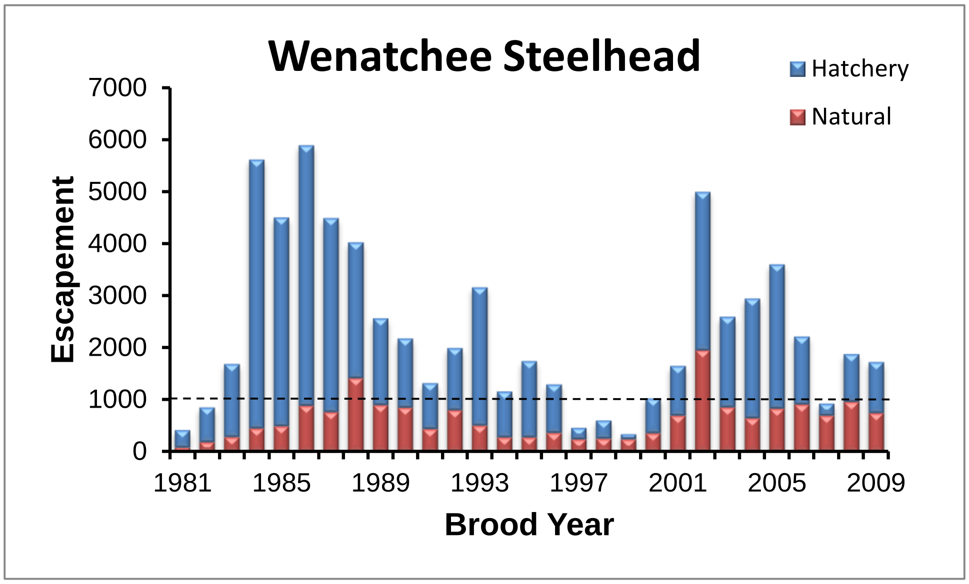


Figure 3.1. Escapement of hatchery and natural-origin steelhead into the Wenatchee Basin, 1981-2009. The dashed horizontal line indicates the TRT recovery level (1,000) for natural-origin steelhead in the Wenatchee Basin. Data are from the NWFSC Salmonid Population Summary Database.

Because the supplementation program changed from using broodstock collected at Wells Dam to broodstock collected within the Wenatchee Basin in 1998, we examined the effects of changing the source of broodstock on adult spawner abundance. The hypothesis is that by switching broodstock collection to the Wenatchee Basin, the total spawning escapement within the Wenatchee Basin should increase. Thus, the "before treatment" period includes spawner data collected during 1981-1999 (period when adult returns to the Wenatchee were produced from adults collected at Wells Dam). The "during treatment" period includes spawner data collected during 2000-present (period when adult returns to the Wenatchee were produced from adults collected in the Wenatchee River).

Trend analysis indicated that the trend in total number of spawners did not change after the switch to local broodstock collection (Figure 3.2). When we compared the mean spawner abundance before the switch with the mean abundance after the switch, we found that the mean spawner abundance was greater, but not significantly, after the switch than before the switch (Table 3.1). Mean spawner abundance increased about 4% between the pre- and post-periods.

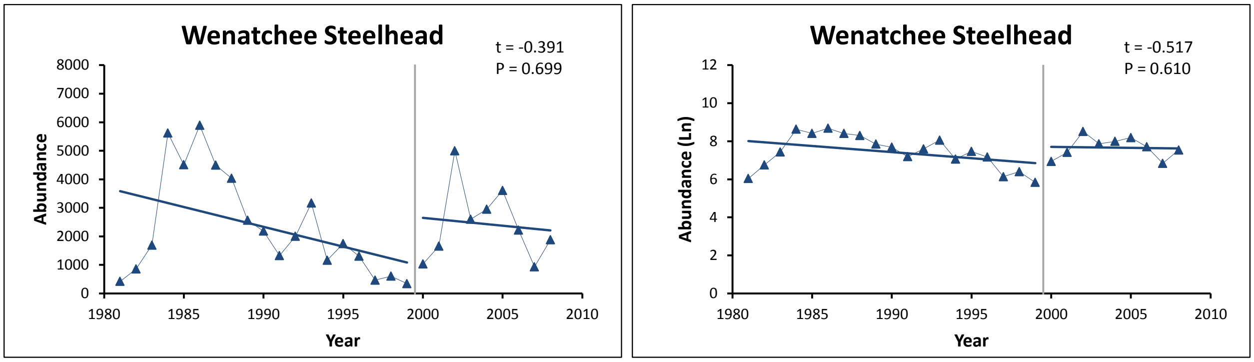


Figure 3.2. Trends in Wenatchee steelhead spawner abundance before and during the local broodstock collection period. The vertical lines in the figures separate the before and during periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during local broodstock collection periods are included on the figures.

Table 3.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during local broodstock collection of Wenatchee steelhead. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	2,335	2,430	-0.159	0.437	0.871	-1,197 – 1,013
LN Abundance	7.4	7.7	-0.864	0.198	0.388	-0.7 – 0.3
NORs	647	857	-1.624	0.061	0.150	-453 – 26
LN NORs	6.3	6.7	-2.629	0.008	0.044	-0.79 – -0.14
Productivity	0.63	0.45	0.756	0.229	0.545	-0.28 – 0.60
LN Productivity	-1.15	-1.01	-0.344	0.631	0.743	-0.92 – 0.62
Adj Productivity	0.68	0.50	0.802	0.216	0.548	-0.27 – 0.57
LN Adj Productivity	-0.95	-0.80	-0.460	0.674	0.652	-0.74 – 0.45

Finally, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Based on the ten years of data available, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in eight of the ten years (Table 3.2).

Table 3.2. Numbers of natural-origin (NOB) and hatchery-origin (HOB) steelhead included in broodstock and numbers of hatchery-origin steelhead spawning naturally (HOS) in the Wenatchee Basin.

Brood year	NOB	HOB	Total Broodstock	HOS
2001	51	103	154	127
2002	96	64	160	542
2003	49	90	139	350

Brood year	NOB	HOB	Total Broodstock	HOS
2004	75	61	136	444
2005	87	104	191	862
2006	93	69	162	210
2007	76	58	134	115
2008	77	54	131	279
2009	86	73	159	545
2010	96	75	171	970
Average	**79**	**75**	**154**	**444**

In summary, there is little evidence that the conversion to local broodstock collection has increased the total number of steelhead spawners (hatchery and natural-origin spawners) within the Wenatchee Basin. This conclusion is based on comparing trends and mean abundances before and after the switch to local broodstock. It is important to note that the before years included large numbers of hatchery steelhead. In addition, there were no suitable reference populations for comparisons. We also note that during the transition to local broodstock, the numbers of smolts released in the early years (1999-2001) were less than 200,000 fish (the goal was 400,000 smolts). Also, smolt release locations and spawning ground surveys have varied over the years. This may further confound the detection of a supplementation effect. Therefore, we cannot be certain that the supplementation program has not increased the total number of steelhead spawners within the Wenatchee Basin.

Natural-Origin Recruits

Another important goal of converting the steelhead program to a local-broodstock collection program is to increase the number of natural-origin recruits (NORs). We tested the success of the switch to local broodstock collection in increasing NORs by analyzing trends and mean NORs before and during the switch. Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before the switch to local broodstock collection, NORs decreased slightly over time. The trend did not change during the period following the switch to local broodstock (Figure 3.3). When we compared mean steelhead NORs before the switch with those after the switch, mean NORs following the switch were significantly greater (based on log transformed NORs) than those before the switch (Table 3.1). Mean NORs increased 32% following the switch to local broodstock.

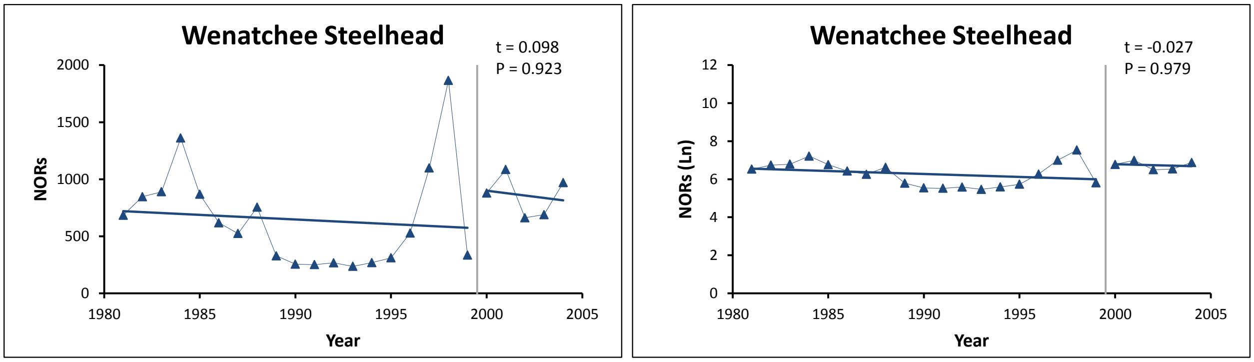


Figure 3.3. Trends in Wenatchee steelhead NORs before and after the switch to collection of local broodstock. The vertical lines in the figures separate the before and after periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and after the switch are included on the figures.

Finally, we used Pearson correlation to test the association between pHOS and steelhead NORs. If the Chelan PUD supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. We found no association between NORs and pHOS (Figure 3.4).

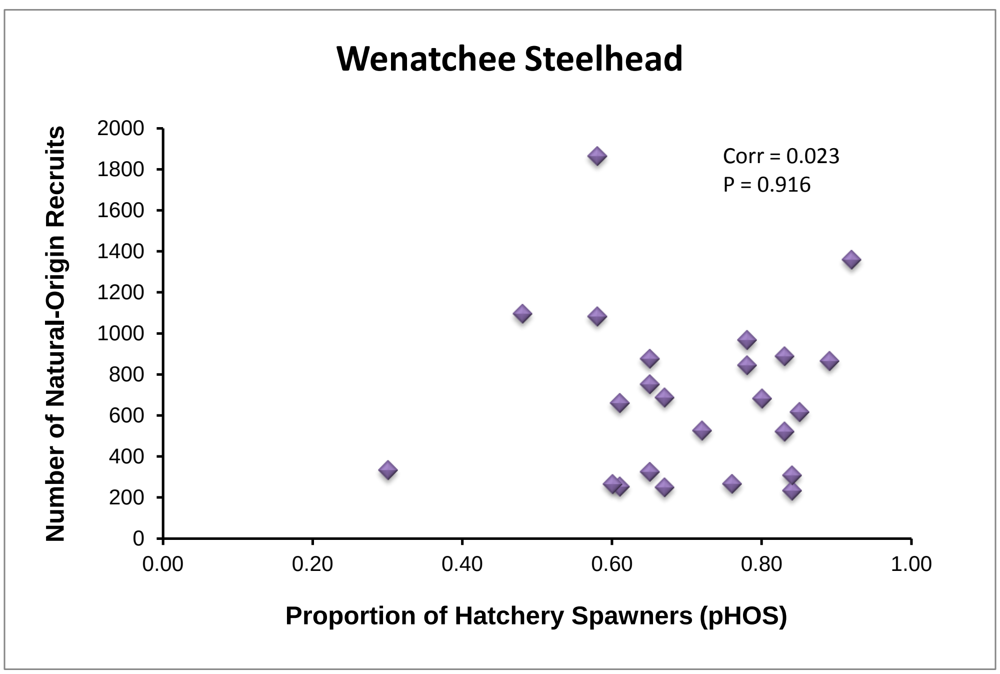


Figure 3.4. Association between the proportion of steelhead spawners that are made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, there is some evidence that converting to local broodstock collection has increased steelhead NORs within the Wenatchee Basin. This conclusion is based on comparing trends and mean NORs before and after the switch to local broodstock. Again, it is important to note that there were no suitable reference populations for comparisons. Therefore, we cannot be certain that the supplementation program has increased steelhead NORs within the Wenatchee Basin.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the switch to collection of local broodstock has significantly reduced the productivity of steelhead in the Wenatchee Basin by analyzing trends and mean productivities before and after the switch. Because productivity can be affected by density dependence, we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker and smooth hockey stick models to the stock-recruitment data.

Trend analysis indicated that before the switch to local broodstock collection, steelhead productivity trended upward over time. Following the switch to local broodstock, the trend decreased over time (Figure 3.5). The change in trend before and after the switch was not significant. When we compared mean steelhead productivities before and after the switch, we found that mean productivities decreased, but not significantly, after the switch to local broodstock (Table 3.1). Productivity before supplementation averaged 0.63 recruits per spawner; during supplementation productivity averaged 0.45 recruits per spawner.

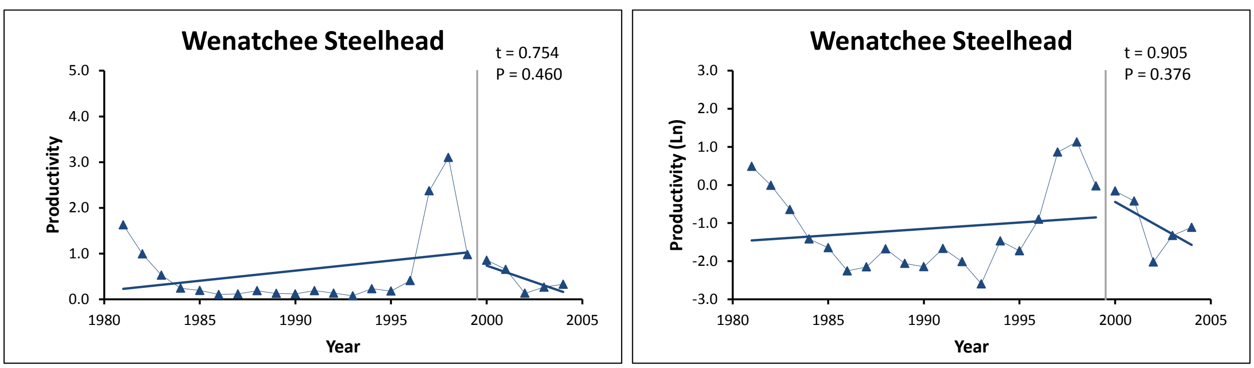


Figure 3.5. Trends in Wenatchee steelhead productivity (adult recruits/spawner; NRRs) before and after the switch to collection of local broodstock. The vertical lines in the figures separate the before and after periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and after the switch are included on the figures.

Next, we analyzed the effects of the switch on productivities adjusted for density dependence. We did this by fitting Ricker, Beverton-Holt, and smooth hockey stick stock-recruitment models to the steelhead data. The Ricker and smooth hockey stick models provided the best fit. Although there is a strong density-dependent relationship between spawners and recruits, both models explained less than 2% of the variability in the stock-recruitment data (Figure 3.6). From the model we estimated the number of spawners (K_{sp}) needed to produce the maximum number or recruits (K_R). We used K_{sp} to separate density-independent productivities and density-dependent productivities (see Appendix C for details).

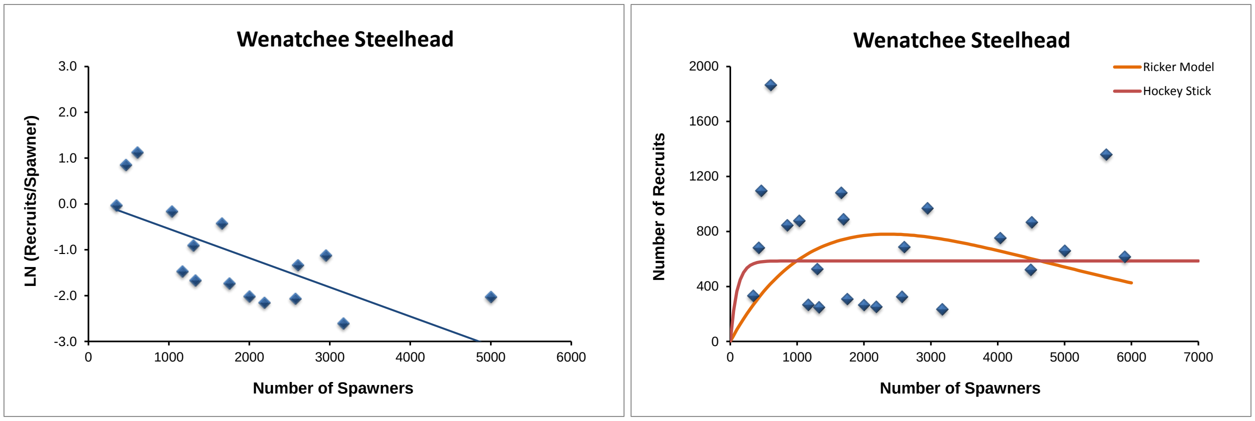


Figure 3.6. Relationship between number of steelhead spawners and recruits/spawner (figure on the left) and recruits (figure on the right). Both the Ricker and smooth hockey stick models fit the stock-recruitment data.

Analysis of the adjusted productivity data provided similar results as those with unadjusted productivity data. That is, adjusted productivities decreased, but not significantly, following the change to local broodstock collection (Table 3.1). Adjusted productivities before supplementation averaged 0.68 recruits per spawner; during supplementation adjusted productivities averaged 0.50 recruits per spawner.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker and smooth hockey stick models to the Wenatchee steelhead stock and recruitment data. These analyses indicated no association between the residuals and pHOS, suggesting that hatchery-origin spawners may be as productive as natural-origin spawners (Figure 3.7). We note that there are few years in which pHOS was less than 0.5. Thus, the lack of a relationship between the residuals and pHOS may be related to the fact that there were few years with low pHOS.

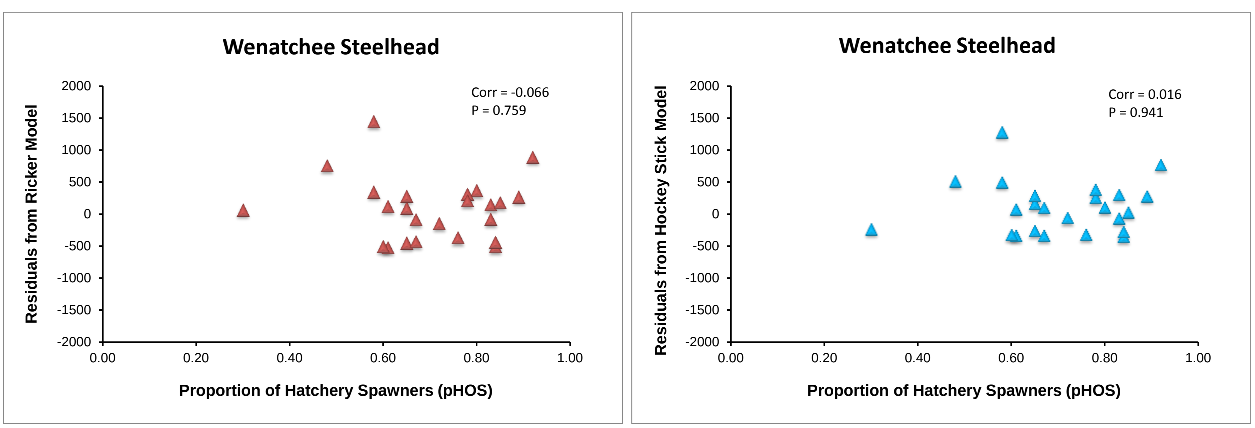


Figure 3.7. Association between the proportion of steelhead spawners that were made up of hatchery adults (pHOS) and the residuals from the Ricker and smooth hockey stick stock-recruitment models. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

In summary, there is no evidence that the conversion to local broodstock collection has significantly reduced the productivity of the Wenatchee steelhead population. This conclusion is based on comparing trends and mean productivities before and after the switch to local broodstock. We caution, however, that there were no suitable reference populations for comparisons. Therefore, the effects of switching to local broodstock collection on steelhead productivity within the Wenatchee Basin remain unclear.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. In the case of Wenatchee steelhead, this is very difficult to assess, because the Wenatchee steelhead population was supplemented for many years before the implementation of the Chelan PUD program. In addition, there are no suitable reference populations to compare with the Wenatchee population. Therefore, we evaluated the effects of switching broodstock collection from Wells Dam to the Wenatchee River on spawning abundance, NORs, and productivity.

The available data do not clearly indicate that the conversion to local broodstock collection has significantly increased the total number of steelhead spawners within the Wenatchee Basin. In contrast, the data do suggest that the conversion to local broodstock has increased NORs. There is no indication that the conversion has decreased productivity. It is important to note that the before-after analyses were based on data that consisted of large numbers of hatchery steelhead. In addition, during the transition to local broodstock, numbers of smolts released in the initial years were about 50% of the target level. Also, smolt release locations and spawning ground surveys have changed over time making it difficult to detect possible supplementation effects. Therefore, the effects of switching to local broodstock collection on steelhead abundance, NORs, and productivity within the Wenatchee Basin remain unclear.

3.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin steelhead by comparing cumulative frequency polygons using data collected during video sampling at Tumwater Dam and PIT interrogations at Bonneville Dam, Tumwater Dam, Chiwawa River and Nason Creek.

We compared cumulative frequency polygons of migration timing of PIT-tagged hatchery and natural-origin steelhead interrogated at Bonneville Dam, Tumwater Dam, Chiwawa River, and Nason Creek (Figure 3.8). Based on migration years 2008-2010, both hatchery and natural-origin fish passed Bonneville Dam at the same time. There was a small difference in migration timing at Tumwater Dam between the two groups, with hatchery fish migrating later during the latter half of the migration period. That is, the 90th percentile of natural-origin migrants passed Tumwater Dam about 13 days before the 90th percentile of hatchery migrants passed Tumwater. There was also a difference between the two groups that entered the Chiwawa River. There, the 90th percentile of hatchery migrants entered the Chiwawa River about 136 days earlier than did the 90th percentile of natural-origin migrants. Interestingly, there was virtually no difference between the two groups at the 10th and 50th percentiles. Also, there was no difference in migration timing between the two groups entering Nason Creek.

We also compared the mean migration timing of hatchery and natural-origin steelhead by comparing the mean week that 10%, 50%, and 90% of the fish passed Tumwater Dam (based on video monitoring). Because the migration of steelhead over Tumwater Dam is bimodal (Hillman et al. 2011), we estimated migration statistics separately for each migration pulse (i.e., summer-autumn migration and winter-spring migration). That is, we compared migration statistics for hatchery and natural-origin steelhead passing Tumwater Dam during the summer-autumn period (June-December) independent of those for the winter-spring migration period (January-May).

Based on 12 years of sampling, there was no significant difference in migration timing of wild and hatchery fish enumerated at Tumwater Dam (Table 3.3). For both the summer-autumn and winter-spring migration periods, wild and hatchery steelhead arrived at the dam during the same week. The mean and median migration timing for wild and hatchery steelhead was also similar. However, at the tail end of both migration periods, on average, wild steelhead appeared to end their migration about one week earlier than hatchery steelhead. These results are consistent with those from PIT-tag analyses.

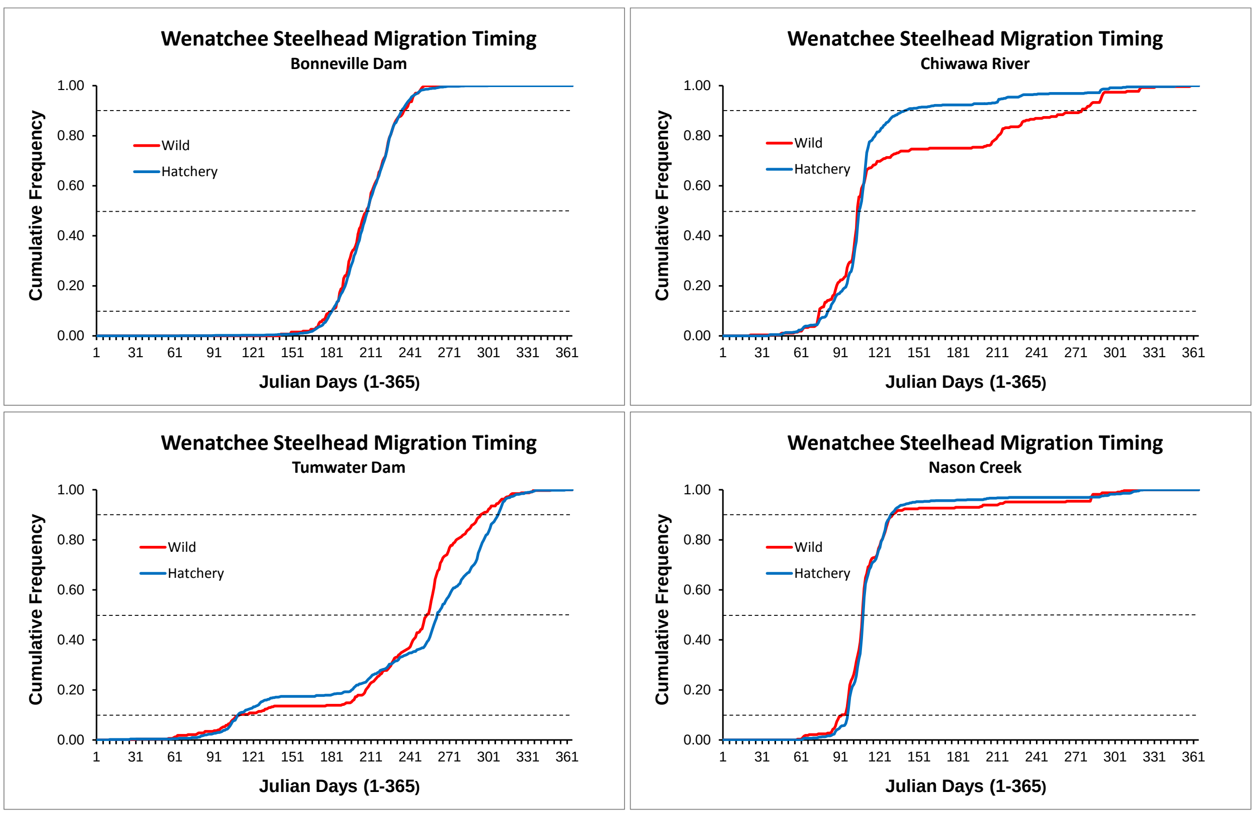


Figure 3.7. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Wenatchee steelhead passing Bonneville Dam, Tumwater Dam, and interrogation sites in Nason Creek and the Chiwawa River. Migration timing was based on PIT-tagged steelhead detected during 2008-2010 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 266 wild and 2,321 hatchery steelhead at Bonneville; 324 wild and 597 hatchery at Tumwater; 268 wild and 610 hatchery at the Chiwawa River detector; and 328 wild and 861 hatchery at the Nason Creek detector.

Table 3.3. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average week that hatchery and natural-origin (wild) Wenatchee steelhead migrated past Tumwater Dam during the summer-autumn and winter-spring migration periods, 1999-2010 (N = 12 years). Migration timing was based on video monitoring at Tumwater Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Summer-Autumn Migration Period (Jun-Dec)								
Mean	30	30	37	38	43	45	37	37
Effect size	0		1		2		0	
t-value	-0.244		-1.625		-1.151		-1.106	
P-value	0.812		0.132		0.274		0.293	
Bootstrap CI	-1 – 1		-2 – 0		-2 – 1		-1 – 0	
Power	0.056		0.317		0.183		0.173	
Winter-Spring Migration Period (Jan-May)								
Mean	11	11	15	15	17	18	15	15
Effect size	0		0		1		0	
t-value	0.785		-1.735		-0.821		-0.518	
P-value	0.449		0.111		0.429		0.515	
Bootstrap CI	-1 – 2		-1 – 0		-1 – 0		-1 – 0	
Power	0.111		0.354		0.117		0.076	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin steelhead should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We have no information on the time that hatchery and natural-origin steelhead actually spawn (i.e., there are few to no steelhead carcasses collected during spawning surveys); therefore, we rely on the time that hatchery and natural-origin fish enter spawning tributaries to assess spawn timing. Here, we assume that spawn timing is correlated with migration timing. We compared cumulative frequency polygons of the time when PIT-tagged hatchery and natural-origin steelhead entered spawning tributaries (Chiwawa River, Nason Creek, and Peshastin Creek).

There was little difference in the spawn timing of hatchery and natural-origin steelhead spawning within three tributaries (Figure 3.8). Spawn timing was similar in both Nason Creek and the Chiwawa River. The difference in timing between hatchery and natural-origin steelhead later in the year in the Chiwawa was related to fish migrating into the Chiwawa during the summer following spawning. These later arriving fish remain in the Chiwawa and spawn the following spring. Within Peshastin Creek, natural-origin steelhead appear to spawn earlier than hatchery steelhead. This difference may be related to small samples sizes. A larger sample size may indicate little difference between the two groups spawning in Peshastin Creek.

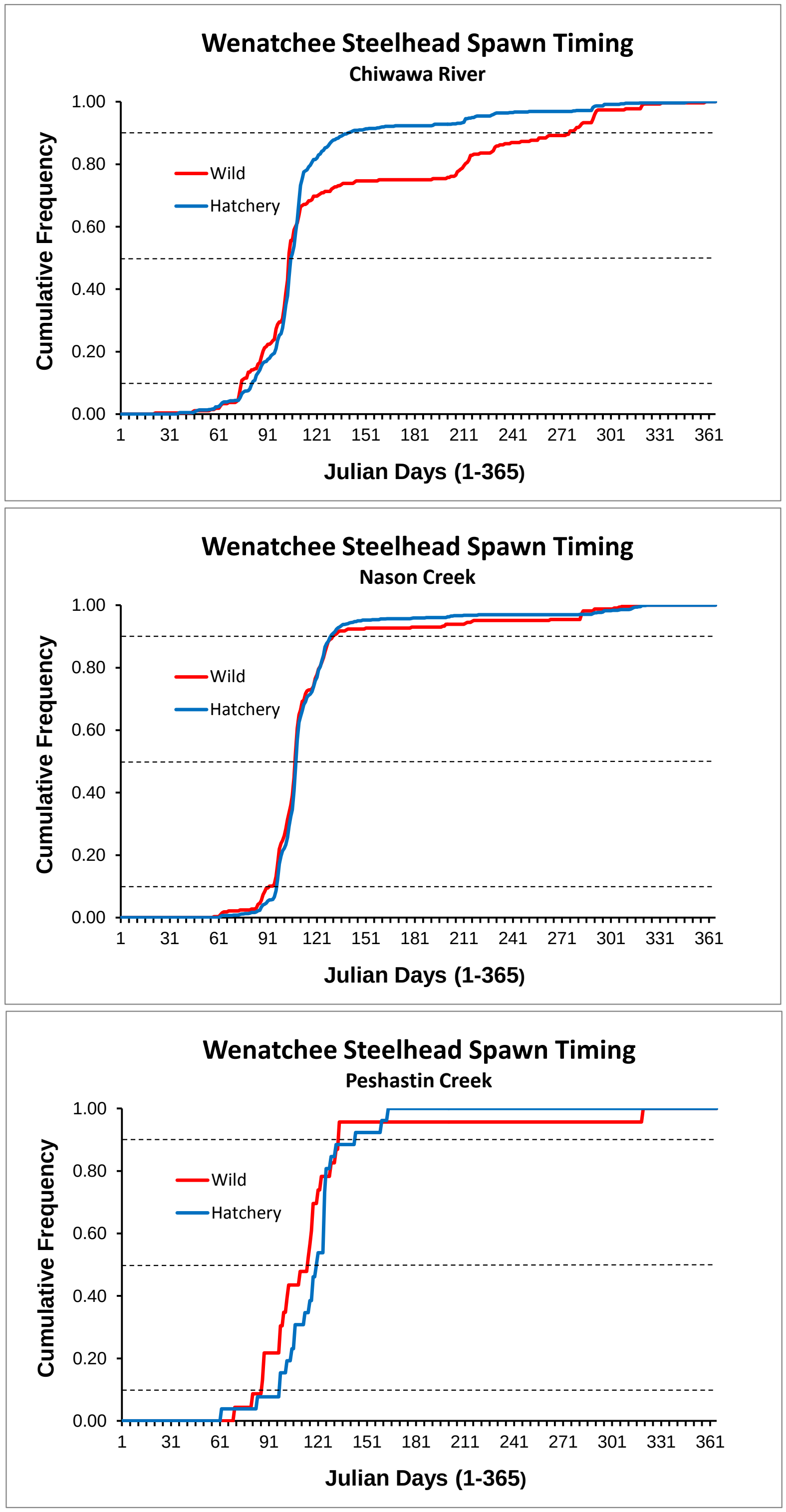


Figure 3.8. Cumulative frequency polygons of spawn timing of hatchery and natural-origin (wild) steelhead in the Chiwawa, Nason, and Peshastin basins. Spawn timing was based on the Julian date that PIT-tagged steelhead entered spawning tributaries during 2008-2010. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 268 wild and 610 hatchery steelhead in the Chiwawa, 328 wild and 861 hatchery in Nason, and 23 wild and 26 hatchery steelhead in Peshastin Creek.

Redd Distribution

Under a fully integrated program, both hatchery and natural-origin steelhead should spawn in the same location. Because we cannot determine at this time if a given redd was constructed by a hatchery or natural-origin steelhead, we cannot evaluate the distribution of hatchery and natural-origin steelhead redds in the Wenatchee Basin.

Conclusions

Based on interrogations of PIT-tagged steelhead, hatchery and natural-origin fish had similar migration timings at Bonneville Dam and Tumwater Dam. However, they differed in their timing of entry into the Chiwawa River, but not Nason Creek. For the Chiwawa, the 90th percentile of the hatchery migrants entered the river about 136 days earlier than did the 90th percentile for natural-origin migrants. This difference appears to be related to the latter 25% of the natural-origin migrants entering the Chiwawa during the summer following spawning. These fish remain in the Chiwawa and spawn the following year. Some of these fish have been observed during August snorkel surveys (Hillman, personal communication). In contrast, the latter 3% of the hatchery steelhead migrants enter during the summer and remain there until spawning the following spring. Thus, there is a difference in the proportion of hatchery and natural-origin steelhead that enter the Chiwawa River during the summer and hold over until the next spring.

The spawn timing of hatchery and natural-origin steelhead was determined by examining the timing of tributary entry of PIT-tagged steelhead. The assumption was that spawn timing and migration timing into spawning tributaries are correlated. Based on this assumption, there was little difference in the spawn timing of hatchery and natural-origin steelhead in Nason Creek and the Chiwawa River. There was a difference in Peshastin Creek, with natural-origin fish spawning earlier than hatchery fish. This difference may be related to small sample size.

3.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to determine the potential effects of the Wenatchee Supplementation Program on natural-origin summer steelhead in the Wenatchee Basin (Seamons et al. 2012; the entire report is appended as Appendix F). Temporal collections of tissue samples from Wenatchee hatchery-produced and natural-origin adults sampled at Dryden and Tumwater dams and from natural-origin juveniles from three Wenatchee River tributaries and the Entiat River were surveyed for genetic variation with 132 genetic (single nucleotide polymorphism loci; SNPs) markers. Peshastin Creek and the Entiat River served as no-hatchery-outplant controls. Genetic data were interrogated for the presence or absence of spatial and temporal trends in allele frequencies, genetic distances, and effective population size.

Allele Frequencies—Changes to the summer steelhead hatchery supplementation program had no detectable effect on genetic diversity of wild populations. On average, hatchery-origin adults had higher minor allele frequencies (MAF) than natural-origin adults, which may simply reflect the mixed ancestry of hatchery adults. Both hatchery and natural-origin adults had MAF similar to juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants. This suggests that the hatchery program has had little effect on allele frequencies since broodstock sources changed in 1998 from mixed-ancestry broodstock collected in the Columbia River to using broodstock collected in the Wenatchee River.

Genetic Distances—As intended, interbreeding of Wenatchee River hatchery and natural-origin adults reduced the genetic differences between Wells Hatchery adults and Wenatchee River natural-origin adults observed in the first few years after changing the broodstock collection protocol. Although there were detectable genetic differences between hatchery and natural-origin adults, the magnitude of that difference declined over time. Hatchery adults were genetically different from natural-origin adults and juveniles based on pair-wise F_{ST} and principal components analysis, most likely because of the smaller effective population size (N_b) in the hatchery population (see below). Pair-wise F_{ST} estimates and genetic distances between hatchery and natural-origin adults collected the same year declined over time suggesting that the interbreeding of hatchery and natural-origin adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year were inconclusive because of limitations in the data.

Effective Population Size—Although the effective population size of the Wenatchee River hatchery steelhead program was consistently small, it does not appear to have caused a reduction in the effective population size of the wild population. On average, estimates of N_b were much lower and varied less for hatchery adults than for natural-origin adults and juveniles. Estimates of N_b for hatchery adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1998. There was no indication that this had any effect on N_b in natural-origin adults and juveniles; N_b estimates for natural-origin adults and juveniles were, on average, higher and varied considerably over the 1998-2010 time period and showed no temporal trend.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin Wenatchee steelhead. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin steelhead differed significantly. Because of the wide range of years that natural origin steelhead can spend in freshwater and the narrow range in years that hatchery steelhead spend in freshwater, we evaluated age at maturity using only ocean ages (salt age). We evaluated male and female steelhead separately.

The age at maturity of female steelhead did not differ significantly between hatchery and natural-origin fish (Yates' Chi-square = 0.65; P = 0.723), but did for male steelhead (Yates' Chi-square = 4.77; P = 0.043) (Figure 3.9). Most hatchery and natural-origin females matured after spending two years in saltwater. In contrast, most males matured after spending one year in saltwater. For males, a higher percentage of hatchery steelhead matured after one year in saltwater than natural-origin fish, while a higher percentage of natural-origin fish matured after spending two years in saltwater than hatchery fish. Very few steelhead mature as 3-salt fish.

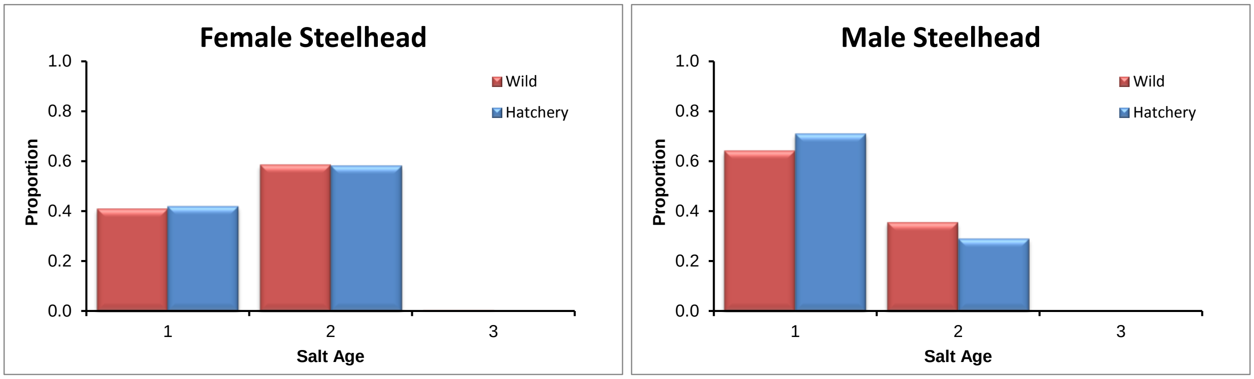


Figure 3.9. Proportion of hatchery and natural-origin female and male steelhead spawners of different salt ages sampled in broodstock for the combined years 1997-2010. Sample sizes for females = 558 wild and 618 hatchery steelhead and for males = 444 wild and 562 hatchery steelhead.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin Wenatchee steelhead. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin steelhead of the same age. We used three-way General Linear Models (GLM) ANOVA to test differences in sizes of hatchery and natural-origin fish.

The size at maturity differed significantly between hatchery and natural-origin female and male steelhead (Table 3.4; Figure 3.10). Across the saltwater ages, natural-origin fish were significantly larger than hatchery fish; however, the mean differences across ages were 2 cm or less, which is probably not biologically significant.

Table 3.4. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Wenatchee steelhead. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Salt Age (1 or 2), resulting in a 2 x 2 x 2 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	129.36	10.61	0.001	0.903
Origin	1	1,441.94	118.31	0.000	0.999
Sex x Origin	1	19.178	1.57	0.210	0.241
Age	1	47,040.95	3,859.79	0.000	0.999
Sex x Age	1	511.07	41.93	0.000	0.999
Origin x Age	1	21.32	1.75	0.186	0.262
Sex x Origin x Age	1	0.23	0.02	0.890	0.052
Error	1,928	12.18			

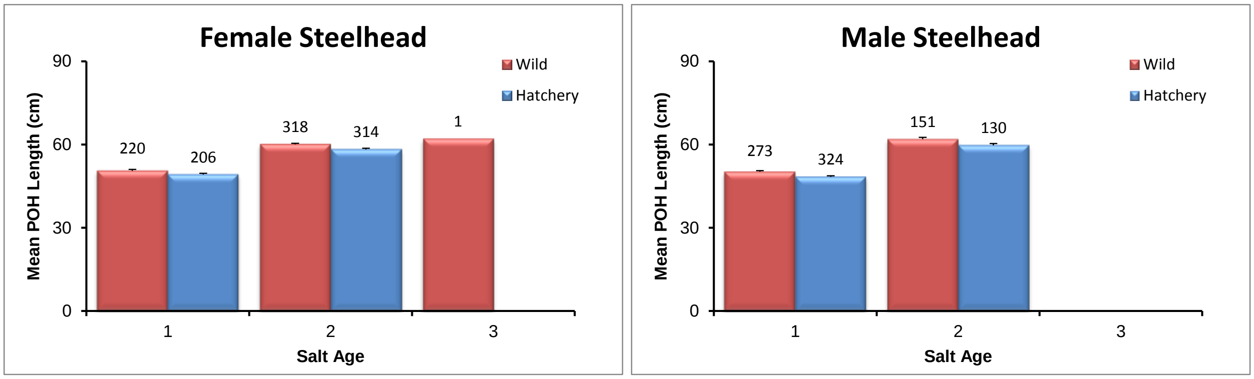


Figure 3.10. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male steelhead spawners of different salt ages sampled in broodstock for the combined years 1997-2010. Sample sizes are shown above each bar.

Conclusions

Genetic analyses found no indication that changing from mixed-ancestry broodstock collected in the Columbia River to broodstock collected in the Wenatchee River affected allele frequencies. That is, changing the broodstock collection protocol in 1998 did not affect the genetic diversity of natural-origin steelhead in the Wenatchee Basin. Although there were detectable genetic differences between hatchery and natural-origin adults, the magnitude of the difference has declined over time. Thus, the interbreeding of hatchery and natural-origin adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Finally, there was no evidence that the Wenatchee supplementation program has reduced the effective population size of the Wenatchee summer steelhead population.

There was a significant difference in age at maturity between hatchery and natural-origin male steelhead, but not for female steelhead. For males, a higher percentage of hatchery steelhead matured as 1-salt fish than natural-origin fish, while a higher percentage of natural-origin fish matured as 2-salt fish than hatchery fish. Males matured earlier than females. Differences in size at maturity between hatchery and natural-origin fish of the same age were generally less than 2 cm, which is probably not significant biologically.

3.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 19.2 (the calculated target value in Murdoch and Peven 2005).

HRRs exceeded NRRs in six of the seven years of data (Figure 3.11). In addition, HRRs exceeded the estimated target value of 19.2 in one of the seven years (Figure 3.11).

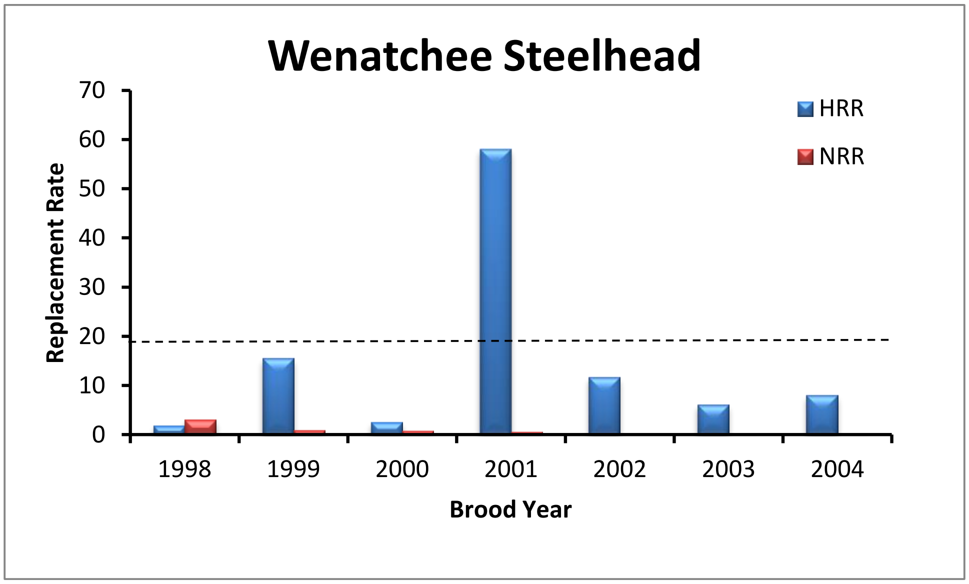


Figure 3.11. Natural and hatchery replacement rates (NRR and HRR, respectively) for steelhead in the Wenatchee Basin, brood years 1998-2004. The horizontal dashed line represents the target value of 19.2 in Murdoch and Peven (2005).

Conclusions

In all but one year, the steelhead supplementation program has demonstrated a significant full life-cycle survival advantage over natural-origin steelhead with a productivity advantage of over 16:1 during the period 1998 to 2004. That is, on average, HRRs were about 16 times greater than NRRs.

3.5 Stray Rates

Stray rates of Wenatchee steelhead can be estimated by examining the locations where PIT-tagged hatchery steelhead were last detected. PIT tagging of steelhead began with brood year 2005, which allows estimation of stray rates by brood return. These data only provide estimates for brood years 2005 through 2007, because later brood years are still rearing in the ocean. The target for brood year stray rates should be less than 5%.

At this time, we cannot estimate among population stray rates by return year, because we have no estimates of detection efficiencies for PIT-tag interrogation sites within different tributaries. These data are needed to estimate the total number of Wenatchee steelhead that stray into areas outside the Wenatchee Basin. Finally, for the same reason, we cannot evaluate within population stray rates.

Among Population Stray Rates by Brood Return

Based on PIT-tag analyses, on average, about 34% of the hatchery steelhead returns were last detected in streams outside the Wenatchee Basin (Table 3.5). The numbers in Table 3.5 should be considered rough estimates because they are not based on confirmed spawning (only last detections) and the numbers have not been adjusted for detection efficiencies, which currently do not exist for most PIT-tag detection arrays in tributaries. What these data do indicate is that large numbers of hatchery steelhead from the Wenatchee program have wandered or strayed into the

Entiat and Methow rivers, and also into the Tucannon River. Most (about 70%) of the strays were detected in the Methow River.

Table 3.5. Number and percent of hatchery-origin Wenatchee steelhead that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005 to 2007. Estimates were based on last detections of PIT-tagged hatchery steelhead. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	80	75.5	0	0.0	26	24.5	0	0.0
2006	71	62.3	1	0.9	43	37.7	0	0.0
2007	171	60.6	0	0.0	111	39.4	0	0.0
Average	***107***	***66.1***	***0***	***0.3***	***60***	***33.9***	***0***	***0.0***

Conclusions

Based on PIT-tag analyses for three brood years (2005-2007), on average, about 34% of the hatchery steelhead brood returns were last detected in streams outside the Wenatchee Basin. Most of these strays were detected in the Methow River, although hatchery steelhead also strayed into the Entiat and Tucannon rivers. It is important to point out that PIT-tag analyses are based on last detections, not observed spawning. Therefore, we cannot be certain that these fish actually spawned in areas outside the Wenatchee Basin. The over-winter acclimation of steelhead at the Chiwawa facility should reduce the straying of Wenatchee steelhead.

3.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the Wenatchee steelhead supplementation program is to release smolts into the Wenatchee Basin that average 198 mm long (fork length) and 75.6 g. The program has not consistently met the length and weight targets (Figure 3.12). For example, releases of HxH crosses met the length and weight targets in five out of the nine years. Releases of HxW crosses met the length target in five out of the 12 years and the weight target in nine out of the 12 years. The WxW crosses met the length and weight targets in four out of the 12 years.

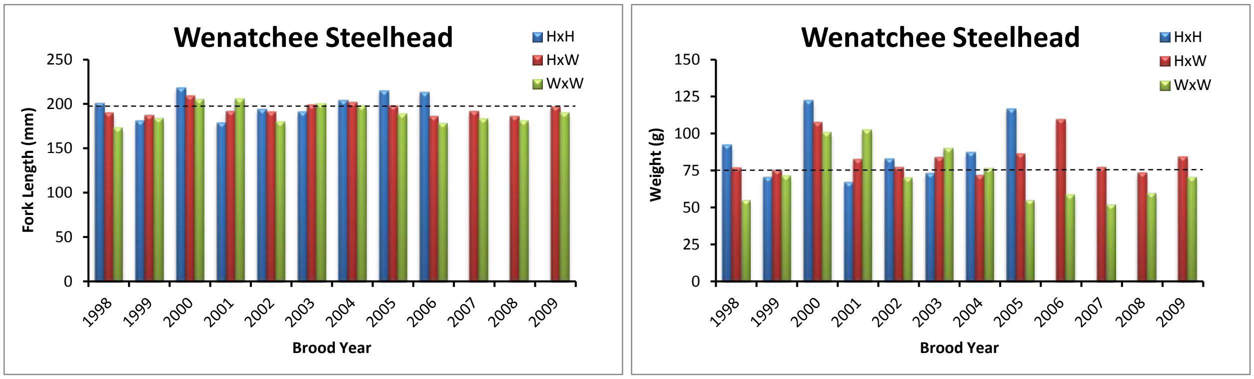


Figure 3.12. Average lengths (mm) and weights (g) of hatchery x hatchery (HxH), hatchery x wild (HxW), and wild x wild (WxW) crosses of Wenatchee steelhead smolts released in the Wenatchee Basin for brood years 1998-2009. No HxH crosses have been released since 2006. The dashed horizontal lines represent the target length (198 mm) and target weight (75.6 g).

The length and weight targets for the Wenatchee steelhead supplementation program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Wenatchee steelhead based on data collected within the hatchery over a five-year period (Figure 3.13). Based on this relationship, if the goal is to release smolts at 198 mm, then the target weight of the smolts should be 78.5 g, not 75.6 g. On the other hand, if the goal is to release smolts that weigh 75.6 g, then the fork length at release should be 195 mm, not 198 mm.

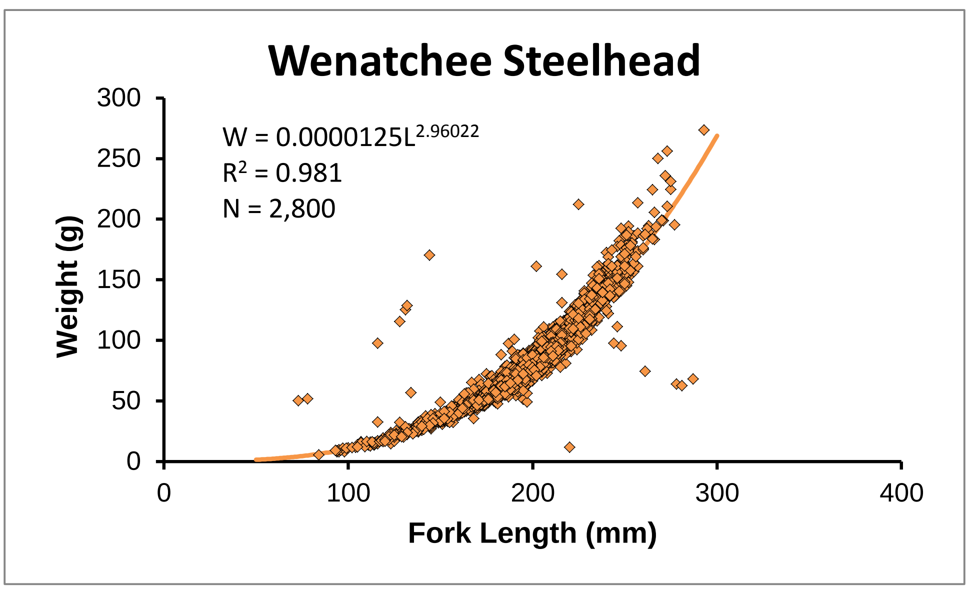


Figure 3.13. Relationship between fork length (mm) and weight (g) of juvenile Wenatchee steelhead sampled during 2003-2007. Because of the large number of outliers, Robust Regression estimated the length-weight parameters.

Number of Hatchery Fish Released

The past goal of the steelhead supplementation program was to release 400,000 steelhead smolts in the Wenatchee Basin (the current goal is to release 247,300 steelhead smolts). The program has reached the goal of releasing 400,000 smolts in two out of the 12 years (Figure 3.14). The primary reason the program did not achieve the release target in most years was because the number of broodstock collected fell below the total needed (208 adults) to meet the program goal. This was in part a consequence of converting from an out-of-basin broodstock source to a local (Wenatchee) source, with a natural-origin component objective. In addition, the unfertilized egg-to-release survivals have been below the standard for the program (Hillman et al. 2011). For reasons unknown, the steelhead program has experienced highly variable fertilization rates.

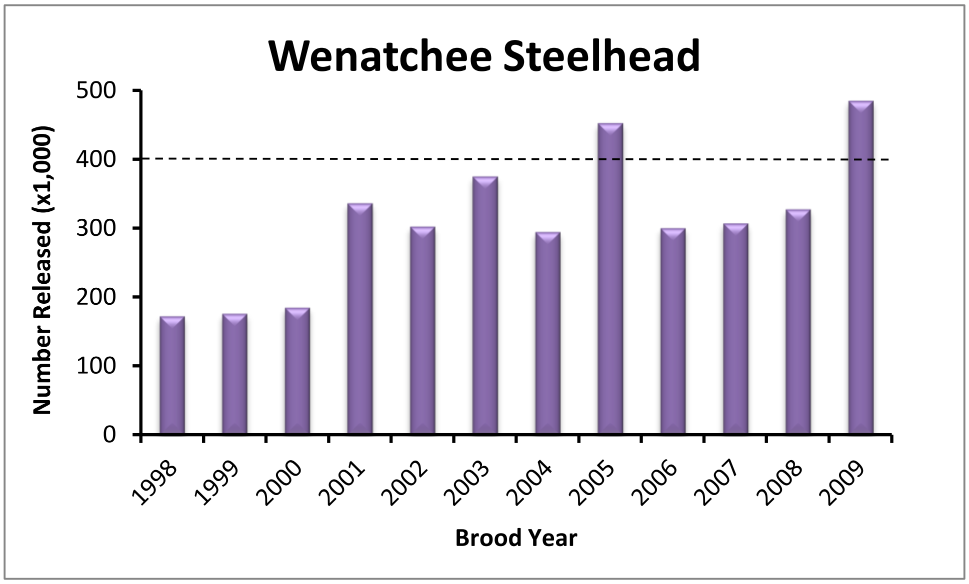


Figure 3.14. Total number of Wenatchee steelhead smolts released in the Wenatchee Basin for brood years 1998-2009 (period following the switch to local broodstock collection). The dashed horizontal line represents the target release number (400,000 juveniles).

Conclusions

The Wenatchee steelhead supplementation program has rarely achieved its past goal of releasing 400,000 smolts per year. This is largely because the number of broodstock collected fell below the total needed (208 adults) to meet the program goal. In addition, the unfertilized egg-to-release survivals have been below the standard for the program and fertilization rates have been highly variable. It is important to note that the smolt release target for the program has recently changed. The current goal is to release 247,300 steelhead smolts in the Wenatchee Basin. This goal requires the collection of 130 adult steelhead (64 natural-origin and 66 hatchery-origin steelhead). This goal appears more reasonable than the release target of 400,000 smolts.

Steelhead smolts released into the Wenatchee Basin have not consistently met the size goals for the program. The WxW smolts have met the length and weight targets less frequently than the HxH and HxW smolts. This may be related to the different hatchery facilities in which the different crosses are reared. It may also be related to the use of "standard" length and weight goals. Because of the unique relationship between length and weight of Wenatchee steelhead, the program should consider using more realistic size targets based on the length-weight relationship specific to this population. These targets should closely resemble those of natural-origin smolts (e.g., 148 mm or 35 g; mean sizes from steelhead smolts sampled at the Chiwawa Smolt Trap).

3.7 Freshwater Productivity

Juvenile Productivity

Because we found no suitable reference populations for juvenile Wenatchee steelhead productivity and there are no pre-supplementation juvenile data for the Wenatchee population, we used stock-recruitment models to assess the productivity and capacity of the Wenatchee steelhead population. Here, we define recruitment as the number of natural-origin smolts produced in the Wenatchee Basin (smolt estimates are from the lower Wenatchee trap). We also compared the number of smolts/spawner to pHOS, and the residuals from the stock-recruitment curves to pHOS. If there is a negative association between pHOS and the productivity of smolts (or residuals from the stock-recruitment curves), then the hatchery fish may be reducing the productivity of juvenile steelhead in the Wenatchee Basin.

There was a significant negative relationship between numbers of steelhead spawners and smolts/spawner produced in the Wenatchee Basin (Figure 3.15). This indicates the presence of density dependence, which explains why the smooth hockey stick model provided the best fit to the stock-recruitment data. However, the model only explained about 3% of the variability in the smolt data. Assuming the stock-recruitment relationship is real, the mean capacity of the Wenatchee Basin is about 36,744 smolts.[3] According to the model, it takes about 1,048 spawners to fully saturate the habitat in the Wenatchee Basin. For reference, the recovery criterion for Wenatchee steelhead is 1,000 natural-origin spawners.

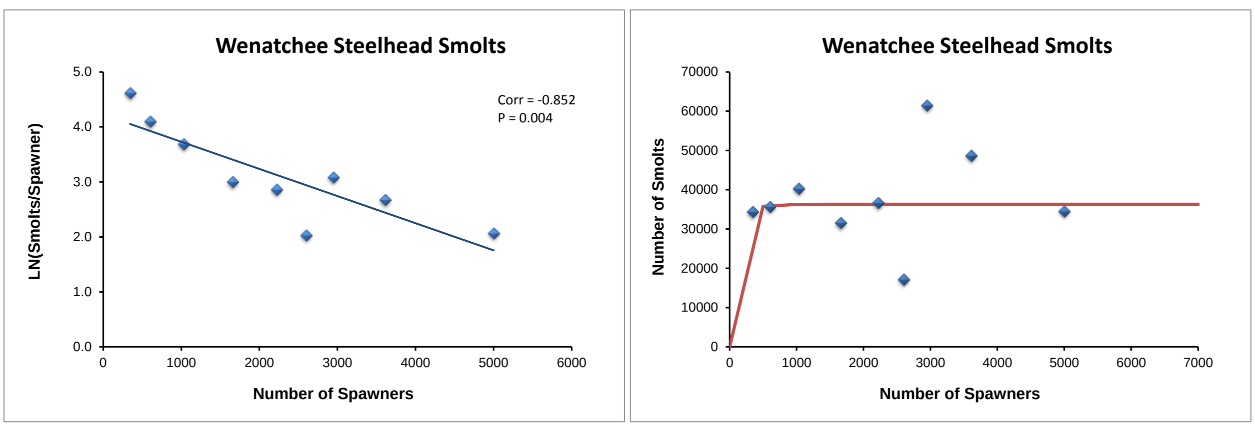


Figure 3.15. Relationship between number of Wenatchee steelhead spawners and number of smolts/spawner (figure on the left) and number of smolts produced (figure on the right) in the Wenatchee Basin for brood years 1998-2006. The smooth hockey stick model provided the best fit to the stock-recruitment data.

[3] For comparison, we used several different habitat models to estimate steelhead smolt capacity within the Wenatchee Basin. The models estimated a steelhead smolt capacity that ranged from 62,000 to 129,000 (average of about 100,000 smolts), which is about 2.7 times greater than then estimate based on modeling stock and recruitment data.

There was a significant negative association between the number of smolts/spawner and the spawning escapement made up of hatchery steelhead (pHOS) (Figure 3.16). This association is in part influenced by the single, low pHOS value. Additional low pHOS scores are needed to more fully describe the association between pHOS and smolts/spawner. In contrast, we found no association between pHOS and the residuals from fitting the smooth hockey stick model to the stock-recruitment data (Figure 3.16).

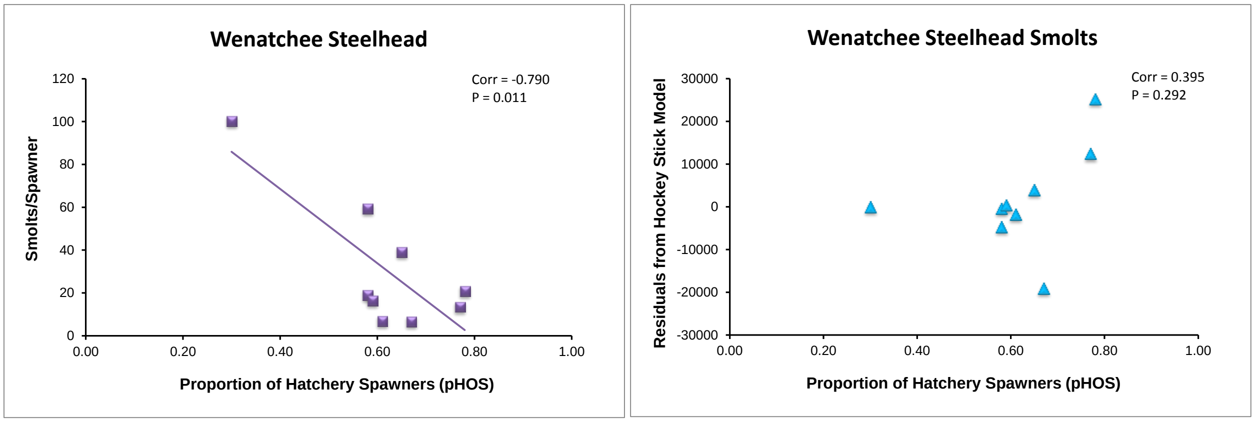


Figure 3.16. Association between the proportion of steelhead spawners that were made up of hatchery adults (pHOS) and the number of smolts/spawner (figure on the left) and the residuals from fitting the smooth hockey stick model to the stock-recruitment data (figure on the right). The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

Conclusions

The existing data indicate a density-dependent relationship between numbers of steelhead spawners in the Wenatchee Basin and numbers of smolts produced. According to the smooth hockey stick model, the capacity of the Wenatchee Basin appears to average about 36,744 smolts (habitat models indicate a mean capacity closer to 100,000 smolts). As spawner abundance exceeds 1,048 adults, density dependent mortality increases.

The effects of hatchery-origin spawners on juvenile productivity are equivocal. There was a clear negative association between pHOS and juvenile steelhead productivity. However, there was no association between pHOS and the residuals from the smooth hockey stick model. Without pre-supplementation data and/or reference population data, it is difficult to determine whether or not supplementation has reduced juvenile productivity in the Wenatchee Basin.

3.8 Harvest

Harvest Rates

Nearly all harvest on Wenatchee steelhead occurs within the Columbia Basin. Harvest rates on steelhead in the Lower Columbia River fisheries (both tribal and non-tribal) are generally less than 5-10% (NMFS 2004). However, about 33% of PIT tagged Wenatchee steelhead detected at Bonneville Dam are missing by the time they arrive at Rock Island Dam. This loss includes natural mortality, fishing mortality, and straying.

WDFW regulates steelhead harvest in the Upper Columbia. Under certain conditions, WDFW may allow a harvest on hatchery steelhead (adipose fin clipped fish). The intent is to reduce the number of hatchery steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of natural-origin steelhead in the spawning population.

The current management goal for the Wenatchee Basin calls for a spawning escapement of 2,500 adult steelhead before a recreational fishery can be opened. An additional 130 adults are needed for broodstock. Therefore, a total of 2,630 adult steelhead are currently needed to satisfy broodstock and spawning escapement goals for the Wenatchee Basin. Based on the total escapement goal of 2,630 adults, there were nine brood years between 1981 and 2009 that produced escapements large enough to support a terminal recreational fishery (Figure 3.17).

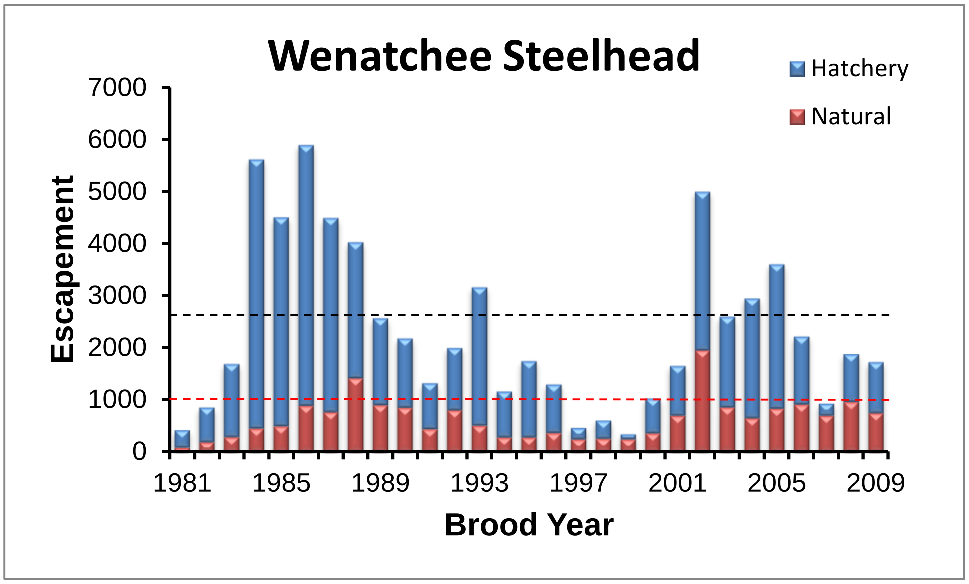


Figure 3.17. Numbers of hatchery and natural-origin steelhead adults that escaped into the Wenatchee Basin for brood years 1981-2009. The black dashed line represents the number needed to satisfy the current broodstock collection goal (130 adults) plus the number needed to meet the current escapement goal of 2,500 spawners (total = 2,630 adults). The red dashed line represents the minimum number of natural-origin steelhead needed to meet the TRT recovery level for the Wenatchee population (1,000 natural-origin steelhead). Data are from the NWFSC Salmonid Population Summary Database.

Conclusions

Wenatchee steelhead are harvested within the Columbia River Basin primarily within the recreational fishery. There are no data indicating that Wenatchee steelhead are harvested in the ocean. Assuming a total escapement of 2,630 adults is needed to meet current broodstock collection (130 adults) and spawning escapement (2,500 adults) goals; there were nine brood years between 1981 and 2009 that produced escapements large enough to support a recreational fishery.

It is important to point out that the escapement needed before a terminal fishery is allowed in the Wenatchee Basin is about 2.6 times larger than the TRT recovery criterion. If smolt productivity decreases as the spawning escapement exceeds about 1,500 spawners (based on the spawner-smolt function)[4] and that there may be potential benefits in reducing pHOS, it may be wise to

[4] According to the Ricker model, which included adult recruits (see Section 3.1), the maximum spawner abundance before recruits/spawner decreases is about 2,400 spawners.

reconsider the escapement needed before a terminal steelhead fishery is allowed within the Wenatchee Basin.

3.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available data were unable to show that converting to local broodstock collection has significantly increased total steelhead spawning abundance in the Wenatchee Basin.
2. The conversion to local broodstock collection appears to have increased NORs. Analyses indicate that the conversion did not decrease productivity of the steelhead population.
3. Hatchery and natural-origin steelhead had similar migration timings at Bonneville and Tumwater dams and into Nason Creek, but not into the Chiwawa River. The latter 25% of natural-origin steelhead entering the Chiwawa River did so about 136 days later than did hatchery fish. That is, about 25% of the steelhead entered the Chiwawa River during the summer following the spawning period. These fish remained in the Chiwawa until the next spawning period. About 3% of the hatchery fish demonstrated this behavior.
4. Based on time of entry into spawning streams, there was little difference in spawn timing of hatchery and natural-origin steelhead in Nason Creek and the Chiwawa River. There was a difference in Peshastin Creek, with natural-origin fish spawning earlier than hatchery fish.
5. There was no indication that changing the broodstock collection protocol in 1998 affected the genetic diversity of natural-origin steelhead in the Wenatchee Basin.
6. There were genetic differences between hatchery and natural-origin adults, but the magnitude of the difference has declined over time. Thus, the interbreeding of hatchery and natural-origin adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead.
7. There was no evidence that the Wenatchee supplementation program has reduced the effective population size of the Wenatchee summer steelhead population.
8. There was a difference in age-at-maturity (based on salt age) between hatchery and natural-origin male steelhead, but not female steelhead. More hatchery males matured as 1-salt fish than natural-origin males, while more natural-origin males matured as 2-salt fish than hatchery-origin males.
9. Differences in size-at-maturity between hatchery and natural-origin steelhead of the same age were generally less than 2 cm, which is probably not significant biologically.
10. HRRs were on average 16 times greater than NRRs.
11. Based on PIT-tag analysis for three years (2005-2007), on average, about 34% of the hatchery steelhead brood returns have strayed into, or were lasted detected in streams outside the Wenatchee Basin. Although most were last detected in the Methow, they were also last detected in the Entiat and Tucannon rivers. The over-winter acclimation of steelhead at the Chiwawa facility beginning in 2012 should decrease the straying of Wenatchee steelhead.

12. Largely because of inadequate broodstock collection, the supplementation program rarely achieved its past goal of releasing 400,000 juveniles per year. The current goal is to release 247,300 smolts (123,650 for conservation and 123,650 for safety net). Based on the number of smolts released in the past, the release of 247,300 smolts should be achieved in most years.
13. Steelhead smolts released into the Wenatchee Basin have not consistently met the size goals for the program. The WxW smolts have met the length and weight targets less frequently than the HxH and HxW smolts. The release of hatchery smolts at about 148 mm or 35 g would closely mimic the mean sizes of natural-origin smolts produced in the Chiwawa Basin.
14. There was a clear density-dependent relationship between numbers of steelhead spawners and the productivity of juvenile steelhead (smolts per spawner) in the Wenatchee Basin. Based on the smooth hockey stick model, the capacity of the Wenatchee Basin appears to average about 36,744 smolts (note that habitat models indicate a mean capacity closer to 100,000 smolts). As spawner abundance exceeds 1,048 adults, density-dependent mortality appears to increase.
15. The effects of hatchery-origin spawners on juvenile productivity are equivocal. There was a clear negative association between pHOS and juvenile steelhead productivity; however, there was no association between pHOS and the residuals from the smooth hockey stick model.
16. Wenatchee steelhead are harvested within Columbia River fisheries, not ocean fisheries, with harvest rates generally less than 5-10%.
17. Assuming a total escapement of 2,630 adults is needed to meet current broodstock collection and spawning escapement goals; there were nine brood years between 1981 and 2009 that produced escapements large enough to support a terminal recreational fishery. The total spawning escapement needed before a terminal fishery is allowed should be reconsidered based on the TRT recovery criterion, stock-recruitment modeling, and the potential benefits of reducing pHOS.

The low abundance of adult steelhead has limited broodstock collection and smolt releases in most years. In addition, the unfertilized egg-to-release survivals have been below the standard set for the program and fertilization rates have been highly variable. The relatively poor survival and variable fertilization rates may be related to water temperatures at adult holding facilities and/or to innate differences in spawners. The latter can be tested by implementing a partial or full factorial mating design (Busack and Knudsen 2007). This design will allow managers to determine if gamete viability is related to specific breeding adults. It is important to note that the smolt release target for the program recently changed. The current goal is to release 247,300 steelhead smolts into the Wenatchee Basin. This requires the collection of 130 adult steelhead (64 natural-origin and 66 hatchery-origin steelhead).

The size of fish released has not consistently met program goals. The HxH and HxW smolts met the size targets more frequently than did the WxW smolts. This may be related to the hatchery facility in which the different crosses of fish were reared. It may also be related to the fact that the length and weight targets for the program were not based on the unique length-weight relationship of Wenatchee steelhead. If the goal is to release smolts at 198 mm, then the target weight of the smolts should be 78.5 g, not 75.6 g. On the other hand, if the goal is to release smolts that weigh 75.6 g, then the fork length at release should be 195 mm, not 198 mm. We believe it is important to match the size of hatchery produced smolts to the size of natural-origin smolts (i.e., 148 mm or 35 g based on natural-origin smolts produced in the Chiwawa Basin). Even though the size goals for the program were not achieved, the productivity of these fish was over 16 times greater than the productivity of natural-origin fish.

Wenatchee steelhead appear to be exploited at low rates (<10%) with most of the adults produced escaping to the upper Columbia Basin. However, based on PIT-tag analysis, about 33% of Wenatchee steelhead detected at Bonneville Dam are lost before they arrive at Rock Island Dam. Some of these PIT-tagged fish stray into non-target populations, including the Methow, Entiat, and Tucannon populations. On average, 34% of the brood returns strayed into non-target areas, exceeding the 5% target limit established for the program. This may in part explain why the supplementation program has not significantly increased the total spawning escapement to the Wenatchee Basin. The reason for the high straying may be related to the source water used at the hatchery rearing facilities. Most of the rearing facilities use Columbia River water. Several of the smolts produced at these facilities are trucked and released into the Wenatchee Basin, which may not give the smolts enough time to imprint on target stream waters. Beginning in 2012, the entire steelhead program will overwinter at the Chiwawa Ponds. This should give the fish adequate time to imprint on target waters and thus reduce future stray rates of Wenatchee steelhead.

There were some differences in genetic and phenotypic characteristics between hatchery and natural-origin steelhead. For example, there were genetic differences between hatchery and natural-origin adults, but the magnitude of the difference has declined over time. In addition, more hatchery males matured as 1-salt fish than natural-origin males, while more natural-origin males matured as 2-salt fish than hatchery-origin males. There was no difference in age at maturity between hatchery and natural-origin females. Adult return timing was similar between the two groups, but natural-origin fish demonstrated a different migration characteristic into the Chiwawa River than did hatchery fish. Except in Peshastin Creek, both hatchery and natural-origin fish appeared to spawn at the same time. Finally, there were differences in size at age between hatchery and natural-origin fish, but these differences are probably not significant biologically. Some of these phenotypic differences may be related to unintentional selective broodstock collection. It is unknown why hatchery males returned at an earlier age than the natural-origin males. Hatchery fish returning at an earlier age than natural-origin fish is a common outcome among hatchery programs and may be related to rapid growth rates in the hatchery and size at release.

In all but one year the steelhead supplementation program has demonstrated a significant full life-cycle survival advantage over natural-origin steelhead. On the other hand, we were unable to detect an increase in total spawning escapement following the implementation of the supplementation program. We did find an increase in NORs following supplementation, but because there were no reference populations to compare with the Wenatchee steelhead population, we cannot be certain that the increase was a result of supplementation. Importantly, NRRs have exceeded 1.0 in only two of the last 12 complete brood years (period of Chelan supplementation program). Possible reasons why the program has not been as successful as planned include:

- *Poor Reproductive Success of Hatchery Steelhead*—Given the results from other relative reproductive success (RRS) studies, the low PNI[5] for this program, the negative association between pHOS and productivity, and some differences in life-history characteristics (e.g., younger age at maturity), it is possible that hatchery fish have reduced reproductive success. WDFW is currently evaluating the reproductive success of hatchery steelhead in the upper Columbia Basin.
- *Columbia River Acclimation*—Juvenile steelhead have been reared at facilities that rely primarily on Columbia River water. During the spring, the fish are trucked from the facilities and released at different locations within the Wenatchee River basin providing them with little opportunity to imprint on those locations. This practice is likely responsible for the large stray rates, which in turn may have prevented the increase in abundance and productivity of steelhead within the Wenatchee Basin. Beginning in 2012, over-winter acclimation of steelhead will occur at the Chiwawa facility, which should reduce stray rates and hopefully increase steelhead abundance and productivity within the Wenatchee Basin.
- *Density Dependence*—Because there is a negative relationship between spawning abundance and productivity, it is possible that the density of spawners is reducing productivity through density-dependent effects.
- *Ecological Interactions*—With the large numbers of hatchery fish released in the upper Columbia Basin, it is possible that the survival and productivity of natural-origin fish have been reduced. The HETT is currently evaluating the effects of hatchery releases on non-target taxa of concern. In addition, it is possible that the supplementation program has increased the incidence of disease (e.g., BKD or Rs) in the naturally spawning population.

The low abundance and productivity of the natural spawning population are challenges for meeting supplementation objectives. These factors may be addressed by improving PNI and allowing juvenile steelhead to imprint on target streams.

[5] PNI = Proportion of Natural Influence, which is calculated as the proportion of naturally produced fish in the hatchery broodstock (pNOB) divided by the proportion of hatchery fish on the spawning grounds (pHOS) plus pNOB.

SECTION 4: WENATCHEE SOCKEYE SALMON

The goal of sockeye salmon supplementation in the Wenatchee Basin is to use artificial production to replace adult production lost because of mortality at Rock Island Dam, while not reducing the natural production or long-term fitness of sockeye in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Adult sockeye were collected for broodstock from the run-at-large at Tumwater Dam. Beginning in 2011, because of passage delays at Tumwater Dam during trapping operations, sockeye broodstock will be collected at Dryden Dam. The goal is to collect up to 260 natural-origin adult sockeye for the program. Broodstock collection occurs from about 7 July through 28 August with trapping occurring no more than 16 hours per day, three days a week at Tumwater Dam and up to seven days per week at the Dryden Dam left and right-bank facilities.

Adult sockeye are currently held and spawned at Eastbank Fish Hatchery. The fertilized eggs are also incubated at the hatchery. For brood years 1989 through 1998, unfed fry were transferred from the hatchery to Lake Wenatchee net pens. Since then, juvenile sockeye have reared at Eastbank Fish Hatchery until July when they are transferred to the net pens. The initial rearing at Eastbank is to increase growth rates. During most years up through 2005, juvenile sockeye were released from net pens at two different times, August and November. Since 2006, all juvenile sockeye have been released in late October.

The production goal for the Wenatchee sockeye supplementation program is to release 200,000 subyearlings into Lake Wenatchee at 20 fish per pound. Targets for fork length and weight are 133 mm (CV = 9.0) and 22.7 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2006, about 15,000 juvenile sockeye have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

4.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the sockeye supplementation program is to increase the total number of spawners in the Wenatchee Basin. This, however, is difficult to test because we have only four years of escapement data before supplementation and there are no suitable reference populations for comparison. Based on this limited data series, we analyzing trends and mean abundances before and during supplementation.

Trend analysis indicated that before supplementation, the total number of spawners decreased over time; however, during supplementation the trend reversed and increased over time (Figure 4.1). The change in trend before and during supplementation was not significant. We then compared the mean spawner abundance before supplementation with the mean abundance during supplementation. Although not statistically significant, mean spawner abundance during the supplementation period was less than the pre-supplementation spawner abundance (Table 4.1). Mean spawner abundance decreased 41% between the pre- and post-supplementation periods.

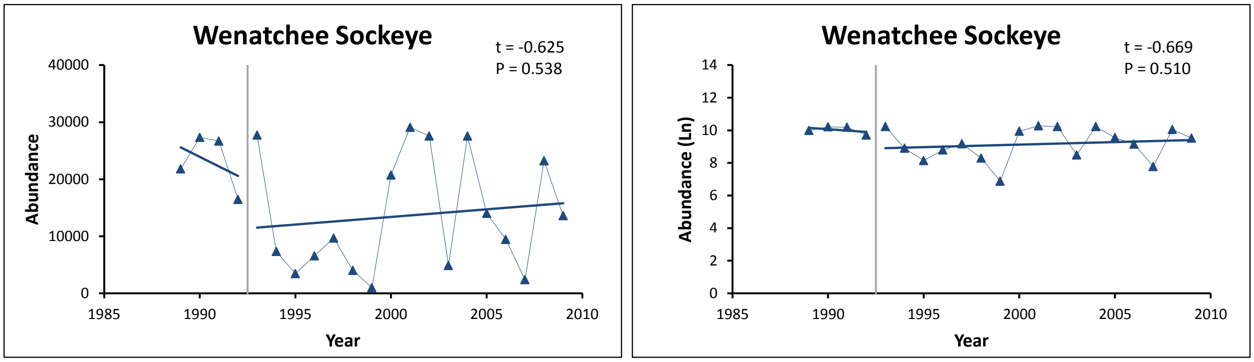


Figure 4.1. Trends in Wenatchee sockeye spawner abundance before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

Table 4.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Wenatchee sockeye. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	23,069	13,656	2.668	0.988	0.067	3,188 – 15,549
LN Abundance	10.0	9.1	3.248	0.998	0.032	0.36 – 1.37
NORs	11,431	16,671	-0.667	0.265	0.502	-20,189 – 7,212
LN NORs	8.9	9.0	-0.091	0.465	0.923	-1.23 – 1.01
Productivity	0.53	1.61	-1.809	0.954	0.180	-2.14 – 0.09
LN Productivity	-1.08	-0.13	-1.544	0.912	0.181	-2.10 – 0.07
Adj Productivity	0.53	1.61	-1.820	0.955	0.178	-2.13 – 0.03
LN Adj Productivity	-1.08	-0.12	-1.559	0.914	0.180	-2.09 – 0.06

As a final test of the effects of supplementation on total spawner abundance, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Excluding the first four years following the start of the supplementation program, when no hatchery fish had yet returned, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in eight of the 17 years (Table 4.2).

Table 4.2. Numbers of natural-origin (NOB) and hatchery-origin (HOB) sockeye included in broodstock and numbers of hatchery-origin sockeye spawning naturally (HOS) in the Wenatchee Basin.

Brood year	NOB	HOB	Total Broodstock	HOS
1989	115	0	115	0
1990	302	0	302	0
1991	199	0	199	0
1992	320	0	320	0
1993	207	0	207	2,662
1994	236	5	241	396
1995	194	3	197	186
1996	225	0	225	546
1997	192	19	211	77
1998	122	6	128	32
1999	79	60	139	60
2000	170	5	175	1,161
2001	200	7	207	815
2002	256	0	256	193
2003	198	0	198	58
2004	177	0	177	1,460
2005	166	0	166	28
2006	214	0	214	255
2007	210	0	210	59
2008	243	2	245	93
2009	239	0	239	449
Average	**203**	**5**	**208**	**406**

In summary, there is currently no evidence that the supplementation program has increased the total number of sockeye spawners (hatchery and natural-origin spawners) within the Wenatchee Basin. This conclusion is based on comparing trends and mean abundances before and after supplementation. It is important to note that the number of pre-supplementation years is small (i.e., N = 4) and there were no suitable reference populations for comparisons. Therefore, we cannot be certain that the supplementation program has not increased the total number of sockeye spawners within the Wenatchee Basin.

Natural-Origin Recruits

Another important goal of the sockeye supplementation program is to increase the number of natural-origin recruits (NORs). We tested the success of the supplementation program in increasing NORs by analyzing trends and mean NORs before and during supplementation. Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before supplementation, NORs decreased over time; however, during supplementation the trend reversed and increased over time (Figure 4.2). The change in trend before and during supplementation was not significant. We then compared mean sockeye NORs before supplementation with mean NORs during supplementation. Although not statistically significant, mean NORs during the supplementation period were greater than pre-supplementation NORs (Table 4.1). Mean NORs increased 46% between the pre- and post-supplementation periods.

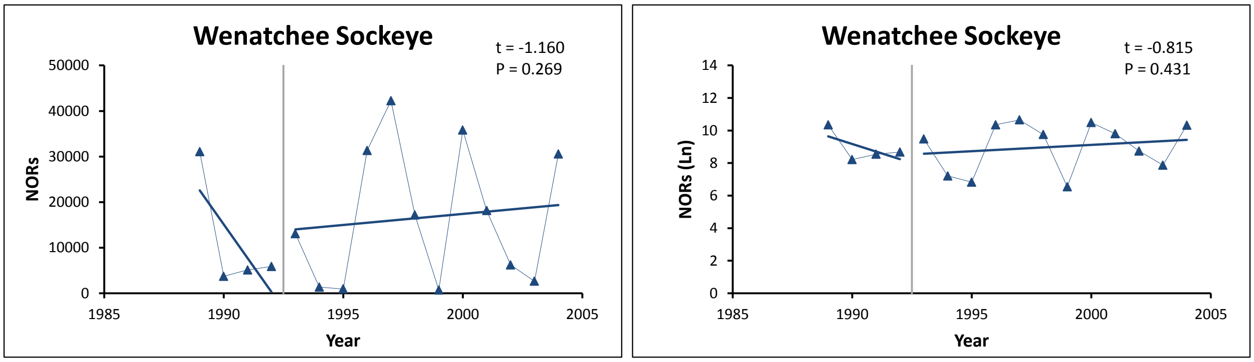


Figure 4.2. Trends in Wenatchee sockeye NORs before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

Finally, we used Pearson correlation to test the association between pHOS and sockeye NORs. If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. During the pre-supplementation period, NORs averaged 11,431 adults; during the supplementation period, NORs averaged 16,671 adults. This increase in NORs did not appear to be strongly correlated to pHOS (Figure 4.3). Correlation analysis showed that there was no significant association between pHOS and NORs, even though NORs increased with increasing pHOS.

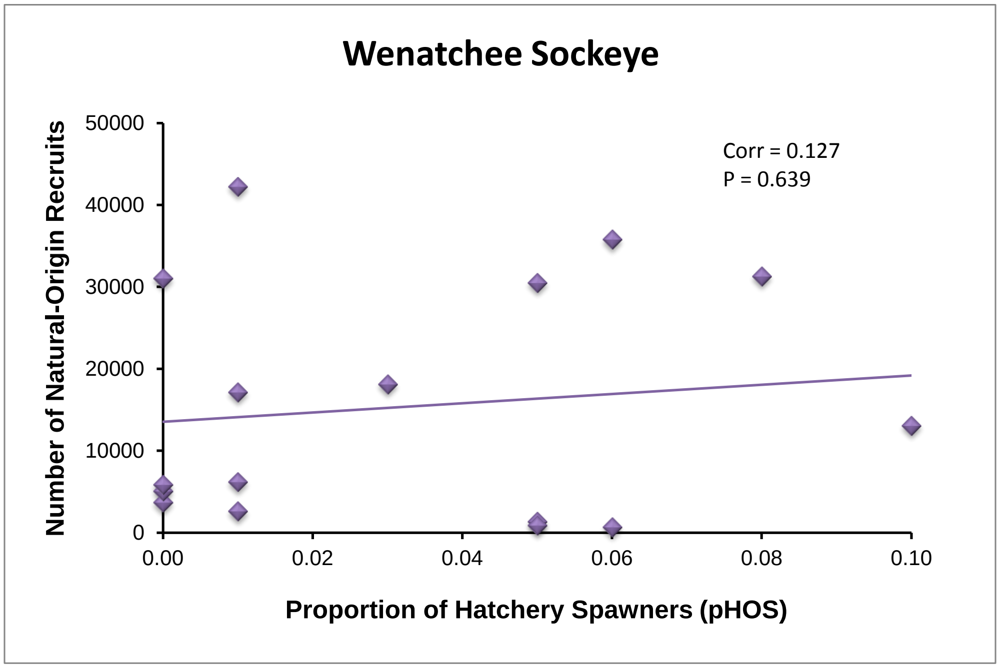


Figure 4.3. Association between the proportion of sockeye spawners that are made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

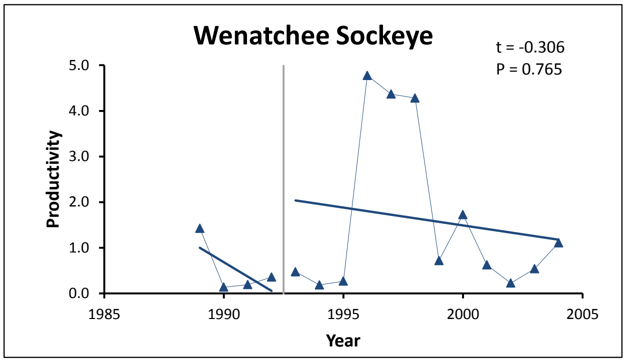
In summary, there is some evidence that the supplementation program has increased sockeye NORs within the Wenatchee Basin. This conclusion is based on comparing trends and mean NORs before and after supplementation. Again, it is important to note that there were only four years of pre-supplementation data and there were no suitable reference populations for comparisons. Therefore, we cannot be certain that the supplementation program has increased sockeye NORs within the Wenatchee Basin.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the supplementation program has significantly reduced the productivity of sockeye in the Wenatchee Basin by analyzing trends and mean productivities before and during supplementation. Because productivity can be affected by density dependence, we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the stock-recruitment data.

Trend analysis indicated that productivity decreased both before and during supplementation (Figure 4.4). The decrease in trend before supplementation was greater than the decrease during supplementation. The change in trend before and during supplementation was not significant, largely because of the large variability in productivity during the supplementation period. We then compared mean sockeye productivities before supplementation with mean productivities during supplementation. Mean productivities increased, but not significantly, between the pre- and post-supplementation periods (Table 4.1). Productivity before supplementation averaged

0.53 recruits per spawner; during supplementation productivity averaged 1.61 recruits per spawner.



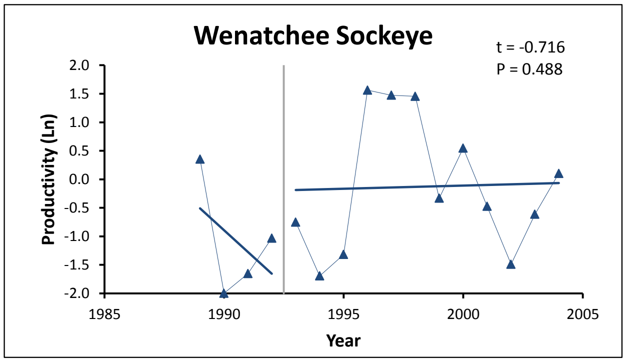


Figure 4.4. Trends in Wenatchee sockeye productivity (adult recruits/spawner; NRRs) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

Next, we analyzed the effects of supplementation on productivities adjusted for density dependence. We did this by fitting Ricker, Beverton-Holt, and smooth hockey stick stock-recruitment models to the sockeye data. The Ricker model provided the best fit and explained 24% of the variability in the stock-recruitment data (Figure 4.5). From the model we estimated the number of spawners (K_{sp}) needed to produce the maximum number or recruits (K_R). We used K_{sp} to separate density-independent productivities and density-dependent productivities (see Appendix C for details).

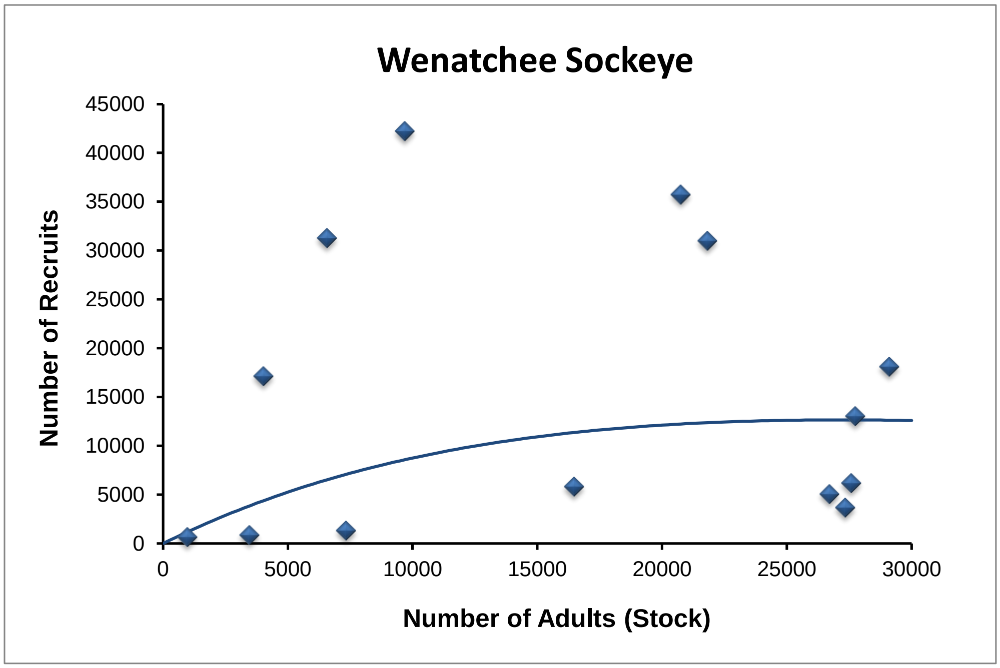


Figure 4.5. Relationship between number of sockeye spawners and adult recruits (1989-2004) in the Wenatchee Basin. The Ricker model was fit to the stock-recruitment data.

Analysis of the adjusted productivity data provided similar results as those with unadjusted productivity data. That is, adjusted productivities increase, but not significantly, between the pre- and post-supplementation periods (Table 4.1). Adjusted productivities before supplementation averaged 0.53 recruits per spawner; during supplementation adjusted productivities averaged 1.61 recruits per spawner. This lack of difference between adjusted and unadjusted productivities is because most of the spawner escapements in the Wenatchee Basin have been below the spawning level needed to produce the maximum number of recruits. In other words, recruitment has been affected more by density-independent factors than density-dependent factors.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the Wenatchee sockeye stock and recruitment data. Although there was a positive trend in residuals with increasing pHOS, suggesting that hatchery-origin spawners may be as productive as natural-origin spawners, the association was not significant (Figure 4.6).

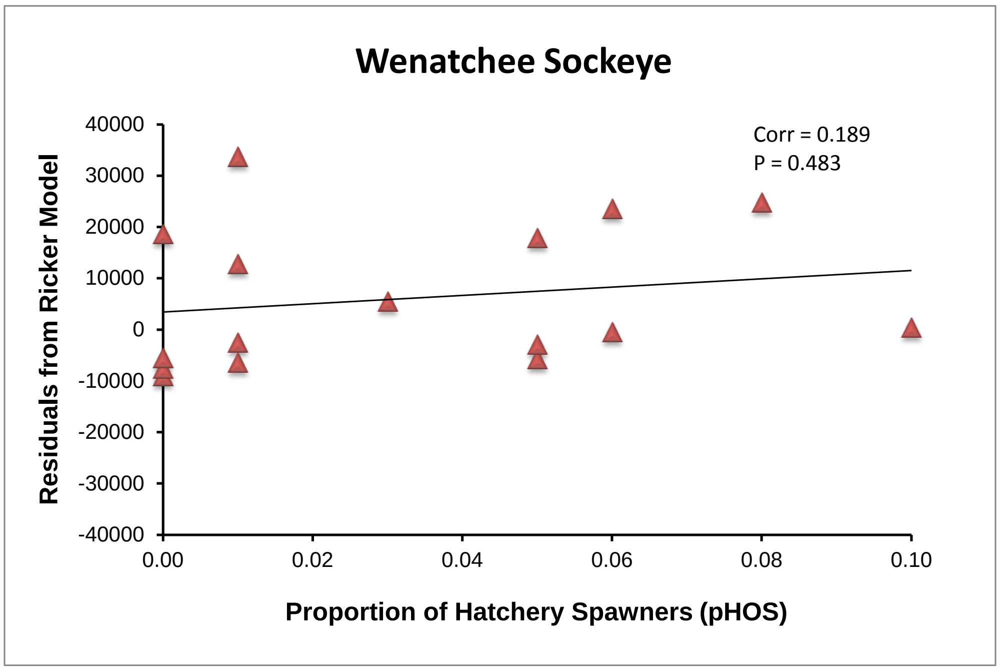


Figure 4.6. Association between the proportion of sockeye spawners that were made up of hatchery adults (pHOS) and the residuals from the Ricker stock-recruitment model. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, there is some evidence that the supplementation program has improved the productivity of the Wenatchee sockeye population. This conclusion is based on comparing trends and mean productivities before and after supplementation. We caution, however, that these results are based on only four years of pre-supplementation data and that there were no suitable reference populations for comparisons. Therefore, we cannot be certain that the supplementation program has increased sockeye productivity within the Wenatchee Basin.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. Analysis of the available data suggests that the Wenatchee sockeye supplementation program has not significantly increased total spawning abundance in the Wenatchee Basin. In contrast, there is some indication that supplementation has increased NORs and the productivity of the population. That is, the before-after analyses suggest that supplementation has increased NORs and productivity, but not total spawners. Furthermore, there was a positive, but not significant, association between pHOS and NORs and a positive, but not significant, association between pHOS and the residuals from the Ricker stock-recruitment relationship. The latter suggests that hatchery-origin spawners may be as productive as natural-origin spawners. However, it is important to note that the before-after analyses were based on a four years of pre-supplementation data and there were no suitable reference populations for comparison. Therefore, we cannot be certain that supplementation has or has not improved NORs and the productivity of the Wenatchee sockeye population.

4.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin sockeye by comparing cumulative frequency polygons using data collected during video sampling at Tumwater Dam and PIT interrogations at Bonneville Dam, Tumwater Dam, and in the White and Little Wenatchee rivers.

We compared cumulative frequency polygons of migration timing of PIT-tagged hatchery and natural-origin sockeye interrogated at Bonneville Dam, Tumwater Dam, and within the White and Little Wenatchee rivers (Figure 4.7). Based on migration years 2009-2011, both hatchery and natural-origin fish passed Bonneville and Tumwater dams at about the same time. Only toward the end of the migration period (90^{th} percentile) did the two groups differ in migration timing at the dams. In contrast, natural-origin sockeye entered the spawning tributaries earlier than did hatchery sockeye (Figure 4.7). On average, natural-origin fish entered the spawning tributaries about five days earlier than hatchery fish. We could not compare migration timing of different age sockeye, because of the small sample size of aged fish.

We also compared the mean migration timing of hatchery and natural-origin sockeye by comparing the mean Julian date that 10%, 50%, and 90% of the fish passed Tumwater Dam (based on video monitoring). Based on 13 years of sampling, there were significant differences in the migration timing of hatchery and natural-origin sockeye at Tumwater Dam (Table 4.3). There was a tendency for natural-origin sockeye to complete the migration earlier than hatchery fish. That is, based on these data, the 10^{th} percentile of natural-origin fish passed Tumwater Dam one day before the 10^{th} percentile of hatchery fish passed the dam (this comparison was not significantly different). In contrast, on average, the 90^{th} percentile of natural-origin fish passed the dam about eight days earlier than 90^{th} percentile of hatchery fish. These results are in contrast with those based on PIT tags.

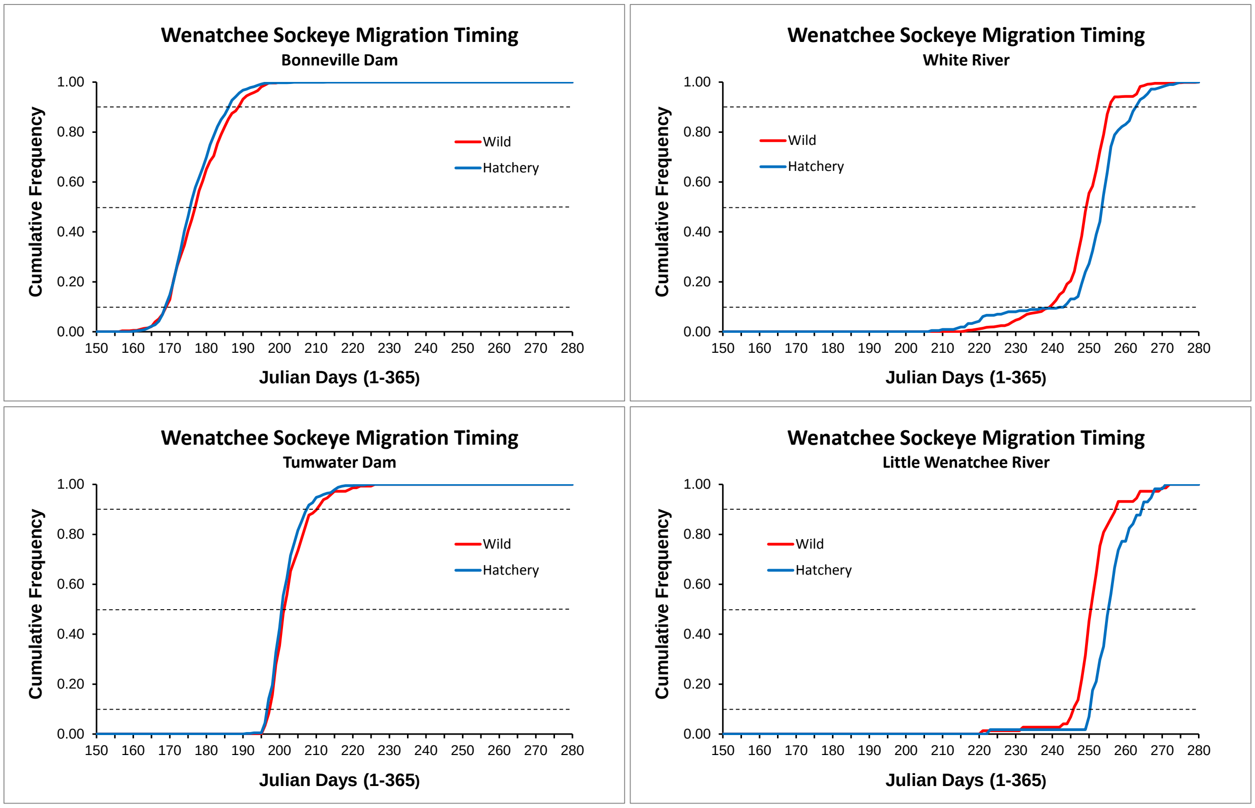


Figure 4.7. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Wenatchee sockeye passing Bonneville Dam, Tumwater Dam, and interrogation sites in the White and Little Wenatchee rivers. Migration timing was based on PIT-tagged sockeye detected during 2009-2011 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 528 wild and 1,279 hatchery sockeye at Bonneville; 147 wild and 425 hatchery at Tumwater; 859 wild and 213 hatchery at the White River detector; and 73 wild and 57 hatchery at the Little Wenatchee detector.

Table 4.3. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date that hatchery and natural-origin (wild) Wenatchee sockeye migrated past Tumwater Dam during the period 1998-2010 (N = 13 years). Migration timing was based on video monitoring at Tumwater Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	199	200	205	209	218	226	207	211
Effect size	1		4		8		4	
t-value	-1.048		-2.244		-2.705		-2.750	
P-value	0.315		0.044		0.019		0.018	
Bootstrap CI	-2 – 1		-7 – -1		-13 – -2		-7 – -1	
Power	0.162		0.541		0.700		0.714	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin sockeye should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We tested differences in spawn timing between hatchery and natural-origin Wenatchee sockeye by comparing cumulative frequency polygons of the time when female carcasses were recovered on the spawning grounds.

There were differences in the spawn timing of hatchery and natural-origin sockeye in the White and Little Wenatchee basins (Figure 4.8). On average, natural-origin sockeye spawned about one to four days earlier than hatchery fish. However, for both groups, the 10th percentile spawn times were nearly identical in both basins.

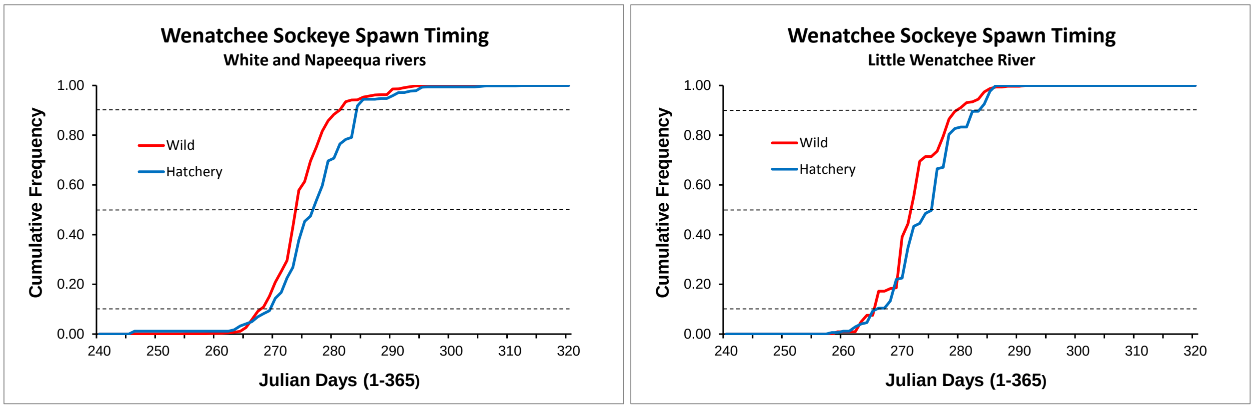


Figure 4.8. Cumulative frequency polygons of spawn timing of hatchery and natural-origin (wild) sockeye in the White and Little Wenatchee basins. Spawn timing was based on the Julian date that female carcasses were recovered on the spawning grounds. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 7,265 wild and 704 hatchery sockeye in the White and 650 wild and 173 hatchery sockeye in the Little Wenatchee.

We also compared the spawn timing of hatchery and natural-origin sockeye by comparing the mean Julian data that 10%, 50%, and 90% of the female carcasses were recovered on the spawning grounds. Based on 18 years of sampling, there was no significant difference in the spawn timing of hatchery and natural-origin sockeye in the White or Little Wenatchee basins (Table 4.4). Although the results are not significant statistically, they are consistent with the cumulative frequency polygons in that the natural-origin fish spawned slightly earlier than hatchery fish.

Table 4.4. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date of spawn timing of hatchery and natural-origin (wild) sockeye in the White and Little Wenatchee rivers during the period 1993-2010.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
White River (and Napeequa River)								
Mean	270	271	274	277	279	283	275	277
Effect size	1		3		4		2	
t-value	0.178		1.819		1.597		1.596	
P-value	0.862		0.094		0.136		0.137	
Bootstrap CI	-4 – 6		0 – 6		-1 – 7		-1 – 5	
Power	0.053		0.387		0.312		0.312	
Little Wenatchee River								
Mean	269	270	273	274	278	277	273	274
Effect size	1		1		1		1	
t-value	0.600		0.940		-0.135		0.624	
P-value	0.567		0.379		0.897		0.553	
Bootstrap CI	-2 – 3		-1 – 4		-4 – 3		-1 – 2	
Power	0.082		0.129		0.052		0.084	

Because spawning generally progresses from higher elevations to lower elevations, we examined the relationship between elevation and spawn timing of hatchery and natural-origin sockeye. We found little difference in the spawn time of hatchery and natural-origin sockeye across the range of spawning elevations within the Little Wenatchee and White rivers (including the Napeequa River). In general, both hatchery and natural-origin sockeye spawned at about the same time across the range of elevations within the two rivers (Figure 4.9).

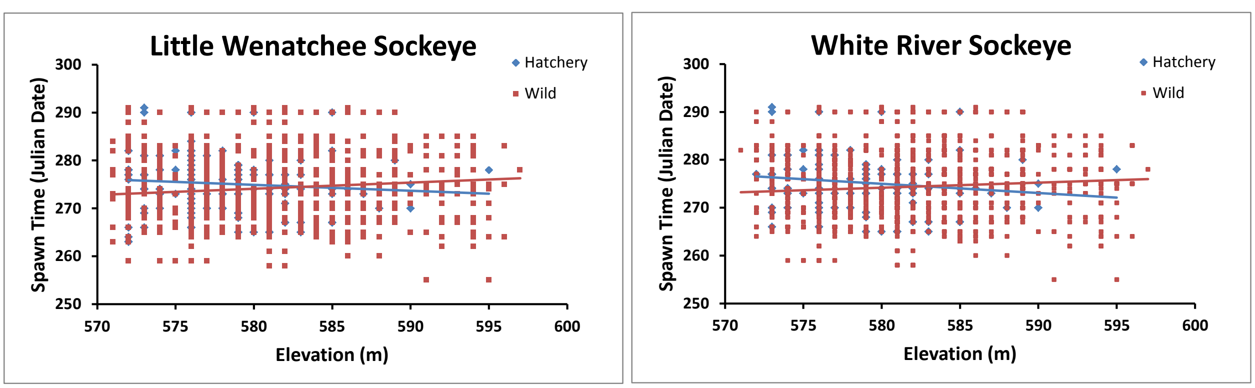


Figure 4.9. Relationship between elevation and spawn timing of hatchery and natural-origin (wild) sockeye spawners within the Little Wenatchee and White rivers (including the Napeequa River).

Redd Distribution

Under a fully integrated program, both hatchery and natural-origin sockeye should spawn in the same location. We evaluated differences in spawning locations at two different spatial scales; at the historic reach scale and at the 0.5 km scale.

Both hatchery and natural-origin sockeye spawned within specific reaches within the White and Little Wenatchee basins. There was a significant difference in the distribution of hatchery and natural-origin spawners among the historic sampling reaches in the Little Wenatchee Basin (Yates' Chi-square = 5.6; P = 0.018; Effect Size = 0.095), but not in the White River Basin (Yates' Chi-square = 2.2; P = 0.137; Effect Size = 0.018). Within the White River Basin, over 96% of the hatchery and natural-origin sockeye spawned in Reach 2 (Figure 4.10). The remaining 4% of the fish spawned in the lower Napeequa River. Within the Little Wenatchee River, 99% of the hatchery and 95% of the natural-origin sockeye spawned in the second reach (Figure 4.10). The remaining hatchery and natural-origin sockeye spawned in the upper-most reach of the Little Wenatchee River.

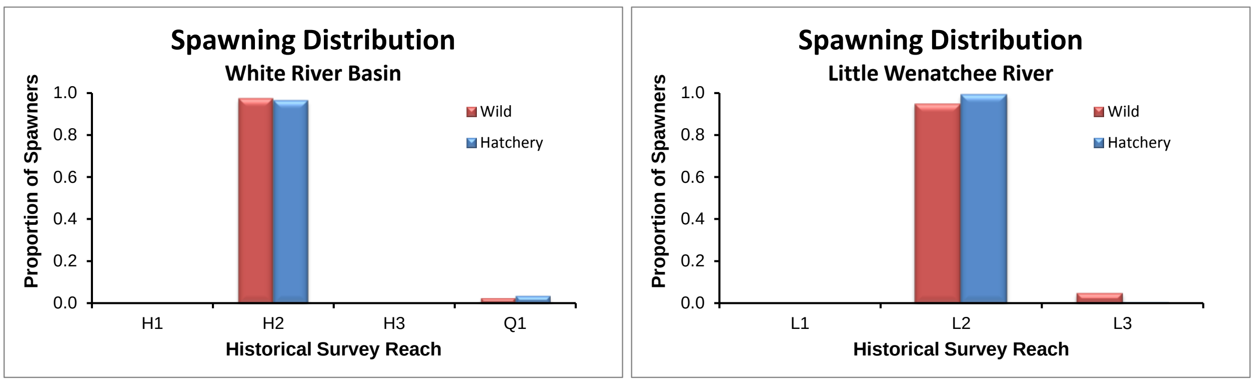


Figure 4.10. Proportion of hatchery and natural-origin (wild) sockeye spawners distributed among the different historic sampling reaches on the White and Little Wenatchee rivers. For the White River basin, H1 is from 0.0-10.3 km; H2 10.3-17.7; H3 17.7-20.8; and Q1 (Napeequa River) is from 0.0-2.0. For the Little Wenatchee River, L1 is from 0.0-4.3 km; L2 4.3-8.4; and L3 8.4-14.8. Sample sizes = 7,168 wild and 634 hatchery sockeye in the White and 572 wild and 168 hatchery sockeye in the Little Wenatchee.

When we analyzed spawning distribution at a finer scale (0.5 km reaches), there was a greater difference in the distribution of hatchery and natural-origin sockeye (Figure 4.11). In the White River, the difference in spawning distribution was minor, with a slightly larger percentage of hatchery fish spawning between Rkms 11 and 14, and a larger percentage of natural-origin fish spawning around Rkm 15-17. Within the Little Wenatchee River, a larger percentage of natural-origin fish spawned between Rkms 4.5 and 6.5, while a larger percentage of hatchery fish spawned between Rkms 7.0 and 8.5.

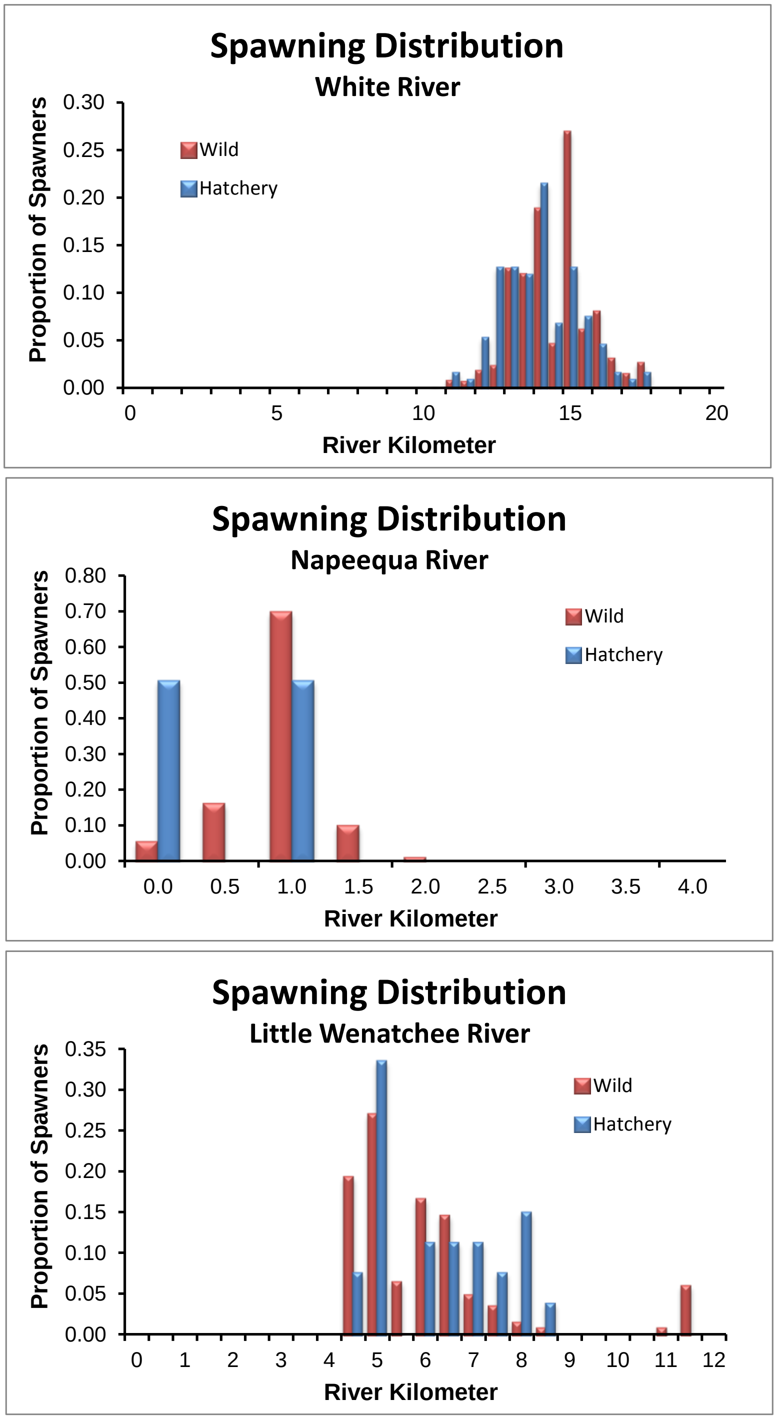


Figure 4.11. Proportion of hatchery and natural-origin sockeye spawners distributed along the length of the White, Napeequa, and Little Wenatchee rivers. Distribution was based on 0.5-km long reaches. Sample sizes = 6,416 wild and 136 hatchery sockeye in the White; 179 wild and 2 hatchery sockeye in the Napeequa; and 443 wild and 27 hatchery sockeye in the Little Wenatchee.

Conclusions

Based on interrogations of PIT-tagged sockeye salmon, hatchery and natural-origin fish had similar migration timings at Bonneville Dam and Tumwater Dam. However, they differed in their timing of entry into the spawning tributaries (White and Little Wenatchee rivers). On average, natural-origin fish entered spawning tributaries about five days earlier than hatchery fish. This difference in migration timing into the spawning tributaries translated into earlier spawning of natural-origin fish. That is, natural-origin sockeye spawned about one to four days earlier than hatchery sockeye. These differences were not significantly different statistically.

The distribution of hatchery and natural-origin sockeye spawners differed significantly in the Little Wenatchee River, but not in the White River. Within the Little Wenatchee River, 99% and 1% of the hatchery sockeye spawned within reaches 2 and 3, respectively. In contrast, 95% and 5% of the natural-origin sockeye spawned within reaches 2 and 3, respectively. These differences in the distribution of hatchery and natural-origin spawners are probably not significant biologically.

4.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to determine the potential effects of the Wenatchee sockeye supplementation program on natural-origin sockeye in the upper Wenatchee Basin (Blankenship et al. 2008; the entire report is appended as Appendix G). Specifically, the objective of the study was to determine if the genetic composition of the Lake Wenatchee sockeye population had been altered by the supplementation program, which was based on the artificial propagation of a small subset of the Wenatchee population. Microsatellite DNA allele frequencies were used to differentiate between temporally replicated collections of natural and hatchery-origin sockeye in the Wenatchee Basin. A total of 13 collections of Wenatchee sockeye were analyzed; eight temporally replicated collections of natural-origin sockeye and five temporally replicated collections of hatchery-origin sockeye. Paired natural-hatchery collections were available from return years 2000, 2001, 2004, 2006, and 2007.

Overall, the study showed that allele frequency distributions were consistent over time, regardless of origin, resulting in small, insignificant measures of genetic differentiation among collections. This indicates that there was no year-to-year differences in allele frequencies between natural and hatchery-origin sockeye. In addition, the analyses found no differences between pre- and post-supplementation collections. Thus, it was concluded that the allele frequencies of the broodstock collections equaled the allele frequency of the natural collections. Finally, there was no observed trend in N_e, suggesting that the supplementation program has not reduced the N_e of the Wenatchee sockeye population.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin Wenatchee sockeye. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin sockeye differed significantly. Because of different age-at-migration characteristics, we evaluated male and female sockeye separately.

The age at maturity differed significantly between hatchery and natural-origin female (Yates' Chi-square = 79.3; P = 0.000) and male sockeye (Yates' Chi-square = 35.8; P = 0.000) (Figure 4.12). Most female and male natural-origin sockeye returned at ages 1.2, 2.2, and 1.3, while most hatchery sockeye returned at ages 1.2 and 1.3. The differences in ages between hatchery and natural-origin sockeye was related to the number of years spent in freshwater. When we examined saltwater age, there was no difference between hatchery and natural-origin female (Yates' Chi-square = 0.5; P = 0.767) and male sockeye (Yates' Chi-square = 2.5; P = 0.282) (Figure 4.12). About 80% of the females returned as 2-salt fish and 20% as 3-salt fish. About 75% of the males returned as 2-salt fish and 25% returned as 3-salt fish.

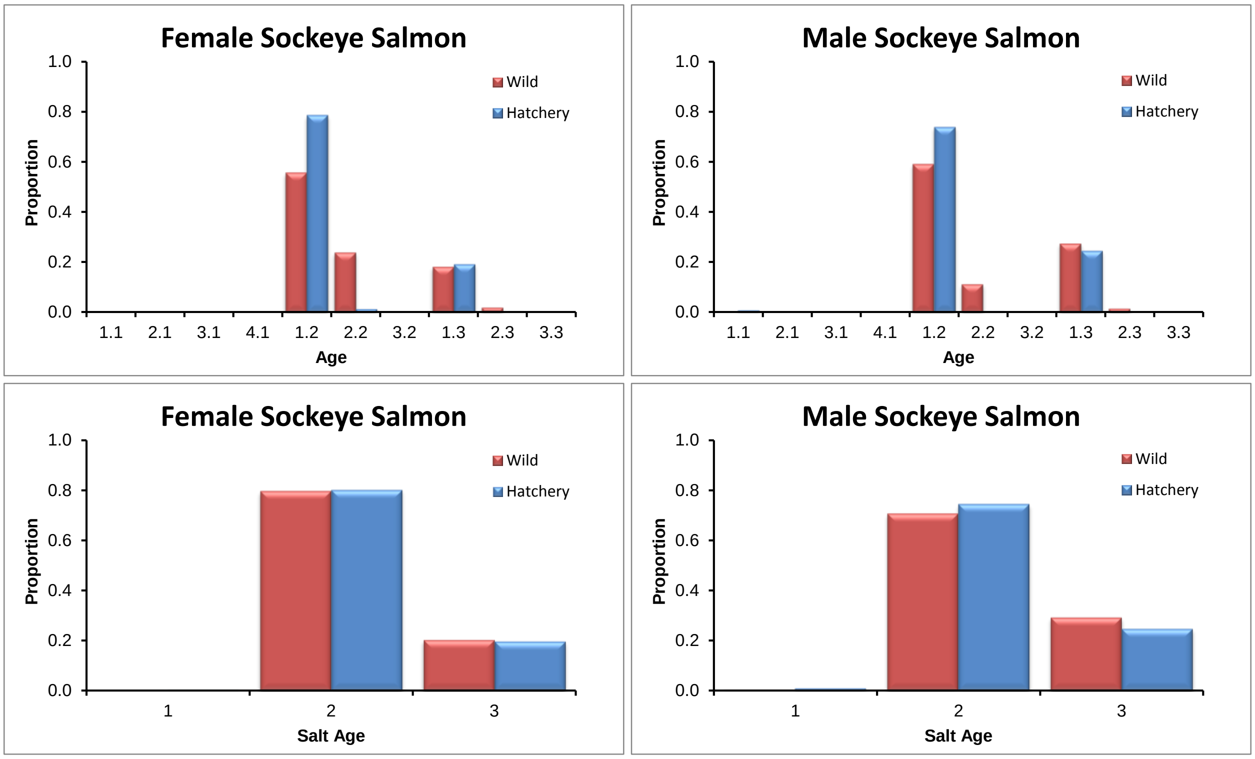


Figure 4.12. Proportion of hatchery and natural-origin female and male sockeye spawners of different ages (total ages in top figures and salt ages in bottom figures) sampled in broodstock and on the spawning grounds in the White and Little Wenatchee basins for the combined years 1993-2010. Sample sizes for females = 1,743 wild and 342 hatchery sockeye and for males = 1,599 wild and 211 hatchery sockeye.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin Wenatchee sockeye. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin sockeye of the same age. We used three-way ANOVA to test differences in sizes of hatchery and natural-origin fish.

The size at maturity differed significantly between hatchery and natural-origin female and male sockeye (Table 4.5; Figure 4.13). The significant three-way interaction term indicates that differences in sizes between hatchery and natural-origin sockeye were affected by age and sex. For female sockeye, 3-salt natural-origin fish were significantly larger than 3-salt hatchery fish (mean difference = 2 cm). For male sockeye, 1 and 2-salt natural-origin fish were larger than 1 and 2-salt hatchery fish (mean difference = 7 and 1 cm, respectively). It is important to note that significance here is a statistical result, not a biological result. Although a mean difference of 2 cm or less was significant statistically, it is unlikely that such a difference in size is significant biologically.

Table 4.5. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Wenatchee sockeye salmon. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Salt Age (1, 2, and 3), resulting in a 2 x 2 x 3 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	24.05	3.90	0.048	0.506
Origin	1	51.75	8.39	0.004	0.825
Sex x Origin	1	17.46	2.83	0.092	0.391
Age	2	3,361.54	545.12	0.000	0.999
Sex x Age	2	15.93	2.58	0.076	0.517
Origin x Age	2	5.44	0.88	0.414	0.203
Sex x Origin x Age	2	34.96	5.67	0.003	0.863
Error	3,814	6.17			

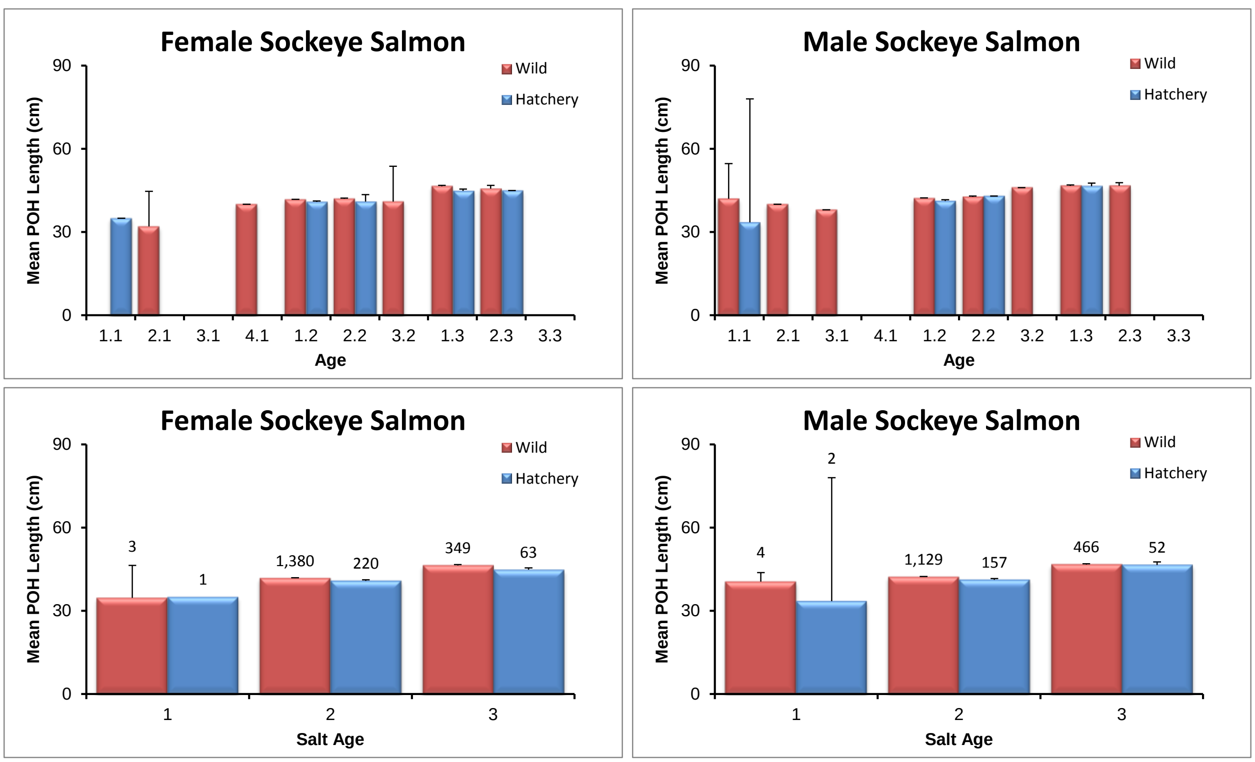


Figure 4.13. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male sockeye spawners of different ages (total ages in top figures and salt ages in bottom figures) sampled in broodstock and on the spawning grounds in the White and Little Wenatchee basins for the combined years 1993-2010. Sample sizes are shown above each bar in the bottom figures.

Conclusions

Genetic analyses found no differences in allele frequencies within and between natural and hatchery-origin Wenatchee sockeye. In addition, there was no significant difference between pre- and post-supplementation collections. Finally, there was no evidence that the supplementation program has reduced the effective population size of the Wenatchee sockeye population.

Although there were no significant genetic differences between hatchery and natural-origin Wenatchee sockeye, there were significant differences between the two groups in age at maturity and size at maturity. Differences in age at maturity were the result of years spent in freshwater. There was no difference in salt age between hatchery and natural-origin fish. Both groups matured primarily as 2-salt fish. Differences in size at maturity between hatchery and natural-origin fish of the same age were generally less than 2 cm, which is probably not significant biologically.

4.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.4 (the calculated target value in Murdoch and Peven 2005).

The number of years that HRRs exceeded NRRs was not significant (paired-sample sign test; P = 0.402). HRRs exceeded NRRs in nine of the 16 years of data, regardless if harvest was or was not included in the analysis (Figure 4.14). In addition, HRRs exceeded the estimated target value of 5.4 in three of the 16 years (Figure 4.14). Based on the one-sample sign test, the number of times HRRs exceeded the target value was not significant (P = 0.998).

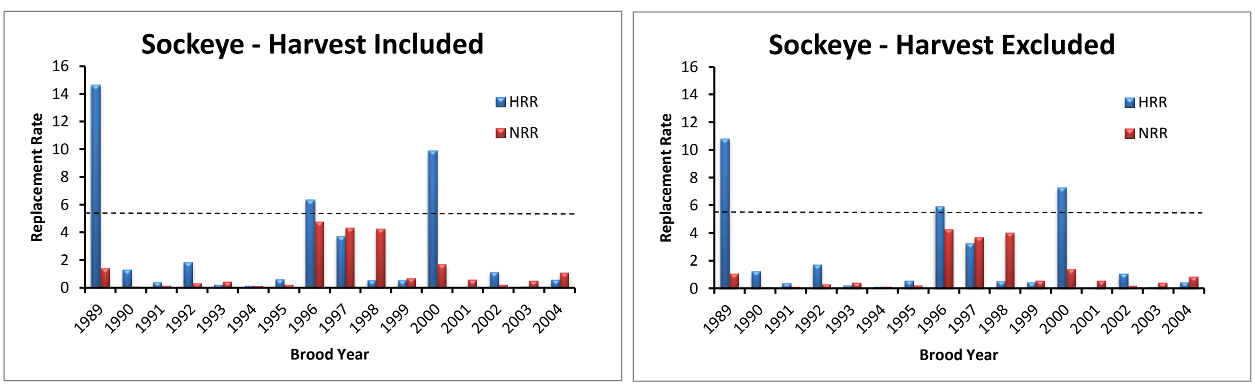


Figure 4.14. Natural and hatchery replacement rates (NRR and HRR, respectively) for sockeye in the Wenatchee Basin, brood years 1989-2004. Figure on the left includes harvested fish; figure on the right does not. The horizontal dashed line represents the target value of 5.4 in Murdoch and Peven (2005).

Conclusions

The sockeye supplementation program has not consistently demonstrated a significant full life-cycle survival advantage over natural-origin sockeye during the period 1989 to 2004. However, on average (average of HRRs and NRRs over the survey period), the supplementation program has demonstrated an 85% productivity advantage over NRRs. That is, on average, HRRs were about 1.85 times greater than NRRs. This was true regardless if harvested fish were included in the analyses.

4.5 Stray Rates

Stray rates of Wenatchee sockeye can be estimated by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. In addition, PIT tagging of hatchery sockeye began with brood year 2005, which allows estimation of stray rates by brood return. However, PIT-tag data only provide estimates for brood years 2005 and 2006, because later brood years are still rearing in the ocean. The target for brood year stray rates should be less than 5%.

We cannot estimate among population stray rates by return year, because we have no estimates of population size of sockeye in areas outside the Wenatchee Basin (e.g., in the Entiat, Methow, and Okanogan systems). Furthermore, there are no sampling efficiencies for carcass surveys outside the Wenatchee Basin and no detection efficiencies for PIT-tag interrogation sites within different tributaries. These data are needed to estimate the total number of Wenatchee sockeye that stray into areas outside the Wenatchee Basin. Finally, based on genetic analysis (see Section 4.3), the Wenatchee population does not have a well-defined within population structure. Therefore, there is no need to evaluate within population straying.

Among Population Stray Rates by Brood Return

Based on CWT analyses, on average, less than 1% of the hatchery sockeye returns have strayed into non-target spawning streams and hatcheries (Figure 4.15). Thus, based on these data, at no time has the number of hatchery sockeye exceeded the target of 5%. This may be related to the lack of carcass surveys in areas outside the Wenatchee Basin.

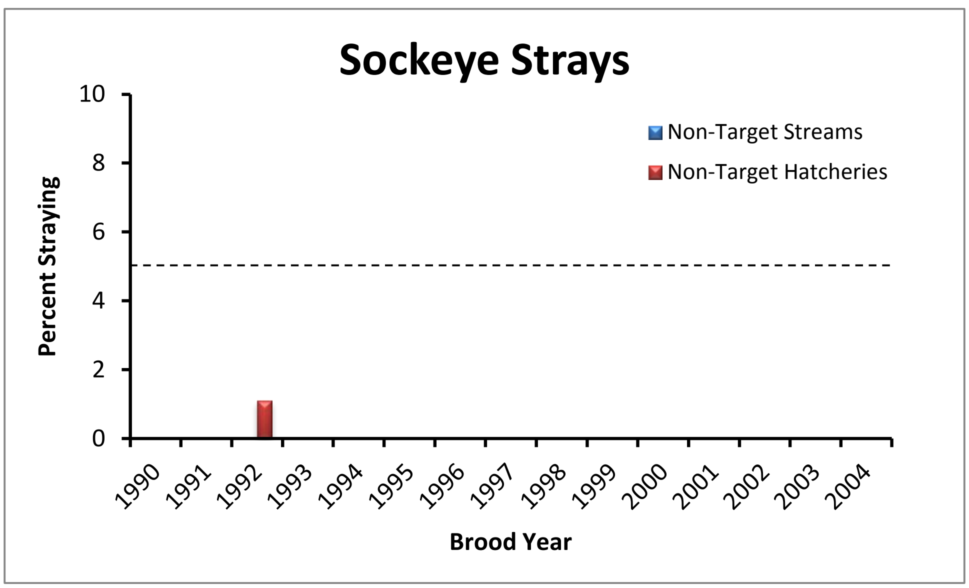


Figure 4.15. Percent of hatchery-origin Wenatchee sockeye that strayed to non-target spawning streams and non-target hatchery programs, for brood years 1990-2004. Percent strays should be less than 5% (represented by the horizontal dashed line).

Based on PIT-tag analyses, on average, about 7% of the hatchery sockeye returns were last detected in streams outside the Wenatchee Basin (Table 4.6). The numbers in Table 4.6 should be considered rough estimates because they are not based on confirmed spawning (only last detections) and the numbers have not been adjusted for detection efficiencies, which currently do not exist for PIT-tag detection arrays in tributaries. What these data do indicate is that some hatchery sockeye from the Wenatchee program have wandered or strayed into the Entiat and Methow rivers and possibly into the Okanogan system (based on sockeye detected at Wells Dam but not in the Methow River). Data analyses conducted by Chelan PUD indicate that trapping operations at Tumwater Dam affects the migration of adult sockeye in the Wenatchee River. Thus, some of the straying may be related to the trapping operations at Tumwater Dam.

Table 4.6. Number and percent of hatchery-origin Wenatchee sockeye that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005 and 2006. Estimates were based on last detections of PIT-tagged hatchery sockeye. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	167	92	0	0.0	15	8	0	0.0
2006	421	95	0	0.0	20	5	0	0.0
Average	***294***	***94***	***0***	***0.0***	***18***	***7***	***0***	***0.0***

Conclusions

Based on CWT analyses, on average, less than 1% of the hatchery sockeye returns have strayed into non-target spawning streams. Based on PIT-tag analyses for two brood years (2005 and 2006), on average, about 7% of the hatchery sockeye returns were last detected in streams outside the Wenatchee Basin. The differences between the two methods may be related to poor carcass sampling in areas outside the Wenatchee Basin (thus affecting the CWT analyses). In addition, PIT-tag analyses are based on last detections, not observed spawning. Therefore, we are not certain that these fish actually spawned in areas outside the Wenatchee Basin.

4.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the Wenatchee sockeye supplementation program is to release juveniles into Lake Wenatchee that average 133 mm long (fork length) and 22.7 g. Before brood year 1999, juveniles released into the lake were usually below the target length and weight (Figure 4.16). This is because these fish were transferred from the hatchery to the net pens as unfed fry in April. Thus, they were unable to accumulate significant growth. Since brood year 1999, juveniles have been allowed to rear in the hatchery until early July. These fish have consistently met or exceeded the length and weight targets when they were released from the net pens into the lake (Figure 4.16).

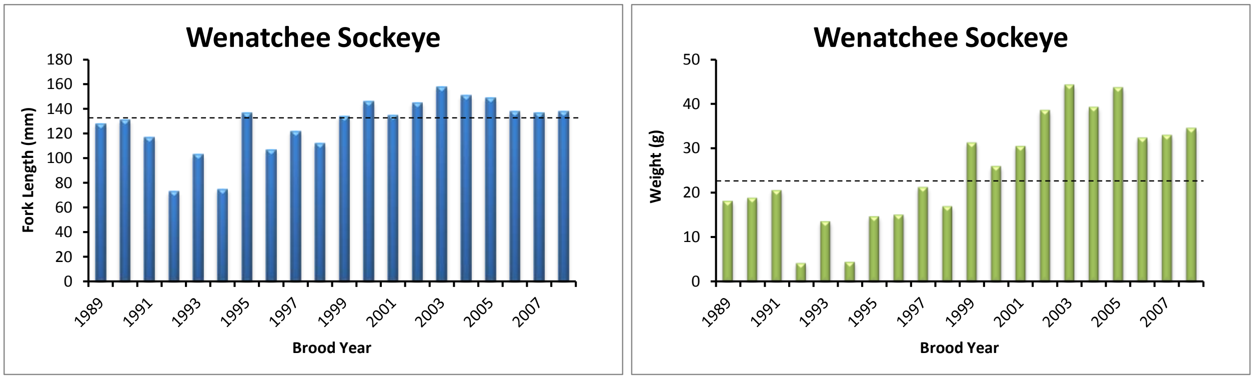


Figure 4.16. Average lengths (mm) and weights (g) of juvenile Wenatchee sockeye released into Lake Wenatchee for brood years 1989-2008. The dashed horizontal lines represent the target length (133 mm) and target weight (22.7 g).

The length and weight targets for the Wenatchee sockeye supplementation program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Wenatchee sockeye based on data collected within the hatchery and net pens over a five-year period (Figure 4.17). Based on this relationship, if the target is to release juveniles at 133 mm, then the target weight of the juveniles should be 28.6 g, not 22.7 g. On the other hand, if the goal is to release juveniles that weigh 22.7 g, then the fork length at release should be 122 mm, not 133 mm.

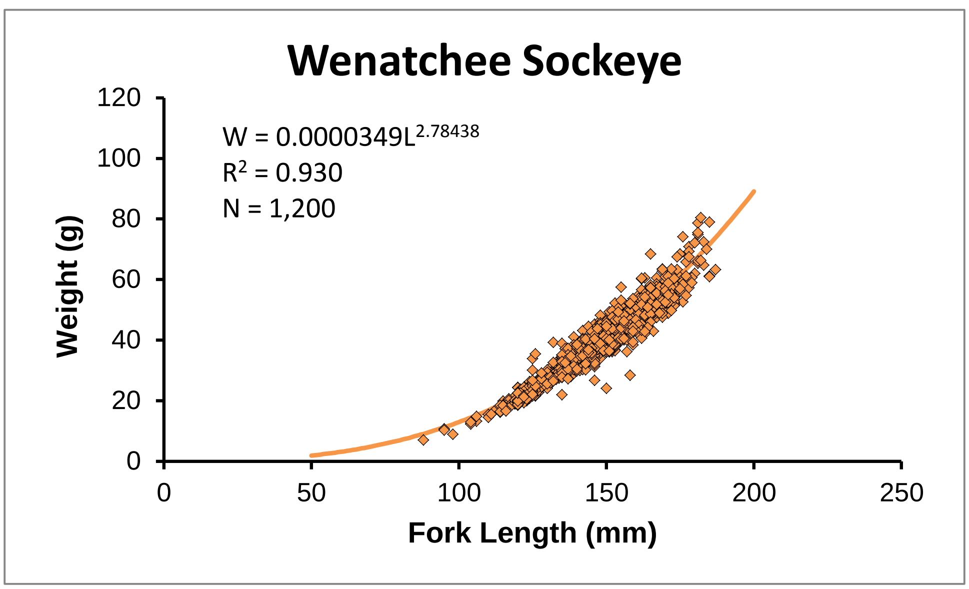


Figure 4.17. Relationship between fork length (mm) and weight (g) of juvenile Wenatchee sockeye salmon sampled during 2003-2007.

Number of Hatchery Fish Released

The goal of the sockeye supplementation program is to release 200,000 juvenile sockeye into Lake Wenatchee annually. The program has reached this goal in ten out of the 21 years (Figure 4.18). The reason the program did not achieve the target in most of those ten years is because the number of eggs taken fell below the total needed (246,914 eggs) to meet the release goal. In addition, unfertilized-to-eyed-egg survivals were below the standard for the program (Hillman et al. 2011). This low survival may be related to holding adult sockeye broodstock in warm surface waters at Lake Wenatchee. The warm water may affect gamete maturation and viability.

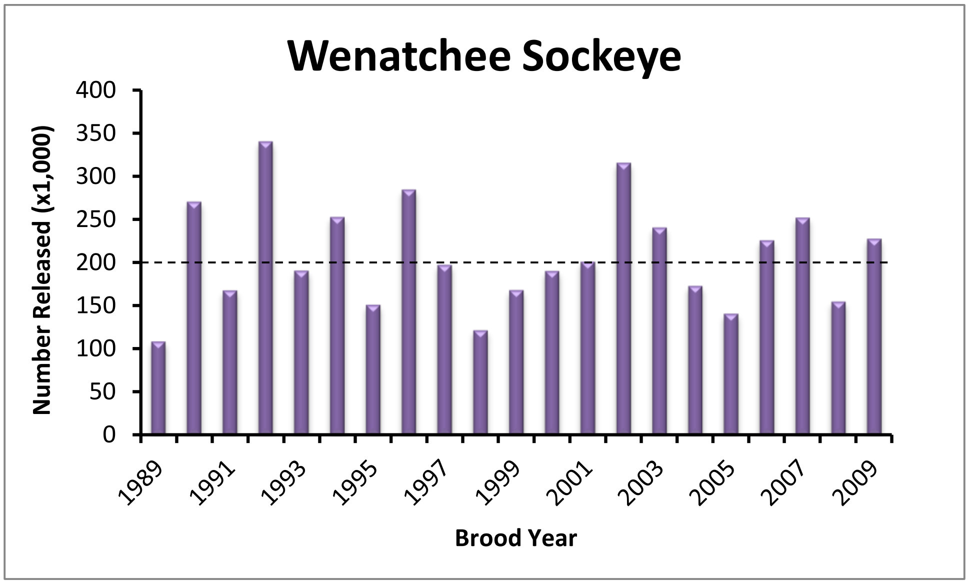


Figure 4.18. Number of juvenile Wenatchee sockeye released into Lake Wenatchee for brood years 1989-2009. The dashed horizontal line represents the target release number (200,000 juveniles).

Conclusions

The Wenatchee sockeye supplementation program has not consistently achieved its goal of releasing 200,000 juveniles per year. This is largely because the egg take was below the number needed to meet the release goal. In addition, relatively low unfertilized-to-eyed-egg survivals may have contributed to the program not meeting its release goals. These relatively low survivals may be related to the effects of warm surface waters at Lake Wenatchee on gamete maturation and viability.

Since brood year 1999, juvenile sockeye released into Lake Wenatchee have consistently met or exceeded the length and weight goals for the program. Before brood year 1999, the size goals were rarely met, because unfed fry were transferred to the net pens in April. Starting with brood year 1999, fry have remained in the hatchery until July, when they are transferred to the Lake Wenatchee net pens.

Because of the unique relationship between length and weight of Wenatchee sockeye, the program should consider using more realistic size targets based on the length-weight relationship specific to this population.

4.7 Freshwater Productivity

Juvenile Productivity

Because we found no suitable reference populations for juvenile sockeye productivity within the Wenatchee Basin and there are no pre-supplementation juvenile data for the Wenatchee population, we used stock-recruitment models to assess the productivity and capacity of the Wenatchee sockeye population. Here, we define recruitment as the number of natural-origin smolts produced in Lake Wenatchee. We also compared the number of smolts/spawner to pHOS. If there is a negative association between pHOS and the productivity of juveniles, then the hatchery fish may be reducing the productivity of juvenile sockeye in the Wenatchee Basin.

There was a significant linear relationship between numbers of sockeye spawners and numbers of smolts (Figure 4.19). Because the density-independent (proportional) model fit the stock and recruitment data the best, there is no estimate of carrying capacity. In addition, the positive relationship between numbers of spawners and smolts/spawner indicates the lack of density dependence under past spawning escapements (Figure 4.20).

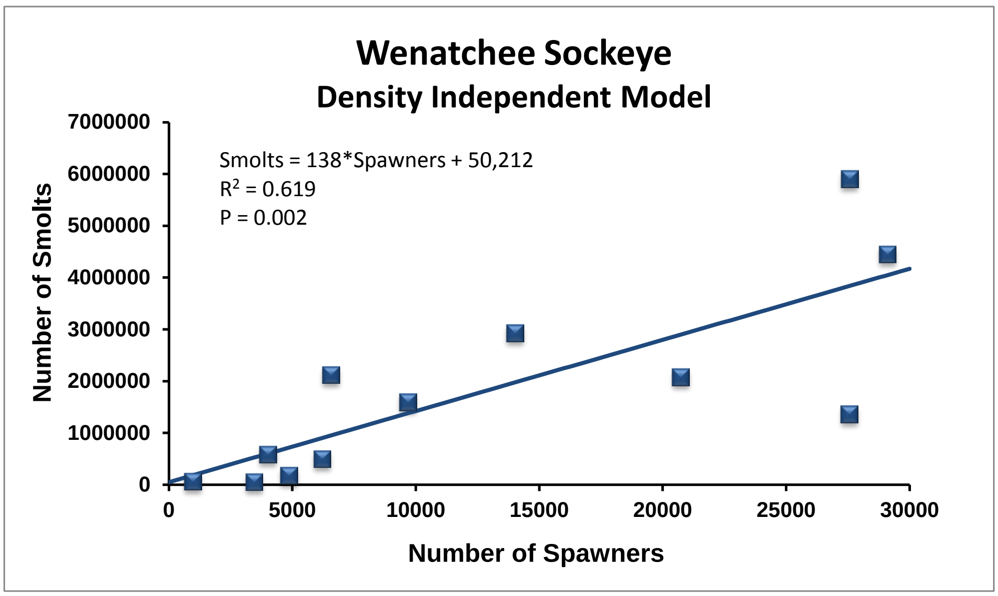


Figure 4.19. Relationship between number of Wenatchee sockeye spawners and number of smolts produced in the Wenatchee Basin for brood years 1995-2006. The density-independent model provided the best fit to the stock-recruitment data.

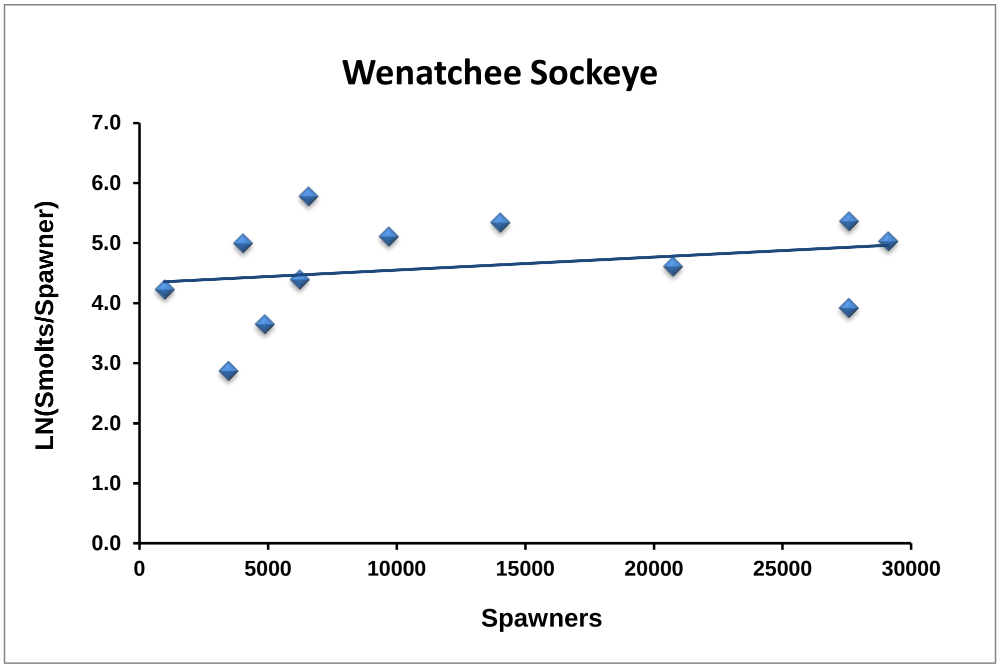


Figure 4.20. Relationship between number of Wenatchee sockeye spawners and number of smolts/spawner produced in the Wenatchee Basin.

There was no association between the number of smolts/spawner and the spawning escapement made up of hatchery sockeye (pHOS) (Figure 4.21). This is because the proportion of hatchery fish spawning naturally has been very low in the past (less than 10%).

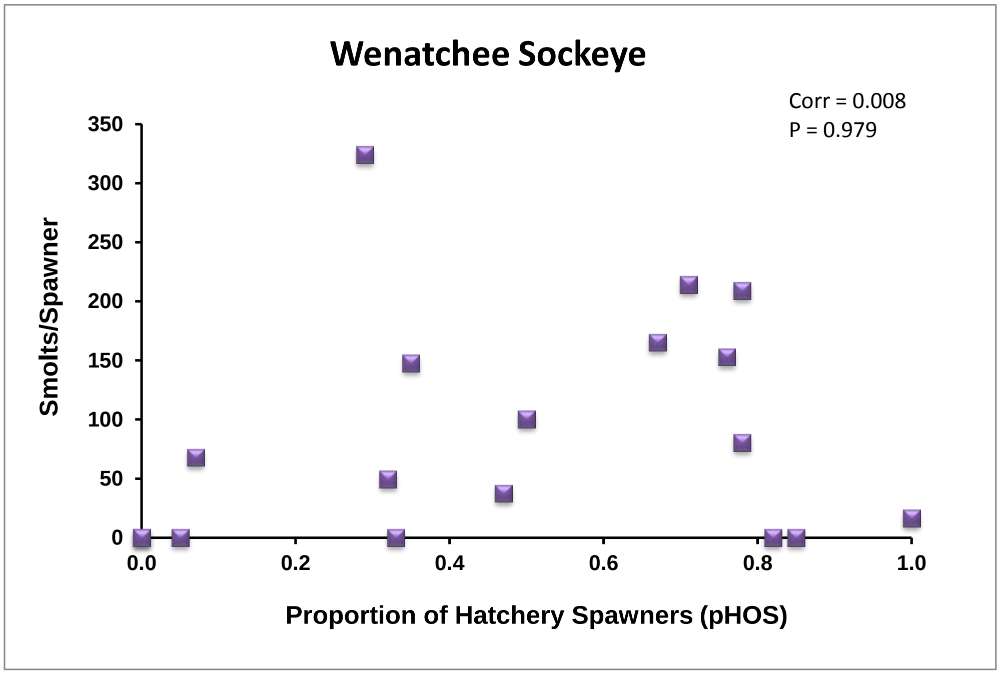


Figure 4.21. Association between the proportion of sockeye spawners that were made up of hatchery adults (pHOS) and the number of smolts/spawner. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

Conclusions

Currently, there is no apparent density-dependent relationship between numbers of Wenatchee sockeye spawners and numbers of smolts produced. The density-independent (proportional) model provided the best fit to the stock-recruitment data, indicating that under past spawning escapement levels, density-independent factors regulate numbers of sockeye smolts produced in Lake Wenatchee.

Because the number of hatchery fish spawning naturally has been low (making up less than 10% of the spawning escapement), there is no relationship between smolt production and pHOS. Thus, there is no evidence that supplementation has increased or decreased the productivity of sockeye smolts in the Wenatchee Basin.

4.8 Harvest

Harvest Rates

All the harvest on hatchery-origin sockeye salmon occurs within the Columbia Basin (Figure 4.22). Ocean catch records indicate that no Wenatchee sockeye are taken in ocean fisheries. Most of the harvest on hatchery-origin sockeye occurs in the recreational and tribal fisheries. The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams. Few Wenatchee sockeye are taken in the commercial fishery in Zones 1-5, which are downstream from Bonneville Dam. PIT-tag analyses indicate that about 33% of PIT tagged Wenatchee sockeye detected at Bonneville Dam are missing by the time they arrive at Rock Island Dam. This loss includes natural mortality, fishing mortality, and straying.

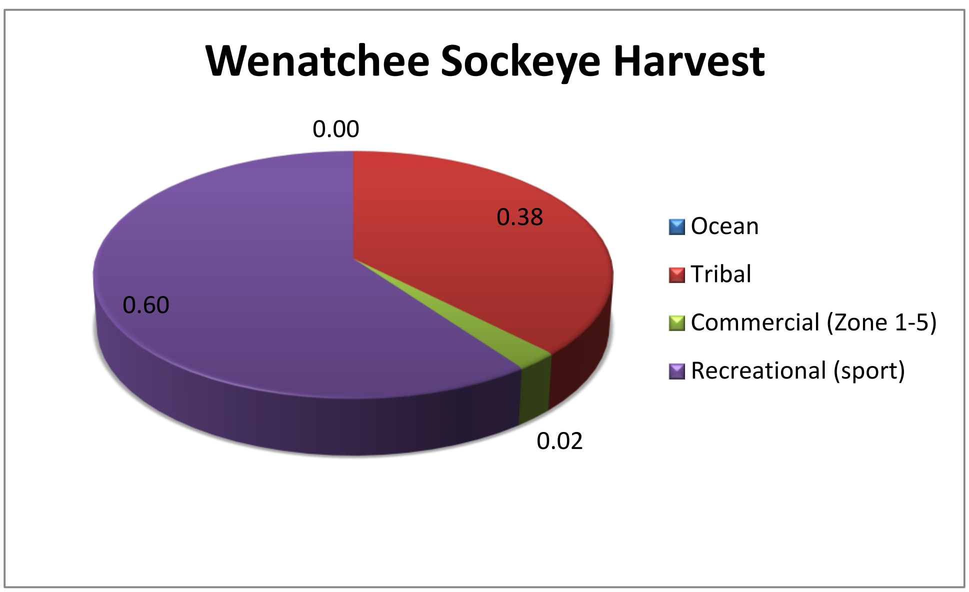


Figure 4.22. Mean allocation of Wenatchee sockeye harvested among the different fisheries for brood years 1989-2004. The total number of Wenatchee sockeye harvested across the brood years was 1,845 (average = 115 fish/year; range = 3-976).

The current management goal calls for a spawning escapement of 23,000 adult sockeye before a sport fishery can be opened in Lake Wenatchee. An additional 260 adults are needed for broodstock. Therefore, a total of 23,260 adult sockeye are currently needed to satisfy broodstock and spawning escapement goals. Based on the total escapement goal of 23,260 adults, there were six brood years between 1989 and 2004 that produced escapements large enough to support a Lake Wenatchee fishery (Figure 4.23).

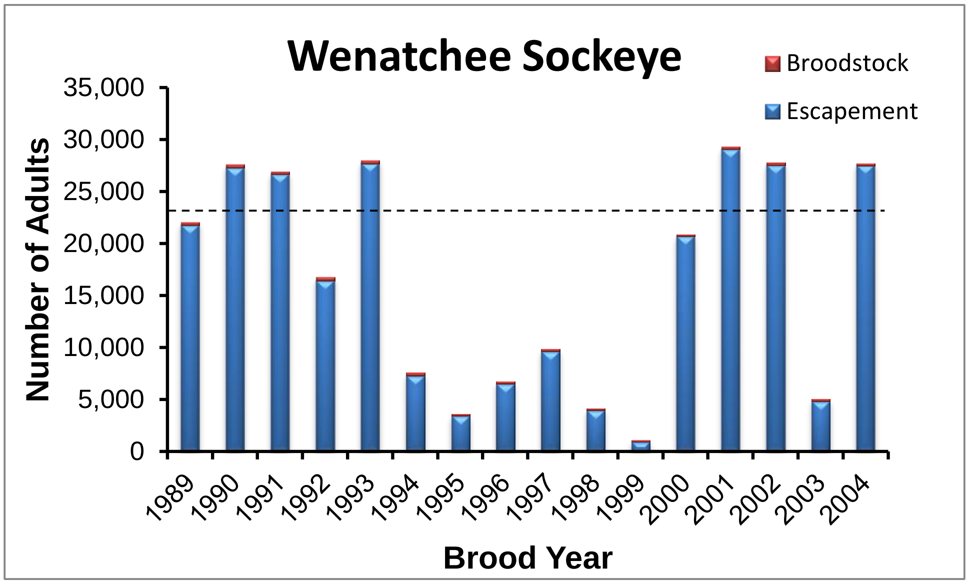


Figure 4.23. Numbers of sockeye adults collected for broodstock and numbers that spawned naturally within the Wenatchee Basin for brood years 1989-2004. The dashed horizontal line represents the number needed to satisfy the broodstock collection goal (260 adults) plus the number needed to meet the current escapement goal of 23,000 spawners.

Conclusions

Wenatchee sockeye are harvested within the Columbia River Basin with the recreational fishery making up about 60% of the catch. No Wenatchee sockeye have been harvested in the ocean. The average number of Wenatchee sockeye harvested per brood year is about 115 adults. Assuming a total escapement of 23,260 adults is needed to meet current broodstock collection and spawning escapement goals; there were six brood years between 1989 and 2004 that produced escapements large enough to support a Lake Wenatchee fishery.

4.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available data were unable to show that the sockeye supplementation program has increased total spawning abundance in the Wenatchee Basin.
2. The supplementation program may have increased NORs and the productivity of the sockeye population, but because there were no suitable reference populations to compare with the Wenatchee sockeye population, we cannot be certain that the increase was a result of supplementation.
3. Hatchery and natural-origin sockeye had similar migration timings at Bonneville and Tumwater dams, but they differed in their timing of entry into spawning streams.

Natural-origin fish migrated into spawning streams and spawned earlier than hatchery-origin fish.

4. The spawning distribution of hatchery and natural-origin sockeye differed significantly in the Little Wenatchee River but not in the White River, where the majority of spawning occurs. Within the Little Wenatchee River, a higher fraction of hatchery sockeye spawned lower in the river, while a higher fraction of natural-origin sockeye spawned in the upper river.
5. There was no evidence that supplementation significantly affected allele frequencies within and between natural and hatchery-origin sockeye in the Wenatchee Basin.
6. There was no evidence that the supplementation program has reduced the effective population size of the Wenatchee sockeye population.
7. There was no difference in age-at-maturity (based on salt age) between hatchery and natural-origin sockeye. There was a difference if time spent in freshwater was included in the age comparisons.
8. Differences in size-at-maturity between hatchery and natural-origin sockeye of the same age were generally less than 2 cm, which is probably not significant biologically.
9. HRRs were on average about 1.85 times greater than NRRs. This was true regardless if harvested fish were included in the analyses.
10. Depending on the type of tag analyzed (CWT or PIT), on average, less than 1 to 7% of the hatchery brood-year returns have strayed into other spawning areas, or were last detected outside the Wenatchee Basin. PIT-tagged hatchery sockeye were last detected in the Entiat and Methow rivers, and at Wells Dam.
11. Largely because of inadequate numbers of eggs collected, the supplementation program has not consistently achieved its goal of releasing 200,000 juveniles per year.
12. Since brood year 1999, juvenile sockeye released into Lake Wenatchee have consistently met or exceeded the length and weight goals for the program. Before brood year 1999, when fry were transferred to the net pens in April as unfed fry, the size goals were rarely met.
13. There is no apparent density-dependent relationship between numbers of sockeye spawners and numbers of smolts produced. Thus, at escapements less than about 30,000 spawners, density-independent factors appear to regulate numbers of sockeye smolts produced in Lake Wenatchee.
14. There is no evidence that hatchery-origin spawners affect juvenile productivity. The proportion of total spawners made up of hatchery fish has been less than 10%.
15. Wenatchee sockeye are harvested within Columbia River fisheries, not ocean fisheries, with most of the harvest occurring within the recreational fishery. The average number of sockeye harvested per brood year was about 115 adults.
16. Assuming a total escapement of 23,260 adults is needed to meet current broodstock collection and spawning escapement goals; there were six brood years between 1989 and 2004 that produced escapements large enough to support a Lake Wenatchee fishery.

Broodstock collection and therefore egg take appears to be the primary reason why the sockeye program has not achieved its goal of releasing 200,000 juveniles annually. During nine of the 11 years in which the number released was below the release goal, the egg take was not sufficient to meet the goal. In addition, the program has suffered lower than expected unfertilized-to-eyed-egg survivals (Hillman et al. 2011). During the 20-year sampling period, unfertilized-to-eyed-egg survivals have ranged from 59 to 96% (average = 85%). The goal for the program is to achieve a 92% unfertilized-to-eyed-egg survival. The relatively low unfertilized-to-eyed-egg survival may be related to the effects of warm surface waters at Lake Wenatchee on gamete maturation and viability. It may be prudent to test this hypothesis by holding adults at different temperatures before spawning.

After the program changed the time at which fry were transferred to the Lake Wenatchee net pens, the program has consistently met the length and weight targets for the program. The program was unsuccessful in achieving size goals when unfed fry were transferred to the net pens in April. Even though the program has consistently met size goals since the change in date of transfer, it is appropriate to readjust the length and weight goals for the program based on the unique length-weight relationship for Wenatchee sockeye salmon. If the goal is to release juvenile sockeye at 22.7 g, then the fork length at release should be about 122 mm, not 133 mm.

The stray rate of hatchery sockeye appears low. This is difficult to assess accurately, however, because there is little effort in collecting carcasses outside the Wenatchee Basin. The use of PIT tags to assess straying holds promise, but there are few brood years available for the analysis (2005 and 2006) and we cannot be certain that the last detection locations indicate the place where the sockeye spawned. With a larger number of sample years and detection efficiencies for the remote PIT-tag interrogation systems, we should be able to more accurately estimate stray rates by brood year.

At this time we are unable to assess stray rates by return year. This is in part because there are no detection efficiencies for most remote PIT-tag interrogation systems in tributaries. These detection efficiencies are needed to determine the total number of Wenatchee sockeye that spawn within non-target streams. In addition, there are no population estimates for sockeye in the Entiat and Methow rivers, where Wenatchee sockeye have been detected.

Based on examination of allele frequencies, the supplementation program has not affected the genetic characteristics or effective population size of the population. In contrast, there were some differences in phenotypic characteristics. Although there was little difference in age-at-maturity (based on salt age) and size-at-maturity between hatchery and natural-origin sockeye, natural-origin fish entered spawning streams earlier than hatchery fish and they spawned earlier than hatchery fish. The spawning distribution of hatchery and natural-origin sockeye differed significantly in the Little Wenatchee River but not in the White River, where the majority of spawning occurs. The difference in the Little Wenatchee is likely related to the small number of hatchery fish collected there. Some of these phenotypic differences may be related to unintentional selective broodstock collection.

The supplementation program has not consistently demonstrated a significant full life-cycle survival advantage over natural-origin sockeye during the period 1989 to 2004. This may be why we were unable to detect an increase in total spawning escapement following the implementation of the supplementation program. We did find an increase in NORs and productivity (NRRs) following supplementation, but because there were no reference populations to compare with the

Wenatchee sockeye population, we cannot be certain that the increase was a result of supplementation. It appears that the Wenatchee population would benefit from supplementation, because the NRRs have exceeded 1.0 in only six of the last 16 complete brood years. Possible reasons why the program has not been as successful as planned include:

- *Ecological Interactions*—Juvenile sockeye are currently released in late October after rearing for about four months in net pens in Lake Wenatchee. Because the juveniles are released at a specific location within the lake, predators may key in on the release location. Mortality associated with predation may be significant. For example, the parr-to-adult ratios (PARs) for hatchery fish averaged 0.0029 (range, 0.0001-0.0143), while the smolt-to-adult ratios (SARs) averaged 0.0054 (range, 0.002-0.0258) (Hillman et al. 2011). Thus, during the period 1989-2003, on average, about 46% of the juveniles released were lost before smolting. Because nearly all hatchery juveniles smolt at age 1 (i.e., they smolt the spring following release) (Figure 4.12), the loss is occurring within about a five month period. Analysis of PIT-tagged sockeye indicates similar results. For the period 2008 to 2010, on average, 59% of the PIT-tagged juvenile sockeye released from net pens were lost before smolting (based on survival from release to the middle Wenatchee interrogation array).
- *Density Dependence*—Although we found no evidence of density dependence affecting the productivity of natural-origin juveniles, it may affect the survival of hatchery juveniles. Rearing within the net pens may alter the foraging behavior of the juveniles such that when they are released, they may be less effective at finding and harvesting entomostracan zooplankton. Because juvenile sockeye are visual predators, they must seek prey under sufficient light intensities and therefore they become vulnerable to predators. It is believed that sockeye have a brief “anti-predatory window” for feeding at dawn and dusk. To survive, they must balance risk of predation with time, duration, and location of feeding, the prey organisms to pursue, and their behavior when not feeding. As a result, juvenile sockeye have complex diel feeding migrations that vary with season. Hatchery juveniles must learn this complex foraging behavior shortly after release or risk increased predation and competition for food.

Identifying the reasons for the relatively low performance of the sockeye supplementation program is challenging. It appears that the primary factors limiting the success of the program include low egg take in some years, relatively low unfertilized-to-eyed-egg survival, and poor parr-smolt survival. If the goal is to continue the sockeye supplementation program, studies are needed to identify the mechanisms that currently limit post-release survival of hatchery sockeye. An alternative is to discontinue the sockeye supplementation program.

SECTION 5: CHIWAWA SPRING CHINOOK

The goal of Chiwawa spring Chinook salmon supplementation is to achieve "No Net Impact" to the productivity of spring Chinook caused by the operation of the Rock Island Hydroelectric Project (currently identified as 6.25% unavoidable project mortality for juvenile spring Chinook). The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Rock Island and Rocky Reach Anadromous Fish Agreement and Habitat Conservation Plans.

Adult spring Chinook are collected for broodstock at the Chiwawa Weir and Tumwater Dam. Both natural-origin and hatchery Chinook are collected at the weir, only hatchery Chinook are collected at Tumwater Dam. Beginning in 2011, all spring Chinook broodstock will be collected at the Chiwawa Weir in order to reduce passage delays caused by trapping at Tumwater Dam. The goal was to collect up to 379 adult spring Chinook for the program with natural-origin fish making up not less than 33% of the broodstock. The current goal is to collect 170 spring Chinook of which 78 are natural-origin fish and 92 are hatchery-origin fish. The number collected cannot exceed 33% of the spring Chinook population. Broodstock collection occurs from about 1 May through 12 September with trapping occurring up to 24 hours per day, four days a week.

Adult spring Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile spring Chinook are transferred from the hatchery to the Chiwawa Acclimation Ponds in late September or early October. They are released volitionally from the Chiwawa facility during April and May the following year.

The original production goal for the Chiwawa spring Chinook supplementation program was to release 672,000 yearling smolts into the Chiwawa River at 12 fish per pound. The current production goal is to release 298,000 smolts (150,000 for conservation and 148,000 for safety net). Targets for fork length and weight are 176 mm (CV = 9.0) and 37.8 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2006, about 10,000 juvenile spring Chinook have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

5.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the spring Chinook supplementation program is to increase the number of spawners in the Chiwawa Basin. We tested the success of the supplementation program at increasing total spawners (both hatchery and natural-origin spawners) by analyzing trends and mean abundances before and during supplementation. We also compared trends and mean abundance of Chiwawa spring Chinook with reference populations (Naches, Entiat, Sesech, and Little Wenatchee populations). Appendix C describes in detail the methods and results for selecting reference populations for Chiwawa spring Chinook.

It is important to note that both the Entiat and Little Wenatchee populations are influenced with hatchery fish. The Entiat population has been supplemented, while the Little Wenatchee population has received large numbers of hatchery strays. The Entiat spring Chinook Hatchery Program has been discontinued; thus, it provides a unique type of reference with the Chiwawa where the comparison changes from both populations being supplemented to only one population being supplemented. For the Little Wenatchee, nearly all the strays came from the Chiwawa program. Straying should stop or be greatly reduced with the change in water supply to the Chiwawa Rearing Ponds. Operational changes at Tumwater to decrease passage delays may also reduce stray rates in the future. We will continue to track the relationship between these two reference populations and the Chiwawa to see if the supplementation program in the Chiwawa is improving spawning abundance and NORs, and not decreasing productivity.

As a first step in analyzing the effects of the Chiwawa supplementation program on total spawning abundance, we examined the trends in abundances of spring Chinook spawners in the Chiwawa Basin before and during supplementation. Trend analysis indicated that before supplementation, the total number of spawners decreased over time; however, during supplementation the trend reversed and increased over time (Figure 5.1). The change in trend before and during supplementation was significant. When we compared the trends of the Chiwawa population with reference populations, we found that most reference populations also trended downward during the period before the Chiwawa was supplemented and then trended upward during the supplementation period (Figure 5.2). This indicates that the change in trends in the Chiwawa population may not be the result of supplementation, but rather common factors acting upon several populations within the Columbia Basin.

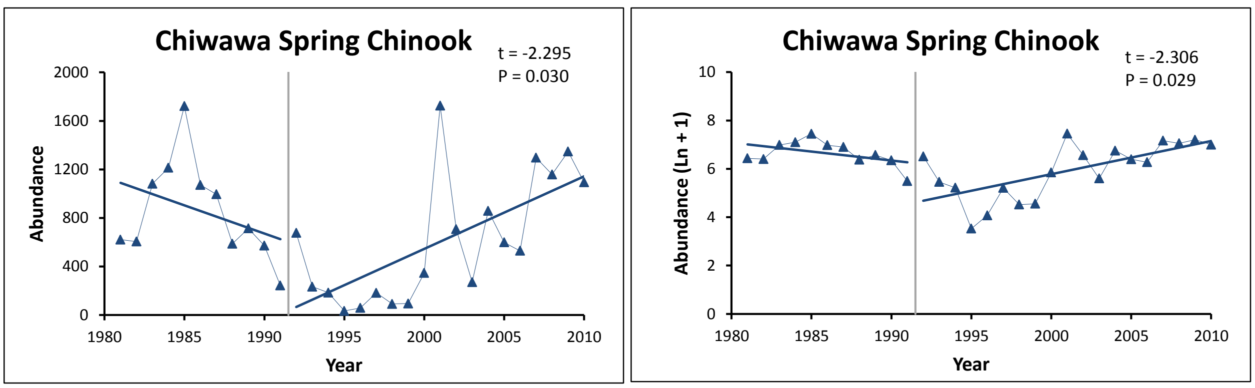


Figure 5.1. Trends in Chiwawa spring Chinook spawner abundance before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

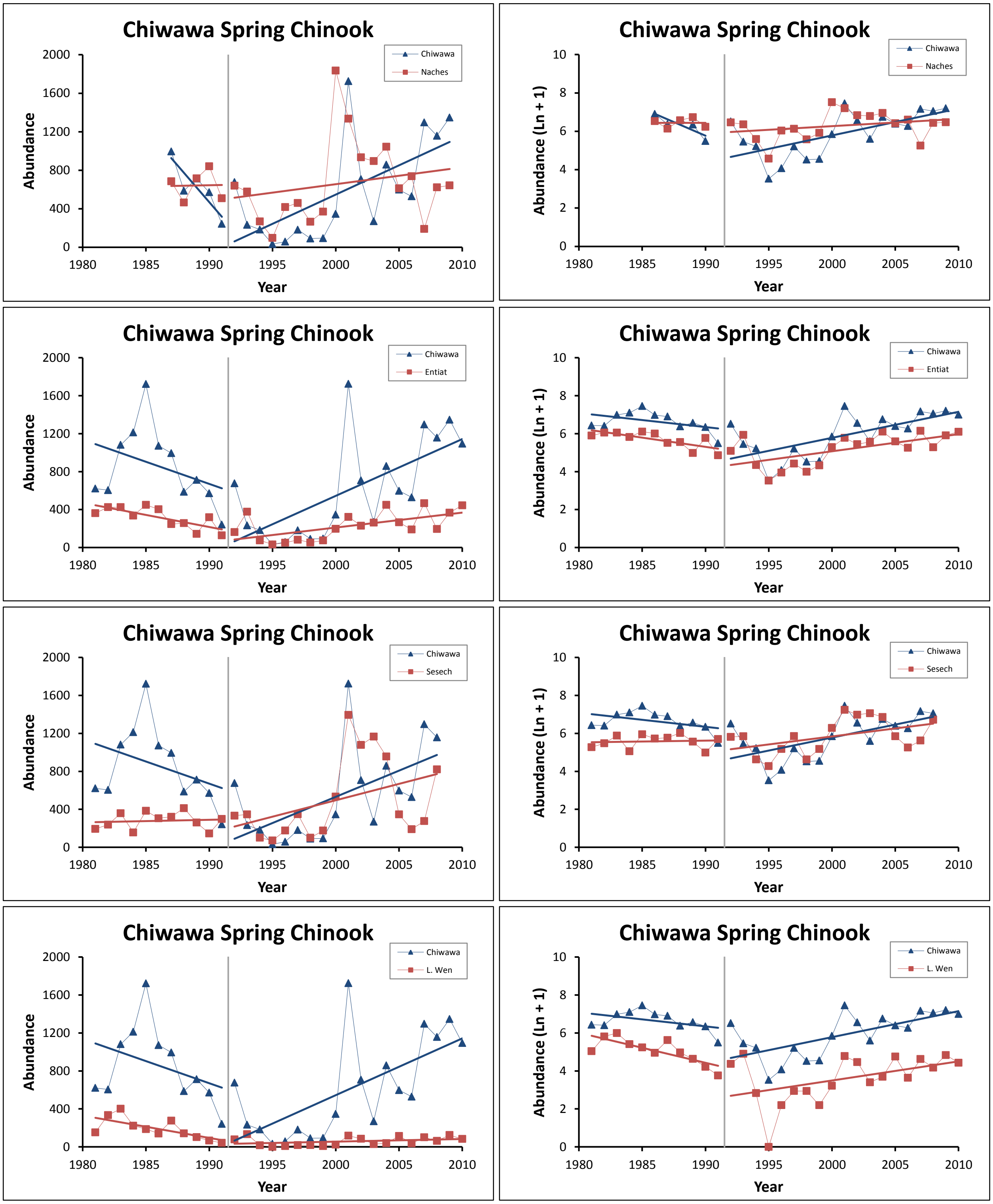


Figure 5.2. Trends in spring Chinook spawner abundance in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.

We then compared the mean spawner abundance before supplementation with the mean abundance during supplementation. Mean spawner abundance during the supplementation period was less than the pre-supplementation spawner abundance (Table 5.1). Although not significant, mean spawner abundance decreased 30% between the pre- and post-supplementation periods. When we compared the Chiwawa abundance with reference populations using ratios (treatment/reference), we found that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 5.2; Figure 5.3). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in spawning abundance following supplementation. Analysis with both transformed and untransformed Little Wenatchee-Chiwawa data indicated a significant effect. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, spawner abundance decreased in the Chiwawa Basin during the supplementation period (Figure 5.3).

Table 5.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Chiwawa spring Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	857	604	1.483	0.151	0.154	-74 – 573
LN Abundance	6.6	5.9	2.348	0.026	0.027	0.11 – 1.29
NORs	905	266	2.948	0.012	0.007	222 – 1,033
LN NORs	6.0	5.1	1.181	0.256	0.260	-0.40 – 2.49
Productivity	1.13	1.39	-0.473	0.641	0.641	-1.28 – 0.80
LN Productivity	0.65	0.69	-0.211	0.835	0.841	-0.45 – 0.38
Adj Productivity	1.13	1.39	-0.473	0.641	0.650	-1.30 – 0.78
LN Adj Productivity	0.65	0.69	-0.211	0.835	0.837	-0.46 – 0.36

Table 5.2. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spring Chinook spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Naches	-0.261	0.398	0.105	0.877	-0.751 – 0.736
Entiat	0.605	0.725	0.290	0.558	-0.603 – 1.206
Sesech	3.366	0.998	2.052	0.001	0.834 – 3.125
Little Wenatchee	-4.139	0.000	5.620	0.001	-8.197 – -3.049
LN Spawner Abundance					
Naches	1.048	0.845	0.052	0.335	-0.037 – 0.146
Entiat	0.752	0.771	0.026	0.466	-0.039 – 0.089
Sesech	4.230	0.999	0.203	0.001	0.115 – 0.298
Little Wenatchee	-4.717	0.000	0.307	0.000	-0.429 – -0.186

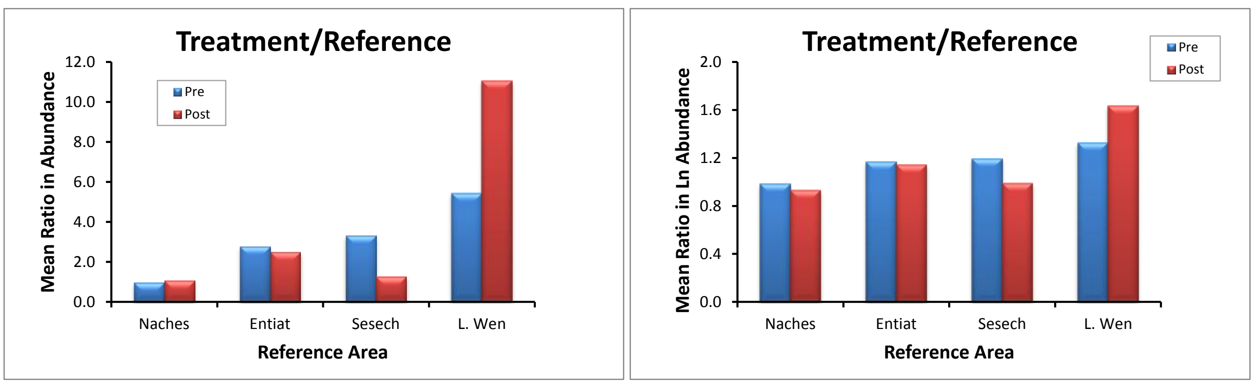


Figure 5.3. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on spawner abundance are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

As a final test of the effects of supplementation on total spawner abundance, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Excluding the first four years following the start of the supplementation program, when no hatchery fish had yet returned, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in 14 of the 17 years (Table 5.3). Since brood year 1999, numbers of hatchery fish spawning naturally have consistently exceeded the total number of fish taken for broodstock.

Table 5.3. Numbers of natural-origin (NOB) and hatchery-origin (HOB) spring Chinook included in broodstock and numbers of hatchery-origin spring Chinook spawning naturally (HOS) in the Chiwawa Basin.

Brood year	NOB	HOB	Total Broodstock	HOS
1989	28	0	28	0
1990	18	0	18	0
1991	27	0	27	0
1992	78	0	78	0
1993	94	0	94	12
1994	8	4	12	61
1995	0	0	0	33
1996	8	10	18	17
1997	32	79	111	122
1998	13	34	47	32
1999	0	0	0	7
2000	9	21	30	173
2001	113	259	372	1,311
2002	20	51	71	502
2003	41	53	94	127
2004	83	132	215	276
2005	91	181	279	464
2006	91	224	315	413
2007	43	104	147	1,104
2008	83	220	303	953
2009	96	111	207	1,039
Average	**46**	**71**	**117**	**316**

In summary, the supplementation program has not significantly increased the total number of spawners (hatchery and natural-origin spawners) within the Chiwawa Basin. This conclusion is based on comparing trends and mean abundances before and after supplementation, and comparing the supplemented population with reference populations. It is important to point out that large numbers of Chiwawa hatchery fish have strayed into other spawning areas within the Wenatchee Basin and into other populations (see Section 5.5). If these fish would have homed successfully to the Chiwawa Basin, the total number of spawners would have increased significantly.

Natural-Origin Recruits

Another important goal of the spring Chinook supplementation program is to increase the number of natural-origin recruits (NORs). We tested the success of the supplementation program in increasing NORs by analyzing trends and mean NORs before and during supplementation. We also compared trends and mean NORs of Chiwawa spring Chinook with reference populations

(Naches, Entiat, Marsh, and Little Wenatchee populations). In addition, because NORs can be affected by the capacity of the environment, we adjusted NORs for differences in carrying capacities between the Chiwawa and reference populations. We did this by calculating the percent saturation of NORs (Appendix C describes in detail the methods used to calculate percent saturation). Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before supplementation, NORs decreased over time; however, during supplementation the trend reversed and increased over time (Figure 5.4). The change in trend before and during supplementation was significant. When we compared the trends of the Chiwawa population with reference populations, we found that the reference populations also trended downward during the period before the Chiwawa was supplemented and then trended upward during the supplementation period (Figure 5.5). This indicates that the change in trends in the Chiwawa population was not the result of supplementation, but rather common factors acting upon several populations within the Columbia Basin.

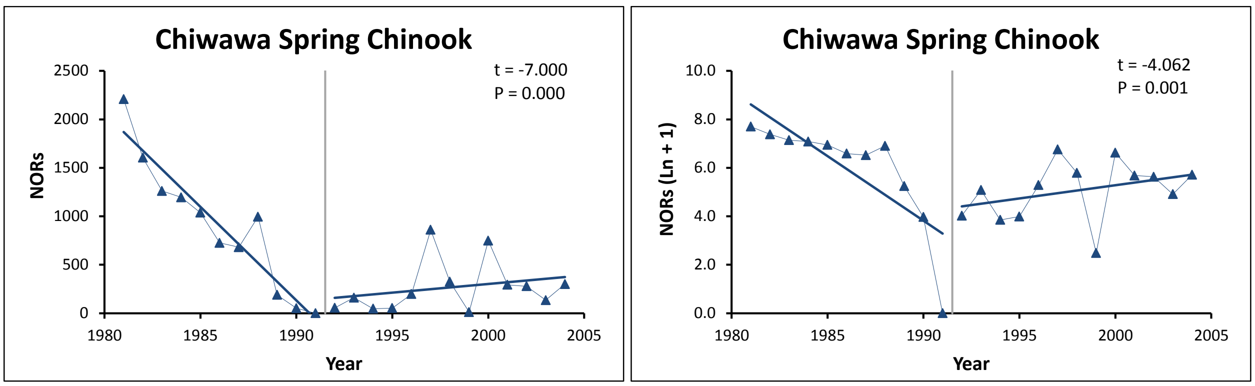


Figure 5.4. Trends in Chiwawa spring Chinook NORs before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

We then compared mean spring Chinook NORs before supplementation with mean NORs during supplementation. Mean NORs during the supplementation period were significantly less than pre-supplementation NORs (Table 5.1). Mean NORs decreased 71% between the pre- and post-supplementation periods. When we compared Chiwawa NORs with reference populations using ratios (treatment/reference), we found that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 5.4; Figure 5.6). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in NORs following supplementation. Analysis with both transformed and untransformed Little Wenatchee-Chiwawa data indicated a significant effect. The randomization test indicated a significant difference in the Marsh-Chiwawa pairing, but the bootstrap CIs indicated that the difference was in the wrong direction. That is, compared to the reference population, NORs decreased in the Chiwawa Basin during the supplementation period (Figure 5.6).

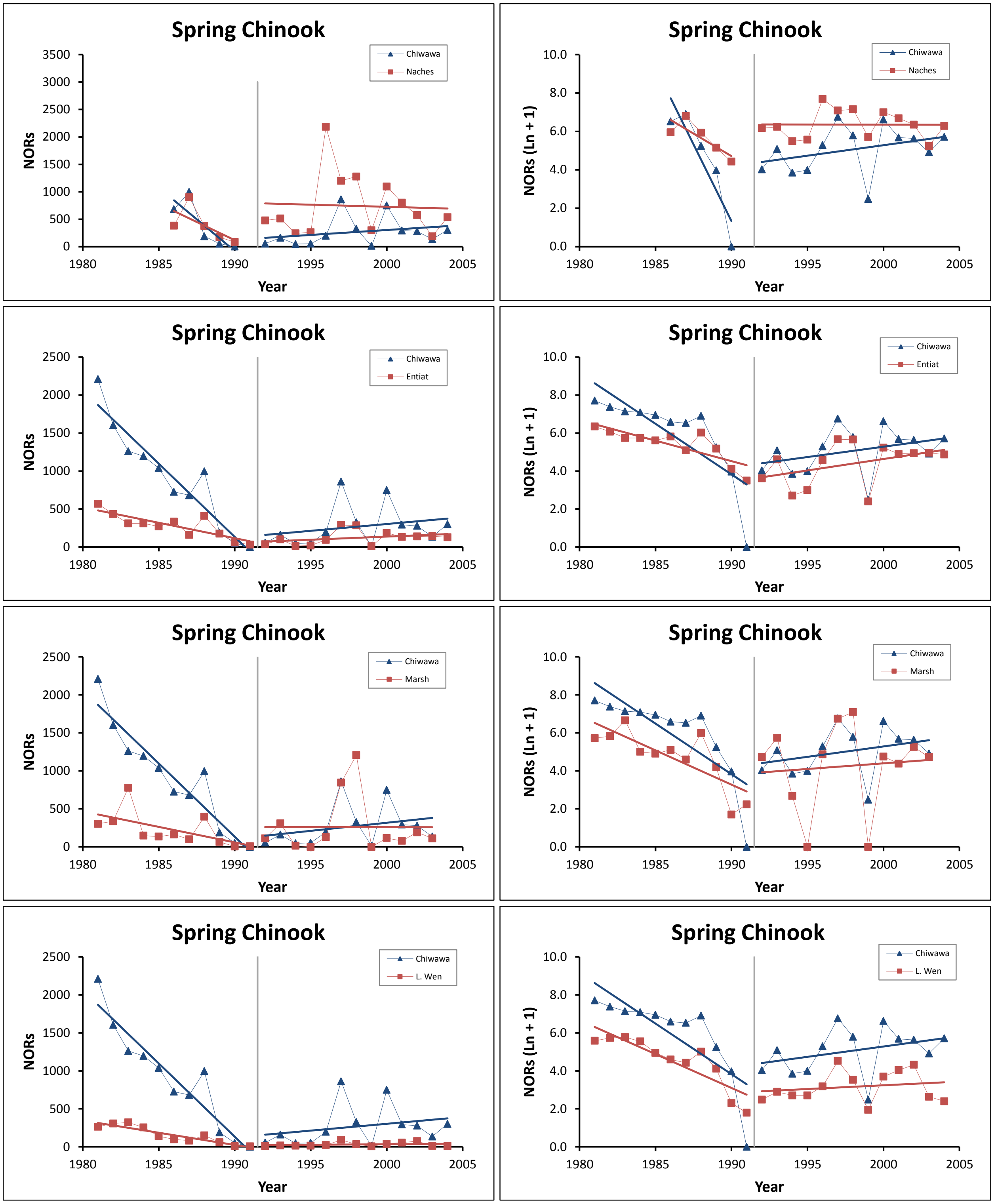


Figure 5.5. Trends in spring Chinook natural-origin recruits (NORs) in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.

Table 5.4. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spring Chinook natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Naches	1.150	0.845	0.374	0.297	-0.216 – 0.904
Entiat	1.110	0.858	0.581	0.277	-0.345 – 1.616
Marsh	2.705	0.992	3.253	0.012	1.066 – 5.510
Little Wenatchee	-1.614	0.064	3.681	0.117	-7.459 – 0.938
LN Natural-Origin Recruits					
Naches	-0.194	0.427	0.039	0.886	-0.328 – 0.357
Entiat	-0.862	0.203	0.100	0.536	-0.271 – 0.141
Marsh	1.034	0.840	0.182	0.353	-0.146 – 0.530
Little Wenatchee	-2.327	0.016	0.361	0.012	-0.619 – -0.026

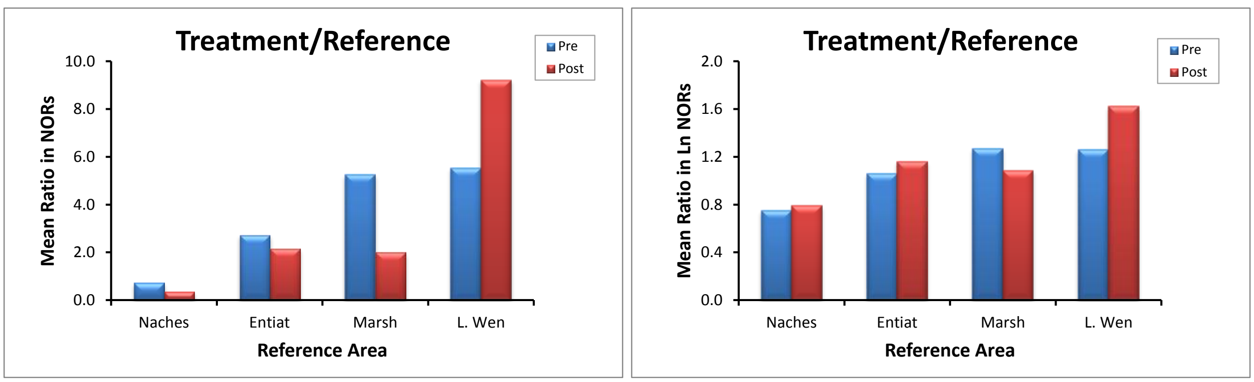


Figure 5.6. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) natural-origin recruits (NORs) data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

Next, we analyzed the effects of supplementation on filling the capacity of the habitat with NORs. The smooth hockey stick model derived the carrying capacity (K_R) estimates for the Chiwawa and reference populations. The mean fraction of the carrying capacity filled with Chinook NORs before and during supplementation for the Chiwawa and reference populations is provided in Table 5.5. These data indicate that for the Chiwawa population, the mean fraction of the K_R filled with fish decreased significantly from the pre-supplementation period through the supplementation period (Table 5.5). Likewise, the Entiat and Little Wenatchee populations showed a significant decline in the mean fraction of K_R filled with adult recruits. In contrast, the mean fraction of K_R in the Naches and Marsh Creek populations increased during the same period (Table 5.5). Interestingly, the fraction of K_R filled with adult recruits for all populations trended downward during the pre-supplementation period (Figure 5.7). During the supplementation period, however, the fraction of K_R filled with adult recruits trended upward for all populations. These results suggest that agents of mortality outside the Chiwawa and reference populations were reducing recruitment to the populations.

Table 5.5. Statistical results comparing the fraction of the carrying capacity that was filled with Chinook NORs in the Chiwawa and reference populations before and during supplementation of Chiwawa spring Chinook. The smooth hockey stick model estimated carrying capacity for each population.

Populations	Mean scores		Aspin-Welch test	
	Before	During	t-value	P-value
Chiwawa	0.87	0.26	2.948	0.012
Naches	0.78	1.51	-1.691	0.114
Entiat	0.71	0.31	2.852	0.012
Marsh	1.28	1.50	-0.295	0.771
Little Wenatchee	0.37	0.08	3.438	0.006

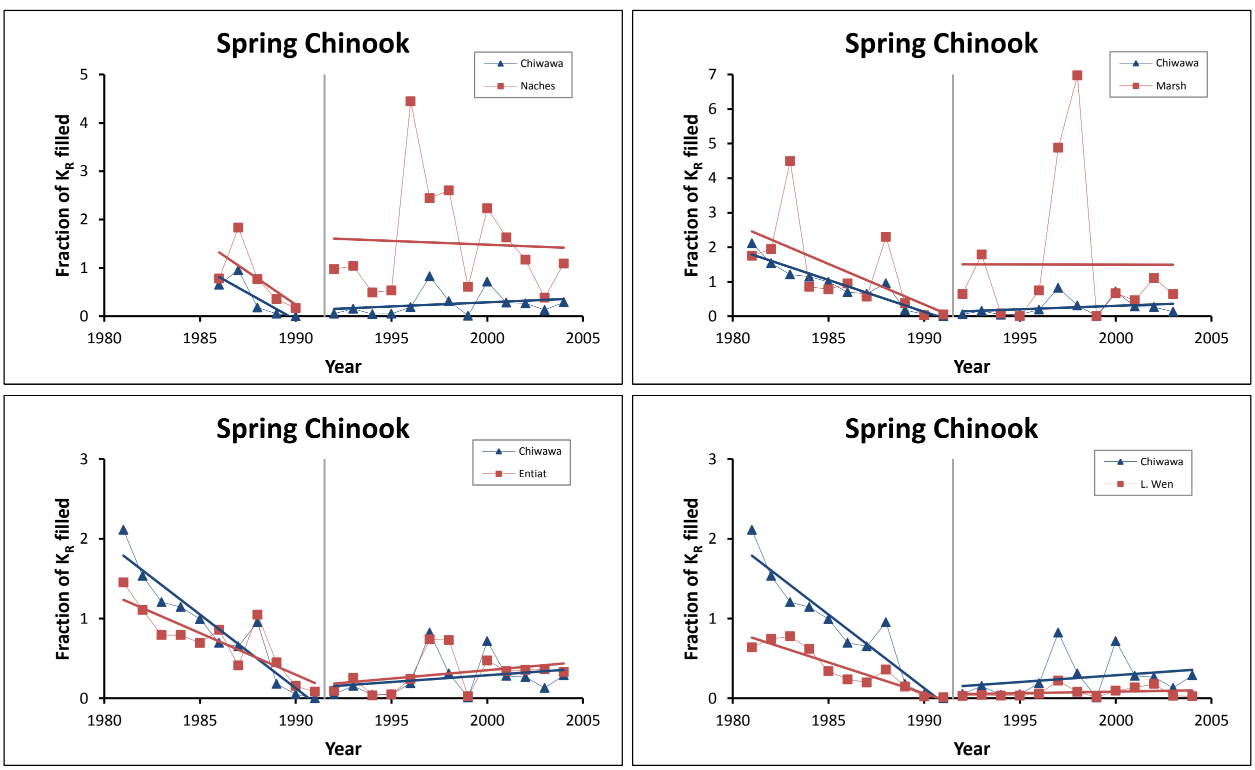


Figure 5.7. Trends in the fraction of the carrying capacity that was filled with Chinook salmon NORs in the Chiwawa and reference populations before (pre) and during (post) supplementation in the Chiwawa Basin. The vertical lines in the figures separate the pre- and post-supplementation periods. The smooth hockey stick model estimated carrying capacity for each population.

We then compared the mean ratios between the Chiwawa and reference populations before and during supplementation using data representing the fraction of K_R filled with adult recruits. Mean ratio scores were generally smaller during the supplementation period than during the pre-supplementation period (Figure 5.8). This indicated that the mean fraction of K_R filled by adult recruits in most reference populations was greater during the supplementation period than during the pre-supplementation period (i.e., the denominator in the ratio increased between the pre- and post-supplementation periods). In contrast, the fraction of K_R filled by adult recruits in the Chiwawa decreased from the pre- to post-supplementation period (i.e., the numerator in the ratio decreased between the pre- and post-supplementation periods). Thus, unlike the Chiwawa population, the capacity of most reference populations was becoming more saturated during the period when the Chiwawa was being supplemented. Statistical analysis with mean ratios indicated that only the Little Wenatchee-Chiwawa pairing using transformed data was significant (Table 5.6).

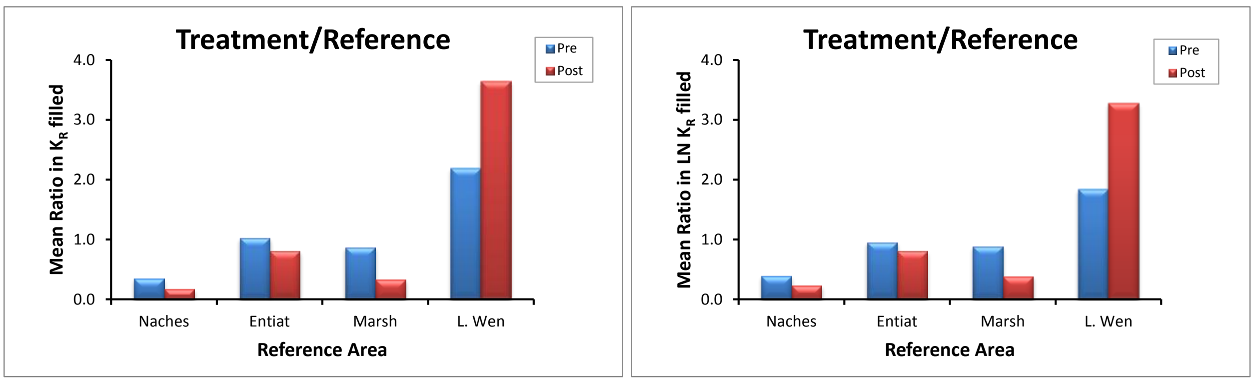


Figure 5.8. Mean ratios (Treatment/Reference) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin.

Table 5.6. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with spring Chinook NORs. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Fraction of Capacity Filled					
Naches	1.150	0.845	0.176	0.303	-0.101 – 0.429
Entiat	1.109	0.858	0.217	0.272	-0.128 – 0.594
Marsh	2.704	0.992	0.538	0.015	0.159 – 0.897
Little Wenatchee	-1.614	0.064	1.455	0.112	-2.937 – 0.322
LN Fraction of Capacity Filled					
Naches	0.957	0.807	0.158	0.373	-0.137 – 0.434
Entiat	0.837	0.793	0.144	0.405	-0.157 – 0.477
Marsh	2.792	0.994	0.502	0.009	0.171 – 0.828
Little Wenatchee	-1.889	0.039	1.439	0.047	-2.695 – 0.149

Analyses comparing the Little Wenatchee with the Chiwawa indicate that adult recruits to the Little Wenatchee have been well below its carrying capacity. During the pre-supplementation period, the capacity of the Little Wenatchee was on average 37% saturated with adult recruits. During the supplementation period, the capacity of the Little Wenatchee declined to 8% saturation with adult recruits (a 78% decline). The Chiwawa, during the pre-supplementation period, was on average 87% saturated. During the supplementation period, percent saturation in the Chiwawa decreased to 26% (a 70% decrease). During the same time periods, the capacity of the Entiat population, which until recently has been supplemented, declined from 71% to 31% saturation (a 56% decline).

Finally, we used Pearson correlation to test the association between pHOS and NORs. If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. During the pre-supplementation period, NORs averaged 905 adults; during the supplementation period, NORs averaged 266 adults. This 71% decrease in NORs did not appear to be correlated to pHOS (Figure 5.9). Correlation analysis showed that there was no significant association between pHOS and NORs, even though NORs decreased with increasing pHOS.

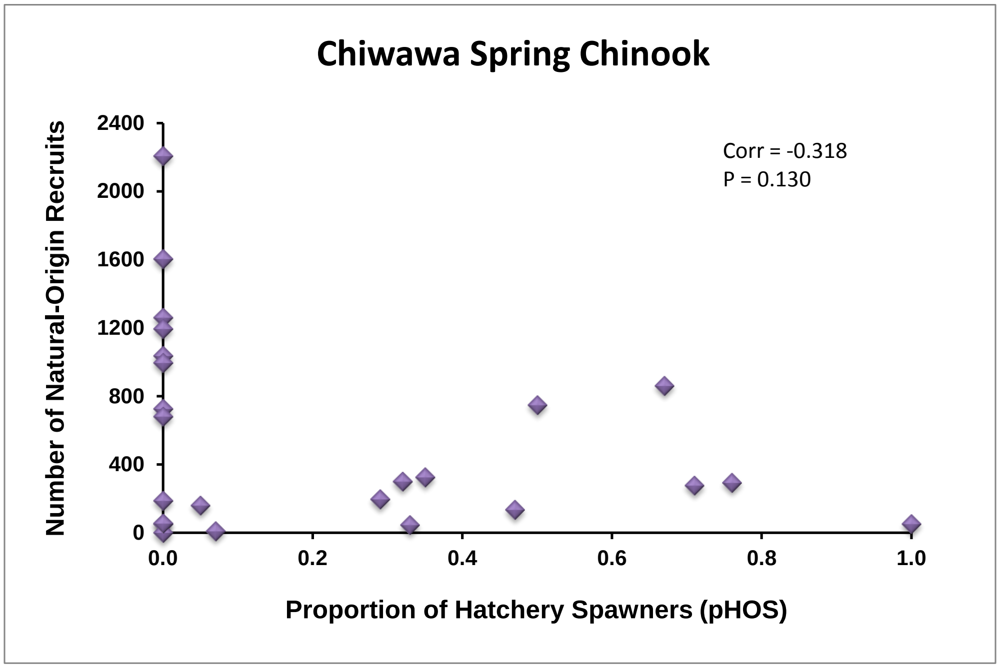


Figure 5.9. Association between the proportion of spring Chinook spawners that were made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, the supplementation program has not significantly increased NORs within the Chiwawa Basin. This conclusion is based on comparing trends and mean abundances before and after supplementation, and comparing the supplemented population with reference populations. It also includes comparing NORs adjusted for carrying capacity.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the supplementation program has reduced the productivity of spring Chinook in the Chiwawa Basin by analyzing trends and mean productivities before and during supplementation. We also compared trends and mean productivities of Chiwawa spring Chinook with reference populations (Naches, Sesech, Marsh, and Little Wenatchee populations). In addition, because productivity can be affected by density (density-dependent effects), we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Beverton-Holt and smooth hockey stick models to the stock-recruitment data.

Trend analysis indicated that before supplementation, productivity decreased over time; during supplementation the trend increased and then decreased resulting in an overall decrease in trend over time (Figure 5.10). The change in trend before and during supplementation was not significant, largely because of the variability in productivity during the supplementation period. When we compared the trends of the Chiwawa population with reference populations, we found that the reference populations also trended downward during the period before the Chiwawa was supplemented (Figure 5.11). During the period of supplementation, productivities fluctuated widely in both the Chiwawa and reference populations. Nevertheless, during the supplementation period, trends in productivities generally decreased in both the reference and Chiwawa populations.

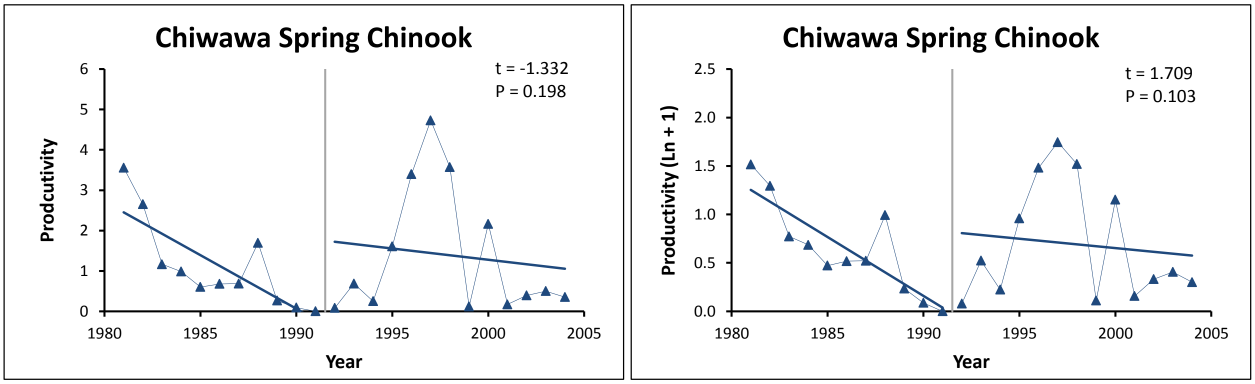


Figure 5.10. Trends in Chiwawa spring Chinook productivity (adult recruits/spawner; NRRs) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

We then compared spring Chinook productivities before supplementation with productivities during supplementation. Mean productivities of Chiwawa spring Chinook increased slightly, but not significantly, between the pre- and post-supplementation periods (Table 5.1). When we compared Chiwawa productivities with reference populations using ratios (treatment/reference), we found that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 5.7). However, it is important to point out that the comparisons with Marsh and Sesech suggest that supplementation has reduced productivities in the Chiwawa, although not significantly (Figure 5.12). On the other hand, comparisons with the Little Wenatchee and Entiat indicate the opposite effect. This apparent contradiction is probably related to the fact the both the Little Wenatchee and Entiat populations have been influenced by hatchery fish. Thus, we would not expect their productivities to differ greatly from Chiwawa spring Chinook.

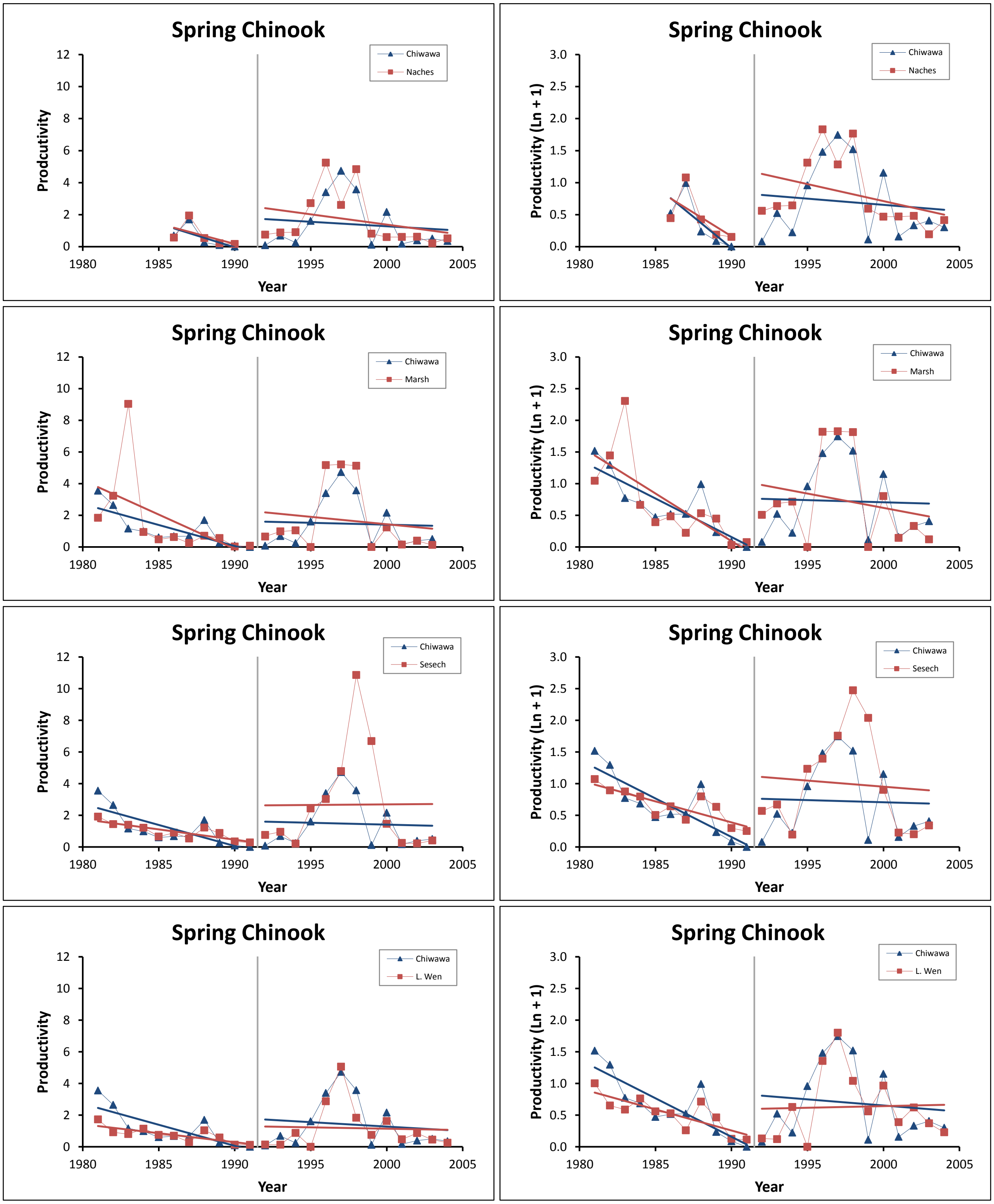


Figure 5.11. Trends in spring Chinook productivity (adult recruits/spawner) in the Chiwawa (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.

Table 5.7. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spring Chinook productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	-1.047	0.844	0.369	0.389	-0.956 – 0.319
Marsh	0.531	0.301	0.246	0.609	-0.572 – 1.171
Sesech	0.311	0.380	0.075	0.764	-0.373 – 0.530
Little Wenatchee	0.046	0.482	0.022	0.971	-0.795 – 1.030
LN Productivity					
Naches	-0.960	0.822	0.269	0.411	-0.758 – 0.236
Marsh	0.436	0.334	0.168	0.676	-0.512 – 0.911
Sesech	-0.023	0.509	0.004	0.981	-0.377 – 0.360
Little Wenatchee	-0.080	0.531	0.029	0.952	-0.635 – 0.699

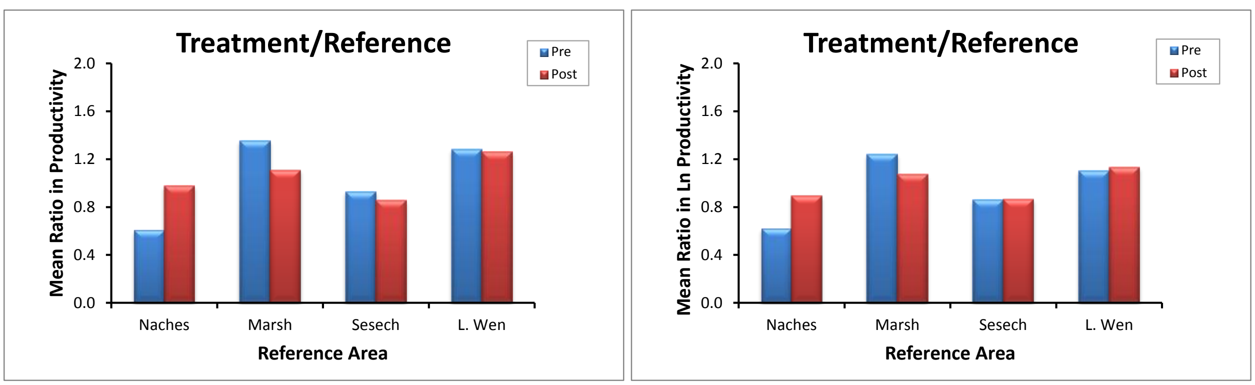


Figure 5.12. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) productivity (adult recruits/spawner; NRRs) data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Next, we analyzed the effects of supplementation on productivities adjusted for density dependence. These analyses, based on ratios, indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 5.8; Figure 5.13). Although not significant statistically, comparisons with the Marsh and Sesech populations indicated a reduction in productivity in the Chiwawa. This was not true when the Chiwawa was compared with the Little Wenatchee and Entiat populations. As noted above, this is probably because these two populations have been influenced by hatchery fish.

Table 5.8. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spring Chinook productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test	Bootstrap 95% CI
	t-value	P-value	Effect size	P-value	
Productivity					
Naches	-0.746	0.763	0.149	0.500	-0.513 – 0.219
Marsh	1.304	0.105	0.437	0.207	-0.196 – 1.033
Sesech	0.717	0.241	0.165	0.475	-0.278 – 0.603
Little Wenatchee	0.046	0.482	0.022	0.966	-0.804 – 1.026
LN Productivity					
Naches	-0.753	0.763	0.148	0.466	-0.496 – 0.192
Marsh	1.197	0.125	0.343	0.256	-0.220 – 0.849
Sesech	0.395	0.349	0.073	0.694	-0.282 – 0.408
Little Wenatchee	-0.080	0.531	0.029	0.956	-0.629 – 0.730

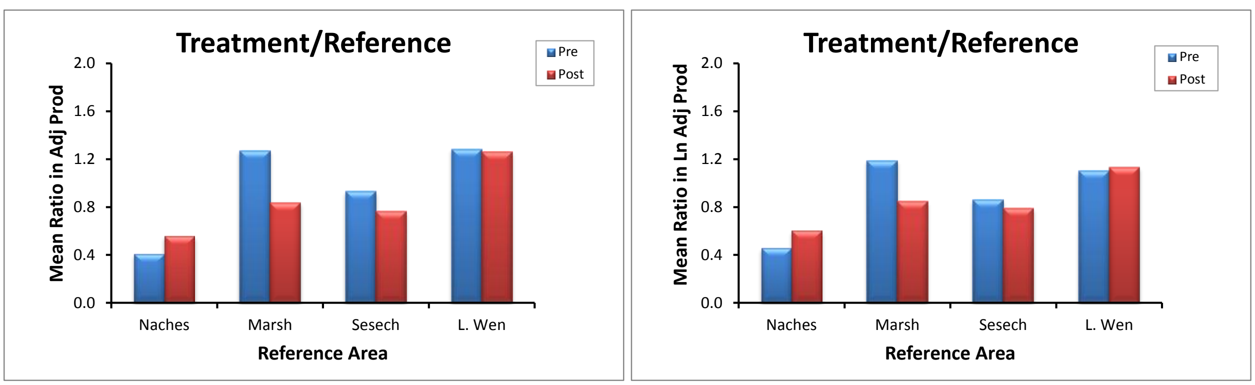


Figure 5.13. Mean ratios (Treatment/Reference) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Beverton-Holt and smooth hockey stick models to the Chiwawa spring Chinook stock and recruitment data. Although there was a negative trend in residuals with increasing pHOS, suggesting that hatchery-origin spawners may not be as productive as natural-origin spawners, the association was not significant (Figure 5.14).

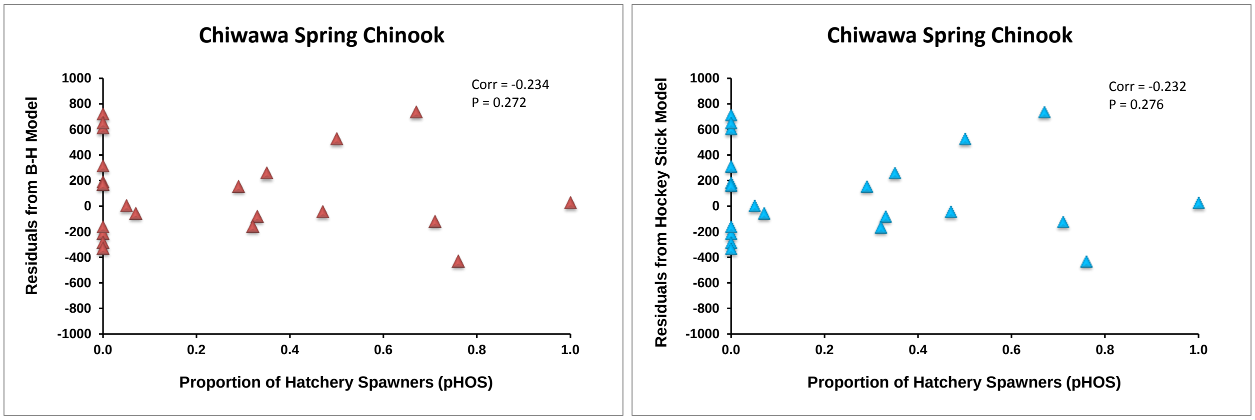


Figure 5.14. Association between the proportion of spring Chinook spawners that are made up of hatchery adults (pHOS) and the residuals from the Beverton-Holt and smooth hockey stick stock-recruitment models. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

In summary, based on the analyses above, there is no evidence that the supplementation program has significantly improved the productivity of the Chiwawa population. On the other hand, there is weak evidence that supplementation may have harmed the productivity of the Chiwawa population.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. Analyses of the available data suggest that the Chiwawa spring Chinook supplementation program has not increased the total spawning abundance and NORs in the Chiwawa Basin. Adjusting NORs for carrying capacity also indicated no apparent effect of supplementation on NORs. When compared to the reference populations, the analyses indicated that the fraction of the environment filled with NORs in the Chiwawa Basin may have declined during the supplementation period. In addition, there was a negative, although not significant, association between pHOS and NORs, suggesting that supplementation has not increased NORs in the Chiwawa Basin.

The effects of the supplementation program on productivity are equivocal. Analyses with two of the reference populations (Marsh and Sesech populations) suggest that the supplementation program may have reduced the productivity of the Chiwawa population. Analysis with the other two reference populations (Entiat and Little Wenatchee populations) suggests that supplementation has not decreased productivity in the Chiwawa population. Importantly, the two reference populations that did not indicate a reduction in productivity were themselves influenced by hatchery fish. Finally, there was a negative, but not significant, trend in stock-recruitment residuals with increasing pHOS, suggesting that hatchery-origin spawners may not be as productive as natural-origin spawners. Therefore, at this time, it is not clear whether the supplementation program has reduced the productivity of the Chiwawa population.

5.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin spring Chinook by comparing cumulative frequency polygons using data collected during video monitoring at Tumwater Dam and PIT interrogations at Bonneville Dam, Tumwater Dam, and in the Chiwawa River.

We compared cumulative frequency polygons of migration timing of PIT-tagged hatchery and natural-origin spring Chinook interrogated at Bonneville Dam, Tumwater Dam, and within the Chiwawa River (Figure 5.15). Based on migration years 2007-2010, natural-origin fish migrated earlier than hatchery Chinook. Among the three interrogation sites, the 10th and 90th percentiles differed by about two to five days between hatchery and natural-origin Chinook. In contrast, the median travel times differed by five to ten days. That is, median migration timing of natural-origin Chinook was about five to ten days earlier than hatchery Chinook. Using data collected at Tumwater Dam during stock assessment and relative reproductive success studies for migration years 2004-2010, we tested if the difference between hatchery and natural-origin Chinook migration timing differed among age classes. We found virtually no difference in migration timing of age-3 hatchery and natural-origin fish (Figure 5.16). Age-4 fish differed the most, with natural-origin fish migrating earlier than hatchery fish. For age-5 Chinook, the 10th percentile differed the most (ten day difference), but there was virtually no difference in the median or 90th percentile migration timing of hatchery and natural-origin Chinook.

We also compared the mean migration timing of hatchery and natural-origin spring Chinook by comparing the mean Julian date that 10%, 50%, and 90% of the fish passed Tumwater Dam (based on video monitoring). Because these data were based on video monitoring, all age groups were pooled together in the analysis. Based on 13 years of sampling, there was no significant difference in the migration timing of hatchery and natural-origin spring Chinook at Tumwater Dam (Table 5.9). At most, the average difference in migration timing between hatchery and natural-origin fish was three days. That is, based on these data, 10% of the natural-origin fish passed Tumwater Dam three days before 10% of the hatchery fish passed the dam. On average, 90% of both groups passed the dam on the same average day.

It is possible that sampling at Tumwater Dam may have affected the migration timing results presented here. That is, there is evidence that sampling at Tumwater has created unnatural, size-selective delays in the migration timing of spring Chinook at Tumwater Dam. This could confound the comparisons of migration timings between hatchery and natural-origin spring Chinook migrating past Tumwater. However, the migration timing of hatchery and natural-origin Chinook at Tumwater Dam was similar to that at Bonneville Dam. Thus, delays at Tumwater appeared to affect both hatchery and natural-origin fish similarly. Importantly, as noted in the next section, both hatchery and natural-origin Chinook spawned at about the same time. Thus, any migration delays at Tumwater did not translate into differential spawning times on the spawning grounds for the Chinook that successfully ascended the trapping facilities.

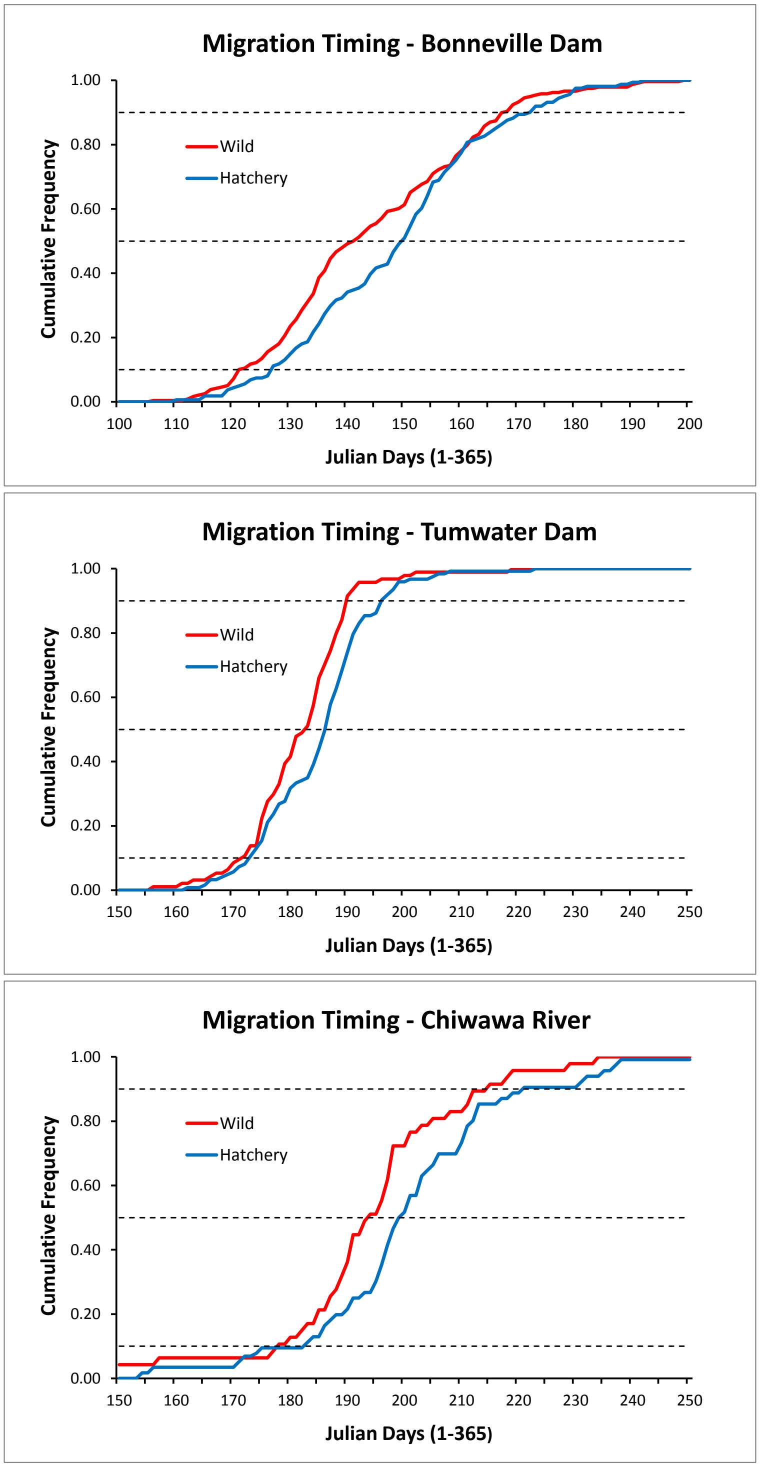


Figure 5.15. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Chiwawa spring Chinook passing Bonneville Dam, Tumwater Dam, and interrogation sites in the Chiwawa River. Migration timing was based on PIT-tagged spring Chinook detected during 2007-2010 migration years. Horizontal dashed lines indicate the 10^{th}, 50^{th}, and 90^{th} percentiles. Sample sizes = 238 wild and 161 hatchery Chinook at Bonneville; 94 wild and 123 hatchery at Tumwater; and 47 wild and 116 hatchery at Chiwawa detectors.

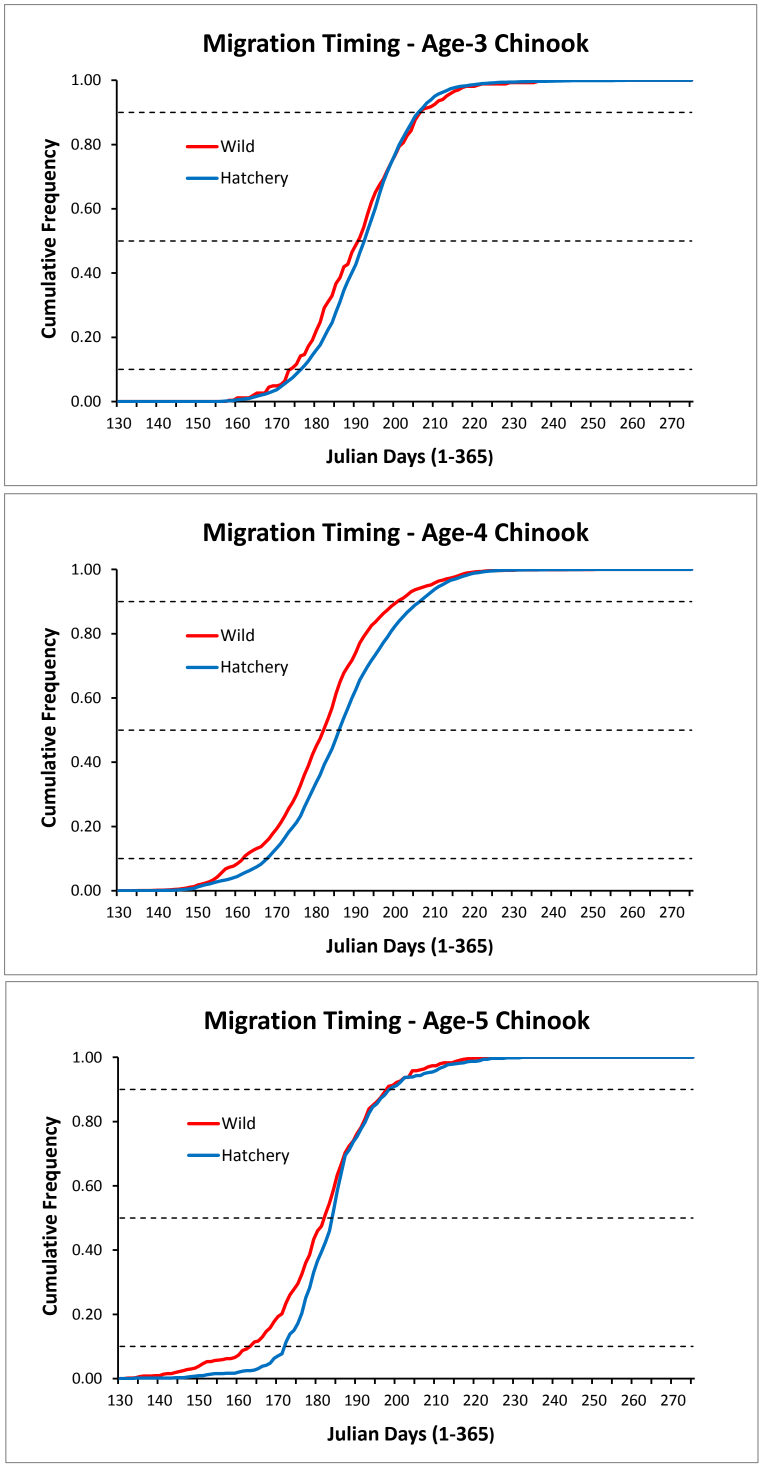


Figure 5.16. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Chiwawa spring Chinook sampled at Tumwater Dam. Migration timing was based on stock sampling at Tumwater Dam during 2004-2010 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 267 wild and 6,508 hatchery age-3 Chinook; 3,769 wild and 16,311 hatchery age-4 Chinook; and 641 wild and 649 hatchery age-5 Chinook.

Table 5.9. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date that hatchery and natural-origin (wild) spring Chinook migrated past Tumwater Dam during the period 1998-2010 (N = 13 years). Migration timing was based on video monitoring at Tumwater Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	168	171	182	184	197	197	182	185
Effect size	3		2		0		3	
t-value	-0.646		-0.475		-0.012		-0.482	
P-value	0.524		0.639		0.991		0.634	
Bootstrap CI	-12 – 6		-12 – 7		-12 – 13		-12 – 7	
Power	0.095		0.074		0.050		0.075	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin spring Chinook should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We tested differences in spawn timing between hatchery and natural-origin spring Chinook by comparing cumulative frequency polygons of the time when female carcasses were recovered on the spawning grounds.

There was virtually no difference in spawn timing of hatchery and natural-origin spring Chinook in the Chiwawa Basin (Figure 5.17). On average, hatchery fish began spawning about five days earlier than wild fish. However, the median and 90th percentile spawn times were nearly identical between hatchery and natural-origin Chinook.

We also compared the mean spawn timing of hatchery and natural-origin spring Chinook by comparing the mean Julian data that 10%, 50%, and 90% of the female carcasses were recovered on the spawning grounds. Based on 16 years of sampling, there was no significant difference in the spawn timing of hatchery and natural-origin spring Chinook in the Chiwawa River (Table 5.10).

Table 5.10. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date of spawn timing of hatchery and natural-origin (wild) spring Chinook in the Chiwawa River during the period 1994-2010 (n = 16 years).

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	242	238	250	241	257	256	249	240
Effect size	4		9		1		9	
t-value	1.067		0.966		0.297		1.048	
P-value	0.303		0.349		0.770		0.311	
Bootstrap CI	-2 – 10		-11 – 21		-4 – 5		-10 – 21	
Power	0.170		0.148		0.059		0.166	

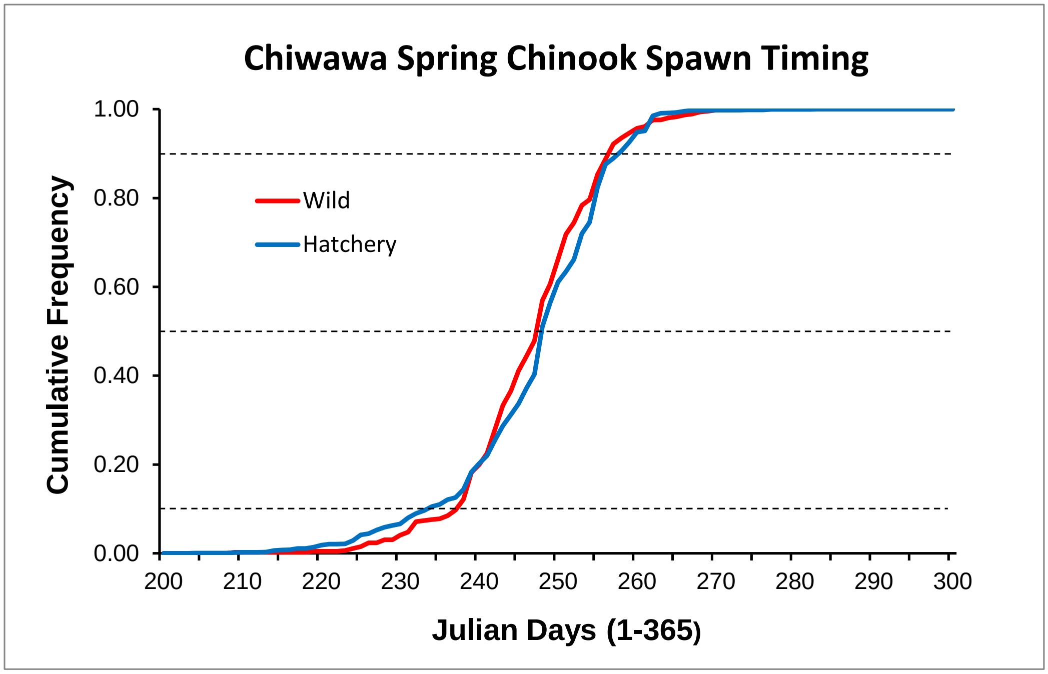


Figure 5.17. Cumulative frequency polygon of spawn timing of hatchery and natural-origin (wild) spring Chinook in the Chiwawa Basin. Spawn timing was based on the Julian date that female carcasses were recovered on the spawning grounds. Sample sizes = 462 wild and 1,392 hatchery Chinook.

Because spawning generally progresses from higher elevations to lower elevations, we examined the relationship between elevation and spawn timing of hatchery and natural-origin spring Chinook within the Chiwawa River. We found little difference in the spawn time of hatchery and natural-origin Chinook across the range of spawning elevations within the Chiwawa River (Figure 5.18). In general, both hatchery and natural-origin Chinook spawned at about the same time across the range of elevations within the Chiwawa River. However, as described in the next section, a higher proportion of hatchery fish spawn at lower elevations (lower in the river) than do natural-origin fish. In contrast, a larger fraction of natural-origin fish spawn at higher elevations than do hatchery fish.

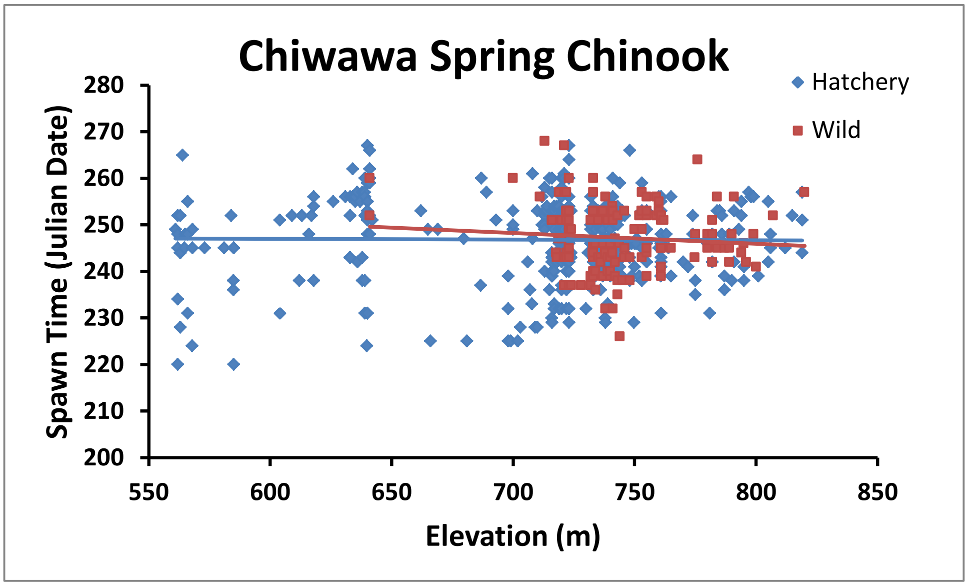


Figure 5.18. Relationship between elevation and spawn timing of hatchery and natural-origin (wild) spring Chinook spawners within the Chiwawa River.

Redd Distribution

Finally, under a fully integrated program, both hatchery and natural-origin spring Chinook should spawn in the same location. We evaluated differences in spawning locations at two different spatial scales; at the historic reach scale and at the 0.5 km scale.

Both hatchery and natural-origin Chinook spawned throughout the Chiwawa River. However, there was a significant difference in the distribution of hatchery and natural-origin spawners among the historic sampling reaches (Yates' Chi-square = 1,452.7; P = 0.000; Effect Size = 0.671). A greater percentage of hatchery-origin Chinook spawned in the lower reach than did natural-origin fish (Figure 5.19). The opposite occurred in the upper reaches where a greater percentage of natural-origin Chinook spawned. This pattern was most obvious when we compared the spawning distribution at the 0.5 km scale (Figure 5.20). Larger percentages of hatchery-origin Chinook spawned in the lower 25 km of the river than in the upper 25 km. In contrast, larger percentages of natural-origin Chinook spawned in the upper 30 km of the river than in the lower 20 km.

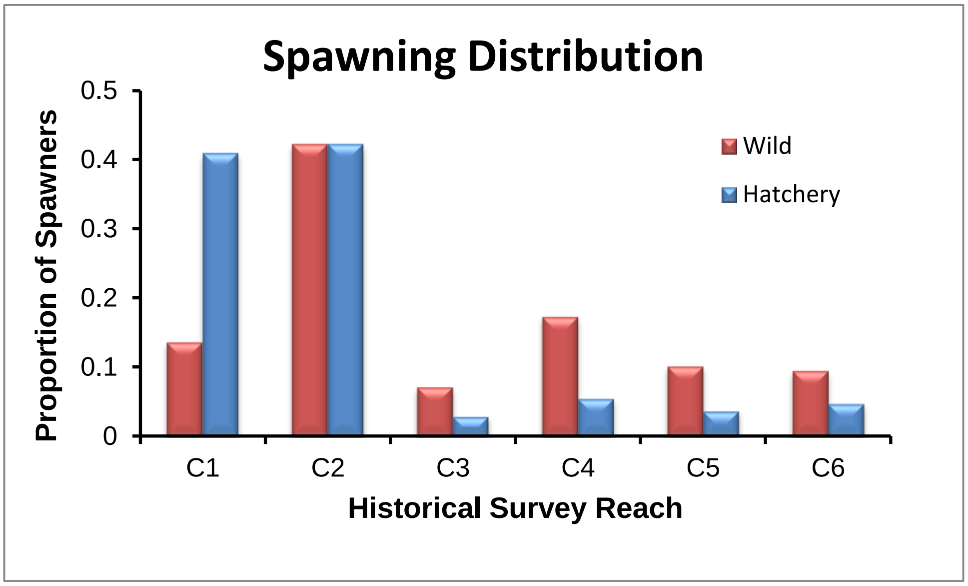


Figure 5.19. Proportion of hatchery and natural-origin spawners distributed among the six historic sampling reaches on the Chiwawa River. C1 is from 0.0-18.8 km; C2 18.8-31.1; C3 31.1-36.1; C4 36.1-41.2; C5 41.2-43.5; and C6 43.5-50.5. Sample sizes = 462 wild and 1,392 hatchery Chinook.

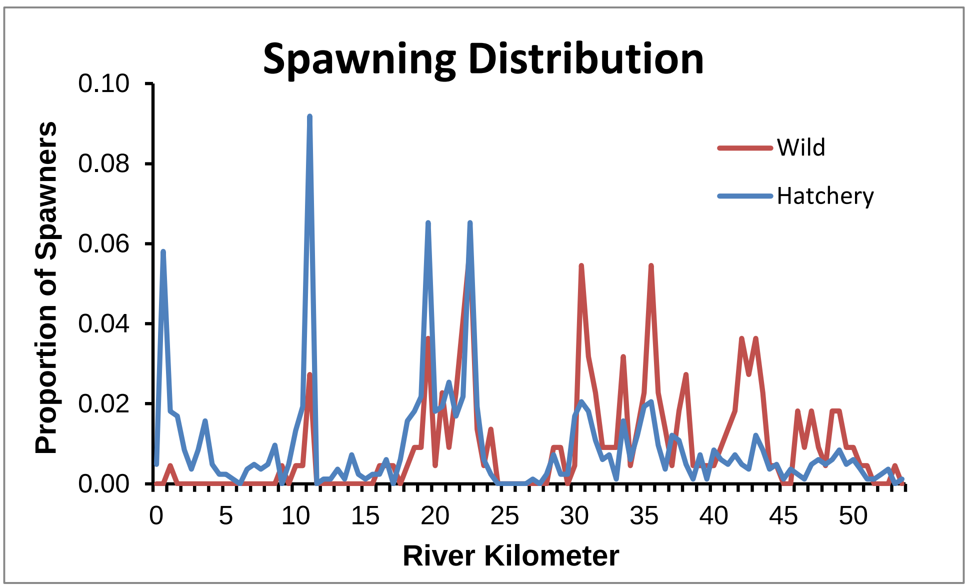


Figure 5.20. Proportion of hatchery and natural-origin spawners distributed along the length of the Chiwawa River. Distribution was based on 0.5-km long reaches. Sample sizes = 462 wild and 1,392 hatchery Chinook.

Conclusions

Hatchery and natural-origin spring Chinook had slightly different migration timings, with natural-origin fish migrating earlier than hatchery-origin fish. This was most apparent in age-4 and 5 fish. Even though there were small differences in migration timing between hatchery and natural-origin Chinook, spawn timing was similar. Hatchery fish began spawning before natural-origin fish, but the median and 90th percentiles were similar between the two groups of fish.

The distribution of hatchery and natural-origin spring Chinook spawners in the Chiwawa River differed significantly. A higher proportion of hatchery-origin Chinook spawned in the lower river, while a higher proportion of natural-origin Chinook spawned in the upper river. This difference in distribution is likely a result of the acclimation ponds located in the lower river.

5.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to determine the potential effects of the Chiwawa Supplementation Program on natural-origin spring Chinook in the upper Wenatchee Basin (Blankenship et al. 2007; the entire report is appended as Appendix H). Microsatellite DNA allele frequencies collected from temporally replicated natural and hatchery-origin spring Chinook were used to statistically assign individual fish to specific demes (locations) within the Wenatchee population. In addition, genetic effects of the hatchery program were assessed by examining relationships between census and effective population sizes (N_e) from samples collected before and after supplementation.

Overall, this work showed that although allele frequencies within and between natural and hatchery-origin spring Chinook were significantly different, there was no evidence (i.e., robust signal) that the difference was the result of the hatchery program. Rather, the differences were more likely the result of life-history characteristics. However, there was an increasing trend toward homogenization of the allele frequencies of the natural and hatchery-origin fish that comprised the broodstock, even though there was consistent year-to-year variation in allele frequencies among hatchery and natural-origin fish. In addition, there were no robust signals indicating that hatchery-origin broodstock, hatchery-origin natural spawners, natural-origin broodstock, and natural-origin natural spawners were substantially different from each other. Finally, the N_e estimate of 387 was only slightly larger than the pre-hatchery N_e (based on demographic data from 1989-1992), which means that the Chiwawa hatchery program has not reduced the N_e of the Wenatchee spring Chinook population.

Significant differences in allele frequencies were observed within and among major spawning areas in the Upper Wenatchee Basin. However, these differences made up only a very small portion of the overall variation, indicating genetic similarity among the major spawning areas. There was no evidence that the Chiwawa program has changed the genetic structure (allele frequency) of spring Chinook in Nason Creek and the White River, despite the presence of hatchery-origin spawners in both systems.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin spring Chinook. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin spring Chinook differed significantly. Because of different age-at-migration characteristics, we evaluated male and female Chinook separately.

The age at maturity differed significantly between hatchery and natural-origin female (Yates' Chi-square = 188.9; P = 0.000; Effect Size = 0.246) and male spring Chinook (Yates' Chi-square = 214.5; P = 0.000; Effect Size = 0.300) (Figure 5.21). Most female and male spring Chinook returned at age-4; however, a larger percentage of hatchery fish returned at younger ages than did natural-origin fish. For example, 93% of hatchery female Chinook returned at age-4, while 76% of the natural-origin females returned at age-4. About 23% of natural-origin females returned at age-5; 6% of hatchery females returned at age-5. A similar pattern was observed with male Chinook. About 29% of the hatchery males returned at age-3, while 8% of natural-origin males returned at age-3. In contrast, about 22% of natural-origin males returned at age-5, while 6% of hatchery males returned at age-5.

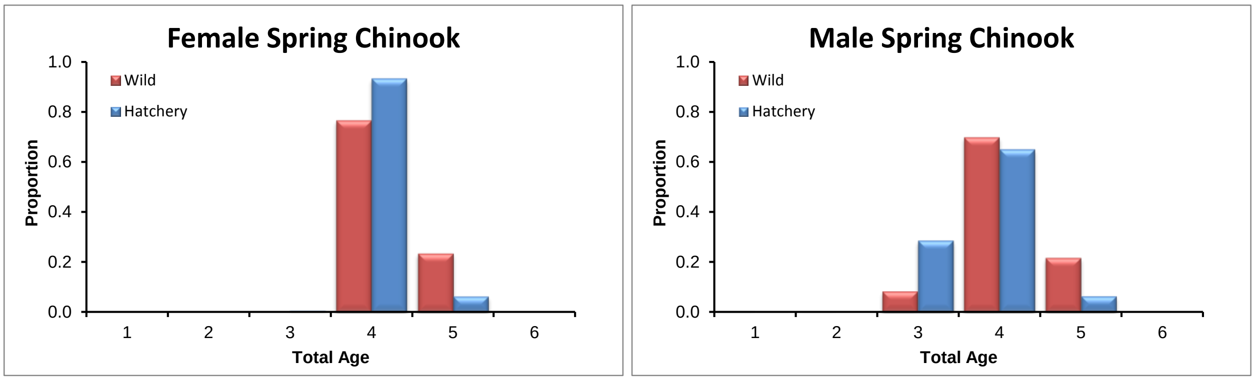


Figure 5.21. Proportion of hatchery and natural-origin female and male spawners of different ages sampled at the Chiwawa Weir and on the spawning grounds in the Chiwawa Basin for the combined years 1991-2010. Sample sizes for females = 858 wild and 2,316 hatchery Chinook and for males = 818 wild and 1,562 hatchery Chinook.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin spring Chinook. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin Chinook of the same age. We used three-way ANOVA to test differences in sizes of hatchery and natural-origin fish.

The size at maturity differed significantly between hatchery and natural-origin female and male spring Chinook (Table 5.11; Figure 5.22). The significant three-way interaction term indicates that differences in sizes between hatchery and natural-origin Chinook were affected by age and sex. For female Chinook, age-3 hatchery fish were significantly larger than age-3 natural-origin fish (mean difference = 12 cm). However, age-5 natural-origin fish were significantly larger than age-5 hatchery fish (mean difference = 1 cm). Likewise, for males, age-5 natural-origin fish were significantly larger than age-5 hatchery fish (mean difference = 2 cm). For both sexes, there was no significant difference in sizes of age-4 hatchery and natural-origin Chinook.

It is important to note that significance here is a statistical result, not a biological result. Although a mean difference of 2 cm or less was significant statistically, it is unlikely that such a difference in size is significant biologically.

Table 5.11. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Chiwawa spring Chinook. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Age (3, 4, and 5), resulting in a 2 x 2 x 3 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	12.53	0.53	0.466	0.113
Origin	1	127.11	5.40	0.020	0.642
Sex x Origin	1	86.06	3.66	0.056	0.481
Age	2	34,108.22	1,449.57	0.000	0.999
Sex x Age	2	574.27	24.41	0.000	0.999
Origin x Age	2	415.30	17.65	0.000	0.999
Sex x Origin x Age	2	130.35	5.54	0.004	0.855
Error	5,538	130,308.40			

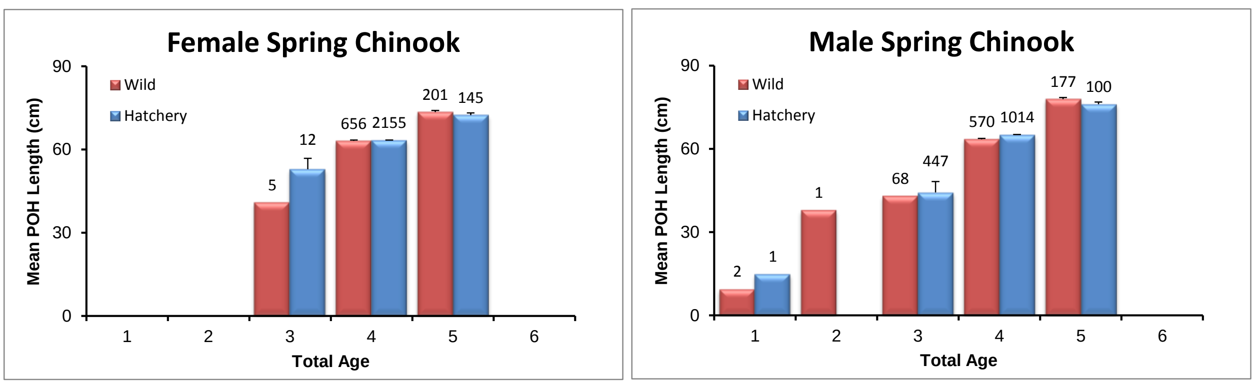


Figure 5.22. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male spawners of different ages sampled at the Chiwawa Weir and on the spawning grounds in the Chiwawa Basin for the combined years 1991-2010. Sample sizes are shown above each bar.

Conclusions

Genetic analyses found no evidence that differences in allele frequencies within and between natural and hatchery-origin spring Chinook were the result of the supplementation program. There was, however, an increasing trend toward homogenization of the allele frequencies of the natural and hatchery-origin fish that comprised the broodstock. In addition, there was no significant difference among hatchery-origin broodstock, hatchery-origin natural spawners, natural-origin broodstock, and natural-origin natural spawners. Finally, there was no evidence that the Chiwawa supplementation program has reduced the effective population size of the Wenatchee spring Chinook population.

Although there were no significant genetic differences between hatchery and natural-origin spring Chinook, there were significant differences between the two groups in age at maturity and size at maturity. Hatchery fish tended to mature at an earlier age than natural-origin fish. In addition, younger mature hatchery fish were larger than younger mature natural-origin fish, while older mature hatchery fish were smaller than older mature natural-origin fish. These differences in mean size at maturity were probably not significant biologically.

5.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.30 (the calculated target value in Murdoch and Peven 2005).

In nearly all years, HRRs were greater than NRRs, regardless if harvest was or was not included (Figure 5.23). The number of years that HRRs exceeded NRRs was significant when harvest was not included in the analysis (paired-sample sign test; P = 0.001). It was also significant when harvest was included in the analysis (paired-sample sign test; P = 0.000). In addition, HRRs exceeded the estimated target value of 5.3 in seven of the 16 years (Figure 5.23). Based on the one-sample sign test, the number of times HRRs exceeded the target value was not significant (P = 0.605 for analyses with and without harvest).

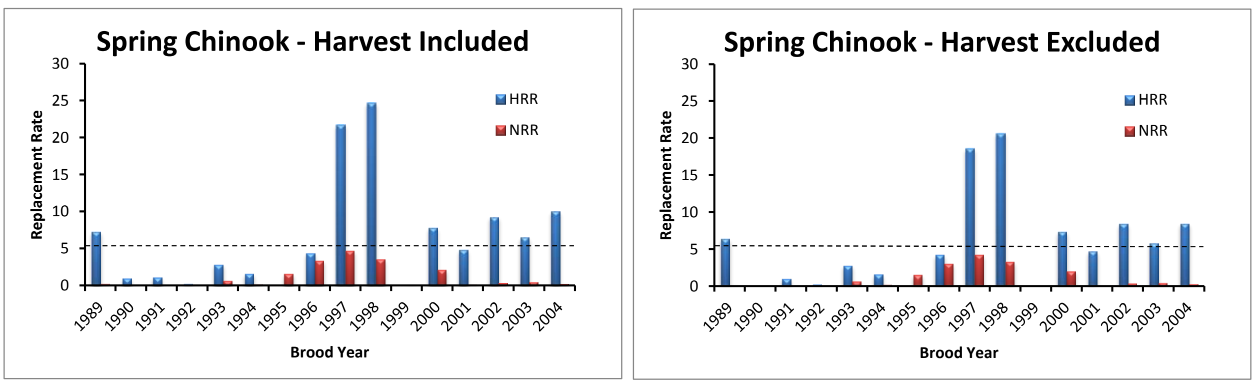


Figure 5.23. Natural and hatchery replacement rates (NRR and HRR, respectively) for spring Chinook in the Chiwawa Basin, brood years 1989-2004. Figure on the left includes harvested fish; figure on the right does not. The horizontal dashed line represents the target value of 5.3 in Murdoch and Peven (2005).

Conclusions

The spring Chinook supplementation program has demonstrated a significant full life-cycle survival advantage over natural-origin Chinook with a productivity advantage of over 6:1. That is, on average, HRRs were nearly six times greater than NRRs. This was true regardless if harvested fish were included in the analyses.

5.5 Stray Rates

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. Less than 5% of the brood returns should stray into non-target areas. In addition, hatchery strays from the Chiwawa program should make up less than 5% of the spawning escapement within non-target spawning areas outside the Wenatchee Basin and less than 10% of the spawning escapement within non-target spawning areas within the Wenatchee Basin.

Among Population Stray Rates by Brood Return

Based on brood year analyses, on average, about 36% of the hatchery returns have strayed into non-target spawning streams, exceeding the target of 5% (Figure 5.24). The number of years that hatchery spring Chinook exceeded the target of 5% was significant (Sign test, P = 0.001). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-81%. Few (<1% on average) have strayed into non-target hatchery programs.

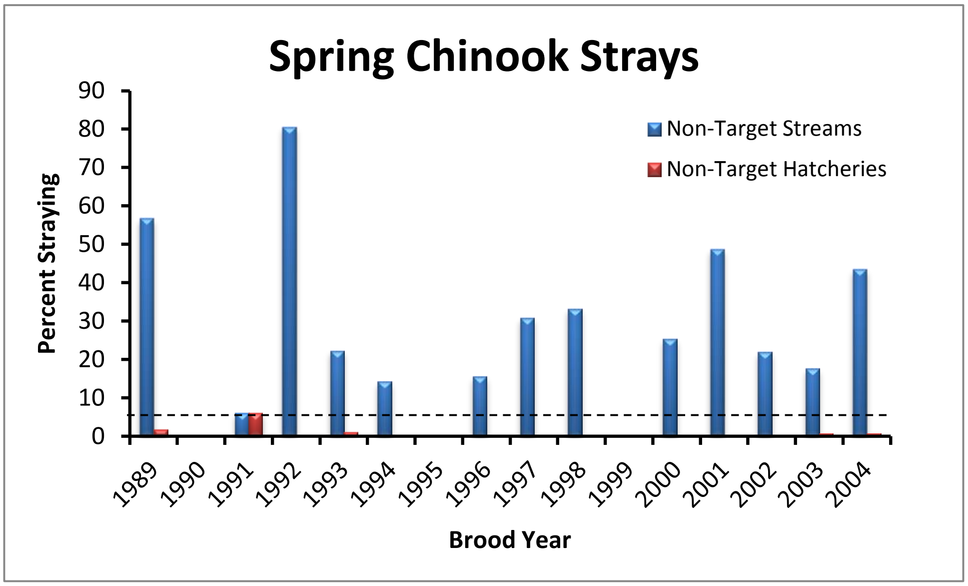


Figure 5.24. Percent of hatchery-origin Chiwawa spring Chinook that strayed to non-target spawning streams and non-target hatchery programs, by brood years 1989-2004. Percent strays should be less than 5% (represented by the horizontal dashed line). There was no hatchery program in 1995 or 1999.

Among Population Stray Rates by Return Year

Hatchery-origin Chiwawa spring Chinook have strayed into the Methow and Entiat basins. Based on return year analyses, rates of hatchery-origin Chiwawa spring Chinook straying into these populations have been low in most years (Figure 5.25). Only during return years 2002, 2006, 2008, and 2009 have Chiwawa spring Chinook made up more than 5% of the spawning escapement in the Entiat Basin.

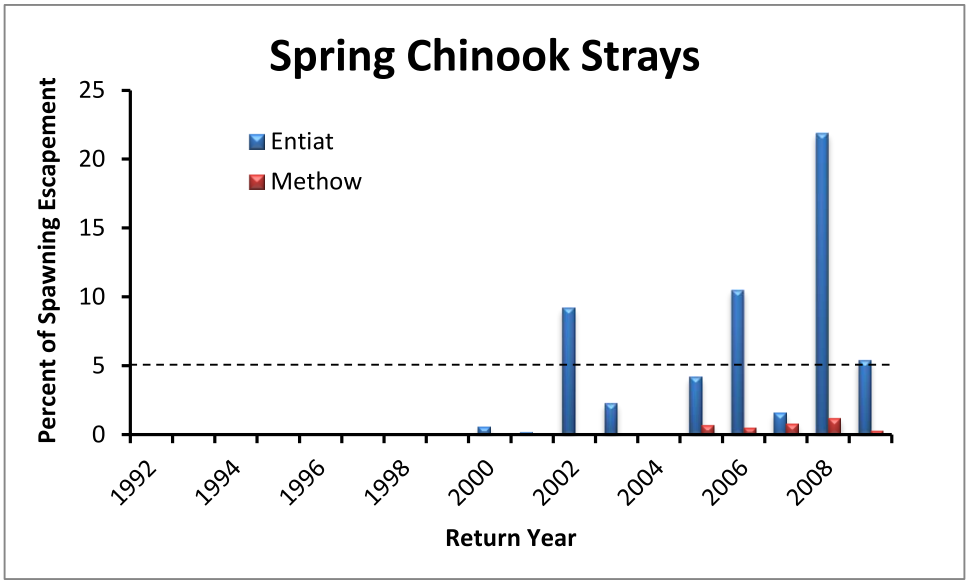


Figure 5.25. Percent of the spawning escapement within non-target spawning populations that are made up of Chiwawa hatchery Chinook, by return years 1992-2009. Percentages should be less than 5% (represented by the horizontal dashed line). There was no hatchery program in 1995 or 1999.

Within Population Stray Rates

Rates of hatchery-origin Chiwawa spring Chinook straying into non-target spawning areas within the Wenatchee Basin have been high in some years and exceeded the target of 10% (Figure 5.26). They have strayed into spawning areas on Nason Creek, Icicle Creek, Peshastin Creek, the White River, the Little Wenatchee River, and the Upper Wenatchee River. On average, stray rates were typically highest in Nason Creek and the Upper Wenatchee River. It is unclear what effects sampling at Tumwater Dam have had on straying of spring Chinook; although, delay of roughly 20% of PIT-tagged adults during recent years may have increased straying into tributaries downstream from Tumwater Dam (e.g., straying into Peshastin and Icicle creeks during return year 2008).

It appears that the percent of the spawning escapement within non-target spawning areas that is made up of Chiwawa hatchery Chinook has increased over time. This, however, may be related to the change in intensity of carcass surveys over time. The intensity of carcass surveys has increased since 2000, possibly resulting in more accurate estimates of straying into non-target spawning areas.

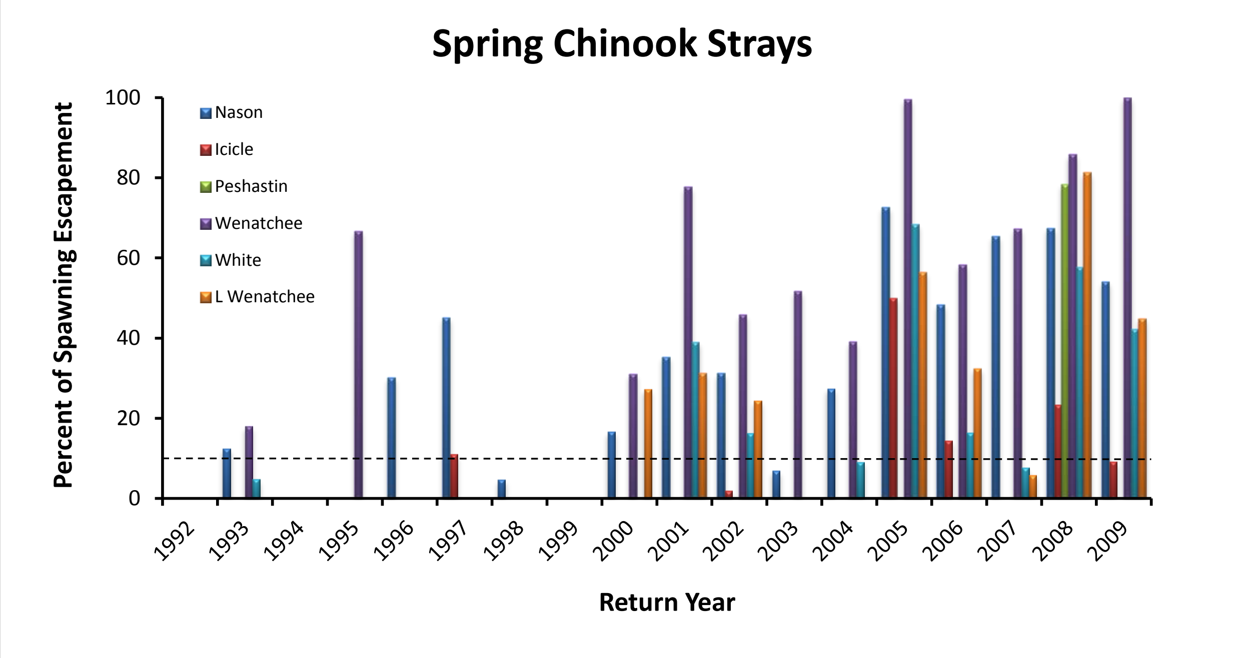


Figure 5.26. Percent of the spawning escapement within non-target spawning areas within the Wenatchee Basin that were made up of Chiwawa hatchery Chinook, by return years 1992-2009. Percentages should be less than 10% (represented by the horizontal dashed line). There was no hatchery program in 1995 or 1999.

Conclusions

Stray rates of hatchery spring Chinook have been high since the inception of the supplementation program. On average, about 36% of the brood year returns have strayed into other spawning areas. Nearly every brood year return has exceeded the 5% threshold. Hatchery spring Chinook have strayed into the Entiat and Methow basins, with most straying into the Entiat; however, in only four of the 18 return years did hatchery Chiwawa Chinook make up more than 5% of the spawning escapement in the Entiat Basin.

Large numbers of hatchery Chinook have strayed into non-target spawning areas within the Wenatchee Basin. The percentage of the spawning escapement within non-target spawning areas in the Wenatchee Basin that is made up of Chiwawa hatchery Chinook has been high in some years and has exceeded the 10% threshold in most years. On average, the percent of the spawning escapement made up of Chiwawa hatchery Chinook was the highest in Nason Creek and the Upper Wenatchee River. Delays and passage obstructions observed at Tumwater Dam trapping facility may have influenced stray rates observed in tributaries downstream from the facility.

5.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the spring Chinook supplementation program is to release smolts that average at least 176 mm long (fork length) and 37.8 g. Since the beginning of the supplementation program, the average size of Chinook released has consistently been below the length target (Figure 5.27).

Over brood years 1989-2008, lengths have averaged about 81% of the target length. In contrast, weight has exceeded the target in seven of the 18 years and averaged about 99% of the supplementation goal (Figure 5.27).

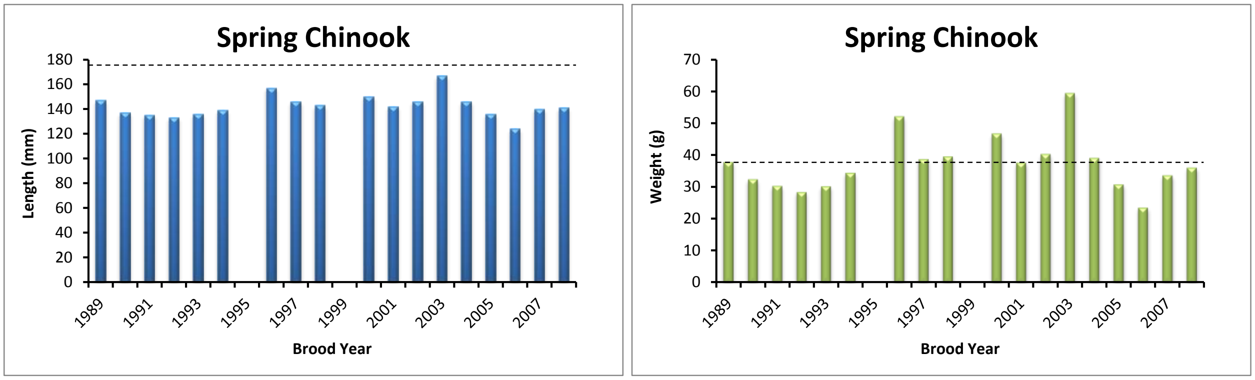


Figure 5.27. Average lengths (mm) and weights (g) of spring Chinook salmon released into the Chiwawa River for brood years 1989-2008. The dashed horizontal lines represent the target length (176 mm) and target weight (37.8 g).

The length and weight targets for the Chiwawa hatchery program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Chiwawa spring Chinook based on data collected within the hatchery over a five-year period (Figure 5.28). Based on this relationship, if the target is to release smolts at 176 mm, then the target weight of the smolts should be 65.6 g, not 37.8 g. On the other hand, if the goal is to release smolts that weigh 37.8 g, then the fork length at release should be 147 mm, not 176 mm.

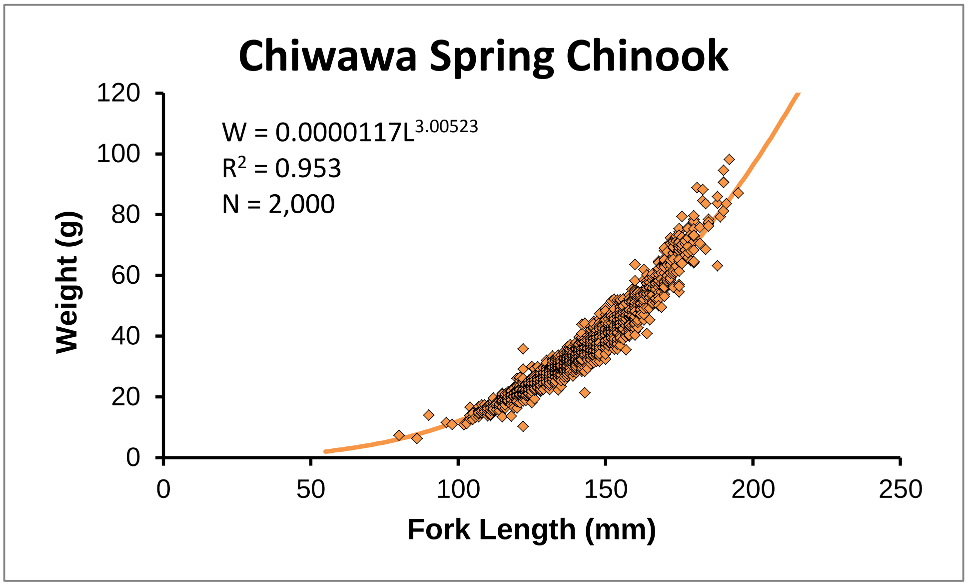


Figure 5.28. Relationship between fork length (mm) and weight (g) of juvenile Chiwawa spring Chinook salmon sampled in the hatchery during 2003-2007.

Number of Hatchery Fish Released

The original goal of the spring Chinook supplementation program was to release 672,000 spring Chinook smolts into the Chiwawa River (the current goal is to release 298,000 smolts). The program did not reach the goal of releasing 672,000 smolts in any year (Figure 5.29). Over the 1989-2008 brood years, the program released an average of 231,348 smolts, which is about 34% of the original program goal.

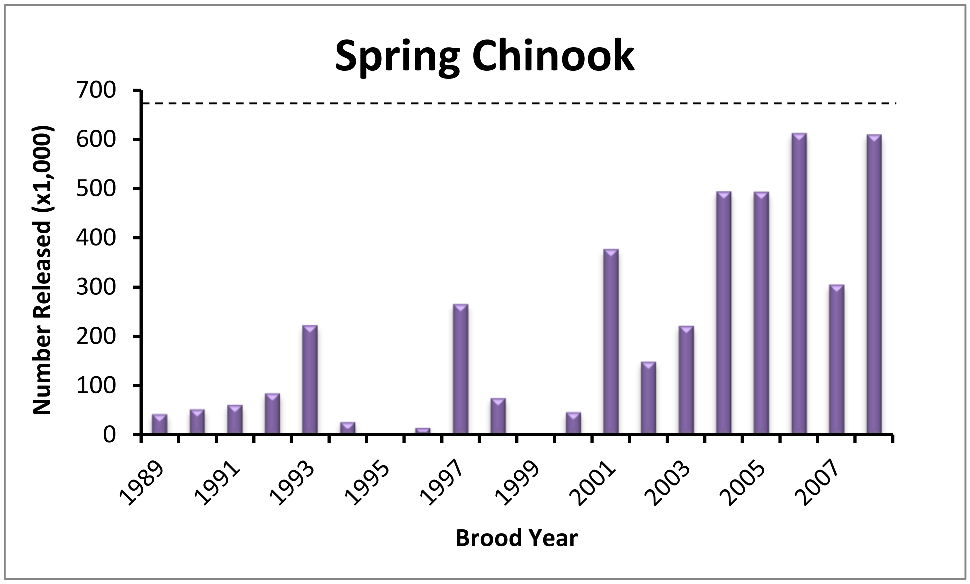


Figure 5.29. Number of spring Chinook smolts released into the Chiwawa River for brood years 1989-2008. The dashed horizontal line represents the original target release number (672,000 smolts). The current goal is to release 298,000 smolts.

Conclusions

The spring Chinook supplementation program did not achieve its original goal of releasing 670,000 fish per year. Since the beginning of the program, it has released on average about 231,348 smolts, which is about 34% of the goal. This is largely because of the lack of broodstock available for the supplementation program. In two years, 1995 and 1999, the program did not collect any broodstock because of low spawning escapement numbers. The current goal is to release 298,000 spring Chinook smolts into the Chiwawa River, which appears to be a more appropriate goal for the Chiwawa Basin.

The size of smolts released into the Chiwawa River has been below the size goals for the program. Average lengths of smolts released have consistently been below the threshold of 176 mm. In addition, in most years, the average weight of the released smolts has been below the goal of 37.8 g. Because of the unique relationship between length and weight of Chiwawa spring Chinook, the current program cannot achieve both the length and weight targets. More realistic targets should be set based on the length-weight relationship specific to this population. In addition, managers should consider setting size targets based on sizes of natural-origin spring Chinook smolts sampled at the Chiwawa Trap, which averaged between 92 and 94 mm in fork length during April and May from 2003 to 2009.

5.7 Freshwater Productivity

Juvenile Productivity

Because we were unable to find reference populations for juvenile productivity for the Chiwawa Basin, and there are no pre-supplementation juvenile data for the Chiwawa, we used stock-recruitment models to assess the productivity and capacity of the Chiwawa spring Chinook population. Here, we define recruitment as the number of natural-origin parr (estimated throughout the Chiwawa Basin in August) and the number of natural-origin yearling smolts produced in the basin. We also compared the number of parr/spawner and smolts/spawner to pHOS, and the residuals from the stock-recruitment curves to pHOS. If there is a negative association between pHOS and the productivity of juveniles (or residuals from the stock-recruitment curve), then the hatchery fish may be reducing the productivity of juvenile Chinook in the Chiwawa Basin.

There was a significant relationship between numbers of spawners and numbers of parr and smolts (Figure 5.30; Table 5.12). According to the smooth hockey stick model, the mean capacity of the Chiwawa Basin is about 98,000 parr or about 55,000 yearling smolts. The negative relationship between numbers of spawners and juveniles/spawner indicates the presence of density dependence (Figure 5.31). Density dependence is strongest when the spawning escapement exceeds about 1,300 spawners.

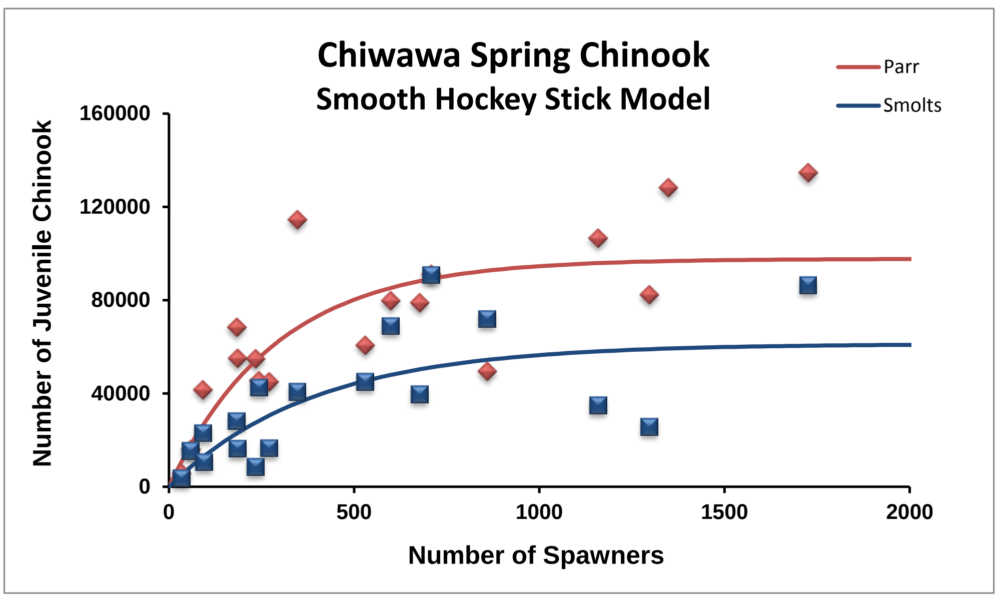


Figure 5.30. Relationship between number of spawners and numbers of parr (1991-2009) and smolt (1991-2008) spring Chinook produced in the Chiwawa Basin. Smooth hockey stick model was fit to the stock-recruitment data.

Table 5.12. Results of fitting the smooth hockey stick model to parr and smolt data from the Chiwawa Basin. Confidence intervals are based on 3,000 bootstrap samples.

Life state	Parameters	95% CI	Asymptotic correlation	Adjusted R^2	Carrying capacity	Intrinsic productivity
Parr	a = 11.49	11.25 – 11.75	-0.435	0.780	97,734	336
	b = 336	115 – 434				
Smolts	a = 10.92	10.32 – 11.35	-0.467	0.634	55,271	162
	b = 162	62 - 220				

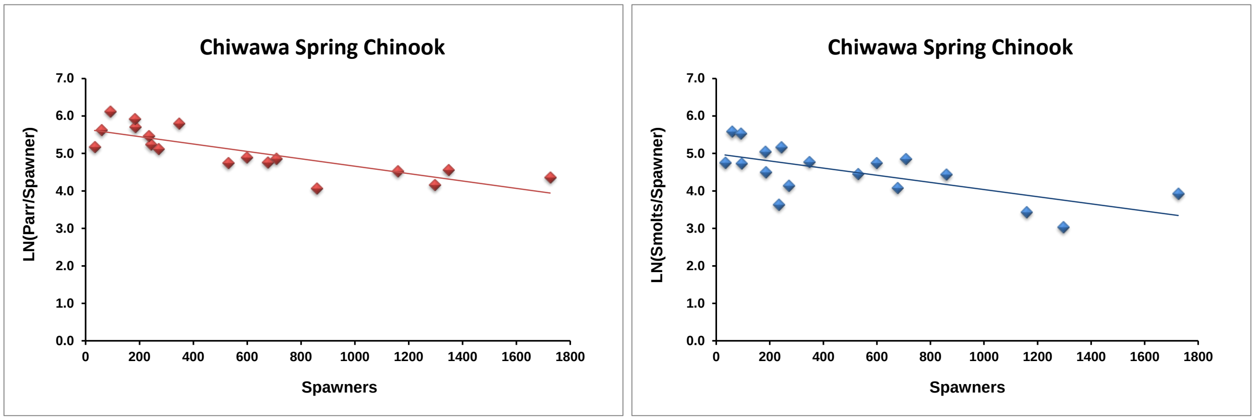


Figure 5.31. Relationship between number of spring Chinook spawners and numbers of parr/spawner (figure on the left) and smolts/spawner (figure on the right) produced in the Chiwawa Basin.

When we compared the number of parr/spawner with the proportion of the spawning escapement made up of hatchery Chinook (pHOS) we found a negative, but not significant relationship (Figure 5.32). On the other hand, when we compared the residuals from the smooth hockey stick model to pHOS, we found a positive, but not significant relationship (Figure 5.32). We found the same pattern with yearling smolts (Figure 5.33).

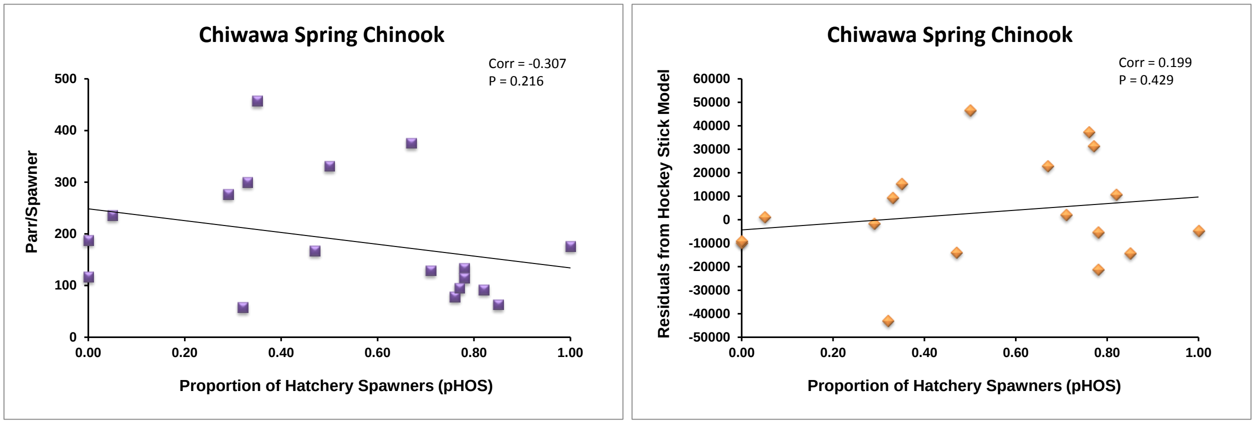


Figure 5.32. Association between the proportion of spawners that were made up of hatchery adults (pHOS) and the number of parr/spawner (figure on the left) and the residuals from the smooth hockey stick stock-recruitment model (figure on the right). The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

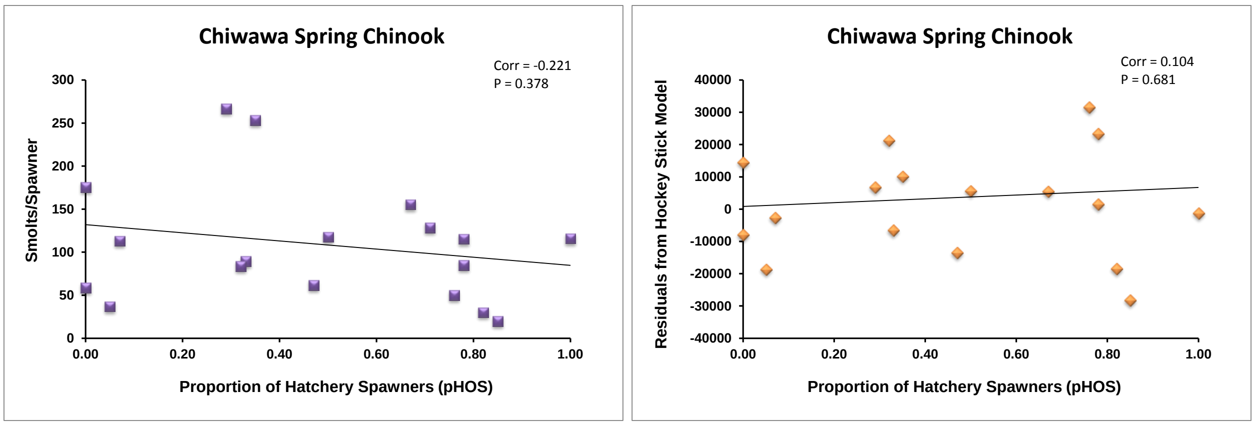


Figure 5.33. Association between the proportion of spawners that were made up of hatchery adults (pHOS) and the number of smolts/spawner (figure on the left) and the residuals from the smooth hockey stick stock-recruitment model (figure on the right). The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

Conclusions

There is a clear density-dependent relationship between numbers of spring Chinook spawners in the Chiwawa Basin and numbers of juveniles produced. According to the smooth hockey stick model, the capacity of the Chiwawa Basin appears to average about 98,000 parr or about 55,000 yearling smolts. As spawner abundance exceeds 1,300 adult Chinook, density dependent mortality increases.

The effects of hatchery-origin spawners on juvenile productivity are equivocal. There is weak evidence that increasing the number of hatchery-origin spawners reduces juvenile productivity, but this cannot be proven definitively without pre-supplementation data and/or reference population data. Therefore, at this time, we cannot determine whether or not supplementation has reduced juvenile productivity in the Chiwawa Basin.

5.8 Harvest

Harvest Rates

Nearly all the harvest on hatchery-origin Chiwawa spring Chinook occurs within the Columbia Basin (Figure 5.34). Ocean catch records (Pacific Fishery Management Council) indicate that very few Chiwawa spring Chinook are taken in ocean fisheries. Most of the harvest on hatchery-origin Chiwawa spring Chinook occurs in the Lower Columbia River fisheries, which are managed by the states and tribes pursuant to management plans developed in *U.S. v Oregon*. The Lower Columbia River fisheries occur during what is referred to in *U.S. v Oregon* as the winter, spring, and summer seasons, which begin in February and ends 31 July of each year. The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams; the non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam. The non-treaty recreational (sport) fishery occurs in the lower mainstem.

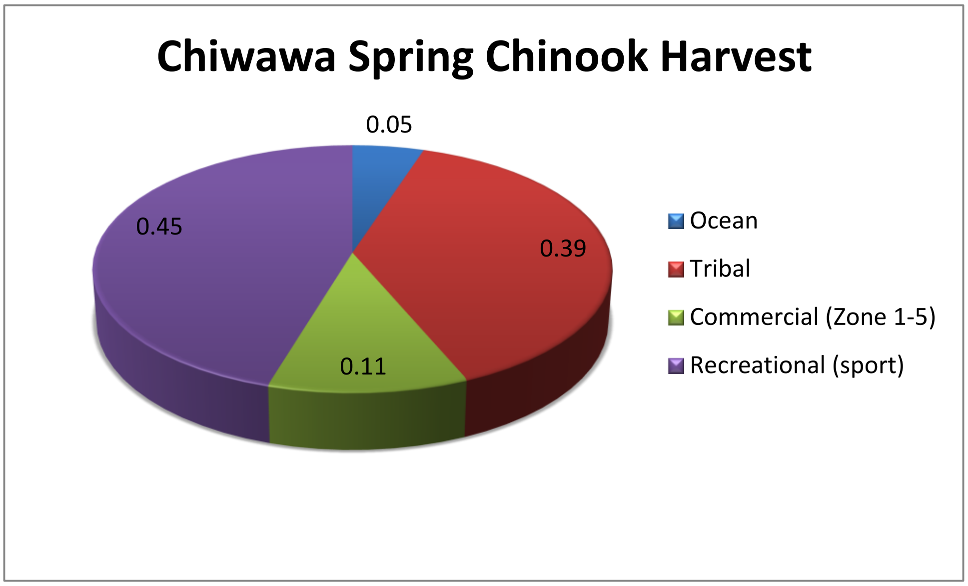


Figure 5.34. Mean allocation of Chiwawa spring Chinook harvested among the different fisheries for brood years 1989-2004. Spring Chinook harvested in the Wanapum fishery are included in the Recreation (sport) fishery. The total number of fish harvested across the brood years was 1,310 (average = 94 fish/year; range = 0-472).

Based on the stock-recruitment analyses conducted above with juvenile Chinook salmon, on average, about 1,300 adult spawners are needed to saturate the habitat in the Chiwawa Basin with parr or smolts. An additional 170 adults are needed to meet the current goal of the supplementation program (the original goal was 379 adults). Thus, a total of 1,470 adult spring Chinook are currently needed to satisfy broodstock and Chiwawa escapement goals. Based on the total escapement goal of 1,470 adults, there was one brood year (2001) that was large enough to support a terminal fishery (Figure 5.35).

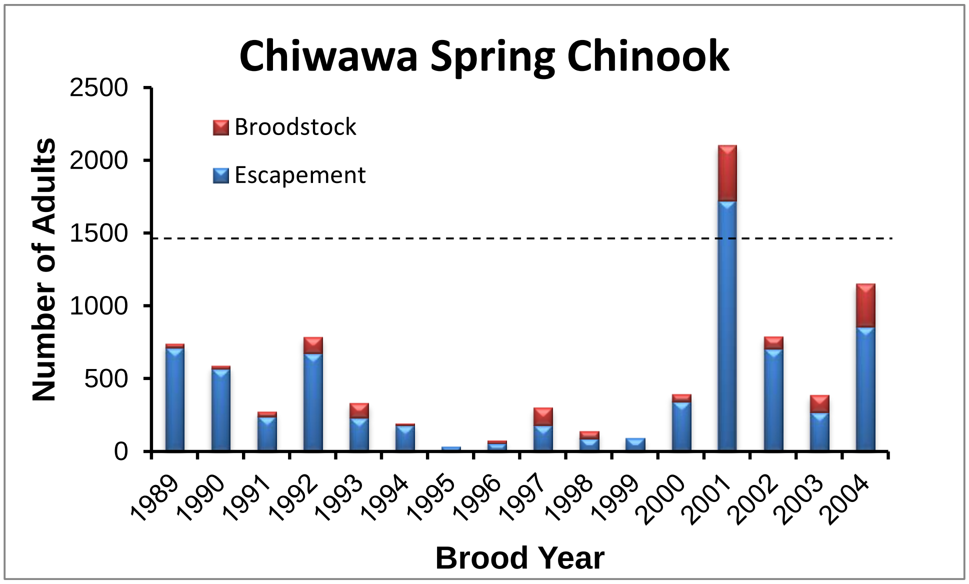


Figure 5.35. Numbers of spring Chinook adults collected for broodstock and numbers that spawned naturally within the Chiwawa Basin for brood years 1989-2004. The dashed horizontal line represents the number needed to satisfy the broodstock collection goal (170 adults) plus the number needed to saturate the habitat with parr or smolts (1,300 spawners).

Conclusions

Chiwawa spring Chinook are harvested within the ocean and Columbia River fisheries. Most of the harvest, however, occurs within the Columbia River. The number of spring Chinook harvested per brood year averaged 94 adults/year. Assuming a total escapement of 1,470 adults (sufficient to meet the current broodstock collection goal and spawning escapement), only brood year 2001 produced an escapement large enough to support a terminal fishery.

5.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available data were unable to show that the Chiwawa spring Chinook supplementation program has significantly increased total spawning abundance and NORs in the Chiwawa Basin.
2. Based on comparisons with suitable reference populations, the supplementation program may have reduced the productivity of the population. However, there was no significant association between pHOS and the residuals from the stock-recruitment models.
3. Hatchery and natural-origin spring Chinook had slightly different (not significant) migration timings, with natural-origin fish migrating earlier than hatchery-origin fish. Spawn timing, however, was similar between the two groups.
4. The spawning distribution of hatchery and natural-origin spring Chinook in the Chiwawa River differed significantly, with a higher proportion of hatchery-origin Chinook spawning in the lower river and a higher proportion of natural-origin Chinook spawning in the upper river.

5. There was no evidence that supplementation significantly affected allele frequencies within and between natural and hatchery-origin spring Chinook.
6. There was no significant genetic difference among hatchery-origin broodstock, hatchery-origin natural spawners, natural-origin broodstock, and natural-origin natural spawners.
7. There was no evidence that the Chiwawa supplementation program has reduced the effective population size of the Wenatchee spring Chinook population.
8. Hatchery fish matured at an earlier age than natural-origin fish. This may be related to the size of released hatchery smolts.
9. Younger mature hatchery fish were larger than younger mature natural-origin fish, while older mature hatchery fish were smaller than older mature natural-origin fish. These differences in mean size at maturity were probably not significant biologically.
10. HRRs were on average six times greater than NRRs. This was true regardless if harvested fish were included in the analyses.
11. On average, about 36% of the hatchery brood-year returns have strayed into other spawning areas. Nearly every brood year return has exceeded the 5% threshold. Straying may be related in part to the water source at the Eastbank Hatchery, water source for the acclimation ponds (which changed in 2006), and possibly trapping activities at Tumwater Dam.
12. Hatchery spring Chinook from the Chiwawa program have strayed into the Entiat and Methow populations, with most of them straying into the Entiat; however, in only four of the 18 return years did hatchery Chiwawa Chinook make up more than the 5% of the spawning escapement within those populations.
13. The percentage of the spawning escapement within non-target spawning areas in the Wenatchee Basin that was made up of Chiwawa hatchery Chinook has been high in some years and has exceeded the 10% threshold in most years. On average, the percent of the spawning escapement made up of Chiwawa hatchery Chinook was the highest in Nason Creek and the Upper Wenatchee River.
14. The supplementation program has not achieved its original goal of releasing 670,000 smolts per year. Since the beginning of the program, it has released on average about 231,348 smolts, which is about 34% of the original goal. The current goal is to release 298,000 smolts, which is a more appropriate goal.
15. The average lengths of smolts released have consistently been below the target of 176 mm. In most years, the average weight of the released smolts has been below the goal of 37.8 g. More realistic targets should be set based on the length-weight relationship specific to Chiwawa spring Chinook and the sizes of natural-origin smolts produced in the Chiwawa Basin (e.g., 94 mm).
16. There was a clear density-dependent relationship between numbers of spring Chinook spawners in the Chiwawa Basin and numbers of juveniles produced. The capacity of the Chiwawa Basin appears to average about 98,000 parr or about 55,000 yearling smolts. As spawner abundance exceeds 1,300 adult Chinook, density dependent mortality increases.

17. The effects of hatchery-origin spawners on juvenile productivity are equivocal. There was weak evidence that increasing the number of hatchery-origin spawners reduces juvenile productivity, but this cannot be proven at this time.
18. Chiwawa spring Chinook were harvested within the ocean and Columbia River fisheries with most of the harvest occurring within the Columbia River. The average number of Chiwawa spring Chinook harvested per year was 94 adults/year.
19. Assuming a total escapement of 1,470 adults (sufficient to meet the current broodstock collection goal and spawning escapement), only brood year 2001 produced an escapement large enough to support a terminal fishery.

Based on these findings, it is clear that the low abundance of adults has limited broodstock collection and smolt releases in most years. The low abundance of natural-origin returns has resulted in a high proportion of hatchery-origin fish in the broodstock and on spawning grounds, resulting in low PNIs (Hillman et al. 2011). In some of the early years, problems with the Chiwawa weir created significant problems for the program. However, these problems have been addressed and the collection of broodstock at the weir and at Tumwater Dam has improved. As long as adult returns remain low, the ability to meet broodstock collection and smolt release goals will remain a potential problem.

Although unfertilized egg-to-release survivals of hatchery fish have generally been high and exceeded the target of 81% (Hillman et al. 2011), the number and size of fish released has not met the original program goals. As noted above, the failure of the program to release the original target number of smolts (670,000) was related to limited adult returns. The reason why hatchery releases did not meet size goals is because the length and weight targets for the program were not based on the unique length-weight relationship of Chiwawa spring Chinook. If the goal is to release spring Chinook smolts at 37.8 g, then the fork length at release should be about 147 mm, not 176 mm. Even though the size goals for the program were not achieved, the productivity of these fish was over six times greater than the productivity of natural-origin fish. It is unknown if SARs and HRRs would increase if fish were released at the program goal of 176 mm. It is likely that releasing spring Chinook at a larger size will further decrease the age at maturity (i.e., increase the return of jacks and mini-jacks). Managers should consider matching the size of hatchery smolts released to those of natural-origin smolts (e.g., 94 mm).

Based on analysis of CWTs, Chiwawa spring Chinook appear to be exploited at low rates with most of the adults produced escaping to the upper Columbia Basin.[6] However, large numbers of these fish stray into non-target populations and spawning areas. On average, 36% of the brood returns strayed into non-target areas, exceeding the 5-10% target limits established for the program. This partly explains why the supplementation program has not significantly increased the total spawning escapement to the Chiwawa Basin. If all the returning fish had successfully homed to the Chiwawa Basin, the total spawning escapement would have increased compared to the reference populations. It is believed that including Wenatchee River source water to the Chiwawa acclimation ponds may have increased straying of Chiwawa spring Chinook. In 2006,

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[6] According to the DART PIT Tag Adult Returns Conversion Rate Report (http://www.cbr.washington.edu/dart/pit_obs_adult_conrate.html), between 10% and 21% of the natural-origin spring Chinook from the Wenatchee are lost between Bonneville and McNary dams. Between 13% and 27% of the hatchery-origin fish are lost between the two dams. It is unknown if these fish are harvested or lost because of other factors.

the source water to the ponds was converted to 100% Chiwawa River water. This should decrease the level of straying that was observed in the past. In addition, trapping operations at Tumwater Dam have been modified in order to ensure that delays and obstructions are within acceptable levels. These changes may also reduce stray rates.

Based on examination of allele frequencies, the supplementation program has not affected the genetic characteristics or effective population size of the population. In contrast, there were differences in phenotypic characteristics. For example, hatchery fish returned at an earlier age than natural-origin fish with more age-3 adults and fewer age-5 adults. Adult return timing was also slightly later for hatchery fish compared to natural-origin fish; however, both hatchery and natural-origin fish spawned at the same time. The spawning distribution of hatchery females was more concentrated near the release location. Thus, they were distributed more downstream than natural-origin females. Finally, there were differences in size-at-age between hatchery and natural-origin fish, but these differences are probably not significant biologically. Some of these phenotypic differences may be related to unintentional selective broodstock collection. On the other hand, differences in spawning distribution are the result of hatchery fish homing to the release location. It is unknown why hatchery fish returned at an earlier age than the natural-origin fish. This is a common outcome among hatchery programs and may be related to rapid growth rates in the hatchery and size at release.

Although the Chiwawa supplementation program demonstrated a full life-cycle survival advantage over natural-origin Chinook, there was no increase in NORs. In addition, productivity (NRRs) in the Chiwawa declined relative to reference populations. These observations existed even when NORs and NRRs were adjusted for density dependence. NRRs have exceeded 1.0 in only five of the last 16 complete brood years. Possible reasons why NORs have not increased and productivity has decreased include:

- *Poor Reproductive Success of Hatchery Spring Chinook*—Given the results from other RRS studies, the low PNI for this program, and the divergent life-history characteristics (e.g., younger age at maturity), it is likely that hatchery fish have reduced reproductive success. WDFW is currently evaluating the reproductive success of hatchery spring Chinook in the upper Wenatchee Basin (Murdoch et al. 2006, 2007, and 2008). Chelan PUD is also evaluating the potential benefits of different rearing strategies on the age at maturity of spring Chinook salmon.
- *Density Dependence*—Although we attempted to correct for density dependence through modeling, it is possible that the concentration of hatchery spawners in the lower half of the river, where habitat conditions for Chinook salmon are more limiting, could be reducing survival and productivity of natural-origin fish. That is, the saturation of habitat in the lower river with hatchery fish may be driving the overall productivity of the Chiwawa population.
- *Ecological Interactions*—With the large numbers of hatchery fish released in the upper Columbia Basin, it is possible that the survival and productivity of natural-origin fish have been reduced. The HETT is currently evaluating the effects of hatchery releases on non-target taxa of concern. In addition, it is possible that the supplementation program has increased the incidence of disease (e.g., BKD or Rs) in the naturally spawning population.

The low productivity of the natural spawning population and the low abundance of NORs are challenges for meeting supplementation objectives. These factors may be addressed by reducing the size of the hatchery program, establishing stock-specific size targets and growth rates, increasing PNI, collecting all broodstock at the Chiwawa weir, and distributing hatchery spawners more evenly throughout the Chiwawa Basin. With regard to the latter recommendation, it may be wise to maintain a partially segregated program by limiting the spawning of hatchery fish within the upper Chiwawa. This would provide a safety net if the productivity of the fish in the lower river crashes.

SECTION 6: WENATCHEE SUMMER CHINOOK

The goal of summer Chinook salmon supplementation in the Wenatchee Basin is to use artificial production to replace adult production lost because of mortality at Rock Island Dam, while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Adult summer Chinook are collected for broodstock from the run-at-large at the right and left-bank traps at Dryden Dam, and at Tumwater Dam if the weekly quotas cannot be achieved at Dryden Dam. The goal is to collect up to 492 adult natural-origin summer Chinook for the program. Broodstock collection occurs from about 7 July through 12 September with trapping occurring up to 24 hours per day, five days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook are transferred from the hatchery to Dryden Acclimation Pond in March. They are released from the pond in late April to early May.

The production goal for the Wenatchee summer Chinook supplementation program is to release 864,000 yearling smolts[7] into the Wenatchee River at ten fish per pound. Targets for fork length and weight are 176 mm (CV = 9.0) and 45.4 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2009, about 10,000 juvenile summer Chinook have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

6.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the summer Chinook supplementation program is to increase the number of spawners in the Wenatchee Basin. We tested the success of the supplementation program at increasing total spawners (both hatchery and natural-origin spawners) by analyzing trends and mean abundances before and during supplementation. We also compared trends and mean abundance of Wenatchee summer Chinook with a reference population (Deschutes fall Chinook). Appendix C describes in detail the methods we used for selecting reference populations.

We first examined the trends in abundances of summer Chinook spawners in the Wenatchee Basin before and during supplementation. Trend analysis indicated that before supplementation, the total number of spawners increased over time. During supplementation there was no apparent trend (i.e., there was no increase or decrease in abundance) (Figure 6.1). The change in trend before and during supplementation was not significant. When we compared the trends of the Wenatchee population with the reference population, we found that the trend in the reference population did not change during the period before the Wenatchee was supplemented, but it trended upward during the supplementation period (Figure 6.2). These analyses do not clearly indicate an increase in total spawning abundance in the Wenatchee following supplementation.

[7] The HCP Hatchery Committees recently agreed that Chelan PUD will release 318,000 summer Chinook smolts into the Wenatchee River.

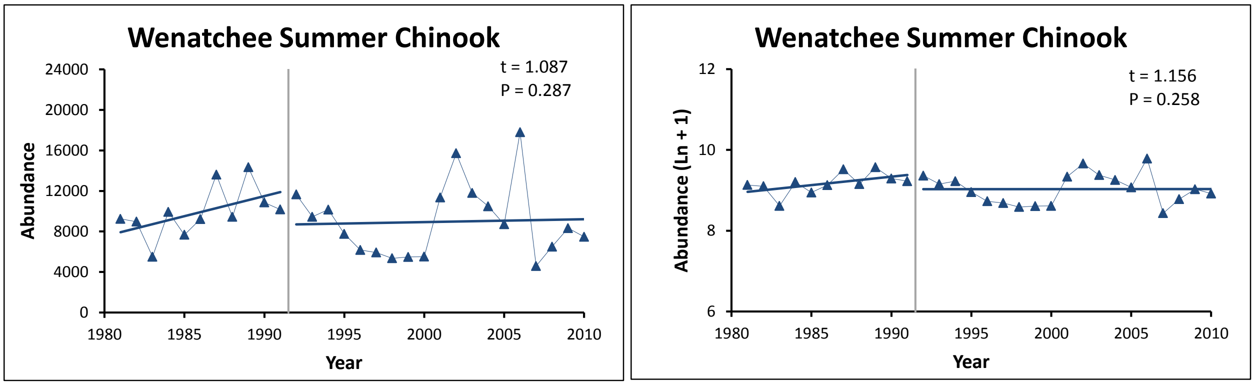


Figure 6.1. Trends in Wenatchee summer Chinook spawner abundance before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

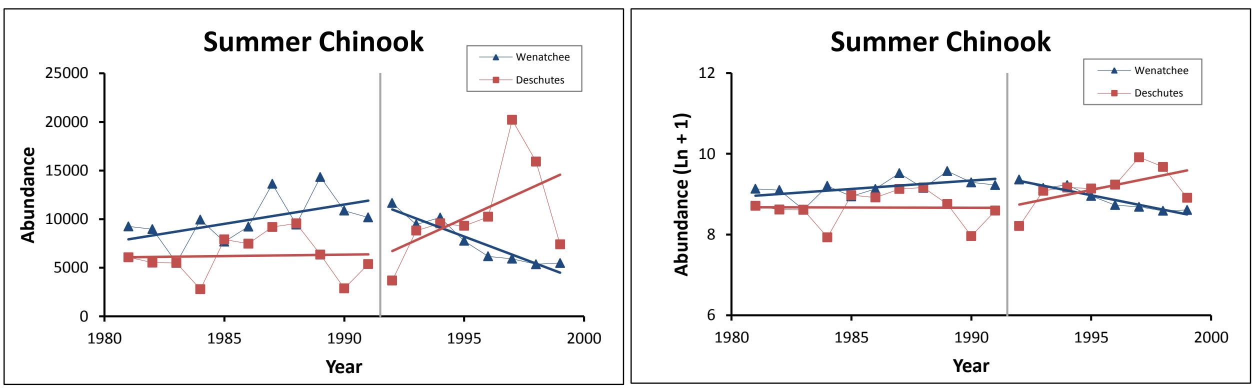


Figure 6.2. Trends in summer Chinook spawner abundance in the Wenatchee and reference population. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.

We then compared the mean spawner abundance before supplementation with the mean abundance during supplementation. Mean spawner abundance during the supplementation period was less than the pre-supplementation spawner abundance (Table 6.1). Although not significant, mean spawner abundance decreased 10% between the pre- and post-supplementation periods. When we compared the Wenatchee abundance with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase spawning abundance in the Wenatchee Basin (Table 6.2; Figure 6.3). The randomization test indicated a significant difference; however, the bootstrap CIs indicated that the difference was in the wrong direction. That is, compared to the reference population, spawner abundance decreased in the Wenatchee Basin during the supplementation period (Figure 6.3).

Table 6.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Wenatchee summer Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	9904	8956	0.854	0.401	0.407	-1107 – 3085
LN Abundance	9.2	9.0	1.209	0.237	0.239	-0.08 – 0.37
NORs	33,589	21,534	1.514	0.144	0.141	-2,578 – 27,065
LN NORs	10.3	9.6	2.467	0.023	0.023	0.20 – 1.27
Productivity	3.81	2.93	0.756	0.458	0.456	-1.24 – 3.11
LN Productivity	1.45	1.11	1.351	0.191	0.192	-0.13 – 0.80
Adj Productivity	5.97	3.88	1.460	0.159	0.162	-0.47 – 4.83
LN Adj Productivity	1.86	1.35	2.228	0.037	0.035	0.09 – 0.95

Table 6.2. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Deschutes	1.889	0.961	0.835	0.084	0.063 – 1.673
LN Spawner Abundance					
Deschutes	2.435	0.984	0.084	0.030	0.023 – 0.151

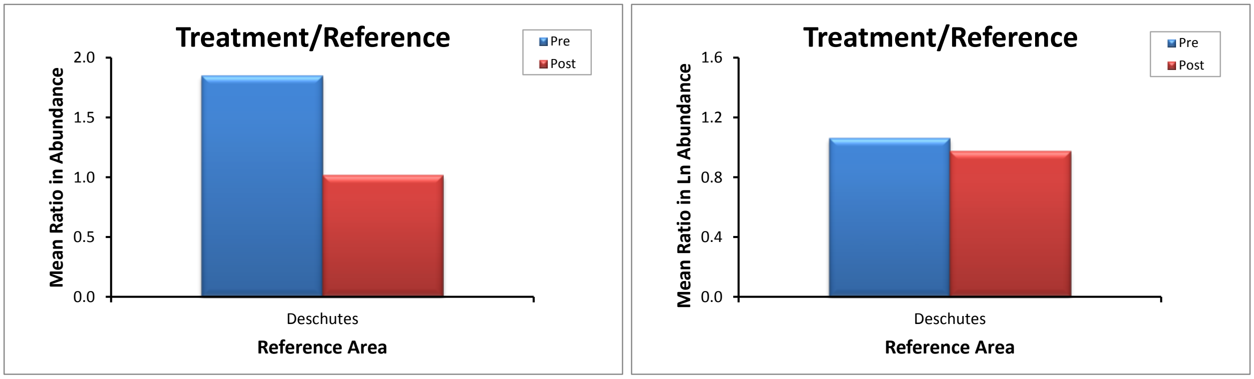


Figure 6.3. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance data before (pre) and after (post) summer Chinook supplementation in the Wenatchee Basin. Positive effects of supplementation on spawner abundance are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

As a final test of the effects of supplementation on total spawner abundance, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Excluding the first four years following the start of the supplementation program, when no hatchery fish had yet returned, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in 16 of the 17 years (Table 6.3).

Table 6.3. Numbers of natural-origin (NOB) and hatchery-origin (HOB) summer Chinook included in broodstock and numbers of hatchery-origin summer Chinook spawning naturally (HOS) in the Wenatchee Basin.

Brood year	NOB	HOB	Total Broodstock	HOS
1989	290	0	290	0
1990	57	0	57	0
1991	105	0	105	0
1992	274	0	274	0
1993	406	44	450	640
1994	333	54	387	1,776
1995	363	16	379	942
1996	263	3	266	177
1997	205	13	218	532
1998	299	78	377	1,349
1999	242	236	478	1,505
2000	275	180	455	1,131
2001	210	136	346	2,098
2002	409	10	419	4,032
2003	337	7	344	2,040
2004	424	2	426	1,394

Brood year	NOB	HOB	Total Broodstock	HOS
2005	397	3	400	1,841
2006	433	4	437	1,732
2007	263	3	266	1,417
2008	378	69	447	1,702
2009	452	8	460	1,214
Average	**305**	**41**	**347**	**1,215**

In summary, the supplementation program has not significantly increased the total number of spawners (hatchery and natural-origin spawners) within the Wenatchee Basin. This conclusion is based on comparing trends and mean abundances before and after supplementation, and comparing the supplemented population with a reference population.

Natural-Origin Recruits

Another important goal of the summer Chinook supplementation program is to increase the number of natural-origin recruits (NORs). We tested the success of the supplementation program in increasing NORs by analyzing trends and mean NORs before and during supplementation. We also compared trends and mean NORs of Wenatchee summer Chinook with a reference population (Deschutes population). In addition, because NORs can be affected by the capacity of the environment, we adjusted NORs for differences in carrying capacities between the Wenatchee and reference populations. We did this by calculating the percent saturation of NORs (Appendix C describes in detail the methods used to calculate percent saturation). Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before supplementation, NORs decreased over time (Figure 6.4). During the period of supplementation the trend reversed and increased over time. The change in trend before and during supplementation was significant. When we compared the trends of the Wenatchee population with the reference population, we found that the reference population also trended downward during the period before the Wenatchee was supplemented and, unlike the Wenatchee, trended downward during the supplementation period (Figure 6.5). This indicates that the change in trends in the Wenatchee population may have been the result of supplementation.

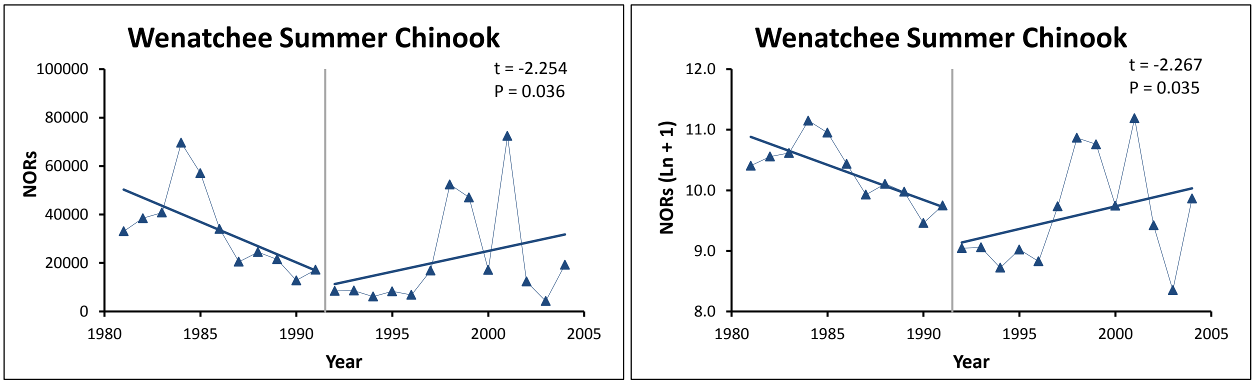


Figure 6.4. Trends in Wenatchee summer Chinook NORs before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

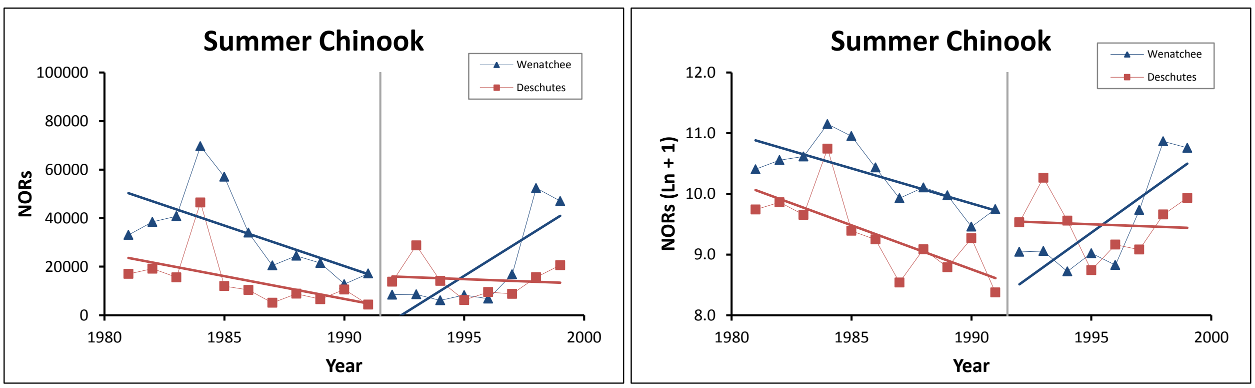


Figure 6.5. Trends in summer Chinook natural-origin recruits (NORs) in the Wenatchee and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.

We then compared mean summer Chinook NORs before supplementation with mean NORs during supplementation. Mean NORs decreased 36% between the pre- and post-supplementation periods (Table 6.1). When we compared Wenatchee NORs with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase NORs in the Wenatchee Basin (Table 6.4; Figure 6.6). The randomization test indicated a significant difference in the Deschutes-Wenatchee pairing, but the bootstrap CIs indicated that the difference was in the wrong direction. That is, compared to the reference population, mean NORs decreased in the Wenatchee Basin during the supplementation period (Figure 6.6).

Table 6.4. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test	Bootstrap 95% CI
	t-value	P-value	Effect size	P-value	
Natural-Origin Recruits					
Deschutes	2.906	0.995	1.482	0.011	0.578 – 2.435
LN Natural-Origin Recruits					
Deschutes	2.986	0.993	0.104	0.010	0.043 – 0.167

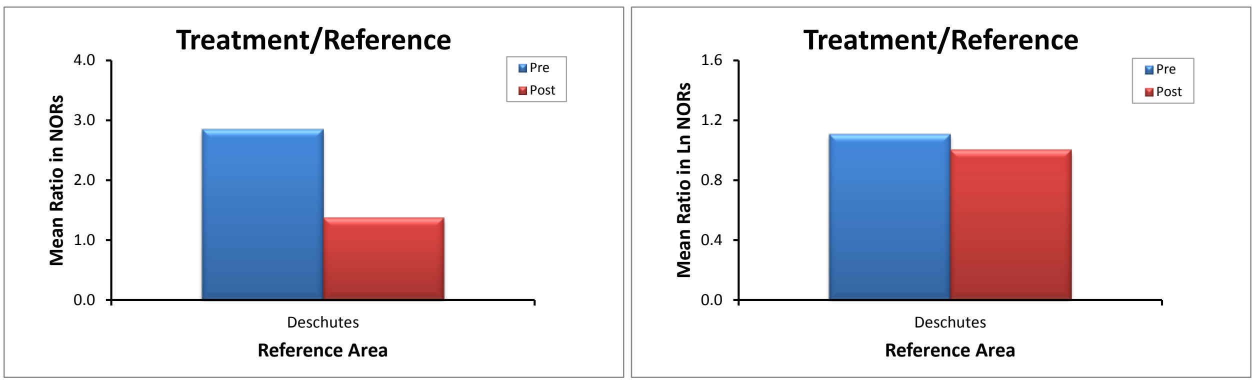


Figure 6.6. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) natural-origin recruits (NORs) data before (pre) and after (post) summer Chinook supplementation in the Wenatchee Basin. Positive effects of supplementation on NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

Next, we analyzed the effects of supplementation on filling the capacity of the habitat with NORs. The Ricker model derived the carrying capacity (K_R) estimates for the Wenatchee and reference populations. The mean fraction of the carrying capacity filled with Chinook NORs before and during supplementation for the Wenatchee and reference population is provided in Table 6.5. These data indicate that for the Wenatchee population, the mean fraction of the K_R filled with fish decreased from the pre-supplementation period through the supplementation period (Table 6.5). In contrast, the mean fraction of K_R in the reference population increased slightly during the same period (Table 6.5). Interestingly, the fraction of K_R filled with adult recruits for both populations trended downward during the pre-supplementation period (Figure 6.7). During the supplementation period, however, the fraction of K_R filled with adult recruits trended upward for the Wenatchee population, but not for the reference population.

Table 6.5. Statistical results comparing the fraction of the carrying capacity that was filled with Chinook NORs in the Wenatchee and reference population before and during supplementation of Wenatchee summer Chinook. The Ricker model estimated carrying capacity for each population.

Populations	Mean scores		Aspin-Welch test	
	Before	During	t-value	P-value
Wenatchee	1.36	0.87	1.513	0.144
Deschutes	1.03	1.06	-0.116	0.454

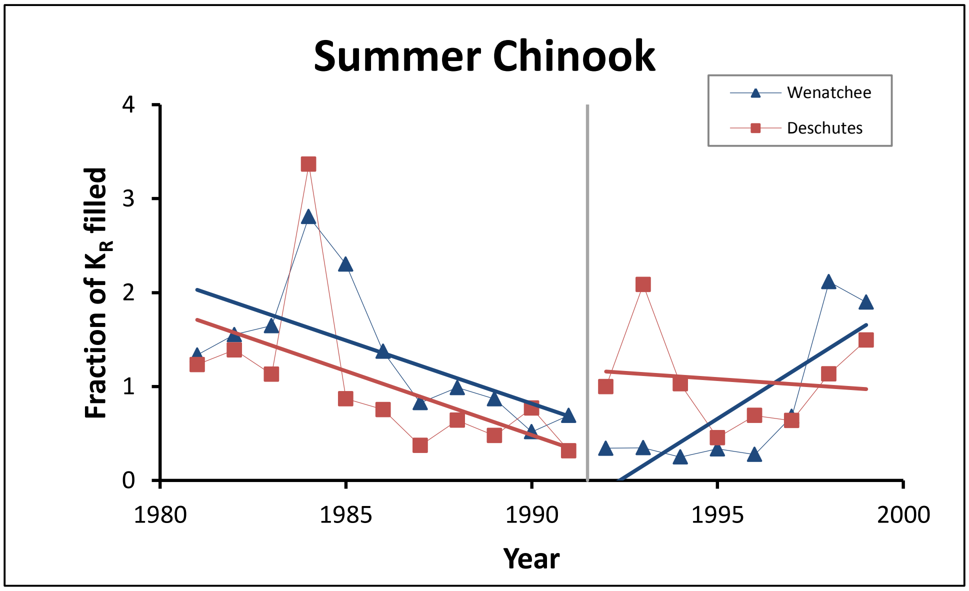


Figure 6.7. Trends in the fraction of the carrying capacity that was filled with Chinook salmon NORs in the Wenatchee and reference population before (pre) and during (post) supplementation in the Wenatchee Basin. The vertical line in the figure separates the pre- and post-supplementation periods. The Ricker model estimated carrying capacity for each population.

We then compared the mean ratios between the Wenatchee and reference populations before and during supplementation using data representing the fraction of K_R filled with adult recruits. Mean ratio scores were smaller during the supplementation period than during the pre-supplementation period (Figure 6.8). This indicated that the mean fraction of K_R filled by adult recruits in the reference population was greater during the supplementation period than during the pre-supplementation period (i.e., the denominator in the ratio increased between the pre- and post-supplementation periods). In contrast, the fraction of K_R filled by adult recruits in the Wenatchee decreased from the pre- to post-supplementation period (i.e., the numerator in the ratio decreased between the pre- and post-supplementation periods). Thus, unlike the Wenatchee population, the capacity of the reference population was becoming more saturated during the period when the Wenatchee was being supplemented. Statistical analysis with mean ratios indicated that the capacity of the Wenatchee did not fill significantly during the supplementation period compared to the reference population (Table 6.6).

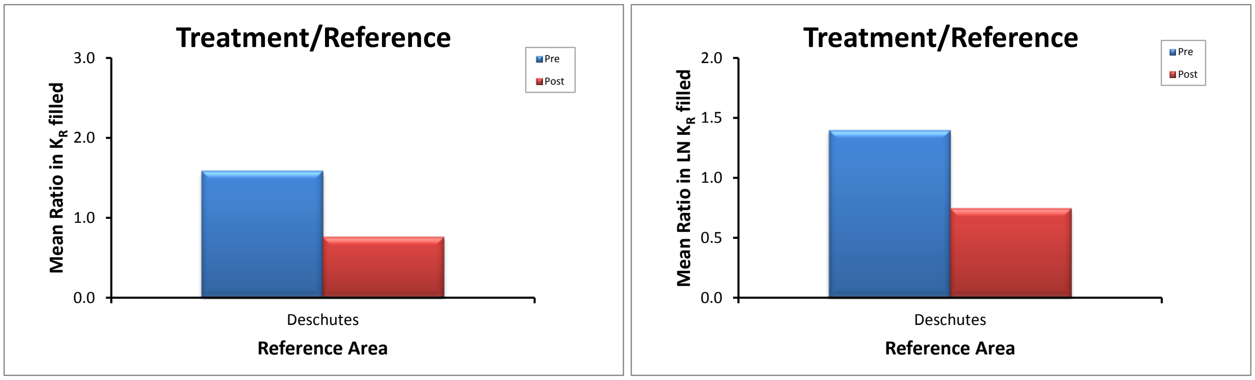


Figure 6.8. Mean ratios (Treatment/Reference) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) summer Chinook supplementation in the Wenatchee Basin.

Table 6.6. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with summer Chinook NORs. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Fraction of Capacity Filled					
Deschutes	2.906	0.995	0.825	0.012	0.304 – 1.373
LN Fraction of Capacity Filled					
Deschutes	3.175	0.997	0.651	0.008	0.268 – 1.035

Finally, we used Pearson correlation to test the association between pHOS and NORs. If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. During the pre-supplementation period, NORs averaged 33,589 adults; during the supplementation period, NORs averaged 21,534 adults. This 36% decrease in NORs was not associated with pHOS (Figure 6.9). Correlation analysis showed that there was no association between pHOS and NORs.

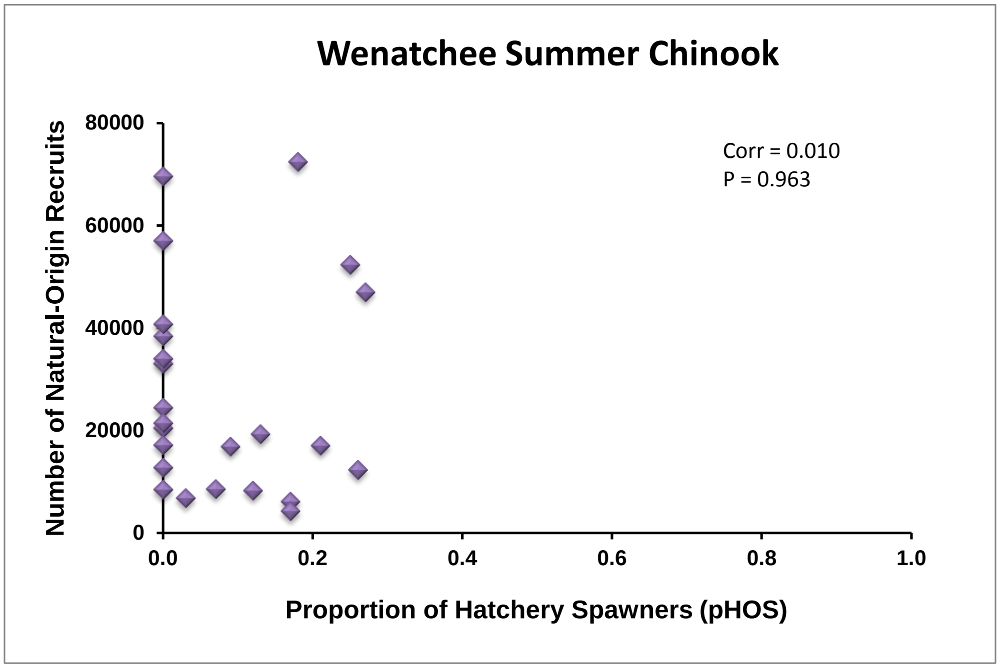


Figure 6.9. Association between the proportion of Wenatchee summer Chinook spawners that were made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, the supplementation program has not significantly increased NORs within the Wenatchee Basin. This conclusion is based on comparing trends and mean NORs before and after supplementation, and comparing the supplemented population with a reference population. It also includes comparing NORs adjusted for carrying capacity.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the supplementation program has reduced the productivity of summer Chinook in the Wenatchee Basin by analyzing trends and mean productivities before and during supplementation. We also compared trends and mean productivities of Wenatchee summer Chinook with a reference population (Deschutes population). In addition, because productivity can be affected by density (density-dependent effects), we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the stock-recruitment data.

Trend analysis indicated that before supplementation, productivity decreased over time; during supplementation the trend increased, even though there was large variability in productivity during the supplementation period (Figure 6.10). The change in trend before and during supplementation was significant. When we compared the trends of the Wenatchee population with the reference population, we found that the reference population also trended downward during the period before the Wenatchee was supplemented (Figure 6.11). During the period of supplementation, unlike the Wenatchee population, productivities in the reference population trended downward.

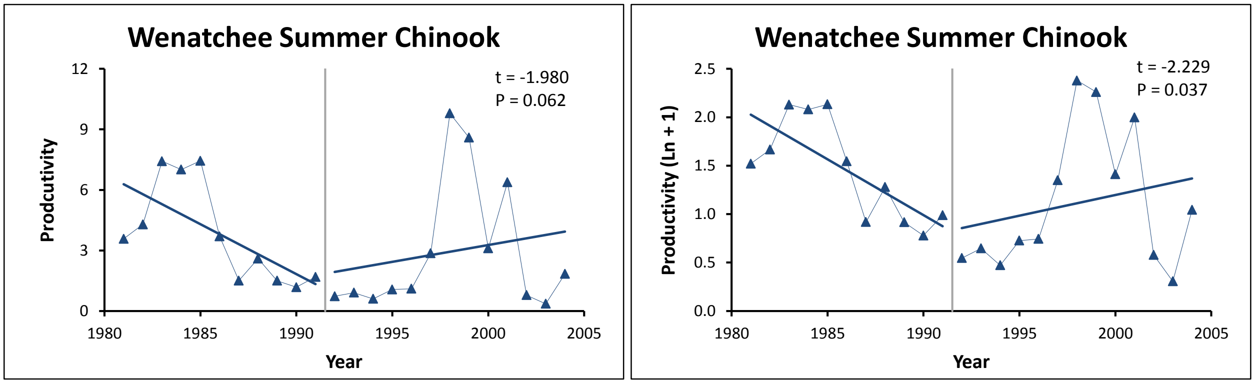


Figure 6.10. Trends in Wenatchee summer Chinook productivity (adult recruits/spawner; NRRs) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

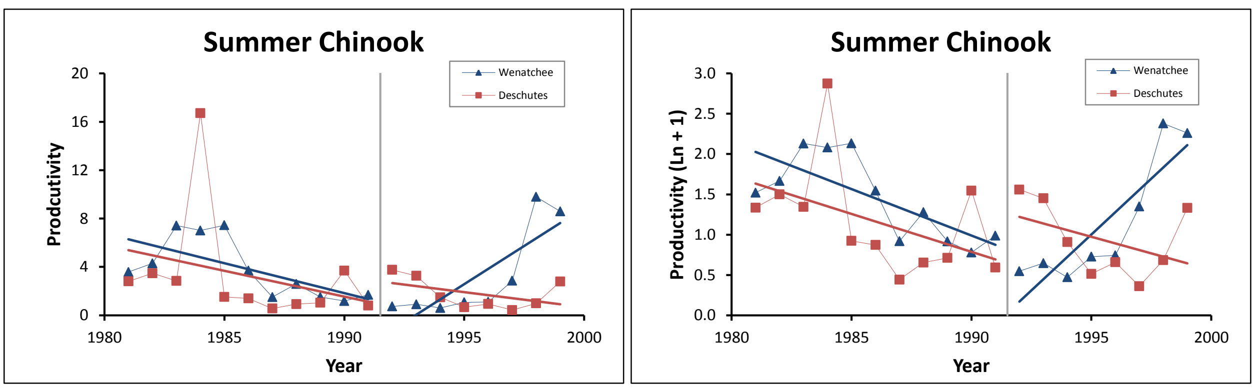
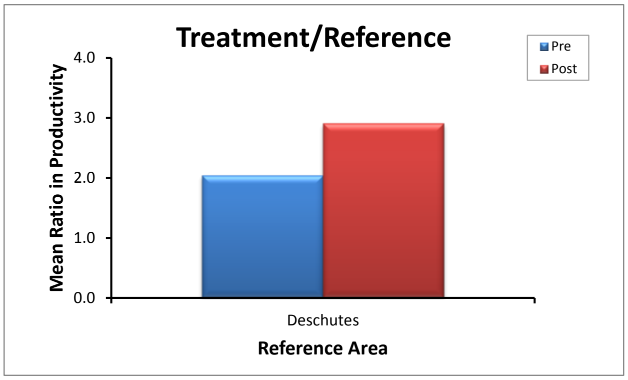


Figure 6.11. Trends in summer Chinook productivity (adult recruits/spawner) in the Wenatchee (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.

We then compared mean summer Chinook productivities before supplementation with productivities during supplementation. Mean productivities of Wenatchee summer Chinook decreased, but not significantly, between the pre- and post-supplementation periods (Table 6.1). When we compared Wenatchee productivities with the reference population using ratios (treatment/reference), we found that supplementation did not significantly decrease productivity in the Wenatchee Basin (Table 6.7; Figure 6.12).

Table 6.7. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	-0.656	0.735	0.863	0.549	-3.042 – 1.772
LN Productivity					
Deschutes	-0.257	0.598	0.129	0.791	-1.014 – 0.853



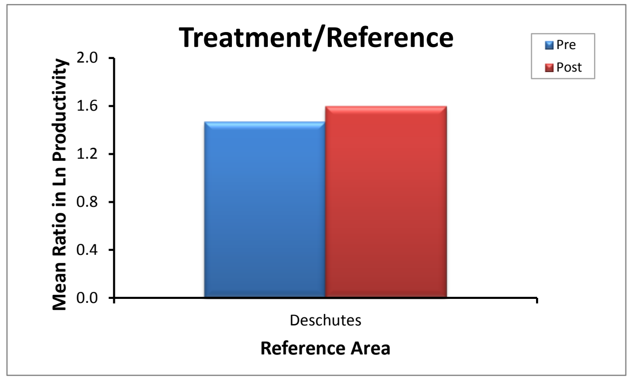


Figure 6.12. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) productivity (adult recruits/spawner; NRRs) data before (pre) and after (post) summer Chinook supplementation in the Wenatchee Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Next, we analyzed the effects of supplementation on productivities adjusted for density dependence. These analyses, based on ratios, indicated that supplementation significantly decreased productivity in the Wenatchee Basin (Table 6.8; Figure 6.13).

Table 6.8. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	1.940	0.035	1.387	0.070	0.074 – 2.737
LN Productivity					
Deschutes	2.226	0.020	0.631	0.045	0.096 – 1.147

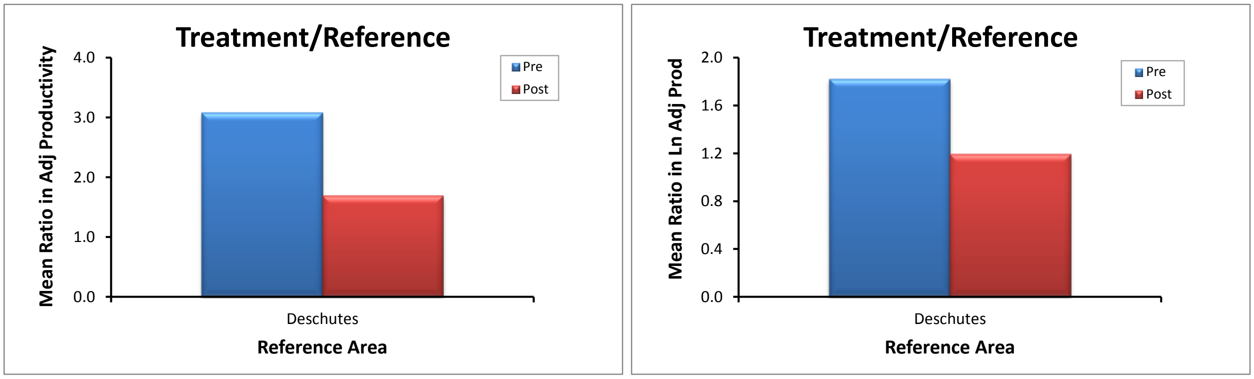


Figure 6.13. Mean ratios (Treatment/Reference) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) summer Chinook supplementation in the Wenatchee Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the Wenatchee summer Chinook stock and recruitment data. There was no association between pHOS and the residuals from the Ricker model, indicating that hatchery-origin spawners may be as productive as natural-origin spawners (Figure 6.14).

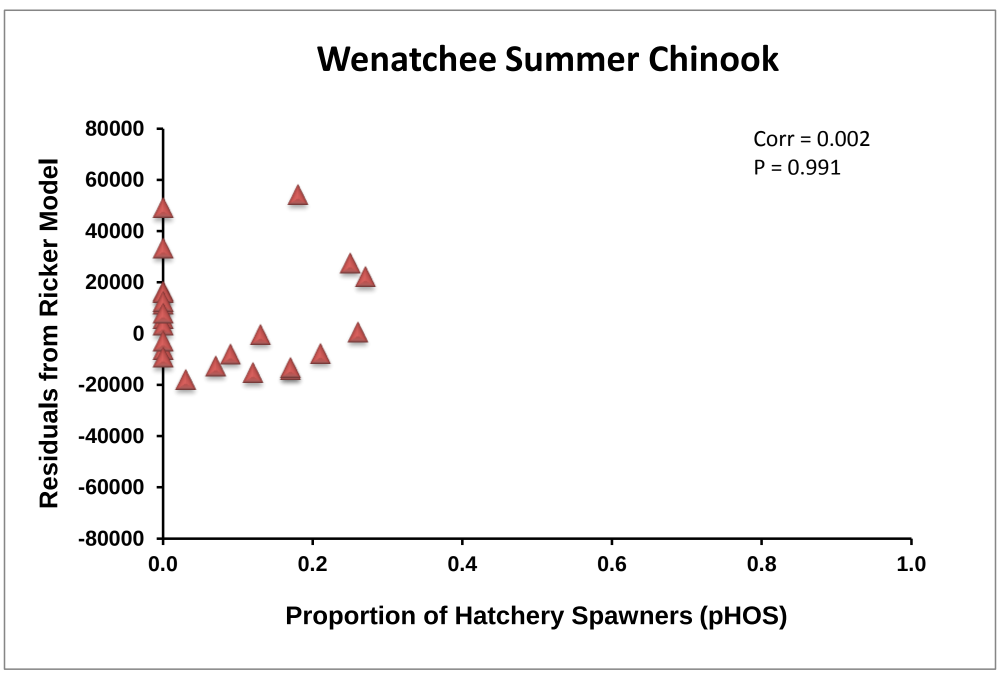


Figure 6.14. Association between the proportion of summer Chinook spawners in the Wenatchee Basin that are made up of hatchery adults (pHOS) and the residuals from the Ricker stock-recruitment model. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

In summary, most of the analyses above indicate that supplementation has not affected the productivity of the Wenatchee summer Chinook population. However, when productivities were adjusted for density dependence, there was evidence that the supplementation program may have negatively affected the productivity of the Wenatchee population.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. Analyses of the available data suggest that the Wenatchee summer Chinook supplementation program has not significantly increased the total spawning abundance and NORs in the Wenatchee Basin. Adjusting NORs for carrying capacity also indicated no apparent effect of supplementation on NORs. When compared to the reference population, the analyses indicated that the fraction of the environment filled with NORs in the Wenatchee Basin may have declined during the supplementation period. The decline in NORs in the Wenatchee Basin was not correlated with pHOS.

The effects of the supplementation program on productivity are equivocal. Most of the analyses indicated that the supplementation program has not negatively affected the productivity of Wenatchee summer Chinook. However, when we adjusted productivities for density dependence, the analysis suggested that the supplementation program may have reduced the productivity of the population. We interpret these results with caution, because stock size only explained about 5% of the variability in NORs and the estimated stock size at capacity was 5,647 adults, which was less than most of the spawning escapements within the Wenatchee Basin over the last 30 years (escapements ranged from 4,590-17,792). Thus, according to the Ricker model, which was the best fitting model, during most years the spawning escapement in the Wenatchee Basin has exceeded the capacity of the basin and therefore reduced productivities. At this time, it is not clear whether the supplementation program has reduced the productivity of the Wenatchee summer Chinook population.

6.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons using data collected during broodstock collection and stock assessment at Dryden Dam.

We compared cumulative frequency polygons of migration timing of hatchery and natural-origin summer Chinook collected or sampled at Dryden Dam during migration years 2007-2010 (Figure 6.15). Natural-origin fish migrated earlier than hatchery Chinook. The 10th percentile differed by about 13 days, the median (50th percentile) by 28 days, and the 90th percentile by 28 days.

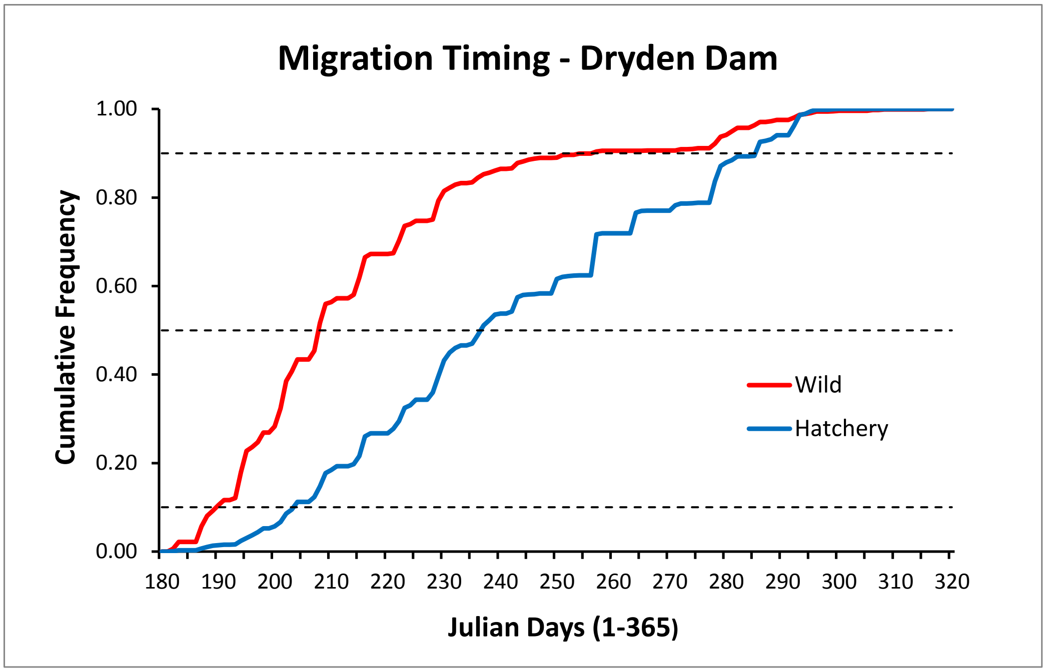


Figure 6.15. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Wenatchee summer Chinook sampled or collected at Dryden Dam. Migration timing was based on stock assessments and broodstock collection at Dryden Dam during 2007-2010 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 1,666 wild and 1,230 hatchery Chinook.

We also compared the mean migration timing of hatchery and natural-origin summer Chinook by comparing the mean Julian date that 10%, 50%, and 90% of the fish passed Dryden Dam. These data were based on stock assessment and broodstock collection at Dryden Dam during the migration period 2007-2010. Based on four years of sampling, there was a significant difference in the migration timing of hatchery and natural-origin summer Chinook sampled at Dryden Dam (Table 6.9). At most, the average difference in migration timing between hatchery and natural-origin fish was 28 days. That is, based on these data, 50% of the natural-origin fish passed Dryden Dam about 28 days before 50% of the hatchery fish passed the dam.

Table 6.9. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date that hatchery and natural-origin (wild) summer Chinook migrated past Dryden Dam during the period 2007-2010 (N = 4 years). Migration timing was based on stock assessment and broodstock collection at Dryden Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	196	209	210	238	261	274	217	241
Effect size	13		28		13		24	
t-value	4.088		3.883		2.134		6.303	
P-value	0.026		0.030		0.123		0.008	
Bootstrap CI	8 – 18		15 – 40		1 – 24		19 – 31	
Power	0.118		0.138		0.214		0.127	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin summer Chinook should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We tested differences in spawn timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons of the time when female carcasses were recovered on the spawning grounds.

There was little difference in spawn timing of hatchery and natural-origin summer Chinook in the Wenatchee Basin (Figure 6.16). On average, natural-origin Chinook began spawning about two-three days earlier than hatchery Chinook.

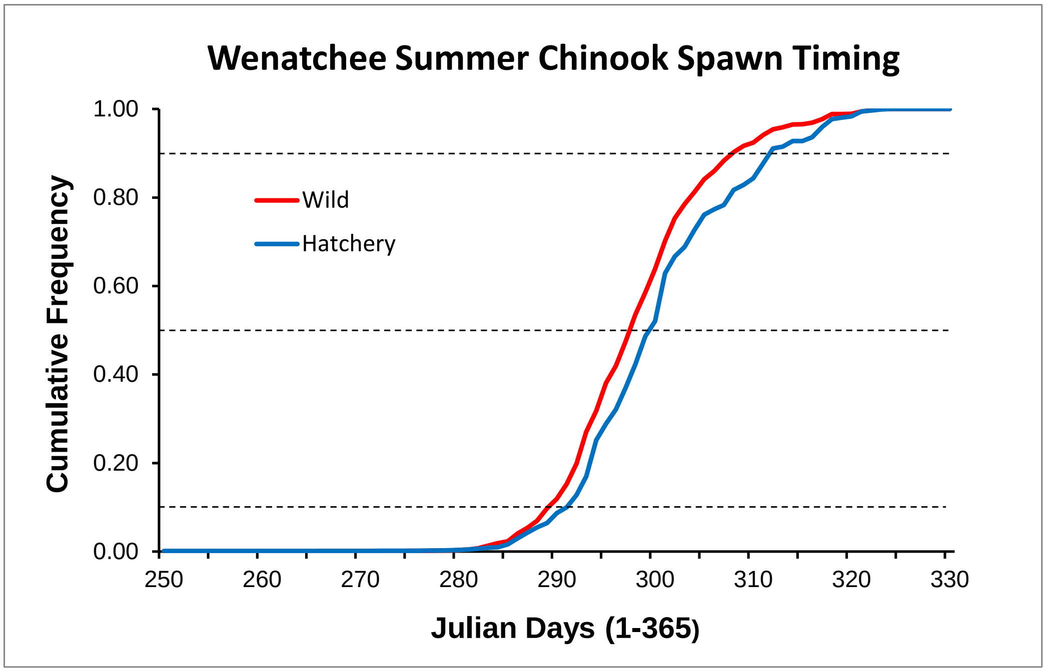


Figure 6.16. Cumulative frequency polygon of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Wenatchee Basin. Spawn timing was based on the Julian date that female carcasses were recovered on the spawning grounds. Sample sizes = 11,381 wild and 2,988 hatchery Chinook.

We also compared the mean spawn timing of hatchery and natural-origin summer Chinook by comparing the mean Julian data that 10%, 50%, and 90% of the female carcasses were recovered on the spawning grounds. Based on 18 years of sampling, natural-origin Chinook spawned significantly earlier than hatchery fish (Table 6.10). However, the difference in spawning timing was on average only two days.

Table 6.10. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Wenatchee River during the period 1993-2010 (n = 18 years).

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	291	293	299	301	306	309	299	301
Effect size	2		2		2		2	
t-value	2.719		3.693		2.324		4.208	
P-value	0.015		0.002		0.033		0.001	
Bootstrap CI	0.5 – 3.3		1.3 – 4.2		0.1 – 3.1		0.9 – 2.4	
Power	0.007		0.001		0.003		0.001	

Because spawning generally progresses from higher elevations to lower elevations, we examined the relationship between elevation and spawn timing of hatchery and natural-origin summer Chinook within the Wenatchee River. We found little difference in the spawn time of hatchery and natural-origin Chinook across the range of spawning elevations within the Wenatchee River (Figure 6.17). In general, both hatchery and natural-origin Chinook spawned at about the same time across the range of elevations within the Wenatchee River. The trend lines in Figure 6.17 indicate that spawning of both hatchery and natural-origin Chinook progressed from higher elevations to lower elevations.

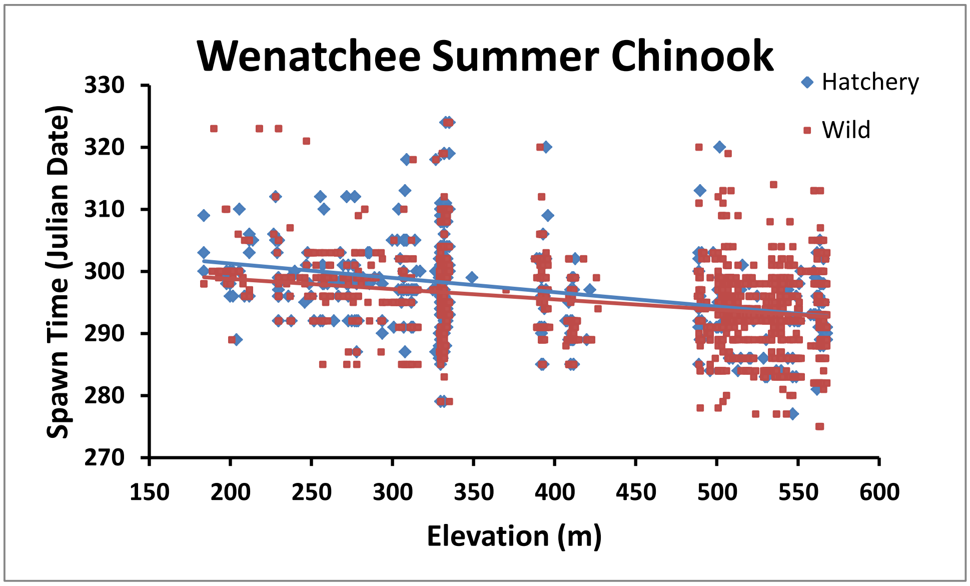


Figure 6.17. Relationship between elevation and spawn timing of hatchery and natural-origin (wild) summer Chinook spawners within the Wenatchee River.

Redd Distribution

Finally, under a fully integrated program, both hatchery and natural-origin summer Chinook should spawn in the same location. We evaluated differences in spawning locations at two different spatial scales; at the historic reach scale and at the 0.5 km scale.

Both hatchery and natural-origin Chinook spawned throughout the Wenatchee River (including Icicle Creek). However, there was a significant difference in the distribution of hatchery and natural-origin spawners among the historic sampling reaches (Yates' Chi-square = 1,657.7; P = 0.000). A greater percentage of hatchery-origin Chinook spawned in the lower reaches (W1-W6; mouth to Icicle Road Bridge) than did natural-origin fish (Figure 6.18). The opposite occurred in the upper reaches where a greater percentage of natural-origin Chinook spawned. This pattern was most obvious when we compared the spawning distribution at the 0.5 km scale (Figure 6.19). Larger percentages of hatchery-origin Chinook spawned in the lower 43 km of the river than in the upper 44 km. In contrast, larger percentages of natural-origin Chinook spawned in the upper 44 km of the river than in the lower 43 km.

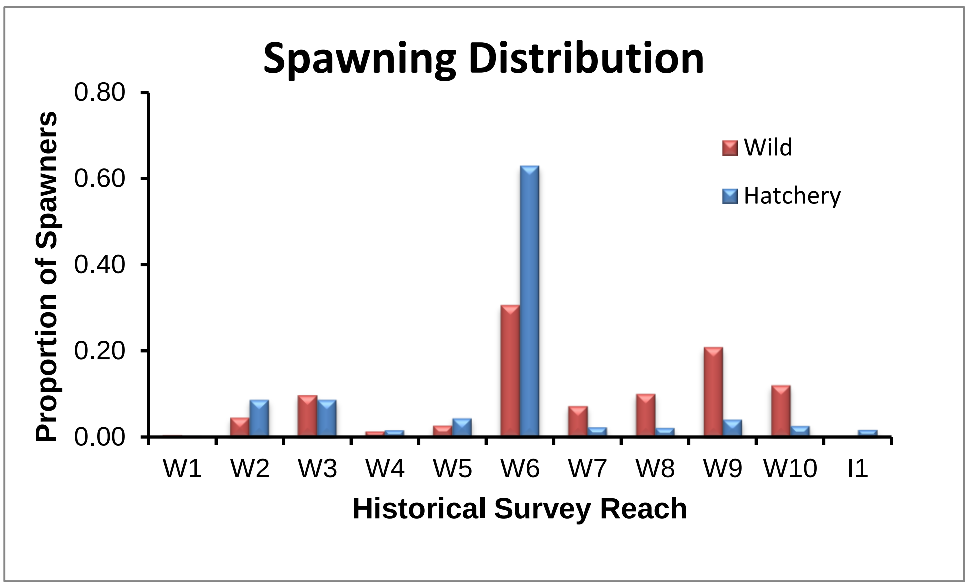


Figure 6.18. Proportion of hatchery and natural-origin summer Chinook spawners distributed among the 11 historic sampling reaches on the Wenatchee River and Icicle Creek. W1 is from 0.0-5.3 km; W2 5.3-15.3; W3 15.3-28.6; W4 28.6-32.2; W5 32.2-38.5; W6 38.5-42.5; W7 42.5-49.7; W8 49.7-57.3; W9 57.3-77.1; W10 77.1-87.2; and Icicle (I1) 1.0-6.4. Sample sizes = 3,371 wild and 965 hatchery Chinook.

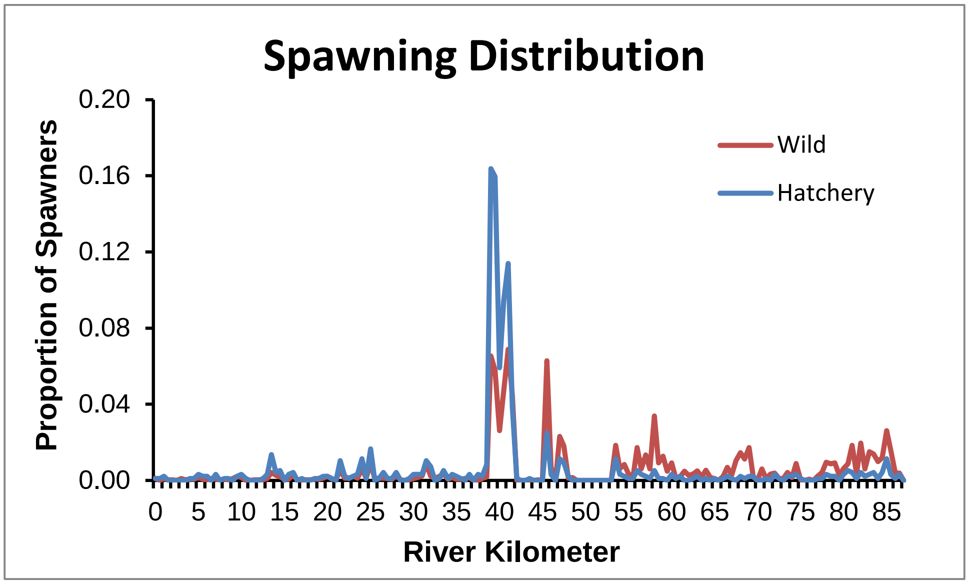


Figure 6.19. Proportion of hatchery and natural-origin summer Chinook spawners distributed along the length of the Wenatchee River. Distribution was based on 0.5-km long reaches. Sample sizes = 3,371 wild and 965 hatchery Chinook.

Conclusions

Based on sampling at Dryden Dam, hatchery and natural-origin summer Chinook had different migration timings at Dryden Dam, with natural-origin fish migrating about 28 days earlier than hatchery-origin fish. Because this was based on broodstock collection and stock assessment sampling, it is possible that the difference in migration timing may be in part related to the sampling process, which did not occur every day during the migration period. In addition, fish collected at Dryden Dam were not sampled randomly. Importantly, spawn timing differed by only two days, with natural-origin fish spawning before hatchery fish. Although the difference in spawn timing was significant statistically, it is probably not significant biologically.

The distribution of hatchery and natural-origin summer Chinook spawners in the Wenatchee River differed significantly. A higher proportion of hatchery-origin Chinook spawned in the lower river, while a higher proportion of natural-origin Chinook spawned in the upper river. This difference in distribution is likely a result of the acclimation pond located in the lower river.

6.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix I). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall-run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin summer Chinook in the Wenatchee Basin. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin summer Chinook differed significantly. Because of different age-at-migration characteristics, we evaluated male and female Chinook separately.

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook. Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

The salt-age at maturity differed significantly between hatchery and natural-origin female (Yates' Chi-square = 187.3; P = 0.000; Effect Size = 0.110) and male summer Chinook (Yates' Chi-square = 255.7; P = 0.000; Effect Size = 0.135) (Figure 6.20). Most female and male Chinook returned as 3-salt fish. However, a larger percentage of hatchery fish returned as 1, 2, and 3-salt fish, while a larger percentage of natural-origin Chinook returned as 4 and 5 salt-fish.

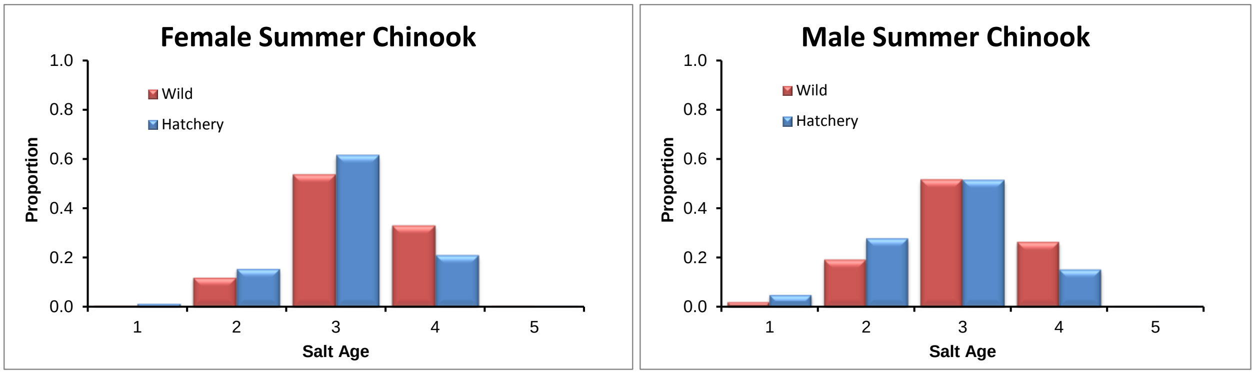


Figure 6.20. Proportion of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Dryden Dam and sampled on spawning grounds in the Wenatchee Basin for the combined years 1993-2009. Sample sizes for females = 12,828 wild and 3,020 hatchery Chinook and for males = 11,367 wild and 2,614 hatchery Chinook.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin summer Chinook. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin Chinook of the same age. We used three-way ANOVA to test differences in sizes of hatchery and natural-origin fish.

Because hatchery and natural-origin summer Chinook out-migrate at different ages, we analyzed differences in sizes at salt age. The size at salt age differed significantly between hatchery and natural-origin female and male summer Chinook (Table 6.11; Figure 6.21). The significant three-way interaction term indicated that differences in sizes between hatchery and natural-origin Chinook were affected by salt age and sex. Female Chinook were significantly larger than males, and natural-origin fish were larger than hatchery Chinook. Natural-origin Chinook were significantly larger than hatchery Chinook across all salt-age classes (Figure 6.21). Female natural-origin Chinook were on average 2-4 cm larger than hatchery fish. Male natural-origin Chinook were on average 1-4 cm larger than hatchery fish.

Table 6.11. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Wenatchee summer Chinook. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Salt Age (1, 2, 3, 4, and 5), resulting in a 2 x 2 x 5 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	26,465.65	398.94	0.000	
Origin	1	9,282.47	139.92	0.000	
Sex x Origin	1	1,736.89	26.18	0.000	
Age	4	15,552.88	234.44	0.000	
Sex x Age	4	6,474.57	97.60	0.000	
Origin x Age	4	436.72	6.58	0.000	
Sex x Origin x Age	4	256.26	3.86	0.004	
Error	27,385				

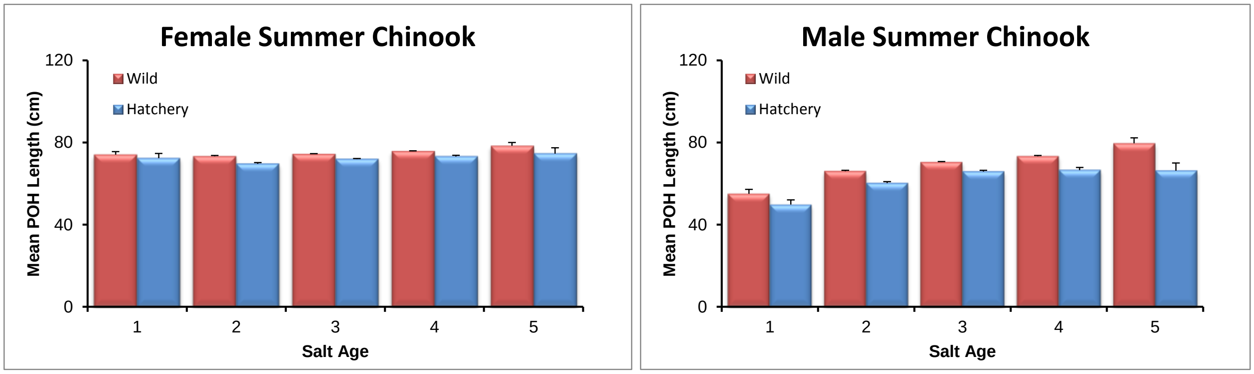


Figure 6.21. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Dryden Dam and sampled on spawning grounds in the Wenatchee Basin for the combined years 1993-2009. Sample sizes for females = 11,452 wild and 2,959 hatchery Chinook and for males = 10,496 wild and 2,540 hatchery Chinook.

Conclusions

Genetic analyses indicated that the supplementation program has not affected the genetic structure of the Wenatchee summer Chinook population. There was no significant difference between hatchery-origin and natural-origin summer Chinook. In addition, there was no evidence that the supplementation program has reduced the effective population size of the Wenatchee summer Chinook population.

Although there were no significant genetic differences between hatchery and natural-origin summer Chinook, there were significant differences between the two groups in age at maturity and size at maturity. Analysis of age at maturity, based on salt age, indicated that natural-origin Chinook matured later than hatchery fish. In addition, natural-origin fish were larger than hatchery fish across all salt-age groups. The differences in size at maturity are probably not significant biologically.

6.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.3 (the calculated target value in Murdoch and Peven 2005).

In most years HRRs were greater than NRRs, regardless if harvest was or was not included (Figure 6.22). However, the number of years that HRRs exceeded NRRs was not significant when harvest was or was not included in the analysis (paired-sample sign test; P = 0.059 for analyses with and without harvest). HRRs exceeded the estimated target value of 5.3 in three out of the 15 years when harvest was not included and six of the 15 years when harvest was included in the analyses (Figure 6.22). Based on the one-sample sign test, the number of times HRRs exceeded the target value was not significant (with harvest included, P = 0.849; without harvest included, P = 0.996).

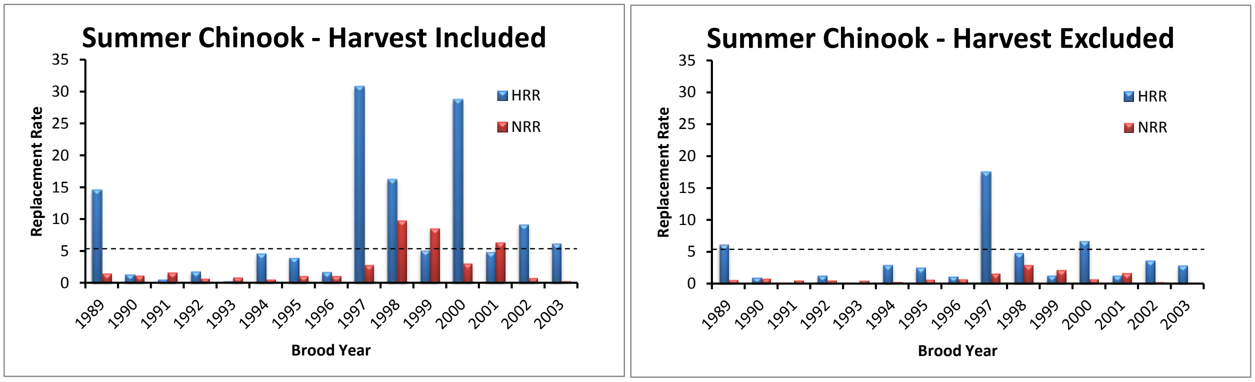


Figure 6.22. Natural and hatchery replacement rates (NRR and HRR, respectively) for Wenatchee summer Chinook, brood years 1989-2003. Figure on the left includes harvested fish; figure on the right does not. The horizontal dashed line represents the target value of 5.3 in Murdoch and Peven (2005).

Conclusions

The Wenatchee summer Chinook supplementation program has demonstrated a significant full life-cycle survival advantage over natural-origin Chinook with a productivity advantage of over 3:1. That is, on average, HRRs were nearly three times greater than NRRs. This was true regardless if harvested fish were included in the analyses.

6.5 Stray Rates

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. Less than 5% of the brood returns should stray into non-target areas. In addition, hatchery strays from the Wenatchee program should make up less than 5% of the spawning escapement within non-target spawning areas outside the basin and less than 10% of the spawning escapement within non-target spawning areas within the basin. Because the Wenatchee population does not have a well-defined within population structure, we did not evaluate within population straying.

Among Population Stray Rates by Brood Return

Based on brood year analyses, on average, about 11% of the hatchery returns have strayed into non-target spawning streams, exceeding the target of 5% (Figure 6.23). The number of years that hatchery summer Chinook exceeded the target of 5% was not significant (Sign test, P = 0.402). However, during the last nine complete brood years, more than 5% of the brood returns have strayed into non-target streams. During that nine year period, percent strays into non-target spawning areas have ranged from 7-19%. Prior to brood year 1996, 7-34% of the brood returns were included in non-target hatchery programs. Since then, few Chinook have been included in non-target hatchery programs.

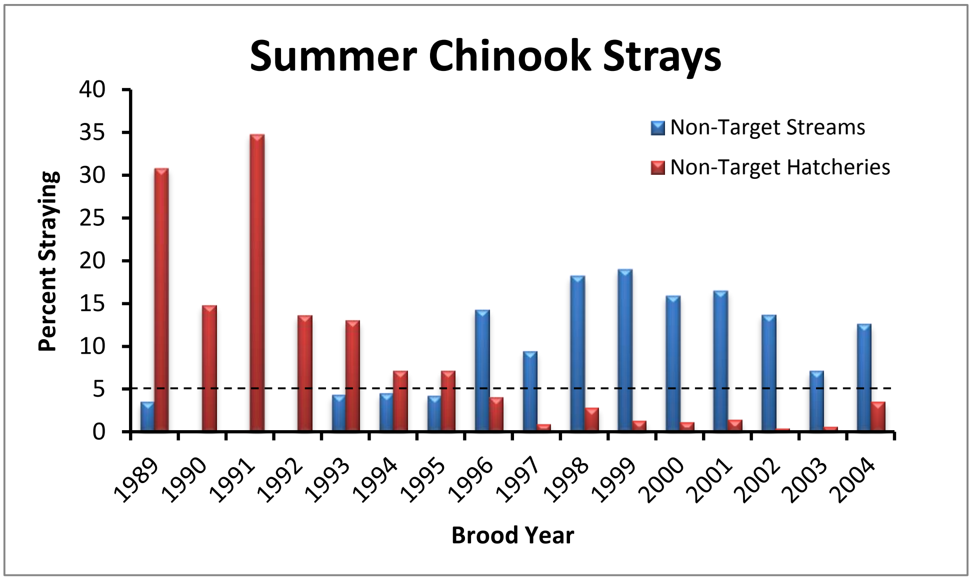


Figure 6.23. Percent of hatchery-origin Wenatchee summer Chinook that strayed to non-target spawning streams and non-target hatchery programs, by brood years 1989-2004. Percent strays should be less than 5% (represented by the horizontal dashed line).

Among Population Stray Rates by Return Year

Hatchery-origin Wenatchee summer Chinook have strayed into the Entiat, Chelan, Methow, and Okanogan basins and into the Hanford Reach (Figure 6.24). In four different years, Wenatchee summer Chinook strays have made up more than 5% of the spawning escapement in the Entiat Basin and Chelan Tailrace. They have made up more than 5% of the spawning escapement in the Methow Basin in five different years. Few have strayed into the Okanogan Basin or into the Hanford Reach.

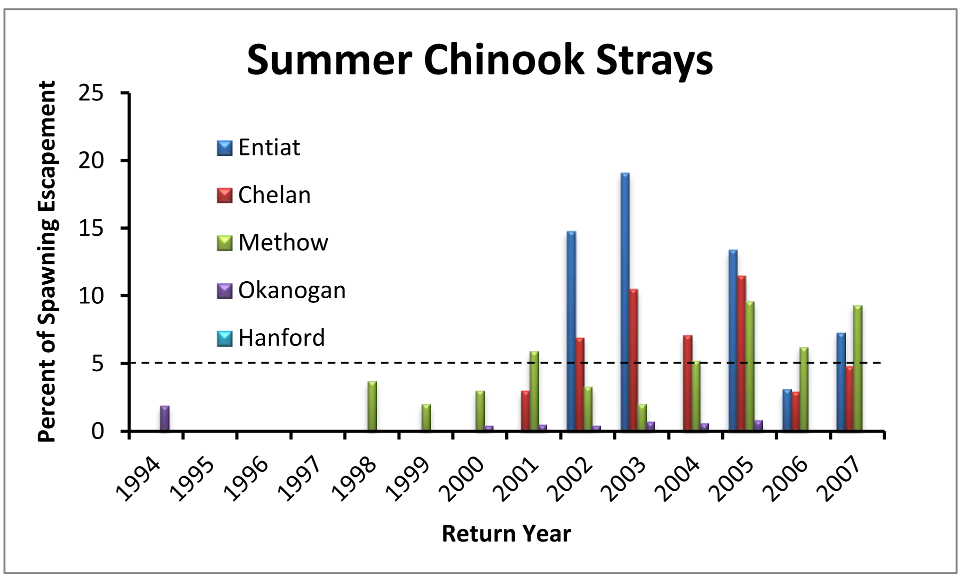


Figure 6.24. Percent of the spawning escapement within non-target spawning populations that are made up of Wenatchee hatchery Chinook, by return years 1994-2007. Percentages should be less than 5% (represented by the horizontal dashed line).

Conclusions

Stray rates of hatchery summer Chinook have been high in some years. On average, about 11% of the brood year returns have strayed into other spawning areas. Since 1996, every brood year return has exceeded the 5% threshold. Hatchery summer Chinook have strayed into the Entiat, Chelan, Methow, and Okanogan basins and into the Hanford Reach. Most have strayed into the Entiat, Chelan, and Methow basins, and in some years made up more than 5% of the spawning escapement within those basins. Few Wenatchee summer Chinook have strayed into the Okanogan Basin or into the Hanford Reach.

The stray rate of Wenatchee hatchery summer Chinook appears in part related to the number of hatchery fish released. That is, larger smolt releases resulted in higher stray rates. This relationship explained about 27% of the variability in stray rates.

6.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the Wenatchee summer Chinook supplementation program is to release smolts that average at least 176 mm long (fork length) and 45.4 g. Since the beginning of the supplementation program, the average size of summer Chinook released has consistently been below the length target (Figure 6.25). Over brood years 1989-2008, lengths have averaged about 86% of the target length. In contrast, weight has met or exceeded the target in five of the 20 years and averaged about 88% of the supplementation goal (Figure 6.25).

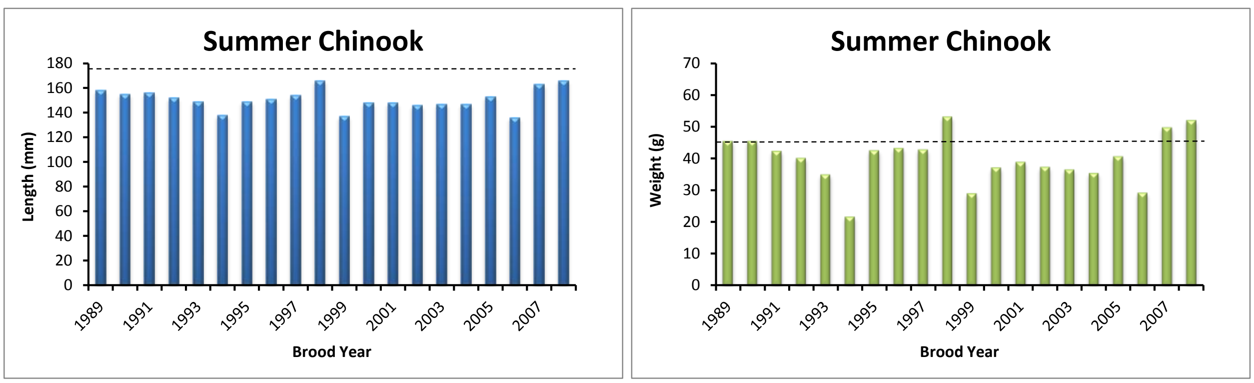


Figure 6.25. Average lengths (mm) and weights (g) of summer Chinook salmon released into the Wenatchee River for brood years 1989-2008. The dashed horizontal lines represent the target length (176 mm) and target weight (45.4 g).

The length and weight targets for the Wenatchee summer Chinook hatchery program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Wenatchee summer Chinook based on data collected within the hatchery over a five-year period (Figure 6.26). Based on this relationship, if the target is to release smolts at 176 mm, then the target weight of the smolts should be 56.0 g, not 45.4 g. On the other hand, if the goal is to release smolts that weigh 45.4 g, then the fork length at release should be 164 mm, not 176 mm.

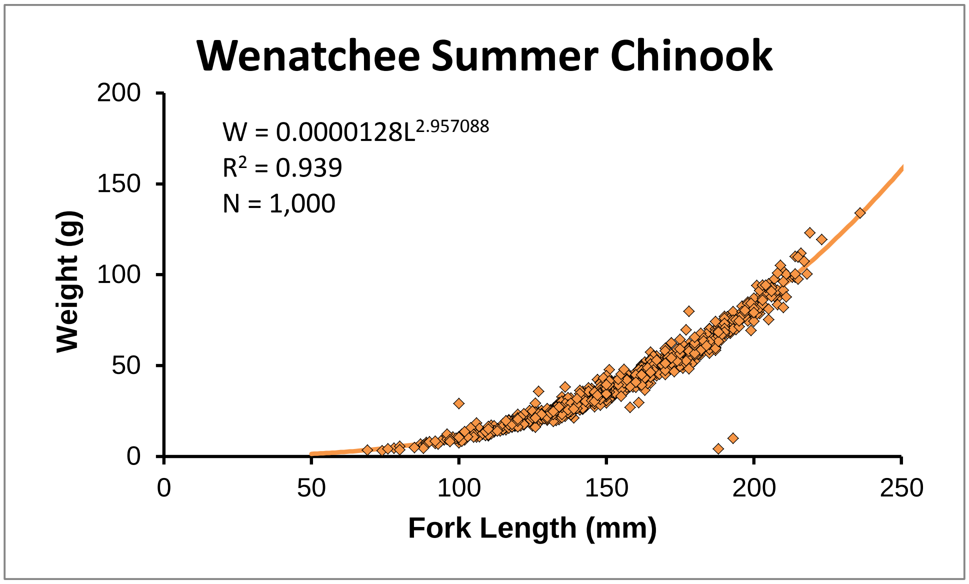


Figure 6.26. Relationship between fork length (mm) and weight (g) of juvenile Wenatchee summer Chinook salmon sampled in the hatchery during 2003-2007.

Number of Hatchery Fish Released

The goal of the Wenatchee summer Chinook supplementation program is to release 864,000 summer Chinook smolts into the Wenatchee River. The program reached or exceeded the goal of releasing 864,000 smolts in six of the 20 years (Figure 6.27). Over the 1989-2008 brood years, the program released an average of 679,932 smolts, which is about 79% of the original program goal.

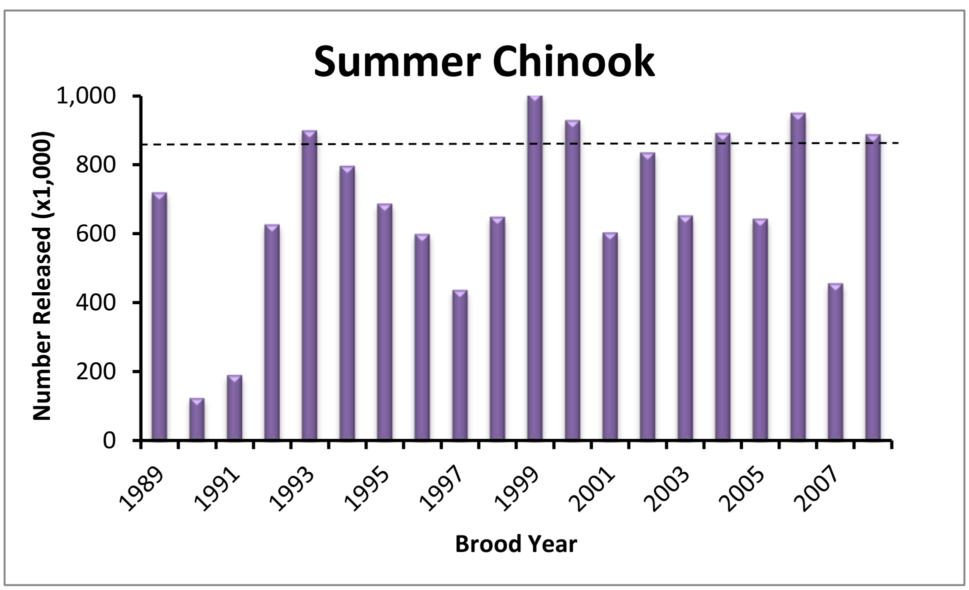


Figure 6.27. Number of summer Chinook smolts released into the Wenatchee River for brood years 1989-2008. The dashed horizontal line represents the target release number (864,000 smolts).

Conclusions

The Wenatchee summer Chinook supplementation program has not consistently achieved its goal of releasing 864,000 fish per year. Since the beginning of the program, it has released on average about 680,000 smolts, which is about 79% of the goal. This is in part because of a lack of broodstock available early in the supplementation program and because of relatively low unfertilized-egg to eyed-egg survival. The unfertilized-egg to eyed-egg survival has averaged 85% (standard = 92%). The reduction in the size of the program to 318,000 smolts should help the program achieve its release goal.

The size of summer Chinook smolts released into the Wenatchee River has been below the size goals for the program. Average lengths of smolts released have consistently been below the threshold of 176 mm. In addition, in most years, the average weight of the released smolts has been below the goal of 45.4 g. Because of the unique relationship between length and weight of Wenatchee summer Chinook, the current program cannot achieve both the length and weight targets. More realistic targets should be set based on the length-weight relationship specific to this population.

6.7 Freshwater Productivity

Juvenile Productivity

Because we were unable to find reference populations for juvenile productivity for Wenatchee summer Chinook, and there are no pre-supplementation juvenile data, we used stock-recruitment models to assess the productivity and capacity of the Wenatchee summer Chinook population. Here, we define recruitment as the number of natural-origin subyearling migrants produced in the basin. We also compared the number of migrants/spawner to pHOS, and the residuals from the stock-recruitment curves to pHOS. If there is a negative association between pHOS and the productivity of juveniles (or residuals from the stock-recruitment curve), then the hatchery fish may be reducing the productivity of juvenile summer Chinook in the Wenatchee Basin.

There was a significant, density-independent relationship between numbers of spawners and numbers of subyearling migrants (Figure 6.28; Table 6.12). Accordingly, we were unable to estimate the mean capacity of the Wenatchee Basin. The lack of a relationship between numbers of spawners and juveniles/spawner indicates that the population has not reached a spawning escapement at which spawning or incubation habitat limits the production of juvenile summer Chinook (Figure 6.29).

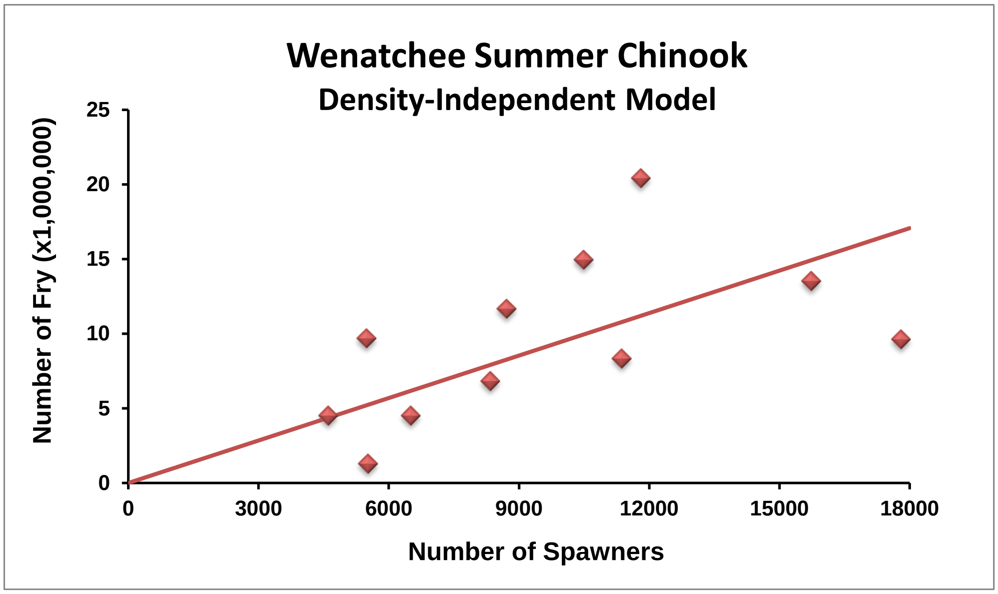


Figure 6.28. Relationship between number of spawners and numbers of subyearling migrant (1999-2009) summer Chinook produced in the Wenatchee Basin. The density-independent model was the best fitting model.

Table 6.12. Results of fitting the density-independent model to subyearling migrant data from the Wenatchee Basin. Confidence intervals are based on 3,000 bootstrap samples.

Life state	Parameters	95% CI	Adjusted R^2	Carrying capacity	Intrinsic productivity
Subyearling migrants	a = 948.2	583.2 – 1,195.6	0.247	NA	948.2

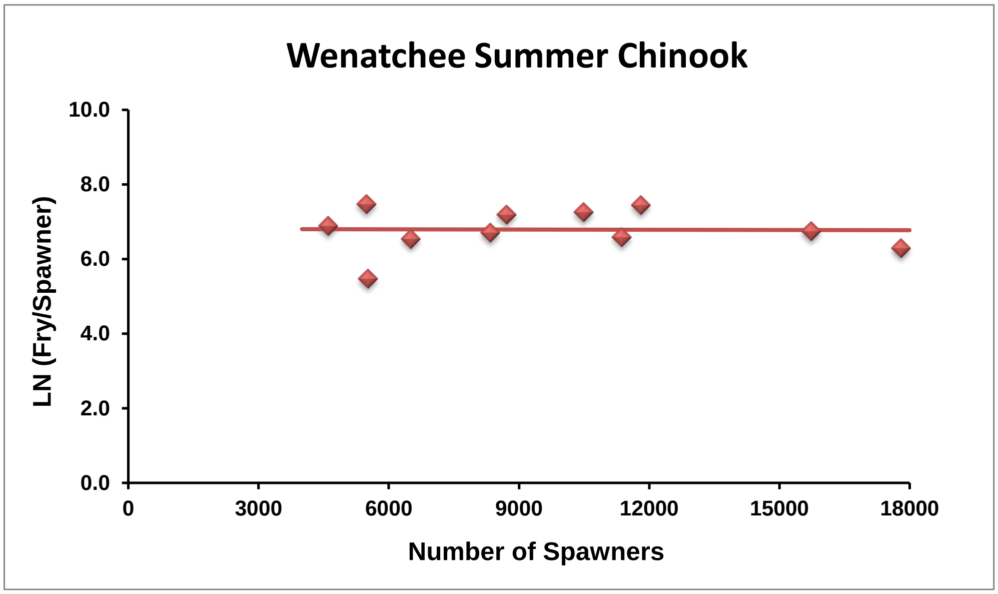
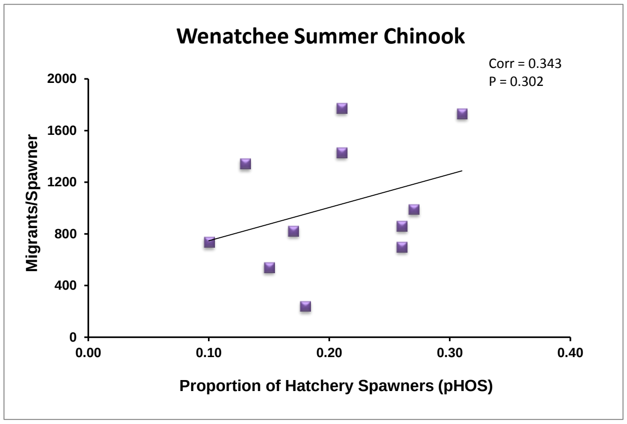


Figure 6.29. Relationship between number of summer Chinook spawners and numbers of subyearling migrant produced in the Wenatchee Basin.

When we compared the number of migrants/spawner with the proportion of the spawning escapement made up of hatchery summer Chinook (pHOS), we found a positive, but not significant relationship (Figure 6.30). Likewise, when we compared the residuals from the density-independent model to pHOS, we found a positive, but not significant relationship (Figure 6.30). These analyses suggest that the supplementation program has not negatively affected the natural productivity of the population.



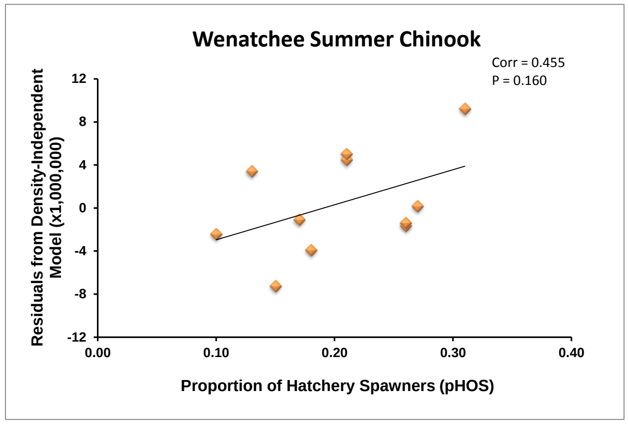


Figure 6.30. Association between the proportion of summer Chinook spawners that were made up of hatchery adults (pHOS) and the number of migrants/spawner (figure on the left) and the residuals from the density-independent model (figure on the right). The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

Conclusions

Analyses of the available data were unable to find a density-dependent relationship between numbers of summer Chinook spawners in the Wenatchee Basin and numbers of subyearling migrants produced. The density-independent (proportional) model was the best fitting model and explained about 25% of the variation in migrant numbers. This suggests that under past spawning escapement levels, spawning and incubation habitat were not limiting the productivity of summer Chinook in the Wenatchee Basin.

The analyses do not indicate that the supplementation program has negatively affected juvenile summer Chinook productivity in the Wenatchee Basin. At most, hatchery-produced adults have made up 31% of the spawning escapement within the Wenatchee Basin.

6.8 Harvest

Harvest Rates

Most of the harvest on hatchery-origin Wenatchee summer Chinook occurred in the ocean (Figure 6.31). Ocean harvest has constituted 49% to 100% of all harvest on Wenatchee summer Chinook. As reported in Hillman et al. (2011), total harvest on early brood years (1990-1996) was lower than for later brood years (1997-2004). The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams. The non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam.

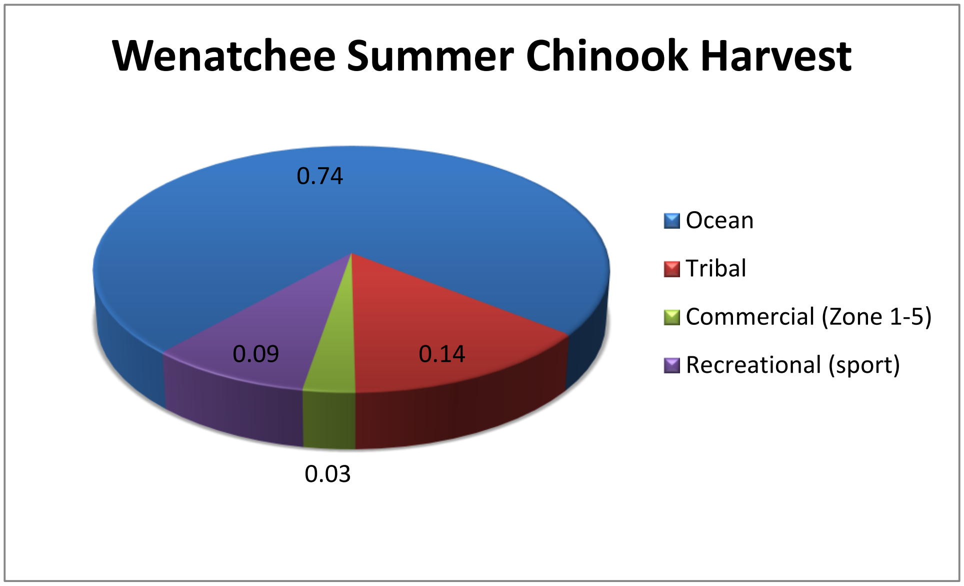


Figure 6.31. Mean allocation of Wenatchee summer Chinook harvested among the different fisheries for brood years 1989-2004. The total number of fish harvested across the brood years was 32,982 (average = 2,061 fish/year; range = 30-10,859).

WDFW (Bartlett and Tweit 2006) established a spawning escapement goal of 13,500 adult summer Chinook for the combined Wenatchee, Entiat, and Chelan rivers. In order to estimate the fraction of this total escapement that belongs to the Wenatchee Basin, we estimated the total kilometers of summer Chinook spawning habitat within each of the three rivers. This work revealed that the Wenatchee contained 71% of the spawning habitat, the Entiat had 28%, and the Chelan had 1%. We applied these percentages to the spawning escapement goal for the three rivers and determined a spawning escapement of 9,585 adults for the Wenatchee River. An additional 492 adults are needed to meet the goal of the Wenatchee supplementation program. Thus, a total of 10,077 adult summer Chinook are needed to satisfy broodstock and WDFW escapement goals for the Wenatchee. Based on the total escapement goal of 10,077 adults, there were eight brood years that produced escapements large enough to support a terminal fishery (Figure 6.32).

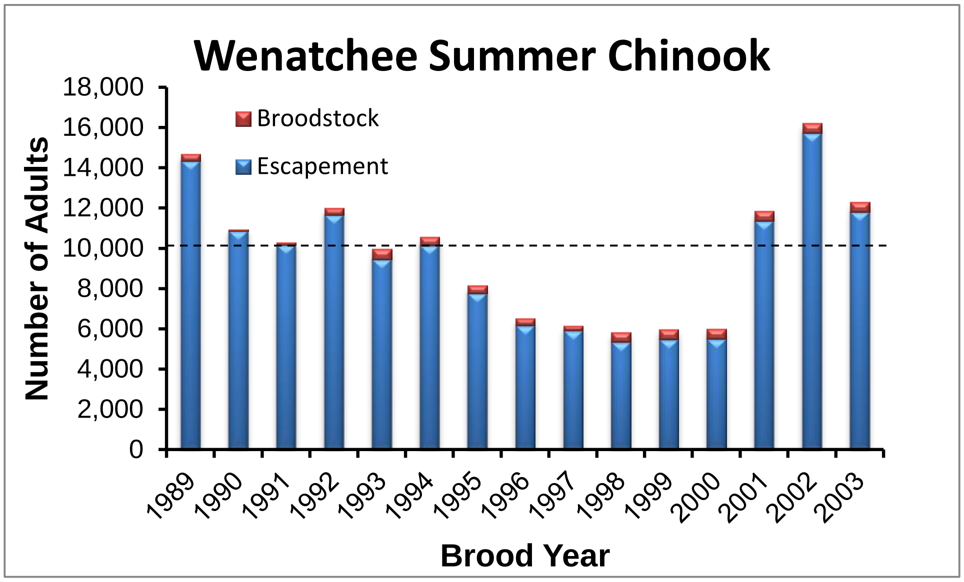


Figure 6.32. Numbers of summer Chinook adults collected for broodstock and numbers that spawned naturally within the Wenatchee Basin for brood years 1989-2003. The dashed horizontal line represents the number needed to satisfy the broodstock collection goal (492 adults) plus the number needed to meet the WDFW spawner escapement goal for the Wenatchee (9,585 spawners).

Conclusions

Wenatchee summer Chinook are harvested primarily within the ocean fisheries. The number of summer Chinook harvested per brood year averaged 2,061 adults/year (range, 30-10,859). Assuming a total escapement of 10,077 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), since 1989, eight brood years produced escapements large enough to support a terminal fishery.

6.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available data were unable to show that the Wenatchee summer Chinook supplementation program has increased total spawning abundance and NORs in the Wenatchee Basin.
2. Based on comparisons with a reference population, the supplementation program may have reduced productivities (based on productivities adjusted for density dependence). On the other hand, we were unable to find an association between pHOS and the residuals from the Ricker stock-recruitment model.
3. Hatchery and natural-origin summer Chinook had significantly different migration timings, with natural-origin fish migrating earlier than hatchery-origin fish. This difference in migration timing is likely due to non-random sampling at Dryden Dam. Spawn timing, however, differed by only two days, which is probably not significant biologically.
4. The spawning distribution of hatchery and natural-origin summer Chinook in the Wenatchee River differed significantly, with a higher proportion of hatchery-origin

Chinook spawning in the lower river and a higher proportion of natural-origin Chinook spawning in the upper river.

5. There was no evidence that supplementation significantly affected allele frequencies within and between natural and hatchery-origin summer Chinook.
6. There was no evidence that the Wenatchee supplementation program has reduced the effective population size of the Wenatchee summer Chinook population.
7. Based on salt age, hatchery fish matured at an earlier age than natural-origin fish. This is likely related to growth rates within the hatchery and the large size at release.
8. Natural-origin summer Chinook were larger than hatchery-origin summer Chinook across all age groups. The differences in size at maturity (based on salt age) are probably not significant biologically.
9. HRRs were on average three times greater than NRRs. This was true regardless if harvested fish were included in the analyses.
10. On average, about 11% of the hatchery brood-year returns have strayed into other spawning areas. Stray rates were correlated with numbers of smolts releases. Higher stray rates were associated with larger releases.
11. Hatchery summer Chinook from the Wenatchee program have strayed into the Entiat, Chelan, Methow, and Okanogan basins and into the Hanford Reach. Most have strayed into the Entiat, Chelan, and Methow basins, and in some years made up more than 5% of the spawning escapement within those basins.
12. The supplementation program has not consistently achieved its goal of releasing 864,000 smolts per year. Since the beginning of the program, it has released on average about 680,000 smolts, which is about 79% of the goal. The reduction in the size of the program to 318,000 smolts should help the program achieve its release goal.
13. The average lengths of smolts released have consistently been below the target of 176 mm. In most years, the average weight of the released smolts has been below the goal of 45.4 g. More realistic targets should be set based on the length-weight relationship specific to Wenatchee summer Chinook. In addition, size targets should be selected that minimize the returns of jacks and mini-jacks.
14. Based on available data, we found no density-dependent relationship between numbers of summer Chinook spawners in the Wenatchee Basin and numbers of subyearling migrants produced. The density-independent (proportional) model explained about 25% of the variability in migrant numbers.
15. Analyses of available data indicate that the supplementation program has not negatively affected juvenile summer Chinook productivity in the Wenatchee Basin. At most, hatchery-origin adults made up 31% of the spawning escapement.
16. Wenatchee summer Chinook were harvested primarily within the ocean fisheries. The average number of Wenatchee summer Chinook harvested per brood year was 2,061 adults/year.

17. Assuming a total escapement of 10,077 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), eight brood years produced escapements large enough to support a terminal fishery.

The Wenatchee summer Chinook supplementation program has not consistently achieved its goal of releasing 864,000 smolts into the Wenatchee River. This is in part because the target number of brood stock could not be collected, especially during the early years of the supplementation program. Brood stock collections have averaged about 71% of the 492 adult collection goal. It is also related to relatively low unfertilized-egg to eyed-egg survival rates. The goal is to achieve a 92% unfertilized-egg to eyed-egg survival rate. Since the beginning of the program, the survival rate has averaged 85%. It is unknown why this survival rate has been lower than expected. It may be a natural phenomenon associated with summer Chinook, or it may be related to the warm river temperatures that occur at the time broodstock are collected. These warmer temperatures may negatively affect the fertilization rates of eggs. Additional work is needed to determine the cause of the relatively low unfertilized-egg to eyed-egg survival rates. Importantly, the reduction in the size of the program to 318,000 smolts should help the program achieve its release goals.

The size of summer Chinook smolts released has not met the program goals. This may be because the length and weight targets for the program were not based on the unique length-weight relationship of Wenatchee summer Chinook. If the goal is to release summer Chinook smolts at 45.4 g, then the fork length at release should be about 164 mm, not 176 mm. Even though the size goals for the program were not achieved, the productivity of these fish was over three times greater than the productivity of natural-origin fish. It is unknown if SARs and HRRs would increase if fish were released at the program goal of 176 mm. It is likely that releasing summer Chinook at a larger size will further decrease the age at maturity (i.e., increase the return of mini-jacks and 1and 2-salt fish).

Based on analysis of CWTs, Wenatchee summer Chinook are exploited most heavily within the ocean fisheries, which makes up about 74% of the total harvest. On average, about 0.294% of the brood year releases were harvested. In contrast, on average, about 0.206% of the releases escaped to spawn. Of those that escaped to spawn, about 11% of the brood returns strayed into non-target spawning streams, exceeding the 5% target limit established for the program. This in part may explain why the supplementation program has not significantly increased the total spawning escapement to the Wenatchee Basin. If all the returning fish had successfully homed to the Wenatchee Basin, the total spawning escapement would have increased compared to the reference population.

Although the straying of Wenatchee summer Chinook was correlated with the number of smolts released, it also may be related to the growth rates and size of fish at release. Decreasing growth rates within the hatchery and releasing fish at a smaller size, according to their specific length-weight relationship, may reduce straying of Wenatchee summer Chinook.

Based on examination of allele frequencies, the supplementation program has not affected the genetic characteristics or effective population size of the population. In contrast, there were differences in phenotypic characteristics. For example, hatchery fish returned at an earlier salt age than natural-origin fish with more 2 and 3-salt females and fewer 4-salt females. Adult return timing was also significantly later for hatchery fish compared to natural-origin fish; however, both hatchery and natural-origin fish spawned at about the same time. The spawning distribution of hatchery females was more concentrated near the release location. Thus, they were distributed more downstream than natural-origin females. Finally, there were differences in size-at-age between hatchery and natural-origin fish, but most of these differences are probably not significant biologically. Size differences between older (4 and 5-salt) hatchery and natural-origin males may be significant biologically. Some of these phenotypic differences may be related to unintentional selective broodstock collection. On the other hand, differences in spawning distribution are likely the result of hatchery fish homing to the release location. It is unknown why hatchery fish returned at an earlier salt age than the natural-origin fish. This is a common outcome among hatchery programs and may be related to rapid growth rates in the hatchery and size at release.

Although the Wenatchee summer Chinook supplementation program demonstrated a full life-cycle survival advantage over natural-origin Chinook, it does not appear that it has significantly increase spawning escapements or NORs. In addition, productivity (NRRs) adjusted for density dependence appeared to decline relative to the reference population. Possible reasons why NORs have not increased and adjusted productivity has decreased include:

- *Density Dependence*—Although we attempted to correct for density dependence through modeling, it is possible that the large spawning escapements into specific areas within the Wenatchee River (i.e., Leavenworth Reach), could be reducing survival and productivity of natural-origin fish. That is, the saturation of habitat in specific spawning areas may be driving the overall productivity of the Wenatchee population. The fact that the Ricker model was the best fitting model to the stock-recruitment data suggests that spawning or incubation habitat may be limiting the productivity of summer Chinook in the Wenatchee River. According to the Ricker model, the estimated stock size at capacity is 5,647 adult spawners, which is less than most of the spawning escapements within the Wenatchee Basin over the last 30 years (escapements ranged from 4,590-17,792 spawners). In addition, NRRs have exceeded 1.0 in ten of the last 15 complete brood years and averaged 2.71 (range, 0.36-9.79). Interestingly, however, the relationship between the number of spawners and the number of subyearling migrants produced showed no density-dependent effects. That is, as spawning abundance increased, numbers of subyearling migrants increased linearly. It is possible the any density-dependent effects were masked by the large errors (confidence intervals) associated with the subyearling migrant estimates.
- *Ecological Interactions*—With the large numbers of hatchery fish released in the upper Columbia Basin, it is possible that the survival and productivity of natural-origin Chinook have been reduced. The HETT is currently evaluating the effects of hatchery releases on non-target taxa of concern. In addition, it is possible that the supplementation program has increased the incidence of disease (e.g., BKD or Rs) in the naturally spawning population.
- *Measurement Error*—In the Wenatchee Basin, summer Chinook spawning escapements are estimated by multiplying the total number of redds by a fish/redd estimate. Unlike in other basins (i.e., Methow and Okanogan basins), numbers of redds in the Wenatchee Basin are estimated by converting peak redd counts to total redd counts (see Appendix B). The process of expanding peak counts to total counts and then to spawning escapements may greatly increase the error in spawning escapement estimates. This could

confound analyses of effects of the supplementation program on NORs and productivity. Indeed, stock-recruitment analyses are sensitive to errors in stock sizes.

The apparent reduced productivities and NORs are challenges for meeting supplementation objectives. These factors may be addressed by reducing the size of the hatchery program (the program was recently reduced to 318,000 smolts), establishing stock-specific size targets and growth rates, and distributing hatchery spawners more evenly throughout the Wenatchee River. With regard to the latter recommendation, it may be wise to maintain a partially segregated program by limiting the spawning of hatchery fish within the upper Wenatchee River. This would provide a safety net if the productivity of the fish in the lower river crashes. Additionally, if hatchery fish have a lower reproductive success than natural-origin fish, it may be wise to reduce the number of hatchery fish spawning within the Leavenworth Reach. This could be accomplished in part through a selective fishery.

SECTION 7: METHOW SUMMER CHINOOK

The goal of summer Chinook salmon supplementation in the Methow Basin is in part to use artificial production to replace adult production lost because of mortality at Wells, Rocky Reach, and Rock Island dams[8], while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Adult summer Chinook are collected for broodstock from the run-at-large at the east ladder trapping facility at Wells Dam. The goal is to collect up to 222 natural-origin adult summer Chinook for the Methow program. Broodstock collection occurs from about 7 July through 15 September with trapping occurring no more than 16 hours per day, three days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook are transferred from the hatchery to Carlton Acclimation Pond in March. They are released from the pond in late April to early May.

The production goal for the Methow summer Chinook supplementation program is to release 400,000 yearling smolts[9] into the Methow River at ten fish per pound. Targets for fork length and weight are 176 mm (CV = 9.0) and 45.4 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2009, about 5,000 to 10,000 juvenile summer Chinook have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

7.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the summer Chinook supplementation program is to increase the number of spawners in the Methow Basin. We tested the success of the supplementation program at increasing total spawners (both hatchery and natural-origin spawners) by analyzing trends and mean abundances before and during supplementation. We also compared trends and mean abundance of Methow summer Chinook with a reference population (Deschutes fall Chinook). Appendix C describes in detail the methods we used for selecting reference populations.

We first examined the trends in abundances of summer Chinook spawners in the Methow Basin before and during supplementation. Trend analysis indicated that before supplementation there was no apparent trend (i.e., there was no increase or decrease in abundance). During supplementation, abundance trended upward, but the change in trend before and during supplementation was not significant (Figure 7.1). When we compared the trends of the Methow

[8] The majority of the production at Carlton Pond is initial production, which terminates in 2013, and is not necessarily tied to hydro facility mortality. The balance of the production is the result of a swap between spring and summer Chinook. That is, Chelan PUD is currently producing summer Chinook at Carlton for Douglas PUD in exchange for Douglas PUD producing spring Chinook at the Methow Fish Hatchery for Chelan PUD.

[9] The HCP Hatchery Committees recently agreed to reduce this program to 200,000 summer Chinook smolts. This program will switch to Grant PUD.

population with the reference population, we found that like the Methow there was no apparent trend in the reference population before the Methow was supplemented. During the period of supplementation, abundances in both the Methow and reference populations trended upward (Figure 7.2). These analyses do not clearly indicate that supplementation caused an increase in total spawning abundance in the Methow following supplementation.

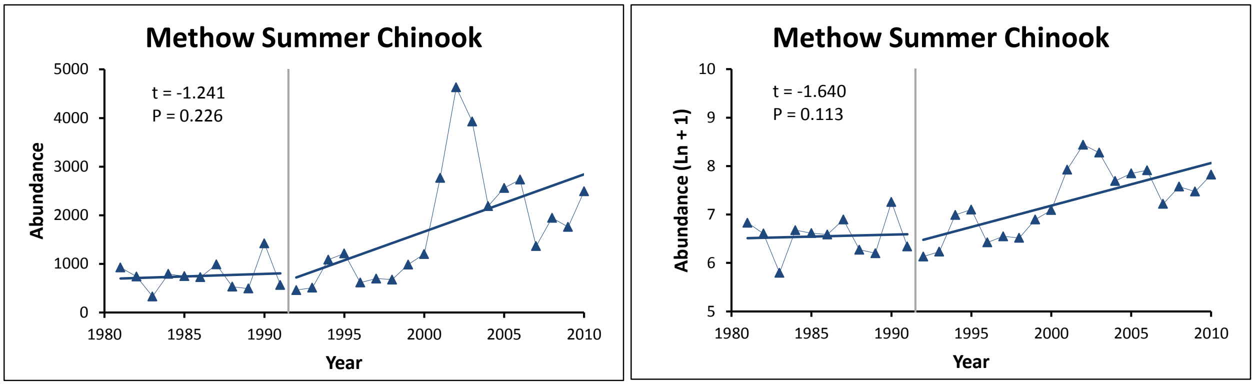


Figure 7.1. Trends in Methow summer Chinook spawner abundance before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

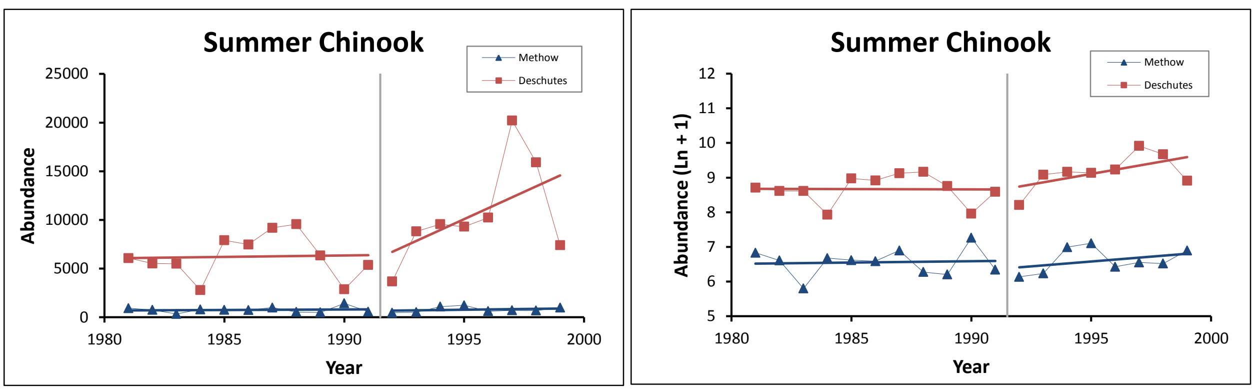


Figure 7.2. Trends in summer Chinook spawner abundance in the Methow and reference population. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.

We then compared the mean spawner abundance before supplementation with the mean abundance during supplementation. Mean spawner abundance during the supplementation period was significantly greater than the pre-supplementation spawner abundance (Table 7.1). When we compared the Methow abundance with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase spawning abundance in the Methow Basin (Table 7.2; Figure 7.3). This is because mean abundance in the reference stream also increased significantly during the period of supplementation in the Methow Basin.

Table 7.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Methow summer Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	750	1,780	-3.619	0.002	0.001	-1,535 – -478
LN Abundance	6.6	7.3	-3.617	0.001	0.003	-1.09 – -0.33
NORs	2,632	2,994	-0.396	0.697	0.706	-2,036 – 1,368
LN NORs	7.6	7.6	0.166	0.869	0.866	-0.62 – 0.76
Productivity	3.9	2.6	1.191	0.246	0.246	-0.74 – 3.48
LN Productivity	1.4	1.1	1.501	0.148	0.146	-0.10 – 0.84
Adj Productivity	3.9	2.7	1.063	0.299	0.304	-0.82 – 3.20
LN Adj Productivity	1.4	1.1	1.301	0.207	0.204	-0.14 – 0.77

Table 7.2. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Deschutes	1.555	0.928	0.06	0.126	-0.022 – 0.131
LN Spawner Abundance					
Deschutes	1.334	0.900	0.04	0.214	-0.014 – 0.084

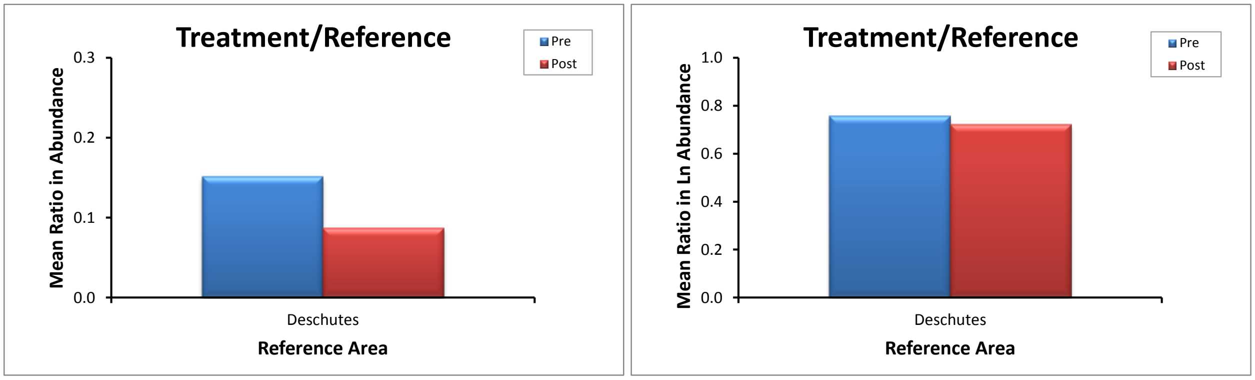


Figure 7.3. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance data before (pre) and after (post) summer Chinook supplementation in the Methow Basin. Positive effects of supplementation on spawner abundance are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

As a final test of the effects of supplementation on total spawner abundance, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Because the number of hatchery and natural-origin adults collected for broodstock supports both the Methow and Okanogan/Similkameen programs, the number of hatchery fish spawning naturally includes estimates from both the Methow and Okanogan/Similkameen rivers. Excluding the first four years following the start of the supplementation program, when no hatchery fish had yet returned, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in 16 of the 17 years (Table 7.3).

Table 7.3. Numbers of natural-origin (NOB) and hatchery-origin (HOB) summer Chinook included in broodstock and numbers of hatchery-origin summer Chinook spawning naturally (HOS) in the Methow and Okanogan basins.

Brood year	NOB	HOB	Total Broodstock	HOS
1989	1,297	312	1,609	0
1990	828	206	1,034	0
1991	924	314	1,238	0
1992	297	406	703	0
1993	681	388	1,069	769
1994	341	244	585	3,222
1995	173	240	413	2,674
1996	290	223	513	1,412
1997	198	264	462	1,512
1998	153	211	364	735
1999	224	289	513	2,791
2000	164	339	503	2,889
2001	91	266	357	8,267

Brood year	NOB	HOB	Total Broodstock	HOS
2002	247	241	488	11,624
2003	381	101	482	3,194
2004	506	16	522	1,992
2005	391	9	400	3,337
2006	500	10	510	3,788
2007	456	17	473	2,034
2008	404	41	445	4,631
2009	553	5	558	4,005
Average	**433**	**197**	**631**	**2,804**

In summary, although total numbers of spawners (hatchery and natural-origin spawners) increased significantly in the Methow Basin during the period of supplementation, the increase did not appear to be related to the supplementation program. This conclusion is based on comparing trends and mean abundances before and after supplementation with a reference population.

Natural-Origin Recruits

Another important goal of the summer Chinook supplementation program is to increase the number of natural-origin recruits (NORs). We tested the success of the supplementation program in increasing NORs by analyzing trends and mean NORs before and during supplementation. We also compared trends and mean NORs of Methow summer Chinook with a reference population (Deschutes population). In addition, because NORs can be affected by the capacity of the environment, we adjusted NORs for differences in carrying capacities between the Methow and reference populations. We did this by calculating the percent saturation of NORs (Appendix C describes in detail the methods used to calculate percent saturation). Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before supplementation, NORs decreased over time (Figure 7.4). During the period of supplementation the trend reversed and increased over time. The change in trend before and during supplementation was significant. When we compared the trends of the Methow population with the reference population, we found that the reference population also trended downward during the period before the Methow was supplemented and, unlike the Methow, trended downward during the supplementation period (Figure 7.5). This indicates that the change in trends in the Methow population may have been the result of supplementation.

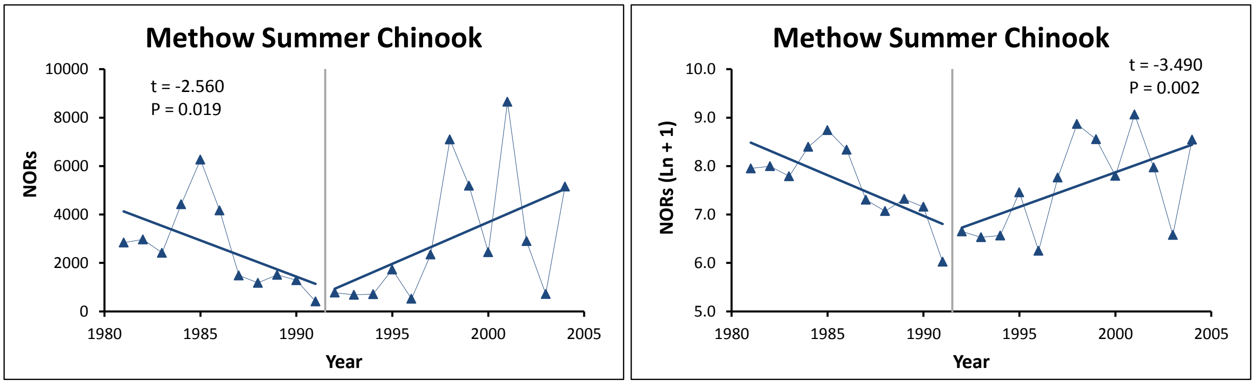


Figure 7.4. Trends in Methow summer Chinook NORs before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

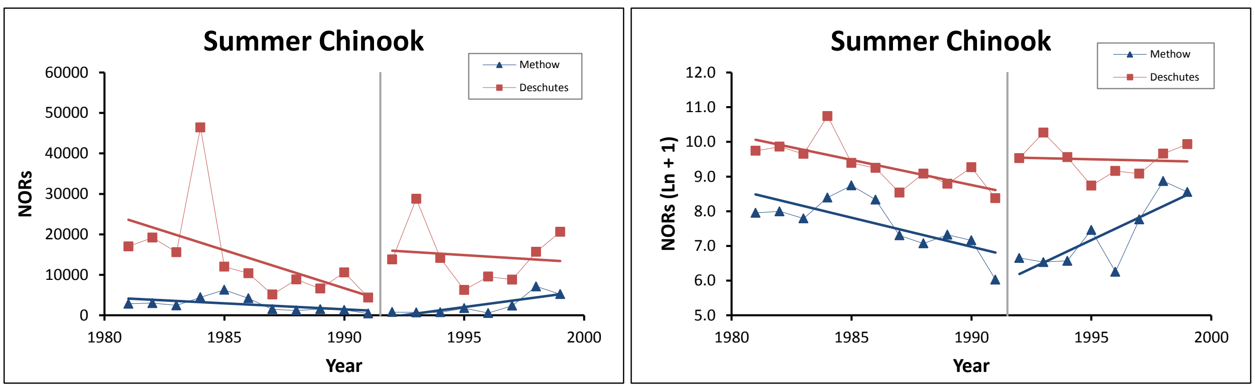
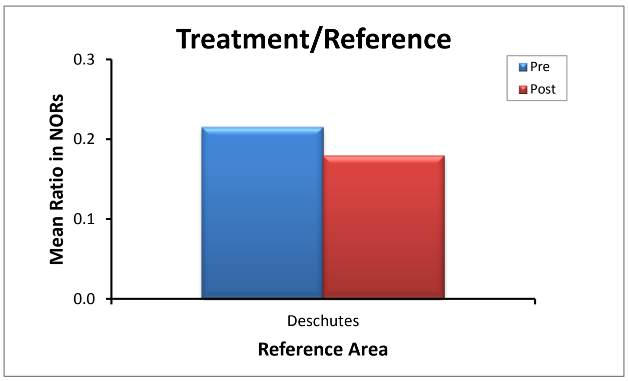


Figure 7.5. Trends in summer Chinook natural-origin recruits (NORs) in the Methow and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.

We then compared mean summer Chinook NORs before supplementation with mean NORs during supplementation. Although not significant, mean NORs increased about 14% between the pre- and post-supplementation periods (Table 7.1). When we compared Methow NORs with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase NORs in the Methow Basin (Table 7.4; Figure 7.6).

Table 7.4. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Deschutes	0.518	0.694	0.04	0.617	-0.094 – 0.163
LN Natural-Origin Recruits					
Deschutes	1.063	0.844	0.04	0.303	-0.031 – 0.123



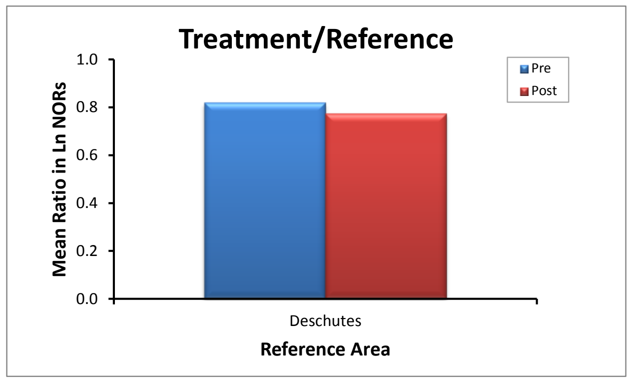


Figure 7.6. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) natural-origin recruits (NORs) data before (pre) and after (post) summer Chinook supplementation in the Methow Basin. Positive effects of supplementation on NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

Next, we analyzed the effects of supplementation on filling the capacity of the habitat with NORs. The Ricker model derived the carrying capacity (K_R) estimates for the Methow and reference populations. The mean fraction of the carrying capacity filled with Chinook NORs before and during supplementation for the Methow and reference population is provided in Table 7.5. These data indicate that for both the Methow and reference populations, the mean fraction of the K_R filled with fish increased, but not significantly, from the pre-supplementation period through the supplementation period (Table 7.5). The fraction of K_R filled with adult recruits for both populations trended downward during the pre-supplementation period (Figure 7.7). During the supplementation period, however, the fraction of K_R filled with adult recruits trended upward for the Methow population, but not for the reference population.

Table 7.5. Statistical results comparing the fraction of the carrying capacity that was filled with Chinook NORs in the Methow and reference population before and during supplementation of Methow summer Chinook. The Ricker model estimated carrying capacity for each population.

Populations	Mean scores		Aspin-Welch test	
	Before	During	t-value	P-value
Methow	0.88	1.00	-0.396	0.696
Deschutes	1.03	1.06	-0.116	0.454

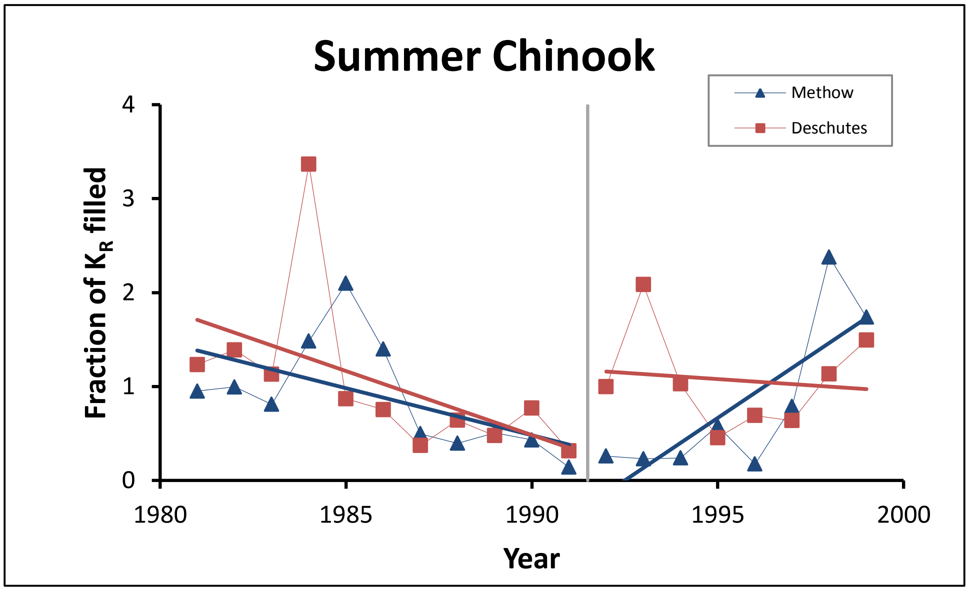


Figure 7.7. Trends in the fraction of the carrying capacity that was filled with Chinook salmon NORs in the Methow and reference population before (pre) and during (post) supplementation in the Methow Basin. The vertical line in the figure separates the pre- and post-supplementation periods. The Ricker model estimated carrying capacity for each population.

We then compared the mean ratios between the Methow and reference populations before and during supplementation using data representing the fraction of K_R filled with adult recruits. Mean ratio scores were smaller during the supplementation period than during the pre-supplementation period (Figure 7.8). This indicated that the mean fraction of K_R filled by adult recruits in the reference population was greater during the supplementation period than during the pre-supplementation period (i.e., the denominator in the ratio increased between the pre- and post-supplementation periods). In contrast, the fraction of K_R filled by adult recruits in the Methow decreased from the pre- to post-supplementation period (i.e., the numerator in the ratio decreased between the pre- and post-supplementation periods). Thus, unlike the Methow population, the capacity of the reference population was becoming more saturated during the period when the Methow was being supplemented. Statistical analysis with mean ratios indicated that the capacity of the Methow did not fill significantly during the supplementation period compared to the reference population (Table 7.6).

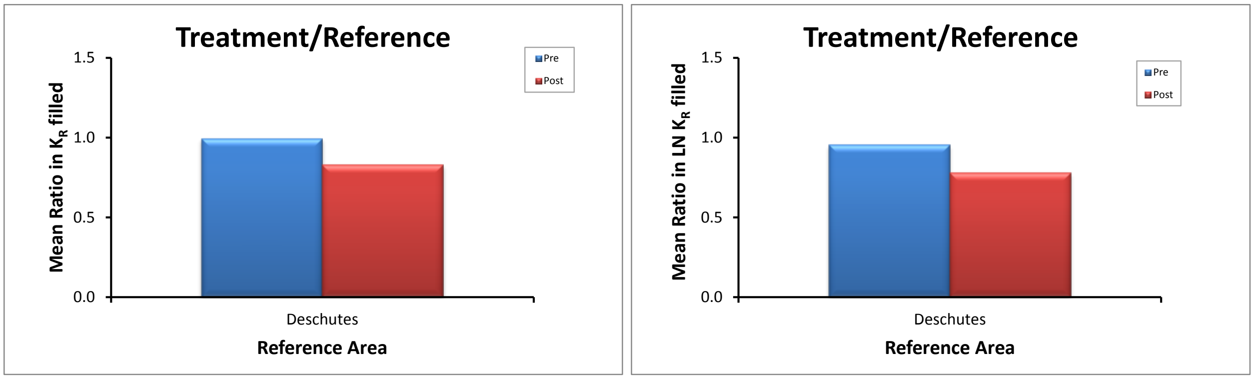


Figure 7.8. Mean ratios (Treatment/Reference) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) summer Chinook supplementation in the Methow Basin.

Table 7.6. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with summer Chinook NORs. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Fraction of Capacity Filled					
Deschutes	0.521	0.695	0.17	0.611	-0.409 – 0.759
LN Fraction of Capacity Filled					
Deschutes	0.750	0.766	0.18	0.461	-0.260 – 0.601

Finally, we used Pearson correlation to test the association between pHOS and NORs. If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. During the pre-supplementation period, NORs averaged 2,632 adults; during the supplementation period, NORs averaged 2,994 adults. This 14% increase in NORs was not associated with pHOS (Figure 7.9). Correlation analysis showed that there was no association between pHOS and NORs.

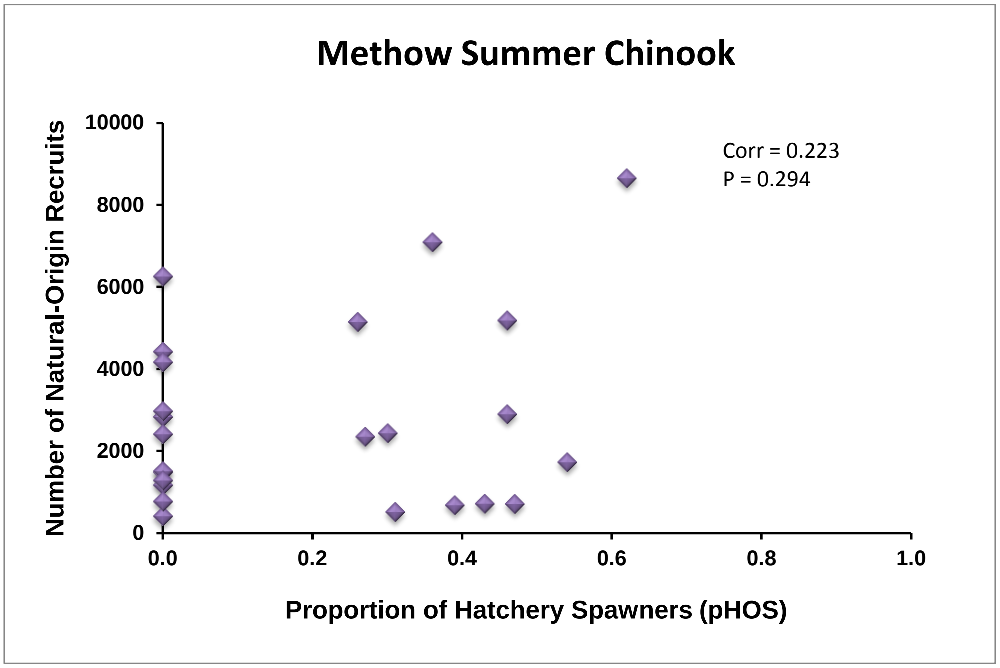


Figure 7.9. Association between the proportion of Methow summer Chinook spawners that were made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, although NORs increased during the period of supplementation in the Methow Basin, the increase did not appear to be correlated with the supplementation program. This conclusion is based on comparing trends and mean NORs before and after supplementation with a reference population. It also includes comparing NORs adjusted for carrying capacity.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the supplementation program has reduced the productivity of summer Chinook in the Methow Basin by analyzing trends and mean productivities before and during supplementation. We also compared trends and mean productivities of Methow summer Chinook with a reference population (Deschutes population). In addition, because productivity can be affected by density (density-dependent effects), we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the stock-recruitment data.

Trend analysis indicated that before supplementation, productivity decreased over time; during supplementation the trend increased slightly, even though there was large variability in productivity during the supplementation period (Figure 7.10). The change in trend before and during supplementation was not significant. When we compared the trends of the Methow population with the reference population, we found that the reference population also trended downward during the period before the Methow was supplemented (Figure 7.11). During the period of supplementation, unlike the Methow population, productivities in the reference population trended downward.

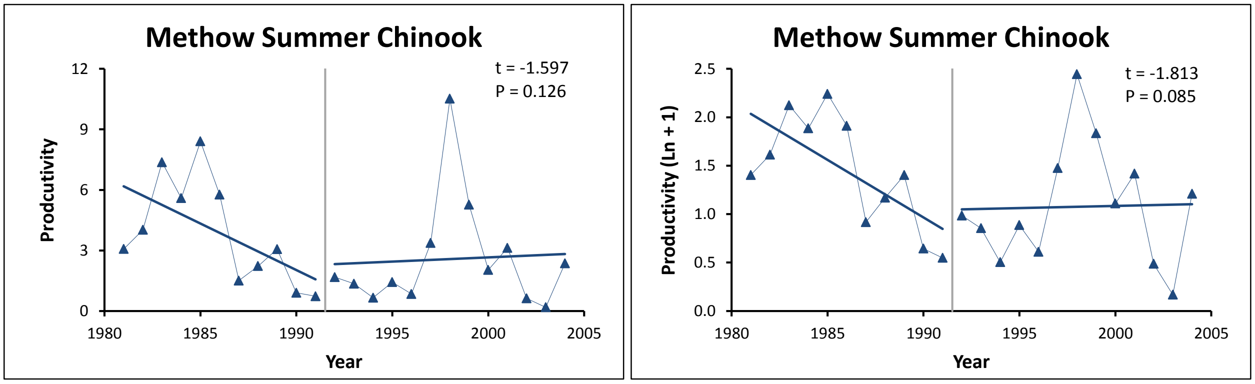


Figure 7.10. Trends in Methow summer Chinook productivity (adult recruits/spawner; NRRs) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

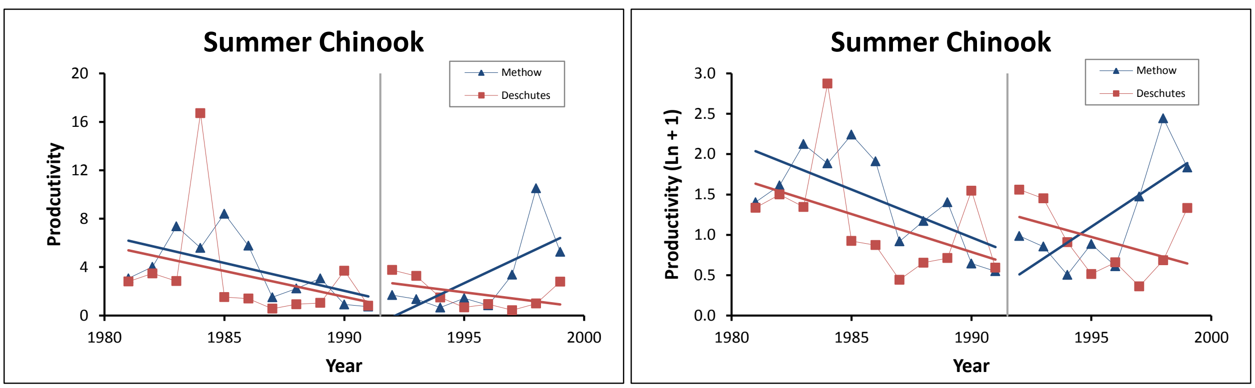


Figure 7.11. Trends in summer Chinook productivity (adult recruits/spawner) in the Methow (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.

We then compared mean summer Chinook productivities before supplementation with productivities during supplementation. Mean productivities of Methow summer Chinook decreased, but not significantly, between the pre- and post-supplementation periods (Table 7.1). When we compared Methow productivities with the reference population using ratios (treatment/reference), we found that supplementation did not significantly decrease productivity in the Methow Basin (Table 7.7; Figure 7.12).

Table 7.7. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	-0.606	0.720	0.89	0.573	-3.301 – 2.038
LN Productivity					
Deschutes	-0.400	0.651	0.21	0.691	-1.133 – 0.839

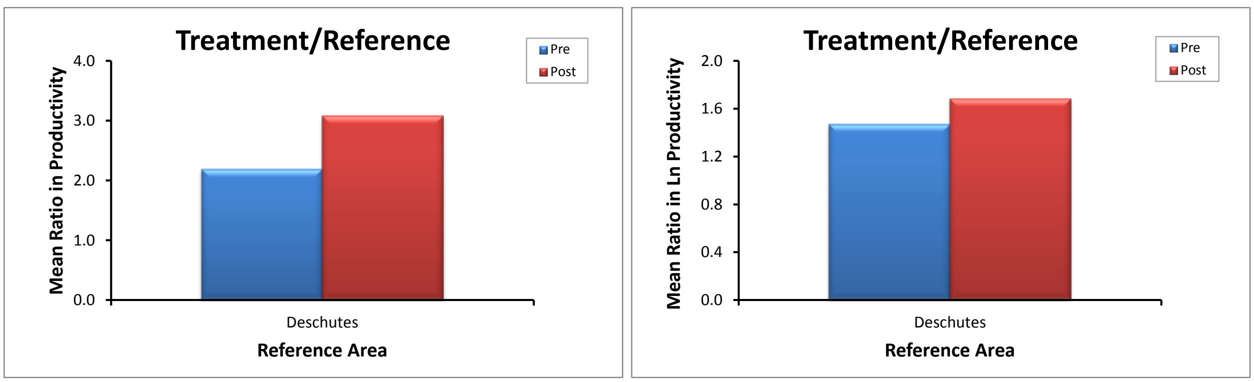
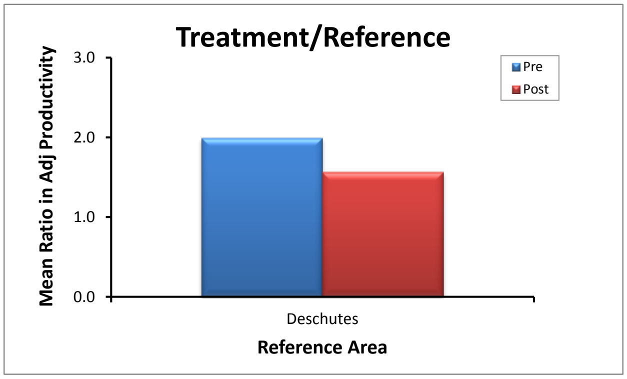


Figure 7.12. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) productivity (adult recruits/spawner; NRRs) data before (pre) and after (post) summer Chinook supplementation in the Methow Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Next, we analyzed the effects of supplementation on productivities adjusted for density dependence. These analyses, based on ratios, indicated that supplementation did not significantly decrease productivity in the Methow Basin (Table 7.8; Figure 7.13).

Table 7.8. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	0.613	0.275	0.43	0.548	-0.822 – 1.730
LN Productivity					
Deschutes	0.902	0.191	0.26	0.384	-0.268 – 0.766



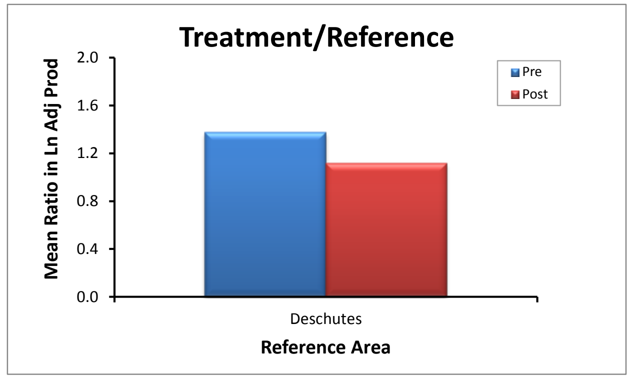


Figure 7.13. Mean ratios (Treatment/Reference) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) summer Chinook supplementation in the Methow Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the Methow summer Chinook stock and recruitment data. There was no association between pHOS and the residuals from the Ricker model, indicating that hatchery-origin spawners may be as productive as natural-origin spawners (Figure 7.14).

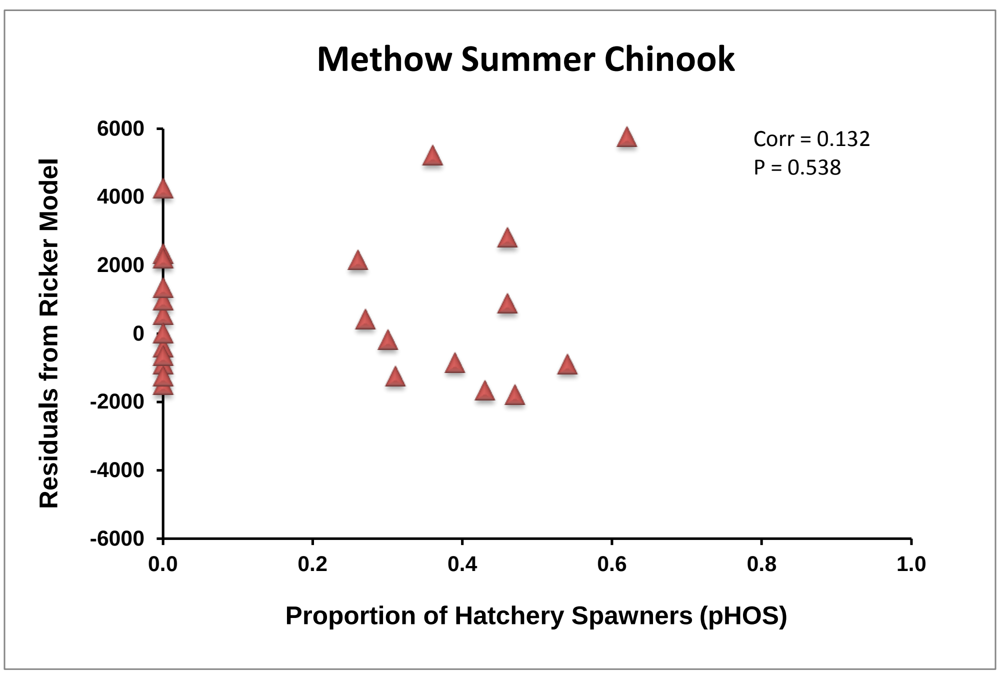


Figure 7.14. Association between the proportion of summer Chinook spawners in the Methow Basin that are made up of hatchery adults (pHOS) and the residuals from the Ricker stock-recruitment model. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

In summary, the analyses above indicate that supplementation has not negatively affected the productivity of the Methow summer Chinook population. This is based on analysis of both unadjusted and adjusted productivity estimates.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. Total spawning abundance and NORs of summer Chinook increased during supplementation in the Methow Basin and in the reference population. Thus, the increase in abundance and NORs in the Methow Basin may not be related to the supplementation program. Adjusting NORs for carrying capacity did not reveal a supplementation effect on NORs. In addition, we found no association between pHOS and NORs in the Methow Basin.

The data do not indicate that the supplementation program has negatively affected the productivity of the Methow summer Chinook population. Also, there was no association between pHOS and the residuals from fitting the Ricker model to the Methow summer Chinook stock and recruitment data.

7.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons using data collected during broodstock collection and stock assessment at Wells Dam. Migration timing at Wells Dam includes Chinook from both the Methow and Okanogan basins. At this time, we are unable to assess independent migration timings for the two populations.

We compared cumulative frequency polygons of migration timing of hatchery and natural-origin summer Chinook collected or sampled at Wells Dam during migration years 2007-2010 (Figure 7.15). These data indicate no difference in migration timing of Methow/Okanogan summer Chinook at Wells Dam.

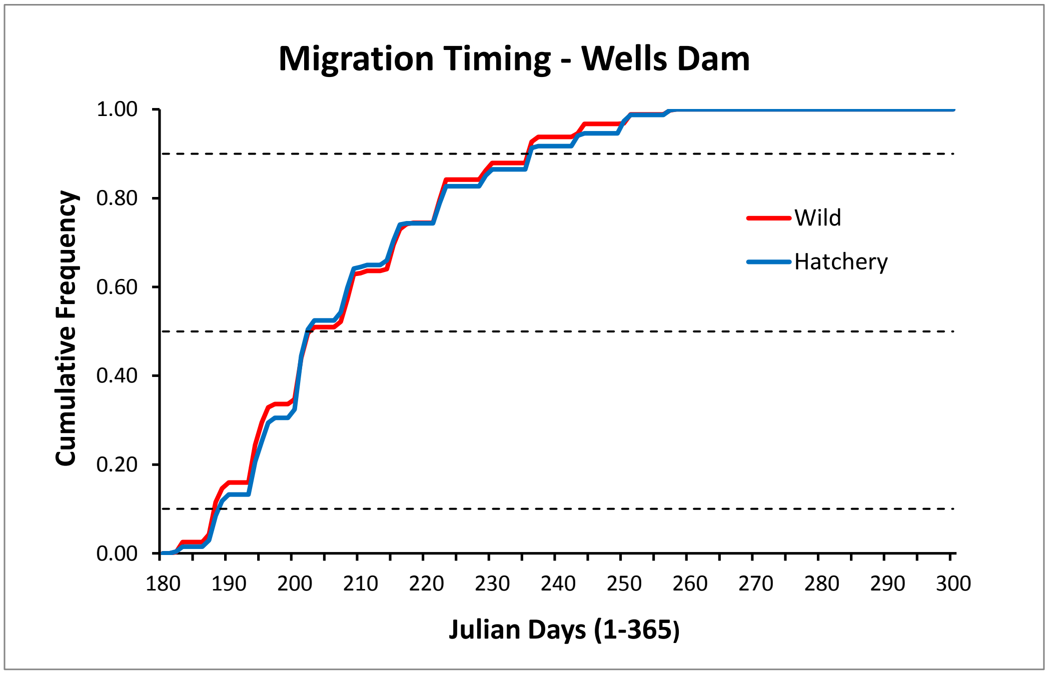


Figure 7.15. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Methow/Okanogan summer Chinook sampled or collected at Wells Dam. Migration timing was based on stock assessments and broodstock collection at Wells Dam during 2007-2010 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 1,989 wild and 2,826 hatchery Chinook.

We also compared the mean migration timing of hatchery and natural-origin summer Chinook by comparing the mean Julian date that 10%, 50%, and 90% of the fish passed Wells Dam. These data were based on stock assessment and broodstock collection at Wells Dam during the migration period 2007-2010. Based on four years of sampling, there was no significant difference in the migration timing of hatchery and natural-origin summer Chinook sampled at Wells Dam (Table 7.9). At most, the average difference in migration timing between hatchery and natural-origin fish was one day.

Table 7.9. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date that hatchery and natural-origin (wild) summer Chinook migrated past Wells Dam during the period 2007-2010 (N = 4 years). Migration timing was based on stock assessment and broodstock collection at Wells Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	189	190	205	205	234	233	209	209
Effect size	1		0		1		0	
t-value	1.732		-1.000		-0.290		0.454	
P-value	0.182		0.391		0.791		0.681	
Bootstrap CI	0.0 – 1.0		-0.5 – 0.3		-11.8 – 4.0		-2.3 – 3.5	
Power	0.484		0.999		0.999		0.742	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin summer Chinook should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We tested differences in spawn timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons of the time when female carcasses were recovered on the spawning grounds.

There was a difference in spawn timing of hatchery and natural-origin summer Chinook in the Methow Basin (Figure 7.16). On average, natural-origin Chinook began spawning about four-six days earlier than hatchery Chinook.

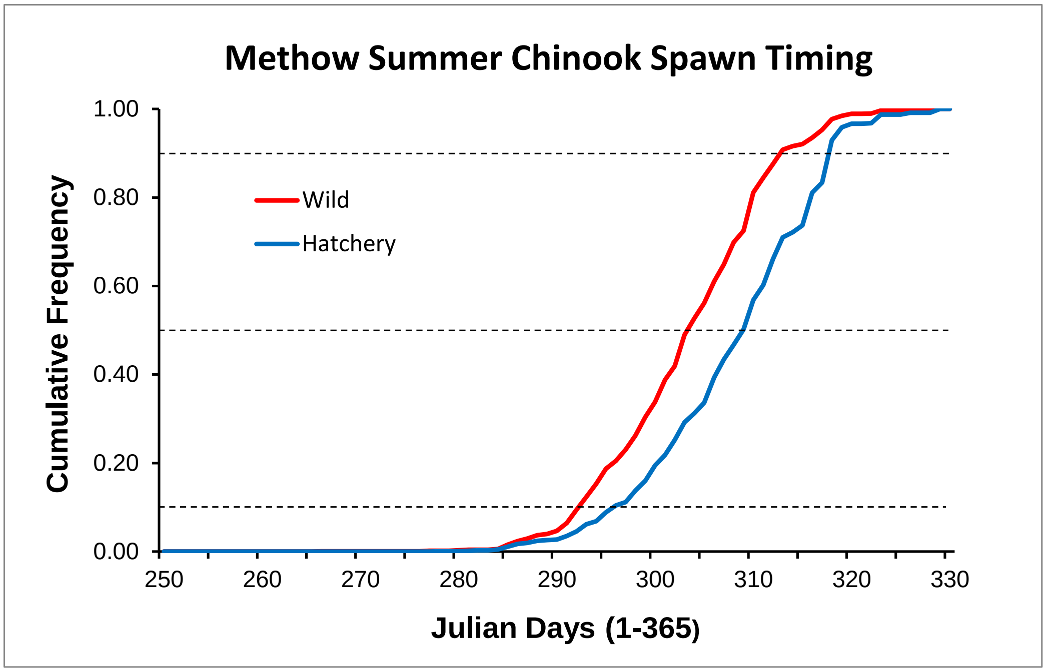


Figure 7.16. Cumulative frequency polygon of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Methow Basin. Spawn timing was based on the Julian date that female carcasses were recovered on the spawning grounds. Sample sizes = 2,690 wild and 1,850 hatchery Chinook.

We also compared the mean spawn timing of hatchery and natural-origin summer Chinook by comparing the mean Julian data that 10%, 50%, and 90% of the female carcasses were recovered on the spawning grounds. Based on 18 years of sampling, natural-origin Chinook spawned significantly earlier than hatchery fish (Table 7.10). However, the difference in spawning timing was on average only three-four days.

Table 7.10. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Methow River during the period 1993-2010 (n = 18 years).

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	295	298	304	308	313	316	305	308
Effect size	3		4		3		3	
t-value	1.462		2.613		2.919		2.223	
P-value	0.162		0.018		0.009		0.040	
Bootstrap CI	-0.9 – 6.8		1.3 – 7.2		1.1 – 4.8		0.6 – 5.7	
Power	0.176		0.026		0.020		0.036	

Because spawning generally progresses from higher elevations to lower elevations, we examined the relationship between elevation and spawn timing of hatchery and natural-origin summer Chinook within the Methow River. We found little difference in the spawn time of hatchery and natural-origin Chinook across the range of spawning elevations within the Methow River (Figure 7.17). In general, both hatchery and natural-origin Chinook spawned at about the same time across the range of elevations within the Methow River. The trend lines in Figure 7.17 indicate that spawning of both hatchery and natural-origin Chinook progressed from higher elevations to lower elevations.

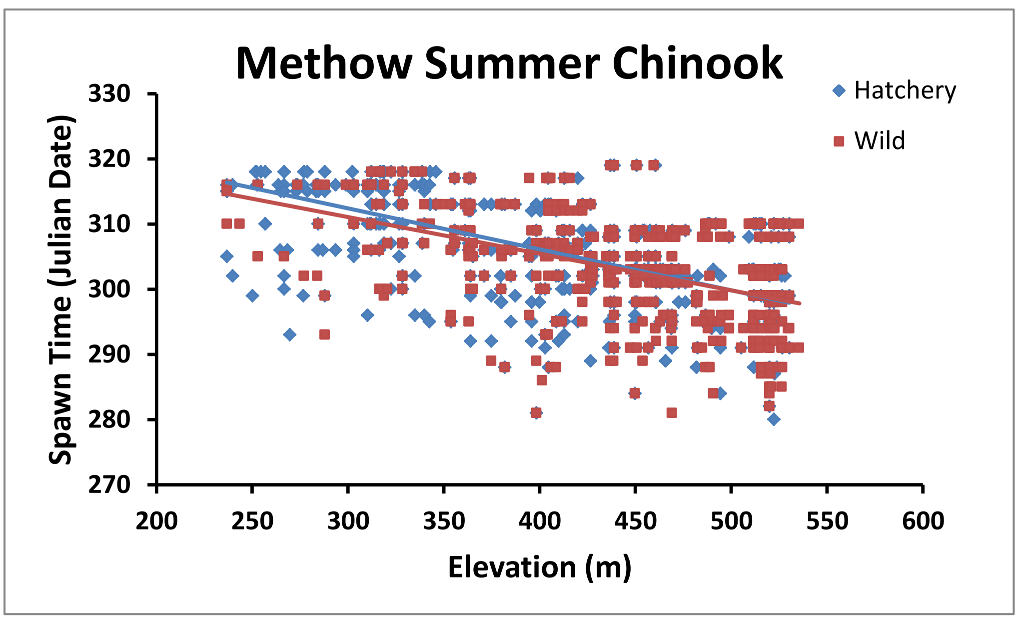


Figure 7.17. Relationship between elevation and spawn timing of hatchery and natural-origin (wild) summer Chinook spawners within the Methow River.

Redd Distribution

Finally, under a fully integrated program, both hatchery and natural-origin summer Chinook should spawn in the same location. We evaluated differences in spawning locations at two different spatial scales; at the historic reach scale and at the 0.5 km scale.

Both hatchery and natural-origin Chinook spawned throughout the Methow River. However, there was a significant difference in the distribution of hatchery and natural-origin spawners among the historic sampling reaches (Yates' Chi-square = 679.9; P = 0.000; Effect Size = 0.392). A greater percentage of hatchery-origin Chinook spawned in the lower reaches (M1-M2; mouth to Carlton Bridge) than did natural-origin fish (Figure 7.18). The opposite occurred in the upper reaches where a greater percentage of natural-origin Chinook spawned. This pattern was most obvious when we compared the spawning distribution at the 0.5 km scale (Figure 7.19). Larger percentages of hatchery-origin Chinook spawned in the lower 45 km of the river than in the upper 39 km. In contrast, larger percentages of natural-origin Chinook spawned in the upper 39 km of the river than in the lower 45 km.

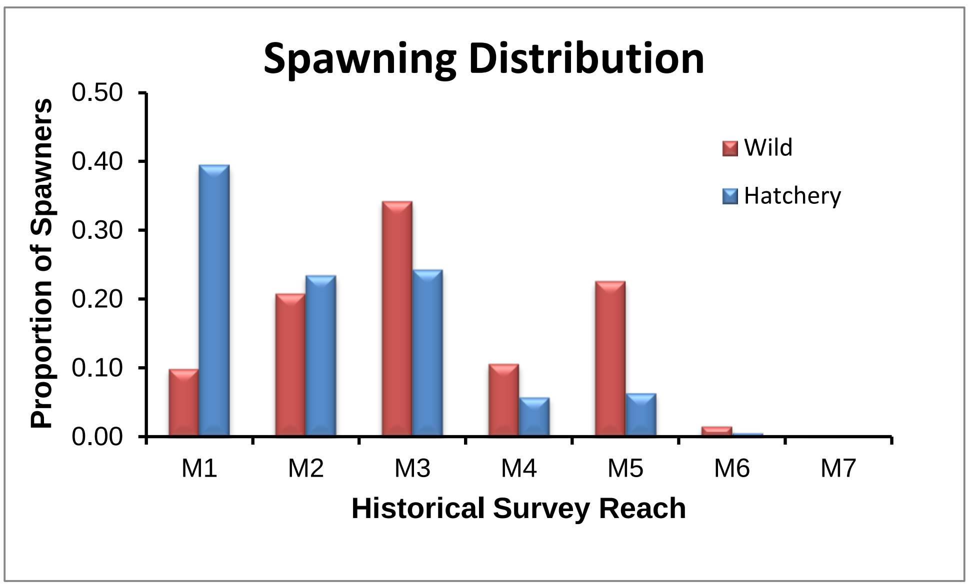


Figure 7.18. Proportion of hatchery and natural-origin summer Chinook spawners distributed among the seven historic sampling reaches on the Methow River. M1 is from 0.0-23.8 km; M2 23.8-43.8; M3 43.8-63.7; M4 63.7-72.2; M5 72.2-84.0; M6 80.1-83.0; and M7 83.0-96.5. Sample sizes = 2,658 wild and 1,799 hatchery Chinook.

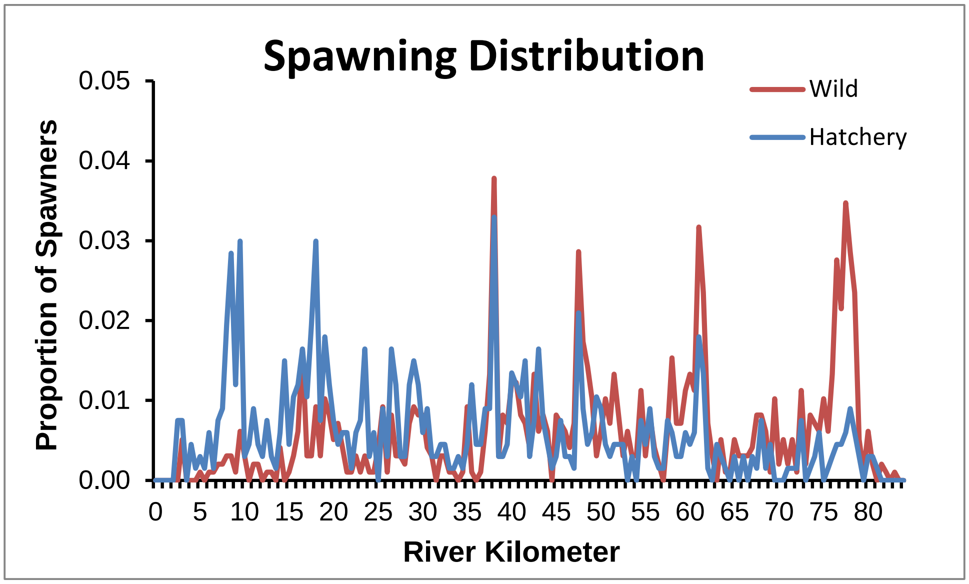


Figure 7.19. Proportion of hatchery and natural-origin summer Chinook spawners distributed along the length of the Methow River. Distribution was based on 0.5-km long reaches. Sample sizes = 2,658 wild and 1,799 hatchery Chinook.

Conclusions

There was no difference in migration timing of hatchery and natural-origin summer Chinook at Wells Dam. Even though there was no difference in migration timing, spawn timing of hatchery and natural-origin Chinook in the Methow Basin differed significantly, with natural-origin fish spawning about three-four days before hatchery fish. Although the difference in spawn timing was significant statistically, it is probably not significant biologically.

The distribution of hatchery and natural-origin summer Chinook spawners in the Methow River differed significantly. A higher proportion of hatchery-origin Chinook spawned in the lower river, while a higher proportion of natural-origin Chinook spawned in the upper river. This difference in distribution is likely a result of the location of the acclimation pond in the river.

7.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix I). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall-run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin summer Chinook in the Methow Basin. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin summer Chinook differed significantly. Because of different age-at-migration characteristics, we evaluated male and female Chinook separately.

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook. Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

The salt-age at maturity differed significantly between hatchery and natural-origin female (Yates' Chi-square = 379.8; P = 0.000; Effect Size = 0.305) and male summer Chinook (Yates' Chi-square = 447.3; P = 0.000; Effect Size = 0.333) (Figure 7.20). A larger percentage of hatchery Chinook returned at younger salt ages than natural-origin fish. This was true for both males and females.

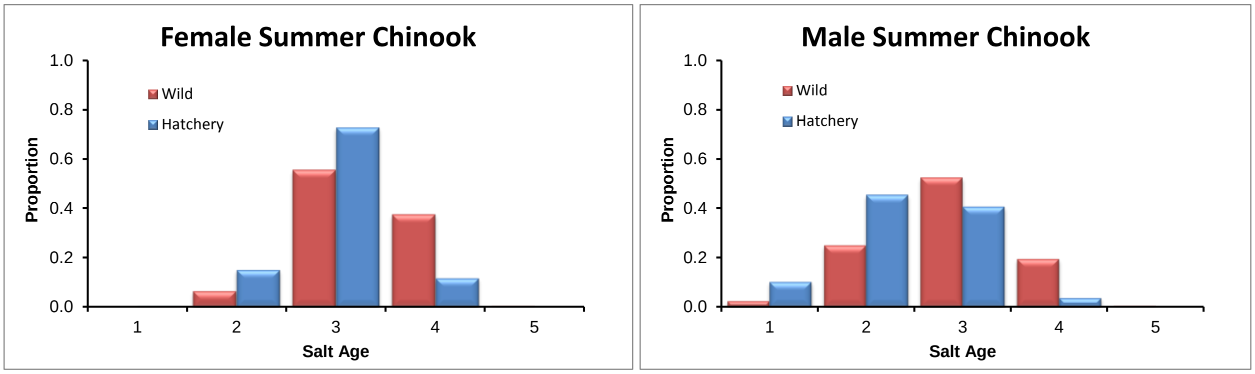


Figure 7.20. Proportion of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Wells Dam and sampled on spawning grounds in the Methow Basin for the combined years 1993-2009. Sample sizes for females = 2,372 wild and 1,740 hatchery Chinook and for males = 2,379 wild and 1,680 hatchery Chinook.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin summer Chinook. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin Chinook of the same age. We used three-way ANOVA to test differences in sizes of hatchery and natural-origin fish.

Because hatchery and natural-origin summer Chinook out-migrate at different ages, we analyzed differences in sizes at salt age. The size at salt age differed significantly between hatchery and natural-origin female and male summer Chinook (Table 7.11; Figure 7.21). The significant three-way interaction term indicated that differences in sizes between hatchery and natural-origin Chinook were affected by salt age and sex. Female Chinook were significantly larger than males and hatchery and natural-origin Chinook differed significantly in size at salt age (Figure 7.21). On average, female hatchery and natural-origin Chinook differed by 1-3 cm. Male hatchery and natural-origin Chinook also differed by 1-3 cm. These differences are probably not significant biologically.

Table 7.11. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Methow summer Chinook. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Salt Age (1, 2, 3, 4, and 5), resulting in a 2 x 2 x 5 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	759.81	21.52	0.000	0.996
Origin	1	319.19	9.04	0.003	0.852
Sex x Origin	1	692.30	19.61	0.000	0.993
Age	4	28,600.05	810.14	0.000	0.999
Sex x Age	4	1,304.96	36.96	0.000	0.999
Origin x Age	4	306.85	8.69	0.000	0.999
Sex x Origin x Age	4	262.90	7.45	0.000	0.997
Error	7,982				

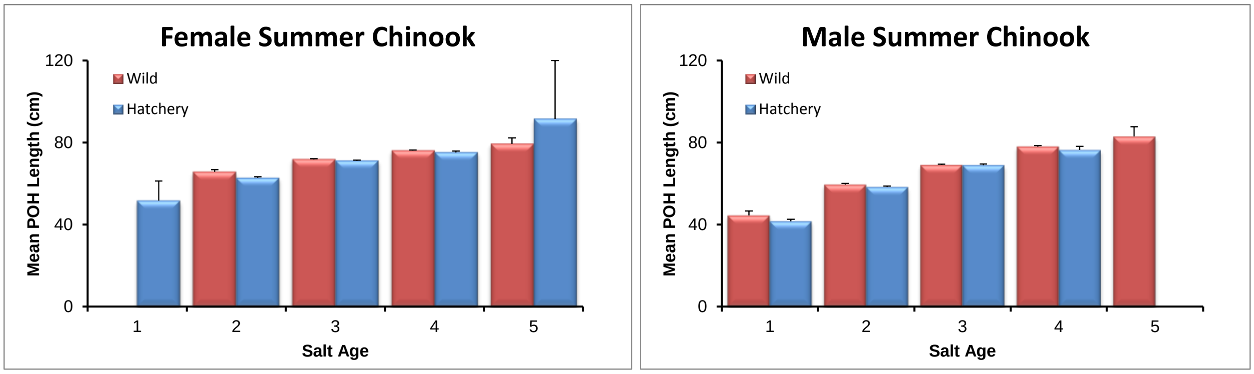


Figure 7.21. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Wells Dam and sampled on spawning grounds in the Methow Basin for the combined years 1993-2009. Sample sizes for females = 2,311 wild and 1,680 hatchery Chinook and for males = 2,325 wild and 1,653 hatchery Chinook.

Conclusions

Genetic analyses indicated that the supplementation program has not affected the genetic structure of the Methow summer Chinook population. There was no significant difference between hatchery-origin and natural-origin summer Chinook. In addition, there was no evidence that the supplementation program has reduced the effective population size of the Methow summer Chinook population.

Although there were no significant genetic differences between hatchery and natural-origin summer Chinook, there were significant differences between the two groups in age at maturity and size at maturity. Analysis of age at maturation, based on salt age, indicated that natural-origin Chinook matured later than hatchery fish. In addition, natural-origin fish were larger than hatchery fish across most age groups. The differences in size at maturity are probably not significant biologically.

7.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.3 (the calculated target value in Murdoch and Peven 2005).

In eight of the 15 years, HRRs exceeded NRRs, regardless if harvest was or was not included (Figure 7.22). Thus, the number of years that HRRs exceeded NRRs was not significant (paired-sample sign test; P = 0.500 for analyses with and without harvest). HRRs exceeded the estimated target value of 5.3 in two out of the 15 years (Figure 7.22). Based on the one-sample sign test, the number of times HRRs exceeded the target value was not significant (P = 0.999 for analyses with and without harvest).

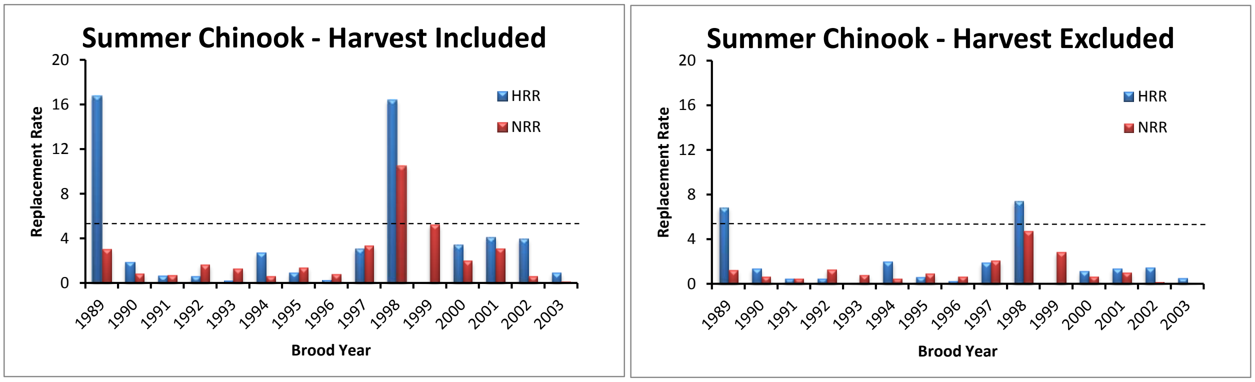


Figure 7.22. Natural and hatchery replacement rates (NRR and HRR, respectively) for Methow summer Chinook, brood years 1989-2003. Figure on the left includes harvested fish; figure on the right does not. The horizontal dashed line represents the target value of 5.3 in Murdoch and Peven (2005).

Conclusions

The Methow summer Chinook supplementation program has not demonstrated a significant full life-cycle survival advantage over natural-origin Chinook. The productivity advantage of hatchery summer Chinook over natural-origin Chinook was 1.5:1. That is, on average, HRRs were only 1.5 times greater than NRRs. This was true regardless if harvested fish were included in the analyses.

7.5 Stray Rates

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Methow Basin. Less than 5% of the brood returns should stray into non-target areas. In addition, hatchery strays from the Methow program should make up less than 5% of the spawning escapement within non-target spawning areas outside the basin and less than 10% of the spawning escapement within non-target spawning areas within the basin. Because the Methow population does not have a well-defined within population structure, we did not evaluate within population straying.

Among Population Stray Rates by Brood Return

Based on brood year analyses, on average, about 4% of the hatchery returns have strayed into non-target spawning streams, falling below the 5% level (Figure 7.23). The number of years that hatchery summer Chinook exceeded the target of 5% was not significant (Sign test, P = 0.962). Only in five of the 16 brood years did stray rates exceed the 5% target. During that 16 year period, percent strays into non-target spawning areas have ranged from 0-15%. Few (<2% on average) have strayed into non-target hatchery programs.

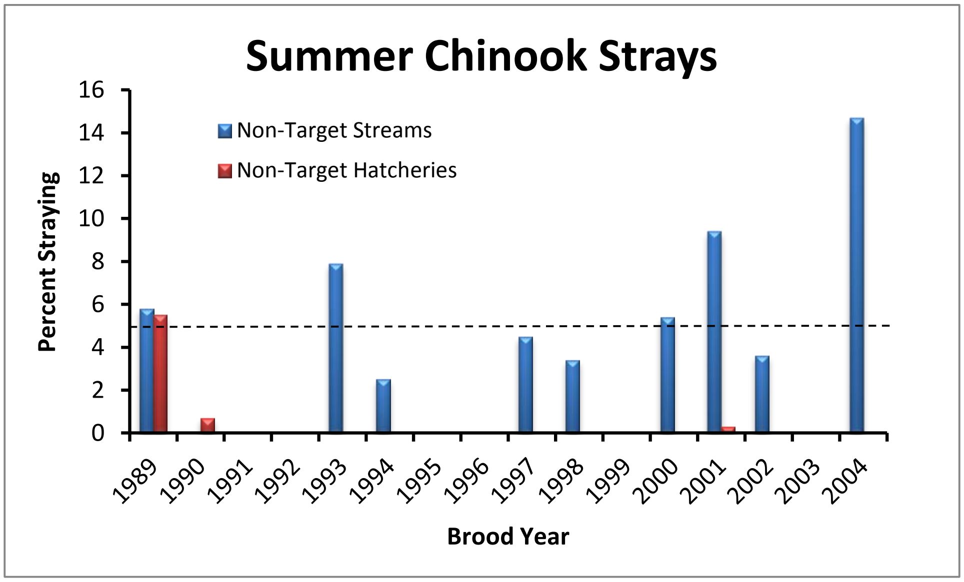


Figure 7.23. Percent of hatchery-origin Methow summer Chinook that strayed to non-target spawning streams and non-target hatchery programs, by brood years 1989-2004. Percent strays should be less than 5% (represented by the horizontal dashed line).

Among Population Stray Rates by Return Year

Although hatchery-origin Methow summer Chinook have strayed into the Entiat, Chelan, and Okanogan basins, they have made up less than 5% of the spawning escapement within those basins (Figure 7.24).

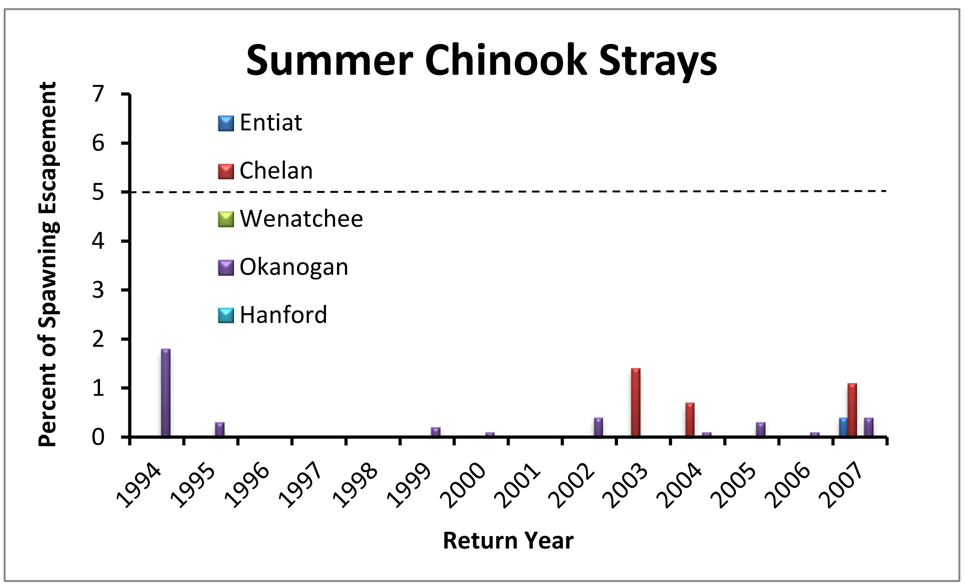


Figure 7.24. Percent of the spawning escapement within non-target spawning populations that are made up of Methow hatchery Chinook, by return years 1994-2007. Percentages should be less than 5% (represented by the horizontal dashed line).

Conclusions

Stray rates of hatchery summer Chinook have been relatively low, with about 4%, on average, of the brood year returns straying into non-target spawning areas. In only five of the 16 brood years did stray rates exceed the 5% target. Hatchery summer Chinook have strayed into the Entiat, Chelan, and Okanogan basins, but they made up less than 5% of the spawning escapements within those basins.

7.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the Methow summer Chinook supplementation program is to release smolts that average at least 176 mm long (fork length) and 45.4 g. Since the beginning of the supplementation program, the average size of summer Chinook released has nearly always been below the length target (Figure 7.25). Over brood years 1991-2008, lengths have averaged about 89% of the target length. In contrast, weight has met or exceeded the target in five of the 18 years and averaged about 98% of the supplementation goal (Figure 7.25).

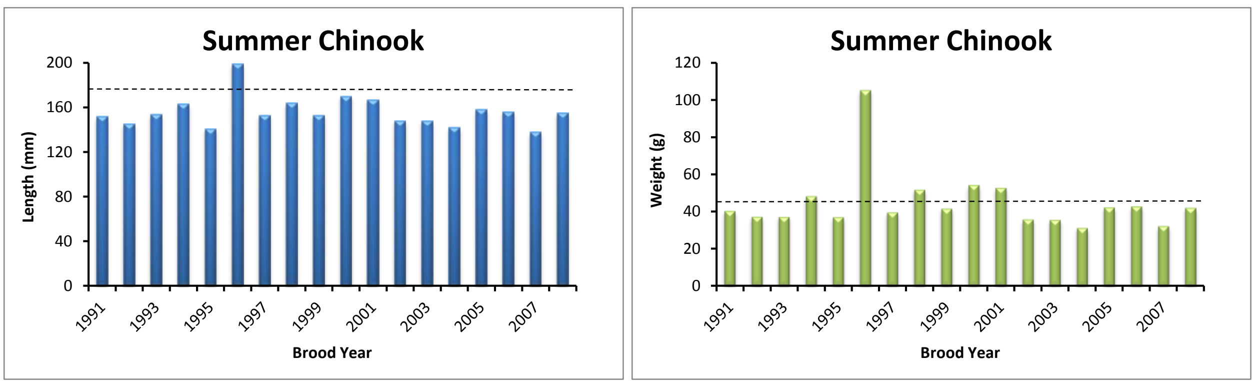


Figure 7.25. Average lengths (mm) and weights (g) of summer Chinook salmon released into the Methow River for brood years 1991-2008. The dashed horizontal lines represent the target length (176 mm) and target weight (45.4 g).

The length and weight targets for the Methow summer Chinook hatchery program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Methow summer Chinook based on data collected within the hatchery over a five-year period (Figure 7.26). Based on this relationship, if the target is to release smolts at 176 mm, then the target weight of the smolts should be 55.3 g, not 45.4 g. On the other hand, if the goal is to release smolts that weigh 45.4 g, then the fork length at release should be 165 mm, not 176 mm.

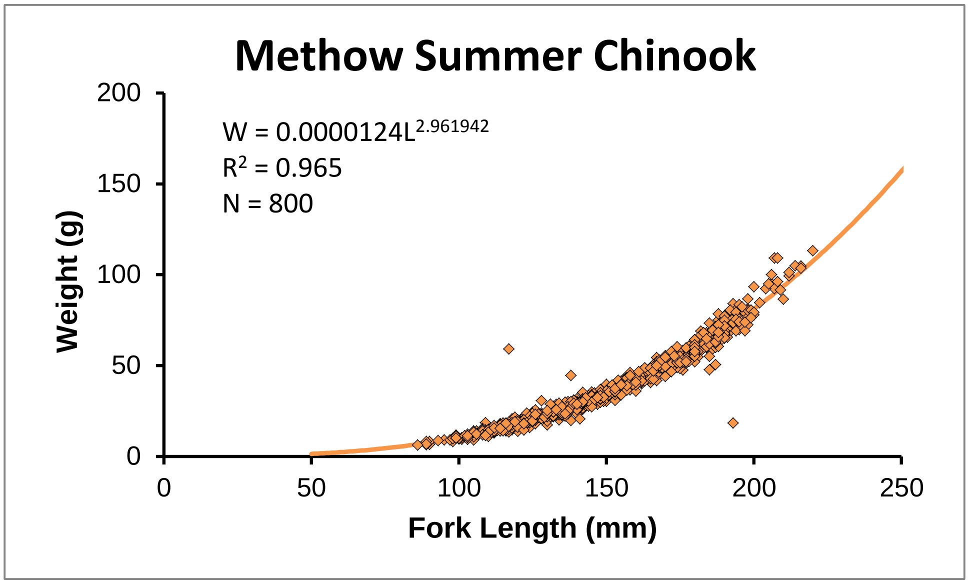


Figure 7.26. Relationship between fork length (mm) and weight (g) of juvenile Methow summer Chinook salmon sampled in the hatchery during 2003-2007.

Number of Hatchery Fish Released

The goal of the Methow summer Chinook supplementation program is to release 400,000 summer Chinook smolts into the Methow River. The program reached or exceeded the goal of releasing 400,000 smolts in nine of the 20 years (Figure 7.27). Over the 1989-2008 brood years, the program released an average of 375,829 smolts, which is about 94% of the original program goal.

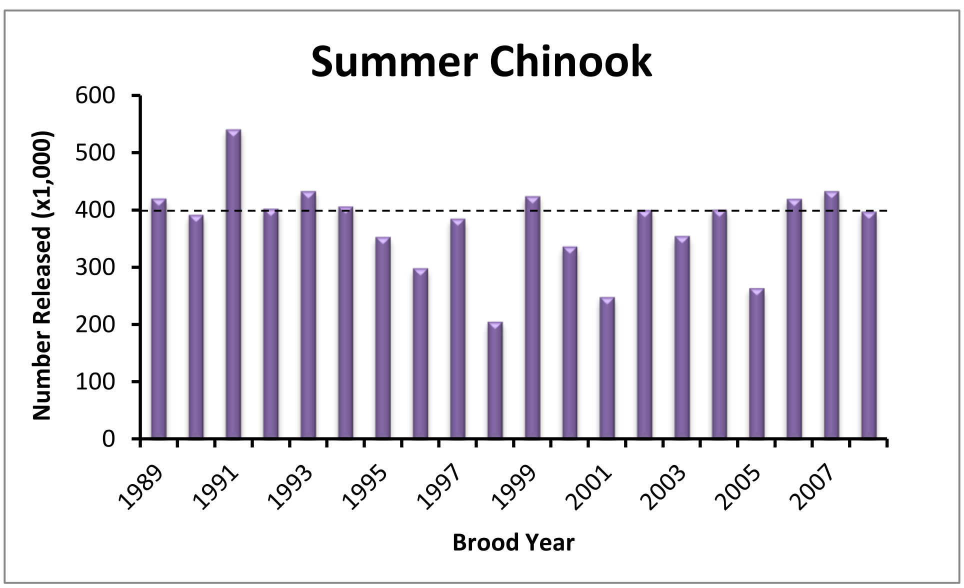


Figure 7.27. Number of summer Chinook smolts released into the Methow River for brood years 1989-2008. The dashed horizontal line represents the target release number (400,000 smolts).

Conclusions

The Methow summer Chinook supplementation program has not consistently achieved its goal of releasing 400,000 fish per year. Since the beginning of the program, it has released on average about 376,000 smolts, which is about 94% of the goal. This is in part because of relatively low unfertilized-egg to eyed-egg survival. The unfertilized-egg to eyed-egg survival has averaged 86% (standard = 92%). The reduction in the size of the program to 200,000 smolts should help the program achieve its release goal.

The size of summer Chinook smolts released into the Methow River has been below the size goals for the program. Average lengths of smolts released have nearly always been below the threshold of 176 mm. In addition, in most years, the average weight of the released smolts has been below the goal of 45.4 g. Because of the unique relationship between length and weight of Methow summer Chinook, the current program cannot achieve both the length and weight targets. More realistic targets should be set based on the length-weight relationship specific to this population.

7.7 Freshwater Productivity

Because there are no juvenile summer Chinook data for the Methow Basin, we cannot assess whether the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of the Methow population.

7.8 Harvest

Harvest Rates

Most of the harvest on hatchery-origin Methow summer Chinook occurred in the ocean (Figure 7.28). Ocean harvest has constituted 13% to 99% of all harvest on Methow summer Chinook. Brood years 1989 and 1998 provided the largest harvests, while brood years 1996 and 1999 provided the lowest (Hillman et al. 2011). The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams. The non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam.

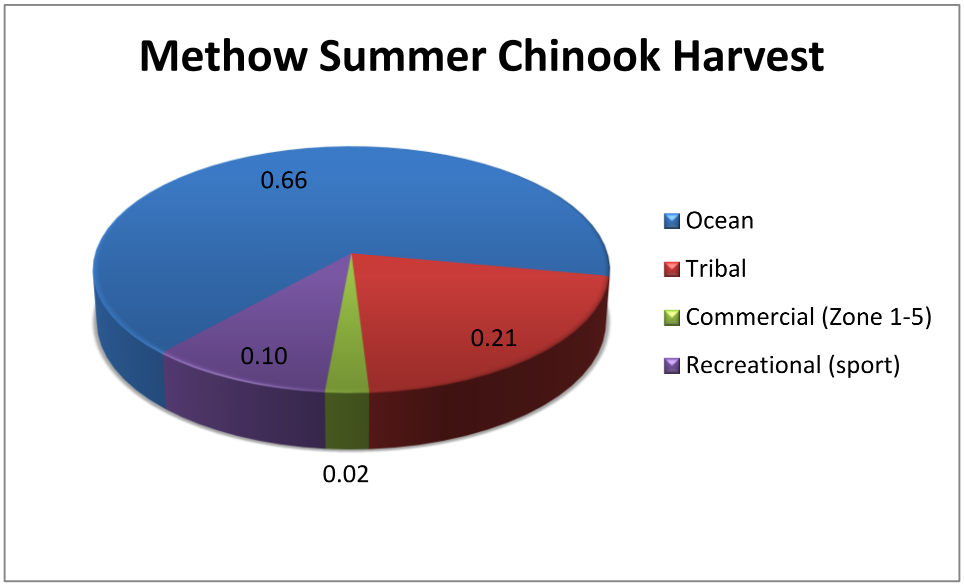


Figure 7.28. Mean allocation of Methow summer Chinook harvested among the different fisheries for brood years 1989-2004. The total number of fish harvested across the brood years was 6,845 (average = 428 fish/year; range = 14-2,113).

WDFW (Bartlett and Tweit 2006) established a spawning escapement goal of 3,500 adult summer Chinook for the combined Methow and Okanogan basins. In order to estimate the fraction of this total escapement that belongs to each basin, we estimated the total kilometers of summer Chinook spawning habitat within each of the basins. This work revealed that the Methow and the Okanogan basins contained 55% and 45%, respectively, of the spawning habitat. We applied these percentages to the spawning escapement goal and determined a spawning escapement of 1,925 adults for the Methow and 1,575 for the Okanogan. An additional 222 adults are needed to meet the goal of the Methow supplementation program. Thus, a total of 2,147 adult summer Chinook are needed to satisfy broodstock and WDFW escapement goals for the Methow. Based on the total escapement goal of 2,147 adults, there were three brood years that produced escapements large enough to support a terminal fishery (Figure 7.29).

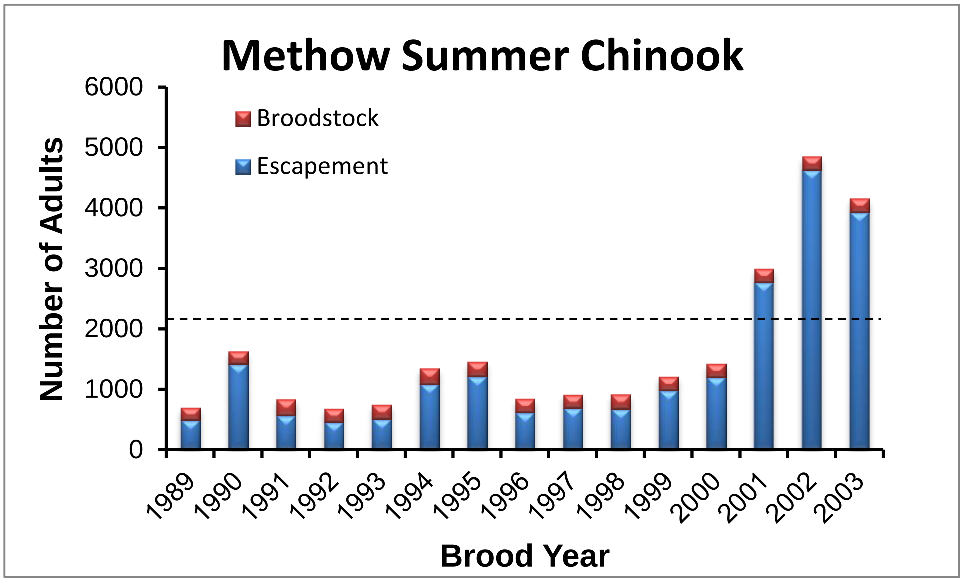


Figure 7.29. Numbers of summer Chinook adults collected for broodstock and numbers that spawned naturally within the Methow Basin for brood years 1989-2003. The dashed horizontal line represents the number needed to satisfy the broodstock collection goal (222 adults) plus the number needed to meet the WDFW spawner escapement goal for the Methow (1,925 spawners).

Conclusions

Methow summer Chinook are harvested primarily within the ocean fisheries. The number of summer Chinook harvested per brood year averaged 428 adults/year (range, 14-2,113). Assuming a total escapement of 2,147 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), since 1989, three brood years produced escapements large enough to support a terminal fishery.

7.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available date were unable to show that the Methow summer Chinook supplementation program has increased total spawning abundance and NORs in the Methow Basin.
2. Based on comparisons with a reference population, the supplementation program does not appear to have reduced the productivity of the population. There was no significant association between pHOS and the residuals form the Ricker stock-recruitment model. In addition, pHOS has ranged from 0.00 to 0.62 (averaged, 0.32).
3. Although there was no difference in the migration timing of hatchery and natural-origin summer Chinook (measured at Wells Dam), there was a significant difference in spawn timings, with natural-origin fish spawning about 3-4 days earlier than hatchery-origin fish. This difference in spawn timing may not be significant biologically.
4. The spawning distribution of hatchery and natural-origin summer Chinook in the Methow River differed significantly, with a higher proportion of hatchery-origin Chinook spawning in the lower river and a higher proportion of natural-origin Chinook spawning in the upper river.

5. There was no evidence that supplementation significantly affected allele frequencies within and between natural and hatchery-origin summer Chinook.
6. There was no evidence that the Methow supplementation program has reduced the effective population size of the Methow summer Chinook population.
7. Based on salt age, hatchery fish matured at an earlier age than natural-origin fish. This is likely related to growth rates within the hatchery and the large size at release.
8. Natural-origin summer Chinook were larger than hatchery-origin summer Chinook across most age groups. The differences in mean size at maturity (based on salt age) are probably not significant biologically.
9. HRRs were on average 1.5 times greater than NRRs. This was true regardless if harvested fish were included in the analyses.
10. On average, about 4% of the hatchery brood-year returns have strayed into other spawning areas. Only five of the 16 brood years had stray rates that exceeded the 5% threshold.
11. Hatchery summer Chinook from the Methow program have strayed into the Entiat, Chelan, and Okanogan basins, but they made up less than 5% of the spawning escapement within those basins.
12. The supplementation program has not consistently achieved its goal of releasing 400,000 smolts per year. Since the beginning of the program, it has released on average about 376,000 smolts, which is about 94% of the goal. The reduction in the size of the program to 200,000 smolts should help the program achieve its release goal.
13. The average lengths of smolts released have nearly always been below the target of 176 mm. In most years, the average weight of the released smolts has been below the goal of 45.4 g. More realistic targets should be set based on the length-weight relationship specific to Methow summer Chinook. In addition, size targets should be selected that minimize the returns of jacks and mini-jacks.
14. Methow summer Chinook were harvested primarily within the ocean fisheries. The average number of Methow summer Chinook harvested per brood year was 428 adults/year.
15. Assuming a total escapement of 2,147 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), three brood years produced escapements large enough to support a terminal fishery.

The Methow summer Chinook supplementation program has not consistently achieved its goal of releasing 400,000 smolts into the Methow River. This is in part because of relatively low unfertilized-egg to eyed-egg survival rates. The goal is to achieve a 92% unfertilized-egg to eyed-egg survival rate. Since the beginning of the program, the survival rate has averaged 86%. It is unknown why this survival rate has been lower than expected. It may be a natural phenomenon associated with summer Chinook, or it may be related to the warm river temperatures that occur at the time broodstock are collected at Wells Dam. These warmer temperatures may negatively affect the fertilization rates of eggs. Additional work is needed to determine the cause of the relatively low unfertilized-egg to eyed-egg survival rates. Importantly, the reduction in the size of the program to 200,000 smolts should help the program achieve its release goals.

The size of summer Chinook smolts released has not met the program goals. This may be because the length and weight targets for the program were not based on the unique length-weight relationship of Methow summer Chinook. If the goal is to release summer Chinook smolts at 45.4 g, then the fork length at release should be about 165 mm, not 176 mm. It is unknown if SARs and HRRs would increase if fish were released at the program goal of 176 mm. It is likely that releasing summer Chinook at a larger size will further decrease the age at maturity (i.e., increase the return of mini-jacks and 1and 2-salt fish).

Based on analysis of CWTs, Methow summer Chinook are exploited most heavily within the ocean fisheries, which makes up about 66% of the total harvest. On average, about 0.151% of the brood year releases were harvested. In contrast, on average, about 0.129% of the releases escaped to spawn. These relatively poor returns are reflected in the hatchery return rates, which were on average only 1.5 times greater than natural return rates. Of those that escaped to spawn, about 4% of the brood returns strayed into non-target spawning streams. Only five of the 16 brood years had stray rates that exceeded the 5% target limit established for the program. Methow strays made up less than 5% of the spawning escapement within non-target spawning areas. Thus, straying does not appear to be a reason for the relatively low return rates to the Methow Basin.

Based on examination of allele frequencies, the supplementation program has not affected the genetic characteristics or effective population size of the population. In contrast, there were differences in phenotypic characteristics. For example, hatchery fish returned at an earlier salt age than natural-origin fish with more 2 and 3-salt females and fewer 4-salt females. The spawning distribution of hatchery females was more concentrated in the lower river. That is, they were distributed more downstream than natural-origin females. Finally, there were differences in size-at-age between hatchery and natural-origin fish, but most of these differences are probably not significant biologically. Some of these phenotypic differences may be related to unintentional selective broodstock collection. It is unknown why hatchery fish returned at an earlier salt age than the natural-origin fish. This is a common outcome among hatchery programs and may be related to rapid growth rates in the hatchery and size at release.

The available data do not indicate that the Methow summer Chinook supplementation program has significantly increased the spawning escapement and NORs in the Methow Basin. This is probably because HRRs were only 1.5 times greater than NRRs. Since brood year 1989, SARs for Methow summer Chinook have averaged 0.00227, which is about 40% of the mean SAR for Wenatchee summer Chinook and 22% of the mean SAR for Okanogan summer Chinook. Possible reasons why HRRs and NORs have not increased as expected include:

- *Ecological Interactions*—Eggs for the Methow program generally come from female broodstock with high ELISA values. Thus, the relatively low SARs and HRRs for this program may be related to an increased incidence of disease. In addition, with the large numbers of hatchery fish released in the upper Columbia Basin, it is possible that the survival and productivity of Methow summer Chinook have been reduced. The HETT is currently evaluating the effects of hatchery releases on non-target taxa of concern.
- *Hatchery Rearing Conditions*—Methow summer Chinook are held on well water throughout the winter period. Because the well water temperatures are generally highest

during the winter period, overwinter growth rates of fish may be abnormally high. These higher growth rates may increase the production of mini-jacks, which are rarely sampled on the spawning grounds. Thus, the relatively low SARs and HRRs may be an artifact of biased sampling methods on the spawning grounds.

- *Broodstock Collection*—Broodstock for the Methow summer Chinook program are collected at Wells Dam, which includes a mix of summer Chinook destined for the Methow, Okanogan, and Columbia rivers. It is likely that summer Chinook adapted to the Okanogan and Columbia rivers are included in the Methow program. This could reduce the productivity of hatchery fish.

The lack of a significant increase in spawning escapements and NORs is a potential challenge for meeting supplementation objectives. It is important to note, however, that the program has not reduced NORs and population productivity. Nevertheless, changes may be needed to improve the quality of the program. The program may benefit from collecting broodstock from the Methow Basin, eliminating the inclusion of eggs from high ELISA females, establishing stock-specific size targets and growth rates, and distributing hatchery spawners more evenly throughout the Methow Basin. The reduction in the size of the program to 200,000 smolts will decrease rearing densities and should reduce the incidence of disease within the hatchery and acclimation facilities.

SECTION 8: OKANOGAN/SIMILKAMEEN SUMMER CHINOOK

The goal of summer Chinook salmon supplementation in the Okanogan Basin is to use artificial production to replace adult production lost because of mortality at Well, Rocky Reach, and Rock Island dams, while not reducing the natural production or long-term fitness of summer Chinook in the basin. The Rock Island Fish Hatchery Complex began operation in 1989 under funding from Chelan PUD. The Complex operated originally through the Rock Island Settlement Agreement, but since 2004 has operated under the Anadromous Fish Agreement and Habitat Conservation Plans.

Adult summer Chinook are collected for broodstock from the run-at-large at the east ladder trapping facility at Wells Dam. The goal is to collect up to 334 adult summer Chinook for the Okanogan program. Broodstock collection occurs from about 7 July through 15 September with trapping occurring no more than 16 hours per day, three days a week. If natural-origin broodstock collection falls short of expectation, hatchery-origin adults can be collected to make up the difference.

Adult summer Chinook are spawned and reared at Eastbank Fish Hatchery. Juvenile summer Chinook are transferred from the hatchery to Similkameen Acclimation Pond in October. In addition, since 2005, about 20% (100,000) of the juveniles are transferred to Bonaparte Pond. Chinook are released from the ponds in April to early May.

The production goal for the Okanogan summer Chinook supplementation program is to release 576,000 yearling smolts[10] into the Similkameen and Okanogan rivers at ten fish per pound. Targets for fork length and weight are 176 mm (CV = 9.0) and 45.4 g, respectively. Over 90% of these fish are marked with CWTs. In addition, since 2009, about 5,000 to 10,000 juvenile summer Chinook have been PIT tagged annually. These data are summarized in Hillman et al. (2011).

8.1 Abundance, Recruitment, and Productivity

Adult Returns

An important goal of the summer Chinook supplementation program is to increase the number of spawners in the Okanogan Basin. We tested the success of the supplementation program at increasing total spawners (both hatchery and natural-origin spawners) by analyzing trends and mean abundances before and during supplementation. We also compared trends and mean abundance of Okanogan summer Chinook with a reference population (Deschutes fall Chinook). Appendix C describes in detail the methods we used for selecting reference populations.

We first examined the trends in abundances of summer Chinook spawners in the Okanogan Basin before and during supplementation. Trend analysis indicated that before supplementation there was no apparent trend (i.e., there was no increase or decrease in abundance). During supplementation, abundance trended upward, but the change in trend before and during supplementation was not significant (Figure 8.1). When we compared the trends of the Okanogan population with the reference population, we found that like the Okanogan there was no apparent trend in the reference population before the Okanogan was supplemented. During

[10] The HCP Hatchery Committees recently agreed to reduce this program to 166,569 summer Chinook smolts.

the period of supplementation, abundances in both the Okanogan and reference populations trended upward (Figure 8.2). These analyses do not clearly indicate that supplementation caused an increase in total spawning abundance in the Okanogan following supplementation.

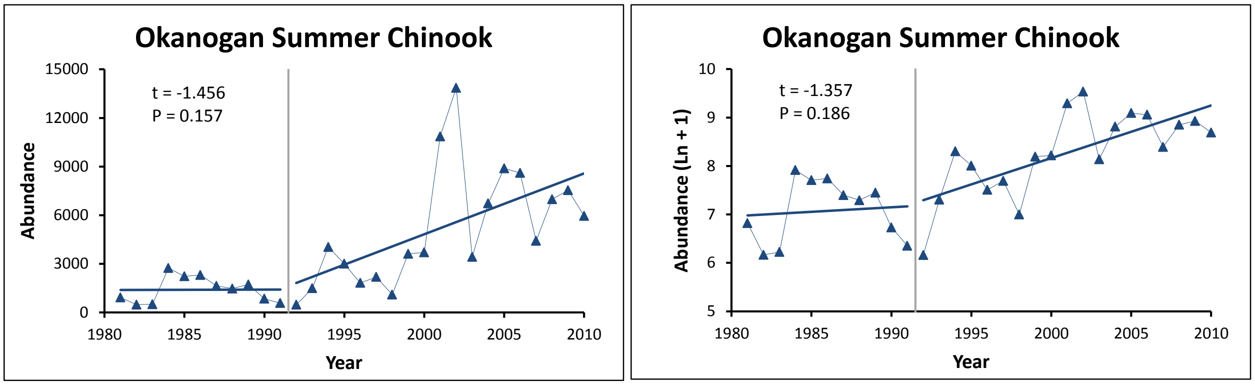


Figure 8.1. Trends in Okanogan summer Chinook spawner abundance before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

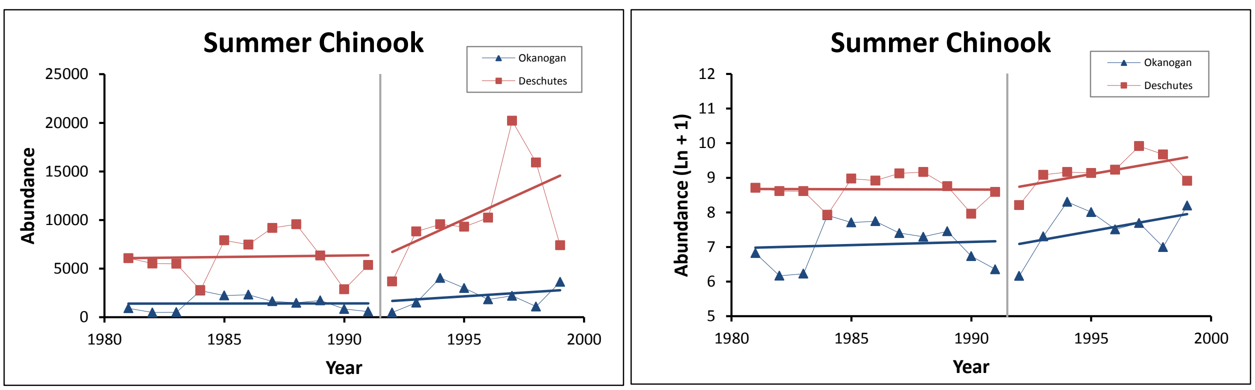


Figure 8.2. Trends in summer Chinook spawner abundance in the Okanogan and reference population. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.

We then compared the mean spawner abundance before supplementation with the mean abundance during supplementation. Mean spawner abundance during the supplementation period was significantly greater than the pre-supplementation spawner abundance (Table 8.1). When we compared the Okanogan abundance with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase spawning abundance in the Okanogan Basin (Table 8.2; Figure 8.3). This is because mean abundance in the reference stream also increased significantly during the period of supplementation in the Okanogan Basin.

Table 8.1. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Okanogan summer Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	1,399	5,192	-4.421	0.000	0.000	-5,368 – -2,081
LN Abundance	7.1	8.3	-4.353	0.000	0.000	-1.72 – -0.68
NORs	5,225	8,817	-1.065	0.305	0.334	-9,512 – 3,286
LN NORs	8.28	8.29	-0.016	0.988	0.986	-0.87 – 0.92
Productivity	5.0	2.6	1.465	0.162	0.155	-0.77 – 5.50
LN Productivity	1.5	1.0	1.742	0.096	0.094	-0.05 – 1.07
Adj Productivity	5.0	2.6	1.465	0.162	0.160	-0.82 – 5.60
LN Adj Productivity	1.5	1.0	1.742	0.096	0.097	-0.06 – 1.08

Table 8.2. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Deschutes	0.293	0.613	0.03	0.837	-0.161 – 0.186
LN Spawner Abundance					
Deschutes	-0.106	0.458	0.00	0.915	-0.071 – 0.059

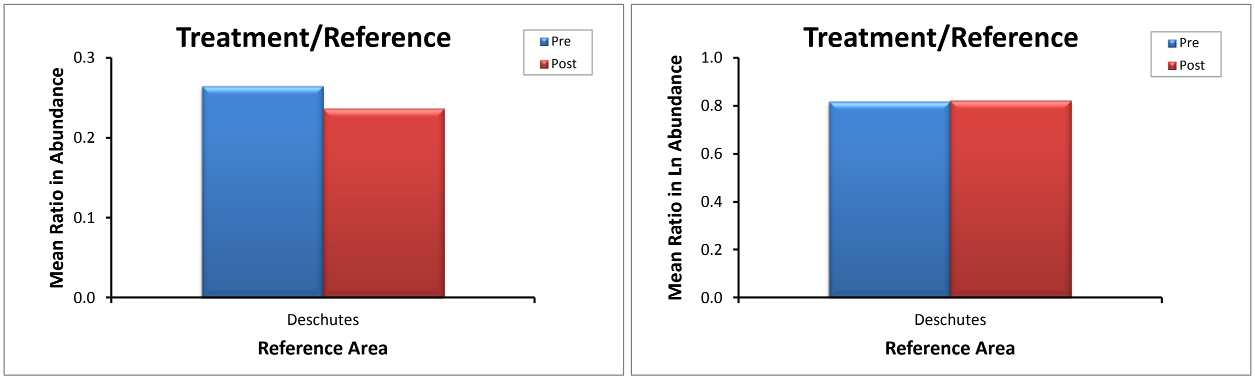


Figure 8.3. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance data before (pre) and after (post) summer Chinook supplementation in the Okanogan Basin. Positive effects of supplementation on spawner abundance are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

As a final test of the effects of supplementation on total spawner abundance, we evaluated if the number of hatchery fish that spawned naturally was greater than the total number of fish taken for broodstock. Because the number of hatchery and natural-origin adults collected for broodstock supports both the Methow and Okanogan/Similkameen programs, the number of hatchery fish spawning naturally includes estimates from both the Methow and Okanogan/Similkameen rivers. Excluding the first four years following the start of the supplementation program, when no hatchery fish had yet returned, numbers of hatchery fish spawning naturally exceeded the total number of fish taken for broodstock in 16 of the 17 years (Table 8.3).

Table 8.3. Numbers of natural-origin (NOB) and hatchery-origin (HOB) summer Chinook included in broodstock and numbers of hatchery-origin summer Chinook spawning naturally (HOS) in the Methow and Okanogan basins.

Brood year	NOB	HOB	Total Broodstock	HOS
1989	1,297	312	1,609	0
1990	828	206	1,034	0
1991	924	314	1,238	0
1992	297	406	703	0
1993	681	388	1,069	769
1994	341	244	585	3,222
1995	173	240	413	2,674
1996	290	223	513	1,412
1997	198	264	462	1,512
1998	153	211	364	735
1999	224	289	513	2,791
2000	164	339	503	2,889
2001	91	266	357	8,267

Brood year	NOB	HOB	Total Broodstock	HOS
2002	247	241	488	11,624
2003	381	101	482	3,194
2004	506	16	522	1,992
2005	391	9	400	3,337
2006	500	10	510	3,788
2007	456	17	473	2,034
2008	404	41	445	4,631
2009	553	5	558	4,005
Average	**433**	**197**	**631**	**2,804**

In summary, although total numbers of spawners (hatchery and natural-origin spawners) increased significantly in the Okanogan Basin during the period of supplementation, the increase did not appear to be related to the supplementation program. This conclusion is based on comparing trends and mean abundances before and after supplementation with a reference population.

Natural-Origin Recruits

Another important goal of the summer Chinook supplementation program is to increase the number of natural-origin recruits (NORs). We tested the success of the supplementation program in increasing NORs by analyzing trends and mean NORs before and during supplementation. We also compared trends and mean NORs of Okanogan summer Chinook with a reference population (Deschutes population). In addition, because NORs can be affected by the capacity of the environment, we adjusted NORs for differences in carrying capacities between the Okanogan and reference populations. We did this by calculating the percent saturation of NORs (Appendix C describes in detail the methods used to calculate percent saturation). Finally, we used Pearson correlation to test the association between NORs and the proportion of adult spawners that were made up of hatchery fish (pHOS).

Trend analysis indicated that before supplementation, NORs decreased over time (Figure 8.4). During the period of supplementation the trend reversed and increased over time. The change in trend before and during supplementation was significant. When we compared the trends of the Okanogan population with the reference population, we found that the reference population also trended downward during the period before the Okanogan was supplemented and, unlike the Okanogan, trended downward during the supplementation period (Figure 8.5). This indicates that the change in trends in the Okanogan population may have been the result of supplementation.

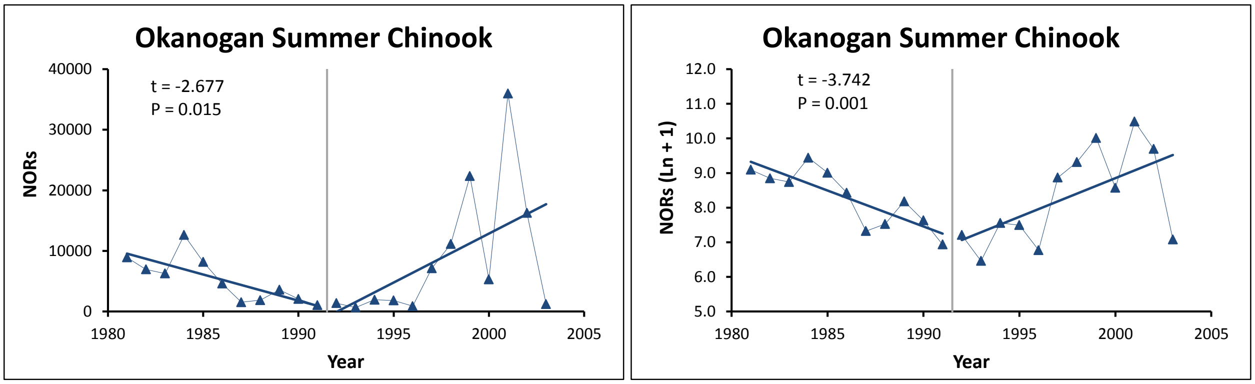


Figure 8.4. Trends in Okanogan summer Chinook NORs before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

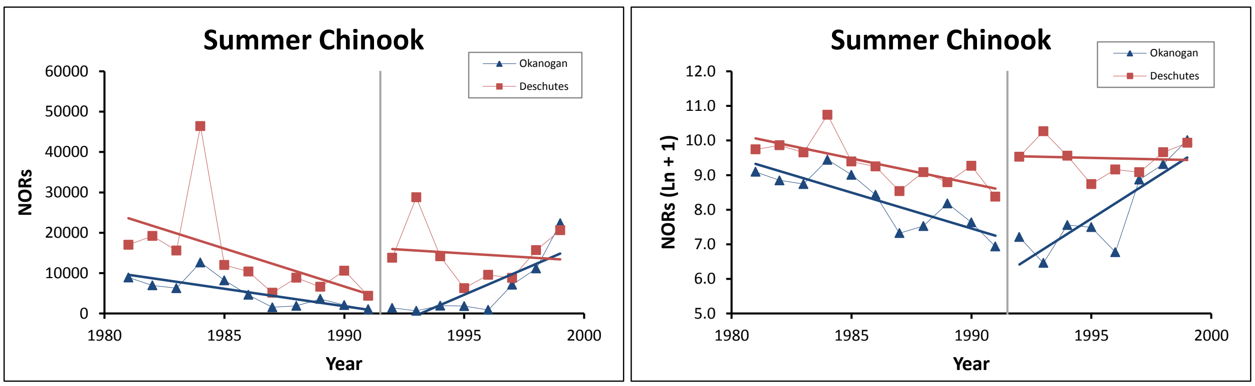
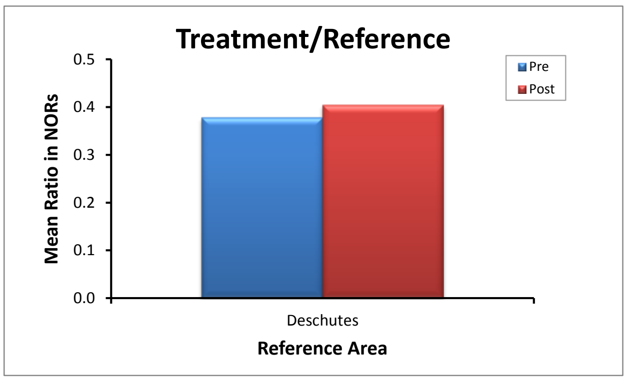


Figure 8.5. Trends in summer Chinook natural-origin recruits (NORs) in the Okanogan and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.

We then compared mean summer Chinook NORs before supplementation with mean NORs during supplementation. Although not significant, mean NORs increased about 69% between the pre- and post-supplementation periods (Table 8.1). When we compared Okanogan NORs with the reference population using ratios (treatment/reference), we found that supplementation did not significantly increase NORs in the Okanogan Basin (Table 8.4; Figure 8.6).

Table 8.4. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Deschutes	-0.175	0.433	0.03	0.867	-0.286 – 0.261
LN Natural-Origin Recruits					
Deschutes	0.931	0.811	0.05	0.368	-0.048 – 0.137



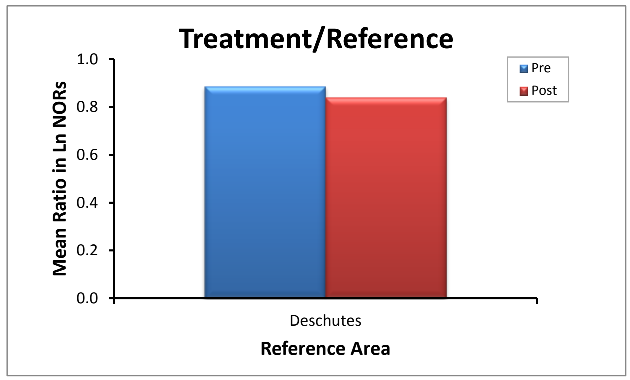


Figure 8.6. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) natural-origin recruits (NORs) data before (pre) and after (post) summer Chinook supplementation in the Okanogan Basin. Positive effects of supplementation on NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars.

Next, we analyzed the effects of supplementation on filling the capacity of the habitat with NORs. The Ricker model derived the carrying capacity (K_R) estimates for the Okanogan and reference populations. The mean fraction of the carrying capacity filled with Chinook NORs before and during supplementation for the Okanogan and reference population is provided in Table 8.5. These data indicate that for the Okanogan population, the mean fraction of the K_R filled with fish increased from the pre-supplementation period through the supplementation period (Table 8.5). The fraction of K_R filled with adult recruits for both populations trended downward during the pre-supplementation period (Figure 8.7). During the supplementation period, however, the fraction of K_R filled with adult recruits trended upward for the Okanogan population, but not for the reference population.

Table 8.5. Statistical results comparing the fraction of the carrying capacity that was filled with Chinook NORs in the Okanogan and reference population before and during supplementation of Okanogan summer Chinook. The Ricker model estimated carrying capacity for each population.

Populations	Mean scores		Aspin-Welch test	
	Before	During	t-value	P-value
Okanogan	0.37	0.63	-1.064	0.306
Deschutes	1.03	1.06	-0.116	0.454

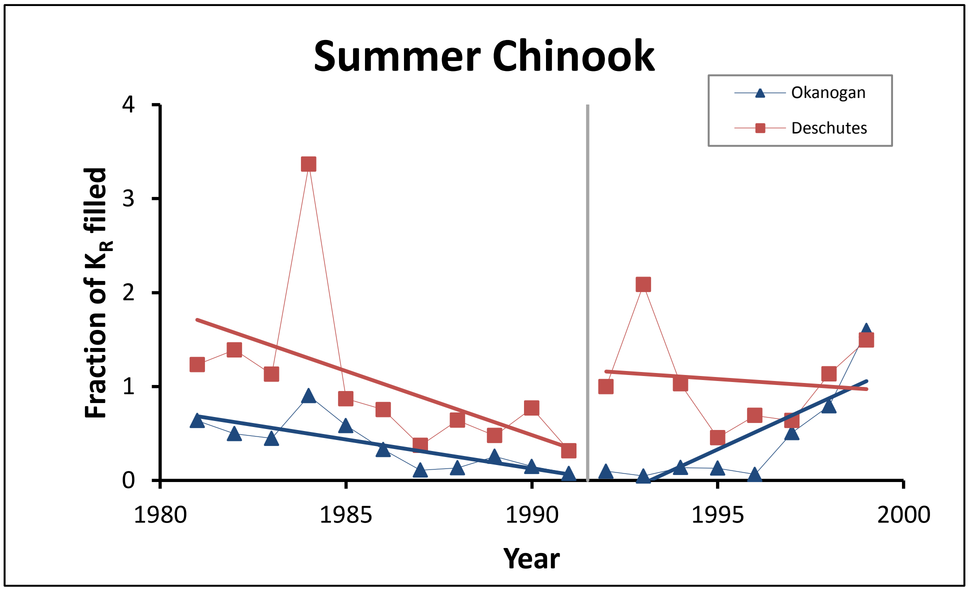


Figure 8.7. Trends in the fraction of the carrying capacity that was filled with Chinook salmon NORs in the Okanogan and reference population before (pre) and during (post) supplementation in the Okanogan Basin. The vertical line in the figure separates the pre- and post-supplementation periods. The Ricker model estimated carrying capacity for each population.

We then compared the mean ratios between the Okanogan and reference populations before and during supplementation using data representing the fraction of K_R filled with adult recruits. Mean ratio scores were similar during the supplementation and pre-supplementation periods (Figure 8.8). This indicated that the mean fraction of K_R filled by adult recruits in the Okanogan was similar to the reference population. Statistical analysis with mean ratios indicated that there was no difference in the mean fraction of K_R filled by adult recruits between the pre-supplementation and supplementation periods (Table 8.6).

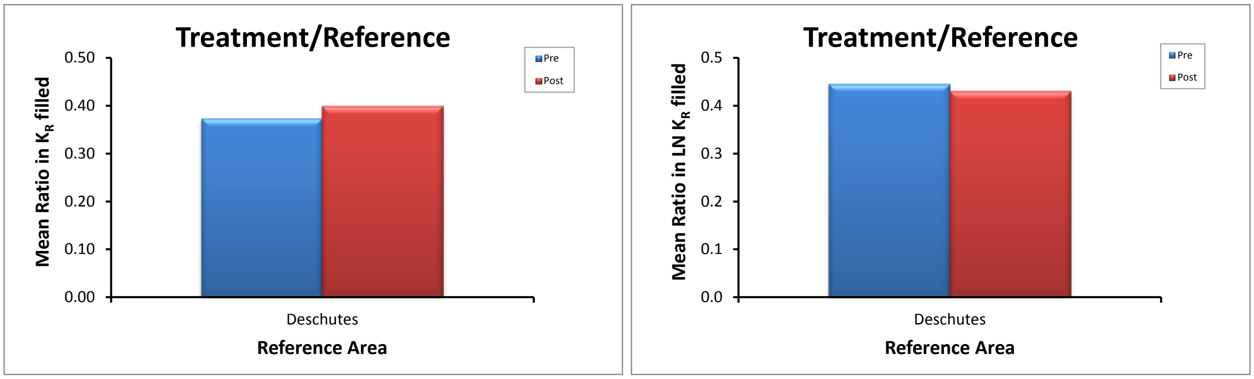


Figure 8.8. Mean ratios (Treatment/Reference) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) summer Chinook supplementation in the Okanogan Basin.

Table 8.6. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with summer Chinook NORs. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test	Bootstrap 95% CI
	t-value	P-value	Effect size	P-value	
Fraction of Capacity Filled					
Deschutes	-0.176	0.432	0.03	0.869	-0.286 – 0.251
LN Fraction of Capacity Filled					
Deschutes	0.107	0.541	0.02	0.913	-0.254 – 0.301

Finally, we used Pearson correlation to test the association between pHOS and NORs. If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the number of NORs, provided the population is below the carrying capacity of the environment. During the pre-supplementation period, NORs averaged 5,225 adults; during the supplementation period, NORs averaged 8,817 adults. This 69% increase in NORs was not associated with pHOS (Figure 8.9). Correlation analysis showed that there was no association between pHOS and NORs.

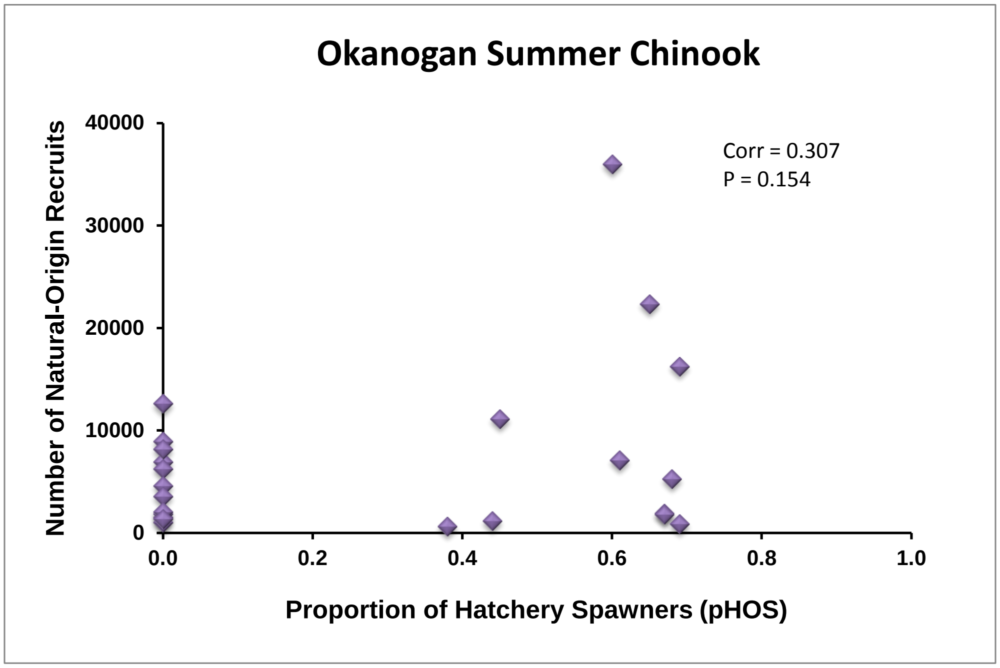


Figure 8.9. Association between the proportion of Okanogan summer Chinook spawners that were made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

In summary, although NORs increased during the period of supplementation in the Okanogan Basin, the increase did not appear to be related to the supplementation program. This conclusion is based on comparing trends and mean NORs before and after supplementation with a reference population. It also includes comparing NORs adjusted for carrying capacity.

Natural Replacement Rates (Productivity)

A supplementation program should not reduce the productivity (adult recruits/spawner or NRRs) of the supplemented population. Therefore, we evaluated whether the supplementation program has reduced the productivity of summer Chinook in the Okanogan Basin by analyzing trends and mean productivities before and during supplementation. We also compared trends and mean productivities of Okanogan summer Chinook with a reference population (Deschutes population). In addition, because productivity can be affected by density (density-dependent effects), we adjusted productivities by calculating separate density-independent productivities and density-dependent productivities and then combining them into a single test (Appendix C describes in detail the methods used to correct for density dependence). Finally, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the stock-recruitment data.

Trend analysis indicated that before supplementation, productivity decreased over time; during supplementation the trend increased, even though there was large variability in productivity during the supplementation period (Figure 8.10). The change in trend before and during supplementation was significant. When we compared the trends of the Okanogan population with the reference population, we found that the reference population also trended downward during the period before the Okanogan was supplemented (Figure 8.11). During the period of supplementation, unlike the Okanogan population, productivities in the reference population trended downward.

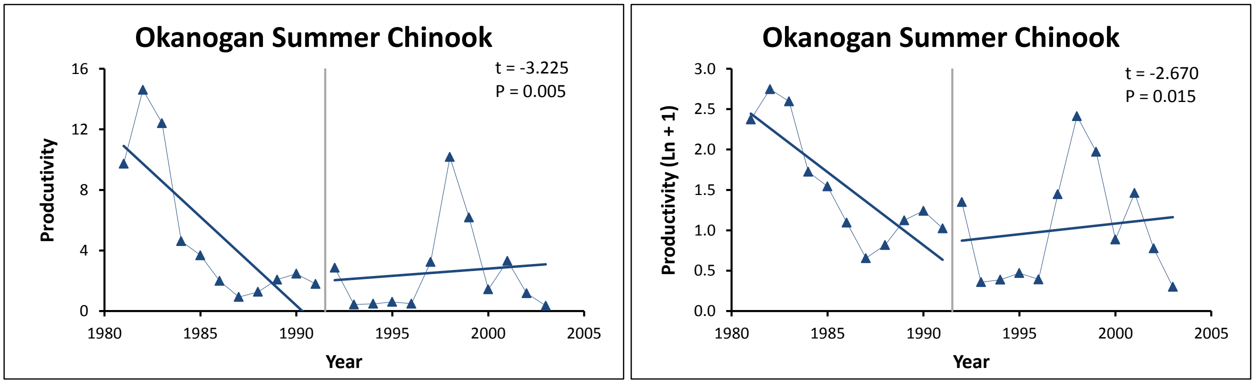


Figure 8.10. Trends in Okanogan summer Chinook productivity (adult recruits/spawner; NRRs) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figure on the left shows untransformed data; figure on the right includes natural-log transformed data. Results of t-tests comparing slopes before and during supplementation are included on the figures.

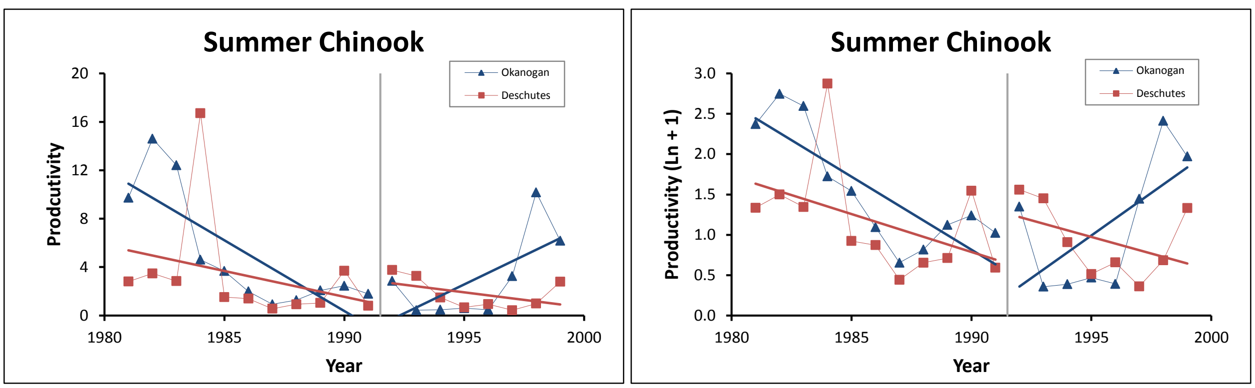


Figure 8.11. Trends in summer Chinook productivity (adult recruits/spawner) in the Okanogan (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.

We then compared mean summer Chinook productivities before supplementation with productivities during supplementation. Mean productivities of Okanogan summer Chinook decreased, but not significantly, between the pre- and post-supplementation periods (Table 8.1). When we compared Okanogan productivities with the reference population using ratios (treatment/reference), we found that supplementation did not significantly decrease productivity in the Okanogan Basin (Table 8.7; Figure 8.12).

Table 8.7. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	-0.448	0.667	0.64	0.673	-2.988 – 2.227
LN Productivity					
Deschutes	-0.115	0.544	0.06	0.909	-0.951 – 1.002

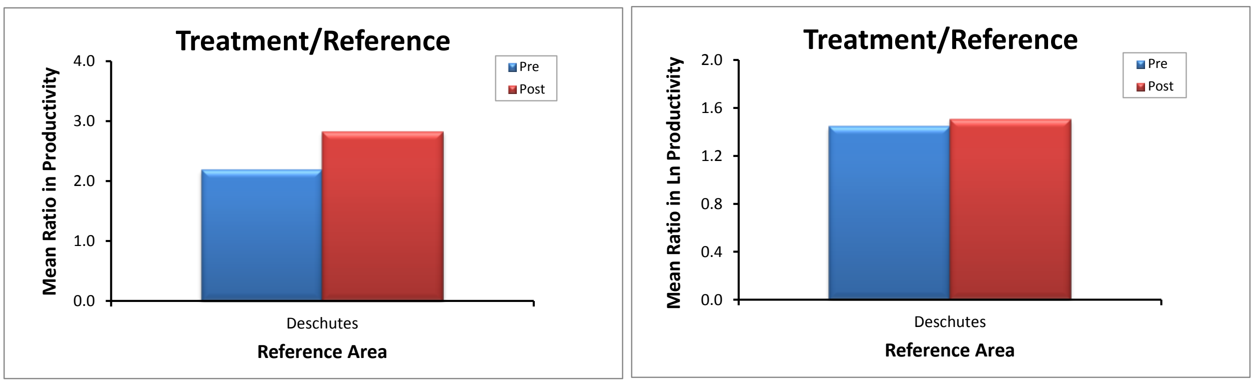


Figure 8.12. Mean ratio (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) productivity (adult recruits/spawner; NRRs) data before (pre) and after (post) summer Chinook supplementation in the Okanogan Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Next, we analyzed the effects of supplementation on productivities adjusted for density dependence. These analyses, based on ratios, indicated that supplementation did not significantly decrease productivity in the Okanogan Basin (Table 8.8; Figure 8.13).

Table 8.8. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed summer Chinook productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Deschutes	0.966	0.175	0.67	0.341	-0.602 – 2.002
LN Productivity					
Deschutes	1.416	0.092	0.39	0.174	-0.099 – 0.914

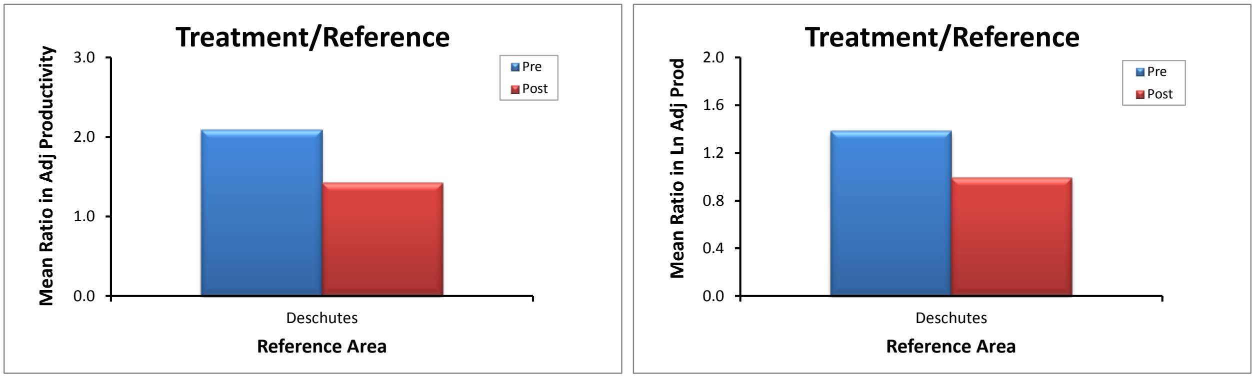


Figure 8.13. Mean ratios (Treatment/Reference) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) summer Chinook supplementation in the Okanogan Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

As a final set of analyses, we used Pearson correlation to test the association between pHOS and the residuals from fitting the Ricker model to the Okanogan summer Chinook stock and recruitment data. There was no association between pHOS and the residuals from the Ricker model, indicating that hatchery-origin spawners may be as productive as natural-origin spawners (Figure 8.14).

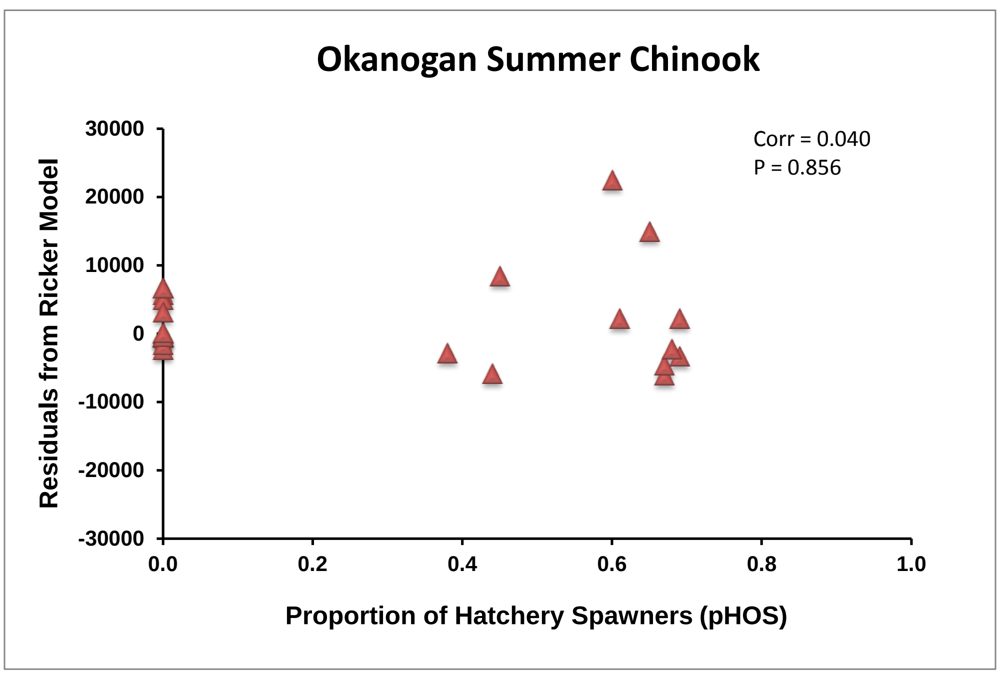


Figure 8.14. Association between the proportion of summer Chinook spawners in the Okanogan Basin that are made up of hatchery adults (pHOS) and the residuals from the Ricker stock-recruitment model. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

In summary, the analyses above indicate that supplementation has not negatively affected the productivity of the Okanogan summer Chinook population. This is based on analysis of both unadjusted and adjusted productivity estimates.

Conclusions

An overall goal of supplementation is to increase total spawning abundance and NORs of the supplemented population, and not reduce the productivity (adult recruits/spawner; NRRs) of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. Total spawning abundance and NORs of summer Chinook increased during supplementation in the Okanogan Basin and in the reference population. Thus, the increase in abundance and NORs in the Okanogan Basin may not be related to the supplementation program. Adjusting NORs for carrying capacity did not reveal a supplementation effect on NORs. In addition, we found no association between pHOS and NORs in the Okanogan Basin.

The data do not indicate that the supplementation program has negatively affected the productivity of the Methow summer Chinook population. Also, there was no association between pHOS and the residuals from fitting the Ricker model to the Okanogan summer Chinook stock and recruitment data.

8.2 Migration and Spawning Characteristics

Migration Timing

A successful supplementation program will produce hatchery fish that have the same migration characteristics and timing as the natural-origin fish. Hatchery adults that migrate at different times than natural-origin fish may be subject to differential survival. We tested differences in migration timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons using data collected during broodstock collection and stock assessment at Wells Dam. Migration timing at Wells Dam includes Chinook from both the Methow and Okanogan basins. At this time, we are unable to assess independent migration timings for the two populations.

We compared cumulative frequency polygons of migration timing of hatchery and natural-origin summer Chinook collected or sampled at Wells Dam during migration years 2007-2010 (Figure 8.15). These data indicate no difference in migration timing of Methow/Okanogan summer Chinook at Wells Dam.

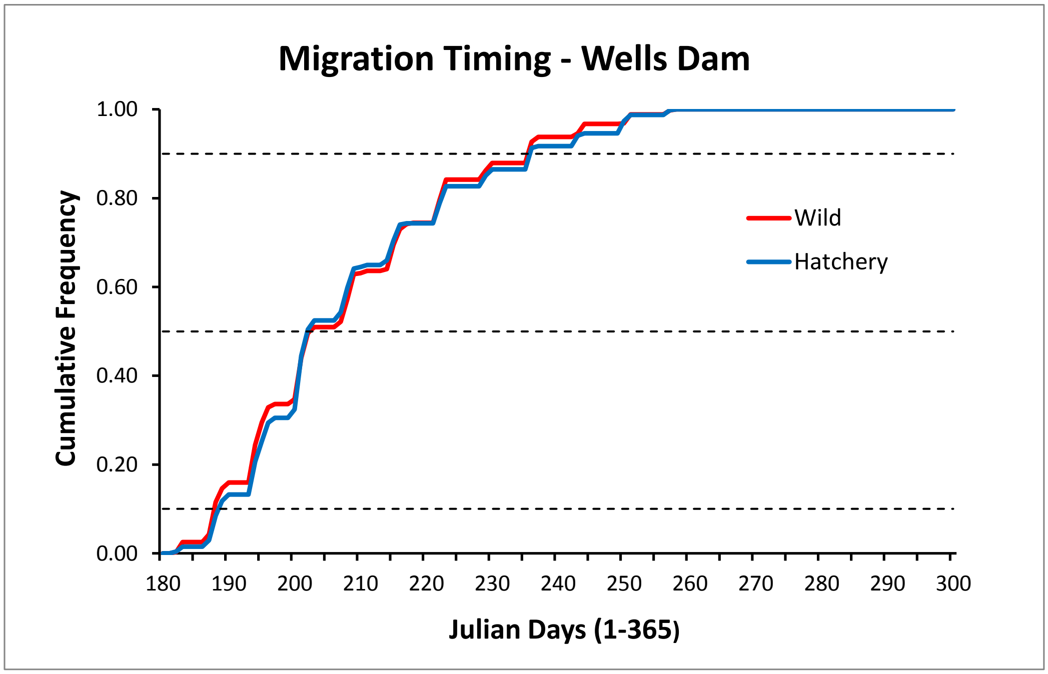


Figure 8.15. Cumulative frequency polygons of migration timings of adult hatchery and natural-origin (wild) Methow/Okanogan summer Chinook sampled or collected at Wells Dam. Migration timing was based on stock assessments and broodstock collection at Wells Dam during 2007-2010 migration years. Horizontal dashed lines indicate the 10th, 50th, and 90th percentiles. Sample sizes = 1,989 wild and 2,826 hatchery Chinook.

We also compared the mean migration timing of hatchery and natural-origin summer Chinook by comparing the mean Julian date that 10%, 50%, and 90% of the fish passed Wells Dam. These data were based on stock assessment and broodstock collection at Wells Dam during the migration period 2007-2010. Based on four years of sampling, there was no significant difference in the migration timing of hatchery and natural-origin summer Chinook sampled at Wells Dam (Table 8.9). At most, the average difference in migration timing between hatchery and natural-origin fish was one day.

Table 8.9. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date that hatchery and natural-origin (wild) summer Chinook migrated past Wells Dam during the period 2007-2010 (N = 4 years). Migration timing was based on stock assessment and broodstock collection at Wells Dam.

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	189	190	205	205	234	233	209	209
Effect size	1		0		1		0	
t-value	1.732		-1.000		-0.290		0.454	
P-value	0.182		0.391		0.791		0.681	
Bootstrap CI	0.0 – 1.0		-0.5 – 0.3		-11.8 – 4.0		-2.3 – 3.5	
Power	0.484		0.999		0.999		0.742	

Spawn Timing

In addition to having similar migration timings, hatchery and natural-origin summer Chinook should spawn at the same time. If they do not, then the hatchery fish are not fully integrated into the naturally produced spawning population. We tested differences in spawn timing between hatchery and natural-origin summer Chinook by comparing cumulative frequency polygons of the time when female carcasses were recovered on the spawning grounds.

There was little difference in spawn timing of hatchery and natural-origin summer Chinook in the Okanogan Basin (Figure 8.16). On average, natural-origin Chinook began spawning about two-four days earlier than hatchery Chinook.

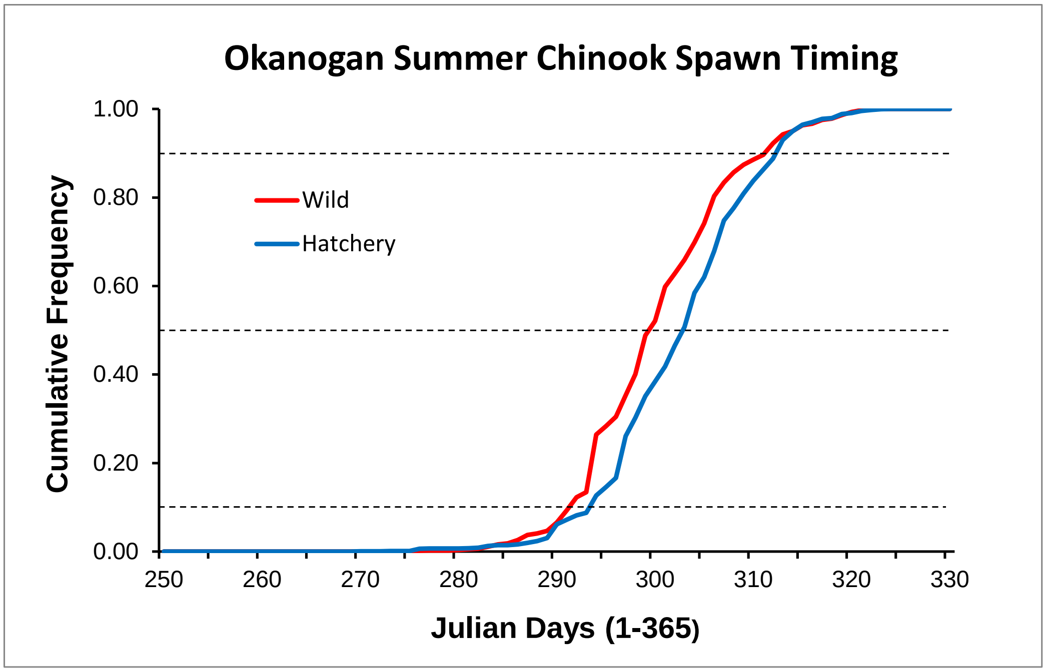


Figure 8.16. Cumulative frequency polygon of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Okanogan Basin. Spawn timing was based on the Julian date that female carcasses were recovered on the spawning grounds. Sample sizes = 5,686 wild and 5,289 hatchery Chinook.

We also compared the mean spawn timing of hatchery and natural-origin summer Chinook by comparing the mean Julian data that 10%, 50%, and 90% of the female carcasses were recovered on the spawning grounds. Based on 18 years of sampling, natural-origin Chinook spawned earlier than hatchery fish (Table 8.10). Only the middle of the spawning period differed significantly between hatchery and natural-origin fish; however, the difference in spawning timing was on average only one-two days.

Table 8.10. Results of paired t-tests and 95% CIs (based on 5,000 bootstrap samples) on the 10%, 50% (median), 90%, and average Julian date of spawn timing of hatchery and natural-origin (wild) summer Chinook in the Okanogan River during the period 1993-2010 (n = 18 years).

Statistic	10th Percentile		50th Percentile		90th Percentile		Average	
	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
Mean	294	296	301	303	312	312	303	304
Effect size	2		2		0		1	
t-value	1.713		2.945		-0.809		4.258	
P-value	0.105		0.009		0.430		0.001	
Bootstrap CI	-0.1 – 3.9		0.4 – 2.0		-2.2 – 0.9		0.8 – 1.9	
Power	0.102		0.001		0.474		0.003	

Because spawning generally progresses from higher elevations to lower elevations, we examined the relationship between elevation and spawn timing of hatchery and natural-origin summer Chinook within the Okanogan Basin. We found little difference in the spawn time of hatchery and natural-origin Chinook across the range of spawning elevations within the Okanogan Basin (Figure 8.17). In general, both hatchery and natural-origin Chinook spawned at about the same time across the range of elevations within the Okanogan Basin. The trend lines in Figure 8.17 indicate that spawning of both hatchery and natural-origin Chinook progressed from higher elevations to lower elevations.

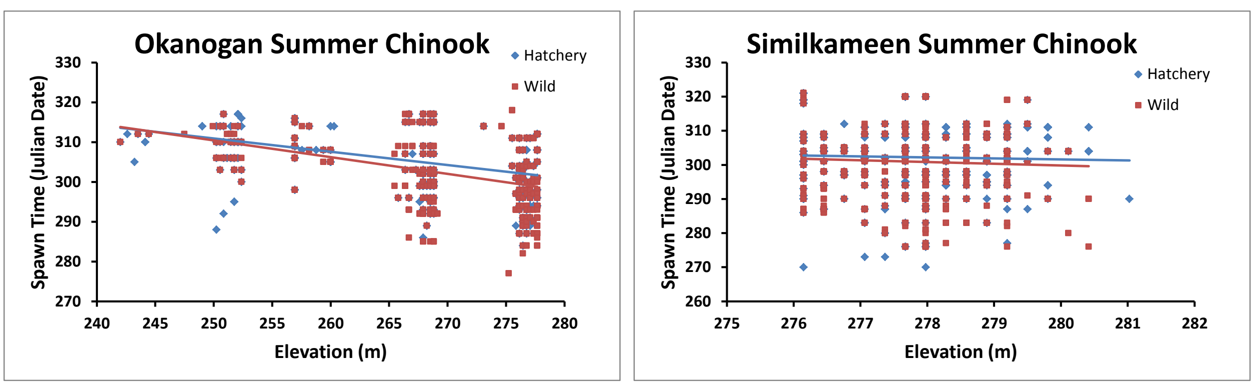


Figure 8.17. Relationship between elevation and spawn timing of hatchery and natural-origin (wild) summer Chinook spawners within the Okanogan Basin (Okanogan and Similkameen rivers).

Redd Distribution

Finally, under a fully integrated program, both hatchery and natural-origin summer Chinook should spawn in the same location. We evaluated differences in spawning locations at two different spatial scales; at the historic reach scale and at the 0.5 km scale.

Hatchery and natural-origin Chinook spawned primarily within the upper reaches of the Okanogan River and in the lower reaches of the Similkameen River (Figure 8.18). There was a significant difference in the distribution of hatchery and natural-origin spawners among those sampling reaches (Yates' Chi-square = 280.9; P = 0.000; Effect Size = 0.161). A greater percentage of hatchery-origin Chinook spawned in the Similkameen River than did natural-origin fish (Figure 8.18). The opposite occurred in the upper reaches of the Okanogan River where a greater percentage of natural-origin Chinook spawned. This pattern was less clear when we compared the spawning distribution at the 0.5 km scale (Figure 8.19). At a fine scale, there was little difference in the spawning distribution of hatchery and natural-origin summer Chinook; although more natural-origin Chinook spawned near Zosel Dam than did hatchery Chinook.

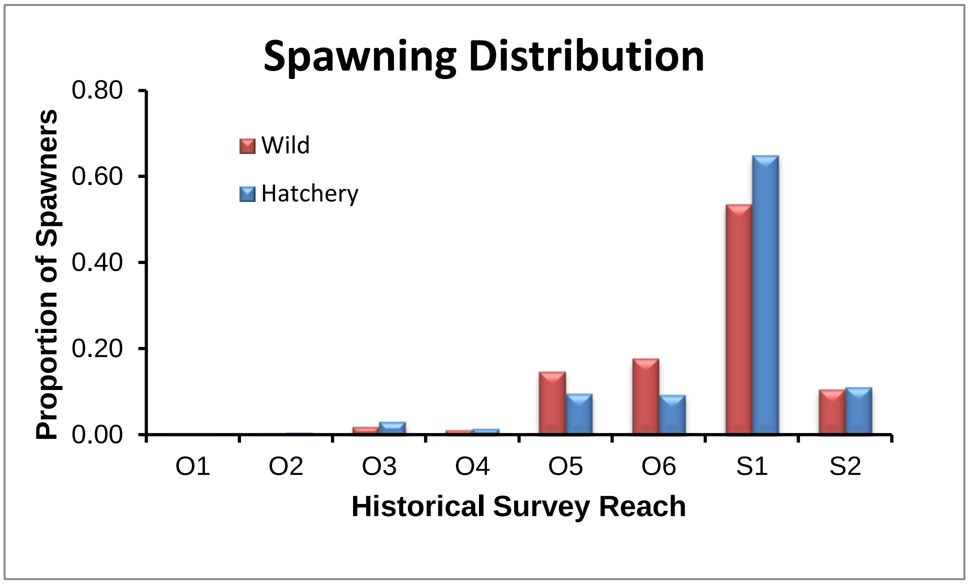


Figure 8.18. Proportion of hatchery and natural-origin summer Chinook spawners distributed among the eight historic sampling reaches in the Okanogan Basin (Okanogan and Similkameen rivers). O1 is from 0.0-27.2 km; O2 27.2-42.0; O3 42.0-49.4; O4 49.4-65.5; O5 65.5-91.4; O6 91.4-124.5; and Similkameen S1 0.0-2.9; and S2 2.9-9.2. Sample sizes = 5,670 wild and 5,262 hatchery Chinook.

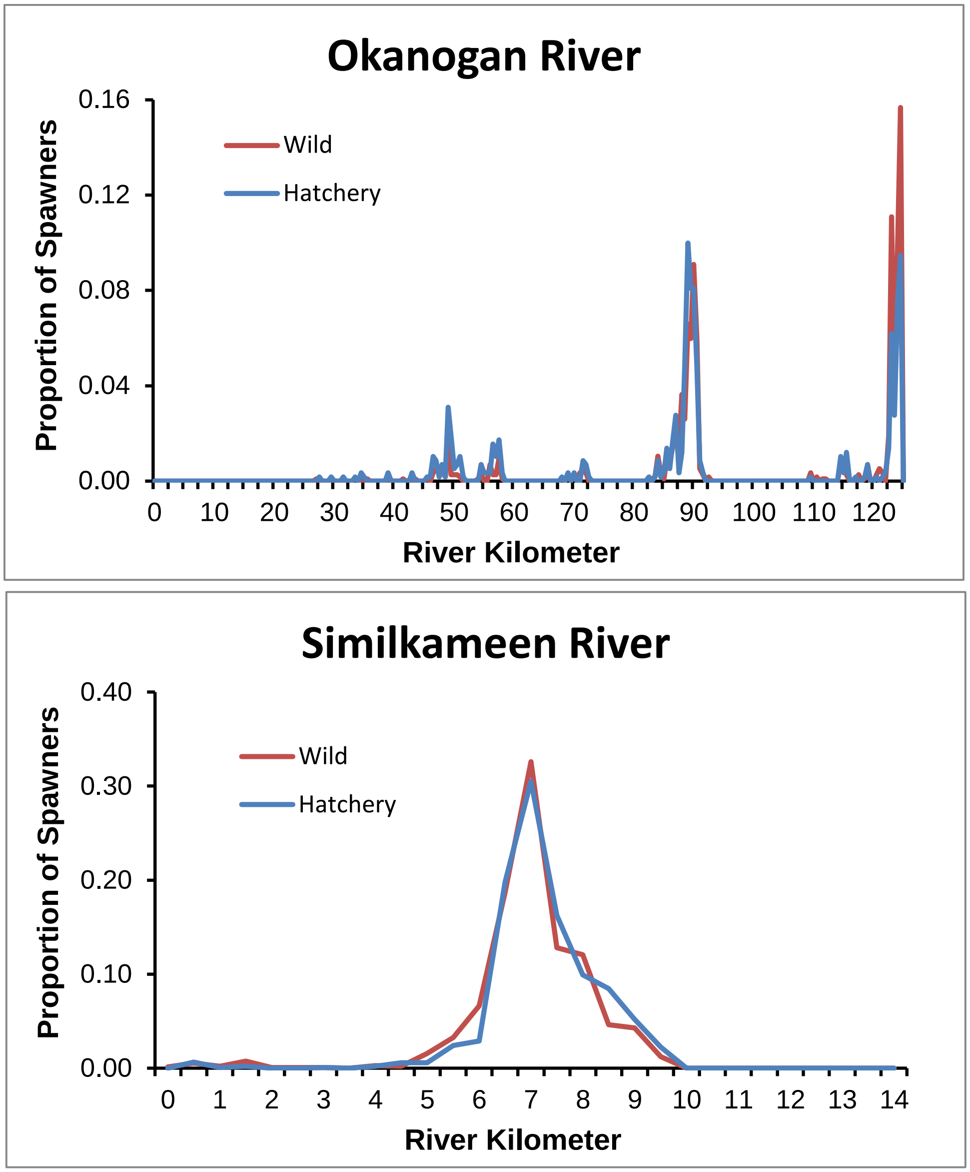


Figure 8.19. Proportion of hatchery and natural-origin summer Chinook spawners distributed along the length of the Okanogan River (top figure) and Similkameen River (bottom figure). Distribution was based on 0.5-km long reaches. Sample sizes = 1,155 wild and 581 hatchery Chinook for the Okanogan River and 1,476 wild and 1,421 hatchery for the Similkameen River.

Conclusions

There was no difference in migration timing of hatchery and natural-origin summer Chinook at Wells Dam. Even though there was no difference in migration timing, spawn timing of hatchery and natural-origin Chinook in the Okanogan Basin differed, with natural-origin fish spawning about one-four days before hatchery fish. This difference is probably not significant biologically.

The distribution of hatchery and natural-origin summer Chinook spawners in the Okanogan and Similkameen rivers differed significantly at the historic reach scale but not at the 0.5 km scale. There was a higher proportion of hatchery-origin Chinook spawning in the Similkameen River, while a higher proportion of natural-origin Chinook spawned in the upper Okanogan River. This difference in distribution is likely a result of the acclimation pond located in the Similkameen River. With the releases of summer Chinook from Bonaparte Pond, we should see an increase in the proportion of hatchery Chinook spawners in the upper Okanogan River.

8.3 Genetic and Phenotypic Characteristics

Genetic Characteristics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix I). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall-run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Age at Maturity

Supplementation programs should produce fish that have the same phenotypic characteristics as those of the natural-origin population. Here, we evaluated the age at maturity of hatchery and natural-origin summer Chinook in the Okanogan Basin. We used two-way Yates' Chi-square to determine if age at maturity of hatchery and natural-origin summer Chinook differed significantly. Because of different age-at-migration characteristics, we evaluated male and female Chinook separately.

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook. Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

The salt-age at maturity differed significantly between hatchery and natural-origin female (Yates' Chi-square = 1,091.1; P = 0.000; Effect Size = 0.238) and male summer Chinook (Yates' Chi-square = 978.4; P = 0.000; Effect Size = 0.350) (Figure 8.20). A larger percentage of hatchery Chinook returned at younger salt ages than natural-origin fish. This was true for both males and females.

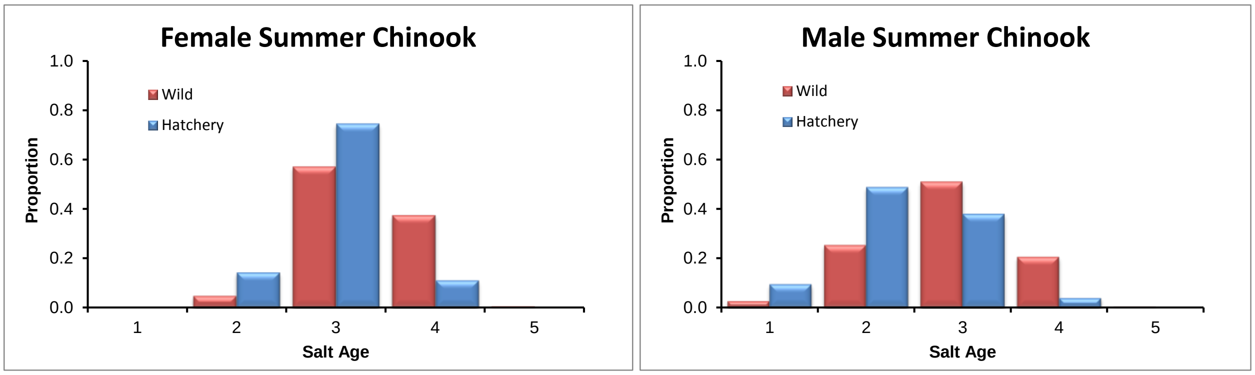


Figure 8.20. Proportion of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Wells Dam and sampled on spawning grounds in the Okanogan Basin for the combined years 1993-2009. Sample sizes for females = 5,014 wild and 5,119 hatchery Chinook and for males = 4,163 wild and 3,861 hatchery Chinook.

Size at Maturity

We also compared the size at maturity of hatchery and natural-origin summer Chinook. Here, we evaluated the size (post-orbital to hypural length in cm) of hatchery and natural-origin Chinook of the same age. We used three-way ANOVA to test differences in sizes of hatchery and natural-origin fish.

Because hatchery and natural-origin summer Chinook out-migrate at different ages, we analyzed differences in sizes at salt age. The size at salt age differed significantly between hatchery and natural-origin female and male summer Chinook (Table 8.11; Figure 8.21). The significant three-way interaction term indicated that differences in sizes between hatchery and natural-origin Chinook were affected by salt age and sex. Female Chinook were significantly larger than males and hatchery and natural-origin Chinook differed significantly in size at salt age (Figure 8.21). On average, female hatchery and natural-origin Chinook differed by 1-14 cm. Male hatchery and natural-origin Chinook differed by 1-3 cm. The differences for most age classes are probably not significant biologically.

Table 8.11. Summary of three-way, unbalanced, GLM ANOVA on size at maturity of Okanogan summer Chinook. The analysis included the following fixed factors: Sex (male or female), Origin (hatchery or natural-origin), and Salt Age (1, 2, 3, 4, and 5), resulting in a 2 x 2 x 5 factorial comparison. DF = degrees of freedom.

Source term	DF	Mean square	F-ratio	P-value	Power
Sex	1	281.54	9.82	0.002	
Origin	1	164.71	5.75	0.017	
Sex x Origin	1	87.44	3.05	0.081	
Age	4	67,601.57	2,358.14	0.000	
Sex x Age	4	604.14	21.07	0.000	
Origin x Age	4	3,618.38	126.22	0.000	
Sex x Origin x Age	4	776.71	27.09	0.000	
Error	17,790				

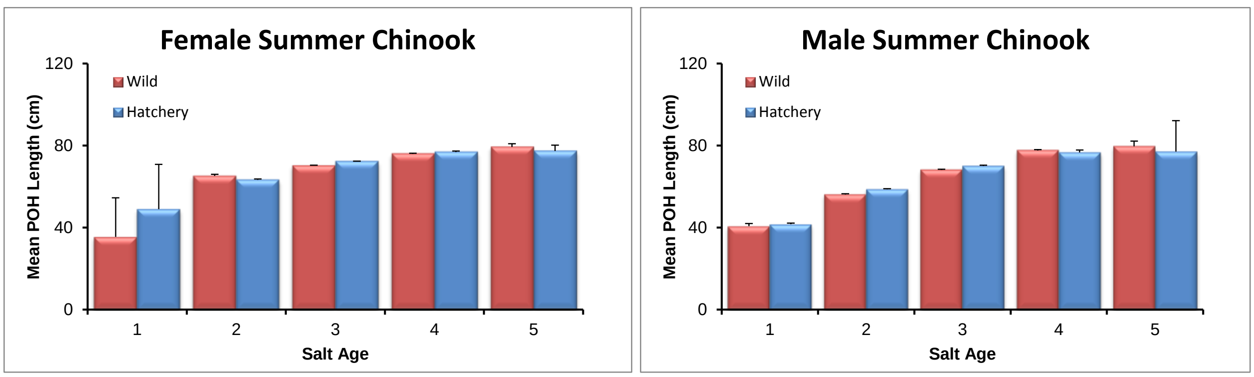


Figure 8.21. Mean lengths (post-orbital to hypural length; cm) and 95% CI of hatchery and natural-origin female and male spawners of different salt ages collected for broodstock at Wells Dam and sampled on spawning grounds in the Okanogan Basin for the combined years 1993-2009. Sample sizes for females = 4,944 wild and 4,975 hatchery Chinook and for males = 4,110 wild and 3,766 hatchery Chinook.

Conclusions

Genetic analyses indicated that the supplementation program has not affected the genetic structure of the Okanogan summer Chinook population. There was no significant difference between hatchery-origin and natural-origin summer Chinook. In addition, there was no evidence that the supplementation program has reduced the effective population size of the Okanogan summer Chinook population.

Although there were no significant genetic differences between hatchery and natural-origin summer Chinook, there were significant differences between the two groups in age at maturity and size at maturity. Analysis of age at maturity, based on salt age, indicated that natural-origin Chinook matured later than hatchery fish. In addition, natural-origin fish were larger than hatchery fish across most age groups. The differences in size at maturity (based on salt age) are probably not significant biologically.

8.4 Hatchery Fish Survival Rates

Hatchery Replacement Rates

Hatchery replacement rates (HRRs) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HORs) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.3 (the calculated target value in Murdoch and Peven 2005).

In most years HRRs were greater than NRRs, regardless if harvest was or was not included (Figure 8.22). The number of years that HRRs exceeded NRRs was significant when harvest was or was not included in the analysis (paired-sample sign test; P = 0.018 for analyses with and without harvest). HRRs exceeded the estimated target value of 5.3 in six out of the 15 years when harvest was not included and nine of the 15 years when harvest was included in the analyses (Figure 8.22). Based on the one-sample sign test, the number of times HRRs exceeded the target value was not significant (with harvest included, P = 0.304; without harvest included, P = 0.849).

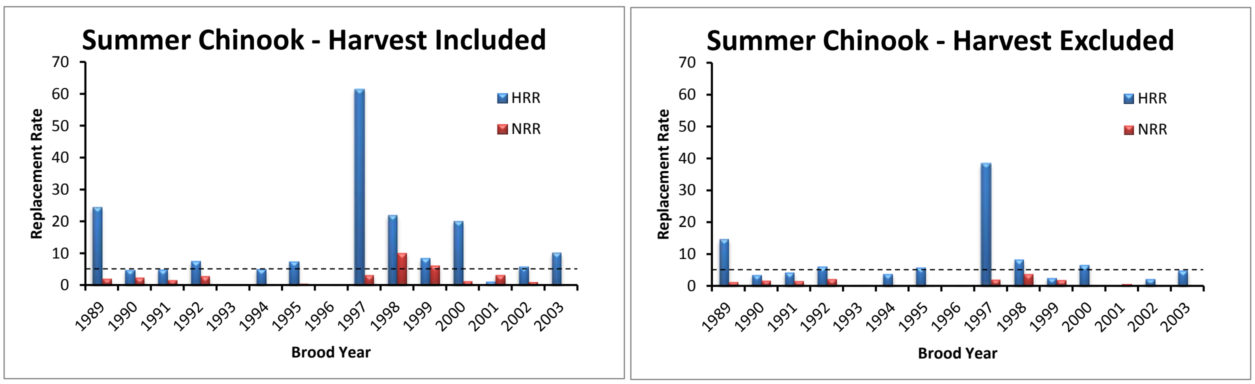


Figure 8.22. Natural and hatchery replacement rates (NRR and HRR, respectively) for Okanogan summer Chinook, brood years 1989-2003. Figure on the left includes harvested fish; figure on the right does not. The horizontal dashed line represents the target value of 5.3 in Murdoch and Peven (2005).

Conclusions

The Okanogan summer Chinook supplementation program has demonstrated a significant full life-cycle survival advantage over natural-origin Chinook with a productivity advantage of over 5:1. That is, on average, HRRs were nearly five times greater than NRRs. This was true regardless if harvested fish were included in the analyses.

8.5 Stray Rates

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Okanogan Basin. Less than 5% of the brood returns should stray into non-target areas. In addition, hatchery strays from the Okanogan program should make up less than 5% of the spawning escapement within non-target spawning areas outside the basin and less than 10% of the spawning escapement within non-target spawning areas within the basin. Because the Okanogan population does not have a well-defined within population structure, we did not evaluate within population straying.

Among Population Stray Rates by Brood Return

Based on brood year analyses, on average, less than 1% of the hatchery returns have strayed into non-target spawning streams, falling below the 5% level (Figure 8.23). Indeed, stray rates for all brood returns have been below the 5% target. During that 16 year period, percent strays into non-target spawning areas have ranged from 0-4%. Few (<1% on average) have strayed into non-target hatchery programs.

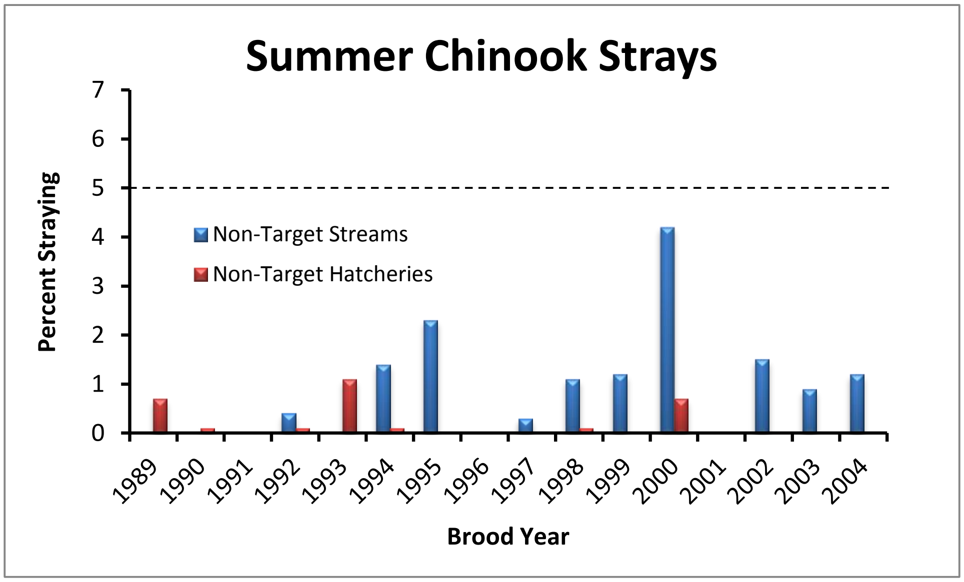


Figure 8.23. Percent of hatchery-origin Okanogan summer Chinook that strayed to non-target spawning streams and non-target hatchery programs, by brood years 1989-2004. Percent strays should be less than 5% (represented by the horizontal dashed line).

Among Population Stray Rates by Return Year

Although hatchery-origin Okanogan summer Chinook have strayed into the Wenatchee, Entiat, Chelan, and Methow basins, they have generally made up less than 5% of the spawning escapement within those basins (Figure 8.24). The Chelan Tailrace has received the largest number of Okanogan strays. Only in two years did Okanogan strays make up more than 5% of the Chelan Tailrace spawning escapement.

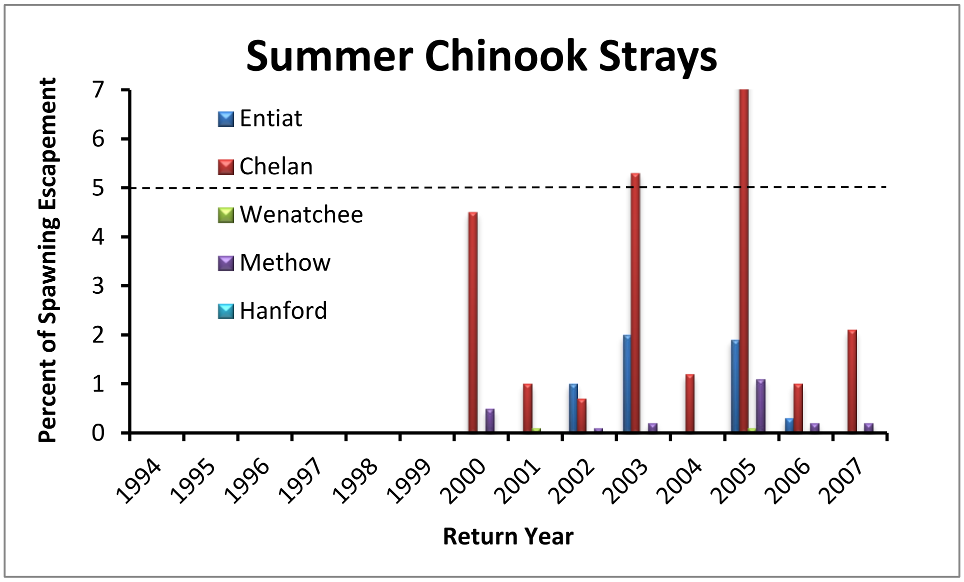


Figure 8.24. Percent of the spawning escapement within non-target spawning populations that are made up of Okanogan hatchery Chinook, by return years 1994-2007. Percentages should be less than 5% (represented by the horizontal dashed line).

Conclusions

Stray rates of Okanogan hatchery summer Chinook have been low, with less than 1%, on average, of the brood year returns straying into non-target spawning areas. None of the brood year returns exceeded the 5% stray rate target. Hatchery summer Chinook have strayed into the Wenatchee, Entiat, Chelan, and Methow basins; however, except for two years in the Chelan Tailrace, they made up less than 5% of the spawning escapements within those basins.

8.6 Hatchery Release Characteristics

Size of Hatchery Fish

The goal of the Okanogan summer Chinook supplementation program is to release smolts that average at least 176 mm long (fork length) and 45.4 g. Since the beginning of the supplementation program, the average size of summer Chinook released has consistently been below the length target (Figure 8.25). Over brood years 1990-2008, lengths have averaged about 75% of the target length. Likewise, average weights of released summer Chinook have consistently been below the target of 45.4 g (Figure 8.25). Weights have averaged about 63% of the supplementation goal (Figure 8.25).

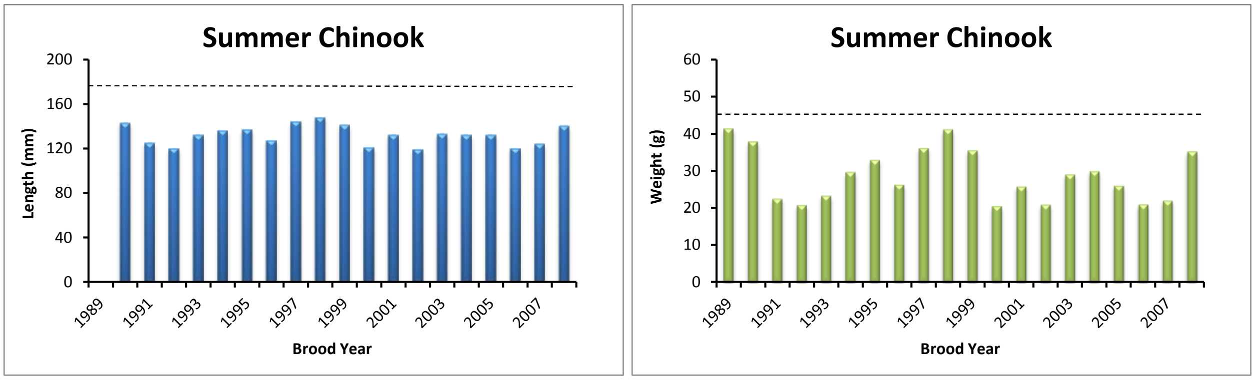


Figure 8.25. Average lengths (mm) and weights (g) of summer Chinook salmon released into the Okanogan Basin for brood years 1989-2008. The dashed horizontal lines represent the target length (176 mm) and target weight (45.4 g).

The length and weight targets for the summer Chinook hatchery program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Okanogan summer Chinook based on data collected within the hatchery over a five-year period (Figure 8.26). Based on this relationship, if the target is to release smolts at 176 mm, then the target weight of the smolts should be 64.4 g, not 45.4 g. On the other hand, if the goal is to release smolts that weigh 45.4 g, then the fork length at release should be 157 mm, not 176 mm.

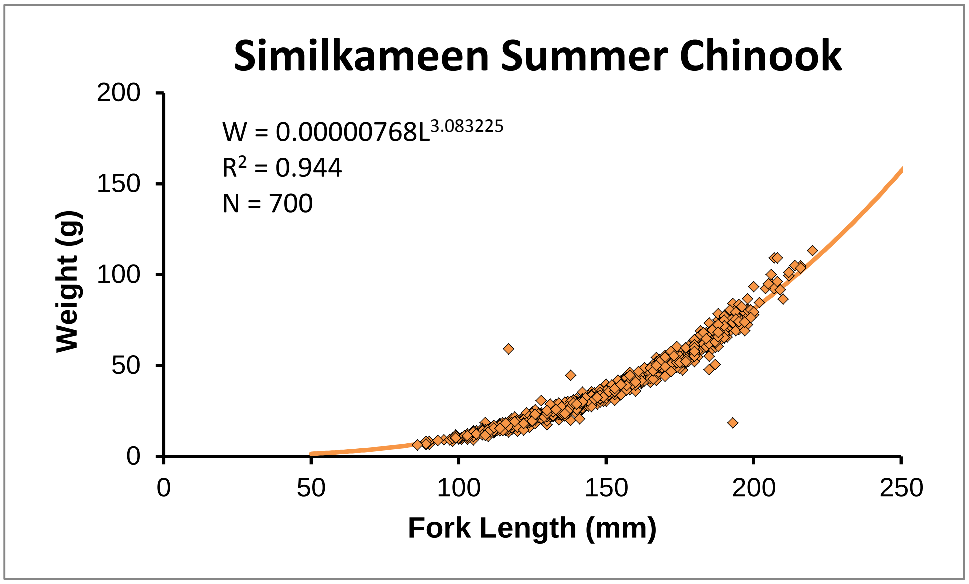


Figure 8.26. Relationship between fork length (mm) and weight (g) of juvenile Okanogan summer Chinook salmon sampled in the hatchery during 2003-2007.

Number of Hatchery Fish Released

The goal of the Okanogan summer Chinook supplementation program is to release 576,000 summer Chinook smolts into the Okanogan Basin. The program reached or exceeded the goal of releasing 576,000 smolts in nine of the 20 years (Figure 8.27). Over the 1989-2008 brood years, the program released an average of 504,563 smolts, which is about 88% of the original program goal.

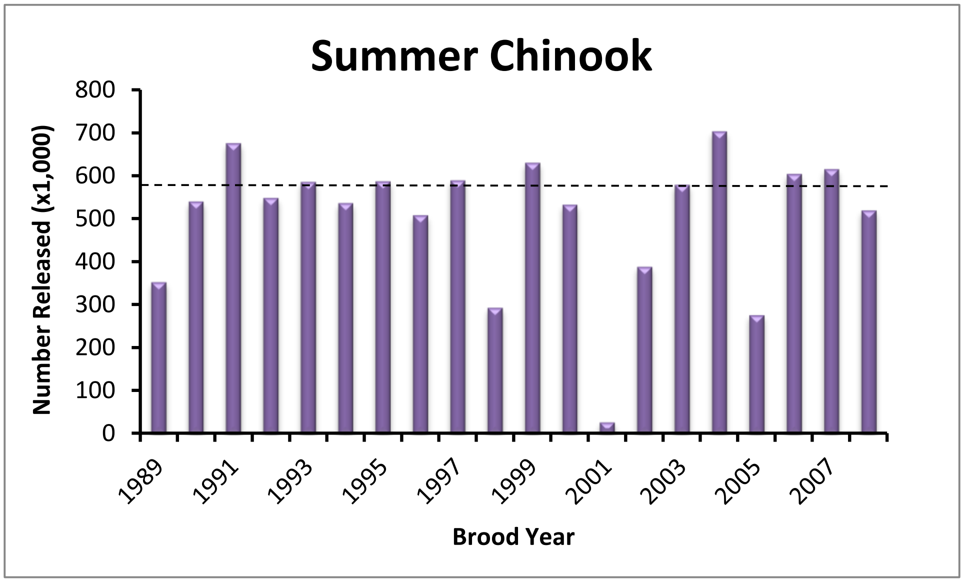


Figure 8.27. Number of summer Chinook smolts released into the Okanogan Basin for brood years 1989-2008. The dashed horizontal line represents the target release number (576,000 smolts).

Conclusions

The Okanogan summer Chinook supplementation program has not consistently achieved its goal of releasing 576,000 fish per year. Since the beginning of the program, it has released on average about 505,000 smolts, which is about 88% of the goal. This is in part because of relatively low unfertilized-egg to eyed-egg survival. The unfertilized-egg to eyed-egg survival has averaged 86% (standard = 92%). In addition, ponding-to-release and transport-to-release survivals have been relatively low compared to their respective standards.

The size of summer Chinook smolts released into the Okanogan Basin has been below the size goals for the program. Average lengths of smolts released have consistently been below the threshold of 176 mm. In addition, average weights of the released smolts have consistently been below the goal of 45.4 g. Because of the unique relationship between length and weight of Okanogan summer Chinook, the current program cannot achieve both the length and weight targets. More realistic targets should be set based on the length-weight relationship specific to this population.

8.7 Freshwater Productivity

Because there are no juvenile summer Chinook data for the Okanogan Basin, we cannot assess whether the proportion of hatchery fish on the spawning grounds affects the freshwater productivity of the Okanogan population.

8.8 Harvest

Harvest Rates

Most of the harvest on hatchery-origin Okanogan summer Chinook occurred in the ocean (Figure 8.28). Ocean harvest has constituted 38% to 100% of all harvest on Okanogan summer Chinook. Brood years 1989, 1997-2000, and 2002-2004 provided the largest harvests, while brood year 1996 provided the lowest (Hillman et al. 2011). The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams. The non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam.

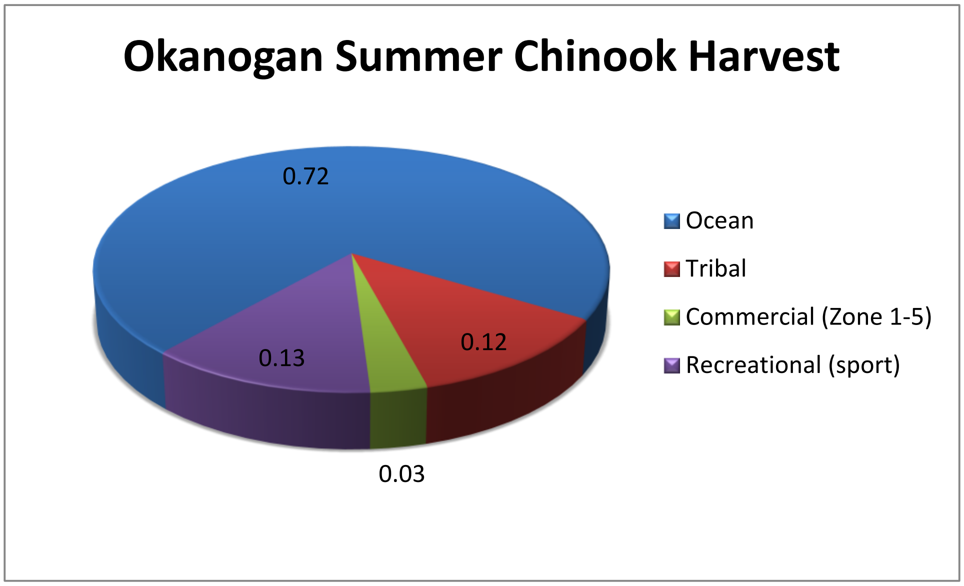


Figure 8.28. Mean allocation of Okanogan summer Chinook harvested among the different fisheries for brood years 1989-2004. The total number of fish harvested across the brood years was 33,808 (average = 2,113 fish/year; range = 5-7,203).

WDFW (Bartlett and Tweit 2006) established a spawning escapement goal of 3,500 adult summer Chinook for the combined Methow and Okanogan basins. In order to estimate the fraction of this total escapement that belongs to each basin, we estimated the total kilometers of summer Chinook spawning habitat within each of the basins. This work revealed that the Methow and the Okanogan basins contained 55% and 45%, respectively, of the spawning habitat. We applied these percentages to the spawning escapement goal and determined a spawning escapement of 1,925 adults for the Methow and 1,575 for the Okanogan. An additional 334 adults are needed to meet the goal of the Okanogan supplementation program. Thus, a total of 1,909 adult summer Chinook are needed to satisfy broodstock and WDFW escapement goals for the Okanogan. Based on the total escapement goal of 1,909 adults, there were ten brood years that produced escapements large enough to support a terminal fishery (Figure 8.29).

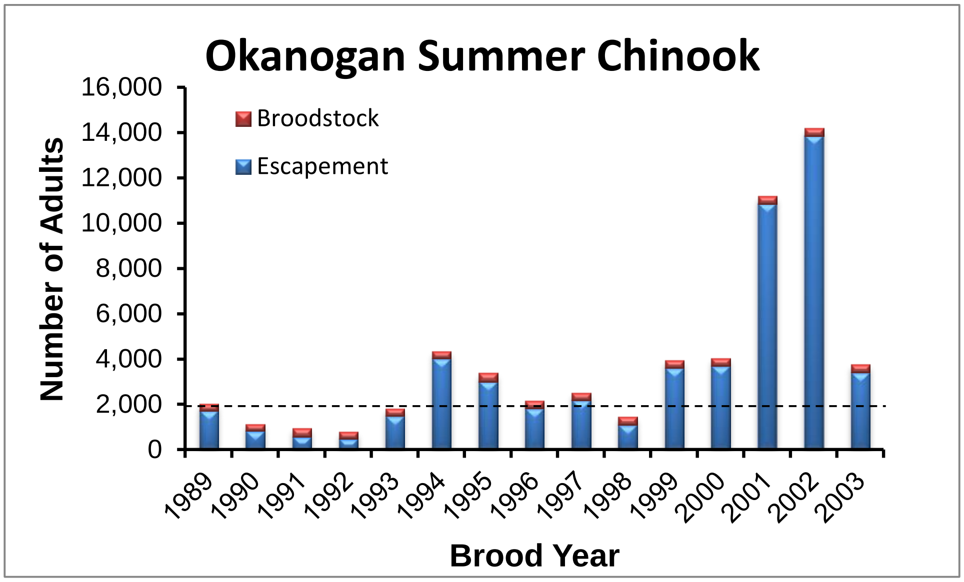


Figure 8.29. Numbers of summer Chinook adults collected for broodstock and numbers that spawned naturally within the Okanogan Basin for brood years 1989-2003. The dashed horizontal line represents the number needed to satisfy the broodstock collection goal (334 adults) plus the number needed to meet the WDFW spawner escapement goal for the Okanogan (1,575 spawners).

Conclusions

Okanogan summer Chinook are harvested primarily within the ocean fisheries. The number of summer Chinook harvested per brood year averaged 2,113 adults/year (range, 5-7,203). Assuming a total escapement of 1,909 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), since 1989, ten brood years produced escapements large enough to support a terminal fishery.

8.9 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. Analyses of the available data were unable to show that the Okanogan/Similkameen summer Chinook supplementation program has increased total spawning abundance and NORs in the Okanogan Basin.
2. Based on comparisons with a reference population, the supplementation program does not appear to have reduced the productivity of the population. There was no significant association between pHOS and the residuals form the Ricker stock-recruitment model. In addition, pHOS has ranged from 0.00 to 0.69 (averaged, 0.41).
3. Although there was no difference in the migration timing of hatchery and natural-origin summer Chinook (measured at Wells Dam), there was a significant difference in spawn timings, with natural-origin fish spawning about 1-4 days earlier than hatchery-origin fish. This difference in spawn timing may not be significant biologically.
4. The spawning distribution of hatchery and natural-origin summer Chinook in the Okanogan Basin differed significantly, with a higher proportion of hatchery-origin Chinook spawning in the Similkameen River and a higher proportion of natural-origin Chinook spawning in the upper Okanogan River.

5. There was no evidence that supplementation significantly affected allele frequencies within and between natural and hatchery-origin summer Chinook.
6. There was no evidence that the Okanogan/Similkameen supplementation program has reduced the effective population size of the Okanogan summer Chinook population.
7. Based on salt age, hatchery fish matured at an earlier age than natural-origin fish. This is likely related to growth rates within the hatchery and the large size at release.
8. Hatchery and natural-origin summer Chinook differed significantly in size at maturity; however, the differences (based on salt age) are probably not significant biologically.
9. HRRs were on average five times greater than NRRs. This was true regardless if harvested fish were included in the analyses.
10. On average, about 1% of the hatchery brood-year returns have strayed into other spawning areas. None of the brood year returns have exceeded the 5% threshold.
11. Hatchery summer Chinook from the Okanogan/Similkameen program have strayed into the Wenatchee, Entiat, Chelan, and Methow basins, but made up less than 5% of the spawning escapements within the Wenatchee, Entiat, and Methow basins. Only in two years did they make up more than 5% in the Chelan River.
12. The supplementation program has not consistently achieved its goal of releasing 576,000 smolts per year. Since the beginning of the program, it has released on average about 505,000 smolts, which is about 88% of the goal. The reduction in the size of the program to 166,569 smolts should help the program achieve its release goal.
13. The average lengths of smolts released have consistently been below the target of 176 mm. In addition, the average weights of the released smolts have been below the goal of 45.4 g. More realistic targets should be set based on the length-weight relationship specific to Okanogan summer Chinook. In addition, size targets should be selected that minimize the returns of jacks and mini-jacks.
14. Okanogan summer Chinook were harvested primarily within the ocean fisheries. The average number of Okanogan summer Chinook harvested per brood year was 2,113 adults/year.
15. Assuming a total escapement of 1,909 adults (sufficient to meet the broodstock collection goal and spawning escapement goal), ten brood years produced escapements large enough to support a terminal fishery.

The Okanogan/Similkameen summer Chinook supplementation program has not consistently achieved its goal of releasing 576,000 smolts into the Okanogan Basin. This is mostly because of relatively low unfertilized-egg to eyed-egg survival and ponding to release survival rates. The goal is to achieve a 92% unfertilized-egg to eyed-egg survival and a 90% ponding to release survival rate. Since the beginning of the program, the respective survival rates have averaged 86% and 83%. It is unknown why the unfertilized-egg to eyed-egg survival rate has been lower than expected. It may be a natural phenomenon associated with summer Chinook, or it may be related to the warm river temperatures that occur at the time broodstock are collected at Wells Dam. These warmer temperatures may negatively affect the fertilization rates of eggs. Additional work is needed to determine the cause of the relatively low unfertilized-egg to eyed-egg survival rates. Importantly, the reduction in the size of the program to 166,569 smolts should help the program achieve its release goals.

The relatively low ponding to release survival rate appears to be related to changes in water quality that favor Bacterial Cold Water Disease (BCWD), Bacterial Gill Disease (BGD), and parasites. During high flow events, turbid water enters the acclimation facilities and the incidence of BCWD, BGD, and parasites (e.g., ichthyophthiriasis) increase. Toxics may also enter the facilities during high flow events and further decrease the ponding to release survival rates. Increasing water temperatures by using well water may help improve water quality and reduce the incidence of disease.

The size of summer Chinook smolts released has not met the program goals. This may be related to disease problems and because the length and weight targets for the program were not based on the unique length-weight relationship of Okanogan summer Chinook. If the goal is to release summer Chinook smolts at 45.4 g, then the fork length at release should be about 157 mm, not 176 mm. Even though the size goals for the program were not achieved, the productivity of these fish was over five times greater than the productivity of natural-origin fish. It is unknown if SARs and HRRs would increase if fish were released at the program goal of 176 mm. It is likely that releasing summer Chinook at a larger size will further decrease the age at maturity (i.e., increase the return of mini-jacks and 1and 2-salt fish).

Based on analysis of CWTs, Okanogan summer Chinook are exploited most heavily within the ocean fisheries, which makes up about 72% of the total harvest. On average, about 0.476% of the brood year releases were harvested. In contrast, on average, about 0.473% of the releases escaped to spawn. Of those that escaped to spawn, about 1% of the brood returns strayed into non-target spawning streams. Okanogan summer Chinook rarely made up more than 5% of the spawning escapement within non-target basins. Thus, straying does not appear to be a problem for the Okanogan/Similkameen program

Based on examination of allele frequencies, the supplementation program has not affected the genetic characteristics or effective population size of the population. In contrast, there were differences in phenotypic characteristics. For example, hatchery fish returned at an earlier salt age than natural-origin fish with more 2 and 3-salt females and fewer 4-salt females. The spawning distribution of hatchery females was more concentrated near the release location. Thus, they were more abundant in the Similkameen River and less abundance in the upper Okanogan River than natural-origin females. Finally, there were differences in size-at-age between hatchery and natural-origin fish, but most of these differences are probably not significant biologically. Some of these phenotypic differences may be related to unintentional selective broodstock collection. On the other hand, differences in spawning distribution are likely the result of hatchery fish homing to the release location. The release of summer Chinook from the Bonaparte facility should even the distribution of hatchery and natural-origin spawners. It is unknown why hatchery fish returned at an earlier salt age than the natural-origin fish. This is a common outcome among hatchery programs and may be related to rapid growth rates in the hatchery and size at release.

Although the Okanogan/Similkameen summer Chinook supplementation program demonstrated a full life-cycle survival advantage over natural-origin Chinook, there was no significant increase in spawning abundance or NORs. Possible reasons why abundance and NORs have not increased include:

- *Ecological Interactions*—It is possible that the supplementation program has increased the incidence of disease in the naturally spawning population. As noted above, the incidence of BCWD, BGD, and parasites is relatively high among the hatchery fish. In addition, with the large numbers of hatchery fish released in the upper Columbia Basin, it is possible that the survival and productivity of natural-origin Chinook have been reduced. The HETT is currently evaluating the effects of hatchery releases on non-target taxa of concern.
- *Density Dependence*—Although we attempted to correct for density dependence through modeling, it is possible that the large spawning escapements into specific areas within the Okanogan Basin (i.e., Similkameen River) could be reducing survival and productivity of natural-origin fish. That is, the saturation of habitat in specific spawning areas may be driving the overall productivity of the Okanogan population. The fact that the Ricker model was the best fitting model to the stock-recruitment data suggests that spawning or incubation habitat may be limiting the productivity of summer Chinook in the Okanogan Basin. However, according to the Ricker model, the estimated stock size at capacity is 14,641 adult spawners, which is greater than the spawning escapements within the Okanogan Basin over the last 30 years (escapements ranged from 473-13,857 spawners). In addition, NRRs have exceeded 1.0 in ten of the last 15 complete brood years and averaged 2.47 (range, 0.35-10.17).

The lack of a significant increase in spawning escapements and NORs is a potential challenge for meeting supplementation objectives. However, it is important to note that the program has not reduced NORs and population productivity. Nevertheless, the program may benefit from the addition of groundwater to improve water quality at the acclimation facilities, establishing stock-specific size targets and growth rates, and distributing hatchery spawners more evenly throughout the Okanogan Basin. The reduction in the size of the program to 166,569 smolts will decrease rearing densities and should reduce the incidence of disease within the hatchery and acclimation facility. Additionally, if hatchery fish have a lower reproductive success than natural-origin fish, it may be wise to reduce the number of hatchery fish spawning within the Similkameen River. This could be accomplished in part through a selective fishery.

SECTION 9: TURTLE ROCK SUMMER CHINOOK

Although the Turtle Rock summer Chinook program is an augmentation program, 200,000 is NNI compensation for passage mortalities associated with Rocky Reach Dam. In addition, the conversion of the subyearling program to a 400,000 yearling program is compensation for lost spawning habitat as a result of the construction of Rocky Reach Dam. Broodstock for the Turtle Rock program are collected at Wells Dam and consists of volunteers to the Wells Fish Hatchery. In recent years, some natural-origin Chinook have been incorporated into the broodstock. Summer Chinook are spawned at Wells Fish Hatchery. Fertilized eggs are then transferred to Eastbank Fish Hatchery for hatching and rearing.

The program consisted of both subyearling (normal and accelerated groups) and yearling releases. Subyearlings were transferred to Turtle Rock Fish Hatchery for acclimation in May. These fish were released in June after about 30 days of acclimation on Columbia River water. The goal of this program was to release 1,620,000 subyearling summer Chinook (810,000 normal and 810,000 accelerated subyearlings) into the Columbia River at 40 fish per pound. Targets for fork length and weight were 112 mm (CV = 9.0) and 11.4 g, respectively. Over 50% of both subyearling groups were marked with CWTs. These data are summarized in Hillman et al. (2011). In 2010, the subyearling program was converted to a 400,000 yearling program.

The goal of the yearling program was to release 200,000 summer Chinook smolts into the Columbia River from Turtle Rock Fish Hatchery at 10 fish per pound. Targets for fork length and weight were 176 mm (CV = 9.0) and 45.4 g, respectively. Beginning with the 2006 brood year, yearling summer Chinook were acclimated at both Turtle Rock Fish Hatchery and the Chelan River net pens. With the conversion of the subyearling program to a yearling program, the current goal is to release 600,000 yearling summer Chinook smolts (200,000 from the existing program plus 400,000 from the subyearling program). Beginning in 2012, the 600,000 yearlings will be acclimated overwinter at facilities at Chelan Falls on Chelan River water. At that time, the Turtle Rock program will officially become the Chelan Falls summer Chinook program.

Over 90% of yearling summer Chinook have been marked with CWTs. In addition, in 2008 and 2009, about 10,000 to 11,000 juvenile summer Chinook were PIT tagged within each of the circular reuse and standard raceways. In 2010, about 5,000 fish from each of the Turtle Rock and Chelan River net pens were PIT tagged. These data are summarized in Hillman et al. (2011).

Because the Turtle Rock program is primarily an augmentation program, our evaluation focuses on straying, release characteristics, and harvest. The program has released “normal” subyearling Chinook, “accelerated” subyearling Chinook, and yearling Chinook. In the sections that follow, we evaluate each group separately.

9.1 Stray Rates

Stray rates were determined by examining CWTs recovered on spawning grounds in the upper basin (Hanford Reach, Wenatchee River, Entiat River, Chelan River, Methow River, and Okanogan/Similkameen rivers). Hatchery strays from the Turtle Rock program should make up less than 5% of the spawning escapement within non-target spawning areas.

Among Population Stray Rates by Brood Return

Normal Subyearling Releases: Based on brood year analyses, on average, about 31% of the hatchery returns from normal subyearling releases have strayed into non-target spawning streams (Figure 9.1). Depending on the brood year, percent stays into spawning areas have ranged from 0-100%. Few (<1% on average) have strayed into non-target hatchery programs.

Accelerated Subyearling Releases: On average, about 41% of the hatchery returns from accelerated subyearling releases have strayed into non-target spawning streams (Figure 9.1). Depending on the brood year, percent stays into spawning areas have ranged from 0-83%. Few (<1% on average) have strayed into non-target hatchery programs.

Yearling Releases: On average, about 66% of the hatchery returns from yearling releases have strayed into non-target spawning streams (Figure 9.1). Depending on the brood year, percent stays into spawning areas have ranged from 37-86%. Few (<1% on average) have strayed into non-target hatchery programs.

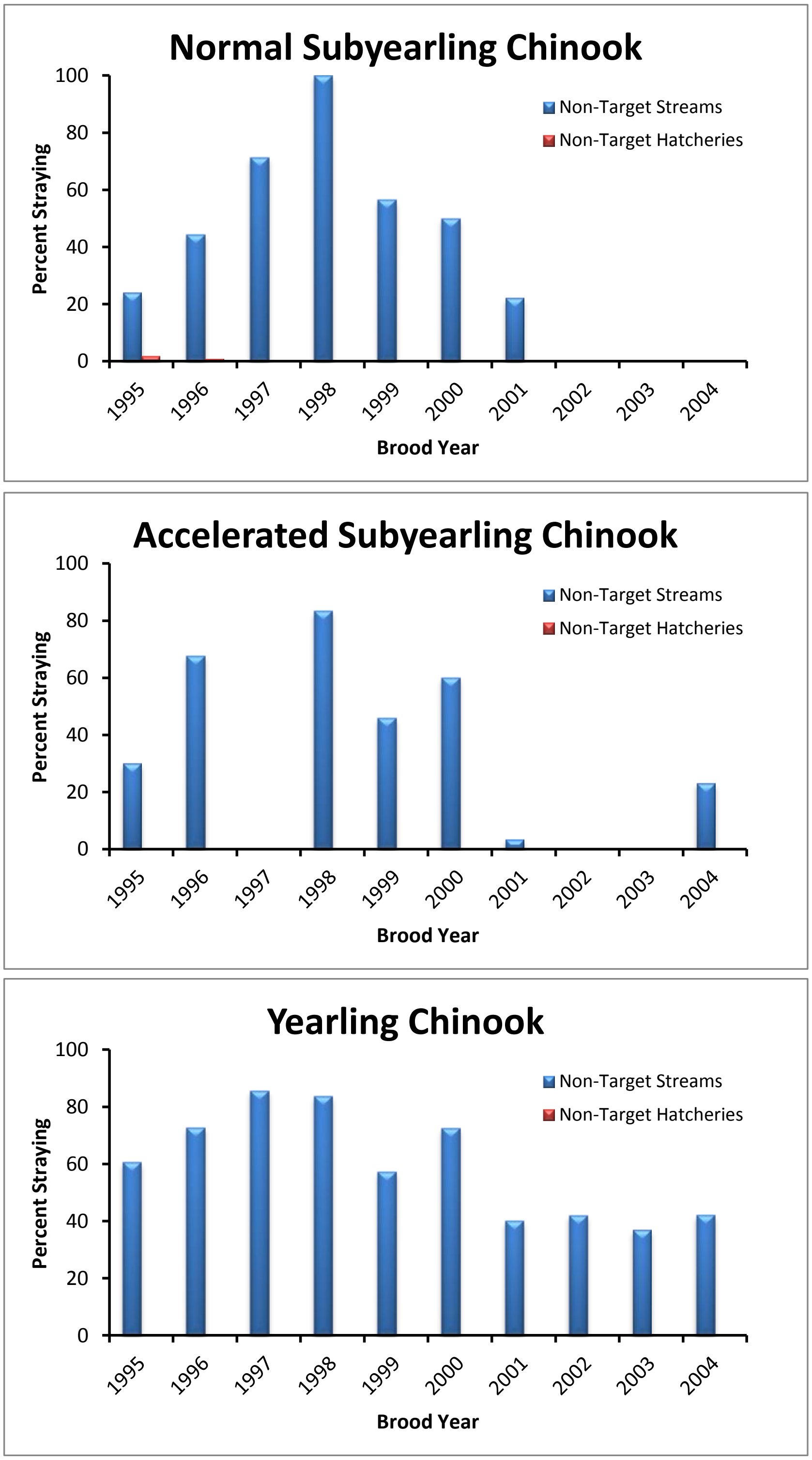


Figure 9.1. Percent of hatchery-origin Turtle Rock summer Chinook (normal subyearling releases, accelerated subyearling releases, and yearling releases) that strayed to non-target spawning streams and non-target hatchery programs, by brood years 1995-2004.

Among Population Stray Rates by Return Year

Normal Subyearling Releases: Although hatchery-origin Turtle Rock summer Chinook from normal subyearling releases have strayed into the Wenatchee, Entiat, Chelan, Methow, and Okanogan basins, they have generally made up less than 5% of the spawning escapement within those basins (Figure 9.2). The Chelan Tailrace has received the largest number of Turtle Rock summer Chinook strays. However, only in one year did Turtle Rock strays from normal subyearling releases make up more than 5% of the Chelan Tailrace spawning escapement.

Accelerated Subyearling Releases: Hatchery-origin Turtle Rock summer Chinook from accelerated subyearling releases strayed into the Wenatchee, Entiat, Chelan, Methow, and Okanogan basins, and into the Hanford Reach. However, they have generally made up less than 5% of the spawning escapement within those basins (Figure 9.2). The Chelan Tailrace has received the largest number of Turtle Rock summer Chinook strays. Only in one year did Turtle Rock strays from accelerated subyearling releases make up more than 5% of the Chelan Tailrace spawning escapement.

Yearling Releases: Hatchery-origin Turtle Rock summer Chinook from yearling releases have strayed into the Wenatchee, Entiat, Chelan, Methow, and Okanogan basins, and into the Hanford Reach. In several years, these fish have made up more than 5% of the spawning escapement within the Entiat, Chelan, and Methow basins (Figure 9.2). The Chelan Tailrace has received the largest number of Turtle Rock summer Chinook strays. In some years, Turtle Rock strays from yearling releases made up more than 30% of the Chelan Tailrace spawning escapement.

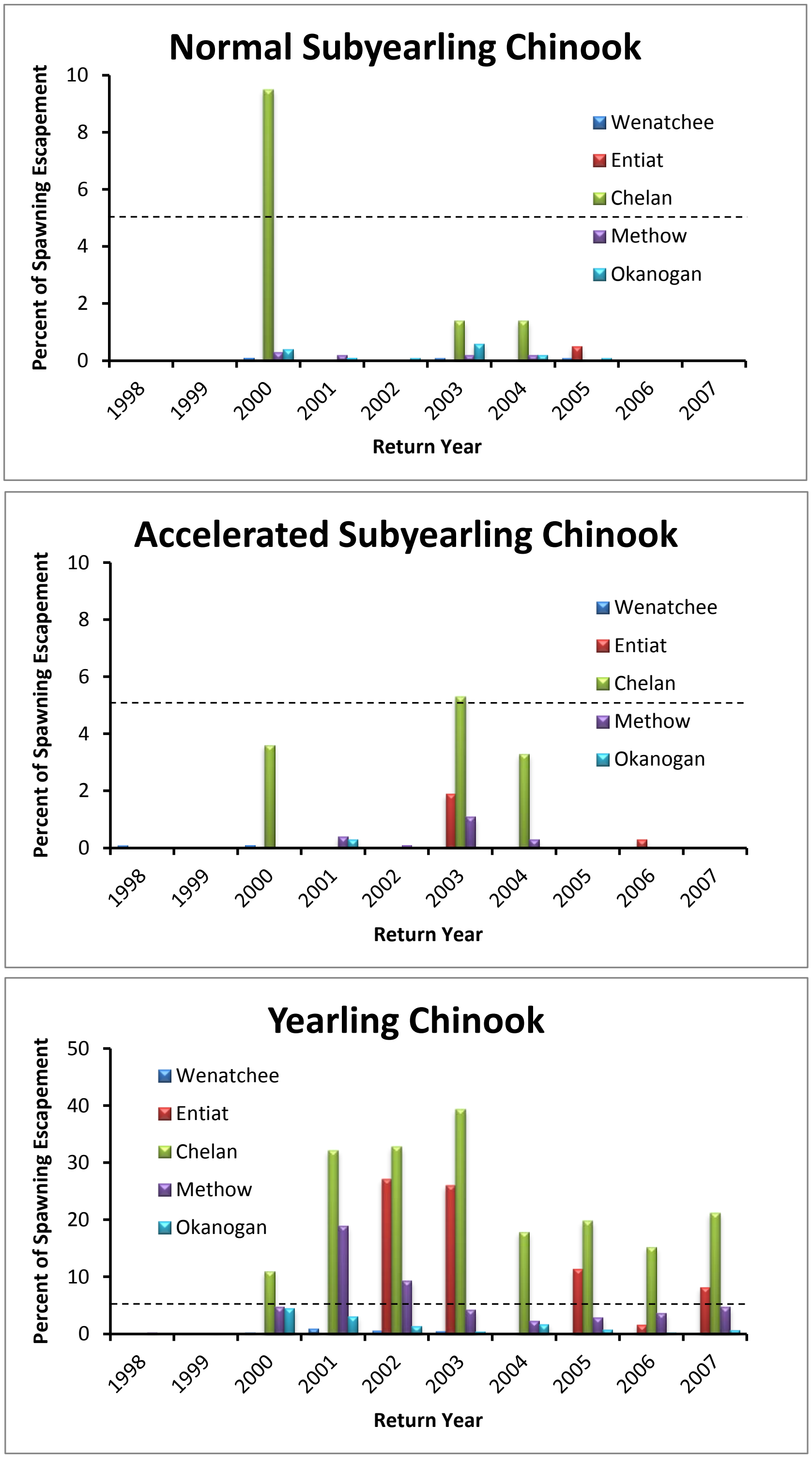


Figure 9.2. Percent of the spawning escapement within non-target spawning populations that are made up of Turtle Rock hatchery Chinook (normal subyearling releases, accelerated subyearling releases, and yearling releases), by return years 1998-2007. Percentages should be less than 5% (represented by the horizontal dashed line).

Conclusions

Stray rates of hatchery summer Chinook from the Turtle Rock Program varied among the three release groups (normal subyearling releases, accelerated subyearling releases, and yearling releases). Summer Chinook from the subyearling releases strayed the least, with 31% and 41% of the respective normal and accelerated subyearling releases straying into non-target spawning areas. These fish strayed into the Wenatchee, Entiat, Chelan, Methow, and Okanogan basins but generally made up less than 5% of the spawning escapement within those basins. On the other hand, on average, 66% of the summer Chinook from yearling releases strayed into non-target spawning areas. In some years, these fish made up more than 5% of the spawning escapement within the Entiat, Chelan, and Methow basins.

9.2 Hatchery Release Characteristics

Size of Hatchery Fish

Normal Subyearling Releases: The goal of the Turtle Rock summer Chinook program was to release normal subyearlings that averaged at least 112 mm fork length and 11.4 g. Since brood year 1995, the average size of the normal subyearling group has consistently been below the length target (Figure 9.3). Over brood years 1995-2008, lengths have averaged about 85% of the target length. In contrast, average weights of released normal subyearling summer Chinook have met or exceeded the target of 11.4 g in six different years (Figure 9.3). Weights have averaged about 92% of the supplementation goal.

Accelerated Subyearling Releases: Another goal of the Turtle Rock summer Chinook program was to release accelerated subyearlings that averaged at least 112 mm fork length and 11.4 g. Unlike with normal subyearling releases, since brood year 1995, the average size of the accelerated subyearling group has met or exceeded the length target in ten different years (Figure 9.3). Likewise, average weights of released accelerated subyearling summer Chinook have met or exceeded the target of 11.4 g in 12 different years (Figure 9.3).

Yearling Releases: The final goal of the Turtle Rock summer Chinook program was to release yearlings that averaged at least 176 mm fork length and 45.4 g. Since brood year 1995, the average size of the yearling summer Chinook group has generally been below the length target (Figure 9.3). Over brood years 1995-2008, lengths have averaged about 95% of the target length. In contrast, average weights of released yearling summer Chinook have met or exceeded the target of 45.4 g in ten different years (Figure 9.3).

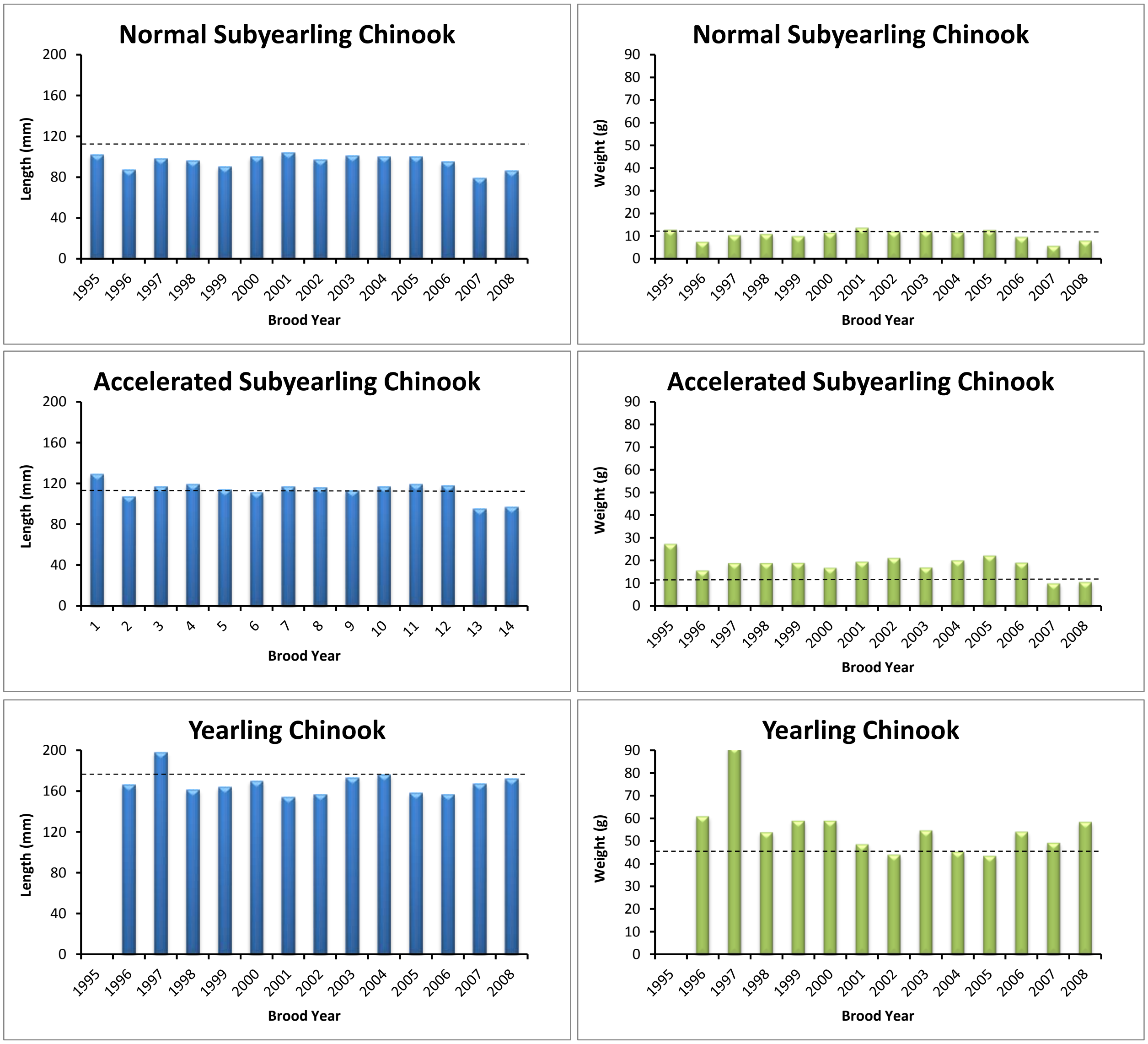


Figure 9.3. Average lengths (mm) and weights (g) of Turtle Rock summer Chinook salmon releases of normal subyearlings, accelerated subyearlings, and yearlings for brood years 1995-2008. The dashed horizontal lines represent the target lengths and target weights for subyearlings (112 mm; 11.4 g) and yearlings (176 mm; 45.4 g).

The length and weight targets for the Turtle Rock summer Chinook hatchery program came from relationships in Piper et al. (1982). Because the relationship between length and weight differs among species, and within species according to the condition of individual fish, we developed length-weight relationships specifically for Turtle Rock summer Chinook based on data collected within the hatchery over a five-year period (Figure 9.4). Based on this relationship, if the target is to release yearlings at 176 mm, then the target weight of the yearlings should be 59.0 g, not 45.4 g. On the other hand, if the goal is to release yearlings that weigh 45.4 g, then the fork length at release should be 161 mm, not 176 mm.

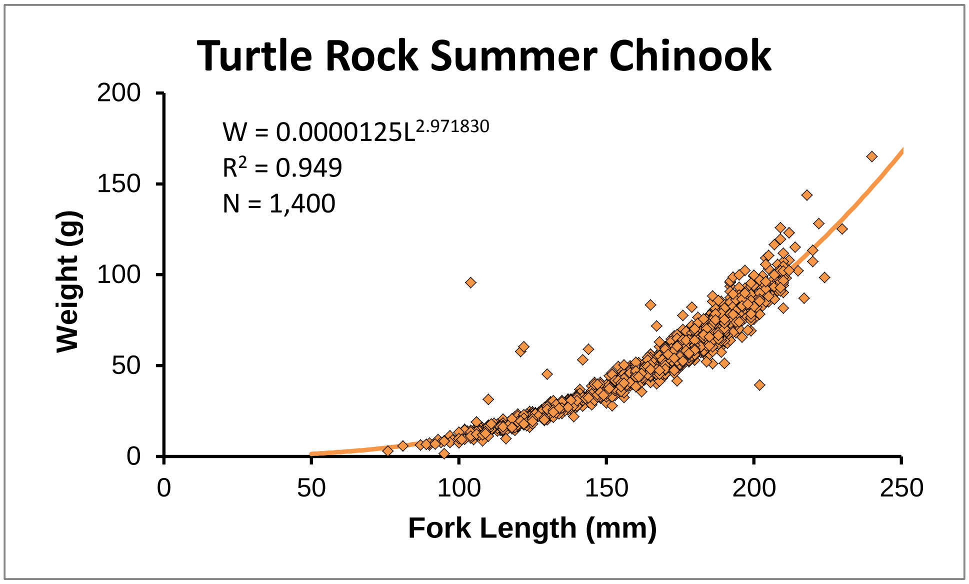


Figure 9.4. Relationship between fork length (mm) and weight (g) of juvenile Turtle Rock summer Chinook salmon sampled in the hatchery during 2003-2007.

Number of Hatchery Fish Released

Normal Subyearling Releases: The goal of the Turtle Rock summer Chinook program was to release 810,000 normal subyearling summer Chinook. The program reached or exceeded the goal of releasing 810,000 subyearlings in one of the 15 years (Figure 9.5). Over the 1995-2009 brood years, the program released an average of 500,508 normal subyearlings, which is about 62% of the original program goal.

Accelerated Subyearling Releases: Another goal of the Turtle Rock summer Chinook program was to release 810,000 accelerated subyearling summer Chinook. The program has not reach the goal of releasing 810,000 subyearlings (Figure 9.5). Over the 1995-2008 brood years, the program released an average of 381,127 normal subyearlings, which is about 47% of the original program goal.

Yearling Releases: The final release goal of the Turtle Rock summer Chinook program was to release 200,000 yearling summer Chinook. The program reached or exceeded the goal of releasing 200,000 yearlings in nine of the 14 years (Figure 9.5). Over the 1995-2008 brood years, the program released an average of 215,829 yearlings.

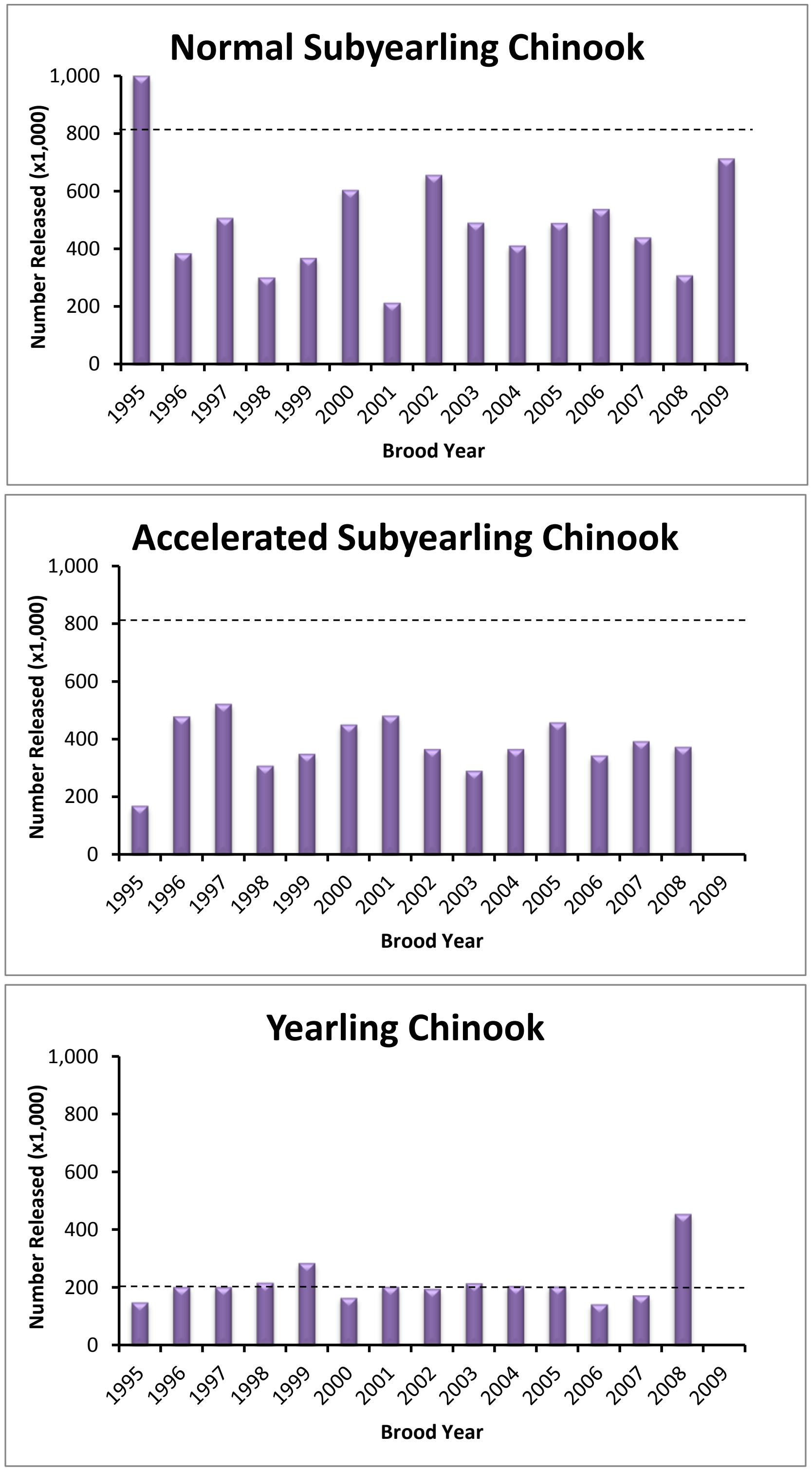


Figure 9.5. Number of Turtle Rock summer Chinook salmon releases of normal subyearlings, accelerated subyearlings, and yearlings for brood years 1995-2008. The dashed horizontal line represents the target release number for each group (810,000 normal subyearlings, 810,000 accelerated subyearlings, and 200,000 yearlings).

Conclusions

The Turtle Rock summer Chinook program did not consistently achieved its goal of releasing 810,000 normal subyearlings, 810,000 accelerated subyearlings, and 200,000 yearlings per year. The program has released on average about 500,508 normal subyearlings (62% of goal), 381,127 accelerated subyearlings (47% of goal), and 215,829 yearlings (108% of goal). The performance of the subyearling programs may be related to coagulated yolk, which has reduced the unfertilized egg to release survival rates. For example, the unfertilized egg to release survival for normal subyearlings averaged 66.4% (range, 59.8-72.4%), while the survival rate for accelerated subyearlings averaged 71.2% (range, 66.5-81.8%). In contrast, the average survival for the yearling group averaged 80.1% (range, 64.8-88.2). The target survival rate for the three programs was 81%.

The lengths of Turtle Rock summer Chinook subyearlings and yearlings released into the Columbia River have generally been below the size goals for the programs. Mean lengths of the normal subyearling and yearling release groups were about 85% and 95% of the size goals. In contrast, the accelerated subyearling release group met or exceeded the size goal in most years. Average weights of the released subyearling and yearling summer Chinook have met or exceeded their respective goals in most years. Because of the unique relationship between length and weight of Turtle Rock summer Chinook, the current program cannot achieve both the length and weight targets. More realistic targets should be set based on the length-weight relationship specific to this population.

9.3 Harvest

Harvest Rates

Normal Subyearling Releases: Most of the harvest on Turtle Rock summer Chinook released as normal subyearlings occurred in the ocean (Figure 9.6). Ocean harvest has constituted 10% to 100% of all harvest on the normal subyearling release group (average, 67%). Brood years 1995, 1999, and 2001 provided the largest harvests, while brood years 1997 and 2003 provided the lowest (Hillman et al. 2011). The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams. The non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam.

Accelerated Subyearling Releases: Most of the harvest on Turtle Rock summer Chinook released as accelerated subyearlings occurred in the ocean (Figure 9.6). Ocean harvest has constituted 27% to 100% of all harvest on the accelerated subyearling release group (average, 72%). Brood year 1999 provided the largest harvest, while brood years 1995, 1997, 2002, and 2003 provided the lowest (Hillman et al. 2011).

Yearling Releases: Most of the harvest on Turtle Rock summer Chinook released as yearlings occurred in the ocean (Figure 9.6). Ocean harvest has constituted 43% to 95% of all harvest on the yearling release group (average, 71%). Brood year 1998 provided the largest harvest, while brood year 1995 provided the lowest (Hillman et al. 2011).

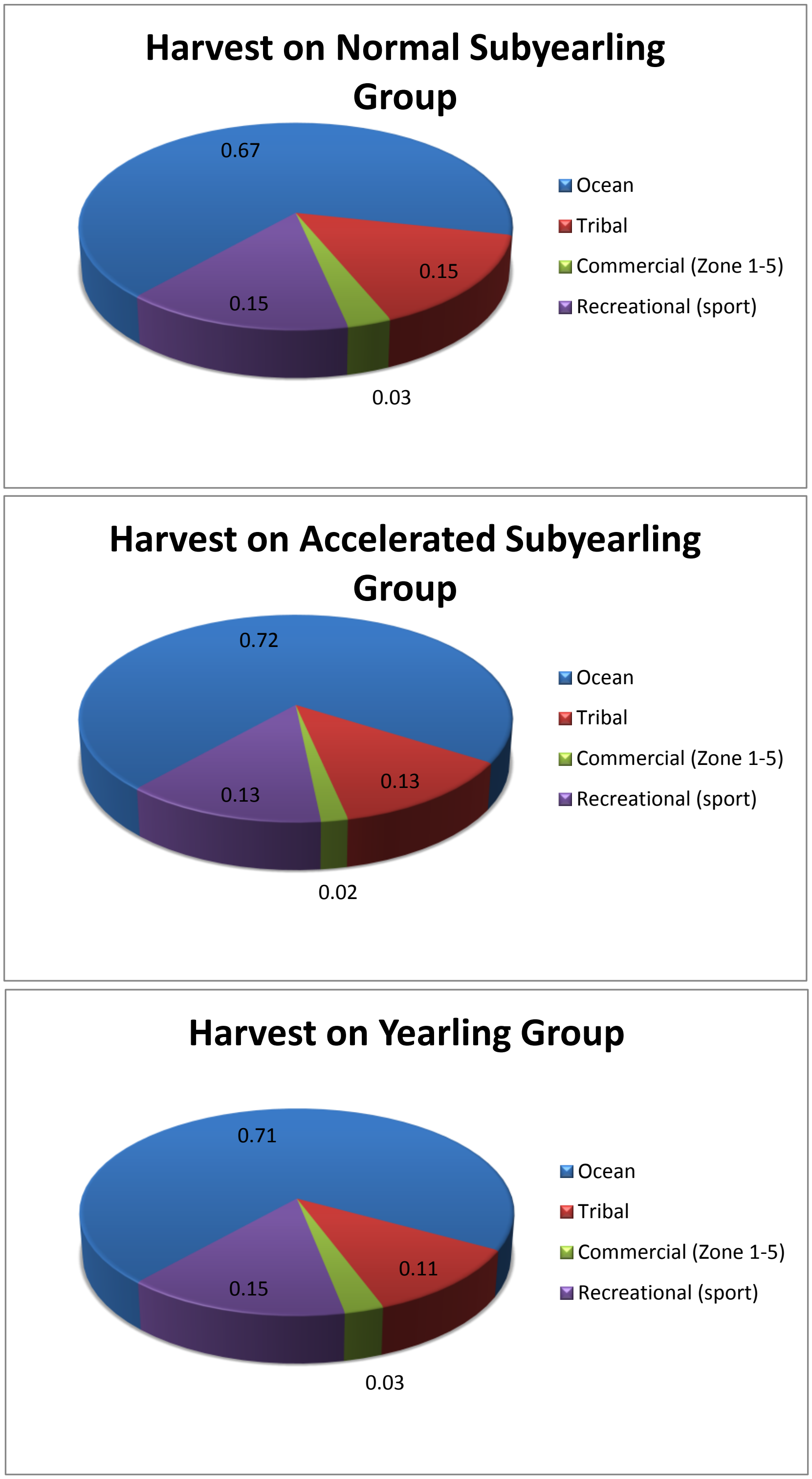


Figure 9.6. Mean allocation of Turtle Rock summer Chinook harvested among the different fisheries for the three different release groups for brood years 1995-2004. The total number of fish harvested across the brood years from the normal subyearling release group was 1,882 (average = 188 fish/year; range = 10-826), from the accelerated subyearling release group was 2,194 (average = 219 fish/year; range = 0-1,361), and from the yearling release group was 21,963 (average = 2,196 fish/year; range = 604-4,769).

The total number of Turtle Rock summer Chinook that were harvested varied among the different release groups (normal subyearling releases, accelerated subyearling releases, and yearling releases) (Figure 9.7). On average, the normal subyearling release group provided the lowest harvest rates (188 fish/BY; range, 10-826 fish), while the yearling release group provided the highest harvest rates (2,196 fish/BY; range, 604-4,769 fish). The accelerated subyearling group provided harvest rates that were intermediate (219 fish/BY; range, 0-1,361 fish).

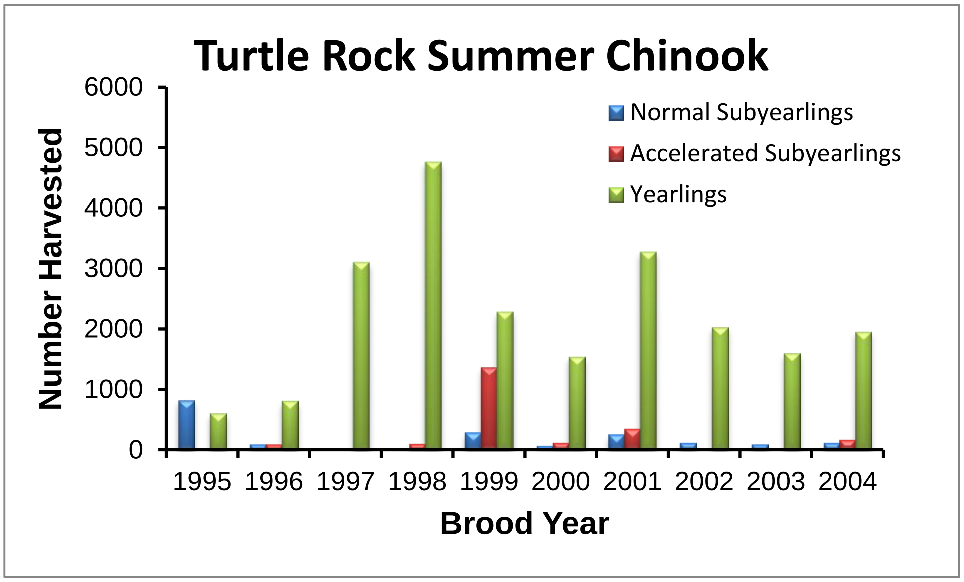


Figure 9.7. Numbers of different release groups of Turtle Rock summer Chinook adults harvested for brood years 1989-2004.

The percent of Turtle Rock summer Chinook released that were harvested also varied among the different release groups (Figure 9.8). The percent of the normal subyearling release group that was harvested averaged 0.038% (range, 0.002-0.121%). In contrast, the percent of the yearling release group that was harvested averaged 1.058% (range, 0.398-2.190%). The percent of the accelerated subyearling release group that was harvested averaged 0.059% (range, 0.000-0.391%).

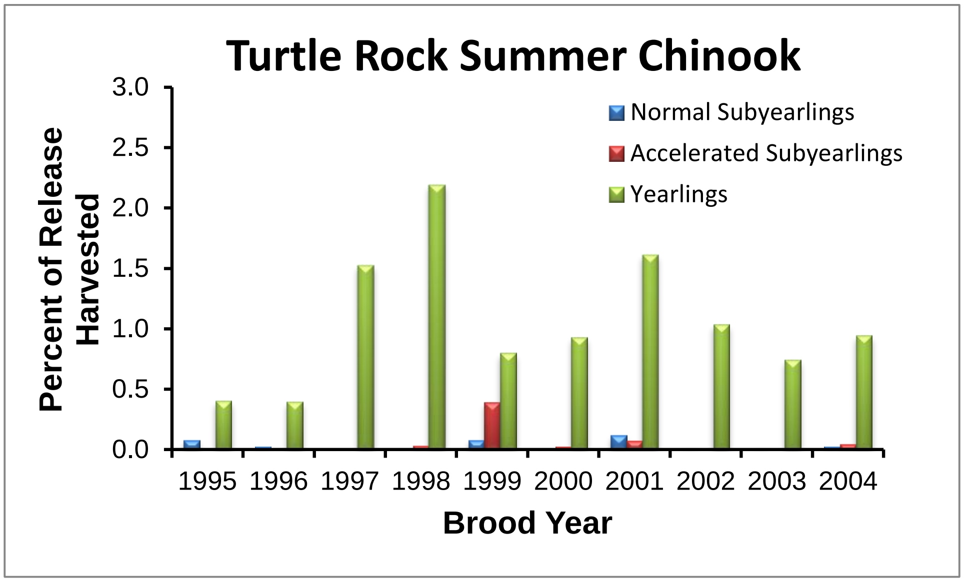


Figure 9.8. Percentages of the number of different Turtle Rock summer Chinook release groups that were harvested for brood years 1989-2004.

Conclusions

Regardless of release group, Turtle Rock summer Chinook were harvested primarily within the ocean fisheries. The number of Turtle Rock summer Chinook harvested per brood year varied among release groups. The normal subyearling release group provided the lowest average harvest (188 fish/BY), while the yearling release group provided the highest average harvest (2,196 fish/BY). Likewise, the percent of the number of fish released that were harvested was lowest for the normal subyearling release group (0.038%), while the yearling release group was the highest (1.058%). The accelerated subyearling release group provided intermediate harvest rates.

9.4 Summary and Recommendations

The major findings from this evaluation can be summarized as follows:

1. On average, about 31%, 41%, and 66% of the normal subyearling, accelerated subyearling, and yearling brood-year returns, respectively, strayed into non-target spawning areas.
2. Hatchery summer Chinook from the Turtle Rock program have strayed into the Wenatchee, Entiat, Chelan, Methow, and Okanogan basins and into the Hanford Reach. Normal subyearling and accelerated subyearling releases rarely made up more than 5% of the spawning escapements within those basins. In contrast, in several years, yearling releases made up more than 5% of the spawning escapement within the Entiat, Chelan, and Methow basins.
3. The Turtle Rock summer Chinook program has not consistently achieved its goal of releasing 810,000 normal subyearlings and 810,000 accelerated subyearlings. The subyearling program has released on average about 500,508 normal subyearlings (62% of goal) and 381,127 accelerated subyearlings (47% of goal). In contrast, yearling releases

usually met or exceeded the goal of releasing 200,000 yearlings per year. The yearling program released on average 215,829 yearlings, which is 108% of the goal.

4. The average lengths of the normal subyearling and yearling release groups were about 85% and 95% of the size goals. In contrast, the accelerated subyearling release group met or exceeded the size goal in most years. Average weights of the released subyearling and yearling summer Chinook met or exceeded their respective goals in most years. More realistic targets should be set based on the length-weight relationship specific to Turtle Rock summer Chinook.
5. Turtle Rock summer Chinook were harvested primarily within the ocean fisheries. The average number of Turtle Rock summer Chinook harvested per brood year was 188, 219, and 2,196 adults/year for the normal subyearling, accelerated subyearling, and yearling releases, respectively.
6. The mean percent of Turtle Rock releases that were harvested was 0.038%, 0.059%, and 1.058% for the normal subyearling, accelerated subyearling, and yearling releases, respectively.

Subyearling releases of Turtle Rock summer Chinook have failed to meet release goals and have provided relatively low harvest rates. Few adults from the subyearling release groups stray, primarily because of poor return rates. SARs for the normal subyearling release group averaged 0.000472 (range, 0.000034-0.001562) and the accelerated subyearling release group averaged 0.000754 (range, 0.000011-0.004619) (Hillman et al. 2011). In contrast, the yearling release group has provided larger SARs (average, 0.014340; range, 0.007184-0.026799) and harvest rates.

Because of the poor performance of the subyearling releases, managers eliminated subyearling releases and converted the subyearling program into a 400,000 yearling release program. Thus, with the conversion of the subyearling program to a yearling program, the current goal is to release 600,000 yearling summer Chinook smolts (200,000 from the existing yearling program and 400,000 from the subyearling program). The 600,000 yearlings will be acclimated and released in the Chelan River.

It will be important to release yearlings at an appropriate size. The size of yearling releases of Turtle Rock summer Chinook has not consistently met the program goals. This may be because the length and weight targets for the program were not based on the unique length-weight relationship of Turtle Rock summer Chinook. If the goal is to release summer Chinook smolts at 45.4 g, then the fork length at release should be about 161 mm, not 176 mm. It is unknown if SARs and harvest rates will increase if fish are released at the program goal of 176 mm. It is likely that releasing summer Chinook at a larger size will decrease the age and size at maturity (i.e., increase the return of 1and 2-salt fish).

Straying will also need to be addressed. Based on analysis of CWTs, yearling releases of Turtle Rock summer Chinook have strayed into non-target spawning areas at relatively high rates. Of those that escaped to spawn, about 66% of the brood returns have strayed into non-target spawning streams. In addition, these spawners have made up more than 5% of the spawning escapement within the Entiat, Chelan, and Methow basins in some years. The straying of Turtle Rock summer Chinook may be in part related to the early rearing of juvenile summer Chinook on well and Columbia River water. With the rearing and release of summer Chinook into the Chelan River, the rate of straying into the Entiat and Methow basins may decrease.

It will be important to monitor the success of the revised summer Chinook program (now known as the Chelan Falls summer Chinook program). Because of the larger number of yearlings released (which have larger SARs than subyearling releases) and the small size of the Chelan Basin available to anadromous fish, it is possible that large returns of summer Chinook to the Chelan River could significantly reduce the productivity and NORs of summer Chinook there. Density-dependent effects, including redd superimposition, competition, predation, and disease could reduce the productivity and NORs within the Chelan River. It is also possible that crowding on spawning grounds in the Chelan River could increase the number of fish that stray into other basins. Thus, managers will need to be vigilant and establish terminal fisheries when the escapement is large enough to create reductions in population productivity.

The Chelan Falls summer Chinook program should provide greater harvest opportunities than the Turtle Rock program. Managing straying and harvest will be important in determining the success of the program.

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SECTION 11: APPENDICES

Appendix A

METHODS FOR ESTIMATING NATURAL ORIGIN RECRUITS (NORS) AND NATURAL REPLACEMENT RATES (NRRS) FOR CHIWAWA SPRING CHINOOK

Methods for Estimating Natural Origin Recruits (NORs) and Natural Replacement Rates (NRRs) for Chiwawa Spring Chinook

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T. Hillman
A. Murdoch

September 2011

This paper describes the methods and data used to estimate natural origin recruits (NORs) and natural replacement rates (NRRs) for spring Chinook in the Chiwawa River. In the annual report (Hillman et al. 2011), we display most of the data used to estimate NORs and NRRs, but have also developed spreadsheets to hold the data and perform the calculations. For the purpose of this paper, we define natural origin recruits as naturally produced (wild)[1] salmon that survive to contribute to harvest (directly or indirectly), to broodstock, or to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality). The sum of the natural-origin recruits from each brood year are then used to estimate stock-recruit relationships, natural replacement rates, and as a means to compare the survival of wild and hatchery-origin fish.

In the Chelan Hatchery Evaluation Program, objectives were identified to evaluate the performance of the program. Specifically, Objectives 1 and 4 assess the adult-to-adult survival of naturally produced and hatchery produced fish (Murdoch and Peven 2005). Under Objective 1, the hypothesis tests if the supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population (supplemented stream) relative to a non-supplemented population (reference stream). Objective 4 compares the natural replacement rate (NRR) to the hatchery replacement rate (HRR). The specific hypotheses tested under each objective are as follows:

Objective 1:

- Ho: The annual change in the number of natural origin recruits for the supplemented population is greater than or equal to the annual change in the number of natural origin recruits of the non-supplemented population.
- Ho: The annual change in natural replacement rates for the supplemented population is greater than or equal to the annual change in natural replacement rates for the non-supplemented population.

Objective 4:

- Ho: The hatchery replacement rate is greater than or equal to the natural replacement rate for the same year.

Two estimates of the number of recruits are identified in the Chelan Hatchery Evaluation Program. First, there is the number of adult wild salmon (NORs) that survive to return to

[1] In this paper, "natural origin" and "wild" are used interchangeably and refer to the same thing.

spawn in either the hatchery or spawning grounds. The second is an estimate of the number of recruits that survived to return to spawn plus the number of recruits that were harvested. No pre-spawn mortality, other than harvest, was used to adjust total recruits.

In the following sections, we summarize the data used to estimate natural-origin recruits and the natural replacement rates for spring Chinook spawning in the Chiwawa River. Data for the period 1981 to 1992 represent population dynamics before initiation of the hatchery program; 1992 to present represent the period of hatchery supplementation. The following sections describe data used to estimate spawning escapement, hatchery-wild fish origin, age structure, and harvest rates. These data are then used to estimate NORs.

Total Spawning Escapement

Redd surveys have been used to estimate the number and distribution of redds of spring Chinook within the Chiwawa River. Redd surveys have evolved over the period 1981 to present. During the period 1981 through 1986, numbers of redds were estimated during "ground peak single surveys" (GPSS), which were conducted once annually during peak spawning (Table 1). From 1987 through 1989, survey effort increased to a "ground peak multiple surveys" (GPMS) during peak spawning. From 1990 through 2003, surveys were conducted once a week throughout the entire spawning period (August-September). Numbers of redds based on this method are referred to as "total ground" (GT) counts. From 2004 to present, survey effort increased to twice a week throughout the spawning period. These different survey methods were used to estimate spawning escapement in the Chiwawa River basin. These escapement estimates include the total number of fish (hatchery and wild) that contribute to natural production in a given return year.

Table 1. Chiwawa River redd counts, expansion factors, and methods used to estimate spawning escapements from 1981 to 2008. GPSS = ground peak single surveys, GPMS = ground peak multiple surveys, GT = total ground count surveys, LJ = Lavoy method, TUM = sampling at Tumwater Dam, and BS = broodstock sampling.

Return Year	Redd Counts		Expansion Factors			Spawning Escapement
	Total	Method	Multiplier	Fish/Redd	Method	
1981	187	GPSS	1.496	2.22	LJ	621
1982	175	GPSS	1.496	2.31	LJ	605
1983	313	GPSS	1.496	2.31	LJ	1,082
1984	348	GPSS	1.496	2.33	LJ	1,213
1985	507	GPSS	1.496	2.27	LJ	1,722
1986	320	GPSS	1.496	2.24	LJ	1,072
1987	444	GPMS		2.24	LJ	995
1988	262	GPMS		2.24	LJ	587
1989	314	GPMS		2.27	LJ	713
1990	255	GT		2.24	LJ	571
1991	104	GT		2.33	LJ	242
1992	302	GT		2.24	LJ	676
1993	106	GT		2.20	LJ	233
1994	82	GT		2.24	LJ	184
1995	13	GT		2.51	LJ	33
1996	23	GT		2.53	LJ	58
1997	82	GT		2.22	LJ	182
1998	41	GT		2.21	LJ	91

Return Year	Redd Counts		Expansion Factors			Spawning Escapement
	Total	Method	Multiplier	Fish/Redd	Method	
1999	34	GT		2.77	LJ	94
2000	128	GT		2.70	TUM	346
2001	1,078	GT		1.60	BS	1,725
2002	345	GT		2.05	BS	707
2003	111	GT		2.43	BS	270
2004	241	GT		3.56	TUM	858
2005	332	GT		1.80	TUM	598
2006	297	GT		1.78	TUM	529
2007	283	GT		4.58	TUM	1,296
2008	689	GT		1.68	TUM	1,158
2009	421	GT		3.20	TUM	1,347
2010	502	GT		2.18	TUM	1,094

Spawning escapements in the Chiwawa River basin are based on expanded redd counts (Table 1). Murdoch et al. (2009) found that on average each female spring Chinook builds and defends one redd (mean = 1.01 redds). Therefore, each redd accounts for one female in the spawning population. By applying an expansion factor (fish/redd), one can account for the number of females and males on the spawning grounds.

Methods for estimating spawning escapements have changed over time based on survey effort and expansion factors used. From 1981 to 1986 when GPSS surveys were conducted, a multiplier of 1.496 was applied to redd counts to make counts based on a single survey comparable to cumulative ground counts (Lavoy 1995). These products were then multiplied by an expansion factor developed by Lavoy (1994; LJ method). The LJ expansion factor was estimated as follows:

$$LJ\ Expansion\ Factor = \left(\frac{Fish}{Redd}\right) \times \left(1 + \left(\frac{Number\ of\ Jacks}{Total\ Escapement}\right)\right)$$

The LJ method used a fish/redd estimate of 2.2, which was calculated as the escapement into the Wenatchee Basin (1,339), divided by the total number or redds (600) counted in the Wenatchee Basin in 1993 (1,339 fish / 600 redds = 2.2 fish/redd). The 2.2 fish/redd estimate was then multiplied by the proportion of jacks in the run (where the number of jacks in the run was estimated as the difference in jack counts at Rocky Reach Dam and Rock Island Dam). For example, if jacks made up 14% of the run, the 2.2 fish/redd was multiplied by 1.14 to estimate an expansion factor of 2.51 fish/redd (2.2 fish/redd x 1.14 = 2.51 fish/redd). This product was then used to convert GPSS and GPMS redd counts into spawning escapements for return years 1987 to 1999.

For return years 2000 to present, the fish/redd expansion estimate was based on the male-to-female ratios observed during sampling at Tumwater Dam (TUM) or during brood stock (BS) sampling at the Chiwawa Weir each return year (Table 1). The sex-based expansion factor was estimated as follows:

$$Gender\ Expansion\ Factor = 1 + \left(\frac{Number\ of\ Males}{Number\ of\ Females}\right)$$

For example, if the sex ratio of a random sample of the run was 1.43 males to 1.00 females, the expansion factor would be 2.43 fish/redd (1.00 + 1.43 = 2.43). This sex-based expansion factor was then multiplied by the total redd count to estimate the spawning escapement. This method assumes that on average males spawn with only one female.

Hatchery and Wild Spawner Escapements

The proportion of hatchery and wild fish within the spawning escapement was estimated from fish collected during broodstock sampling (BS) at Tumwater Dam or at the Chiwawa River weir, and carcass sampling (CS) on the spawning grounds. Prior to initiation of the supplementation program in 1989 and before the return of hatchery fish, returns to the Chiwawa River were assumed to be naturally produced fish. Although it is possible that hatchery fish from the Leavenworth Hatchery strayed into the Chiwawa Basin during this period, the number of strays is assumed to be very low (Pastor 2004). From 1993 to present, the origin of returning fish was determined from analysis of scale growth patterns, presence/absence of adipose fin, and recovery of coded wire tags.

The number of wild and hatchery spawners was estimated by multiplying the total spawning escapement by the proportion of wild and hatchery fish observed in broodstock and carcass sampling. Table 2 presents the proportions of hatchery and wild fish used to estimate the total number of hatchery and wild spring Chinook spawners in the Chiwawa Basin. During return years 1993, 1994, and 1997, when carcass recovery rates were low on the spawning grounds, broodstock and carcass sampling were combined to estimate proportions of hatchery and wild spawners.

From 2004 to present, reach-specific wild and hatchery proportions were estimated for each survey reach in the Chiwawa Basin. Reach-specific hatchery-to-wild proportions reduce the possible bias associated with an uneven spawning distribution of hatchery and wild fish within the Chiwawa River.

To estimate the number of wild fish in the spawning escapement, the proportion of wild fish sampled was multiplied to the total spawning escapement to get the escapement of wild fish. For example, in 2001, the proportion of wild fish sampled (0.29) was multiplied by the total spawning escapement (1,725 fish) to get a wild spawning escapement of 500 fish (0.29 x 1,725 = 500). The number of hatchery fish was estimated similarly (0.71 x 1,725 = 1,225). To calculate the total wild return, we added wild fish collected and retained as broodstock to the wild spawning escapement estimate for each year.

Table 2. Total spawning escapements of hatchery and wild spring Chinook calculated from proportions of wild and hatchery spring Chinook sampled in broodstock (BS), from carcass sampling (CS), and reach-specific carcass recovery sampling (CS/reach).

Year	Hatchery and Wild Proportions			Spawning Escapement			Wild Broodstock	Total Wild Return
	Wild	Hatchery	Method	Wild	Hatchery	Total		
1981	1.00	0.00	All wild return	621	0	621	0	621
1982	1.00	0.00		605	0	605	0	605
1983	1.00	0.00		1,082	0	1,082	0	1,082
1984	1.00	0.00		1,213	0	1,213	0	1,213
1985	1.00	0.00		1,722	0	1,722	0	1,722
1986	1.00	0.00		1,072	0	1,072	0	1,072
1987	1.00	0.00		995	0	995	0	995
1988	1.00	0.00		587	0	587	0	587
1989	1.00	0.00		713	0	713	28	741
1990	1.00	0.00		571	0	571	19	590
1991	1.00	0.00		242	0	242	32	274
1992	1.00	0.00		676	0	676	78	754
1993	0.99	0.01	BS+CS	231	2	233	100	331
1994	0.67	0.33	BS+CS	123	61	184	9	132
1995	0.00	1.00	CS	0	33	33	0	0
1996	0.70	0.30	CS	41	17	58	8	49
1997	0.33	0.67	BS+CS	60	122	182	37	97
1998	0.65	0.35	CS	59	32	91	13	72
1999	0.93	0.07	CS	87	7	94	0	87
2000	0.67	0.33	CS	233	113	346	10	243
2001	0.29	0.71	CS	500	1,225	1,725	115	615
2002	0.36	0.64	CS	255	452	707	21	276
2003	0.62	0.38	CS	168	102	270	44	212
2004	0.68	0.32	CS/Reach	580	278	858	100	680
2005	0.23	0.77	CS/Reach	139	459	598	98	237
2006	0.22	0.78	CS/Reach	114	415	529	95	209
2007	0.12	0.88	CS/Reach	156	1,140	1,296	45	201
2008	0.17	0.83	CS/Reach	197	961	1,158	88	285
2009	0.23	0.77	CS/Reach	303	1,044	1,347	113	416

Age Structure (Wild Fish)

In order to estimate the year in which fish were produced (brood year), we organized wild fish by age class (i.e., 1.1, 1.2, and 1.3) within a return year. The age-class structure presented in Table 3 identifies what proportion of the return-year escapement is made up of each age class. The age of returning wild fish was determined from analysis of scales collected on the spawning grounds and/or from fish collected for broodstock. Two year old fish (age-2; 1.0) are not included in the age structure, although a few have been recovered (see Hillman et al. 2001; Table 5.29). A few were recovered in 2006 and 2008, but these fish resided within freshwater till their second year. We developed separate age-class structures for fish sampled on spawning grounds and for fish collected for broodstock. For some years the age structure was unknown, so an average age structure was used from data collected during 1986-1993 on the spawning grounds (from Chapman et al. 1995; reported in their Table 9). That age structure was used for 1981-1986 and 1995 on the spawning grounds, and 1989, 1990, and 1992 for wild broodstock.

Table 3. Proportion of wild Chinook of different ages in broodstock and sampled on the spawning grounds.

<table>
<tr><th rowspan="3">Return Year</th><th colspan="6">Wild Spring Chinook Age Class Proportions (Total Age)</th></tr>
<tr><th colspan="3">Spawning</th><th colspan="3">Broodstock</th></tr>
<tr><th>Age-3 (1.1)</th><th>Age-4 (1.2)</th><th>Age-5 (1.3)</th><th>Age-3 (1.1)</th><th>Age-4 (1.2)</th><th>Age-5 (1.3)</th></tr>
<tr><td>1981</td><td>0.010</td><td>0.564</td><td>0.425</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1982</td><td>0.010</td><td>0.564</td><td>0.425</td><td>-</td><td>-</td><td>-</td></tr>
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<tr><td>1988</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1989</td><td>0.010</td><td>0.564</td><td>0.426</td></tr>
<tr><td>1990</td><td>0.010</td><td>0.564</td><td>0.426</td></tr>
<tr><td>1991</td><td>0.156</td><td>0.594</td><td>0.250</td></tr>
<tr><td>1992</td><td>0.010</td><td>0.564</td><td>0.426</td></tr>
<tr><td>1993</td><td>0.000</td><td>0.286</td><td>0.714</td><td>0.000</td><td>0.220</td><td>0.780</td></tr>
<tr><td>1994</td><td>0.000</td><td>0.250</td><td>0.750</td><td>0.000</td><td>0.286</td><td>0.714</td></tr>
<tr><td>1995</td><td>0.000</td><td>0.100</td><td>0.000</td><td colspan="3">No Hatchery Program</td></tr>
<tr><td>1996</td><td>0.294</td><td>0.647</td><td>0.059</td><td>0.286</td><td>0.714</td><td>0.000</td></tr>
<tr><td>1997</td><td>0.000</td><td>0.871</td><td>0.129</td><td>0.000</td><td>0.875</td><td>0.125</td></tr>
<tr><td>1998</td><td>0.000</td><td>0.054</td><td>0.946</td><td>0.000</td><td>0.636</td><td>0.364</td></tr>
<tr><td>1999</td><td>0.050</td><td>0.650</td><td>0.300</td><td colspan="3">No Hatchery Program</td></tr>
<tr><td>2000</td><td>0.018</td><td>0.946</td><td>0.036</td><td>0.200</td><td>0.700</td><td>0.100</td></tr>
<tr><td>2001</td><td>0.011</td><td>0.949</td><td>0.040</td><td>0.028</td><td>0.944</td><td>0.028</td></tr>
<tr><td>2002</td><td>0.000</td><td>0.556</td><td>0.444</td><td>0.000</td><td>0.667</td><td>0.333</td></tr>
<tr><td>2003</td><td>0.083</td><td>0.000</td><td>0.917</td><td>0.270</td><td>0.027</td><td>0.703</td></tr>
<tr><td>2004</td><td>0.060</td><td>0.930</td><td>0.010</td><td>0.063</td><td>0.906</td><td>0.031</td></tr>
<tr><td>2005</td><td>0.015</td><td>0.776</td><td>0.209</td><td>0.010</td><td>0.850</td><td>0.140</td></tr>
<tr><td>2006</td><td>0.030</td><td>0.560</td><td>0.400</td><td>0.021</td><td>0.702</td><td>0.277</td></tr>
<tr><td>2007</td><td>0.103</td><td>0.241</td><td>0.655</td><td>0.163</td><td>0.535</td><td>0.302</td></tr>
<tr><td>2008</td><td>0.023</td><td>0.814</td><td>0.163</td><td>0.091</td><td>0.753</td><td>0.156</td></tr>
</table>

Return Year	Wild Spring Chinook Age Class Proportions (Total Age)					
	Spawning			Broodstock		
	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)
2009	0.089	0.867	0.044	0.084	0.800	0.116

The age-class proportions in Table 3 were applied to the wild spawning escapement and broodstock to estimate the number of returning fish of a given age (Table 4). The number of wild fish of a given age within a return year was estimated as the spawning escapement or broodstock times the proportion for that return year and age. For example, in 2004, the wild spawning escapement in the Chiwawa Basin was 580 fish (Table 2). The number of wild fish of each age class on the spawning grounds in 2004 was estimated to be 35 age-3 fish (580 x 0.060 = 35 fish), 539 age-4 fish (580 x 0.930 = 539 fish), and 6 age-5 fish (580 x 0.010 = 6 fish). When this exercise is carried out for each return year, the age-specific escapement can be estimated for all wild fish collected for broodstock or returning to spawn in the Chiwawa Basin (Table 4).

This approach does not address the issue of carcass recovery bias. Carcass recovery bias is important for spring Chinook stock reconstruction because a majority of the recruits for any given year are recovered on the spawning grounds. Larger fish may be recovered on the spawning grounds at a greater rate than smaller fish. Furthermore, if hatchery fish return as smaller and younger adults compared to wild fish, they would be underrepresented in the carcass surveys. We intend to address this bias once methodologies have been fully developed.

Table 4. Number of wild fish by age class estimated on the spawning grounds and collected for broodstock.

Return Year	Wild Spring Chinook Age Classes (Total Age)							
	Spawning Grounds				Broodstock			
	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)	Total	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)	Total
1981	6	351	264	621	-	-	-	-
1982	6	342	257	605	-	-	-	-
1983	11	611	460	1,082	-	-	-	-
1984	12	685	516	1,213	-	-	-	-
1985	18	972	732	1,722	-	-	-	-
1986	11	605	456	1,072	-	-	-	-
1987	10	562	423	995	-	-	-	-
1988	6	332	249	587	-	-	-	-
1989	7	403	303	713	0	16	12	28
1990	6	322	243	571	0	11	8	19
1991	2	137	103	242	5	19	8	32
1992	7	382	287	676	1	44	33	78
1993	0	66	165	231	0	22	78	100
1994	0	31	92	123	0	3	6	9
1995	0	0	0	0	0	0	0	0
1996	12	27	2	41	2	6	0	8
1997	0	52	8	60	0	32	5	37

Return Year	Wild Spring Chinook Age Classes (Total Age)							
	Spawning Grounds				Broodstock			
	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)	Total	Age-3 (1.1)	Age-4 (1.2)	Age-5 (1.3)	Total
1998	0	3	56	59	0	8	5	13
1999	4	57	26	87	0	0	0	0
2000	4	221	8	233	2	7	1	10
2001	6	481	20	507	3	109	3	115
2002	0	142	113	255	0	14	7	21
2003	14	0	154	168	12	1	31	44
2004	35	539	6	580	6	91	3	100
2005	2	108	29	139	1	83	14	98
2006	3	59	52	114	2	67	26	95
2007	16	38	102	156	7	24	14	45
2008	5	160	32	197	8	66	14	88
2009	27	263	12	303	9	90	13	112

NORs and NRRs (without harvest)

Natural origin recruits (NORs) can be estimated by reorganizing the data in Table 4. First, the number of wild fish in each age class must be backed to brood year (the year the fish were produced). This is calculated by subtracting the total age of the fish from their return year. The number of recruits of each age class for a given brood year are then added together to estimate the total number of wild recruits for a given brood year. For example, the number of wild fish returning from the 2001 brood year was 310 fish, which is the sum of wild fish returns from 2004-2006:

Return year	Age at Return	Spawning Escapement	Broodstock	Total
2004	3	35	6	41
2005	4	108	83	191
2006	5	52	26	78
			Total	**310**

These 310 fish represent the NORs that returned from natural production in 2001. Table 5 identifies the total number of wild recruits to the Chiwawa Basin organized by age and brood year along with the spawning escapement that produced them. These NORs do not include fish harvested in the ocean, estuary, or Columbia River.

Natural replacement rate (NRR) was estimated as follows:

$$NRR = \frac{NOR}{Spawning\ Escapement}$$

In words, NRR is the total number of wild recruits divided by the spawning escapement (includes both wild and hatchery spawners) that produced them. The NRR for brood year 2001 is 0.18, which was calculated by dividing the total number of wild recruits (310) by the spawning escapement (1,725) to get 0.18 wild recruits per spawner. Table 5 identifies the NRRs for brood years 1981 to 2004.

Table 5. Chiwawa spring Chinook natural origin recruits for brood years 1981 to 2004. The natural replacement rate is total recruits divided by spawning escapement.

Brood Year	Natural Origin Recruits	Spawning Escapement	Natural Replacement Rate
1981	1,440	621	2.32
1982	1,046	605	1.73
1983	822	1,082	0.76
1984	657	1,213	0.54
1985	676	1,722	0.39
1986	451	1,072	0.42
1987	482	995	0.48
1988	676	587	1.15
1989	194	713	0.27
1990	34	571	0.06
1991	2	242	0.01
1992	46	676	0.07
1993	159	233	0.68
1994	37	184	0.20
1995	66	33	2.00
1996	255	58	4.40
1997	716	182	3.93
1998	350	91	3.85
1999	10	94	0.11
2000	699	346	2.02
2001	310	1,725	0.18
2002	245	707	0.35
2003	113	270	0.42
2004	275	858	0.32

NORs and NRRs (with harvest)

So far we have described the wild return as the sum of the wild spawning escapement and wild fish collected for broodstock (Table 2). However, it is also important to add the number of wild fish harvested in various fisheries and the incidental loss of wild fish killed in mark-selective fisheries, which began in 2001, to the wild return. Thus, the total wild escapement is here defined as the number of wild fish harvested, plus the estimated incidental mortalities, plus the number of wild fish in broodstock, plus the number of wild fish spawning in the Chiwawa Basin.

$$Total\ Wild\ Escapement = Spawning\ escapement + Broodstock + Harvest + Incidental\ Loss$$

One way to estimate the number of wild spring Chinook harvested is to apply the return-year harvest rates that are reported in the Joint Staff Reports produced by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife (ODFW and WDFW 2009). Another way is to use a hatchery indicator stock, such as the Chiwawa Hatchery or Leavenworth National Fish Hatchery (LNFH) to estimate brood-year harvest rates on wild fish. Below we describe both methods as they apply to wild spring Chinook in the Chiwawa Basin. Selection of the most appropriate method, or combination of methods, will be determined by the HETT and Hatchery Committees.

<u>Hatchery Indicator Stock Harvest Rates</u>—The assumption when using a hatchery indicator stock, such as spring Chinook from the LNFH or the Chiwawa River Hatchery, is that hatchery and wild fish have a similar adult migration pattern. That is, hatchery fish and wild fish have similar encounter and capture rates in different fisheries. We used these hatchery indicator stocks to produce brood-year harvest rates that could be applied to brood-year returns of wild spring Chinook. During brood years 1981-1996, when there were no mark-selective fisheries, the harvest rate on hatchery fish that was applied to wild fish was estimated as follows:

$$Hatchery\ Harvest\ Rate = \frac{Total\ Expanded\ Estimate\ of\ CWT\ Fish\ Harvested}{Total\ Expanded\ Estimate\ of\ CWTs\ Collected}$$

The denominator (total expanded estimate of CWTs collected) includes all CWTs estimated in hatchery programs, on spawning grounds, and in fisheries. As an example, the harvest rate on brood year 1993 spring Chinook was 2.6% (16 / 606 = 0.026 or 2.6%). We used the mean harvest rate from several years (1984, and 1986-1989) to describe the harvest rate in missing years (1981-1983, and 1985). Table 6 shows harvest rates on Icicle Creek spring Chinook from the LNFH for brood years 1981 to 1996 and 1999.

These harvest rates were then applied to the wild return (wild spawners plus wild fish in broodstock) to estimate total wild fish escapement, which includes harvest, as follows:

$$Total\ Wild\ Fish\ Escapement = \frac{(Wild\ Fish\ Spawners) + (Wild\ Fish\ in\ Broodstock)}{1-(Harvest\ Rate)}$$

For example, the total wild escapement (including harvest) for brood year 1989 was estimated at 282 wild spring Chinook. This method of estimating harvest was used for brood years before 1997 (Table 6).

$$Total\ Wild\ Fish\ Escapement = \frac{165+29}{1-0.313} = \frac{194}{0.687} = 282$$

LNFH harvest rate was also used in 1999 for mark-selective fisheries because there was no broodstock collected for the Chiwawa Hatchery Program that year.

Table 6. Harvest rates on Icicle Creek spring Chinook from the LNFH that were used to estimate harvest on wild Chiwawa River spring Chinook.

Brood Year	Icicle Creek Harvest Rates (LNFH)			Chiwawa River Spring Chinook		
	Total Harvest	Total Collected	Harvest Rate	Total Wild Escapement	Estimated Wild Harvest	Total Wild Escapement + Harvest
1981	---	---	0.348	1,440	769	2,209
1982	---	---	0.348	1,046	558	1,604
1983	---	---	0.348	822	439	1,261
1984	9	20	0.450	657	538	1,195
1985	---	---	0.348	676	361	1,037
1986	144	380	0.379	451	275	726
1987	261	895	0.292	482	199	681
1988	269	884	0.304	676	295	971
1989	112	358	0.313	194	88	282
1990	2	13	0.154	34	6	40
1991	7	93	0.075	2	0	2
1992	8	160	0.050	46	2	48
1993	16	606	0.026	159	4	163
1994	4	158	0.025	37	1	38
1995	16	354	0.045	66	3	69
1996	90	1,054	0.085	255	24	279
1999	40	231	0.048	10	1	11

Mark-selective (adipose fin clipped) harvest was initiated on spring Chinook returns in 2001 for recreational sport fisheries and in 2002 on commercial fisheries in the Columbia River. As a result, total harvest on wild spring Chinook was reduced. However, incidental mortality still occurred on wild spring Chinook as a result of catch-and-release in the mark-selective fisheries. These mark-selective fisheries affected the harvest rate on wild spring Chinook from brood year 1997 to present. We applied the incidental mortality estimates in the Joint Staff Report (2009), which used a 10% incidental mortality rate on wild spring Chinook released from sport-selective fisheries and a 14.7% incidental mortality rate on wild fish released from commercial gillnet fisheries.

Table 7 shows the estimated harvest on hatchery spring Chinook from the Chiwawa Hatchery and LNFH (1999 only) for brood years 1997-2002. The harvest rates were adjusted to estimate the harvest on wild fish based on an incidental mortality rate of 10% in recreational sport fisheries and an incidental mortality rate of 14.7% in commercial gillnet fisheries. Harvest rates (including indirect mortality) on wild fish for brood years 1997-2002 were estimated as follows:

$$HR = \frac{(Sport\ Harvest\ \ x\ 0.10) + (Commercial\ \ Harvest\ \ x\ 0.147) + (Nonselective\ Harvest)}{Total\ Expanded\ \ CWT\ Estimate}$$

For example, for brood year 1997, the estimated harvest rate on wild fish was 0.098.

$$HR = \frac{(109\ x\ 0.10) + (27\ x\ 0.147) + (235)}{2{,}549}$$

$$HR = \frac{(11) + (4) + (235)}{2{,}549} = \frac{250}{2{,}549} = 0.09808$$

Thus, the total wild fish escapement (including harvest and incidental mortality) for brood year 1997 was estimated at 794 wild spring Chinook (716 / (1 - 0.098) = 794).

Table 7. Estimated brood-year harvest rates for wild fish based on adjusted hatchery harvest rates. Hatchery harvest rates were based on CWT recoveries of Chiwawa Hatchery spring Chinook in all years except 1999 when there was no program. In 1999, recoveries of spring Chinook from the LNFH were used to estimate the wild harvest rate.

Brood Year	Fisheries			Total		Hatchery Harvest Rates	Wild Incidental Mortality Rates	Wild Escapement	
	Sport Selective	Comm. Selective	Non-Selective	Harvest	Expanded CWT Estimate			Harvest not included	Harvest included
1997	109	27	235	371	2,549	0.1455	0.0980	716	794
1998	119	9	56	184	1,118	0.1646	0.0619	350	373
1999	16	24	0	40	234	0.1709	0.0479	10	11
2000	6	0	17	23	375	0.0613	0.0469	699	733
2001*	11	1	25	37	1,830	0.0143	0.0143	310	314
2002	26	20	25	71	760	0.0934	0.0402	245	255
2003	26	11	47	84	763	0.1101	0.0671	113	121
2004	250	31	190	471	2,973	0.1584	0.0739	275	297

*In brood year 2001 all Chiwawa hatchery fish were released with their adipose fins intact. That is why the hatchery harvest rate and incidental mortality rates are identical.

Joint Staff Report Harvest Rates—The Joint Staff Report (2009) estimates total fisheries harvest by return year for upper Columbia wild spring Chinook (Table 8). The Joint Staff also produces a similar table for wild Snake River spring/summer Chinook. The mainstem harvest rate on wild Chiwawa spring Chinook was estimated as follows:

$$Mainstem\ Harvest\ Rate = \left(\frac{(Total\ Fisheries\ Harvest) \times \left(\frac{Priest\ Rapids\ Dam\ Count}{Upper\ Columbia\ Wild\ Run\ Size}\right)}{Priest\ Rapids\ Dam\ Passage} \right)$$

For example the harvest rate on wild spring Chinook in 1989 was estimated at 0.099.

$$Mainstem\ Harvest\ Rate = \frac{653 \times 0.567}{3{,}732} = 0.099$$

Table 8. Columbia River fisheries and passage-loss impacts on the Upper Columbia wild spring Chinook run and escapements, 1980-2006 (from Joint Staff Report 2009).

Return year	Upper Columbia Wild Run Size	Non-Indian Catch[1]		Treaty Indian Catch[2]		Fisheries Total		Escapement at Priest Rapids[3]	
		No.	% of Run	No.	% of Run	No.	% of Run	No.	% of Run
1980	8,206	17	0.2	266	3.2	283	3.4	3,586	43.7
1981	9,982	141	1.4	506	5.1	647	6.5	6,695	67.1
1982	7,626	135	1.8	526	6.9	661	8.7	3,714	48.7
1983	8,542	413	4.8	346	4.1	759	8.9	5,158	60.4
1984	7,250	252	3.5	483	6.7	735	10.1	5,006	69.0
1985	11,006	402	3.7	376	3.4	778	7.1	9,336	84.8
1986	8,175	170	2.1	476	5.8	646	7.9	5,716	69.9
1987	7,584	120	1.6	462	6.1	582	7.7	5,374	70.9
1988	5,488	354	6.5	365	6.7	719	13.1	3,878	70.7
1989	6,580	158	2.4	495	7.5	653	9.9	3,732	56.7
1990	5,643	287	5.1	372	6.6	659	11.7	4,007	71.0
1991	2,514	100	4.0	152	6.0	252	10.0	1,736	69.1
1992	5,007	83	1.7	302	6.0	385	7.7	3,980	79.5
1993	5,268	45	0.9	322	6.1	367	7.0	4,678	88.8
1994	1,804	71	3.9	88	4.9	159	8.8	1,155	64.0
1995	290	0	0.0	15	5.2	15	5.2	157	54.1
1996	308	0	0.0	16	5.2	16	5.2	173	56.2
1997	1,071	1	0.1	72	6.7	73	6.8	655	61.2
1998	401	0	0.0	21	5.2	21	5.2	284	70.8
1999	642	1	0.2	30	4.7	31	4.8	451	70.2
2000	3,007	6	0.2	183	6.1	189	6.3	2,098	69.8
2001	10,103	156	1.5	1326	13.1	1,482	14.7	8,047	79.6
2002	5,757	112	1.9	625	10.9	737	12.8	4,037	70.1
2003	2,581	40	1.5	204	7.9	244	9.5	1,785	69.2
2004	3,119	65	2.1	271	8.7	336	10.8	2,264	72.6
2005	2,445	40	1.6	153	6.3	193	7.9	1,778	72.7
2006	2,817	38	1.3	185	6.6	223	7.9	1,807	64.1

[1] Includes incidental mortalities in mainstem recreational and commercial fisheries.

[2] Includes winter season commercial sales and spring C&S catches. Since 1982, C&S catch includes gill net, dip net, and hook and line.

[3] Priest Rapids Dam passage.

The return-year harvest rates were then applied to the total wild returns provided in Table 2. Table 9 shows the estimated harvest on wild spring Chinook from 1981 to 2006 from the Chiwawa River. Because the age structure of harvested wild fish is unknown, we used the combined age structure of fish collected as broodstock and on the spawning ground to estimate the age structure of fish harvested in the mainstem Columbia River. No additional harvest estimates from fisheries in Icicle Creek or on the Wenatchee River were made to adjust the total harvest on wild Chiwawa River spring Chinook.

Table 9. Harvest and age-at-return estimates for wild spring Chinook harvested in the mainstem Columbia River.

Year	Total Wild Return	Return-Year Harvest Rate	Total Wild Return + Harvest	Age at Harvest			Total
				Age-3	Age-4	Age-5	
1981	621	0.065	664	1	24	18	43
1982	605	0.087	663	1	32	25	58
1983	1,082	0.089	1,188	1	60	45	106
1984	1,213	0.101	1,349	1	77	58	136
1985	1,722	0.071	1,854	1	75	56	132
1986	1,072	0.079	1,164	1	52	39	92
1987	995	0.077	1,078	1	47	35	83
1988	587	0.131	675	1	50	37	88
1989	741	0.099	822	1	46	34	81
1990	590	0.117	668	1	44	33	78
1991	274	0.100	304	1	17	12	30
1992	754	0.077	817	1	35	27	63
1993	331	0.070	356	0	6	19	25
1994	132	0.088	145	0	3	10	13
1995	0	0.049	0	0	0	0	0
1996	49	0.055	52	1	2	0	3
1997	97	0.067	104	0	6	1	7
1998	72	0.051	76	0	1	3	4
1999	87	0.047	91	0	3	1	4
2000	243	0.063	259	1	14	1	16
2001	622	0.146	728	2	100	4	106
2002	276	0.127	316	0	23	17	40
2003	212	0.094	234	4	0	18	22
2004	680	0.108	762	5	75	2	82
2005	237	0.081	258	0	17	4	21
2006	209	0.067	224	0	10	5	15

The return-year age structure for harvested wild fish was converted into brood-year returns using the methods described earlier in this report. Table 10 provides NORs and NRRs estimates with and without harvest. The table also shows, for comparison, NORs and NRRs adjusted for harvest based on a hatchery indicator stock and return-year harvest rates published in the Joint Staff Report. From 1990 to 2002, both methods provided similar NORs (Table 10 and Figure 1). However, from 1981 to 1989, the hatchery-indicator-stock method consistently estimated larger harvests on wild spring Chinook and therefore higher numbers of NORs (Table 10 and Figure 1).

Table 10. Estimates of total spawning escapement, NORs, and NRRs with and without harvest for Chiwawa spring Chinook for brood years 1981-2002. Results from both the hatchery-indicator-stock method and Joint-Staff-Report method are presented for comparison.

Brood Year	Total Spawning Escapement	Harvest Not Included		Harvest Included			
				Indicator Stock		Joint Staff Report	
		NOR	NRR	NOR	NRR	NOR	NRR
1981	621	1,440	2.32	2,209	3.56	1,555	2.50
1982	605	1,046	1.73	1,604	2.65	1,134	1.87
1983	1082	822	0.76	1,261	1.17	907	0.84
1984	1213	657	0.54	1,195	0.99	742	0.61
1985	1722	676	0.39	1,037	0.60	756	0.44
1986	1072	451	0.42	726	0.68	508	0.47
1987	995	482	0.48	681	0.68	527	0.53
1988	587	676	1.15	971	1.65	731	1.25
1989	713	194	0.27	282	0.40	211	0.30
1990	571	34	0.06	40	0.07	37	0.06
1991	242	2	0.01	2	0.01	2	0.01
1992	676	46	0.07	48	0.07	49	0.07
1993	233	159	0.68	163	0.70	169	0.73
1994	184	37	0.20	38	0.21	39	0.21
1995	33	66	2.00	69	2.09	70	2.12
1996	58	255	4.40	279	4.81	273	4.71
1997	182	716	3.93	794	4.36	834	4.58
1998	91	350	3.85	373	4.10	393	4.32
1999	94	10	0.11	11	0.12	12	0.13
2000	312	699	2.02	733	2.12	782	2.26
2001	2490	310	0.18	316	0.18	337	0.20
2002	707	245	0.35	255	0.36	255	0.36

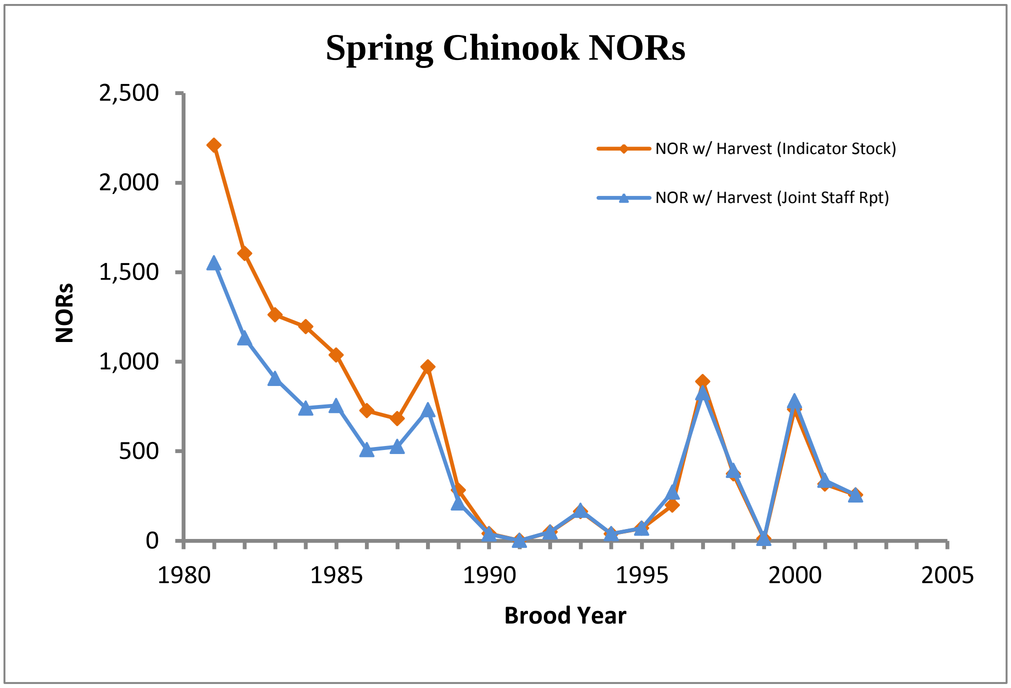

Figure 1. Comparison of the number of harvest-adjusted NORs using the hatchery indicator stock method and the Joint Staff Report method.

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Appendix B

METHODS FOR ESTIMATING NATURAL ORIGIN RECRUITS (NORS) AND NATURAL REPLACEMENT RATES (NRRS) FOR WENATCHEE, METHOW, AND OKANOGAN SUMMER CHINOOK

Methods for Estimating Natural Origin Recruits (NORs) and Natural Replacement Rates (NRRs) for Wenatchee, Methow, and Okanogan Summer Chinook

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This paper describes the methods and data used to estimate natural-origin recruits (NORs) and natural replacement rates (NRRs) for summer Chinook in the Wenatchee, Methow, and Okanogan basins. The Okanogan Basin consists of summer Chinook that spawn in the Similkameen and Okanogan rivers. In the annual report (Hillman et al. 2011), we display most of the data used to estimate NORs and NRRs, but have also developed spreadsheets to hold the data and perform the calculations. For the purpose of this paper, we define natural-origin recruits as naturally produced (wild)[1] salmon that survive to contribute to harvest (directly or indirectly), to broodstock, and to spawning grounds. We do not account for fish that died in route to the spawning grounds (migration mortality) or died just before spawning (pre-spawn mortality). The sum of the natural-origin recruits from each brood year are then used to estimate stock-recruit relationships, natural replacement rates, and as a means to compare the survival of wild and hatchery origin fish.

In the Chelan Hatchery Evaluation Program, objectives were identified to evaluate the performance of the program. Specifically, Objectives 1 and 4 assess the adult-to-adult survival of naturally produced and hatchery produced fish (Murdoch and Peven 2005). Under Objective 1, the hypothesis tests if the supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population (supplemented stream) relative to a non-supplemented population (reference stream). Objective 4 compares the natural replacement rate (NRR) to the hatchery replacement rate (HRR). The specific hypotheses tested under each objective are as follows:

Objective 1:

- Ho: The annual change in the number of natural-origin recruits for the supplemented population is greater than or equal to the annual change in the number of natural-origin recruits of the non-supplemented population.
- Ho: The annual change in natural replacement rates for the supplemented population is greater than or equal to the annual change in natural replacement rates for the non-supplemented population.

[1] In this paper, "natural-origin" and "wild" are used interchangeably and refer to the same thing.

Objective 4:

- Ho: The hatchery replacement rate is greater than or equal to the natural replacement rate for the same brood year.

There are two different estimates of the number of recruits identified in the Chelan Hatchery Evaluation Program. First, there is the number of adult wild salmon (NORs) that survive to return to spawn in either the hatchery or on spawning grounds. The second is an estimate of the number of recruits that survived to return to spawn plus the number of recruits that were harvested. No pre-spawn mortality, other than harvest, was used to adjust total recruits.

In the following sections we summarize the data used to estimate natural-origin recruits and the natural replacement rates for summer Chinook spawning in the Wenatchee, Methow, and Okanogan basins. Data for the period 1981 to 1992 represents population dynamics before initiation of the hatchery program; 1992 to present represents the period of hatchery supplementation. For the Wenatchee River, we also investigate the use of a density model as an alternative to estimating redd counts and spawning escapement from the data collected. The following sections describe data used to estimate redd counts, spawning escapement, fish origin (hatchery or wild), age structure, and harvest rates. These data are then used to estimate NORs.

Estimate of Number of Redds

Different types of redd surveys have been used over the years to estimate the number and distribution of summer Chinook redds within Upper Columbia River tributaries. In the Methow, Okanogan, and Wenatchee River basins, redd counts have been conducted from aerial and ground surveys. In some years, only aerial counts were used and in other years both aerial and ground surveys were conducted. There are also differences in ground survey methods that have been used over the years. There have been three types of ground counts:

(1) A **peak ground count** is the maximum number of redds observed during a given survey within a reach. The sum of the peak counts within all reaches is the total peak ground count.

(2) A **total ground count** or “map count” involves mapping the location of redds on each successive survey so old and new redds are accounted for within a reach. The sum of all new redds within all reaches was the total number of redds.

(3) A **peak expansion count** is a hybrid of the two ground count methods. The expansion count involves paired observations (peak and map counts) within an index area of a reach to provide an expansion factor for that reach. Application of the expansion factors and summing across all reaches provides an estimate of a total ground count.

Peak ground counts and aerial counts only count the maximum number of visible redds on a given survey and thus they do not distinguish between old or new redds on successive surveys and may underestimate the true number of redds. As old redds fade and new redds are constructed, it is possible to count the same number of redds or fewer redds in the same reach on successive survey dates. Total ground counts map out all new redds as they are constructed so new and old redds are accounted for in the survey. Total ground counts are believed to be the most accurate survey method. For developing NORs and NRRs, the goal is to have a complete data set of redd counts based on total ground counts or an estimated total ground count. It is essential to have a normalized data set across all years because redd counts are used to estimate escapement. Escapements along with age structure and hatchery-wild ratios are used to produce the number of natural-origin recruits returning to these streams. We used expansion factors for Upper Columbia River tributaries to adjust the data for years in which aerial counts and peak counts were conducted. Reach-specific expansion factors were developed for each river to expand aerial or peak counts to an estimated ground count.

Methow River

In the Methow Basin, summer Chinook spawn in the mainstem Methow River from just upstream of the Winthrop Hatchery Diversion Dam downstream to the confluence with the Columbia River. Prior to 1990, aerial surveys were used to estimate the number of summer Chinook redds in the Methow River (Kohn 1987, 1988, 1989). In 1990, a peak ground count was used to estimate the total number of redds in the Methow River (Langness 1991). Comprehensive total ground counts on the Methow River began in 1991 and have continued since (Hillman and Ross 1992; Murdoch and Miller 1999; Snyder and Miller 2009). Both total ground counts (map counts) and peak aerial counts were conducted in 1991 to 1996. In 1996, aerial surveys in the Methow were discontinued. To adjust the aerial redd counts for the Methow (redd counts prior to 1990), we used reach-specific expansion factors derived from aerial and total ground counts from 1991 to 1995. Because there are no paired data available for peak ground counts and total counts in the Methow River, the peak ground count in 1990 could not be adjusted. Thus, the peak ground count in 1990 is used to represent the total redd count in that year.

Individual expansion factors for each year were calculated as the aerial count divided by the total ground count for each reach. For example, in 1991 for reach M1 on the Methow River, the expansion factor was 11/14 = 0.79 (Table 1). The mean expansion factors used to adjust aerial counts before 1990 are presented in Table 1. The mean expansion factors indicate that the accuracy of aerial surveys varies by reach and accounts for about 79-98% of the redds that were observed during total ground counts. In some years and reaches, the aerial count exceeded the ground count. We believe this is related to counting test digs or non-target redds (sockeye and spring Chinook) that were not counted by ground survey crews.

Table 1. Aerial and total ground counts used to estimate mean expansion factors for summer Chinook in the Methow Basin.

Reach	Survey	Counts					Mean
		1991	1992	1993	1994	1995	
M1	Aerial	11	8	40	86	54	**0.83**
	Ground	14	9	49	93	74	
	Expansion	0.79	0.89	0.82	0.92	0.73	
M2	Aerial	45	32	26	85	98	**0.79**
	Ground	56	39	34	110	124	

Reach	Survey	Counts					Mean
		1991	1992	1993	1994	1995	
	Expansion	0.80	0.82	0.76	0.77	0.79	
M3	Aerial	42	23	26	76	98	**0.84**
	Ground	56	28	36	72	116	
	Expansion	0.75	0.82	0.72	1.06	0.84	
M4	Aerial	4	9	3	6	15	**0.98**
	Ground	5	12	3	5	13	
	Expansion	0.80	0.75	1.00	1.20	1.15	
M5	Aerial	17	19	21	27	30	**0.89**
	Ground	20	19	32	30	29	
	Expansion	0.85	1.00	0.66	0.90	1.03	
M6	Aerial	1	0	0	0	1	**0.90**
	Ground	2	0	0	0	1	
	Expansion	0.50	1.00	1.00	1.00	1.00	

To expand aerial counts from 1981 to 1989, we divided aerial counts for each reach by the reach-specific mean expansion factor. The reach-expanded aerial counts were then summed to derive an estimated total ground count. For example, in 1985, the aerial count of 164 redds was expanded to 196 redds as follows:

Reach	Aerial Count	Expansion Factor	Expanded Count
M1	34	0.83	41
M2	46	0.79	58
M3	51	0.84	61
M4	6	0.98	6
M5	26	0.89	29
M6	1	0.90	1
Total	**164**		**196**

Table 2 presents the original aerial counts, reach-expanded counts, total ground counts, and the complete data set used to estimate escapement for summer Chinook in the Methow River.

Table 2. Redd counts from aerial surveys, reach-expanded aerial counts, and total counts for summer Chinook in the Methow River. The complete data set was used to estimate spawning escapement to the Methow Basin.

Year	Aerial Survey	Reach-Expanded Aerial Counts	Total Counts	Complete Data Set
1981	195	231	-	*231*
1982	142	168	-	*168*
1983	65	78	-	*78*
1984	162	198	-	*198*
1985	164	196	-	*196*
1986	169	201	-	*201*
1987	235	282	-	*282*
1988	123	147	-	*147*
1989	126	149	-	*149*
1990	229	-	418	418
1991	120	-	153	153
1992	91	-	107	107
1993	116	-	154	154
1994	280	-	310	310
1995	296	-	357	357
1996	-	-	181	181
1997	-	-	205	205
1998	-	-	225	225
1999	-	-	448	448
2000	-	-	500	500
2001	-	-	675	675
2002	-	-	2,013	2,013
2003	-	-	1,624	1,624
2004	-	-	973	973
2005	-	-	874	874
2006	-	-	1,353	1,353
2007	-	-	620	620
2008	-	-	599	599
2009	-	-	692	692
2010	-	-	887	887

Okanogan River

In the Okanogan Basin, summer Chinook spawn in the Okanogan River downstream from Zosel Dam to just downstream of the Mallott Bridge. Redd counts before 1991 were estimated based on aerial surveys (Kohn 1987, 1988, 1989; Langness 1991). Comprehensive total redd counts on the Okanogan River began in 1991 and have continued since (Hillman and Ross 1992; Murdoch and Miller 1999; Snyder and Miller 2009). To estimate reach-specific expansion factors, we used aerial and total ground counts from 1991 to 1999, a period when both methods were used to estimate redd counts.

Individual expansion factors for each year were calculated as the aerial count divided by the total ground count for each reach. For example, in 1991 for reach O3 on the Okanogan River, the expansion factor was 11/12 = 0.92 (Table 3). The mean expansion factors used to adjust aerial counts before 1991 are presented in Table 3. The mean expansion factors indicate that the accuracy of aerial surveys varies by reach and accounts for about 86-100% of the redds that were observed during total ground counts.

Table 3. Aerial and total ground counts used to estimate mean expansion factors for summer Chinook in the Okanogan River.

Reach	Survey	Counts								Mean
		1991	1992	1993	1994	1995	1996	1997	1998	
O1	Aerial	0	0	1	5	1	1	0	0	**1.00**
	Ground	0	0	1	5	1	1	0	0	
	Expansion	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
O2	Aerial	3	0	20	34	9	2	1	8	**0.93**
	Ground	4	0	20	37	9	2	1	10	
	Expansion	0.75	1.00	1.00	0.92	1.00	1.00	1.00	0.80	
O3	Aerial	11	13	27	60	43	12	18	22	**0.95**
	Ground	12	18	31	49	45	12	20	22	
	Expansion	0.92	0.72	0.87	1.22	0.96	1.00	0.90	1.00	
O4	Aerial	1	2	3	23	7	10	4	4	**0.92**
	Ground	1	3	3	23	5	16	4	6	
	Expansion	1.00	0.67	1.00	1.00	1.40	0.63	1.00	0.67	
O5	Aerial	26	9	54	160	149	50	52	17	**0.87**
	Ground	32	14	59	165	148	54	61	21	
	Expansion	0.81	0.64	0.92	0.97	1.01	0.93	0.85	0.81	
O6	Aerial	14	11	39	90	51	27	74	24	**0.86**
	Ground	15	18	48	96	59	31	72	29	
	Expansion	0.93	0.61	0.81	0.94	0.86	0.87	1.03	0.83	

To expand aerial redd counts from 1981 to 1991, we divided aerial counts for each reach by the reach-specific mean expansion factor. The reach-expanded aerial counts were then summed to derive an estimated total ground count. Table 4 presents the original aerial counts, reach-expanded counts, total ground counts, and the complete data set used to estimate escapement.

Table 4. Redd counts from aerial surveys, reach-expanded aerial counts, and total counts for summer Chinook in the Okanogan River. The complete data set was used to estimate spawning escapement to the Okanogan River.

Year	Aerial Survey	Reach-Expanded Aerial Counts	Total Counts	Complete Data Set
1981	55	61	-	*61*
1982	23	26	-	*26*
1983	36	41	-	*41*
1984	235	266	-	*266*
1985	138	156	-	*156*
1986	197	224	-	*224*
1987	202	227	-	*227*
1988	113	126	-	*126*
1989	134	151	-	*151*
1990	88	99	-	*99*
1991	55	-	64	64
1992	35	-	53	53
1993	144	-	162	162
1994	372	-	375	375
1995	260	-	267	267
1996	100	-	116	116
1997	149	-	158	158
1998	75	-	88	88
1999	222	-	369	369
2000	384	-	549	549
2001	883	-	1,108	1,108
2002	1,958	-	2,667	2,667
2003	1,099	-	1,035	1,035
2004	1,310	-	1,327	1,327
2005	1,084	-	1,611	1,611
2006	1,857	-	2,592	2,592
2007	1,265	-	1,301	1,301
2008	1,019	-	1,146	1,146
2009	1,109	-	1,672	1,672
2010	688	-	1,011	1,011

Similkameen River

Summer Chinook spawn in the Similkameen River downstream of Enloe Dam to the confluence with the Okanogan River. Redd counts before 1989 were based on aerial surveys (Kohn 1987, 1988). Ground counts were conducted in 1989 and 1990 (Kohn

1989; Langness 1991). Comprehensive total redd counts on the Similkameen River began in 1991 and have continued since (Hillman and Ross 1992; Murdoch and Miller 1999; Snyder and Miller 2009). To estimate reach-specific expansion factors, we used aerial and total ground counts from 1991 to 1999, a period when both methods were used to estimate redd numbers.

Individual expansion factors for each year were calculated as the aerial count divided by the total ground count for each reach. For example, in 1991 for reach S1 on the Similkameen River, the expansion factor was 58/76 = 0.76 (Table 5). The mean expansion factors used to adjust aerial counts before 1989 are presented in Table 5. The mean expansion factors indicate that the accuracy of aerial surveys varies by reach and accounts for about 67-77% of the redds that were observed during total ground counts.

Table 5. Aerial and total ground counts used to estimate mean expansion factors for summer Chinook in the Similkameen River.

Reach	Survey	Counts								Mean
		1991	1992	1993	1994	1995	1996	1997	1998	
S1	Aerial	58	48	138	369	272	231	277	228	**0.67**
	Ground	76	57	272	606	499	390	456	267	
	Expansion	0.76	0.84	0.51	0.61	0.55	0.59	0.61	0.85	
S2	Aerial	10	0	14	94	65	21	20	10	**0.77**
	Ground	15	0	16	171	117	29	30	9	
	Expansion	0.67	1.00	0.88	0.55	0.56	0.72	0.67	1.11	

To expand aerial counts from 1981 to 1989, we divided aerial counts for each reach by the reach-specific mean expansion factor. The reach-expanded aerial counts were then summed to derive an estimated total ground count. Table 6 presents the original aerial counts, reach expanded counts, total ground counts, and the complete data set used to estimate escapement.

Table 6. Redd counts from aerial surveys, reach-expanded aerial counts, and total counts for summer Chinook in the Similkameen River. The normalized data were used to estimate spawning escapement to the Similkameen River.

Year	Aerial Survey	Reach-Expanded Aerial Counts	Total Counts	Complete Data Set
1981	121	168	-	*168*
1982	59	82	-	*82*
1983	57	79	-	*79*
1984	301	418	-	*418*
1985	309	429	-	*429*
1986	300	417	-	*417*
1987	165	240	-	*240*
1988	191	282	-	*282*
1989	221	-	370	370
1990	94	-	147	147
1991	68	-	91	91
1992	48	-	57	57
1993	152	-	288	288

Year	Aerial Survey	Reach-Expanded Aerial Counts	Total Counts	Complete Data Set
1994	463	-	777	777
1995	337	-	616	616
1996	252	-	419	419
1997	297	-	486	486
1998	238	-	276	276
1999	903	-	1,275	1,275
2000	549	-	993	993
2001	865	-	1,540	1,540
2002	2,000	-	3,358	3,358
2003	103	-	378	378
2004	2,127	-	1,660	1,660
2005	1,111	-	1,423	1,423
2006	1,337	-	1,666	1,666
2007	523	-	707	707
2008	673	-	1,000	1,000
2009	907	-	1,298	1,298
2010	642	-	1,107	1,107

Wenatchee Basin

In the Wenatchee Basin, summer Chinook redd counts have been estimated using aerial surveys, peak ground surveys, and peak expansion counts. Aerial counts were conducted in the Wenatchee up to 1996. Peak ground counts began in 1987 (Fast 1987). In 2006, peak expansion counts were obtained for six of the ten reaches on the Wenatchee River (Peven 2007, 2008). It was not until 2008 that all ten reaches of the Wenatchee River had separate index areas for map counts (Miller 2009, 2010). In 2010, a complete data set was created to adjust for differences in survey methods over the years. We used a two-step process:

(1) Convert aerial counts to peak ground counts.

(2) Convert peak ground counts to an estimated total count (peak expansion count).

To estimate peak ground counts from aerial counts, we used data from years (1990-1996) in which both surveys methods were conducted. Individual expansion factors for each year were calculated as the aerial count divided by the peak ground count for each reach. For example, in 1990 for reach W2 on the Wenatchee River, the expansion factor was 64/89 = 0.72 (Table 7). The mean expansion factors used to adjust aerial counts before 1987 are presented in Table 7.

Table 7. Aerial and peak ground counts used to estimate mean expansion factors for summer Chinook in the Wenatchee Basin.

Reach	Survey	Counts						Mean
		1990	1991	1992	1993	1994	1995	
W1	Aerial	10	0	3	2	1	5	**1.33**
	Ground	5	5	6	1	1	2	
	Expansion	2.00	0.00	0.50	2.00	1.00	2.50	
W2	Aerial	64	32	37	56	97	121	**0.87**
	Ground	89	50	38	74	98	104	
	Expansion	0.72	0.64	0.97	0.76	0.99	1.16	
W3	Aerial	83	186	115	203	268	141	**0.78**
	Ground	187	244	146	268	302	140	
	Expansion	0.44	0.76	0.79	0.76	0.89	1.01	
W4	Aerial	37	73	23	37	25	10	**0.76**
	Ground	31	71	72	49	58	12	
	Expansion	1.19	1.03	0.32	0.76	0.43	0.83	
W5	Aerial	87	69	34	41	36	10	**0.62**
	Ground	161	74	47	52	85	35	
	Expansion	0.54	0.93	0.72	0.79	0.42	0.29	
W6	Aerial	1094	778	374	639	657	517	**0.82**
	Ground	977	797	619	851	783	834	
	Expansion	1.12	0.98	0.60	0.75	0.84	0.62	
W7	Aerial	237	201	64	92	117	69	**0.55**
	Ground	374	339	142	157	178	185	
	Expansion	0.63	0.59	0.45	0.59	0.66	0.37	
W8	Aerial	275	273	247	225	206	90	**0.59**
	Ground	381	336	633	351	381	206	
	Expansion	0.72	0.81	0.39	0.64	0.54	0.44	
W9	Aerial	214	212	276	191	188	121	**0.58**
	Ground	233	258	574	455	498	277	
	Expansion	0.92	0.82	0.48	0.42	0.38	0.44	
W10	Aerial	104	14	40	44	20	95	**1.32**
	Ground	41	6	51	76	42	77	
	Expansion	2.54	2.33	0.78	0.58	0.48	1.23	

The mean expansion factors indicate that the accuracy of aerial surveys varied by reach and account for about 55-133% of the redds observed during peak ground counts. In some years, aerial surveys conducted in the lower and uppermost reaches of the Wenatchee River counted more Chinook redds than were observed on the ground. Wide stream widths and the presence of some spring Chinook redds counted in the uppermost reach (W10) of the Wenatchee River probably account for some of the higher aerial counts observed. We did not attempt to adjust expansion factors for these reaches because it is likely that observations made during previous aerial surveys (before 1987) would have been made under similar conditions. Aerial counts from 1981 to 1987 were expanded by dividing reach-specific aerial counts for each reach by the reach-specific mean expansion factor. The reach-expanded aerial counts were then summed to derive an estimated peak ground count.

In 2006, two different methods were used to derive an estimated total redd count. The first method used map counts (MP) to expand peak counts (PK). In this approach, a map count documents only new or recently constructed redds within the index area on each survey. The objective of the map count method is to capture 1) "early" redds that may fade over time due to siltation or algae growth, and 2) redds that become disfigured by superimposition (when new redds are constructed on top of previously existing redds) (Miller 2011). Peak counts are performed within each reach (both index and non-index areas), while map counts only occur within the index areas. An index area expansion factor (IP) is developed based on the ratio of peak to map counts (PK/MP) for each index area within a reach. Reach specific index area peak expansion factors are applied to all non-index areas and the expanded counts are summed along with the map count for the estimated total redd count for a reach. For example, in 2009, Reach 3 of the Wenatchee had peak counts of 34, 63, and 23. The map count for the index area was 52 so the index peak expansion factor was 0.65 (34/52 = 0.6538). The non-index area peak counts were divided by the index peak expansion factor and then summed to get a reach total (RT) peak expansion estimate of 183 redds. The sum of all reach totals provides the total peak expansion redd count.

Reach	Reach Description	Index or non-Index Area	Peak Count (PK)	Map Count (MP)	Index Peak Expansion Factor (IP)	Peak Expansion (PK/IP)
3A	Dryden Dam to Williams Canyon	Index	34	52	0.6538	52
3B	William Canyon to Upper Cashmere Br.	Non-index	63	-	-	96
3C	Upper Cashmere Br. to Lower Cashmere Br.	Non-index	23	-	-	35
		Peak Total:	**120**	**Reach Total (RT):**		**183**

The second method relied on a "naïve" count (NV) to expand redd counts in non-index areas. As noted above, the areas with map counts are referred to as index areas and those that were not mapped are called non-index areas. Near the end of the spawning period (early November), one team of observers counts all visible redds within all non-index reaches. A separate, independent team counts all visible redds within the index areas (these are the naïve counts). Surveys within the index and non-index areas should occur within one day of each other near the end of the spawning period. The naïve counts are divided by the total map count to estimate an index expansion factor (IF). This factor is then applied to the total visible count in the non-index areas to estimate the total number of redds within each reach. The sum of the expanded counts plus the map count is the estimated total redd count. Using the example above for Reach 3, the naïve count was 7 and the visible counts were 11 and 0. The map count for the index area was 52 so the index expansion factor was 0.1346 (7/52 = 0.1346). The non-index area counts were divided by the index expansion factor and then summed to get a reach total (RT) expansion estimate of 134 redds. The sum of all reach totals provides the total naive expansion redd count.

Reach	Reach Description	Index or non-Index Area	Visible Counts	Naive Count (NV)	Map Count (MP)	Index Expansion Factor (IF)	Naive Expansion (NV/IF)
3A	Dryden Dam to Williams Canyon	Index	-	7	52	0.1346	52
3B	William Canyon to Upper Cashmere Br.	Non-index	11	-	-	-	82
3C	Upper Cashmere Br. to Lower Cashmere Br.	Non-index	0	-	-	-	0
		Naive Total:		**18**	**Reach Total (RT):**		**134**

From the examples provided it can be seen that expansion by naïve counts can be difficult to execute if there are no visible redds for the expansion estimate. A weakness of the naïve count expansion is that time of spawning progresses from upstream to downstream making redds less visible in some reaches than others. Also, the occurrence of freshets in the fall can be unpredictable and are not uncommon to the Wenatchee River making the coordination of naïve counts difficult to manage. Therefore, to expand historical peak ground counts (1981-2005) to total ground counts (map counts), we used data collected from 2008 to 2010 when peak ground counts and map counts were conducted in all reaches. Table 8 presents peak counts (PK), map counts (MP), and index-area peak expansion factors (IP) for all reaches on the Wenatchee River. Based on mean peak expansion estimates, peak ground surveys from 2008-2010 counted about 68-91% of redds documented from mapping surveys within different reaches of the Wenatchee River. To provide an estimated total count across all years, we applied the mean of reach-specific peak expansion factors to all years prior to 2006. The estimated redd counts for 2006 and 2007 remain unadjusted. New peak and map counts will be added to Table 8 as they become available. Additional years of data should be compiled for all reaches to adjust the expansion factors until it appears that the mean has become stable.

Table 8. Peak and map redd counts of summer Chinook in the Wenatchee River used to estimate mean expansion factors from 2008-2010. PK = peak counts; MP = map counts; and IP = index-area peak expansion factors.

Reach	Survey	2008	2009	2010	Mean (IP)
W1	PK	6	9	4	**0.72**
	MP	9	11	6	
	IP	0.67	0.82	0.67	
W2	PK	26	20	64	**0.73**
	MP	37	25	91	
	IP	0.70	0.80	0.70	
W3	PK	40	34	60	**0.68**
	MP	67	52	75	
	IP	0.60	0.65	0.80	
W4	PK	15	70	58	**0.68**
	MP	22	116	77	
	IP	0.68	0.60	0.75	
W5	PK	9	11	11	**0.79**
	MP	10	14	16	
	IP	0.90	0.79	0.69	
W6	PK	453	394	448	**0.79**
	MP	536	504	610	
	IP	0.85	0.78	0.73	

Reach	Survey	2008	2009	2010	Mean (IP)
W7	PK	140	130	169	**0.91**
	MP	144	157	182	
	IP	0.97	0.83	0.93	
W8	PK	73	119	62	**0.80**
	MP	92	158	73	
	IP	0.79	0.75	0.85	
W9	PK	77	183	38	**0.84**
	MP	87	215	48	
	IP	0.89	0.85	0.79	
W10	PK	120	109	114	**0.86**
	MP	131	149	122	
	IP	0.92	0.73	0.93	

We use data collected in 1985 to illustrate the two step process to estimate a peak expansion from aerial counts. In 1985, the aerial surveys estimated 1,120 redds throughout ten reaches on the Wenatchee River. In the first step, we applied the reach-specific expansion factors in Table 7 to the aerial survey counts to derive an estimated total peak ground count of 1,555.

Reach	Aerial Count	Expansion Factor	Estimated Peak Ground Count
W1	7	1.33	5
W2	48	0.87	55
W3	74	0.78	95
W4	29	0.76	38
W5	32	0.62	52
W6	502	0.82	612
W7	234	0.55	425
W8	58	0.59	98
W9	74	0.58	128
W10	62	1.32	47
Total	**1,120**		**1,555**

In the final step, we used the estimated peak ground counts to derive a peak expansion count as an estimate of the total ground count. From the previous example, we applied reach-specific mean expansion factors from Table 8 to the estimated peak ground counts to obtain a peak expansion of 1,916.

Reach	Estimated Peak Ground Count	Expansion Factor	Estimated Peak Expansion
W1	5	0.72	7
W2	55	0.73	75
W3	95	0.68	140
W4	38	0.68	56
W5	52	0.79	66
W6	612	0.79	775
W7	425	0.91	467
W8	98	0.80	123
W9	128	0.84	152
W10	47	0.86	55
Total	**1,555**		**1,916**

Table 9 presents the original redd counts along with their corresponding estimates. The data set used to estimate spawning escapement of summer Chinook to the Wenatchee is the estimated peak expansion counts (1981-2005) and peak expansion counts (2006-2010).

Table 9. Summer Chinook redd counts, estimated counts and expansion counts for Wenatchee summer Chinook. The estimated peak expansion counts and recent peak expansion counts combined were used to create a complete data set to estimate spawning escapement to the Wenatchee River from 1981-2010.

Year	Aerial Survey Counts	Peak Ground Counts	Estimated Peak Ground Counts	Estimated Peak Expansion Counts	Naïve Expansion Counts (IF)	Peak Expansion Counts (IP)
1981	1,489	-	2,010	2,568	-	-
1982	1,141	-	1,561	1,992	-	-
1983	726	-	1,038	1,279	-	-
1984	1,338	-	1,890	2,365	-	-
1985	1,120	-	1,555	1,916	-	-
1986	1,363	-	1,936	2,428	-	-
1987	2,055	2,955	-	3,782	-	-
1988	1,572	2,102	-	2,622	-	-
1989	1,951	3,331	-	4,215	-	-
1990	2,205	2,479	-	3,103	-	-
1991	1,838	2,180	-	2,748	-	-
1992	1,213	2,328	-	2,913	-	-
1993	1,530	2,334	-	2,953	-	-
1994	1,615	2,426	-	3,077	-	-
1995	1,179	1,872	-	2,350	-	-
1996	-	1,435	-	1,814	-	-
1997	-	1,388	-	1,739	-	-
1998	-	1,660	-	2,230	-	-
1999	-	2,188	-	2,738	-	-
2000	-	2,022	-	2,540	-	-
2001	-	2,857	-	3,550	-	-
2002	-	3,889	-	6,836	-	-
2003	-	1,848	-	5,268	-	-
2004	-	4,003	-	4,874	-	-
2005	-	2,895	-	3,538	-	-
2006	-	7,165	-	-	-	8,896
2007	-	1,857	-	-	-	1,970
2008	-	2,338	-	-	2,658	2,800
2009	-	2,667	-	-	2,940	3,420
2010		2,553	-	-	3,730	3,250

For the Wenatchee, we also developed a density model that was used to estimate the number of redds to the Wenatchee Basin. The index area peak expansion method currently used to assess number of redds and spawning escapement may be enhanced by looking at how the relationship between peak counts and map counts change with redd density. Data were plotted from 2008-2010 to see if there was a correlation between peak counts and peak-to-map count ratios (Figure 1).

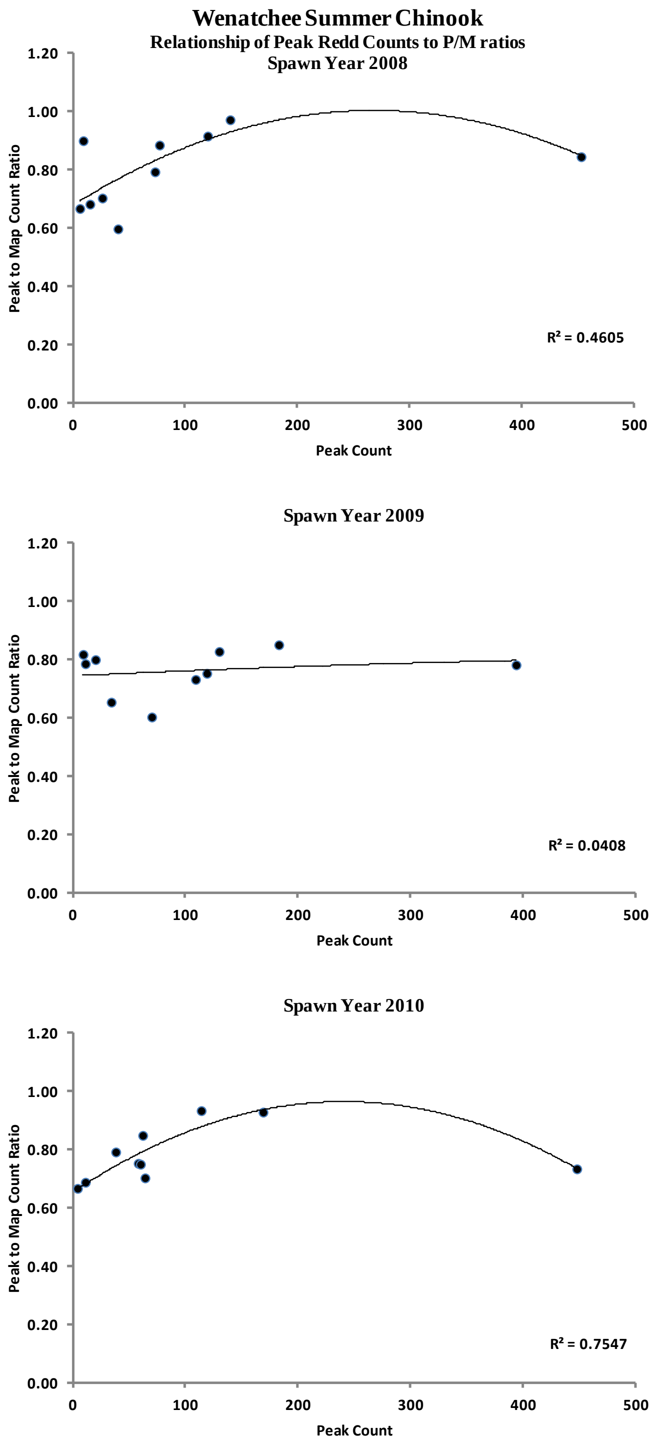

Figure 1. Relationship of peak redd counts of Wenatchee summer Chinook to peak-to-map count ratios (P/M) observed from 2008-2010.

For two of the three years, the data exhibited a curved relationship that shows that as peak counts increase, peak-to-map count ratios also increase. However, at some point the peak-to-map count ratio decreases as peak counts continue to increase. In 2009 there was no apparent relationship. For 2008 and 2010, the plots suggest that peak counts may be less accurate (relative to map counts) at low abundance perhaps because of wide stream widths or little spawning activity or fish to provide a clue to redd location. It may also be that at low redd abundance, missing just a few redds within a reach can have a large effect on the ratio of peak count to map count. However, as peak counts increase, accuracy appears to increase. As peak counts continue to increase, accuracy decreases suggesting that there may be a point at which the peak count has difficulty assessing the abundance of redds overtime as redds fade and become less visible. Map counts have the advantage of tracking individual redds and locations on successive surveys.

Redd counts from 2008-2010 were used to establish a density model. Stream area was determined from stream lengths obtained from GIS line segments of the Wenatchee River and mean stream widths were obtained from measurements made during WDFW surveys (Table 10). The density model compares redd densities (redds/stream area) to peak-to-map count ratios.

Table 10. Length, width, and area calculated for different summer Chinook survey reaches of the Wenatchee River.

Reach	Subreach	Description	Length (m)	Width (m)	Area (m^2)
1	C	Siphon to Mouth	1,351.8	87.2	117,877
	B	River bend to Siphon	708.1	69.3	49,071
	A	Sleepy Hollow Br. to River bend	2,478.4	65.7	162,831
2	B	Monitor Br. to Sleepy Hollow Br.	6,196.0	68.1	421,948
	A	Lower Cashmere Br. to Monitor Br.	3,814.1	62.9	239,907
3	C	Up. Cashmere Br. to L. Cashmere Br.	1,174.8	71.4	83,881
	B	Williams Canyon to Upper Cashmere Br.	8,561.7	63.9	547,093
	A	Dryden Dam to Williams Canyon	3,572.7	70.3	251,161
4	A	Peshastin Br. to Dryden Dam	3,604.9	77.4	279,019
5	B	Irrigation Flume to Peshastin Br.	4,457.9	61.6	274,607
	A	Leavenworth Br. to Irrigation Flume	1,818.6	60.8	110,571
6	C	Boat Takeout to Leavenworth Br.	949.5	53.5	50,798
	B	Icicle Mouth to Boat Takeout	1,802.5	86.1	155,195
	A	Icicle Rd. Br. to Icicle Mouth	1,319.7	72.5	95,678
7	B	Penstock Br. to Icicle Rd. Br.	3,588.8	51.0	183,029
	A	Tumwater Dam to Penstock Br.	3,621.0	48.0	173,808
8	C	Unimproved cmpgd. to Tumwater Dam	3,492.3	63.3	221,063
	B	Swiftwater cmpgd. to unimproved cmpgd.	675.9	62.3	42,109
	A	Tumwater Br. to Swiftwater Campground	3,299.2	48.0	158,362
9	E	Swing Pool to Tumwater Br.	1,802.5	61.4	110,674
	D	RR Tunnel to Swing Pool	4,200.4	73.7	309,569
	C	RR Br. to RR Tunnel	4,232.6	67.3	284,854
	B	Old Plain Br. to RR Br.	6,920.2	62.3	431,128
	A	Schugart Flats to Old Plain Br.	2,768.1	65.6	181,587
10	D	Chiwawa to Schugart Flats	740.3	61.3	45,380
	C	Swamp to Chiwawa	6,871.9	59.2	406,816
	B	Bridge to Swamp	1,480.6	56.3	83,358
	A	Lake to Bridge	997.8	91.5	91,299

Peak count redd densities were calculated for each year and index reach as the number of redds divided by the index area of that reach (Table 11). Peak redd densities in index areas have varied from a low of 2.46 x 10^{-5} (redds/m^2) in reach 1-A to a high of 2.91x10^{-3} (redds/m^2) in reach 6-B (Table 11). These values equate to about 1 redd per 40,700 m^2 for the lowest density and 1 redd per 340 m^2 for the highest density.

Table 11. Peak count redd densities calculated for index areas of the Wenatchee River from 2008 to 2010.

Year	Reach-Subreach	Peak/Map Ratio	Area (m^2)	Peak Redd Count	Peak Count Redd Density (redds/m^2)
2008	1-A	0.67	162,831	6	0.00003685
	2-A	0.70	239,907	26	0.00010838
	3-A	0.60	251,161	40	0.00015926
	4-A	0.68	279,019	15	0.00005376
	5-A	0.90	110,571	9	0.00008140
	6-B	0.85	155,195	453	0.00291891
	7-B	0.97	183,029	140	0.00076491
	8-A	0.79	158,362	73	0.00046097
	9-D	0.89	309,569	77	0.00024873
	10-B	0.92	83,358	120	0.00143957
2009	1-A	0.82	162,831	9	0.00005527
	2-A	0.80	239,907	20	0.00008337
	3-A	0.65	251,161	34	0.00013537
	4-A	0.60	279,019	70	0.00025088
	5-A	0.79	110,571	11	0.00009948
	6-B	0.78	155,195	394	0.00253874
	7-B	0.83	183,029	130	0.00071027
	8-A	0.75	158,362	119	0.00075144
	9-D	0.85	309,569	183	0.00059114
	10-B	0.73	83,358	109	0.00130761
2010	1-A	0.67	162,831	4	0.00002457
	2-A	0.70	239,907	64	0.00026677
	3-A	0.80	251,161	60	0.00023889
	4-A	0.75	279,019	58	0.00020787
	5-A	0.69	110,571	11	0.00009948
	6-B	0.73	155,195	448	0.00288669
	7-B	0.93	183,029	169	0.00092335
	8-A	0.85	158,362	62	0.00039151
	9-D	0.79	309,569	38	0.00012275
	10-B	0.93	83,358	114	0.00136760

Data from Table 11 were plotted to display the relationship of redd density to peak to map count ratios from 2008-2010 (Figure 2). The plots show a moderate (R^2 = 0.45; 2008) to strong (R^2 = 0.82; 2010) correlation between peak redd count density and peak count to map count ratios. The plot for 2009 does not appear to show any relationship (Figure 2). The data from 2008 and 2010 show a moderate correlation (R^2 = 0.54) when combined.

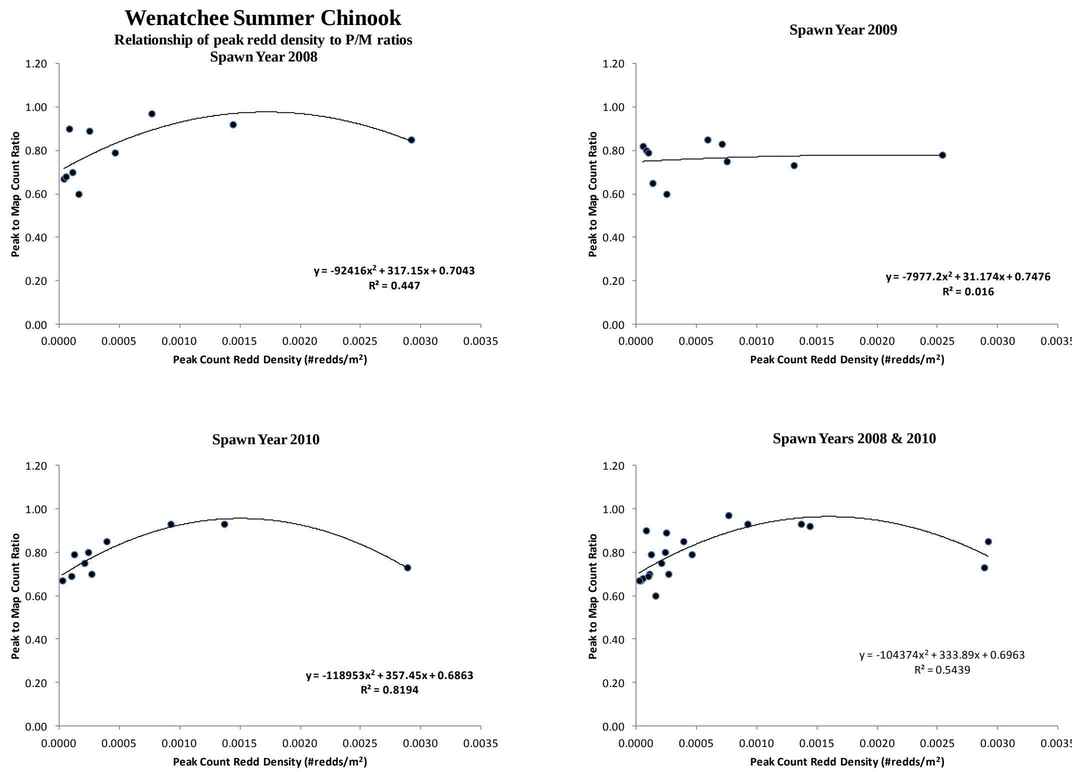

Figure 2. Relationship of Wenatchee summer Chinook peak redd count density to peak to map count ratios (P/M) observed from 2008-2010.

Data for 2008 and 2010 were combined, as well as using only 2010 data, to test the density model (Figure 2). To apply the models, peak counts for each reach were divided by the stream reach areas to get the peak redd densities for each year and reach. The peak redd densities were then placed into the equation of each model to derive the peak-to-map ratio. The original peak counts were then divided by the derived peak-to-map count ratios and summed across reaches to obtain an estimated peak expansion count. For example, in 1999, the total peak count was 2,188 for the ten reaches. Working with Reach W1, the peak count was divided by the area to get the peak redd density (9/329,779 = 0.000027291). The peak redd density was then plugged into the 2008 and 2010 combined model equation seen in Figure 2 to get a peak-to-map ratio of 0.71. The original peak count was then divide by the P/M ratio to get an estimated peak expansion estimate of 13 redds in reach W1. If this method is carried out for all reaches in 1999, the density model estimates a total of 2,728 redds. This process was carried out for both density models to derive redd counts.

Reach	Peak Count	Reach Area (m^2)	Peak Redd Density (# redd/m^2)	Peak to Map ratio	Density Model (2008 and 2010) Expansion
W1	9	329,779	0.000027291	0.71	13
W2	131	661,855	0.000197929	0.76	172
W3	164	882,135	0.000185913	0.75	219
W4	22	279,019	0.000078848	0.72	31
W5	28	385,178	0.000072694	0.72	39
W6	832	301,671	0.002757971	0.82	1,015
W7	187	356,837	0.000524049	0.84	223
W8	227	421,534	0.000538509	0.85	267
W9	430	1,317,812	0.000326298	0.79	544
W10	158	626,853	0.000252053	0.77	205
Total	**2,188**	**5,562,673**	**0.000393336**	**0.81**	**2,728**

To test the models, summer Chinook counts at Tumwater Dam (1999-2010) were used as an estimate of escapement in reaches W8-W10 on the Wenatchee River. Tumwater Dam is the downstream reach break for W8. Tumwater Dam counts were compared to escapement estimates derived from peak expansion redd counts, peak redd counts, and the density model (2008 and 2010; 2010 only) for the same reaches. An expansion factor (see next section) was applied to each redd count method to estimate escapement and compare it to Tumwater Dam counts (Table 12).

Table 12. Redd count estimates for reaches W8-W10 and spawning escapement estimates produced from each of the redd counts for 1999-2010.

Year	Redd Counts				Fish/redd	Escapement Estimates			
	Density Model (08 & 10)	Density Model (2010)	Peak Expansion	Peak Count		Density Model (08 & 10)	Density Model (2010)	Peak Expansion	Peak Count
1999	1,016	1,019	980	815	2.00	2,032	2,038	1,960	1,630
2000	1,068	1,078	1,051	873	2.17	2,318	2,339	2,281	1,894
2001	1,442	1,442	1,466	1,225	3.20	4,614	4,614	4,691	3,920
2002	2,300	2,300	2,511	2,082	2.30	5,290	5,290	5,775	4,789
2003	2,792	2,812	3,135	2,621	2.24	6,254	6,299	7,022	5,871
2004	2,770	2,819	2,951	2,495	2.15	5,956	6,061	6,345	5,364
2005	1,672	1,681	1,738	1,466	2.46	4,113	4,135	4,275	3,606
2006	3,972	4,032	4,434	3,715	2.00	7,944	8,064	8,868	7,430
2007	721	721	596	558	2.33	1,680	1,680	1,389	1,300
2008	1,069	1,078	980	868	2.32	2,480	2,501	2,274	2,014
2009	1,484	1,484	1,571	1,251	2.42	3,591	3,591	3,802	3,027
2010	981	989	932	798	2.29	2,246	2,265	2,134	1,827

The proportion of the Tumwater Dam count best explained by the different escapement estimates produced from redd counts varied (Table 13). The density models account for 68% to 110% of the fish counted at Tumwater Dam. The current method of index area peak expansion accounted for 71% to 101% of the fish counted at Tumwater Dam. Peak counts had the lowest range from 60% to 85%. The density models appear to account for more of the escapement past Tumwater Dam when dam counts are below 5,000 fish, except for year 2009. Conversely, when Tumwater Dam counts are higher (>5,000 fish), the index area peak expansion method accounted for the most fish crossing Tumwater

Dam. As expected the peak counts accounted for the fewest fish past Tumwater Dam. For several years, the proportion of Tumwater Dam count accounted for by the different escapements methods was very high (>0.90).

Table 13. Comparison of counts for summer Chinook at Tumwater Dam to escapement estimates derived from the density models, peak expansion, and peak counts from 1999-2010. An asterisk denotes the highest proportion of Tumwater Dam Count accounted for in the escapement estimates.

Year	Tumwater Dam Count	Escapement Estimates				Ratio (Escapement/Tumwater Dam Count)			
		Density Model (08 & 10)	Density Model (2010)	Peak Expansion	Peak Count	Density Model (08 & 10)	Density Model (2010)	Peak Expansion	Peak Count
1999	2,148	2,032	2,038	1,960	1,630	0.946	0.949*	0.912	0.759
2000	2,357	2,318	2,339	2,281	1,894	0.983	0.992*	0.968	0.804
2001	4,631	4,614	4,614	4,691	3,920	0.996*	0.996*	1.013	0.846
2002	6,716	5,290	5,290	5,775	4,789	0.788	0.788	0.860*	0.713
2003	9,039	6,254	6,299	7,022	5,871	0.692	0.697	0.777*	0.650
2004	6,925	5,956	6,061	6,345	5,364	0.860	0.875	0.916*	0.775
2005	6,048	4,113	4,135	4,275	3,606	0.680	0.684	0.707*	0.596
2006	9,619	7,944	8,064	8,868	7,430	0.826	0.838	0.922*	0.772
2007	1,924	1,680	1,680	1,389	1,300	0.873*	0.873*	0.722	0.676
2008	2,456	2,480	2,501	2,274	2,014	1.010*	1.018	0.926	0.820
2009	4,128	3,591	3,591	3,802	3,027	0.870	0.870	0.921*	0.733
2010	2,528	2,246	2,265	2,134	1,827	0.888	0.896*	0.844	0.723

The density model needs several more years of data to evaluate. In particular, data are needed for higher spawning escapements and peak redd densities greater than 0.0015 redds/m^2. There is a noticeable gap in the data points from near the vertex to the highest peak redd density observed (Figure 2).

Estimate of spawning escapement

Spawning escapements for summer Chinook derived from redd counts have been estimated using two different methods. Before 1998, spawning escapements were calculated as the number of redds times 3.1, based on work conducted by Meekin (1967). However, Meekin (1967) did not include jack Chinook salmon in his estimate of 3.1 adults per redd. Therefore, Washington Department of Fish and Wildlife (WDFW) modified the 3.1 adults per redd ratio by including jacks. The "modified-Meekin" method adjusted the 3.1 adults to account for the proportion of jacks counted in the summer/fall run at Wells Dam (for Methow, Okanogan, and Similkameen summer Chinook), or the difference in jack counts observed at Rock Island and Rocky dams (for Wenatchee summer Chinook). The modified-Meekin estimate was calculated as follows for Methow, Okanogan, and Similkameen stocks:

$$Modified\ Meekin = 3.1\left(1 + \left(\frac{Number\ of\ Jacks\ Counted\ at\ Wells\ Dam}{Total\ Count\ of\ Chinook\ at\ Wells\ Dam}\right)\right)$$

and as follows for Wenatchee summer Chinook:

$$Modified\ Meekin = 3.1\left(1 + \left(\frac{Rock\ Island\ Jack\ Count - Rocky\ Reach\ Jack\ Count}{Rock\ Island\ Total\ Count - Rocky\ Reach\ Total\ Count}\right)\right)$$

Table 14 presents the adjusted (modified-Meekin) fish per redd estimates. As noted above, the adjustment was made by multiplying 3.1 times one plus the proportion of jacks. For example, in 1996, the proportion of jacks at Wells Dam was calculated as 375 (number of jacks at Wells Dam) divided by 3,307 (the total run size at Wells Dam), resulting in the proportion of 0.11 jacks. To calculate the modified expansion factor, we multiplied one plus the proportion of jacks (1 + 0.11 = 1.11) to 3.1. This calculation resulted in an estimated 3.4 fish per redd (1.11 x 3.1 = 3.4). The modified expansion factor (3.4 fish per redd) was then applied to the Methow redd count (181) in 1996 to estimate a spawning escapement of 615 summer Chinook to the Methow Basin (3.4 x 181 = 615). This estimate accounts for jacks on the spawning ground.

A second method was used to adjust estimates from 1998 to present, and it estimated adult escapement based on the annual male-to-female ratio determined from broodstock sampling (BS) at Wells Dam (for the Methow, Okanogan, and Similkameen summer Chinook) and Dryden Dam (for Wenatchee summer Chinook) (Table 14). The expansion factor was calculated as one plus the male-to-female ratio:

$$Gender\ Expansion\ Factor = 1 + \left(\frac{Number\ of\ Males}{Number\ of\ Females}\right)$$

For example, in 1998, the sex ratio determined from sampling at Wells Dam was two males for each female (2.00:1.00). This ratio was added to one, resulting in 3.00 fish per redd. Spawning escapement was then calculated as the product of the expansion factor times the redd count, assuming each female constructed only one redd (Table 14).

Table 14. Summer Chinook redd counts, expansion factors, and estimated spawning escapement in the Wenatchee (WEN), Methow (MET), Okanogan (OKN) and Similkameen (SIM) rivers, 1981 to 2010. MOS = Methow, Okanogan, and Similkameen; MM = Modified-Meekin; and BS = Broodstock sampling.

Year	Redd Counts				Expansion Factors			Spawning Escapement			
					Fish/Redd		Method				
	WEN	MET	OKN	SIM	WEN	MOS		WEN	MET	OKN	SIM
1981	2,568	231	61	168	3.6	4.0	MM	9,245	924	244	672
1982	1,992	168	26	82	4.5	4.4	MM	8,964	739	114	361
1983	1,279	78	41	79	4.3	4.2	MM	5,500	328	172	332
1984	2,365	198	266	418	4.2	4.0	MM	9,933	792	1,064	1,672
1985	1,916	196	156	429	4.0	3.8	MM	7,664	745	593	1,630
1986	2,428	201	224	417	3.8	3.6	MM	9,226	724	806	1,501

Year	Redd Counts				Expansion Factors			Spawning Escapement			
					Fish/Redd		Method				
	WEN	MET	OKN	SIM	WEN	MOS		WEN	MET	OKN	SIM
1987	3,782	282	227	240	3.6	3.5	MM	13,615	987	795	840
1988	2,622	147	126	282	3.6	3.6	MM	9,439	529	454	1,015
1989	4,215	149	151	370	3.4	3.3	MM	14,331	492	498	1,221
1990	3,103	418	99	147	3.5	3.4	MM	10,861	1,421	337	500
1991	2,748	153	64	91	3.7	3.7	MM	10,168	566	237	337
1992	2,913	107	53	57	4.0	4.3	MM	11,652	460	228	245
1993	2,953	154	162	288	3.2	3.3	MM	9,450	508	535	950
1994	3,077	310	375	777	3.3	3.5	MM	10,154	1,085	1,313	2,720
1995	2,350	357	267	616	3.3	3.4	MM	7,755	1,214	908	2,094
1996	1,814	181	116	419	3.4	3.4	MM	6,168	615	394	1,425
1997	1,739	205	158	486	3.4	3.4	MM	5,913	697	537	1,652
1998	2,230	225	88	276	2.40	3.00	BS	5,352	675	264	828
1999	2,738	448	369	1,275	2.00	2.20	BS	5,476	986	812	2,805
2000	2,540	500	549	993	2.17	2.40	BS	5,512	1,200	1,318	2,383
2001	3,550	675	1,108	1,540	3.20	4.10	BS	11,360	2,768	4,543	6,314
2002	6,836	2,013	2,667	3,358	2.30	2.30	BS	15,723	4,630	6,134	7,723
2003	5,268	1,624	1,035	378	2.24	2.42	BS	11,800	3,930	2,505	915
2004	4,874	973	1,327	1,660	2.15	2.25	BS	10,479	2,189	2,986	3,735
2005	3,538	874	1,611	1,423	2.46	2.93	BS	8,703	2,561	4,720	4,169
2006	8,896	1,353	2,592	1,666	2.00	2.02	BS	17,792	2,733	5,236	3,365
2007	1,970	620	1,301	707	2.33	2.20	BS	4,590	1,364	2,862	1,555
2008	2,800	599	1,146	1,000	2.32	3.25	BS	6,496	1,947	3,725	3,250
2009	3,441	692	1,672	1,298	2.42	2.54	BS	8,327	1,758	4,247	3,297
2010	3,261	887	1,011	1,107	2.29	2.81	BS	7,468	2,492	2,841	3,111

Wild Spawner Escapement

The proportion of hatchery and wild fish making up the summer Chinook spawning escapement was estimated from carcass sampling on the spawning grounds. Before initiation of the supplementation program in 1989, and before the return of hatchery fish in 1993, returns to the Wenatchee, Methow, and Okanogan basins were assumed to be mostly naturally produced fish. However, some summer/fall hatchery production from Winthrop National Fish Hatchery likely influenced the ratio of hatchery and wild escapement in the Methow and possibly in the Okanogan basins in the 1980's. The last year summer/fall Chinook were released from the Winthrop facility was 1983. The Leavenworth National Fish Hatchery in the Wenatchee Basin stopped releasing summer/fall Chinook in 1967.

Strays from other hatchery programs, such as Priest Rapids, Turtle Rock, and Wells may have contributed to the spawning escapement of summer/fall Chinook in the Wenatchee, Methow, and Okanogan basins. Because there is little information (carcass sampling) to estimate hatchery-wild ratios before 1993, all returns to the basins were considered wild. The number of wild and hatchery fish in the spawning escapement after 1993 was estimated by the proportion of wild and hatchery fish sampled on the spawning grounds.

From 1993 to present, reach-specific wild and hatchery proportions (CS/Reach) were estimated for each survey reach within each basin. In some years, when no carcasses were found within a reach, the long-term (1993-2006) mean hatchery-wild ratio was used. This only occurred when redds were counted within a reach, but there were no carcasses recovered. Reach-specific hatchery-to-wild proportions reduce the possible bias associated with an uneven spawning distribution of hatchery and wild fish within the basins. From 1993 to present, the origin of returning fish has been determined from analysis of scale growth patterns, presence/absence of adipose fin, and recovery of coded wire tags (CWTs).

To estimate the number of wild fish in the spawning escapement, the escapement within each reach was multiplied by the reach specific wild proportion. The sum of the wild fish in all reaches was the total wild escapement (Table 15). From 1993 to present the total wild fish return was estimated by adding the wild spawning escapement to the number of wild fish collected for broodstock.

Table 15. Number of hatchery (H) and wild (W) summer Chinook in the spawning escapement of the Wenatchee, Methow, and Okanogan basins from 1981-2009. CS = carcasses sampling; CS/Reach = reach specific carcass sampling.

Year	Wenatchee		Methow		Okanogan		Methods
	H	W	H	W	H	W	
1981	0	9,245	0	924	0	916	All wild return
1982	0	8,964	0	739	0	475	
1983	0	5,500	0	328	0	504	
1984	0	9,933	0	792	0	2,736	
1985	0	7,664	0	745	0	2,223	
1986	0	9,226	0	724	0	2,307	
1987	0	13,615	0	987	0	1,635	
1988	0	9,439	0	529	0	1,469	
1989	0	14,331	0	492	0	1,719	
1990	0	10,861	0	1,421	0	837	
1991	0	10,168	0	566	0	574	
1992	0	11,652	0	460	0	473	
1993	640	8,810	199	309	570	915	CS/Reach
1994	1,776	8,378	512	573	2,711	1,322	CS/Reach
1995	942	6,813	651	563	2,023	979	CS/Reach
1996	177	5,991	191	424	1,251	568	CS/Reach
1997	532	5,381	185	512	1,327	862	CS/Reach
1998	1,349	4,003	243	432	492	600	CS/Reach
1999	1,505	3,971	449	537	2,343	1,274	CS/Reach
2000	1,131	4,381	362	838	2,527	1,174	CS/Reach
2001	2,096	9,264	1,716	1,052	6,551	4,306	CS/Reach
2002	4,032	11,691	2,125	2,505	9,511	4,346	CS/Reach
2003	2,040	9,760	1,706	2,224	1,487	1,933	CS/Reach
2004	1,394	9,085	580	1,609	1,412	5,309	CS/Reach
2005	1,841	6,862	889	1,672	2,448	6,441	CS/Reach
2006	1,732	16,060	694	2,039	3,094	5,507	CS/Reach
2007	1,417	3,173	600	764	1,434	2,983	CS/Reach
2008	1,702	4,794	654	1,293	3,977	2,998	CS/Reach
2009	1,214	7,113	665	1,093	3,340	4,204	CS/Reach

Estimating the Wild Component of the Broodstock

Estimating the number of wild Methow and Okanogan summer Chinook collected for broodstock is more difficult than it is for the Wenatchee Basin. In the Wenatchee Basin, summer Chinook are collected at Dryden and Tumwater dams and therefore all wild fish collected there are assumed to belong to the Wenatchee summer Chinook population. Numbers of wild summer Chinook collected for broodstock at Dryden Dam were simply added to the number of wild spawners in the Wenatchee to estimate the total wild return to the Wenatchee (Table 16). In contrast, for the Methow/Okanogan Hatchery Program, wild summer Chinook are collected at Wells Dam. This means that the origin (Methow or Okanogan) of wild fish collected for broodstock at Wells Dam is unknown (i.e., it is not known if a wild fish collected at Wells Dam is returning to the Methow or Okanogan system). In this case, we assigned wild broodstock to the appropriate population (Methow or Okanogan) by either (1) multiplying the number of wild broodstock by the proportion of redds counted within each basin (used for the period 1989-1997), or (2) by multiplying the number of wild broodstock by the proportion of wild fish spawning within each basin (used for the period 1998-present). For the period 1989-1997, we applied proportions of redds counted within each basin to broodstock because carcass survey sample rates were low.

As an example of the first method, in 1994 there were 1,462 redds counted in the Methow and Okanogan basins (310 in the Methow and 1,152 in the Okanogan) (Tables 14). Thus, 21.0% of the redds were counted in the Methow Basin. Applying this proportion (0.21) to the total number of wild broodstock collected that year (385 wild broodstock) means that 81 of those wild fish would have returned to the Methow Basin (0.21 x 385 = 81). The remaining 304 fish collected for broodstock would have returned to the Okanogan Basin.

In the second method, a total of 1,032 wild summer Chinook spawned in the Methow and Okanogan basins in 1998 (432 in the Methow and 600 in the Okanogan; Table 15). The percent of wild spawners in the Methow River was 42% (432/1,032 = 0.42). There was 239 wild summer Chinook captured for broodstock at Wells Dam in 1998. Multiplying the number of wild broodstock times the proportion that spawned in the Methow Basin indicates that 100 of the wild fish collected for broodstock at Wells Dam would have ended up in the Methow Basin (239 x 0.42 = 100). The remaining 139 wild fish would have ended up in the Okanogan Basin (Table 16). Table 16 presents the total wild return (wild broodstock + wild spawning escapement) to the Wenatchee, Methow, and Okanogan basins from 1981 to 2007.

Table 16. Wild spawning escapement plus wild fish collected for broodstock equals total wild return of summer Chinook to the Wenatchee, Methow and Okanogan basins. SE = spawning escapement; BS = broodstock. Harvested fish are not included in estimates of total returns.

Year	Wenatchee			Methow			Okanogan		
	Wild (SE)	Wild (BS)	Wild Total	Wild (SE)	Wild (BS)	Wild Total	Wild (SE)	Wild (BS)	Wild Total
1981	9,245	0	9,245	924	0	924	916	0	916
1982	8,964	0	8,964	739	0	739	475	0	475
1983	5,500	0	5,500	328	0	328	504	0	504
1984	9,933	0	9,933	792	0	792	2,736	0	2,736
1985	7,664	0	7,664	745	0	745	2,223	0	2,223
1986	9,226	0	9,226	724	0	724	2,307	0	2,307
1987	13,615	0	13,615	987	0	987	1,635	0	1,635
1988	9,439	0	9,439	529	0	529	1,469	0	1,469
1989	14,331	346	14,677	492	312	804	1,719	1,107	2,826
1990	10,861	84	10,945	1,421	544	1,965	837	320	1,157
1991	10,168	128	10,296	566	502	1,068	574	501	1,075
1992	11,652	341	11,993	460	153	613	473	159	632
1993	8,810	436	9,246	309	182	491	915	547	1,462
1994	8,378	337	8,715	573	81	654	1,322	304	1,626
1995	6,813	382	7,195	563	57	620	979	139	1,118
1996	5,991	331	6,322	424	79	503	568	237	805
1997	5,381	225	5,606	512	51	563	862	163	1,025
1998	4,003	378	4,381	432	100	532	600	139	739
1999	3,971	250	4,221	537	74	611	1,274	174	1,448
2000	4,381	298	4,679	838	77	915	1,174	107	1,281
2001	9,264	311	9,575	1,052	27	1,079	4,306	108	4,414
2002	11,692	469	12,161	2,505	100	2,605	4,346	170	4,516
2003	9,760	488	10,248	2,224	242	2,466	1,933	206	2,139
2004	9,085	494	9,579	1,609	124	1,733	5,309	417	5,726
2005	6,862	491	7,353	1,672	104	1,776	6,441	392	6,833
2006	16,061	483	16,544	2,039	151	2,190	5,507	409	5,916
2007	3,172	415	3,587	764	101	865	2,983	403	3,386
2008	4,794	400	5,194	1,293	125	1,418	2,998	293	3,291
2009	7,113	482	7,595	1,093	116	1,209	4,204	437	4,641

Age Structure of Wild Fish

In order to estimate the year in which fish were produced (brood year), we organized wild fish by age class within a return year. The age-class structure presented in Table 17 identifies what proportion of the return-year escapement is made up of each age class. The age of returning wild fish was determined from analysis of scales collected from carcasses on the spawning grounds and from fish collected for broodstock. We developed separate age-class structures for fish sampled on spawning grounds and for fish collected for broodstock. For some years, the age structure on the spawning grounds was unknown, so an average age structure was estimated from data collected during 1986-1992 on the spawning grounds (from Chapman et al. 1995; reported in their Table 5). The average age structure was used for 1981-1992 on the Methow and Okanogan basins, and from 1981-1989 in the Wenatchee basin (Table 17).

Table 17. Proportion of wild summer Chinook of different ages sampled on spawning grounds in the Wenatchee, Methow, and Okanogan basins.

Return Year	Wild Fish Age Structure-Carcasses on Spawning Grounds														
	Wenatchee					Methow					Okanogan				
	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6
1981															
1982															
1983															
1984															
1985	0.002	0.061	0.410	0.503	0.024										
1986						0.000	0.088	0.255	0.606	0.051	0.000	0.194	0.445	0.357	0.004
1987															
1988															
1989															
1990	0.000	0.031	0.354	0.615	0.000										
1991	0.000	0.055	0.418	0.515	0.012										
1992	0.000	0.030	0.350	0.600	0.020										
1993	0.000	0.030	0.420	0.550	0.000	0.000	0.050	0.340	0.580	0.030	0.000	0.000	0.760	0.240	0.000
1994	0.010	0.030	0.440	0.520	0.000	0.010	0.020	0.530	0.440	0.000	0.000	0.030	0.420	0.550	0.000
1995	0.000	0.030	0.190	0.730	0.050	0.000	0.020	0.070	0.890	0.020	0.000	0.010	0.270	0.720	0.000
1996	0.000	0.020	0.360	0.600	0.020	0.000	0.040	0.460	0.410	0.090	0.000	0.140	0.500	0.360	0.000
1997	0.000	0.010	0.380	0.580	0.030	0.000	0.000	0.360	0.620	0.020	0.000	0.000	0.050	0.660	0.290
1998	0.000	0.030	0.340	0.620	0.010	0.000	0.130	0.520	0.350	0.000	0.000	0.030	0.630	0.340	0.000
1999	0.000	0.010	0.430	0.550	0.010	0.000	0.020	0.580	0.390	0.010	0.000	0.000	0.340	0.660	0.000
2000	0.010	0.040	0.270	0.680	0.000	0.010	0.050	0.150	0.790	0.000	0.010	0.070	0.280	0.620	0.020
2001	0.000	0.080	0.590	0.320	0.010	0.010	0.150	0.580	0.240	0.020	0.020	0.150	0.750	0.080	0.000
2002	0.000	0.030	0.660	0.310	0.000	0.000	0.040	0.660	0.300	0.000	0.010	0.110	0.650	0.230	0.000
2003	0.000	0.020	0.340	0.640	0.000	0.000	0.010	0.440	0.550	0.000	0.010	0.020	0.760	0.210	0.000
2004	0.000	0.060	0.130	0.800	0.010	0.000	0.040	0.090	0.860	0.010	0.000	0.120	0.110	0.760	0.010
2005	0.000	0.040	0.600	0.320	0.040	0.000	0.030	0.580	0.340	0.050	0.000	0.080	0.760	0.140	0.020
2006	0.000	0.010	0.150	0.830	0.010	0.000	0.020	0.180	0.780	0.020	0.000	0.010	0.470	0.510	0.010
2007	0.010	0.080	0.200	0.610	0.100	0.020	0.080	0.190	0.640	0.070	0.010	0.070	0.100	0.800	0.020
2008	0.010	0.050	0.740	0.200	0.000	0.020	0.110	0.720	0.140	0.010	0.010	0.310	0.630	0.040	0.010
2009	0.000	0.050	0.520	0.430	0.000	0.010	0.080	0.420	0.490	0.000	0.010	0.020	0.810	0.160	0.000

Table 18 presents the proportion of wild summer Chinook of different ages sampled from broodstock for the Wenatchee, Methow, and Okanogan basins. An average age structure for 1989 and 1990 was estimated from data collected in 1991 and 1992.

Table 18. Proportion of wild summer Chinook of different ages sampled in broodstock collections at Dryden and Wells dams.

Return Year	Wild Fish Age Structure-Broodstock Collections									
	Wenatchee (Dryden Dam)					Methow and Okanogan (Wells Dam)				
	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6
1989 1990	0.000	0.035	0.388	0.537	0.040	0.003	0.082	0.354	0.543	0.017
1991	0.000	0.046	0.368	0.575	0.012	0.005	0.068	0.351	0.554	0.022
1992	0.000	0.026	0.404	0.509	0.061	0.000	0.131	0.362	0.507	0.000
1993	0.000	0.015	0.360	0.603	0.023	0.000	0.039	0.753	0.208	0.000
1994	0.000	0.010	0.337	0.643	0.010	0.031	0.097	0.263	0.603	0.006
1995	0.000	0.033	0.192	0.764	0.012	0.000	0.046	0.152	0.756	0.046
1996	0.000	0.046	0.401	0.533	0.020	0.000	0.084	0.566	0.304	0.046
1997	0.000	0.023	0.426	0.532	0.019	0.010	0.093	0.529	0.348	0.020
1998	0.000	0.055	0.349	0.584	0.012	0.020	0.141	0.548	0.291	0.000
1999	0.005	0.019	0.390	0.563	0.024	0.047	0.051	0.537	0.360	0.005
2000	0.026	0.063	0.246	0.665	0.000	0.006	0.140	0.287	0.561	0.006

Return Year	Wild Fish Age Structure-Broodstock Collections									
	Wenatchee (Dryden Dam)					Methow and Okanogan (Wells Dam)				
	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6
2001	0.004	0.166	0.536	0.277	0.017	0.071	0.260	0.520	0.118	0.031
2002	0.016	0.084	0.611	0.283	0.007	0.004	0.174	0.660	0.162	0.000
2003	0.009	0.028	0.314	0.649	0.000	0.007	0.039	0.659	0.295	0.000
2004	0.002	0.036	0.101	0.839	0.021	0.008	0.153	0.116	0.721	0.002
2005	0.000	0.043	0.535	0.351	0.071	0.000	0.172	0.699	0.110	0.019
2006	0.014	0.009	0.149	0.818	0.011	0.016	0.030	0.410	0.529	0.015
2007	0.036	0.150	0.186	0.464	0.165	0.018	0.153	0.082	0.702	0.045
2008	0.005	0.064	0.653	0.262	0.016	0.003	0.171	0.678	0.136	0.012
2009	0.016	0.058	0.463	0.463	0.000	0.013	0.100	0.683	0.204	0.000

The age-class proportions in Tables 17 and 18 were applied to the wild spawning escapement and broodstock to estimate the number of returning fish of a given age (Table 19). The number of wild fish of a given age within a return year was estimated as the spawning escapement or broodstock times the proportion for that return year and age. For example, in 1997, the wild spawning escapement in the Wenatchee Basin was 5,381 fish (Table 16). The number of wild fish of each age class on the spawning grounds in 1997 was estimated as the age-structure proportions times the spawning escapement:

Age	Age Structure	Spawning Escapement
2	0.00	0
3	0.01	54
4	0.38	2,045
5	0.58	3,121
6	0.03	161
Total	**1.00**	**5,381**

Thus, age-4 and 5 fish made up the majority of the spawning escapement in 1997. When this exercise is carried out for each return year, the age-specific escapement can be estimated for all wild fish in the spawning escapement and collected for broodstock (Table 19).

This approach does not address the issue of carcass recovery bias. Carcass recovery bias may be important for summer Chinook stock reconstruction because a majority of the recruits for any given year are recovered on the spawning grounds. Larger fish may be recovered on the spawning grounds at a greater rate than smaller fish. Furthermore, if hatchery fish return as smaller and younger adults compared to wild fish, they would be underrepresented in the carcass surveys. We intend to address this bias once methodologies have been developed.

Table 19. Number of wild summer Chinook by age class estimated on the spawning grounds and collected for broodstock for the Wenatchee, Methow, and Okanogan basins.

Return Year	Wild Fish Age Structure														
	Wenatchee					Methow					Okanogan				
	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6
Spawning Grounds															
1981	16	565	3,787	4,654	223	0	81	236	560	47	0	177	408	327	4
1982	15	548	3,672	4,513	216	0	65	188	448	38	0	92	211	170	2
1983	9	336	2,253	2,769	133	0	29	83	199	17	0	98	224	180	2
1984	17	607	4,069	5,000	240	0	70	202	480	40	0	530	1,218	976	12
1985	13	469	3,139	3,858	185	0	66	190	451	38	0	431	989	793	10
1986	16	564	3,779	4,645	222	0	64	184	439	37	0	447	1,027	823	10
1987	24	832	5,577	6,854	328	0	87	252	598	50	0	317	728	583	7
1988	16	577	3,866	4,752	228	0	46	135	321	27	0	285	654	524	6
1989	25	876	5,870	7,214	346	0	43	126	298	25	0	333	765	613	8
1990	0	334	3,843	6,684	0	0	125	362	861	73	0	162	372	299	4
1991	0	554	4,252	5,239	123	0	50	144	343	29	0	111	255	205	3
1992	0	355	4,022	7,039	236	0	41	117	279	23	0	92	210	169	2
1993	0	264	3,700	4,846	0	0	16	105	179	9	0	0	695	220	0
1994	84	251	3,686	4,357	0	6	11	304	252	0	0	40	555	728	0
1995	0	204	1,294	4,974	341	0	11	40	501	11	0	10	264	705	0
1996	0	120	2,157	3,594	120	0	17	195	174	38	0	80	284	204	0
1997	0	54	2,045	3,121	161	0	0	184	318	10	0	0	43	569	250
1998	0	120	1,361	2,482	40	0	56	225	151	0	0	18	378	204	0
1999	0	40	1,707	2,184	40	0	11	312	209	5	0	0	433	841	0
2000	44	175	1,183	2,979	0	8	42	126	662	0	12	82	329	728	23
2001	0	741	5,466	2,964	93	11	158	610	252	21	86	646	3,230	344	0
2002	0	351	7,717	3,624	0	0	100	1,653	752	0	43	478	2,825	1,000	0
2003	0	195	3,318	6,247	0	0	22	979	1,223	0	19	39	1,469	406	0
2004	0	545	1,181	7,268	91	0	64	145	1,384	16	0	637	584	4,035	53
2005	0	274	4,118	2,196	274	0	50	970	568	84	0	515	4,895	902	129
2006	0	161	2,409	13,330	161	0	41	367	1,590	41	0	55	2,588	2,809	55
2007	32	254	634	1,935	317	15	61	145	489	54	30	209	298	2,386	60
2008	48	240	3,547	959	0	26	142	931	181	13	30	929	1,889	120	30
2009	0	356	3,699	3,058	0	11	87	459	536	0	42	84	3,405	673	0
Broodstock Collection															
1989	0	12	134	186	14	4	91	392	601	19	1	26	111	169	5
1990	0	3	33	45	3	1	26	113	174	6	2	45	193	295	9
1991	0	6	47	74	1	2	34	176	278	11	3	34	176	278	11
1992	0	9	138	173	21	0	21	57	81	0	0	20	55	78	0
1993	0	6	157	263	10	0	21	412	114	0	0	7	137	38	0
1994	0	3	114	217	3	9	30	80	183	2	3	8	21	49	0
1995	0	12	73	292	5	0	6	21	105	7	0	3	8	43	3
1996	0	15	133	176	7	0	20	134	72	11	0	7	45	24	3
1997	0	5	96	120	4	2	15	86	57	3	1	4	27	18	1
1998	0	21	132	221	4	3	20	76	40	0	2	14	55	29	0
1999	1	5	97	141	6	8	9	93	63	1	3	4	40	27	0
2000	8	19	73	198	0	1	15	30	60	1	0	11	22	43	1
2001	1	52	167	86	5	8	28	56	13	3	2	7	14	3	1
2002	7	39	287	133	3	1	30	112	27	0	1	17	66	16	0
2003	4	14	153	317	0	1	8	136	61	0	2	9	160	71	0
2004	1	18	50	415	10	3	64	48	301	1	1	19	14	89	1
2005	0	21	263	172	35	0	67	274	43	8	0	18	73	11	2
2006	7	4	72	395	5	7	12	168	216	6	2	5	62	80	2
2007	15	62	77	193	68	7	62	33	283	18	2	15	8	71	5
2008	2	26	261	105	6	1	50	199	40	3	0	21	85	17	2
2009	8	28	223	223	0	6	44	298	89	0	1	12	79	24	0

NORs and NRRs (without harvest)

Natural-origin recruits (NORs) were estimated by reorganizing the data in Table 19 as follows. First, the number of wild fish in each age class was backed to brood year (the year the fish were produced). This was accomplished by subtracting the total age of the fish from their return year. The number of recruits of each age class for a given brood year were then added together to estimate the total number of wild recruits for a given brood year. For example, the number of wild fish returning to the Wenatchee River from the 1997 brood year was 9,585 fish, which is the sum of wild fish on the spawning grounds and collected for broodstock:

Return Year	Age at Return	Spawning Grounds	Broodstock Collected	Total
1999	2	0	1	1
2000	3	175	19	194
2001	4	5,466	167	5,633
2002	5	3,624	133	3,757
2003	6	0	0	0
	Total:	**9,265**	**320**	**9,585**

These 9,585 fish represent the NORs that returned from natural production in 1997. Table 20 identifies the total number of wild recruits to the Wenatchee, Methow, and Okanogan basins organized by brood year along with the spawning escapements that produced them. These NORs do not include fish harvested in the ocean, estuary, or Columbia River. The natural replacement rate (NRR) was then estimated as follows:

$$NRR = \frac{NOR}{Spawning\ Escapement}$$

In words, NRR is the total number of wild recruits divided by the spawning escapement (includes both wild and hatchery spawners) that produced them. Table 20 identifies the NORs and NRRs for brood years 1981 to 2003. For example, the NRR for Wenatchee summer Chinook for brood year 1997 was 1.62, which was calculated as:

$$NRR = \frac{9{,}585}{5{,}913} = 1.62$$

Table 20. Wenatchee, Methow, and Okanogan natural-origin recruits (NORs) for brood years 1981 to 2003. The natural replacement rate (NRR) is total recruits divided by spawning escapement (SE), where SE includes both wild and hatchery spawners (from Table 14).

Brood Year	Wenatchee			Methow			Okanogan		
	SE	NORs	NRRs	SE	NORs	NRRs	SE	NORs	NRRs
1981	9,245	8,728	0.94	924	749	0.81	916	2,349	2.56
1982	8,964	11,347	1.27	739	875	1.18	475	2,047	4.31
1983	5,500	11,266	2.05	328	667	2.03	504	1,726	3.42
1984	9,933	12,117	1.22	792	771	0.97	2,736	2,195	0.80
1985	7,664	13,458	1.76	745	1,479	1.99	2,223	1,929	0.87
1986	9,226	10,350	1.12	724	1,268	1.75	2,307	1,394	0.60
1987	13,615	11,883	0.87	987	857	0.87	1,635	873	0.53
1988	9,439	9,832	1.04	529	475	0.90	1,469	749	0.51
1989	14,331	9,141	0.64	492	621	1.26	1,719	2,140	1.24
1990	10,861	9,463	0.87	1,421	933	0.66	837	1,477	1.76
1991	10,168	5,556	0.55	566	276	0.49	574	884	1.54
1992	11,652	5,875	0.50	460	599	1.30	473	1,069	2.26
1993	9,450	5,025	0.53	508	420	0.83	1,485	474	0.32
1994	10,154	3,877	0.38	1,085	521	0.48	4,033	1,397	0.35
1995	7,755	5,220	0.67	1,214	1,150	0.95	3,002	1,357	0.45
1996	6,168	4,354	0.71	615	420	0.68	1,819	728	0.40
1997	5,913	9,585	1.62	697	1,448	2.08	2,189	4,418	2.02
1998	5,352	15,514	2.90	675	3,203	4.75	1,092	4,145	3.80
1999	5,476	11,854	2.16	986	2,828	2.87	3,617	6,680	1.85
2000	5,512	3,981	0.72	1,200	813	0.68	3,701	1,729	0.47
2001	11,360	19,058	1.68	2,768	2,857	1.03	10,857	8,993	0.83
2002	15,723	4,911	0.31	4,630	1,073	0.23	13,857	6,043	0.44
2003	11,800	1,940	0.16	3,930	397	0.10	3,420	558	0.16

NORs and NRRs (with harvest)

Thus far, we have estimated the NORs and NRRs as the sum of the wild spawning escapement and wild fish collected for broodstock organized by brood year (Table 20). In this section, we add the number of wild fish harvested in various fisheries to the total wild recruits and recalculate NRRs. Two methods were used to estimate harvest on summer Chinook from the Wenatchee, Methow, and Okanogan basins. The first method estimated harvest on wild fish based on individual hatchery indicator stocks, which were released from the basins of interest. The second method was based on the Pacific Salmon Commission's (PSC) Upper Columbia summer Chinook harvest estimates for total fishing mortality among fisheries and escapement (PSC 2008). The first method presents brood-year harvest rates and the second method produces return-year harvest rates. Below we describe both methods as they apply to wild summer Chinook in the Wenatchee, Methow, and Okanogan basins. Selection of the most appropriate method, or combination of methods, will be determined by the HETT and Hatchery Committees.

Hatchery Indicator Stock Harvest Rates—The assumption when using a hatchery indicator stock, such as hatchery fish from the Wenatchee, Methow, or Okanogan summer Chinook programs, is that hatchery and wild fish have a similar adult migration pattern. That is, hatchery fish and wild fish have similar encounter and capture rates in different fisheries. We used individual hatchery indicator stocks from each of the basins to estimate harvest on wild fish from 1989 to 2002. More recent data will be available as summer Chinook life-cycles are completed, coded wire tags are recovered, and data are uploaded to the Regional Mark Information System (RMIS). For the period 1981 to 1989, we used Priest Rapids Hatchery fall Chinook to estimate harvest on summer Chinook, because no other summer/fall Chinook program had a consistent data series for these years in the Upper Columbia. Hatchery harvest rates from CWT recoveries were estimated as follows:

$$Hatchery\ Harvest\ Rate = \frac{Total\ Expanded\ Estimate\ of\ CWT\ Fish\ Harvested}{Total\ Expanded\ Estimate\ of\ CWTs\ Collected}$$

The denominator (total number of CWTs collected) includes all CWTs collected in hatchery programs, on spawning grounds, and in fisheries. Table 21 presents the harvest rates estimated from different hatchery release programs. As an example, the harvest rate on brood year 1997 for Wenatchee hatchery summer Chinook was 0.432 (3,187/7,371 = 0.432).

Table 21. Harvest rates estimated from CWT recoveries from individual summer/fall Chinook Hatchery programs at Priest Rapids Dam (PRD) and from the Wenatchee (WEN), Methow (MET), and Okanogan (OKN) basins. Harvest rate is estimated as total harvest divided by total CWTs collected.

Brood Year	Total Harvest				Total CWTs Collected				Harvest Rates			
	PRD	WEN	MET	OKN	PRD	WEN	MET	OKN	PRD	WEN	MET	OKN
1981	1,427	-	-	-	1,938	-	-	-	0.736	-	-	-
1982	4,611	-	-	-	6,539	-	-	-	0.705	-	-	-
1983	3,223	-	-	-	4,449	-	-	-	0.724	-	-	-
1984	4,623	-	-	-	5,594	-	-	-	0.826	-	-	-
1985	762	-	-	-	997	-	-	-	0.764	-	-	-
1986	359	-	-	-	516	-	-	-	0.696	-	-	-
1987	43	-	-	-	102	-	-	-	0.422	-	-	-
1988	159	-	-	-	267	-	-	-	0.596	-	-	-
1989	-	585	1,698	1,721	-	1,017	2,882	4,298	-	0.575	0.589	0.400
1990	-	30	101	273	-	115	369	969	-	0.261	0.274	0.282
1991	-	48	43	135	-	71	130	977	-	0.676	0.331	0.138
1992	-	189	31	479	-	617	138	2,299	-	0.306	0.225	0.208
1993	-	65	24	30	-	157	62	117	-	0.414	0.387	0.256
1994	-	708	189	413	-	1,928	710	1,538	-	0.367	0.266	0.269
1995	-	568	77	696	-	1,539	229	2,855	-	0.369	0.336	0.244
1996	-	204	14	5	-	567	74	31	-	0.360	0.189	0.161
1997	-	3,187	249	7,071	-	7,371	649	18,731	-	0.432	0.384	0.378
1998	-	5,356	2,101	4,816	-	7,610	3,824	7,684	-	0.704	0.549	0.627
1999	-	1,860	15	1,949	-	2,487	33	2,779	-	0.748	0.455	0.701
2000	-	10,591	512	4,534	-	13,814	768	6,748	-	0.767	0.667	0.672
2001	-	1,759	618	318	-	2,386	923	424	-	0.737	0.670	0.750
2002	-	2,598	561	1,226	-	4,319	890	1,953	-	0.602	0.630	0.628
2003	-	1,636	95	1,836	-	3,026	213	3,464	-	0.541	0.446	0.530

Harvest rates were then applied to the wild returns (wild spawners and wild fish in broodstock) in Table 19 to estimate total wild fish escapement as follows:

$$Total\ Wild\ Fish\ Escapement = \frac{(Wild\ Fish\ Spawners) + (Wild\ Fish\ in\ Broodstock)}{1 - (Harvest\ Rate)}$$

For example, the total wild escapement (including harvest) for brood-year 1997 Wenatchee summer Chinook was estimated at 16,875. That is:

$$Total\ Wild\ Fish\ Escapement = \frac{9{,}265 + 320}{1 - 0.432} = \frac{9{,}585}{0.568} = 16{,}875$$

This method of estimating harvest was used for all brood years except 1981 to 1988 when Priest Rapids Hatchery harvest rates were applied to all wild summer Chinook brood years. Table 22 presents NORs adjusted for harvest from brood year 1981 to 2003 for wild summer Chinook in the Wenatchee, Methow, and Okanogan basins.

Table 22. Harvest rates on hatchery indicator stocks from Priest Rapids (PRD), Wenatchee (WEN), Methow (MET), and Okanogan (OKN) summer Chinook, natural-origin recruits (NORs), and NORs adjusted for harvest.

Brood Year	Harvest Rates				NORs			NORs + Harvest		
	PRD	WEN	MET	OKN	WEN	MET	OKN	WEN	MET	OKN
1981	0.736	-	-	-	8,728	749	2,349	33,061	2,837	8,898
1982	0.705	-	-	-	11,347	875	2,047	38,464	2,966	6,939
1983	0.724	-	-	-	11,266	667	1,726	40,819	2,417	6,254
1984	0.826	-	-	-	12,117	771	2,195	69,638	4,431	12,615
1985	0.764	-	-	-	13,458	1,479	1,929	57,025	6,267	8,174
1986	0.696	-	-	-	10,350	1,268	1,394	34,046	4,171	4,586
1987	0.422	-	-	-	11,883	857	873	20,559	1,483	1,510
1988	0.596	-	-	-	9,832	475	749	24,337	1,176	1,854
1989	-	0.575	0.589	0.400	9,141	621	2,140	21,508	1,511	3,567
1990	-	0.261	0.274	0.282	9,463	933	1,477	12,805	1,285	2,057
1991	-	0.676	0.331	0.138	5,556	276	884	17,148	413	1,026
1992	-	0.306	0.225	0.208	5,875	599	1,069	8,465	773	1,350
1993	-	0.414	0.387	0.256	5,025	420	474	8,575	685	637
1994	-	0.367	0.266	0.269	3,877	521	1,397	6,125	710	1,911
1995	-	0.369	0.336	0.244	5,220	1,150	1,357	8,273	1,732	1,795
1996	-	0.360	0.189	0.161	4,354	420	728	6,803	518	868
1997	-	0.432	0.384	0.378	9,585	1,448	4,418	16,875	2,351	7,103
1998	-	0.704	0.549	0.627	15,514	3,203	4,145	52,412	7,102	11,113
1999	-	0.748	0.455	0.701	11,854	2,828	6,680	47,040	5,189	22,341
2000	-	0.767	0.667	0.672	3,981	813	1,729	17,086	2,441	5,271
2001	-	0.737	0.670	0.750	19,058	2,857	8,993	72,464	8,658	35,972
2002	-	0.602	0.630	0.628	4,911	1,073	6,043	12,339	2,900	16,245
2003	-	0.541	0.446	0.530	1,940	397	558	4,227	717	1,187

Pacific Salmon Commission (PSC) Harvest Rates—The estimates provided by PSC in Table 23 present percent total fishing mortality among different fisheries and the percent that escaped harvest by catch year. The percent harvested for each year is one hundred minus the escapement, or the sum of the percent harvested from the different fisheries. For example, the harvest, expressed as a rate, for 1998 was 0.227 ((100 – 77.3)/100 = 0.227). For years in which no estimates were provided (1981-1986), we used the mean harvest rate from 1979 to 1984.

To estimate the total wild escapement for each year, we divided the total wild returns in Table 16 by the proportion of the run that escaped harvest in Table 23:

$$Total\ Wild\ Escapement = \frac{Total\ Wild\ Return}{(1 - Harvest\ Rate)}$$

The harvest rate is simply one minus the escapement. For example, in 1998 for the Okanogan Basin, we divided the total wild return (739 fish) from Table 16 by the proportion of the run that escaped harvest (0.770) to estimate 960 fish.

$$Total\ Wild\ Escapement = \frac{739}{(1 - 0.230)} = \frac{739}{0.770} = 960$$

Table 23. Percent distribution of Columbia summer Chinook total fishing mortalities among fisheries and escapement (PSC 2011; Appendix E. 52).

Catch Year	Aggregate Abundance Based Management (AABM)							Individual Stock Based Management (ISBM)													ESC.
	SEAK			NBC		WCVI		Geo State		Canada			WA/OR Coast			Puget Sound		Terminal			
	Troll	Net	Sport	Troll	Sport	Troll	Sport	Troll	Sport	Troll	Net	Sport	Troll	Net	Sport	Net	Sport	Troll	Net	Sport	
1979	13.8	0.0	1.0	8.7	0.0	19.4	0.0	2.6	4.6	4.1	10.2	0.0	0.5	0.0	4.1	0.0	0.0	0.0	3.6	0.0	27.6
1980	32.6	0.0	0.9	9.2	0.0	18.2	0.0	0.0	0.0	4.3	1.2	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.6	0.0	31.4
1987	16.3	0.0	0.0	8.1	2.5	7.5	0.0	0.0	0.0	3.8	4.4	0.0	20.0	0.0	0.6	0.0	0.0	0.0	11.9	0.0	25.0
1988	1.6	1.6	0.0	10.2	1.9	21.3	4.1	0.0	0.0	0.0	8.9	0.0	3.5	0.0	0.0	0.0	0.0	0.0	13.3	2.9	30.8
1989	6.4	2.4	0.7	5.6	0.6	16.5	2.4	0.0	1.4	0.7	2.2	0.0	15.0	0.0	2.5	0.0	0.0	0.0	7.6	0.0	36.1
1990	10.5	0.0	0.0	7.6	0.0	20.3	0.0	0.0	0.6	1.1	1.7	0.0	5.7	0.0	2.4	0.0	0.0	0.0	10.3	0.2	39.6
1991	4.1	0.0	0.0	2.3	0.0	6.1	0.7	0.0	0.0	0.5	2.8	0.0	3.5	0.0	1.9	0.0	0.0	0.0	4.0	0.4	73.7
1992	18.3	0.0	0.0	3.6	0.0	15.7	0.0	0.0	0.7	2.0	1.0	0.0	6.9	0.0	0.0	0.0	1.6	0.0	1.3	0.0	49.0
1993	7.8	0.0	0.0	1.4	0.0	15.6	1.8	0.0	0.0	0.0	2.8	0.0	5.5	0.0	1.4	0.0	0.0	0.0	3.2	0.0	60.6
1994	17.5	0.0	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	57.5
1995	3.6	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	1.2	0.0	1.8	0.0	0.0	2.4	0.0	0.0	0.0	0.0	84.6
1996	20.8	0.7	0.0	1.9	0.2	2.8	0.0	0.0	2.6	0.0	3.0	0.0	2.6	0.0	0.7	0.0	1.2	0.0	3.3	2.1	58.2
1997	8.9	0.1	3.7	0.2	1.4	2.0	0.0	0.0	0.0	0.0	0.2	0.0	3.3	0.0	0.0	0.0	0.2	0.0	1.1	0.5	78.5
1998	10.1	0.3	1.2	0.5	2.4	0.0	0.6	0.0	0.0	0.0	0.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	4.8	1.0	77.0
1999	14.8	3.4	3.2	0.6	2.7	0.5	5.3	0.0	0.0	0.0	0.6	0.0	9.4	0.0	0.5	0.0	0.0	0.0	1.1	2.9	54.8
2000	25.6	1.8	3.4	0.6	2.8	4.6	5.4	0.0	0.8	0.0	0.5	0.0	3.3	0.0	1.4	0.1	0.3	0.0	0.9	2.2	46.5
2001	15.6	4.1	1.4	0.5	1.7	12.3	2.6	0.0	0.2	0.0	0.0	0.0	16.9	0.0	3.6	0.0	1.1	0.0	0.7	1.6	37.8
2002	23.3	0.0	1.5	12.7	2.0	15.1	1.4	0.0	0.1	0.0	0.0	0.0	8.8	0.0	3.6	0.0	0.0	0.0	1.0	2.3	28.2
2003	27.5	0.7	1.1	11.8	2.4	11.7	0.3	0.0	0.1	0.0	0.0	0.0	6.8	0.0	1.0	0.0	0.1	0.0	2.7	5.8	28.0
2004	14.2	0.4	1.1	5.4	1.7	12.1	1.4	0.0	0.2	0.0	0.0	0.0	10.6	0.0	1.5	0.0	0.3	0.0	7.3	14.7	29.1
2005	9.2	0.0	0.7	6.1	2.6	10.4	0.9	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.5	0.0	0.0	0.0	6.8	7.8	48.7
2006	9.9	0.0	0.4	3.0	1.0	9.2	1.1	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.4	0.2	0.1	0.0	10.8	8.5	52.8
2007	7.9	0.8	0.9	1.0	1.6	4.5	0.9	0.0	0.1	0.0	0.0	0.0	2.8	0.0	0.3	0.0	0.1	0.0	7.1	8.7	63.2
2008	6.6	0.5	0.4	0.9	0.2	3.9	3.5	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.2	0.0	0.2	0.0	20.0	9.3	52.6
'79-'08	13.6	0.7	0.9	4.3	1.8	9.8	1.3	0.1	0.5	0.7	1.7	0.0	5.9	0.0	1.1	0.1	0.2	0.0	5.6	2.9	48.8
'79-'84	23.2	0.0	0.9	8.9	0.0	18.8	0.0	1.3	2.3	4.2	5.7	0.0	1.1	0.0	2.0	0.0	0.0	0.0	2.1	0.0	29.5
'85-'95	9.6	0.4	0.1	4.3	2.2	12.2	1.0	0.0	0.3	0.9	2.8	0.0	6.9	0.0	1.0	0.3	0.2	0.0	6.8	0.4	50.8
'96-'98	13.2	0.3	1.6	0.9	1.3	1.6	0.2	0.0	0.9	0.0	1.1	0.0	2.7	0.0	0.2	0.0	0.5	0.0	3.1	1.2	71.2
'99-'08	15.5	1.2	1.4	4.3	1.9	8.4	2.3	0.0	0.1	0.0	0.1	0.0	6.9	0.0	1.3	0.0	0.2	0.0	5.8	6.4	44.2

The number of fish harvested is the total wild escapement less the total wild return (960 - 739 = 221). The total wild return includes the wild spawning escapement plus the wild fish taken for broodstock. This gives the number of adult wild salmon (recruits) that survived to return to their natal stream and the estimated number of wild salmon that were harvested (Table 24).

Table 24. Harvest rate, total wild return, harvest, and total wild return plus harvest for summer Chinook in the Wenatchee (WEN), Methow (MET), and Okanogan (OKN) basins.

Year	Harvest Rate	Total Wild Return			Wild Harvest			Total Wild Return+Harvest		
		WEN	MET	OKN	WEN	MET	OKN	WEN	MET	OKN
1981	0.705	9,245	924	916	22,094	2,208	2,189	31,339	3,132	3,105
1982	0.705	8,964	739	475	21,422	1,766	1,135	30,386	2,505	1,610
1983	0.705	5,500	328	504	13,144	784	1,204	18,644	1,112	1,708
1984	0.705	9,933	792	2,736	23,738	1,893	6,539	33,671	2,685	9,275
1985	0.705	7,664	745	2,223	18,316	1,780	5,313	25,980	2,525	7,536
1986	0.705	9,226	724	2,307	22,049	1,730	5,513	31,275	2,454	7,820
1987	0.750	13,615	987	1,635	40,845	2,961	4,905	54,460	3,948	6,540
1988	0.692	9,439	529	1,469	21,207	1,189	3,300	30,646	1,718	4,769
1989	0.639	14,677	804	2,826	25,980	1,423	5,002	40,657	2,227	7,828
1990	0.604	10,945	1,965	1,157	16,694	2,997	1,765	27,639	4,962	2,922
1991	0.263	10,296	1,068	1,075	3,674	381	384	13,970	1,449	1,459
1992	0.510	11,993	613	632	12,483	638	658	24,476	1,251	1,290
1993	0.394	9,246	491	1,462	6,011	319	951	15,257	810	2,413
1994	0.425	8,715	654	1,627	6,442	483	1,203	15,157	1,137	2,830
1995	0.154	7,195	620	1,118	1,310	113	204	8,505	733	1,322
1996	0.418	6,322	503	805	4,541	361	578	10,863	864	1,383
1997	0.215	5,606	563	1,025	1,535	154	281	7,141	717	1,306
1998	0.230	4,381	532	739	1,309	159	221	5,690	691	960
1999	0.452	4,221	611	1,448	3,482	504	1,194	7,703	1,115	2,642
2000	0.535	4,679	915	1,281	5,383	1,053	1,474	10,062	1,968	2,755
2001	0.622	9,575	1,079	4,414	15,756	1,775	7,263	25,331	2,854	11,677
2002	0.718	12,161	2,605	4,516	30,963	6,633	11,498	43,124	9,238	16,014
2003	0.720	10,248	2,466	2,139	26,352	6,341	5,500	36,600	8,807	7,639
2004	0.709	9,579	1,733	5,726	23,339	4,222	13,951	32,918	5,955	19,677
2005	0.513	7,353	1,776	6,833	7,746	1,871	7,198	15,099	3,647	14,031
2006	0.472	16,544	2,190	5,916	14,789	1,958	5,289	31,333	4,148	11,205

The harvested fish presented in Table 24 have an unknown age structure. Therefore, we used a combined age structure (carcass and broodstock sampling) within a basin to estimate the age structure of harvested fish. As in the previous sections, the proportion of fish in each age class by return year was applied to the number of fish harvested in each catch year. Table 25 presents the distribution of harvested fish based on the age, year of harvest, and river basin.

Table 25. Numbers of fish harvested by age and return year using PSC harvest rates and a combined age structure for fish collected on spawning ground and broodstock within their respective river basins.

Return Year	Wild Fish Age Structure-Harvested Fish														
	Wenatchee					Methow					Okanogan				
	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6	Age-2	Age-3	Age-4	Age-5	Age-6
1981	38	1,350	9,050	11,123	533	0	193	564	1,338	113	0	424	974	781	10
1982	37	1,309	8,775	10,784	517	0	155	451	1,070	90	0	220	505	405	5
1983	23	803	5,384	6,617	317	0	69	200	475	40	0	233	536	430	5
1984	41	1,451	9,723	11,950	573	0	166	483	1,147	97	0	1,268	2,909	2,333	29
1985	31	1,119	7,503	9,221	442	0	156	455	1,078	91	0	1,030	2,364	1,896	23
1986	38	1,347	9,032	11,100	532	0	152	442	1,048	88	0	1,069	2,453	1,967	24
1987	70	2,497	16,731	20,562	985	0	259	757	1,794	151	0	951	2,182	1,750	22
1988	36	1,296	8,687	10,676	512	0	104	304	720	61	0	640	1,468	1,177	15
1989	39	1,486	10,561	13,208	686	3	120	459	801	40	9	657	1,970	2,308	58
1990	0	564	6,339	9,289	502	7	252	966	1,688	84	3	232	695	814	21
1991	0	190	1,472	1,968	44	1	29	120	218	13	1	51	153	174	5
1992	0	361	4,576	7,104	442	0	65	186	365	22	0	118	280	258	2
1993	0	160	2,436	3,381	34	0	14	197	105	3	0	20	720	211	0
1994	35	127	2,470	3,775	35	13	38	158	272	2	27	93	373	706	5
1995	0	40	250	984	36	0	4	15	90	4	0	7	39	152	6
1996	0	134	1,705	2,613	89	0	27	198	117	19	0	52	323	180	23
1997	0	22	603	869	41	1	11	76	63	3	2	19	114	121	25
1998	0	47	449	800	13	2	20	86	51	0	3	18	130	70	0
1999	3	40	1,473	1,923	43	11	17	282	190	4	24	27	509	631	3
2000	71	237	1,429	3,646	0	10	90	215	736	2	12	148	416	879	19
2001	17	1,673	9,032	4,834	200	51	326	996	360	42	221	1,247	5,122	629	44
2002	99	1,259	20,129	9,433	43	5	443	4,380	1,805	0	92	1,460	7,508	2,438	0
2003	50	575	8,817	16,910	0	21	150	3,423	2,747	0	50	162	3,921	1,367	0
2004	9	1,305	2,913	18,834	278	19	436	440	3,304	23	28	1,787	1,554	10,472	110
2005	0	315	4,507	2,548	376	0	203	1,210	395	63	0	767	5,344	943	144
2006	27	148	2,215	12,248	151	19	51	617	1,237	34	34	92	2,363	2,739	61

Natural-origin recruits from harvested fish in Table 25 can be estimated by reorganizing and summing the data by brood year for each river basin. Brood year was calculated by subtracting the total age of the fish from their return year. The number of recruits harvested from each age class for a given brood year was then added together to estimate the total number of wild recruits harvested from a given brood year. The number of recruits that were harvested from each age class for a given brood year are then added together to estimate the total number of wild recruits for a given brood year. Similar to the example used previously, adding the number of Wenatchee wild summer Chinook from spawning grounds, broodstock, and harvest from the 1997 brood year would result in 28,290 fish:

Catch Year	Age	Spawning Ground	Broodstock	Wild Harvest	Total
1999	2	0	1	3	**4**
2000	3	175	19	237	**431**
2001	4	5,465	167	9,032	**14,665**
2002	5	3,625	133	9,433	**13,190**
2003	6	0	0	0	**0**
Total:		**9,265**	**320**	**18,705**	**28,290**

Table 26 presents a comparison of the number of natural-origin recruits with no harvest and with harvest estimated from PSC and hatchery indicator stock harvest rates.

Overall, estimates of harvest on summer Chinook using the hatchery indicator stock and PSC harvest rates were fairly similar, with the greatest differences observed with Wenatchee summer Chinook (Table 26; Figure 3). The hatchery indicator stock estimated a consistently higher harvest from 1984 to 1986 in all basins. From 1987 to 2000, both methods provided similar NORs with the most variation noted in the Wenatchee in the late 1980s and in the Methow after 1997 (Table 26; Figure 3). The harvest estimates after 1997 appear to be fairly synchronous, although large differences appear in 2001 for all basins. In the annual report and five year analysis, NORs with harvest have been developed using hatchery indicator stocks.

Table 26. Wenatchee, Methow, and Okanogan summer Chinook natural-origin recruits (NORs) with and without harvest (harvest was estimated using both PSC and hatchery indicator stocks). The natural replacement rate (NRR) is total recruits (NORs) divided by spawning escapement (SE).

Brood Year	Wenatchee							Methow							Okanogan						
	SE	Harvest Not Included		Harvest Included				SE	Harvest Not Included		Harvest Included				SE	Harvest Not Included		Harvest Included			
				PSC		Indicator Stock					PSC		Indicator Stock					PSC		Indicator Stock	
		NORs	NRRs	NORs	NRRs	NORs	NRRs		NORs	NRRs	NORs	NRRs	NORs	NRRs		NORs	NRRs	NORs	NRRs	NORs	NRRs
1981	9,245	8,728	0.94	29,790	3.22	33,061	3.58	924	749	0.81	2,569	2.78	2,837	3.07	916	2,349	2.56	7,970	8.70	8,898	9.71
1982	8,964	11,347	1.27	42,613	4.75	38,464	4.29	739	875	1.18	3,328	4.50	2,966	4.01	475	2,047	4.31	7,295	15.36	6,939	14.61
1983	5,500	11,266	2.05	40,737	7.41	40,819	7.42	328	667	2.03	2,336	7.12	2,417	7.37	504	1,726	3.42	6,212	12.33	6,254	12.41
1984	9,933	12,117	1.22	37,049	3.73	69,638	7.01	792	771	0.97	2,219	2.80	4,431	5.59	2,736	2,195	0.80	6,943	2.54	12,615	4.61
1985	7,664	13,458	1.76	34,718	4.53	57,025	7.44	745	1,479	1.99	3,743	5.02	6,267	8.41	2,223	1,929	0.87	5,358	2.41	8,174	3.68
1986	9,226	10,350	1.12	20,621	2.24	34,046	3.69	724	1,268	1.75	2,594	3.58	4,171	5.76	2,307	1,394	0.60	2,922	1.27	4,586	1.99
1987	13,615	11,883	0.87	21,096	1.55	20,559	1.51	987	857	0.87	1,600	1.62	1,483	1.50	1,635	873	0.53	1,525	0.93	1,510	0.92
1988	9,439	9,832	1.04	18,014	1.91	24,337	2.58	529	475	0.90	804	1.52	1,176	2.22	1,469	749	0.51	1,299	0.88	1,854	1.26
1989	14,331	9,141	0.64	15,749	1.10	21,508	1.50	492	621	1.26	1,160	2.36	1,511	3.07	1,719	2,140	1.24	3,691	2.15	3,567	2.08
1990	10,861	9,463	0.87	13,166	1.21	12,805	1.18	1,421	933	0.66	1,214	0.85	1,285	0.90	837	1,477	1.76	2,045	2.44	2,057	2.46
1991	10,168	5,556	0.55	8,587	0.84	17,148	1.69	566	276	0.49	449	0.79	413	0.73	574	884	1.54	1,221	2.13	1,026	1.79
1992	11,652	5,875	0.50	8,537	0.73	8,465	0.73	460	599	1.30	877	1.91	773	1.68	473	1,069	2.26	1,547	3.27	1,350	2.85
1993	9,450	5,025	0.53	6,605	0.70	8,575	0.91	508	420	0.83	578	1.14	685	1.35	1,485	474	0.32	713	0.48	637	0.43
1994	10,154	3,877	0.38	6,271	0.62	6,125	0.60	1,085	521	0.48	810	0.75	710	0.65	4,033	1,397	0.35	2,196	0.54	1,911	0.47
1995	7,755	5,220	0.67	10,586	1.37	8,273	1.07	1,214	1,150	0.95	2,231	1.84	1,732	1.43	3,002	1,357	0.45	2,809	0.94	1,795	0.60
1996	6,168	4,354	0.71	10,700	1.73	6,803	1.10	615	420	0.68	1,014	1.65	518	0.84	1,819	728	0.40	1,803	0.99	868	0.48
1997	5,913	9,585	1.62	28,290	4.78	16,875	2.85	697	1,448	2.08	4,350	6.24	2,351	3.37	2,189	4,418	2.02	12,150	5.55	7,103	3.24
1998	5,352	15,514	2.90	54,575	10.20	52,412	9.79	675	3,203	4.75	10,689	15.84	7,102	10.52	1,092	4,145	3.80	14,389	13.18	11,113	10.18
1999	5,476	11,854	2.16	41,157	7.52	47,040	8.59	986	2,828	2.87	10,112	10.26	5,189	5.26	3,617	6,680	1.85	22,898	6.33	22,341	6.18
2000	5,512	3,981	0.72	10,267	1.86	17,086	3.10	1,200	813	0.68	1,837	1.53	2,441	2.03	3,701	1,729	0.47	4,541	1.23	5,271	1.42
2001	11,360	19,058	1.68	37,438	3.30	72,464	6.38	2,768	2,857	1.03	5,788	2.09	8,658	3.13	10,857	8,993	0.83	18,966	1.75	35,972	3.31
2002	15,723	4,911	0.31	8,611	0.55	12,339	0.78	4,630	1,073	0.23	2,271	0.49	2,900	0.63	13,857	6,043	0.44	10,752	0.78	16,245	1.17
2003	11,800	1,940	0.16	3,524	0.30	4,227	0.36	3,930	397	0.10	682	0.17	717	0.18	3,420	558	0.16	1,045	0.31	1,187	0.35
Total	**215,261**	**204,335**	**1.07**	**508,701**	**2.88**	**630,094**	**3.40**	**27,015**	**24,700**	**1.26**	**63,255**	**3.34**	**62,733**	**3.20**	**64,940**	**55,354**	**1.37**	**140,290**	**3.76**	**163,273**	**3.75**

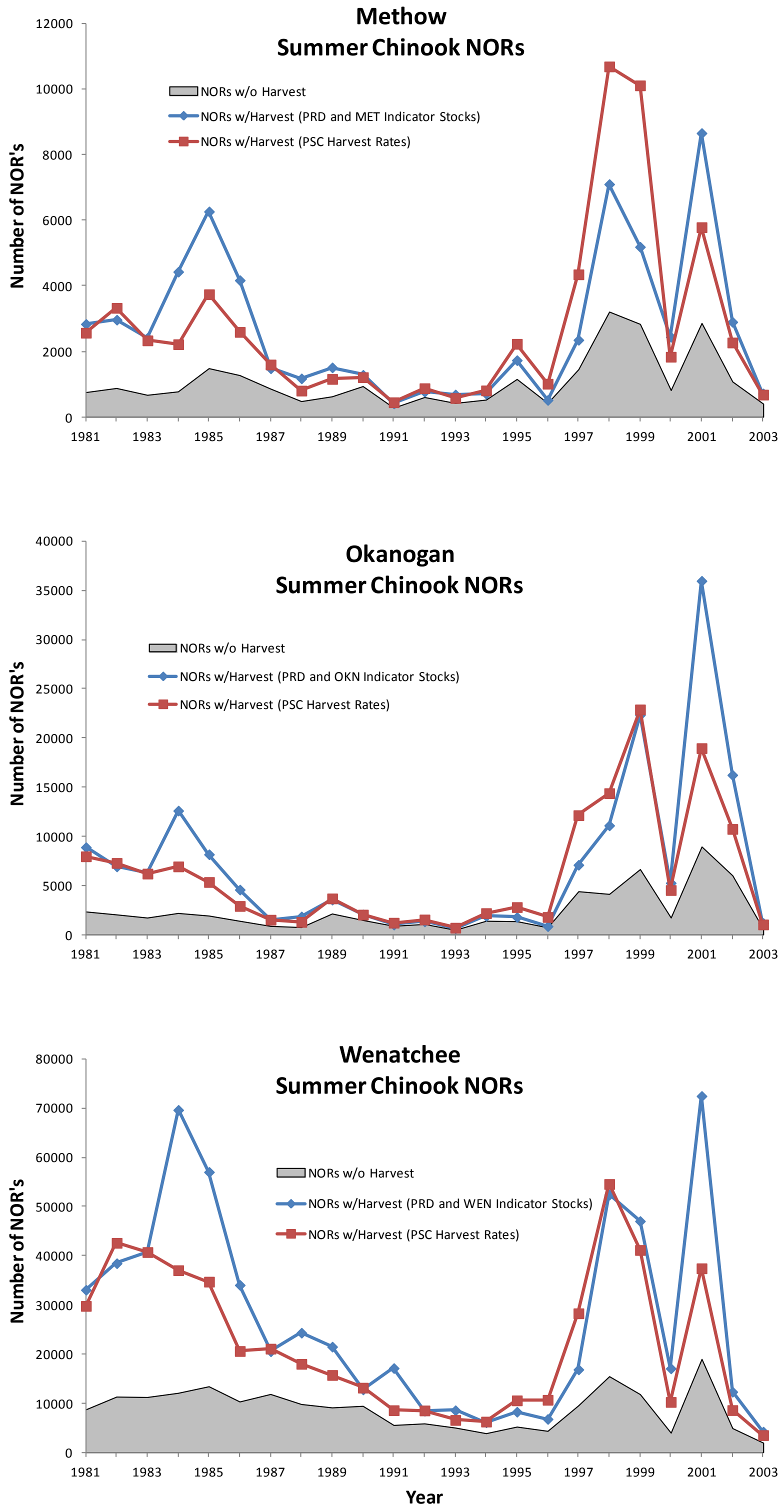

Figure 3. Summer Chinook natural-origin recruits (NORs) with and without harvest adjustments. Harvest adjustments were based on hatchery indicator stocks and Pacific Salmon Commission estimates.

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Appendix C

METHODS FOR IDENTIFYING REFERENCE POPULATIONS AND TESTING DIFFERENCES IN ABUNDANCE AND PRODUCTIVITY BETWEEN REFERENCE POPULATIONS AND SUPPLEMENTED POPULATIONS:
CHIWAWA SPRING CHINOOK CASE STUDY

Methods for Identifying Reference Populations and Testing Differences in Abundance and Productivity between Reference Populations and Supplemented Populations: Chiwawa Spring Chinook Case Study

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An important goal of supplementation is to increase spawning abundance and natural-origin recruitment of the supplemented population, and not reduce the productivity of the supplemented population. Indeed, a successful supplementation program must increase spawning abundance and natural-origin recruitment to levels above those that would have occurred without supplementation. There are several methods that can be used to test the effects of supplementation programs on these population metrics. One important method is to compare the performance of population metrics (e.g., spawning abundance, natural-origin recruitment, and productivity) in the supplemented population to those in un-supplemented (reference) populations. By comparing supplemented populations to reference populations, one can determine if the supplementation programs benefit, harm, or have no effect on the supplemented populations. These comparisons, however, are only valid if the performance of the reference populations is similar to the performance of the supplemented population prior to the period of supplementation. If the performance of the two populations differs significantly before any supplementation occurs, then any results from comparing the two populations after supplementation will be suspect. It is therefore important to select reference populations that are as similar as possible to the supplemented populations.

One of the goals of the Conceptual Approach to Monitoring and Evaluating the Chelan County PUD Hatchery Programs (Murdoch and Peven 2005) is to use reference populations to analyze the potential effects of hatchery supplementation programs on natural-origin salmon and steelhead spawner abundance and productivity[1]. Murdoch and Peven (2005) identified specific objectives to evaluate the performance of the program. For example, Objective 1 determines if the supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population (supplemented population) relative to a reference population. Objective 7 determines if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (e.g., number of juveniles per redd) of supplemented streams when compared to reference streams. The relevant questions tested under each objective are as follows (Hays et al. 2006):

[1] Productivity is defined as adult recruits per spawner, where recruits are the number of adults produced from a given brood year (i.e., spawners plus adults harvested).

Objective 1:

- Is the annual change in the number of natural-origin recruits produced from the supplemented populations greater than or equal to the annual change in natural-origin recruits in an un-supplemented population?
- Is the change in natural replacement rates within the supplemented population greater than or equal to the change in natural replacement rates in an un-supplemented population?

Objective 7:

- Is the change in numbers of juveniles (smolts, parr, or emigrants) per redd in the supplemented population greater than or equal to that in an un-supplemented population? [2]

In this paper, we describe methods used to identify suitable reference streams and statistical techniques that can be used to compare reference populations with supplemented populations. Although we apply the methods described in this paper to Chiwawa spring Chinook salmon (hereafter referred to as Chinook), the methods should also apply to steelhead and other supplemented salmon stocks in the Upper Columbia Basin.

Identification of Reference Populations

Reference populations are an important component of an effectiveness monitoring design because they provide the standard by which treatment conditions are compared (ISRP and ISAB 2005; Murdoch and Peven 2005; Galbreath et al. 2008). Selecting appropriate reference areas and maintaining them over long periods of time is needed to establish the effectiveness of supplementation programs.

We developed a three-step process for identifying suitable reference populations (Figure 1). Each step serves as a filter. That is, potential reference populations are evaluated based on specific criteria under each step. Populations that pass through each step are considered suitable reference populations for a specific supplemented population.

[2] In this paper we only address adult recruits, not juvenile recruits. This is because we were unable to find suitable reference populations for analysis of juveniles. However, the methods described in this paper would also apply to juveniles.

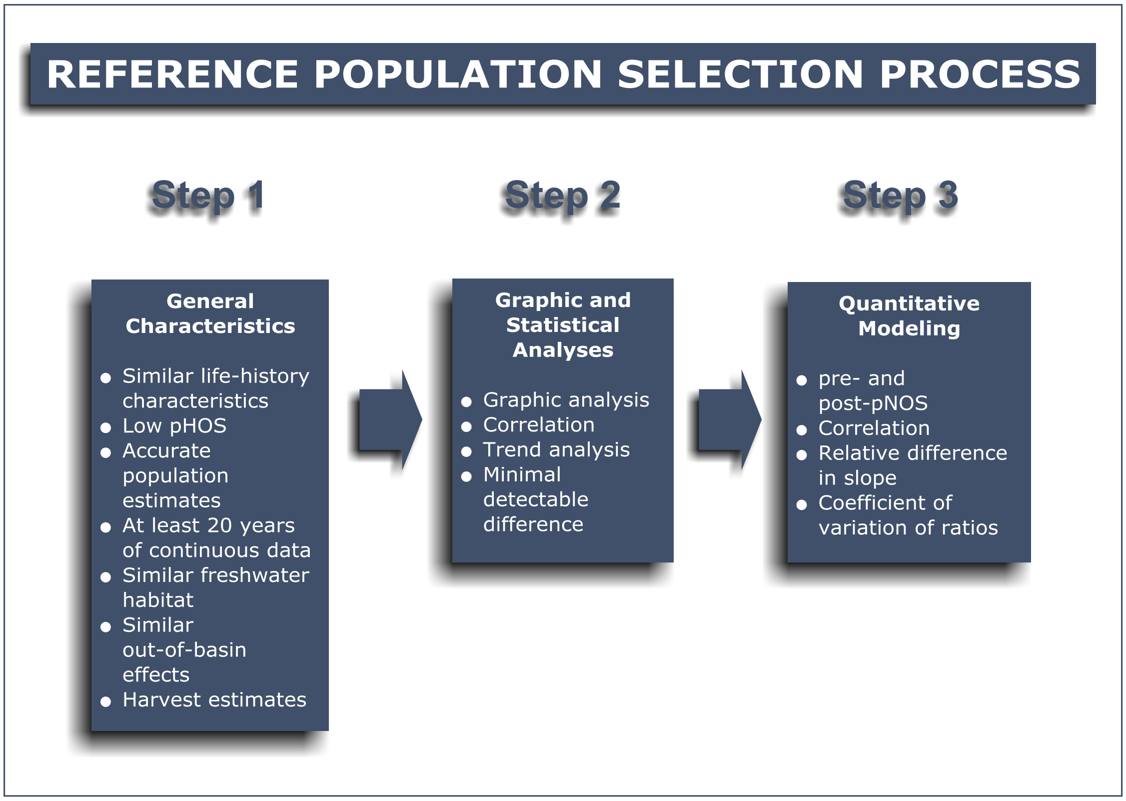

Figure 1. Criteria evaluated during each step in the process of identifying suitable reference populations.

Step 1: General Characteristics

Under step 1, potential reference populations are evaluated based on several general criteria. When compared to the supplemented population, potential reference populations should have:

- Similar life-history characteristics (e.g., run timing, migration characteristics, etc.).
- No or few hatchery fish in the reference area (proportion of hatchery-origin spawners [pHOS] < 10%).
- Accurate abundance estimates.
- Long time series of natural-origin abundance and productivity estimates (at least 20 years of continuous data).
- Similar trends in freshwater habitat.
- Similar out-of-basin effects (i.e., similar migration and ocean survivals).
- Harvest estimates for adjusting escapement estimates.

We used these criteria to begin the process of selecting suitable reference populations for the Chiwawa spring Chinook program. We began by identifying stream-type Chinook populations within the Columbia Basin. Galbreath et al. (2008; their Table 1) identified stream-type Chinook populations within the Columbia River Basin that may serve as suitable reference populations for hatchery programs. Supplementing their work with data from the NOAA Fisheries Salmon Population Summary Database, we identified 24 candidate stream-type Chinook populations that may serve as reference populations for the Chiwawa supplementation program (Table 1).

Table 1. Populations of stream-type Chinook salmon and their comparison to Chiwawa spring Chinook.

Population	Similar life-history	No or few hatchery fish	Accurate abundance estimates	Long time series (at least 20 years)	Similar freshwater habitat impairments	Similar out-of-basin effects	Comments
Deschutes River	Yes	Yes	Yes	Yes	No	No	
John Day mainstem	Yes	Yes	Yes	Yes	No	No	
Middle Fk John Day	Yes	Yes	Yes	Yes	No	No	
North Fk John Day	Yes	Yes	Yes	Yes	No	No	
Granite Creek	Yes	Yes	Yes	Yes	No	No	
Wenaha River	Yes	No	Yes	Yes	Yes	No	Hatchery strays (>10%)
Minam River	Yes	No	Yes	Yes	Yes	No	Hatchery strays (>10%)
Slate Creek	Yes	Yes	Yes	No	No	No	
Secesh River	Yes	Yes	Yes	Yes	Yes	No	
Middle Fk Salmon River	Yes	Yes	Yes	No	No	No	Fair productivity est.
Big Creek	Yes	Yes	Yes	Yes	No	No	
Camas Creek	Yes	Yes	Yes	Yes	No	No	Fair productivity est.
Loon Creek	Yes	Yes	Yes	Yes	No	No	Fair productivity est.
Sulphur Creek	Yes	Yes	Yes	Yes	No	No	
Bear Valley Creek	Yes	Yes	Yes	Yes	No	No	
Marsh Creek	Yes	Yes	Yes	Yes	Yes	No	
North Fk Salmon River	Yes	Yes	No	No	Yes	No	
Lemhi River	Yes	Yes	Yes	Yes	No	No	
East Fk Salmon River	Yes	No	Yes	Yes	No	No	Hatchery strays (>10%)
Valley Creek	Yes	No	Yes	Yes	No	No	Hatchery strays (>10%)
Chamberlain Creek	Yes	Yes	Yes	No	Yes	No	
Naches River	Yes	Yes	Yes	Yes	Yes	No	
Little Wenatchee River	Yes	No	Yes	Yes	Yes	Yes	Hatchery strays (>10%)
Entiat River	Yes	No	Yes	Yes	No	No	Hatchery release ending

We then assessed the accuracy and length of the series of abundance estimates. We assumed that abundance estimates generated from expanded redd counts or adjusted weir counts would compare well with estimates in the Chiwawa Basin, which were based on expanded redd counts. In addition, we looked for populations that had an abundance data series that extended from at least 1981 to present and had few hatchery-origin spawners (pHOS < 10%). Based on this analysis, we identified 14 populations with abundance estimates that could be compared to those from the Chiwawa Basin (Table 1).

Next, we determined if the potential reference populations came from watersheds with habitat conditions similar to those in the Chiwawa Basin. For this exercise, we searched recovery plans and draft recovery plans to identify tributary factors that limit Chinook abundance, productivity, and survival within the reference populations. We compared these factors with those limiting Chinook salmon in the Chiwawa Basin. Based on this analysis, we identified eight populations with habitat impairments similar to those in the Chiwawa Basin (Table 1).

Finally, we examined the potential reference populations to see if they experienced out-of-basin effects similar to spring Chinook from the Chiwawa Basin. In this case, we compared the number of mainstem dams that each potential reference population passes during migration. Six of the potential reference populations pass less than six mainstem dams; the other populations pass eight mainstem dams (Table 1). Only the Little Wenatchee population passes seven dams, similar to the Chiwawa population.

In sum, there were no reference populations that matched the Chiwawa spring Chinook population on all the criteria identified above. Differential out-of-basin effects and freshwater habitat conditions prevented most reference populations from matching with Chiwawa spring Chinook. However, some of the potential reference populations were similar to the Chiwawa population on several criteria and warranted further investigation. We selected the following populations for further investigation: Sesech River, Marsh Creek, Naches River, Little Wenatchee, and Entiat River.

We included the Little Wenatchee because it is within the Wenatchee River basin and experiences similar out-of-basin effects and has the same climatic and environmental conditions as the Chiwawa. A confounding effect with the Little Wenatchee is that Chiwawa hatchery fish have strayed into the Little Wenatchee. However, straying of Chiwawa hatchery fish should decrease with the change in source water to the Chiwawa acclimation ponds in 2006. We also included the Entiat River because it is an adjacent basin to the Chiwawa and experiences similar climatic and environmental conditions. The spring Chinook hatchery program that has operated in the Entiat since 1975 has been discontinued. Therefore, this population offers a unique opportunity to compare the Chiwawa population to a population in which the hatchery program has been discontinued.

Step 2: Graphic and Statistical Analysis

Graphic Analysis

Although we were unable to find potential reference populations that matched with the Chiwawa population on all criteria considered under Step 1, spawner abundance, natural-origin recruits (NORs), and productivity of some of the potential reference populations may nevertheless track closely with the Chiwawa population. If the time series of abundance, NORs, and productivity of a potential reference population tracks closely with the abundance, NORs, and productivity of the Chiwawa population, the reference population may provide a reasonable reference condition for testing the effects of supplementation on the Chiwawa population.

Under Step 2, we used graphing techniques to examine the relationship of abundance, NORs, and productivity between the Chiwawa population and the five potential reference populations (Sesech River, Marsh Creek, Naches River, Little Wenatchee, and Entiat River). We compiled spawner abundance, NORs, and productivity data from local biologists and the NOAA Fisheries Salmon Population Summary Database. We then compared time series plots of spawner abundance, NORs, and productivity data of potential reference populations with the Chiwawa population (Figures 2, 3, and 4; plots on the left side of figures). The time series only included the period 1981 to 1992, which represented the period before supplementation of the Chiwawa population (pre-treatment period). We also plotted the relationship between the abundance, NORs, and productivity of each potential reference population to the Chiwawa population (Figures 2, 3, and 4; plots on right side of figures). These plots show whether the reference populations closely tracked the Chiwawa population. As a point of reference, data points that fall along the dashed line would represent a perfect relationship between the two populations (i.e., both populations have identical abundance, NORs, and productivity estimates). While a perfect relationship between two independent populations is unrealistic, a linear relationship between the two populations indicates that the populations tend to track each other.

Based on analysis of spawner abundance, the Naches River time series tracked more closely with the abundance of Chiwawa spring Chinook than did the other potential reference populations. The poor relationship with the other potential reference streams was largely because of the relatively high abundance of Chiwawa spring Chinook during the mid-1980s. As with spawner abundance, analyses of NORs indicated a close relationship between the Naches and Chiwawa populations. The other potential reference populations tracked poorly with the Chiwawa. The analyses of productivity indicated close relationships between potential reference populations and the Chiwawa population. The Naches, Sesech, and Little Wenatchee populations tracked the closest with the Chiwawa population.

When analyzing the potential effects of a supplementation program on fish performance, it is common to transform the data to meet various assumptions of statistical analysis. The most common transformation used to adjust abundance, NORs, and productivity data is the natural logarithm (LN or $\log_e$). We therefore transformed the spawner abundance, NORs, and productivity data using LN and re-plotted the relationships between the potential reference populations and the Chiwawa population (Figures 5, 6, and 7). We added 1 to each observation before taking its logarithm to avoid taking the logarithm of 0, which is undefined (note that the LN of 1 is 0).

By transforming spawner abundance, NORs, and productivity data, most of the potential reference populations tracked more closely with the Chiwawa population. The Naches, Entiat, and Little Wenatchee abundance data tracked the closest with the Chiwawa abundance data (Figure 5). For NORs, Marsh Creek and the Little Wenatchee populations tracked the closest with the Chiwawa (Figure 6). For productivity, the Naches, Sesech, and Little Wenatchee tracked the closest with the Chiwawa (Figure 7).

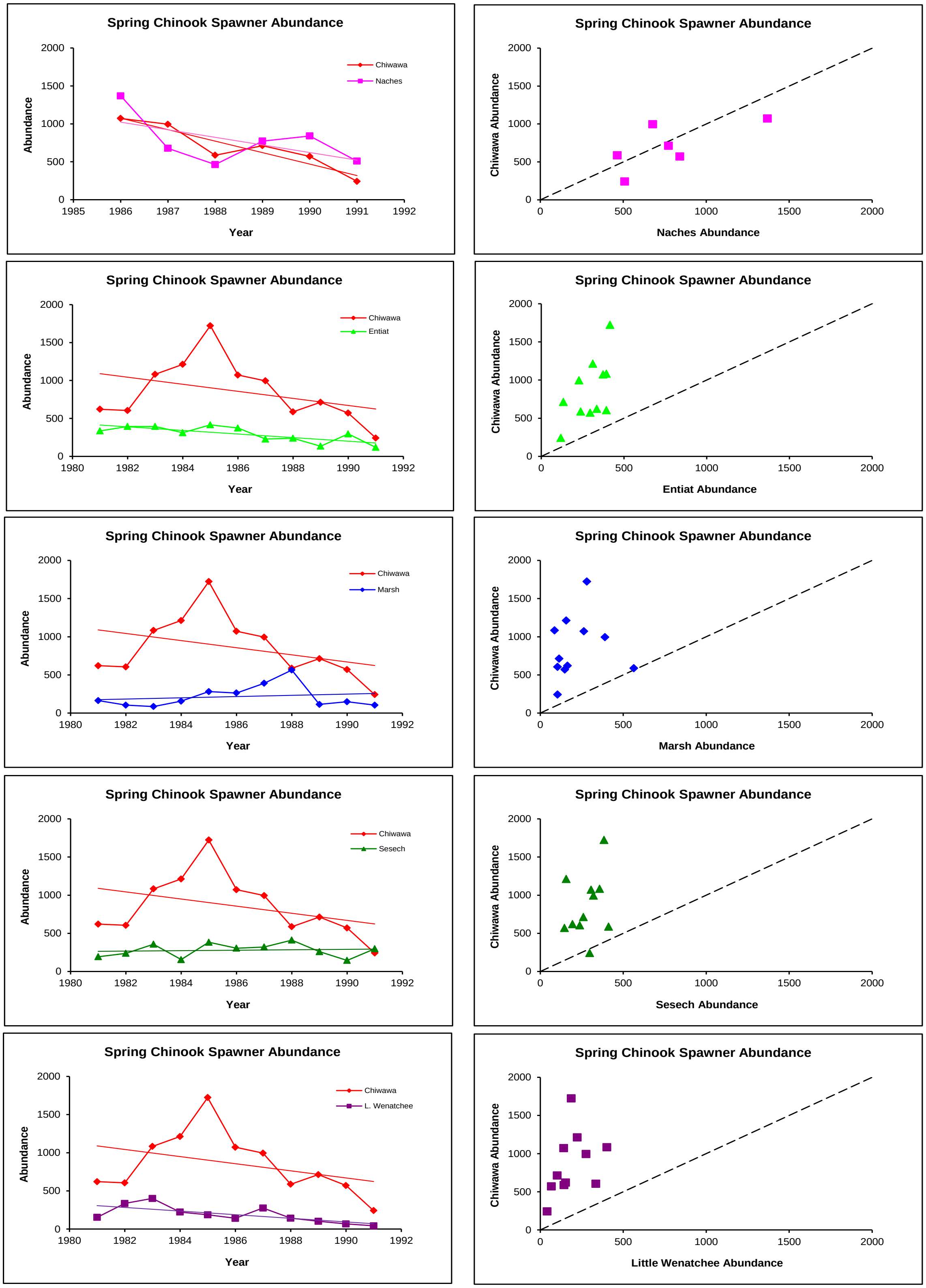

Figure 2. Time series of spawner abundance of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

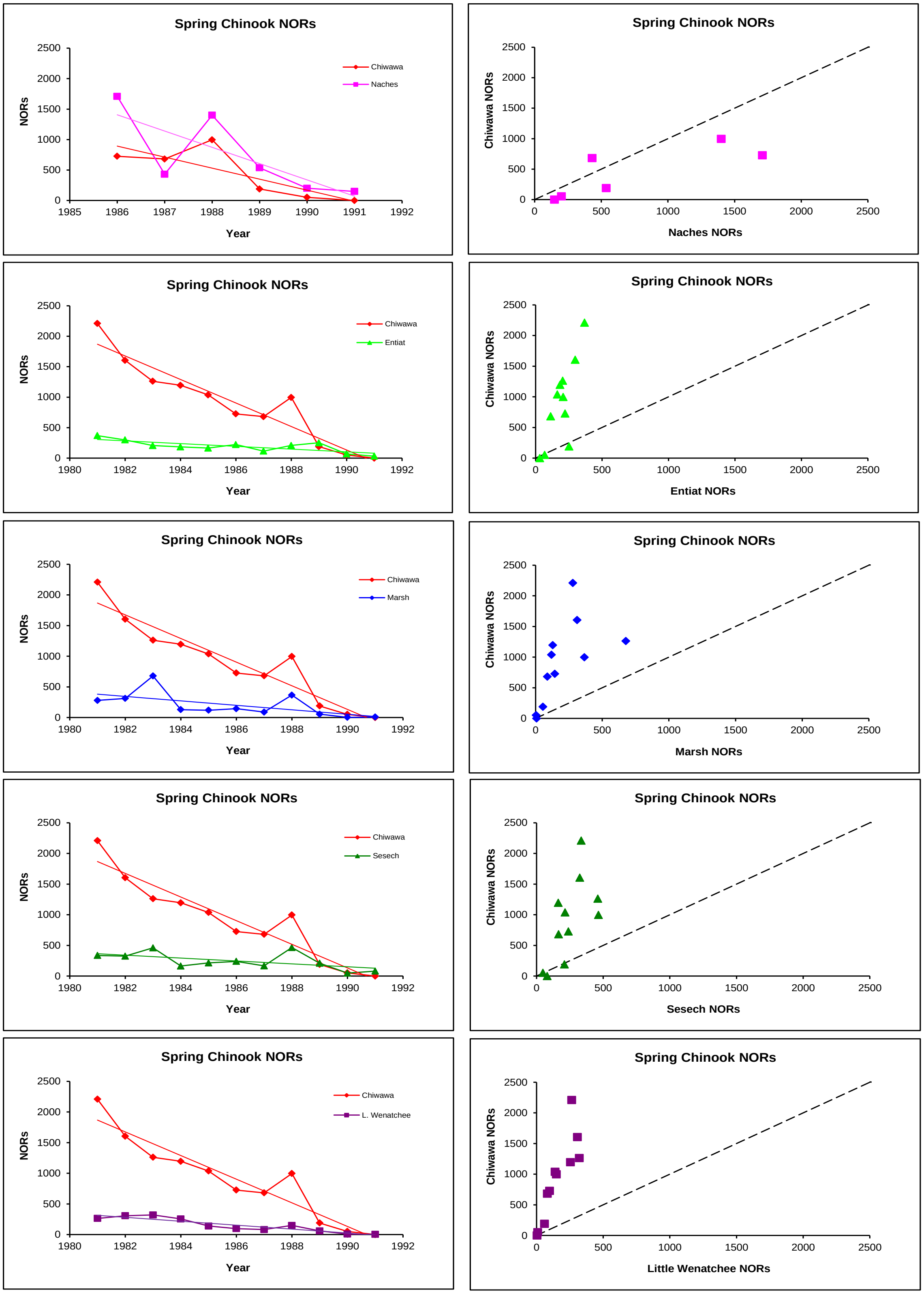

Figure 3. Time series of natural-origin recruits (NORs) of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

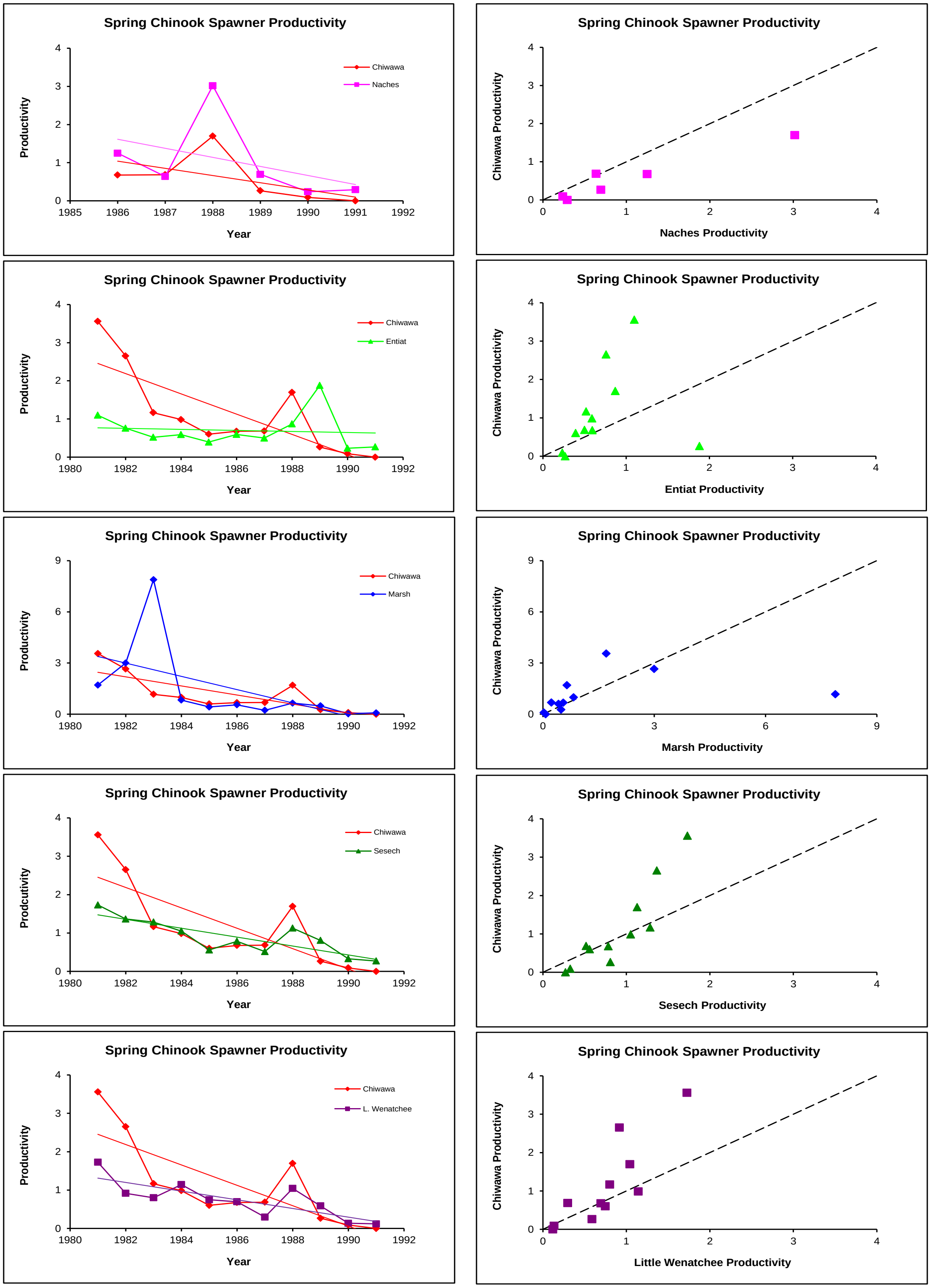

Figure 4. Time series of adult productivity of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

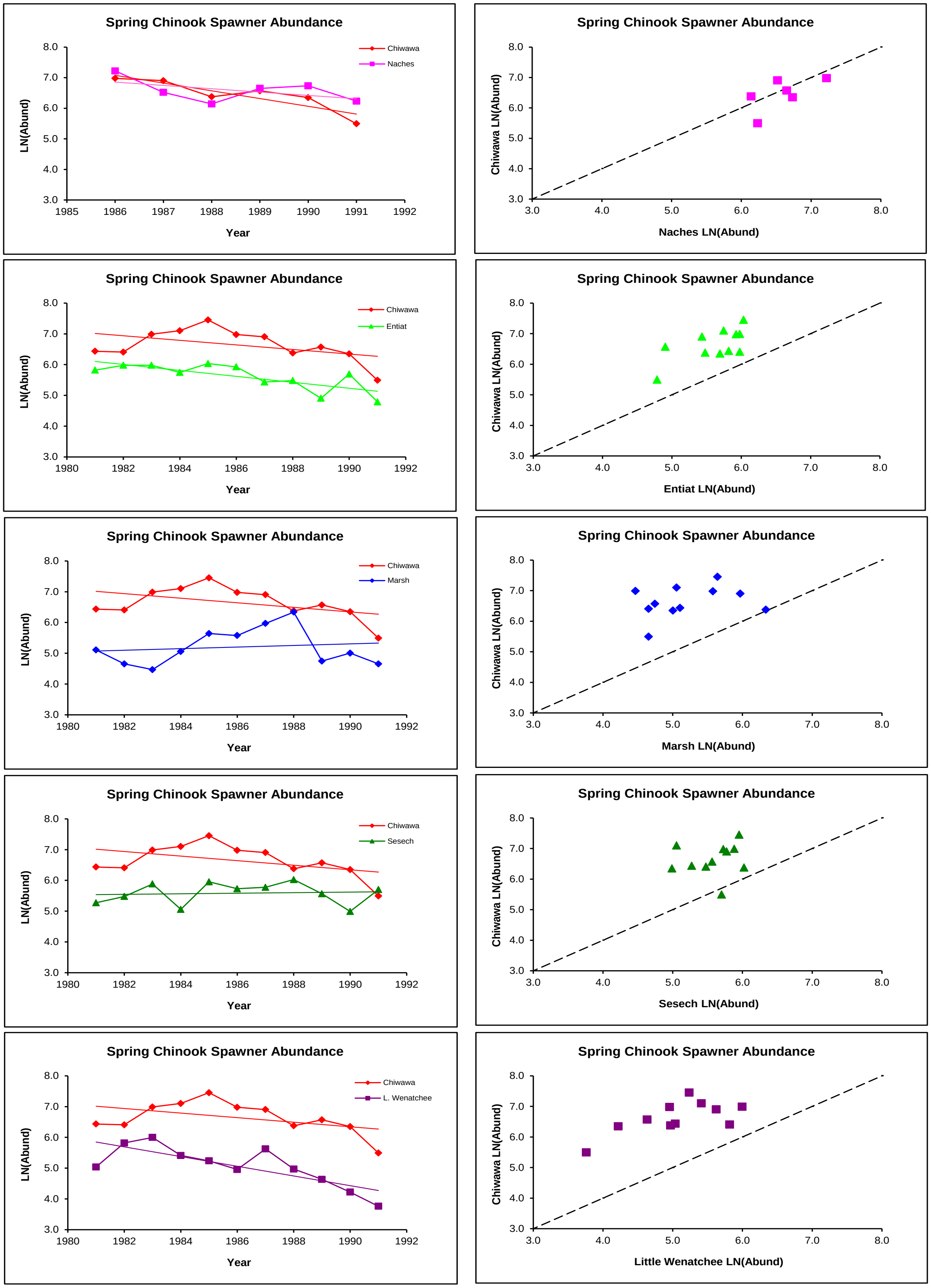

Figure 5. Time series of natural log spawner abundance of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

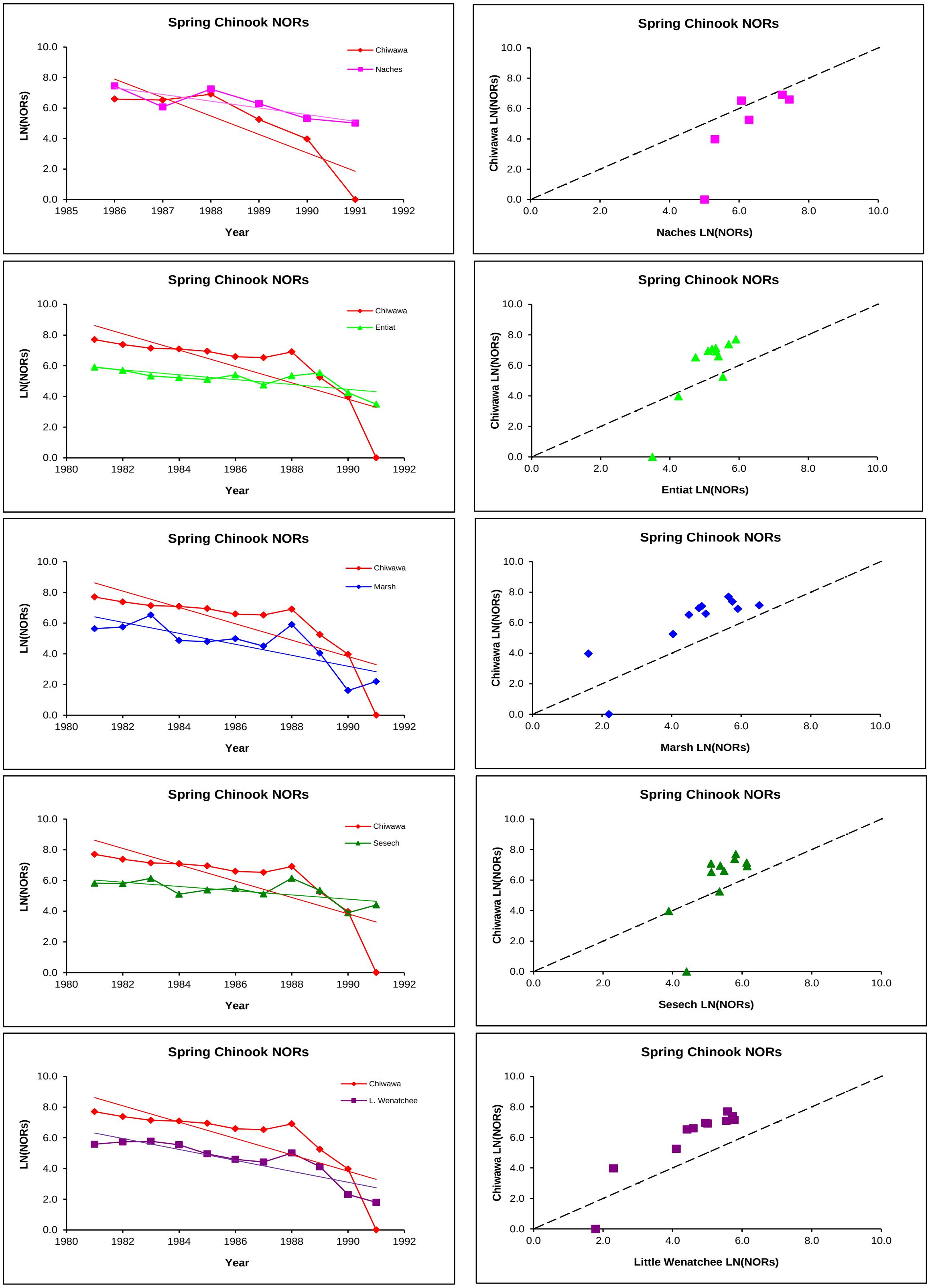

Figure 6. Time series of natural log natural-origin recruits (NORs) of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

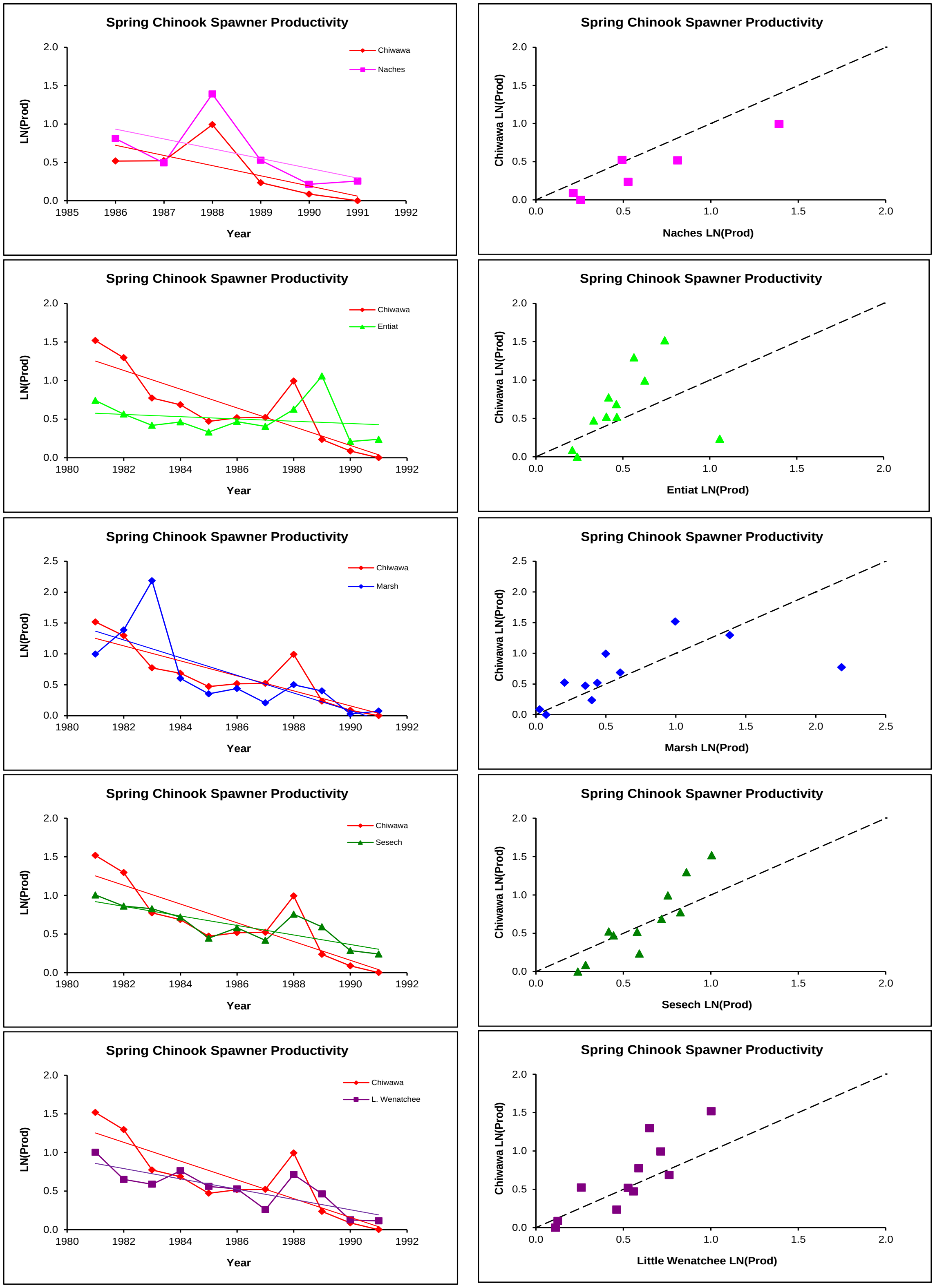

Figure 7. Time series of natural log adult productivity of potential reference populations and the Chiwawa spring Chinook population before the Chiwawa population was supplemented with hatchery fish.

Correlations and Trends

Other methods for evaluating the suitability of potential reference populations under Step 2 include correlation and trend analyses. For correlation analysis, we simply calculated the Pearson correlation coefficient, which is an index of the strength of the association between the potential reference populations and the Chiwawa population. The coefficient ranges from -1 to 1, where a value near 1 or -1 represents that strongest association between the populations. A value of 0 means no association. We used only spawner abundance, NORs, and productivity data during the pre-treatment period (1981-1992). We assumed that populations with coefficients greater than 0.6 represented reasonable reference conditions (i.e., when the coefficient is greater than 0.6, the presence of an association is readily apparent; Sokal and Rohlf 1995).

For trend analyses, we used least squares techniques to compute a straight-line trend through the spawner abundance and productivity data for the potential reference populations and the Chiwawa population. Trends were fit to the pre-treatment time series data (1981-1992). We then used t-tests to determine if the slopes of the trends between potential reference populations and the Chiwawa population differed significantly.

It is important to note that time-series trend analyses are susceptible to temporal correlations in the data. Autoregressive integrated moving average (ARIMA) models can be used to describe the correlation structure in temporal data (Gotelli and Ellison 2004). However, these models require a long time series ($N > 40$) and therefore we could not use them to model the spring Chinook data. As such, we were unable to correct for any temporal correlation that may exist within the time series.

Tests of correlation with spawner abundance data indicated that the Naches River closely correlated with the Chiwawa population (Table 2). There was no difference in abundance trends between the potential reference populations and the Chiwawa population (Table 2; Figure 2). For NORs, all potential reference populations correlated with the Chiwawa population (Table 2). However, trends in NORs of all reference populations, except Naches, differed significantly from the Chiwawa population (Table 2; Figure 3). For productivity, the Naches, Sesech, and Little Wenatchee correlated with the Chiwawa population (Table 2). Only the Entiat productivity trend differed significantly from the Chiwawa population trend (Table 2; Figure 4).

Table 2. Pearson correlation coefficients and t-test results comparing slopes of trends between potential reference populations and the Chiwawa spring Chinook population; d.f. = degrees of freedom and for correlation coefficients, an asterisk (*) indicates significance at $P < 0.05$.

Reference populations	Pearson correlation coefficient	t-test on slopes		
		t-value	d.f.	P-value
Spawner Abundance Data				
Naches	0.684*	-0.659	8	0.528
Entiat	0.598*	-0.596	18	0.559
Marsh	0.147	-1.341	18	0.197
Sesech	0.274	-1.265	18	0.222
Little Wenatchee	0.399	-0.591	18	0.562

Reference populations	Pearson correlation coefficient	t-test on slopes		
		t-value	d.f.	P-value
Natural-Origin Recruits				
Naches	0.803*	0.666	8	0.524
Entiat	0.795*	-7.495	18	0.000
Marsh	0.605*	-5.786	18	0.000
Sesech	0.648*	-6.874	18	0.000
Little Wenatchee	0.880*	-7.206	18	0.000
Productivity Data				
Naches	0.960*	0.169	8	0.870
Entiat	0.272	-3.057	18	0.007
Marsh	0.320	0.605	18	0.553
Sesech	0.903*	-2.059	18	0.054
Little Wenatchee	0.848*	-2.065	18	0.054

We also ran correlation and trend analyses on natural-log transformed spawner abundance, NORs, and productivity data. These analyses indicated that the Naches, Entiat, and Little Wenatchee abundance data correlated with the Chiwawa population data (Table 3). None of the abundance trends of the potential reference populations differed significantly from the Chiwawa population trend (Table 3; Figure 5). For NORs, all potential reference populations correlated with the Chiwawa population (Table 3). Only trends in NORs of the Entiat and Sesech differed significantly from the Chiwawa population (Table 2; Figure 6). For productivity, the Naches, Marsh, Sesech, and Little Wenatchee correlated with the Chiwawa population data (Table 3). Only the Entiat productivity trend differed significantly from the Chiwawa population trend (Table 3; Figure 7).

Table 3. Pearson correlation coefficients and t-test results comparing slopes of trends between potential reference populations and the Chiwawa spring Chinook population; d.f. = degrees of freedom and for correlation coefficients, an asterisk (*) indicates significance at $P < 0.05$. Analyses were conducted on natural-log transformed abundance and productivity data.

Reference populations	Pearson correlation coefficient	t-test on slopes		
		t-value	d.f.	P-value
LN Spawner Abundance Data				
Naches	0.642*	-1.323	8	0.222
Entiat	0.652*	0.412	18	0.685
Marsh	0.294	-1.324	18	0.202
Sesech	0.149	-1.431	18	0.170
Little Wenatchee	0.670*	1.325	18	0.202
LN Natural-Origin Recruits				
Naches	0.824*	-1.985	8	0.082

Reference populations	Pearson correlation coefficient	t-test on slopes		
		t-value	d.f.	P-value
Entiat	0.886*	-2.563	18	0.019
Marsh	0.830*	-1.038	18	0.313
Sesech	0.730*	-2.664	18	0.016
Little Wenatchee	0.927*	-1.150	18	0.265
LN Productivity Data				
Naches	0.944*	-0.042	8	0.968
Entiat	0.373	-3.043	18	0.007
Marsh	0.610*	0.428	18	0.674
Sesech	0.913*	-2.050	18	0.055
Little Wenatchee	0.862*	-1.811	18	0.087

In summary, based on correlation, trend, and graphic analyses, the Naches, Entiat, and Little Wenatchee populations appear to be reasonable reference populations for comparing spawner abundance data with Chiwawa data. For NORs, the Naches, Marsh, and Little Wenatchee appear to be reasonable reference populations. For productivity, the Naches, Marsh, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for the Chiwawa population.

Minimal Detectable Differences (MDD)

Given a suite of potential reference populations, it is important to conduct power analyses to determine the minimum differences that can be detected when comparing the reference populations to the supplemented population. As a final exercise under Step 2, we examined potential reference populations for the smallest minimal detectable differences. Before conducting power analyses, several decisions needed to be made, including what statistical procedures will be used to analyze the data, the desired level of statistical power (probability of rejecting a false null hypothesis), the size of the type-I error (the probability of rejecting a true null hypothesis of no difference), and the number of samples (i.e., years) included in the analysis. In this case, the number of samples represents the number of treatment (supplementation) years. The number of pre-treatment years (1981-1992) was based on the number of years of quality data available for Chiwawa spring Chinook and potential reference populations.

We designed the study as a modified BACI (Before-After, Control-Impact) design, which includes replication before and after supplementation in both the treated (T) population and the reference (R) populations. A common approach used to analyze data from BACI designs includes analysis of difference scores (Stewart-Oaten et al. 1992; Smith et al. 1993). Differences are calculated between paired treatment and reference population scores (i.e., T-R). Another approach is to calculate ratios (treatment/reference; T/R) for paired treatment and reference population scores (Skalski and Robson 1992). Finally, differences in annual changes in paired treatment and reference population scores can be calculated (i.e., ΔT-ΔR) (Murdoch and Peven 2005; Hays et al. 2006).[3] These derived difference and ratio scores are then analyzed for a before-after treatment effect with a two-sample t-test, Aspin-Welch modification of the t-test, or a randomization test. For power analyses, we calculated minimal detectable differences assuming the use of an independent two-sample t-test with a type-I error rate of 0.05, power of 0.80 (beta or type-II error rate of 0.20), and sample sizes (treatment years) of 5, 10, 15, 20, 25, and 50 years.

The power analysis calculated the minimal detectable difference between mean difference or ratio scores before and during supplementation. We used existing data to calculate variances for the pre-supplementation and supplementation periods. Thus, variances were known and unequal. For both spawner abundance and NORs, the null hypothesis tested was that the mean difference or ratio before supplementation equaled the mean difference or ratio during supplementation. The alternative hypothesis was that the mean difference or ratio before supplementation was less than the mean difference during supplementation (one-tail test; Difference < 0). For productivity, the null hypothesis tested was that the mean difference or ratio before supplementation equaled the mean difference or ratio during supplementation. The alternative hypothesis was that the mean difference or ratio before supplementation was greater than the mean difference during supplementation (one-tail test; Difference > 0).

Based on spawner abundance data, power analysis indicated that the Sesech-Chiwawa pairing consistently produced the smallest detectable differences (Table 4). However, when the abundance data were transformed using natural logs, the Entiat-Chiwawa pairing produced the smallest detectable difference (Table 5). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 334 to 394 adult spawners; transformed data ranged from 0.479 to 1.010. These analyses indicate that the Naches, Entiat, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for comparing spawner abundance data with Chiwawa data. The Marsh Creek population produced some of the largest detectable differences and based on these analyses may not be a reasonable reference population.

Table 4. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on spawner abundance data.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	638	604	560	396	652
	10	464	448	444	354	481
	15	405	395	406	341	424
	20	376	368	387	334	394

[3] The difference of annual difference scores was estimated by first subtracting the population parameter (e.g., spawner abundance) in year 2 from year 1. This continues for all years in the data series for both treatment ($T_{t+1} - T_t$) and reference populations ($R_{t+1} - R_t$). We then calculated differences between paired treatment and reference annual difference scores [$(T_{t+1} - T_t) - (R_{t+1} - R_t) = \Delta T\text{-}\Delta R$].

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
	25	358	352	376	331	376
	50	322	319	354	323	340
T/R	5	0.600	2.084	39.251	1.569	5.498
	10	0.506	1.548	24.729	1.508	3.828
	15	0.478	1.367	19.646	1.490	3.256
	20	0.465	1.275	16.828	1.481	2.954
	25	0.458	1.219	14.974	1.475	2.765
	50	0.447	1.105	10.573	1.465	2.366
ΔT-ΔR	5	1,049	761	717	518	766
	10	750	542	539	411	547
	15	650	467	480	376	473
	20	598	429	450	359	434
	25	567	405	431	348	410
	50	506	355	395	329	361

Table 5. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed spawner abundance data.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	0.975	0.871	2.061	0.828	1.013
	10	0.721	0.613	1.375	0.648	0.722
	15	0.637	0.525	1.138	0.588	0.623
	20	0.595	0.479	1.010	0.559	0.571
	25	0.569	0.450	0.928	0.541	0.539
	50	0.521	0.390	0.749	0.505	0.473
T/R	5	0.157	0.162	2.343	0.160	0.368
	10	0.116	0.115	1.474	0.125	0.247
	15	0.102	0.099	1.170	0.114	0.206
	20	0.095	0.090	1.001	0.108	0.183
	25	0.091	0.085	0.890	0.104	0.169
	50	0.082	0.075	0.625	0.098	0.138
ΔT-ΔR	5	1.261	1.288	3.076	1.160	1.467
	10	0.898	0.900	2.020	0.887	1.001
	15	0.776	0.768	1.653	0.797	0.840
	20	0.713	0.698	1.463	0.751	0.755

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
	25	0.675	0.655	1.325	0.724	0.701
	50	0.600	0.564	1.038	0.670	0.585

Based on NORs, power analysis indicated that the Entiat-Chiwawa, Marsh-Chiwawa, and Little Wenatchee-Chiwawa pairings produced the smallest detectable differences (Table 6). When NORs were transformed using natural logs, the Little Wenatchee-Chiwawa pairing produced the smallest detectable difference (Table 7). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 483 to 640 NORs; transformed data ranged from 0.958 to 2.262. These analyses indicate that the Entiat, Marsh, and Little Wenatchee populations appear to be reasonable reference populations for comparing NORs with Chiwawa data.

Table 6. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-origin recruits.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	1,139	541	573	630	546
	10	809	511	515	550	503
	15	698	502	498	526	489
	20	640	497	489	514	483
	25	604	494	484	507	479
	50	534	489	474	493	472
T/R	5	0.469	2.538	5.196	1.976	6.973
	10	0.451	2.183	4.183	1.894	5.118
	15	0.446	2.072	3.854	1.869	4.492
	20	0.445	2.017	3.691	1.857	4.170
	25	0.444	1.986	3.594	1.850	3.973
	50	0.443	1.924	3.405	1.836	3.572
ΔT-ΔR	5	1,639	500	519	609	531
	10	1,239	386	409	433	396
	15	1,109	348	374	372	351
	20	1,046	329	356	341	328
	25	1,009	318	346	321	314
	50	943	295	325	281	285

Table 7. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed natural-origin recruits.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	2.380	1.646	1.967	2.247	1.174
	10	2.291	1.479	1.505	1.835	1.026
	15	2.270	1.428	1.351	1.702	0.980
	20	2.262	1.403	1.273	1.636	0.958
	25	2.258	1.389	1.227	1.597	0.945
	50	2.253	1.361	1.133	1.522	0.920
T/R	5	0.322	0.332	0.739	0.398	0.356
	10	0.301	0.289	0.581	0.334	0.322
	15	0.296	0.275	0.530	0.314	0.312
	20	0.294	0.269	0.504	0.305	0.307
	25	0.293	0.265	0.488	0.299	0.304
	50	0.291	0.258	0.458	0.288	0.298
ΔT-ΔR	5	2.858	2.400	2.355	3.283	2.109
	10	2.560	1.714	1.881	2.311	1.552
	15	2.485	1.481	1.728	1.979	1.365
	20	2.456	1.360	1.652	1.805	1.269
	25	2.443	1.285	1.607	1.697	1.210
	50	2.430	1.130	1.519	1.471	1.092

Using untransformed productivity data, power analysis indicated that the Little Wenatchee-Chiwawa pairing consistently produced the smallest detectable differences (Table 8). The Marsh-Chiwawa pairings produced the largest detectable differences. When we analyzed natural-log transformed productivity data, the Naches-Chiwawa and Little Wenatchee-Chiwawa pairings produced the smallest detectable differences (Table 9). Minimal detectable differences, based on mean difference scores on untransformed data and a treatment period of 20 years, ranged from 0.754 to 1.839; transformed data ranged from 0.277 to 0.477. These analyses indicate that the Naches, Entiat, Sesech, and Little Wenatchee populations appear to be reasonable reference populations for comparing productivity data with Chiwawa data. The Marsh Creek population produced some of the largest detectable differences and based on these analyses may not be a reasonable reference population.

Table 8. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on productivity data.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	2.181	1.382	2.033	3.517	1.192
	10	1.442	1.119	1.900	2.265	0.901
	15	1.186	1.033	1.859	1.828	0.804
	20	1.047	0.991	1.839	1.588	0.754
	25	0.959	0.966	1.828	1.432	0.724
	50	0.764	0.917	1.806	1.074	0.664
T/R	5	1.364	1.773	0.863	0.876	2.167
	10	1.095	1.359	0.831	0.687	1.587
	15	1.011	1.221	0.822	0.625	1.391
	20	0.971	1.152	0.817	0.594	1.290
	25	0.949	1.110	0.814	0.575	1.228
	50	0.910	1.027	0.908	0.538	1.102
ΔT-ΔR	5	3.298	1.864	3.211	4.420	1.942
	10	2.263	1.382	2.968	2.811	1.291
	15	1.909	1.220	2.894	2.248	1.066
	20	1.723	1.137	2.859	1.938	0.944
	25	1.606	1.087	2.839	1.735	0.866
	50	1.365	0.986	2.800	1.259	0.695

Table 9. Minimal detectable differences between mean difference and ratio scores before and during supplementation. Analyses were conducted on natural-log transformed productivity data.

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
T-R	5	0.540	0.551	0.674	0.890	0.585
	10	0.367	0.452	0.542	0.590	0.413
	15	0.308	0.421	0.499	0.486	0.355
	20	0.277	0.405	0.477	0.430	0.324
	25	0.257	0.396	0.465	0.393	0.305
	50	0.215	0.378	0.440	0.314	0.265
T/R	5	0.915	1.286	0.743	0.697	1.685
	10	0.744	0.973	0.704	0.541	1.227
	15	0.691	0.868	0.692	0.489	1.072
	20	0.666	0.815	0.687	0.463	0.993
	25	0.652	0.783	0.683	0.447	0.943

Response variable	Treatment years	Minimal detectable differences by reference population				
		Naches	Entiat	Marsh	Sesech	Little Wenatchee
	50	0.628	0.719	0.677	0.416	0.843
ΔT-ΔR	5	0.885	0.810	1.028	1.252	0.971
	10	0.631	0.609	0.822	0.809	0.640
	15	0.546	0.542	0.755	0.655	0.525
	20	0.502	0.508	0.722	0.570	0.463
	25	0.475	0.487	0.702	0.516	0.423
	50	0.423	0.446	0.664	0.391	0.333

Step 3: Quantitative Method for Ranking Selection Criteria

Not surprisingly, different selection criteria produced different results (Table 10). Determining whether a given population is or is not a suitable reference population based on selection criteria such as graphic analysis can be subjective. In addition, treating each selection criterion as equally important may not be appropriate. For example, using the information in Table 10, is it appropriate to select a reference population that has two or three "Yes" entries, or should only populations with four "Yes" entries be selected as suitable reference populations? This approach does not allow certain selection criteria to carry more weight in the overall selection process. That is, correlation may be more important than graphic analysis in the overall selection process. In order to reduce subjectivity, we developed a method of scoring and weighting each selection criterion. This method allows a more quantitative process for selecting suitable reference populations.

Table 10. Summary of results from graphic analysis, correlations, trend analysis, and power analysis (minimal detectable differences). "Yes" indicates that the population is a suitable reference population for the Chiwawa population; "No" indicates that it may not be a suitable reference population.

Potential reference populations	Graphic analysis	Correlation	Trends	Minimal detectable differences
Spawner Abundance				
Naches	Yes	Yes	Yes	Yes
Entiat	Yes	Yes	Yes	Yes
Marsh	No	No	Yes	No
Sesech	No	No	Yes	Yes
Little Wenatchee	Yes	Yes	Yes	Yes
Natural-Origin Recruits				
Naches	Yes	Yes	Yes	No
Entiat	No	Yes	No	Yes
Marsh	Yes	Yes	Yes	Yes
Sesech	No	Yes	No	No

Potential reference populations	Graphic analysis	Correlation	Trends	Minimal detectable differences
Little Wenatchee	Yes	Yes	Yes	Yes
Productivity				
Naches	Yes	Yes	Yes	Yes
Entiat	No	No	No	Yes
Marsh	No	Yes	Yes	No
Sesech	Yes	Yes	Yes	Yes
Little Wenatchee	Yes	Yes	Yes	Yes

We developed scoring methods for each of the following five selection criteria:

(1) The proportion of natural-origin spawners (pNOS) in the reference population for the period before supplementation (pre-pNOS);

(2) pNOS in the reference population for the period following supplementation (post-pNOS);

(3) The correlation between the reference and supplemented populations before supplementation;

(4) The relative difference in slopes between the reference and supplemented populations before supplementation; and

(5) The coefficient of variation (CV) of the ratio of supplemented to reference populations before the period of supplementation.

Each selection criteria was scored from 0 to 1, with 0 being the worst possible score and 1 being the best.

The pre- and post-pNOS values were calculated as the average pNOS values before and after supplementation, respectively. Because pNOS values range from 0-1, we did not need to rescale these values. When using reference populations to evaluate the effects of supplementation programs, it is important that the reference populations maintain high values of pNOS throughout the life of the monitoring program. Therefore, we heavily weighted the mean pNOS scores. We assigned weights of 30 and 40 to the mean pre- and post-pNOS scores, respectively. The relatively larger weight for the post-supplementation period is to reduce the likelihood of retaining a reference population that becomes influenced by hatchery fish during the supplementation period.

We assessed the association between the reference and supplemented populations during the pre-supplementation period by calculating the Pearson correlation coefficient, which ranges from -1 to 1. To scale the coefficient between 0 and 1, we took the absolute value of the coefficient. Thus, a coefficient of -0.92 would be reported as 0.92. For our analyses, we were not concerned with the direction of the relationship, only the strength of the relationship. The correlation coefficient was given a weight of 12.5.

As noted earlier, we used least squares to fit a linear trend to each of the reference populations and the supplemented population during the pre-supplementation period. Using the slope estimates for each trend line, we calculated the relative difference in slopes as the slope of the supplemented population minus the slope of the reference population, divided by the slope of the reference population. To scale this value between 0 and 1, we used absolute values, and depending on the direction of the slopes, we subtracted the relative difference from 1. The latter was needed to make sure a larger relative difference value indicated a small difference in slopes between the supplemented and reference populations. The relative difference score was given a weight of 7.5.

Finally, as a means to score effect size, we calculated the CV of the ratio of supplemented to reference population parameters (i.e., T/R). The CV was calculated as the standard deviation of the ratios divided by the absolute value of the mean ratios. The CV was subtracted from 1. This scaled the value from 0 to 1 with larger values representing the best condition. The CV was given a weight of 10, which is greater than the weight for trend, but less than the weight for correlation.

The total score for a reference population was calculated by multiplying the estimated value, which ranged from 0 to 1, by its weight. The sum of the five weighted values provided a total score, which ranged from 0 to 100. Based on several simulations, we set the cut-off score at 81. That is, if the total score for a given reference population equaled or exceeded 81, the population was included as a suitable reference population. If the total score fell below 81, the population was not considered a suitable reference. Based on the distribution of all scores possible, a score of 81 or greater represented only 3% of the total distribution. Thus, a cut-off of 81 is quite conservative.

Under Step 3, we used this method to select the final suite of suitable reference populations. Table 11 shows results from scoring each of the reference populations using the quantitative method. Using the cut-off criterion of 81, only the Naches, Marsh, and Sesech populations would be considered suitable reference populations for the Chiwawa supplementation program. Both the Entiat and Little Wenatchee populations failed to meet the minimum score, largely because of the influence of hatchery fish within those populations (i.e., relatively low pNOS values).

Table 11. Results from scoring potential reference populations using the selection criteria (pNOS, correlation, trend, and effect size). Populations with scores less than 81 were considered unsuitable as reference populations. Populations with scores equal to or greater than 81 were considered suitable references. These results were based on natural-log transformed data.

Potential reference populations	Population metric		
	Abundance	NORs	Productivity
Naches	85	88	91
Entiat	23	21	16
Marsh	79	91	87
Sesech	84	85	88
Little Wenatchee	51	53	49

An important benefit from scoring the different selection criteria is that the total scores can be used to weight the outcome of differing statistical results. For example, analyses may show that when three suitable reference populations are compared to the supplemented population, two of the reference populations may indicate a significant treatment effect, while the third indicates no effect. Under this scenario it is not clear if the supplementation program has or has not affected the abundance or productivity of the supplemented population. If, however, the two reference populations that produced a significant result had higher total scores than the reference population that did not indicate a significant result, one can place more weight on the results from populations with higher total scores.

Conclusions

The purpose of this exercise was to develop a method for selecting suitable reference populations that could be used to assess the effects of supplementation programs on spawner abundance, NORs, and productivity. The selection process included a three-step process (Figure 8). Step 1 identified populations with similar life-history characteristics, few or no hatchery spawners, a long time series of accurate abundance and productivity estimates, and similar freshwater habitat impairments and out-of-basin effects. Populations that met these criteria (or most of these criteria) were then examined for their graphical and statistical relationship with the supplemented population (Step 2). The statistical analysis under Step 2 were converted to a quantitative model (Step 3) that was used to generate a weighted score for pNOS, correlation, trends, and effect sizes for each potential reference population. Reference populations with total scores of 81 or greater were selected as suitable reference populations.

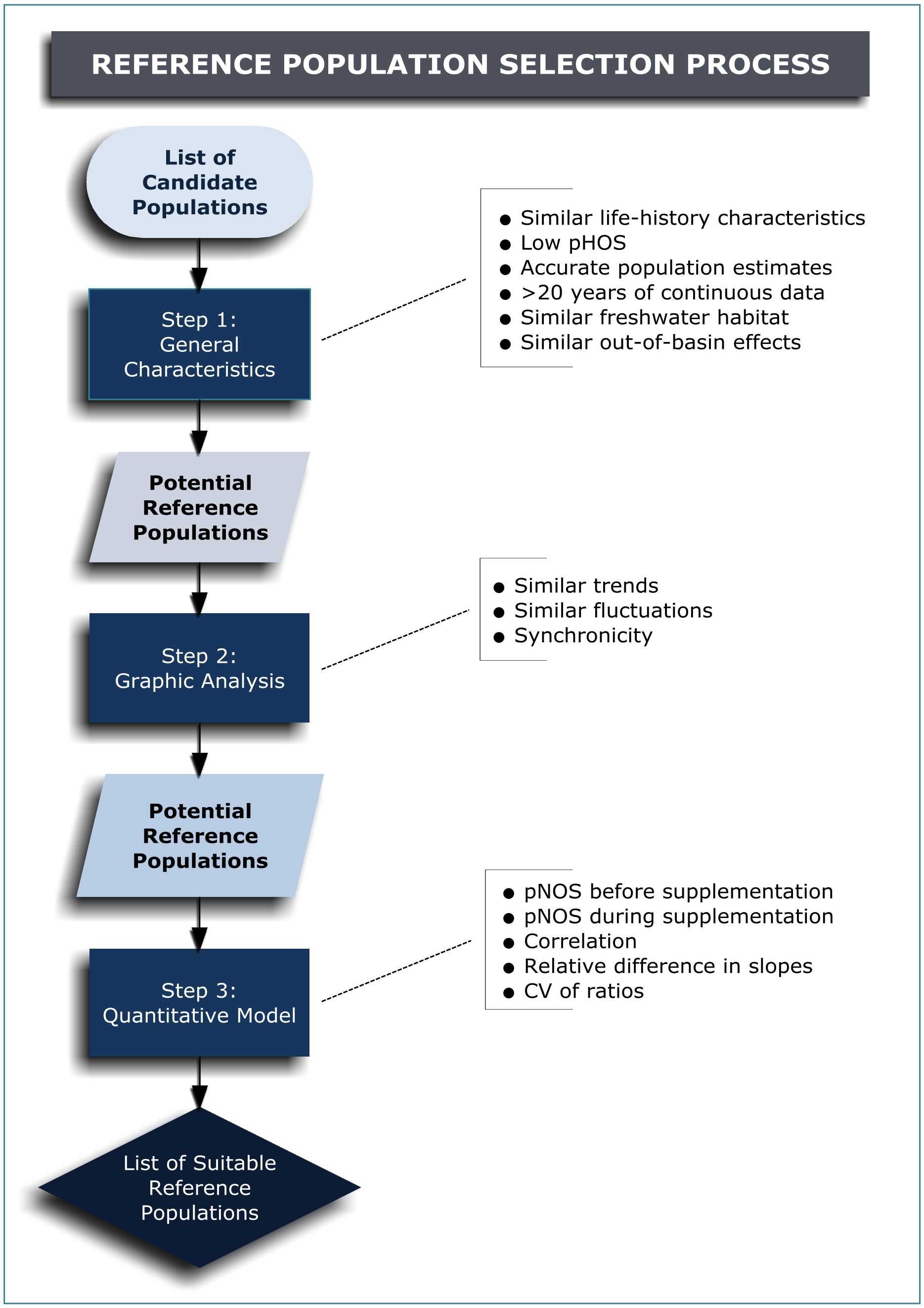

Figure 8. Three-step process for selecting suitable reference populations for supplemented populations.

We used this approach to select suitable reference populations for analyzing the effects of the Chiwawa spring Chinook supplementation program on fish abundance and productivity. The method indicated that the Naches, Marsh, and Sesech populations would serve as suitable reference populations for the Chiwawa spring Chinook supplementation program. Both the Entiat and Little Wenatchee populations failed to meet the minimum score, largely because of the influence of hatchery fish within those populations (i.e., relatively low pNOS values). However, because the presence of hatchery spring Chinook within those populations should decrease, they may serve as unique reference populations in which the comparisons change from all populations receiving hatchery fish to only the Chiwawa population receiving hatchery fish. Therefore, we will continue to include both the Little Wenatchee and Entiat populations in future analyses.

An important assumption in the use of reference populations is that the supplemented and reference populations that tracked each other before supplementation will continue to track each other in the absence of supplementation. Given that the reference populations did not match the Chiwawa population on all criteria examined (Table 1) and some reference populations tracked the Chiwawa population more poorly than others (Figures 2-7; Tables 2-4), there may be some uncertainty as to whether differences observed between the Chiwawa and reference populations during the supplementation period are associated with the hatchery program, "nuisance" factors[4], or a combination of both. In addition, we have no ability to regulate or control activities in reference areas. Any large-scale change (man-made or natural) in reference areas could affect our ability to assess the effectiveness of the supplementation program.

Because we have no ability to maintain reference areas for long periods of time and may not be able to control all activities even within the supplemented populations, we propose the use of a "causal-comparative" approach to strengthen the certainty of our inferences (Pearsons and Temple 2010). The causal-comparative approach relies on correlative data to try and make a case for causal inference.[5] Correlation is used to rule out alternative hypotheses (note that we make our case as much if not more by disproving plausible alternatives as we do by showing that the data are consistent with a hypothesis). For example, large scale land-use activities or natural events can affect stream flows, fine sediment recruitment, and water temperatures. Changes in these factors can affect the freshwater survival and productivity of fish independently of supplementation programs. If changes in habitat, migratory, and ocean conditions do not affect reference and treatment populations similarly, inferences associated with supplementation programs may be confounded. By measuring and tracking these extraneous factors within reference and treatment areas, we can assess the effects of these state variables on population conditions independent of the supplementation programs. This allows us to more effectively assess the influence of supplementation programs on populations.

To that end, we recommend that the following state variables be measured and tracked within the Chiwawa Basin and each of the reference areas: mean annual precipitation, total and riparian forest cover, road density, impervious surface, and alluvium. These variables can be used to describe differences in water temperatures at different life stages (pre-spawning, egg incubation, and summer rearing) and substrate characteristics, including fine sediments and embeddedness (Jorgensen et al. 2009). They can be used to

[4] A "nuisance" factor is any factor that is outside the control of the experimenter and can affect the response variable (spawner abundance or productivity). In this case, nuisance factors may include differences in freshwater habitat trends and conditions, out-of-basin effects (e.g., migration and ocean survival), and hatchery strays that affect the Chiwawa and reference populations differently.

[5] It is important to point out that correlation does not demonstrate cause-and-effect. It only suggests a relationship between variables. Thus, inferences based on correlation lack the certainty that is associated with a design-based approach.

assess possible changes in spawner abundance, NORs, and productivity that are independent of supplementation.

Analyses with Reference Populations

Once suitable reference populations are selected, methods for analyzing the supplemented and reference populations need to be identified. What follows is a description of different analyses that can be used to assess the effects of supplementation programs on spawner abundance, NORs, and productivity using reference populations. Later in this report we describe methods for assessing supplementation effects when reference populations are not available.

We used some of the reference populations selected for the Chiwawa program to illustrate the different methods for evaluating the effects of the supplementation program on spawner abundance, NORs, and productivity. For abundance, we selected the Naches, Entiat, Little Wenatchee, and Sesech populations as suitable references for the Chiwawa population. For NORs, we selected the Naches, Entiat, Marsh, and Little Wenatchee populations as suitable references. For productivity, we selected the Naches, Sesech, Little Wenatchee, and Marsh Creek as suitable references for the Chiwawa. As noted earlier, we included the Little Wenatchee and Entiat populations, even though they did not meet all the criteria for suitable reference populations.

Analysis of Trends

As a first step, we used trend analyses to assess the effects of the Chiwawa supplementation program on spring Chinook spawner abundance, NORs, and productivity. Here, we compared the slopes of the trends between each treatment/reference pair before and during supplementation using t-tests. If the hatchery program is successfully supplementing the natural spring Chinook population, trends in spawner abundance and NORs should deviate significantly (i.e., the slope of the supplemented population should be greater than the slopes of the reference populations during the supplementation period). For productivity, the slope of the supplemented population, relative to the reference population, should increase or remain the same.

Trend analysis indicated that the relationship of slopes of spawner abundance between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 9; Table 12). This was true for both transformed and untransformed abundance data. Before supplementation, spawner abundances trended down in both the Chiwawa and reference populations (Figure 9). During the period of supplementation, abundances in both the Chiwawa and reference populations trended upward. Interestingly, in nearly all treatment/reference comparisons, the Pearson correlation coefficient was greater in the supplementation period than in the pre-supplementation period (Table 12). This was most evident in the transformed abundance data (Figure 9).

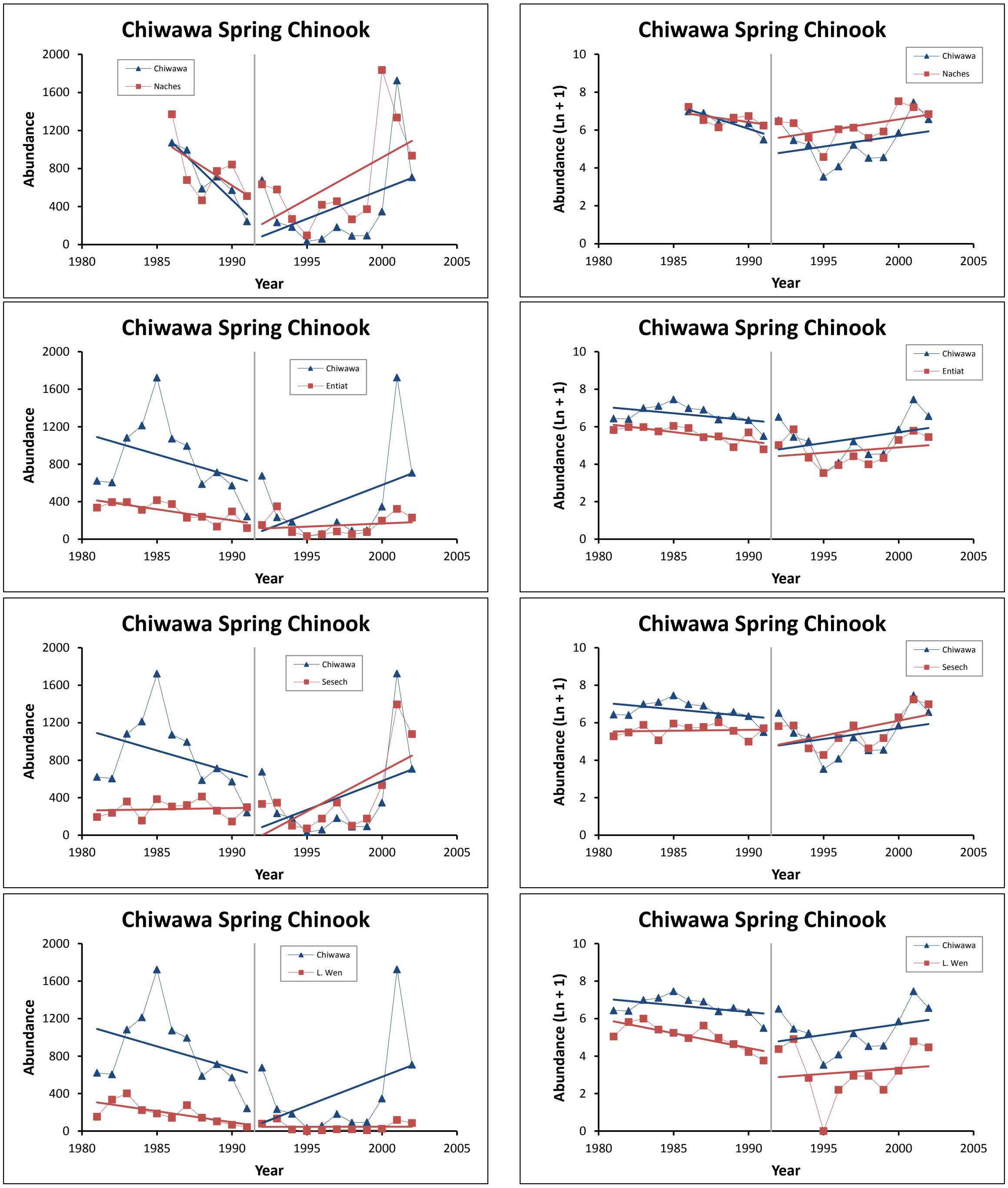

Figure 9. Trends in spring Chinook spawner abundance in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed spawner abundance data; those on the right include natural-log transformed data.

Table 12. Pearson correlation coefficients and t-test results comparing slopes of spawner abundance trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses include both untransformed and natural-log transformed spawner abundance data.

Reference population	Pearson correlation coefficient		Test on slopes			
			t-value		P-value	
	Before	During	Before	During	Before	During
Spawner Abundance						
Naches	0.684*	0.595	-0.659	-0.414	0.528	0.684
Entiat	0.598*	0.672*	-0.596	1.162	0.559	0.260
Sesech	0.274	0.904*	-1.265	-0.418	0.222	0.681
Little Wenatchee	0.399	0.685*	-0.591	1.330	0.562	0.200
LN Spawner Abundance						
Naches	0.642*	0.813*	-1.323	-0.047	0.222	0.963
Entiat	0.652*	0.860*	0.412	0.422	0.685	0.678
Sesech	0.149	0.878*	-1.431	-0.333	0.170	0.743
Little Wenatchee	0.670*	0.861*	1.325	0.316	0.202	0.756

Trend analysis indicated that the relationship of slopes of NORs between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 10; Table 13). Before supplementation, Chiwawa NORs trended downward more strongly than the reference populations (Figure 10). However, during the supplementation period, both the Chiwawa and reference population NORs trended upward in parallel. In nearly all treatment/reference comparisons, the Pearson correlation coefficient was greater in the pre-supplementation period than in the supplementation period (Table 13).

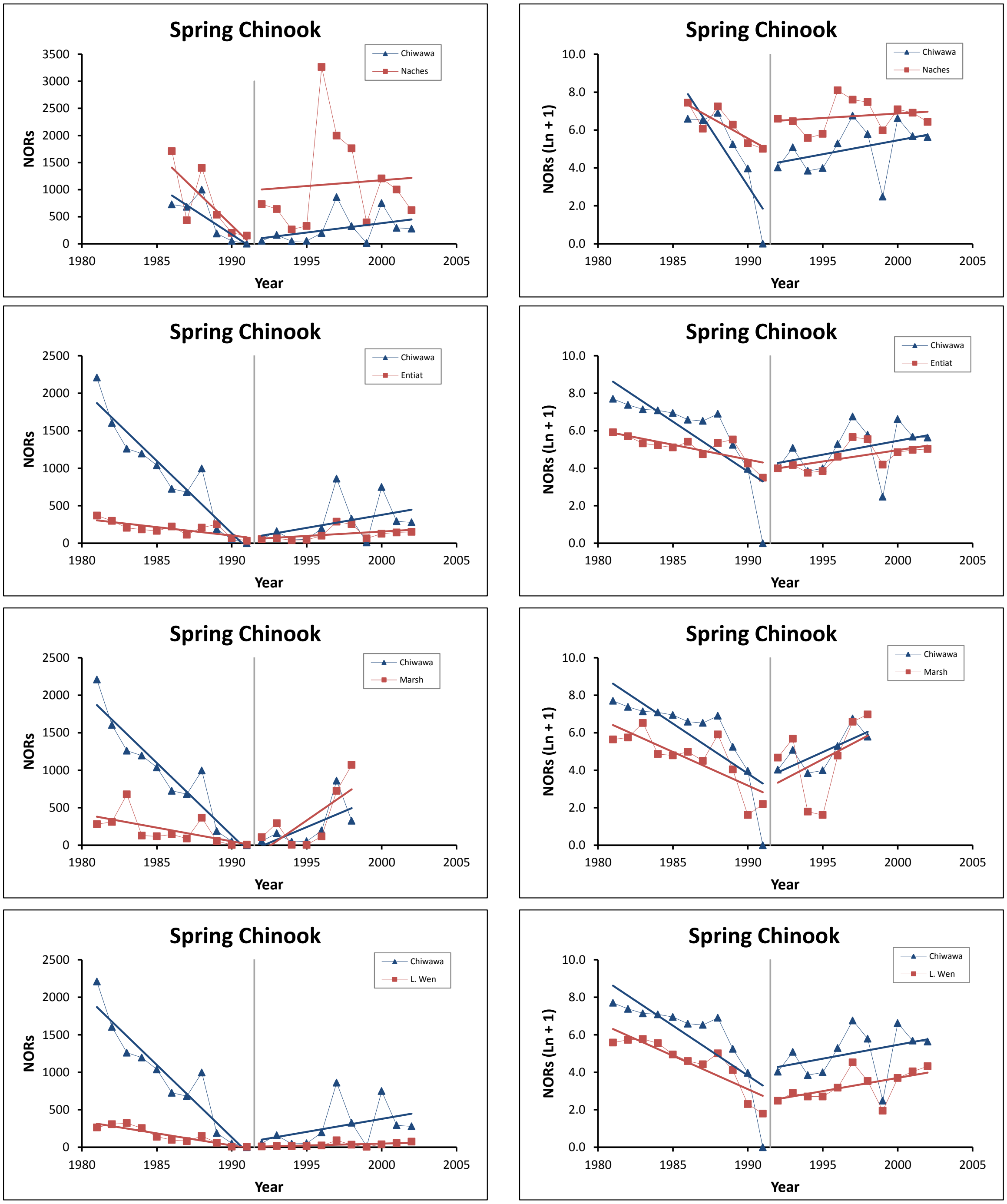

Figure 10. Trends in spring Chinook natural-origin recruits (NORs) in the Chiwawa and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed NORs; those on the right include natural-log transformed data.

Table 13. Pearson correlation coefficients and t-test results comparing slopes of natural-origin recruits trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses include both untransformed and natural-log transformed natural-origin recruits.

Reference population	Pearson correlation coefficient		Test on slopes			
			t-value		P-value	
	Before	During	Before	During	Before	During
Natural-Origin Recruits						
Naches	0.803*	0.432	0.666	0.140	0.524	0.890
Entiat	0.795*	0.754*	-7.495	0.847	0.000	0.408
Marsh	0.605*	0.677*	-5.786	-0.718	0.000	0.489
Little Wenatchee	0.880*	0.758*	-7.206	1.128	0.000	0.274
LN Natural-Origin Recruits						
Naches	0.824*	0.710*	-1.985	0.693	0.082	0.497
Entiat	0.886*	0.796*	-2.563	0.202	0.019	0.842
Marsh	0.830*	0.835*	-1.038	-0.134	0.313	0.896
Little Wenatchee	0.927*	0.898*	-1.150	0.046	0.265	0.964

As with NORs and spawner abundance data, trend analysis indicated that the relationship of slopes of productivity (recruits/spawner) between the Chiwawa and reference populations did not change significantly after the initiation of supplementation (Figure 11; Table 14). This was true for both transformed and untransformed productivity data. Before supplementation, productivities trended down in both the Chiwawa and reference populations (Figure 11). During the period of supplementation, productivities fluctuated widely in both the Chiwawa and reference populations. Nevertheless, during the supplementation period, productivities generally increased in both the reference and Chiwawa populations. Unlike with spawner abundance, the Pearson correlation coefficients resulting from analysis of productivity data were generally higher in the pre-supplementation period than during the supplementation period (Table 14).

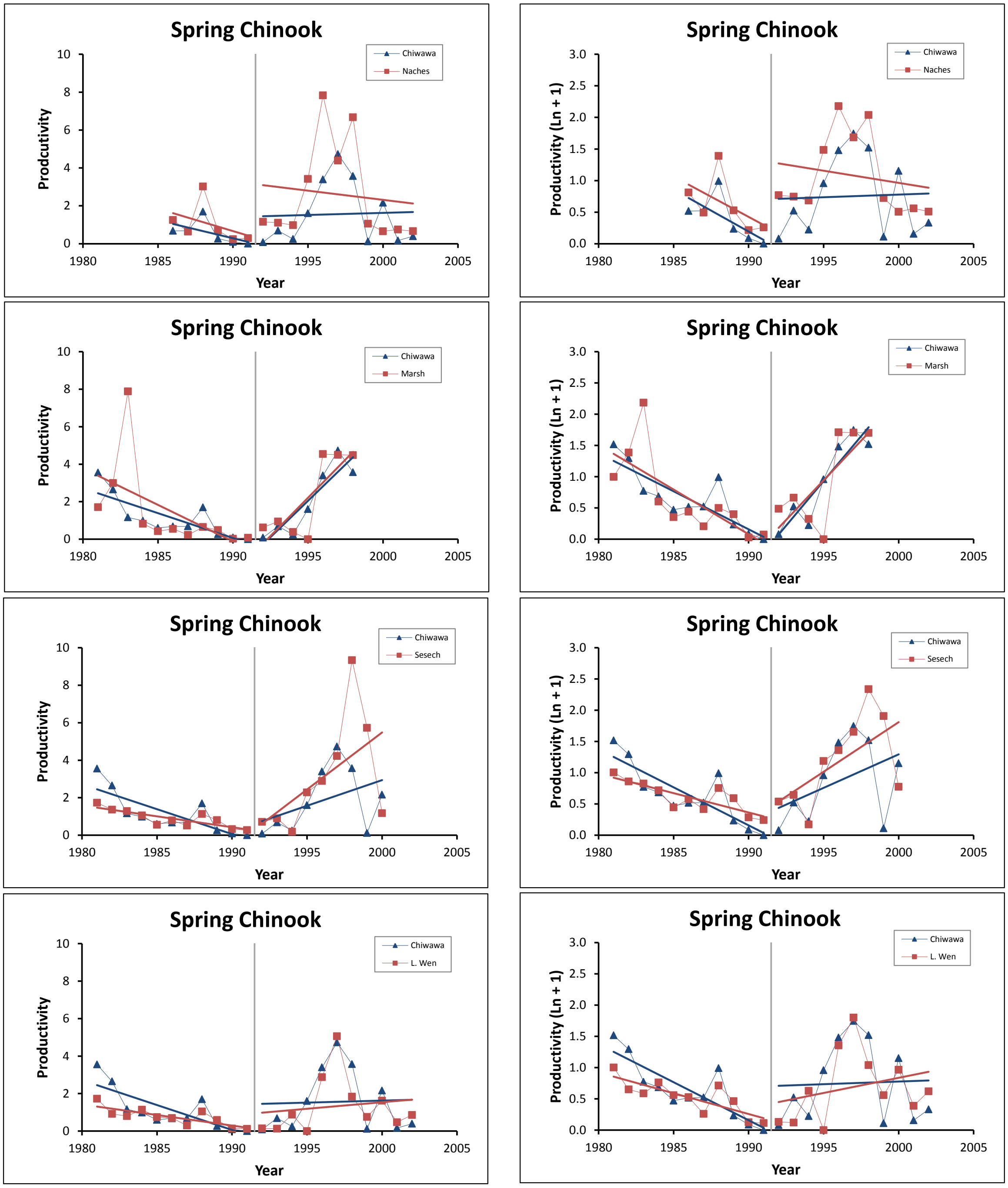

Figure 11. Trends in spring Chinook productivity (recruits/spawner) in the Chiwawa (supplemented) and reference populations. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left include untransformed productivity data; those on the right include natural-log transformed data.

Table 14. Pearson correlation coefficients and t-test results comparing slopes of productivity (recruits/spawner) trends between reference populations and the Chiwawa spring Chinook population before and during the supplementation periods; for correlation coefficients, an asterisk (*) indicates significance at P < 0.05. Analyses include both untransformed and natural-log transformed productivity data.

Reference population	Pearson correlation coefficient		Test on slopes			
			t-value		P-value	
	Before	During	Before	During	Before	During
Productivity						
Naches	0.960*	0.802*	0.169	0.387	0.870	0.703
Marsh	0.320	0.910*	0.605	-0.132	0.553	0.898
Sesech	0.903*	0.491	-2.059	-0.837	0.054	0.417
Little Wenatchee	0.848*	0.864*	-2.065	-0.213	0.054	0.834
LN Productivity						
Naches	0.944*	0.805*	-0.042	0.526	0.968	0.605
Marsh	0.610*	0.804*	0.428	0.281	0.674	0.784
Sesech	0.913*	0.531	-2.050	-0.463	0.055	0.651
Little Wenatchee	0.862*	0.751*	-1.811	-0.480	0.087	0.637

Using trend analysis, we found no evidence that the supplementation program has significantly increased the spawner abundance and NORs of spring Chinook in the Chiwawa Basin. Even though we documented an increasing trend in spawner abundance and NORs during the supplementation period, a similar increase in spawner abundance and NORs was observed in the reference populations. In addition, we found no evidence that the supplementation program has increased the productivity of spring Chinook in the Chiwawa Basin. Importantly, the productivity of spring Chinook in the Chiwawa Basin did not trend downward during the supplementation period. Thus, based on trend analysis, it appears that the supplementation program has not increased or decreased the abundance and productivity of spring Chinook in the Chiwawa Basin.

We note that this exercise only tests the slopes of the trend lines. It does not test for differences in elevations of the trend lines. A supplementation program could increase spawner abundance, NORs, and productivity of the target population without changing the slopes of the trend lines. That is, supplementation could cause the elevation of the trend line to be greater during the supplementation period than during the pre-supplementation period. In the next section we evaluate elevation differences by testing mean differences before and after supplementation.

Analysis of Mean Differences, Ratios, and Rates

For assessing mean differences between supplemented and reference populations, we derived three different response variables using transformed and untransformed spawner abundance, NORs, and productivity data. The first included difference scores, which were calculated as the difference between paired treatment and reference data (T-R). The second included ratios, which were calculated as the ratio of paired treatment and reference data (T/R). Finally, we calculated the differences in annual changes in paired treatment and reference population data (ΔT-ΔR; see footnote #2).

If the hatchery program is successfully supplementing the natural spring Chinook population, the mean difference or ratio score of paired spawner abundance data and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean difference or ratio score during the supplementation period should be equal to or higher than the pre-supplementation period. We tested the following statistical hypotheses.

Spawner Abundance and NORs:

> Ho: Mean Difference (or Ratio) before supplementation ≥ Mean Difference (or Ratio) during supplementation.
>
> Ha: Mean Difference (or Ratio) before supplementation < Mean Difference (or Ratio) during supplementation (i.e., $\mu_{pre} - \mu_{post} < 0$).

Productivity (Recruits/Spawner):

> Ho: Mean Difference (or Ratio) before supplementation ≤ Mean Difference (or Ratio) during supplementation.
>
> Ha: Mean Difference (or Ratio) before supplementation > Mean Difference (or Ratio) during supplementation (i.e., $\mu_{pre} - \mu_{post} > 0$).[6]

For each set of response variables, we tested before/after supplementation effects using a one-tailed Aspin-Welch unequal-variance test. We used the Aspin-Welch unequal-variance test instead of Student's t-test, because in nearly every case, the variances of response variables in the pre-treatment and supplementation periods were unequal.[7] This was true even for natural-log transformed variables. We used the modified Levene equal-variance test to assess the equality of variance. In some cases, the distributions of response variables were not normal (based on the Omnibus Normality test and examination of histograms, normal probability plots, and box plots). Therefore, we also used a randomization test, based on 10,000 Monte Carlo simulations, to assess differences in response variables before and during supplementation. The randomization procedure only allowed the testing of two-tailed hypotheses. Therefore, we generated 95% confidence intervals on the mean difference ($\mu_{pre} - \mu_{post}$) using bootstrapping methods to determine the direction of the difference. We generated 5,000 bootstrap samples to calculate confidence intervals.

All these statistical methods assume that the samples of derived difference or ratio scores from the pre-supplementation and supplementation periods were independent. However, BACI designs, like time-series trend analysis, are repeated-measures designs and therefore are susceptible to temporal correlations in the data. This means that the two

[6] Because of the logic of null hypothesis testing, the rejection of the null hypothesis of no difference in productivity would mean that the supplementation program has reduced the productivity of the target population (here rejection of the null indicates "harm"). Notice that the rejection of the null hypothesis of no difference in spawner abundance means that the supplementation program has improved the spawner abundance in the target population (here rejection of the null indicates "benefit").

[7] In cases in which the variances were equal, both the Aspin-Welch test and Student's t-test gave the same result.

samples of difference or ratio scores may not be independent. Under this scenario, ARIMA models can be used to describe the correlation structure in temporal data (Gotelli and Ellison 2004). ARIMA models can be fit individually to the reference and supplemented time series data, or to a derived data series created by taking the ratio or difference of the supplemented/reference data at each time step. ARIMA models, however, require a long time series (N > 40) and therefore we could not use them to model the spring Chinook data. Thus, we acknowledge that our analyses may be confounded if the samples are not independent.

Difference Scores (T-R)

Analysis of supplementation effects on spawner abundance using difference scores indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 15; Figure 12). Only the Little Wenatchee-Chiwawa pairing using transformed abundance data indicated a significant increase in spawning abundance following supplementation. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction (i.e., CIs > 0). That is, compared to the reference populations, spawner abundance decreased in the Chiwawa Basin during the supplementation period (Figure 12).

Table 15. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Naches	1.066	0.848	184	0.322	-162 – 472
Entiat	1.872	0.962	316	0.078	17 – 633
Sesech	4.502	0.999	607	0.000	349 – 851
Little Wenatchee	1.773	0.954	321	0.093	0 – 690
LN Spawner Abundance					
Naches	2.603	0.990	0.701	0.026	0.210 – 1.214
Entiat	1.701	0.946	0.388	0.108	-0.033 – 0.811
Sesech	5.394	0.999	1.327	0.000	0.891 – 1.805
Little Wenatchee	-2.259	0.018	0.609	0.034	-1.125 – -0.097

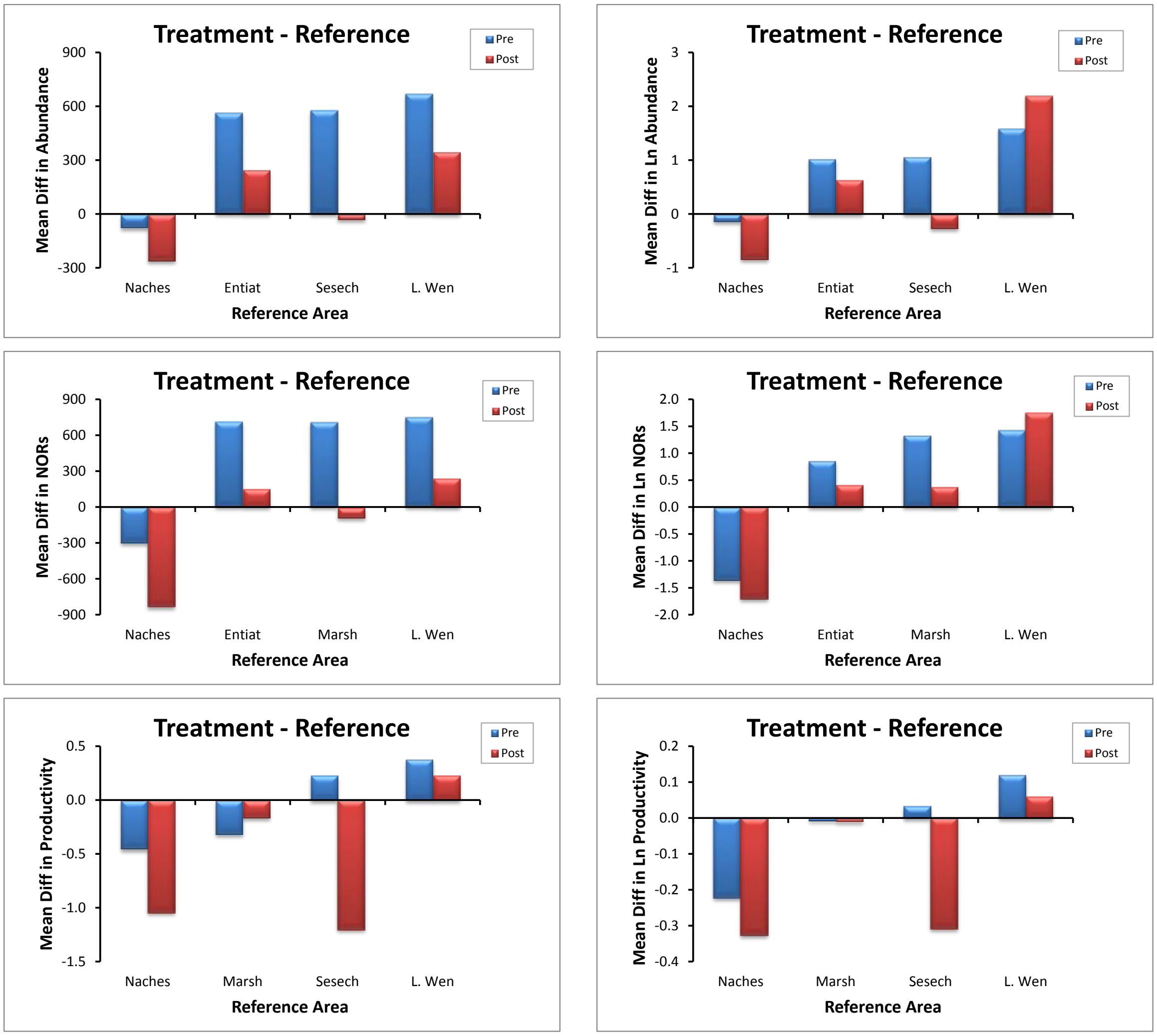

Figure 12. Mean difference (Treatment – Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance, natural-origin recruits (NORs), and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on spawner abundance and NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on NORs using difference scores indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 16; Figure 12). The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, NORs decreased in the Chiwawa Basin during the supplementation period (Figure 12).

Table 16. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Naches	1.787	0.953	537	0.081	-60 – 1039
Entiat	2.879	0.993	558	0.007	201 – 916
Marsh	3.817	0.999	795	0.001	381 – 1153
Little Wenatchee	2.668	0.991	510	0.013	145 – 863
LN Natural-Origin Recruits					
Naches	0.430	0.659	0.354	0.686	-0.948 – 1.975
Entiat	0.788	0.779	0.445	0.465	-0.504 – 1.583
Marsh	1.45	0.916	0.953	0.168	-0.169 – 2.243
Little Wenatchee	-0.813	0.214	-0.319	0.506	-0.948 – 0.484

Analysis of supplementation effects on productivity (adult recruits/spawner) using difference scores indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 17; Figure 12). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period. These tests indicate that supplementation has not negatively affected the productivity of spring Chinook salmon in the Chiwawa Basin.

Table 17. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean difference scores during the supplementation period were less than mean difference scores during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	1.134	0.139	0.594	0.296	-0.427 – 1.540
Marsh	-0.203	0.579	0.152	0.932	-0.304 – 1.381
Sesech	1.607	0.071	1.435	0.151	-0.403 – 2.917
Little Wenatchee	0.431	0.335	0.147	0.665	-0.498 – 0.762
LN Productivity					
Naches	0.770	0.227	0.104	0.480	-0.125 – 0.378
Marsh	0.012	0.495	0.003	0.992	-0.375 – 0.493
Sesech	1.463	0.087	0.343	0.161	-0.135 – 0.732

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Little Wenatchee	0.390	0.351	0.060	0.701	-0.229 – 0.347

Ratio Scores (T/R)

As with difference scores, analysis of supplementation effects on spawner abundance using ratios indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 18; Figure 13). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in spawning abundance following supplementation. Analysis with both transformed and untransformed Little Wenatchee-Chiwawa data indicated a significant effect. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, spawner abundance decreased in the Chiwawa Basin during the supplementation period (Figure 13).

Table 18. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Naches	2.110	0.970	0.398	0.065	0.056 – 0.737
Entiat	1.254	0.888	0.731	0.223	-0.365 – 1.834
Sesech	4.251	0.999	2.428	0.000	1.278 – 3.435
Little Wenatchee	-2.649	0.009	3.897	0.018	-6.579 – -1.202
LN Spawner Abundance					
Naches	2.783	0.993	0.120	0.021	0.045 – 0.199
Entiat	1.273	0.890	0.055	0.220	-0.026 – 0.135
Sesech	5.143	0.999	0.244	0.000	0.160 – 0.335
Little Wenatchee	-3.462	0.002	0.327	0.003	-0.516 – -0.154

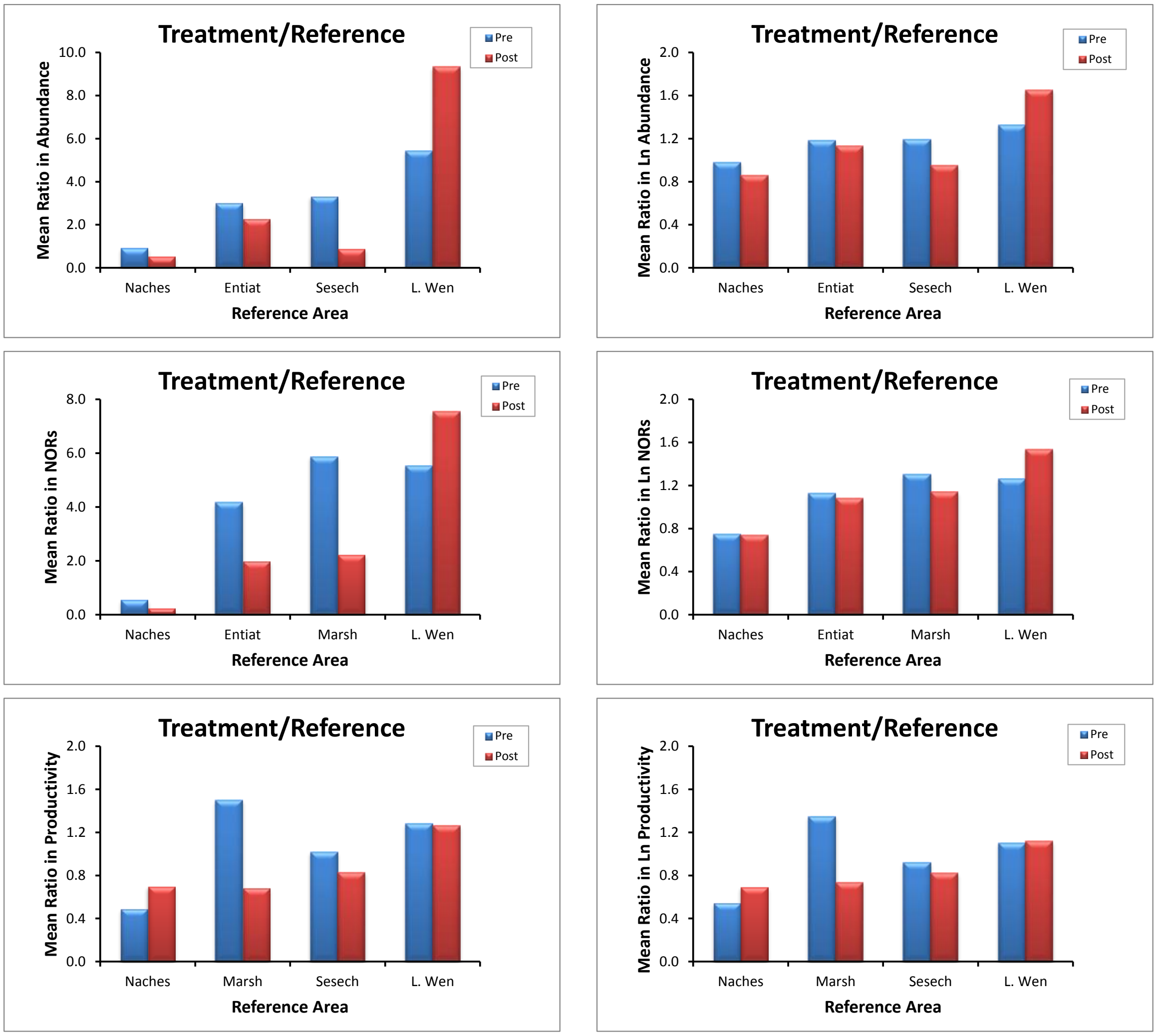

Figure 13. Mean ratios (Treatment/Reference) scores of untransformed (figures on the left) and transformed (figures on the right) spawner abundance, natural-origin recruits (NORs), and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Positive effects of supplementation on spawner abundance and NORs are indicated when the post-supplementation (red) bars are greater than their corresponding pre-supplementation (blue) bars. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on NORs using ratios indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 19; Figure 13). Only the Little Wenatchee-Chiwawa pairing indicated a significant increase in transformed NORs following supplementation. The randomization test indicated significant differences in several of the treatment-reference pairs; however, the bootstrap CIs indicated that those differences were in the wrong direction. That is, compared to the reference populations, NORs decreased in the Chiwawa Basin during the supplementation period (Figure 13).

Table 19. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if the mean ratios during the supplementation period were greater than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Naches	1.318	0.881	0.306	0.219	-0.157 – 0.670
Entiat	2.447	0.987	2.172	0.028	0.593 – 3.871
Marsh	2.001	0.965	3.638	0.075	0.532 – 7.201
Little Wenatchee	-1.148	0.136	2.020	0.284	-5.055 – 1.516
LN Natural-Origin Recruits					
Naches	0.057	0.522	0.009	0.967	-0.230 – 0.351
Entiat	0.359	0.638	0.049	0.759	-0.173 – 0.336
Marsh	0.603	0.721	0.161	0.579	-0.272 – 0.681
Little Wenatchee	-1.914	0.038	0.277	0.027	-0.504 – 0.031

Analysis of supplementation effects on productivity (adult recruits/spawner) using ratios indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 20; Figure 13). Although the Aspin-Welch test indicated a significant effect when comparing the Chiwawa to the Marsh Creek population, both the randomization test and the bootstrap CI did not indicate a significant effect. These tests indicate that supplementation has probably not negatively affected the productivity of spring Chinook salmon in the Chiwawa Basin.

Table 20. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	-0.677	0.745	0.209	0.688	-0.700 – 0.425
Marsh	2.236	0.022	0.814	0.054	0.112 – 1.459
Sesech	0.677	0.253	0.191	0.515	-0.356 – 0.718
Little Wenatchee	0.033	0.487	0.018	0.979	-0.879 – 1.162
LN Productivity					
Naches	-0.639	0.734	0.148	0.616	-0.548 – 0.316
Marsh	1.952	0.036	0.613	0.081	-0.003 – 1.170
Sesech	0.447	0.330	0.098	0.663	-0.301 – 0.515
Little Wenatchee	-0.034	0.513	0.015	0.982	-0.692 – 0.861

Difference of Annual Difference Scores (ΔT-ΔR)

Analysis of supplementation effects on spawner abundance using difference scores of annual changes indicated that supplementation did not significantly increase spawning abundance in the Chiwawa Basin (Table 21; Figure 14). None of the statistical analyses detected a significant increase in annual change in the Chiwawa Basin relative to the reference populations.

Table 21. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed spawner abundance data. Tests determined if mean difference scores of annual change during the supplementation period were greater than mean difference scores of annual change during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Spawner Abundance					
Naches	0.009	0.503	2	0.995	-502 – 539
Entiat	-0.239	0.407	48	0.826	-414 – 327
Sesech	-0.126	0.451	20	0.902	-311 – 266
Little Wenatchee	-0.318	0.377	65	0.761	-452 – 311
LN Spawner Abundance					
Naches	-0.425	0.339	0.142	0.698	-0.744 – 0.466
Entiat	-0.084	0.467	0.028	0.933	-0.681 – 0.593
Sesech	-0.349	0.366	0.117	0.740	-0.741 – 0.515
Little Wenatchee	0.001	0.500	0.000	0.999	-0.663 – 0.687

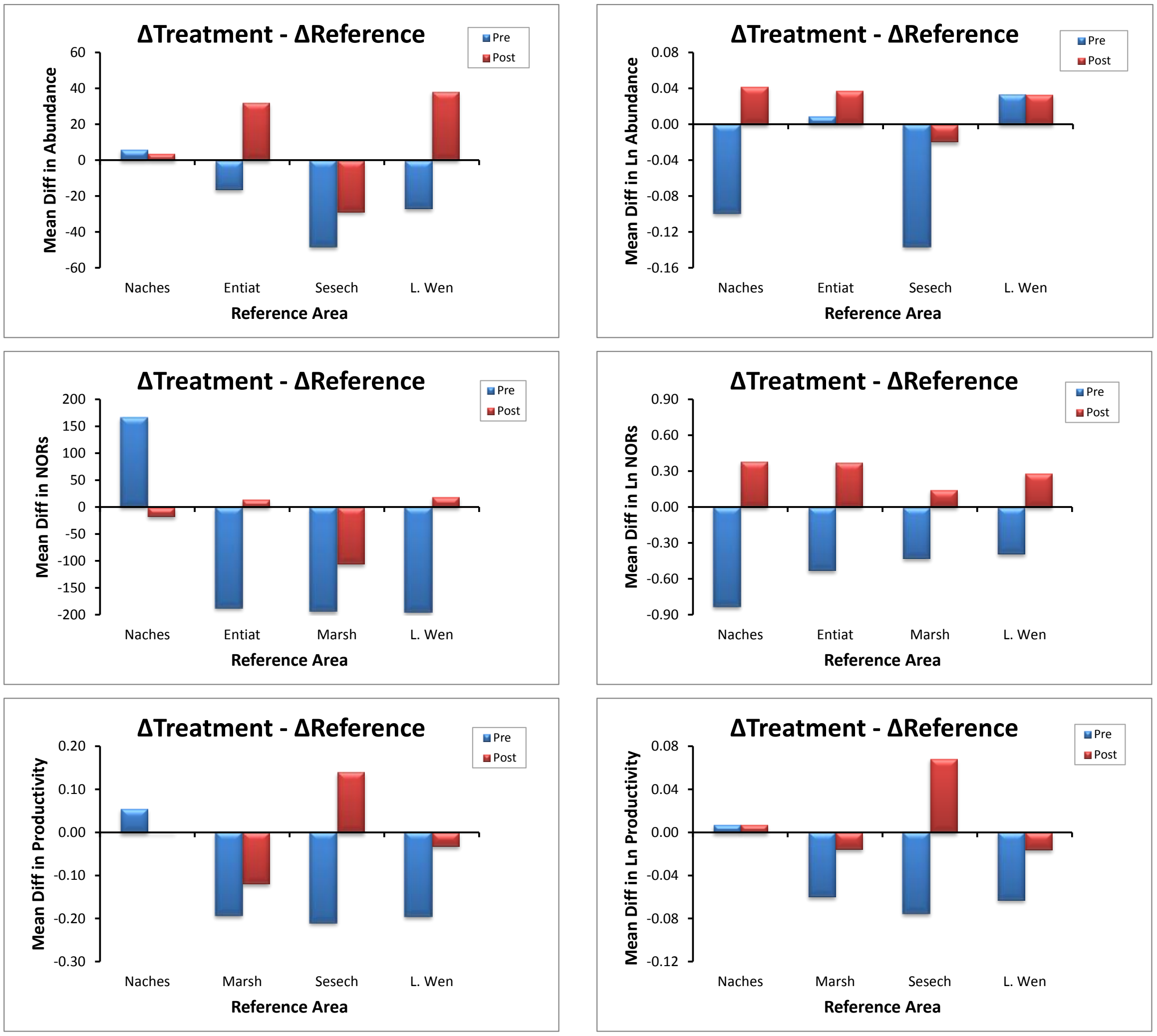

Figure 14. Mean difference scores of annual changes (ΔTreatment – ΔReference) of untransformed (figures on the left) and transformed (figures on the right) spawner abundance and productivity data before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin.

Analysis of supplementation effects on NORs using difference scores of annual changes indicated that supplementation did not significantly increase NORs in the Chiwawa Basin (Table 22; Figure 14). None of the statistical analyses detected a significant increase in annual change in the Chiwawa Basin relative to the reference populations.

Table 22. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed natural-origin recruits. Tests determined if mean difference scores of annual change during the supplementation period were greater than mean difference scores of annual change during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Natural-Origin Recruits					
Naches	0.399	0.652	184	0.741	-699 – 989
Entiat	-1.381	0.092	202	0.194	-471 – 86
Marsh	-0.505	0.311	88	0.624	-425 – 206
Little Wenatchee	-1.437	0.084	214	0.179	-481 – 64
LN Natural-Origin Recruits					
Naches	-1.301	0.118	1.214	0.224	-2.783 – 0.531
Entiat	-1.408	0.088	0.901	0.188	-1.977 – 0.387
Marsh	-0.712	0.244	0.570	0.517	-1.952 – 0.975
Little Wenatchee	-1.154	0.132	0.674	0.274	-1.706 – 0.497

Analysis of supplementation effects on productivity (adult recruits/spawner) using difference scores of annual changes indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 23; Figure 14). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period.

Table 23. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data. Tests determined if the mean difference scores of annual change during the supplementation period were less than mean difference scores of annual change during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	0.002	0.475	0.054	0.952	-1.464 – 1.583
Marsh	-0.063	0.525	0.074	0.948	-2.395 – 2.031
Sesech	-0.317	0.621	0.350	0.628	-2.387 – 1.695
Little Wenatchee	-0.347	0.633	0.163	0.728	-1.023 – 0.725
LN Productivity					
Naches	0.000	0.500	0.000	0.999	-0.408 – 0.445
Marsh	-0.126	0.549	0.044	0.904	-0.715 – 0.595
Sesech	-0.449	0.668	0.144	0.727	-0.685 – 0.509
Little Wenatchee	-0.200	0.578	0.047	0.842	-0.466 – 0.391

We believe results from analysis of mean differences of annual change (ΔT-ΔR) in spawning abundance, NORs, and productivity are difficult to interpret and may be insensitive to treatment effects. A simpler analysis, which is also easier to interpret, is the use of trend analysis. Therefore, we recommend that analyses using differences of annual change be replaced with trend analysis.

Corrections for Density Dependence and Carrying Capacity

The analyses described above assume that the density of spawners or recruits does not affect the survival and productivity of fish. However, it is well known that the density of fish can affect the number of recruits as well as the productivity of the population. This occurs through the relationship between density and mortality. Mortality of fish can be generally classified as density independent and density dependent. In general, when densities are low, the mortality is density independent, but as densities increase, the amount of density-dependent mortality increases. Monitoring programs can make use of this information to derive density-corrected estimates of productivity. In this section, we describe two different methods for deriving density-corrected estimates of productivity.

The first method controlled the effects of density on productivity (adult recruits/spawner; R/S) by partitioning observed productivities into density-independent and density-dependent productivity. When abundance is below the minimum number of spawners (S) needed to produce the maximum number of recruits (K_{sp}), the observed productivity is used in statistical tests. However, when the abundance is equal to or above K_{sp}, the modeled value of productivity (R/K_{sp}) is used in statistical tests.

$$\boldsymbol{Adj\ R/S = \begin{cases} R/S, & if\ S < K_{sp} \\ R/K_{sp}, & if\ S \geq K_{sp} \end{cases}}$$

The density-independent and density-dependent productivities were then combined in a single test.

The second method was based on one of the goals of supplementation, which is to fill the capacity of the environment with fish. This method corrects for differences in carrying capacities between the supplemented and reference populations. We did this by calculating the percent saturation of NORs. That is, we calculated the fraction of the habitat (τ) that was filled with NORs by dividing the observed NOR by the modeled maximum number of NORs (K_R) that the habitat could support.

$$\boldsymbol{\tau = \frac{NOR_{obs}}{K_R}}$$

Note that 1-τ represents the unused portion of the carrying capacity and is the term that is multiplied by the exponential growth equation to derive the logistic growth equation. We included τ in the statistical analyses.

These two methods require the estimation of carrying capacity (K_R) and the spawning abundance that produces the maximum number of recruits (K_{sp}). We estimated these parameters for both reference populations and the supplemented population using Ricker, Beverton-Holt, and smooth hockey stick stock-recruitment models. We used only spawner abundance as a predictor of subsequent brood recruitment. We made the following assumptions in proceeding with the analysis:

- *Density-dependent mortality*—For some time period before recruitment, the brood instantaneous mortality rate is proportional to the number of parent spawners (Ricker 1954).
- *Lognormal variation*—At any particular spawning stock size, the variation in recruitment is log-normally distributed about its average, and acts multiplicatively (Quinn and Deriso 1999).
- *Measurement error*—Error in spawning stock size estimates (measurement error) is small relative to the range of spawning stock sizes observed (Hilborn and Walters 1992). Variation in realized recruitment at any particular spawning stock size (process error) dominates recruitment measurement error.
- *Stationarity*—The average stock-recruitment relationship is constant over time (Hilborn and Walters 1992). That is, environmental conditions randomly affect survival independent of stock size or time.

In general, the methods we used to fit the models to the data followed those outlined in Hilborn and Walters (1992) and Froese (2008). The Ricker model, which assumes that the number of recruits increases to a maximum and then declines as the number of spawners increases, takes the form:

$$\boldsymbol{E(R) = \alpha S e^{-\beta S}}$$

where E(R) is the expected recruitment, S is spawner abundance, α is the number of recruits per spawner at low spawning levels, and β describes how quickly the recruits per spawner drop as the number of spawners increases. We estimated K_R as:

$$\boldsymbol{K_R = \left(\frac{\alpha}{\beta}\right) e^{-1}}$$

and K_{sp} as:

$$\boldsymbol{K_{\mathrm{sp}} = \frac{1}{\beta}}$$

The Beverton-Holt model assumes that the number of recruits increases constantly toward an asymptote as the number of spawners increases. After the asymptote is reached, the number of recruits neither increases nor decreases. The asymptote represents the maximum number of recruits the system can support (i.e., carrying capacity for the system; K_R). The Beverton-Holt curve takes the form:

$$\boldsymbol{E(R) = \frac{(\alpha S)}{(\beta + S)}}$$

where E(R) and S are as above, α is the maximum number of recruits produced (K_R), and β is the number of spawners needed to produce (on average) recruits equal to one-half the maximum number of recruits. Because $K_{sp} = \infty$ in the Beverton-Holt model, we estimated K_{sp} as the number of spawners needed to produce $0.99(K_R)$.

Like the Beverton-Holt model, the smooth hockey stick model assumes that the number of recruits increases toward an asymptote (carrying capacity; K_R) as the number of spawners increases. After the carrying capacity is reached, the number of recruits neither increases nor decreases. The carrying capacity represents the maximum number of recruits the system can support. This curve takes the form (Froese 2008):

$$\boldsymbol{E(R) = R_\infty\left(1 - e^{-\left(\frac{\alpha}{R\infty}\right)S}\right)}$$

where E(R) and S are as above, α is the slope at the origin of the spawner-recruitment curve, and R_∞ is the carrying capacity of recruits (note that $R_\infty = K_R$). As with the Beverton-Holt model, we estimated K_{sp} as the number of spawners needed to produce $0.99(K_R)$.

We used non-linear regression to fit the three models to spawner-recruitment data. Before fitting the models, we transformed recruitment data using natural logs. We estimated bias and uncertainty measures (95% CI) for the model parameters using bootstrap procedures, which assumed that the {R, S} sample represented or approximated the population. The number of bootstrap samples was 3,000. We computed and stored the non-linear regression results for each bootstrap sample. We then calculated the bootstrap 95% CI by arranging the 3,000 bootstrap parameter values in sorted order and selected the 2.5 and 97.5 percentiles from the list.

We used Akaike's Information Criterion for small sample size (AIC_c) to determine which model(s) best explained the relationship between spawners and recruitment in the supplemented and reference populations. AIC_c was estimated as:

$$\boldsymbol{AIC_c = -2log\big(£(\theta|data)\big) + 2K + \left(\frac{2K(K+1)}{n-K-1}\right)}$$

where $log(£(\theta|data))$ is the maximum likelihood estimate, K is the number of estimable parameters (structural parameters plus the residual variance parameter), and n is the sample size (Burnham and Anderson 2002). We used least-squares methods to estimate $log(£(\theta|data))$, which was calculated as $log(\sigma^2)$, where σ^2 = residual sum of squares divided by the sample size ($\sigma^2 = RSS/n$). AIC_c assessed model fit in relation to model complexity (number of parameters). The model with the smallest AIC_c value represented the "best approximating" model within the model set. Remaining models were ranked relative to the best model using AIC_c difference scores (ΔAIC_c), Akaike weights (w_i), and evidence ratios. Models with ΔAIC_c values less than 2 indicated that there is substantial support for these models as being the best-fitting models within the set (Burnham and Anderson 2002). Models with values greater than 2 had less support. Akaike weights are probabilities estimating the strength of the evidence supporting a particular model as being the best model within the model set. Models with small w_i values are less plausible as competing models (Burnham and Anderson 2002). If no single model could be specified as the best model, a "best subset" of competing models was identified using (1) AIC_c differences to indicate the level of empirical support each model had as being the best model, (2) evidence ratios based on Akaike weights to indicate the relative probability that any model is the best model, and (3) coefficients of determination (R^2) assessing the explanatory power of each model.

Stock-Recruitment Analysis

We successfully fit stock-recruitment models to the Chiwawa and reference population data. The span of spawner data for the Chiwawa and reference populations was greater than 14 times the minimum observed spawners, which should provide sufficient contrast for estimation of model parameters. In addition, the span of recruitment data was greater than 12 times the minimum observed recruitment, again providing sufficient contrast for estimation of parameters. The relationship between natural log R/S and spawners indicated that some of the highest productivities occurred at the lower spawner levels and the lowest productivities generally occurred at the highest spawner levels (Figure 15). This is consistent with the assumption of density-dependent mortality.

Although model fits were generally poor, explaining less than 40% of the residual variation in natural-log recruitment data, we were able to estimate average maximum recruitment levels (K_R) and the spawning levels needed to produce maximum recruitment (K_{sp}) (Table 24; Figure 15). For all populations examined, Akaike information criterion was unable to identify a best approximating model (i.e., ΔAIC_c values were less than 2, indicating support for all three models). However, evaluation of 95% CIs and the asymptotic correlation coefficients indicated that the smooth hockey stick model may be the best approximating model for each population. Therefore, we used estimates of K_R and K_{sp} derived from the smooth hockey stick model to correct for density dependence and different carrying capacities in treatment-reference comparisons.

As part of the regression diagnostics, we examined the dependence of the model residuals on time and found a significant ($P < 0.05$), positive, one-year-lag autocorrelation for the Entiat (0.562), Marsh (0.551), Sesech (0.564), and Little Wenatchee (0.629) populations. For the purposes of our work here, we did not attempt to correct for this one-year-lag correlation in the residuals. Future analyses will explore the use of autoregressive models (e.g., AR1; Noakes et al. 1987) to correct for autocorrelation.

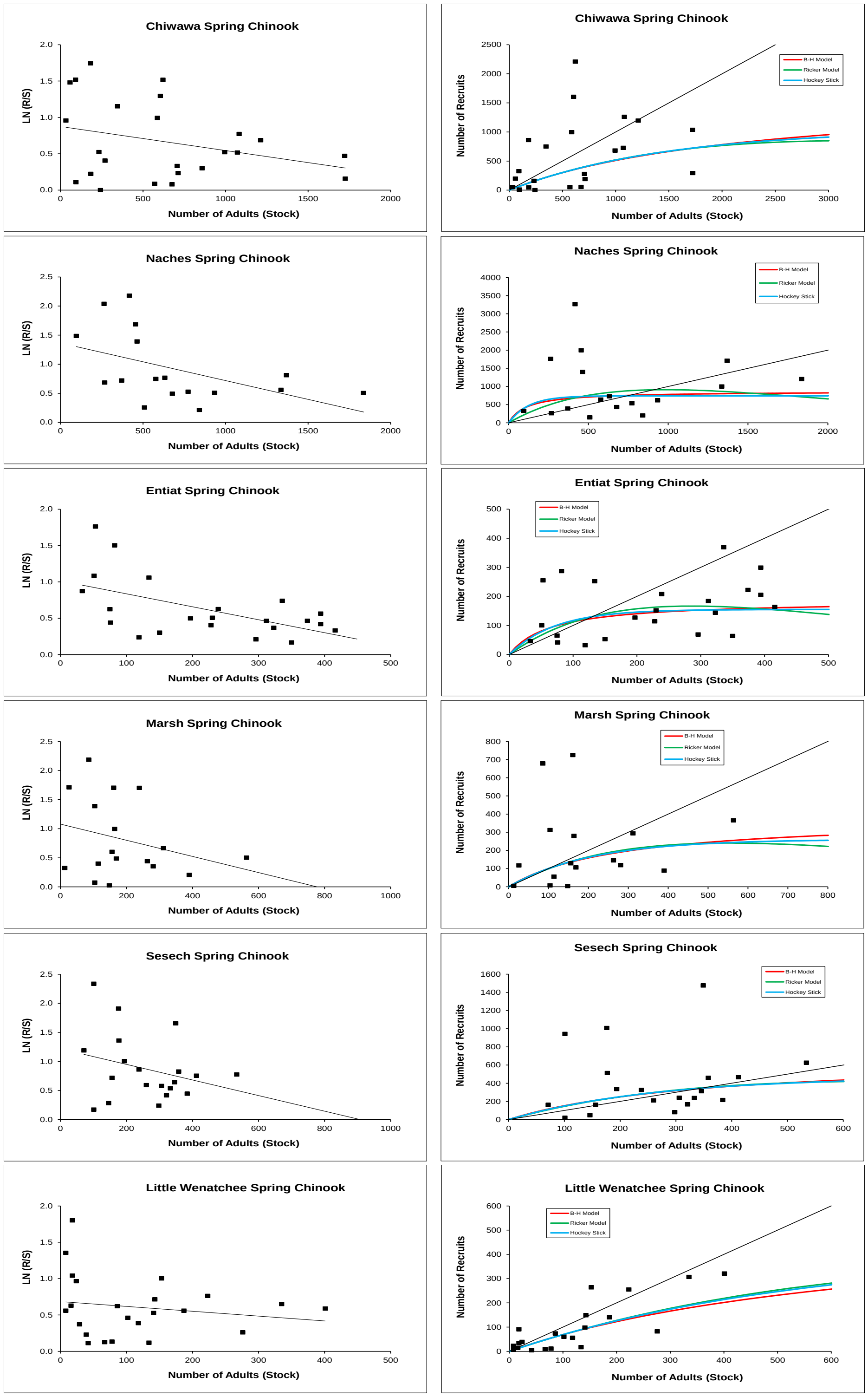

Figure 15. Relationships between natural log recruits/spawner (LN R/S) and spawners (Stock) in the Chiwawa and reference populations (figures on the left) and relationships between numbers of untransformed recruits and spawners in the Chiwawa and reference populations (figures on the right). Figures on the right also show the fit of the Ricker, Beverton-Holt, and the smooth hockey stick models to the data (black straight line represents R=S).

Table 24. Results from fitting Ricker, Beverton-Holt, and smooth hockey stick models to stock-recruitment data from the Chiwawa and reference populations. 95% CI on parameter estimates are based on 3,000 bootstrap trials; Corr coef = asymptotic correlation of the parameter estimates; K_R = maximum natural origin recruits (recruits at carrying capacity); K_{sp} = number of spawners needed to produce K_R; AICc = Akaike's Information Criterion for small sample size; Adj R^2 = coefficient of determination that is adjusted for the number of parameters in the model.

Model	Parameter	Parameter value	Bootstrap 95% CI	Corr coef	K_R	K_{sp}	AICc	Adj R^2
Chiwawa Population								
Ricker	α	0.7048	-0.6197 1.1055	0.791	852	3,285	-47.949	0.125
	β	0.000304	-0.000668 0.000609					
Beverton-Holt	α	1687.4	-65654539 3062.1	0.989	1,687	43,760	-47.962	0.125
	β	2308.5	-99999538 4526.1					
Smooth hockey stick	α	6.956	-41.313 8.2270	-0.708	1,049	6,847	-47.949	0.125
	β	0.7118	-2.397 1.122					
Naches Population								
Ricker	α	2.5223	-2.0003 3.9672	0.844	912	983	-45.063	-0.143
	β	0.001018	-0.000752 0.001717					
Beverton-Holt	α	869.4	97.4 1641.4	0.858	869	11,455	-46.801	-0.097
	β	111.8	-346.2 569.8					
Smooth hockey stick	α	6.612	5.9223 7.006	-0.399	744	565	-46.831	-0.095
	β	6.013	-89.071 12.026					
Entiat Population								
Ricker	α	1.5843	0.1609 2.4178	0.867	167	286	-68.365	-0.049
	β	0.003496	0.001141 0.005906					
Beverton-Holt	α	186.1	67.9 304.3	0.880	186	1,277	-69.895	0.029
	β	65.0	-59.1 189.2					
Smooth hockey stick	α	5.045	4.381 5.378	-0.450	155	344	-69.379	0.003
	β	2.180	-89.369					

Model	Parameter	Parameter value	Bootstrap 95% CI	Corr coef	K_R	K_{sp}	AICc	Adj R^2
			3.704					
Marsh Creek Population								
Ricker	α	1.1852	-1.8268 1.9269	0.823	241	552	-32.237	0.218
	β	0.001810	-0.003063 0.003625					
Beverton-Holt	α	383.3	-85109314 665.4	0.970	383	5,310	-32.291	0.234
	β	282.4	-99999944 564.9					
Smooth hockey stick	α	5.565	-22.631 6.584	-0.694	261	984	-32.264	0.227
	β	1.265	-108.574 2.531					
Sesech Population								
Ricker	α	1.6835	-2.9253 2.5951	0.912	421	680	-54.589	-0.005
	β	0.001470	-0.002951 0.002941					
Beverton-Holt	α	689.9	-986.8 2366.7	0.981	690	6,591	-54.678	0.000
	β	351.7	-1059.0 1762.5					
Smooth hockey stick	α	6.1528	-22.851 6.815	-0.821	470	1,185	-54.633	-0.002
	β	0.8000	-119.370 2.909					
Little Wenatchee Population								
Ricker	α	0.7447	0.0828 1.0280	0.735	356	1,298	-66.978	0.357
	β	0.000770	-0.003052 0.001541					
Beverton-Holt	α	564.7	-74423355 1067.6	0.994	565	13,400	-67.055	0.358
	β	719.7	-99999856 1413.4					
Smooth hockey stick	α	6.0181	-49.5620 8.1122	-0.683	411	2,544	-67.000	0.357
	β	0.7550	-0.9539 1.0452					

Method 1: Productivity Data Adjusted for Density Dependence

Analysis of supplementation effects on productivity (adult recruits/spawner adjusted for density-dependent effects based on the smooth hockey stick model) using difference scores indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 25; Figure 16). All tests, regardless of treatment-reference pairs, indicated that productivity did not change significantly during the supplementation period, even though productivity did decrease during the supplementation period (Figure 16). These results are consistent with those based on unadjusted productivity data (Table 17). This is because most abundance estimates were below the level of assumed density dependence.

Table 25. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data corrected for density dependence. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	0.904	0.190	0.496	0.412	-0.511 – 1.497
Marsh	-0.203	0.579	0.152	0.927	-1.298 – 1.372
Sesech	1.607	0.071	1.435	0.146	-0.359 – 2.911
Little Wenatchee	0.431	0.335	0.147	0.668	-0.487 – 0.781
LN Productivity					
Naches	0.570	0.290	0.083	0.568	-0.168 – 0.362
Marsh	0.012	0.495	0.003	0.991	-0.373 – 0.480
Sesech	1.463	0.087	0.343	0.171	-0.125 – 0.732
Little Wenatchee	0.390	0.351	0.060	0.709	-0.218 – 0.365

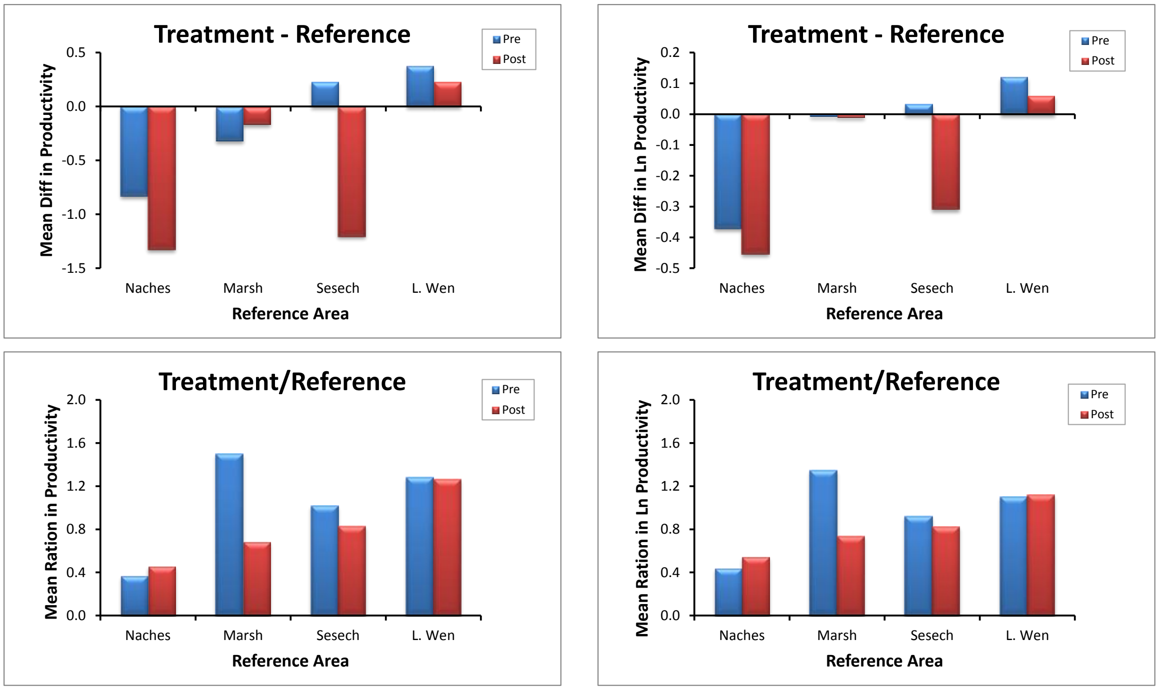

Figure 16. Mean differences (Treatment – Reference; figures on the top) and mean ratios (Treatment/Reference; figures on the bottom) of transformed and untransformed productivity data (adjusted for density dependence) before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin. Negative effects of supplementation on productivity are indicated when the pre-supplementation (blue) bars are greater than their corresponding post-supplementation (red) bars.

Analysis of supplementation effects on productivity (adult recruits/spawner adjusted for density-dependent effects) using ratios indicated that supplementation did not significantly decrease productivity in the Chiwawa Basin (Table 26; Figure 16). The Aspin-Welch test and the 95% CIs did indicate a significant effect when comparing the Chiwawa to the Marsh Creek population. These results are consistent with those using unadjusted productivity data (Table 20). Again, this is because most abundance estimates were below the level of assumed density dependence.

Table 26. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on transformed and untransformed productivity data corrected for density dependence. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Productivity					
Naches	-0.529	0.696	0.087	0.597	-0.394 – 0.214
Marsh	2.236	0.022	0.814	0.056	0.140 – 1.470
Sesech	0.677	0.253	0.191	0.496	-0.343 – 0.727
Little Wenatchee	0.033	0.487	0.018	0.978	-0.902 – 1.181

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
LN Productivity					
Naches	-0.621	0.726	0.104	0.536	-0.406 – 0.191
Marsh	1.952	0.036	0.613	0.076	0.005 – 1.163
Sesech	0.447	0.330	0.098	0.649	-0.312 – 0.498
Little Wenatchee	-0.034	0.513	0.015	0.980	-0.697 – 0.852

Our analyses assume that there is a spawner abundance (K_{sp}) at which density-independent effects end and density-dependent effects begin. In reality, density-dependent effects occur at low spawning abundance and intensify as spawning abundance increases (evident in the changing slope of the three stock-recruitment curves used in our analyses). We did not account for these increasing density-dependent effects at spawner abundances less than K_{sp}. If we accounted for the increasing effects of density dependence at spawning abundances less than K_{sp}, the analysis with and without productivity adjustments may give different results.

Method 2: Fraction of Carrying Capacity Filled with NORs

We analyzed the effects of supplementation on filling the capacity of the habitat with natural-origin recruits. The smooth hockey stick model derived the carrying capacity (K_R) estimates for the Chiwawa and reference populations. The fraction of the carrying capacity filled with Chinook recruits before and during supplementation for the Chiwawa and reference populations is provided in Table 27. These data indicate that for the Chiwawa population, the mean fraction of the K_R filled with fish decreased significantly from the pre-supplementation period through the supplementation period (Table 27). Likewise, the Entiat and Little Wenatchee populations showed a significant decline in the mean fraction of K_R filled with adult recruits. In contrast, the mean fraction of K_R in the Naches and Marsh Creek populations increased during the same period (Table 27).[8] Interestingly, the fraction of K_R filled with adult recruits for all populations trended downward during the pre-supplementation period (Figure 17). During the supplementation period, however, the fraction of K_R filled with adult recruits trended upward for all populations. These results suggest that agents of mortality outside the Chiwawa and reference populations were reducing recruitment to the populations.

[8] Although we do not show the results here, statistical analysis of the mean fraction of carrying capacity filled by adult recruits using natural-log transformed data produced the same result as using untransformed data. This was true for all populations.

Table 27. Fraction of the carrying capacity that was filled with Chinook salmon adult recruits in the Chiwawa and reference populations before (pre) and during (post) supplementation in Chiwawa Basin. The smooth hockey stick model estimated carrying capacity for each population. Statistical results from comparing the pre and post mean scores using the Aspin-Welch unequal-variance test are provided at the bottom of the table.

Supplementation period	Chiwawa	Reference populations			
		Naches	Entiat	Marsh	L. Wenatchee
Pre-supplementation period (1981-1992)	2.11		2.38	1.07	0.64
	1.53		1.93	1.20	0.75
	1.20		1.32	2.60	0.78
	1.14		1.19	0.49	0.62
	0.99		1.06	0.46	0.34
	0.70	2.30	1.43	0.56	0.24
	0.65	0.58	0.74	0.34	0.20
	0.95	1.88	1.34	1.40	0.36
	0.18	0.72	1.63	0.22	0.15
	0.05	0.27	0.45	0.02	0.02
	0.00	0.20	0.21	0.03	0.01
Pre-Mean:	0.86	0.99	1.24	0.76	0.37
Pre-Range:	0.00 – 2.11	0.20 – 2.30	0.21 – 2.38	0.02 – 2.60	0.01 – 0.78
Post-supplementation period (1992-2002)	0.05	0.98	0.34	0.41	0.03
	0.15	0.86	0.41	1.13	0.04
	0.04	0.35	0.27	0.02	0.03
	0.05	0.44	0.30	0.02	0.03
	0.19	4.39	0.65	0.45	0.06
	0.82	2.68	1.85	2.78	0.22
	0.31	2.37	1.65	4.10	0.08
	0.01	0.53	0.42		0.02
	0.71	1.62	0.82		0.10
	0.28	1.35	0.93		0.14
	0.27	0.83	0.98		0.18
Post-Mean:	0.26	1.49	0.78	1.27	0.08
Post-Range:	0.04 – 0.82	0.35 – 4.39	0.30 – 1.85	0.02 – 4.10	0.02 – 0.22
One-sided Aspin-Welch t-test of pre and post means	t = 2.846; P = 0.007	t = -0.967; P = 0.825	t = 1.833; P = 0.041	t = -0.799; P = 0.776	t = 3.321; P = 0.003

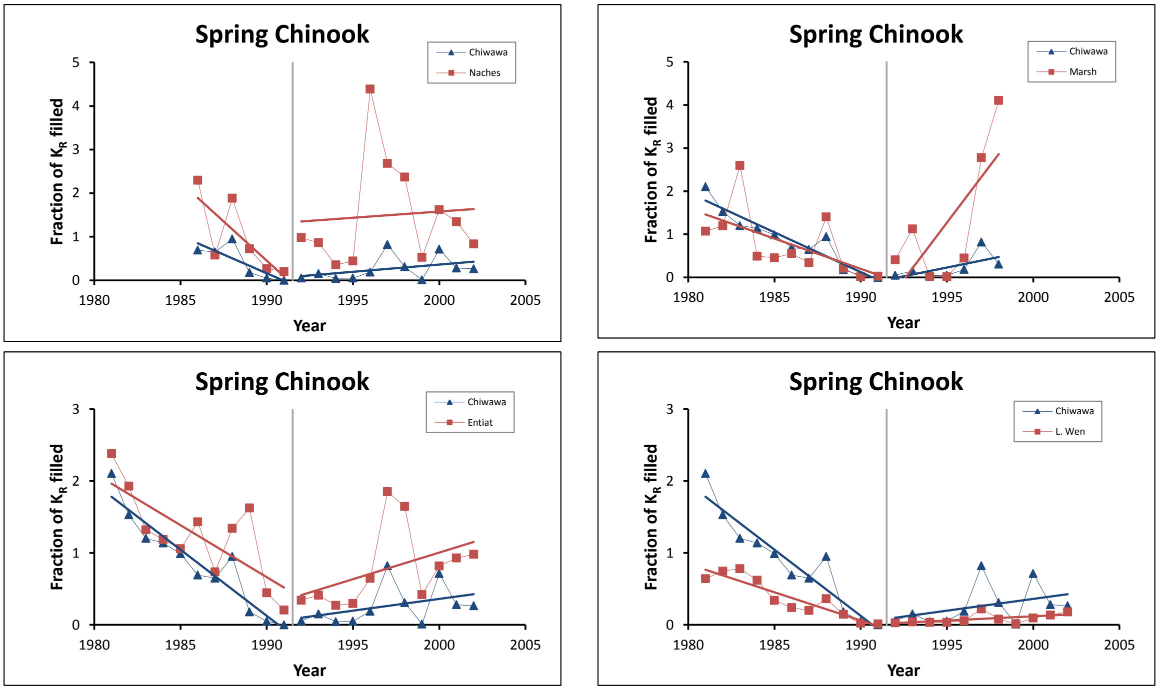

Figure 17. Trends in the fraction of the carrying capacity that was filled with Chinook salmon adult recruits in the Chiwawa and reference populations before (pre) and during (post) supplementation in Chiwawa Basin. The vertical lines in the figures separate the pre- and post-supplementation periods. The smooth hockey stick model estimated carrying capacity for each population.

We then compared the mean difference scores and ratios between the Chiwawa and reference populations before and during supplementation using data representing the fraction of K_R filled with adult recruits. In most of the Chiwawa-reference population comparisons, the absolute value of the mean difference between the fraction of K_R filled with recruits was greater in the supplementation period than during the pre-supplementation period; two of the four pairings were significant (Table 28; Figure 18). Analysis of difference scores using natural-log transformed data indicated that three of the four pairings were significant (Table 28).

Results from analyses using ratios were similar to results using difference scores. Mean ratio scores were generally smaller during the supplementation period than during the pre-supplementation period (Figure 18). This indicated that the mean fraction of K_R filled by adult recruits in most reference populations was greater during the supplementation period than during the pre-supplementation period (i.e., the denominator in the ratio increased between the pre- and post-supplementation periods). In contrast, the fraction of K_R filled by adult recruits in the Chiwawa decreased from the pre- to post-supplementation period (i.e., the numerator in the ratio decreased between the pre- and post-supplementation periods). Thus, unlike the Chiwawa population, the capacity of most reference populations was becoming more saturated during the period when the Chiwawa was being supplemented. Statistical analysis with mean ratios indicated that two of the four pairings were significant (Table 29).

Analyses comparing the Little Wenatchee with the Chiwawa indicate that adult recruits to the Little Wenatchee have been well below its carrying capacity. During the pre-supplementation period, the capacity of the Little Wenatchee was on average 37% saturated with adult recruits. During the supplementation period, the capacity of the Little Wenatchee declined to 8% saturation with adult recruits (a 22% decline). The Chiwawa, during the pre-supplementation period, was on average 86% saturated. During the supplementation period, percent saturation in the Chiwawa decreased to 26% (a 30% decrease). During the same time periods, the capacity of the Entiat population, which until recently has been supplemented, declined from 124% to 78% saturation (a 63% decline).

Table 28. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with natural origin recruits. Analyses include both transformed and untransformed data. Tests determined if the mean difference scores during the supplementation period were greater than mean difference scores during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Fraction of Capacity Filled					
Naches	1.550	0.071	0.657	0.145	-0.173 – 1.378
Entiat	0.835	0.207	0.141	0.422	-0.167 – 0.475
Marsh	2.026	0.040	1.141	0.055	0.064 – 2.054
Little Wenatchee	2.166	0.023	0.310	0.031	0.035 – 0.569
LN Fraction of Capacity Filled					
Naches	2.123	0.026	0.311	0.039	0.031 – 0.575
Entiat	1.405	0.087	0.122	0.176	-0.034 – 0.289
Marsh	2.547	0.017	0.519	0.017	0.125 – 0.864
Little Wenatchee	1.744	0.049	0.130	0.100	-0.004 – 0.273

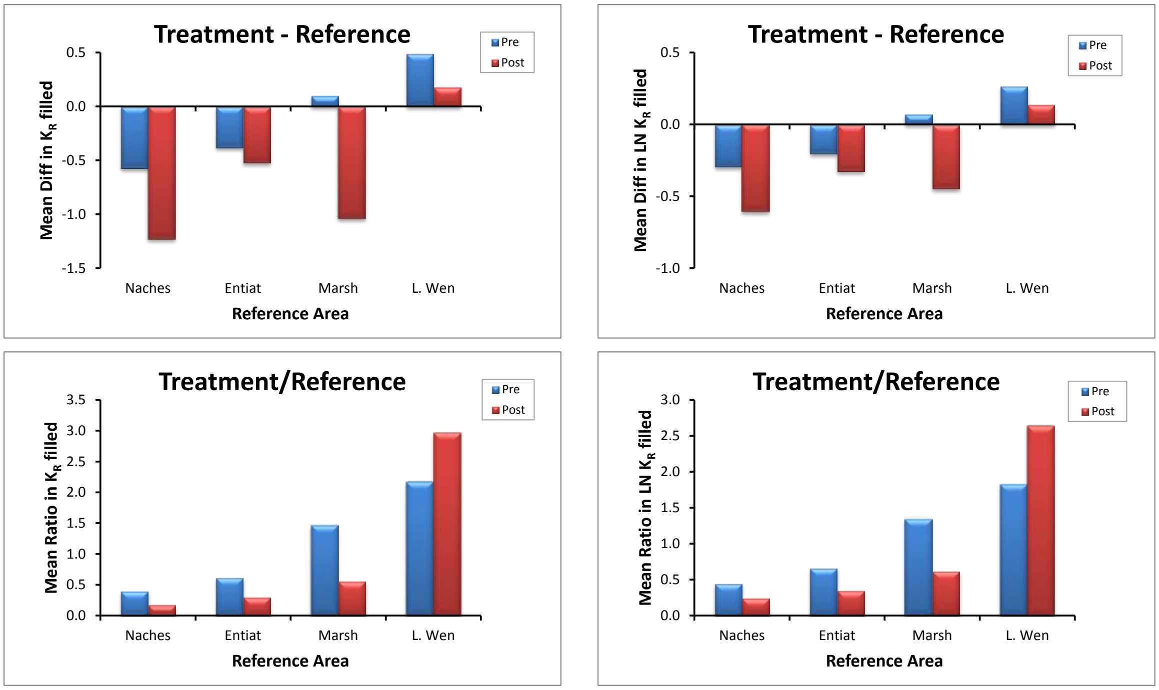

Figure 18. Mean differences (Treatment – Reference; figures on the top) and mean ratios (Treatment/Reference; figures on the bottom) of transformed and untransformed fractions of carrying capacity filled with adult recruits before (pre) and after (post) spring Chinook supplementation in the Chiwawa Basin.

Table 29. Results of the Aspin-Welch unequal-variance test, randomization test (based on 10,000 Monte Carlo samples), and 95% CI (based on 5,000 bootstrap samples) on the fraction of the habitat capacity (K_R) that is filled with natural origin recruits. Analyses include both transformed and untransformed data. Tests determined if the mean ratios during the supplementation period were less than mean ratios during the pre-supplementation period.

Reference population	Aspin-Welch unequal-variance test			Randomization test P-value	Bootstrap 95% CI
	t-value	P-value	Effect size		
Fraction of Capacity Filled					
Naches	1.317	0.119	0.217	0.219	-0.103 – 0.482
Entiat	2.449	0.013	0.321	0.028	0.085 – 0.577
Marsh	2.001	0.035	0.905	0.070	0.138 – 1.788
Little Wenatchee	-1.148	0.864	0.791	0.278	-1.979 – 0.578
LN Fraction of Capacity Filled					
Naches	1.257	0.127	0.207	0.249	-0.099 – 0.484
Entiat	2.346	0.016	0.313	0.031	0.072 – 0.583
Marsh	1.737	0.056	0.729	0.111	0.028 – 1.531
Little Wenatchee	-1.525	0.924	0.815	0.142	-1.751 – 0.195

Comparing Stock-Recruitment Curves

As a final set of treatment and reference population comparisons, we compared the stock-recruitment curves of the Chiwawa population (using {R, S} data only from the supplementation period) to the reference populations (using all available {R, S} data). Specifically, we tested whether the regression parameters were equal between the Chiwawa population and the reference populations, and whether the fitted curves coincided between populations. Earlier in this report we described the data, methods, and results of fitting the Ricker, Beverton-Holt, and smooth hockey stick curves to the data. Because AIC_c was unable to identify a best approximating model, here we included all three models in our analyses. We tested the following hypotheses.

Parameter equivalence:

Ho: Stock-recruitment parameters (α and β) of the Chiwawa population = Stock-recruitment parameters of the reference populations.

Ha: Stock-recruitment parameters (α and β) of the Chiwawa population ≠ Stock-recruitment parameters of the reference populations.

Curve equivalence:

Ho: Modeled stock-recruitment curves of the Chiwawa population = Modeled stock-recruitment curves of the reference populations.

Ha: Modeled stock-recruitment curves of the Chiwawa population ≠ Modeled stock-recruitment curves of the reference populations.

We used two-sided randomization tests to test the null hypotheses of equal model parameters and that fitted curves coincided. Because the total number of permutations was in the millions, we used a Monte Carlo approach to randomly select 10,000 permutations. The test statistic for comparing the model parameters was formed by summing the difference between the population parameter estimates for each pair of populations. The test statistic for comparing the whole curve was formed by summing the difference between the estimated predicted values for each pair of populations at 500 equally spaced points along the curve.

Ricker Relationships

Ricker curves differed significantly between the Chiwawa and reference populations (Figure 19; Table 30). Interestingly, however, the parameters in the Ricker model did not differ significantly among most populations (Table 30). Only the β parameter differed significantly between the Chiwawa and Entiat populations.

In the Ricker model, the α parameter represents intrinsic productivity (i.e., recruits per spawner at low spawner densities). In this analysis, there was not enough evidence in the stock-recruitment data to reject the hypothesis of inequality in intrinsic productivity. Thus, this test was unable to demonstrate that supplementation, based on the Ricker curve, affected productivity in the Chiwawa population.

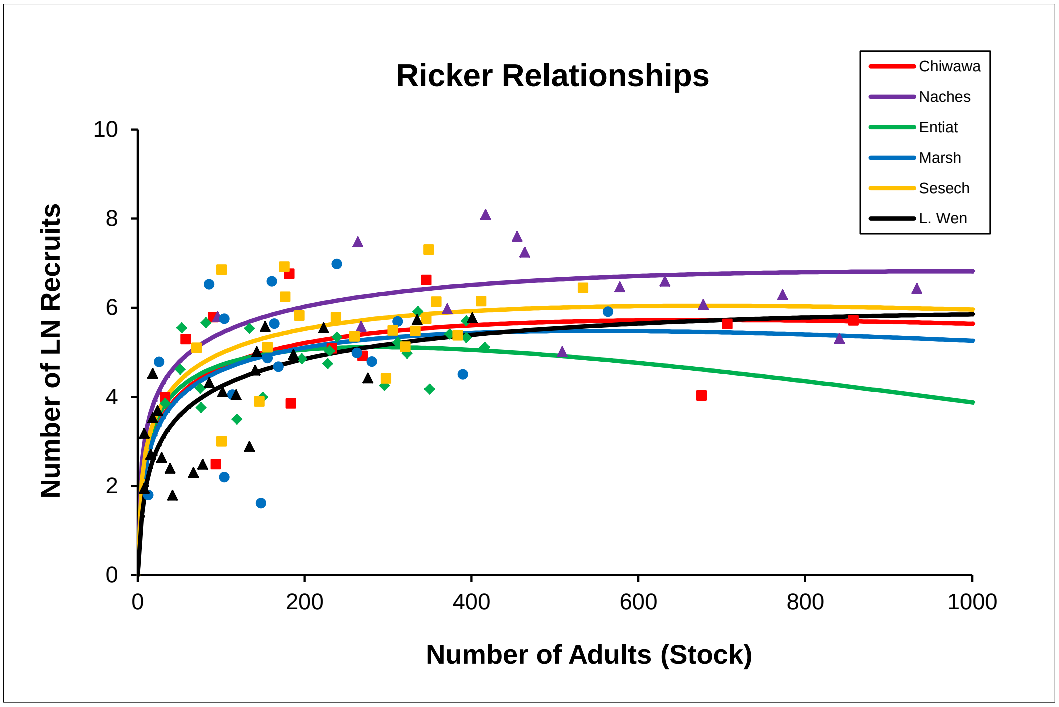

Figure 19. Scatter plot of the number of spawners and natural log adult recruits and fitted Ricker curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.

Table 30. Randomization test results comparing the equality of Ricker curves and equality of parameter values (α and β). Randomization tests were based on 10,000 Monte Carlo samples. Equality or curves was based on 500 points along the x-axis (spawner abundance axis).

Curves tested	Curve inequality randomization P-value	Parameter inequality		
		Model Parameter		Randomization P-value
		Chiwawa	Reference	
Chiwawa v. Naches	0.008	α = 1.2247	α = 2.5267	0.236
		β = 0.0015	β = 0.0010	0.600
Chiwawa v. Entiat	0.004	α = 1.2247	α = 1.5836	0.978
		β = 0.0015	β = 0.0035	0.025
Chiwawa v. Marsh	0.034	α = 1.2247	α = 1.1855	0.997
		β = 0.0015	β = 0.0018	0.688
Chiwawa v. Sesech	0.036	α = 1.2247	α = 1.6818	0.972
		β = 0.0015	β = 0.0015	0.997
Chiwawa v. L. Wenatchee	0.034	α = 1.2247	α = 0.7439	0.969
		β = 0.0015	β = 0.0008	0.203

Beverton-Holt Relationships

Beverton-Holt curves differed significantly only between the Chiwawa and Naches populations (Figure 20; Table 31). There was no significant difference in curves between the Chiwawa and the other reference populations. The parameters in the Beverton-Holt model did not differ significantly among any of the populations (Table 31). This was true even for the Chiwawa and Naches populations.

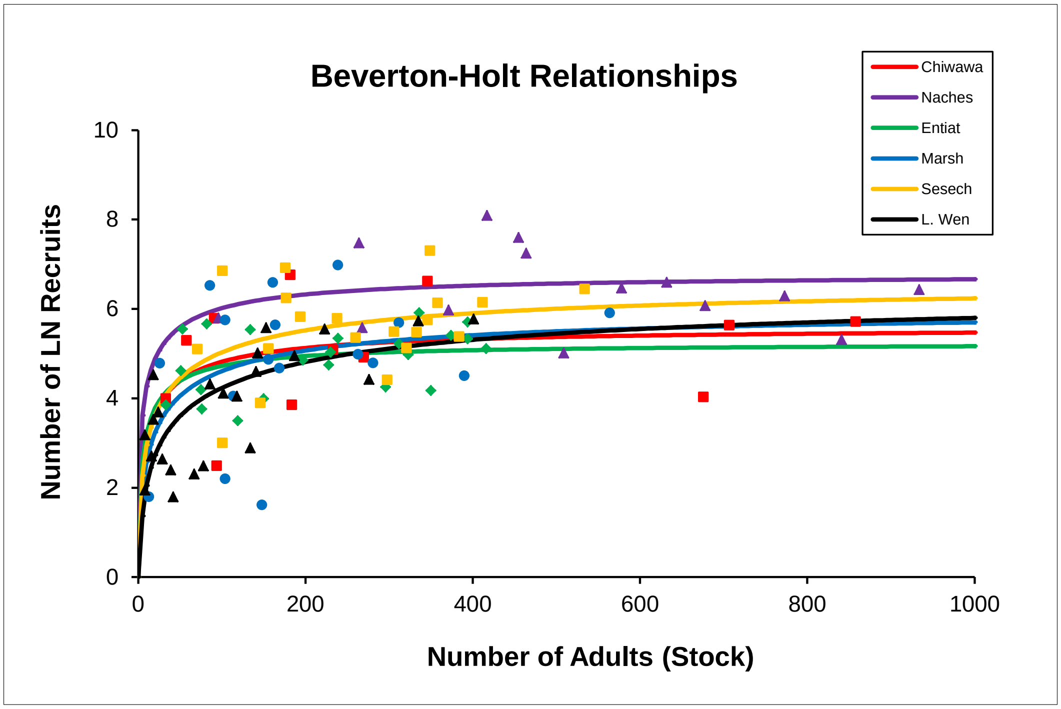

Figure 20. Scatter plot of the number of spawners and natural log adult recruits and fitted Beverton-Holt curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.

Table 31. Randomization test results comparing the equality of Beverton-Holt curves and equality of parameter values (α and β). Randomization tests were based on 10,000 Monte Carlo samples. Equality or curves was based on 500 points along the x-axis (spawner abundance axis).

Curves tested	Curve inequality randomization P-value	Parameter inequality		
		Model Parameter		Randomization P-value
		Chiwawa	Reference	
Chiwawa v. Naches	0.036	α = 264.25	α = 870.62	0.777
		β = 113.79	β = 112.24	0.963
Chiwawa v. Entiat	0.746	α = 264.25	α = 186.34	0.960
		β = 113.79	β = 65.33	0.954
Chiwawa v. Marsh	0.850	α = 264.25	α = 381.79	0.944

Curves tested	Curve inequality randomization P-value	Parameter inequality		
		Model Parameter		Randomization P-value
		Chiwawa	Reference	
		β = 113.79	β = 281.04	0.891
Chiwawa v. Sesech	0.272	α = 264.25	α = 689.31	0.821
		β = 113.79	β = 351.59	0.869
Chiwawa v. L. Wenatchee	0.654	α = 264.25	α = 568.69	0.864
		β = 113.79	β = 725.87	0.751

Smooth Hockey Stick Relationships

Smooth hockey stick curves differed significantly between the Chiwawa and Naches populations and the Chiwawa and Sesech populations (Figure 21; Table 32). There was no significant difference in curves between the Chiwawa and the other reference populations. Most of the parameters in the smooth hockey stick model did not differ significantly among the populations (Table 32). However, the productivity parameter β did differ significantly between the Chiwawa and the Naches and the Chiwawa and Little Wenatchee populations. The β parameter for the Naches was significantly greater than the Chiwawa, while the β parameter for the Little Wenatchee was significantly less than the Chiwawa.

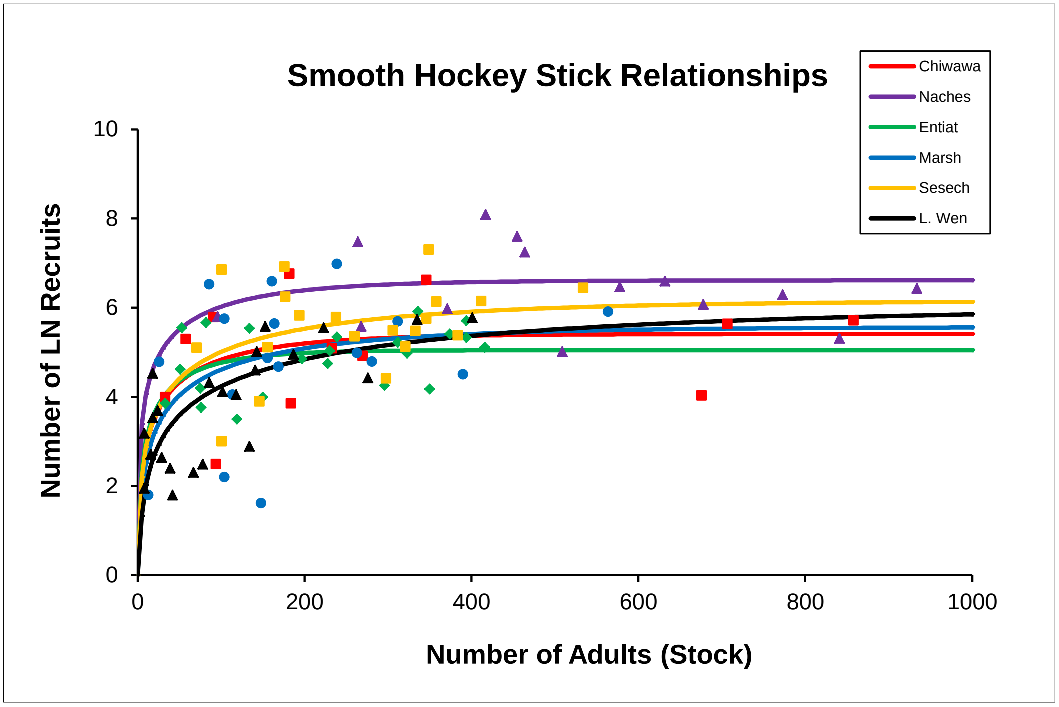

Figure 21. Scatter plot of the number of spawners and natural log adult recruits and fitted smooth hockey stick curves to the Chiwawa (supplemented population) and reference (un-supplemented) populations.

Table 32. Randomization test results comparing the equality of smooth hockey stick curves and equality of parameter values (α and β). Randomization tests were based on 10,000 Monte Carlo samples. Equality or curves was based on 500 points along the x-axis (spawner abundance axis).

Curves tested	Curve inequality randomization P-value	Parameter inequality		
		Model Parameter		Randomization P-value
		Chiwawa	Reference	
Chiwawa v. Naches	0.000	α = 5.41	α = 6.61	0.000
		β = 1.84	β = 5.99	0.000
Chiwawa v. Entiat	0.999	α = 5.41	α = 5.05	0.999
		β = 1.84	β = 2.17	0.999
Chiwawa v. Marsh	0.999	α = 5.41	α = 5.56	0.999
		β = 1.84	β = 1.27	0.999
Chiwawa v. Sesech	0.000	α = 5.41	α = 6.15	0.000
		β = 1.84	β = 1.80	0.999
Chiwawa v. L. Wenatchee	0.990	α = 5.41	α = 6.02	0.999
		β = 1.84	β = 0.75	0.000

Comparing different stock-recruitment curves and their parameters did not provide strong evidence that the supplementation program has negatively affected the productivity of the Chiwawa population.

Analysis without Reference Populations

In some cases, suitable reference populations may not exist to compare with supplemented populations. It is therefore important to have alternative analyses to assess supplementation effects. In this section, we describe methods that can be used to assess supplementation effects when suitable reference populations are not available. We discuss before-after comparisons, correlation analysis, and comparisons to standards as alternatives when reference populations are unavailable.

Before-After Comparisons

Before-after analyses compare population metrics (spawner abundance, NORs, and productivity) before supplementation to those during supplementation. In this case, data collected before supplementation represent the reference condition. The assumption is that population trajectories measured during the pre-supplementation period would continue in the absence of supplementation. We compared trends in abundance and productivity, mean abundance and productivity, and stock-recruitment relationships before and after supplementation.

Trend Analysis

Comparing trends before and after supplementation can be used to assess the effects of supplementation. Here, we compared the slopes of trends of spawner abundance, NORs, and productivity before and during supplementation using t-tests. If the hatchery program is successfully supplementing the natural spring Chinook population, the trend for spawner abundance and NORs during supplementation should be greater than the slope during the pre-supplementation period. For productivity, the slope during the supplementation period should increase or remain the same as that during the pre-supplementation period.

Visual examination of trends of Chiwawa data indicates that spawner abundance, NORs, and productivity decreased during the pre-supplementation period, but increased during the supplementation period (Figure 22). Only the changes in NOR trends were significant (Figure 22). This was true for both transformed and untransformed data.

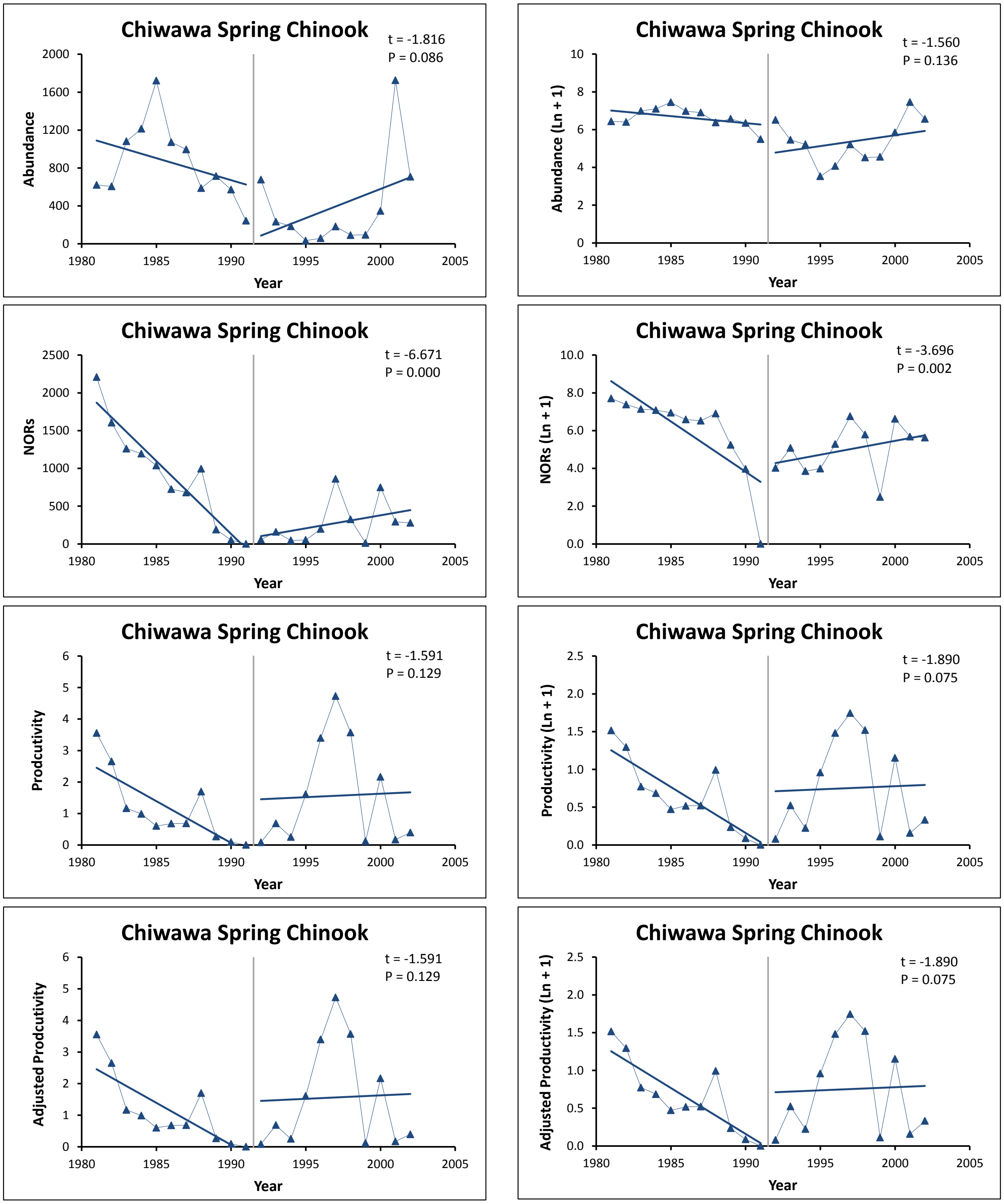

Figure 22. Trends in Chiwawa spring Chinook spawner abundance, natural-origin recruits (NORs), productivity (adults recruits per spawner), and adjusted productivity (adjusted for density dependence) before and during supplementation. The vertical lines in the figures separate the pre- and post-supplementation periods. Figures on the left show untransformed data; figures on the right include natural-log transformed data. Figures include results of t-tests comparing slope of trends before and during supplementation.

Analysis of Mean Scores

We also compared mean spawner abundance, NORs, and productivity data before and after supplementation. If the hatchery program is successfully supplementing the natural spring Chinook population, mean spawner abundance and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean productivity during the supplementation period should be equal to or higher than the pre-supplementation period. We tested the following statistical hypotheses.

Spawner Abundance and NORs:

Ho: Mean spawner abundance and NORs before supplementation ≥ Mean spawner abundance and NORs during supplementation.

Ha: Mean spawner abundance and NORs before supplementation < Mean spawner abundance and NORs during supplementation.

Productivity (Recruits/Spawner):

Ho: Mean productivity before supplementation ≤ Mean productivity during supplementation.

Ha: Mean productivity before supplementation > Mean productivity during supplementation.

We tested before-after supplementation effects using a one-tailed Aspin-Welch unequal-variance test. We also used a randomization test, based on 10,000 Monte Carlo simulations, to assess differences in spawner abundance and productivity before and during supplementation. The randomization procedure only allowed the testing of two-tailed hypotheses. Therefore, we generated 95% confidence intervals on the mean difference (μ_{pre} - μ_{post}) using bootstrapping methods to determine if the significant result from the randomization test was in the right direction. We generated 5,000 bootstrap samples to calculate confidence intervals.

Mean spawner abundance during the supplementation period was significantly less than the pre-supplementation spawner abundance (Table 33). Mean spawner abundance decreased 46% between the pre- and post-supplementation periods. Likewise, mean NORs decreased significantly between the two periods (Table 33). On the other hand, productivity increased slightly, but not significantly, between the pre- and post-supplementation periods (Table 33). This was true for both adjusted and transformed productivity data.

Table 33. Statistical results comparing mean scores of spawner abundance, natural-origin recruits (NORs), and productivity (using both untransformed and natural-log transformed) before and during supplementation of Chiwawa spring Chinook. Randomization tests were based on 10,000 Monte Carlo samples and 95% CI were based on 5,000 bootstrap samples.

Population metric	Mean scores		Test on means			
			Aspin-Welch test		Random test P-value	Bootstrap 95% CI
	Before	During	t-value	P-value		
Abundance	856	393	2.383	0.986	0.028	112 - 843
LN Abundance	6.6	5.4	3.304	0.997	0.004	0.56 – 1.99
NORs	905	275	2.846	0.993	0.009	214 – 1034
LN NORs	6.0	5.0	1.197	0.876	0.250	-0.40 – 2.54
Productivity	1.13	1.56	-0.721	0.759	0.479	-1.55 – 0.73
LN Productivity	0.64	0.75	-0.450	0.671	0.649	-0.55 – 0.35
Adj Productivity	1.12	1.56	-0.721	0.759	0.477	-1.54 – 0.71
LN Adj Productivity	0.64	0.75	-0.450	0.671	0.652	-0.57 – 0.34

Analysis of Stock-Recruitment Curves

The third method compared stock-recruitment curves of the Chiwawa population during supplementation with those generated before supplementation. Specifically, we tested whether the regression parameters were equal between the pre- and post-supplementation periods, and whether the fitted curves coincided between the two time periods. We used the methods described earlier to fit the Ricker, Beverton-Holt, and smooth hockey stick curves to the two data sets. We tested the following hypotheses.

Parameter equivalence:

Ho: Stock-recruitment parameters (α and β) of the pre-supplementation period = Stock-recruitment parameters of the supplementation period.

Ha: Stock-recruitment parameters (α and β) of the pre-supplementation period ≠ Stock-recruitment parameters of the supplementation period.

Curve equivalence:

Ho: Modeled stock-recruitment curves from the pre-supplementation period = Modeled stock-recruitment curves from the pre-supplementation period.

Ha: Modeled stock-recruitment curves from the pre-supplementation period ≠ Modeled stock-recruitment curves from the pre-supplementation period.

We were only able to fit stock-recruitment curves to the post-supplementation data. Non-linear regression was unable to converge on a solution using only pre-supplementation data. Therefore, we were unable to use this method to test supplementation effects on the Chiwawa spring Chinook population. If we could have fit curves to both the pre- and post-supplementation periods, we would have used two-sided randomization tests to evaluate the null hypotheses of equal model parameters and that fitted curves coincided.

Before describing correlation approaches, it is important to note that comparing before-after data can sometimes be misleading. For example, the spawner abundance, NORs, and productivity data presented in Figure 22 suggest that supplementation is increasing the abundance and productivity of spring Chinook in the Chiwawa Basin. However, when we compared these trends to those from reference populations during the same time periods (Figures 9-11), it becomes clear that supplementation was not responsible for increasing the trends in spawner abundance, NORs, and productivity of the Chiwawa population. Thus, whenever possible, it is wise to compare before-after data with a reference population.

Correlation Analyses

A simple way to see if the supplementation program is increasing or decreasing productivity is to assess the association between the proportion of adult spawners that are made up of hatchery adults (pHOS) and productivity (recruits/spawner). If the supplementation program is working as planned, the increase in hatchery fish spawning naturally should increase the productivity of the population. It should not decrease the productivity of the population.

We tested the association between pHOS and adult productivity[9] using Pearson correlation. During the pre-supplementation period, productivity averaged 1.13 recruits/spawner; during the supplementation period, productivity averaged 1.39 recruits/spawner. This increase in productivity did not appear to be strongly correlated with pHOS (Figure 23). Correlation analysis showed that there was no significant association between pHOS and productivity, even though productivity increased with increasing pHOS.

It is important to point out that a significant correlation between pHOS and productivity does not demonstrate cause-and-effect. Indeed, productivity is also correlated with spawner abundance and therefore it is not clear if the change in productivity is a result of spawner abundance or pHOS or both. Here, our intent is to use correlations to see if there is an association between pHOS and productivity. If a significant association exists, then additional analyses (described below) are needed to assess the association between pHOS and productivity.

[9] Note that the analysis could also include juvenile productivity (e.g., smolts/spawner).

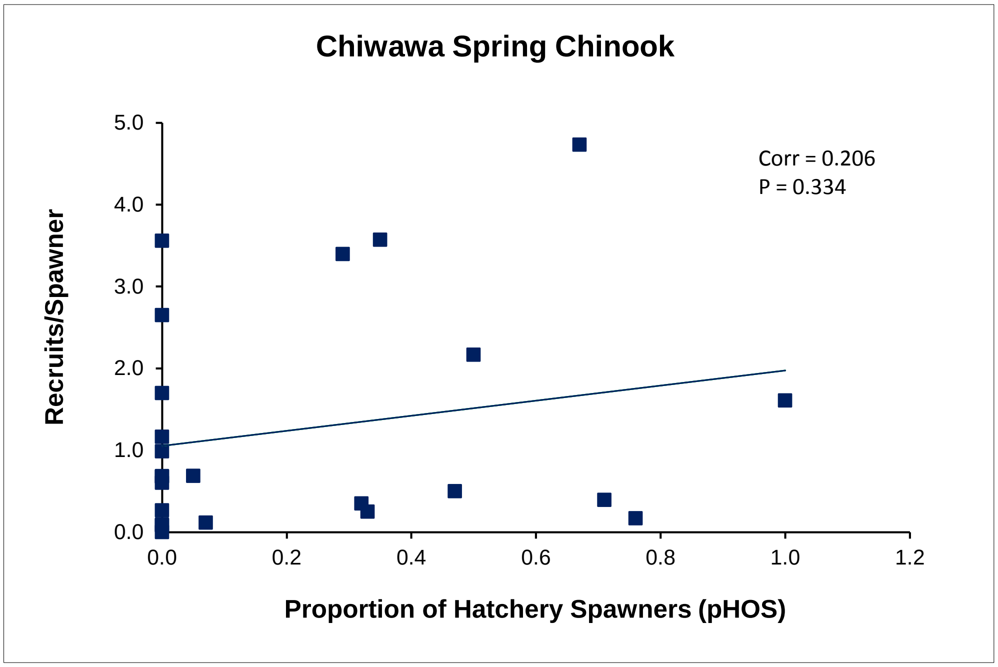

Figure 23. Association between the proportion of spawners that are made up of hatchery adults (pHOS) and the number of natural-origin recruits. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figure.

Because the association between pHOS and productivity can be confounded with spawner abundance, we used correlation to test the association between pHOS and the residuals from stock-recruitment curves fitted to the Chiwawa spawner and natural-origin recruitment data. This approach removes the effects of density dependence on the relationship between pHOS and productivity. A significant negative association provides evidence that hatchery-origin spawners may not be as productive as natural-origin spawners.

The Ricker, Beverton-Holt, and smooth hockey stick models were fit to the Chiwawa stock and recruitment data (including {S, R} data from both the pre- and post-supplementation period, 1981-2004) using methods described earlier. Residuals were calculated by subtracting the predicted recruitment values from the observed (modeled) values. Pearson correlation then tested the association between pHOS and the residuals from each model.

Although there was a negative trend in residuals with increasing pHOS, suggesting that hatchery-origin spawners may not be as productive as natural-origin spawners, the association was not significant (Figure 24). Thus, based on these analyses, there is no strong evidence that the supplementation program has significantly benefited or harmed the natural spring Chinook population.

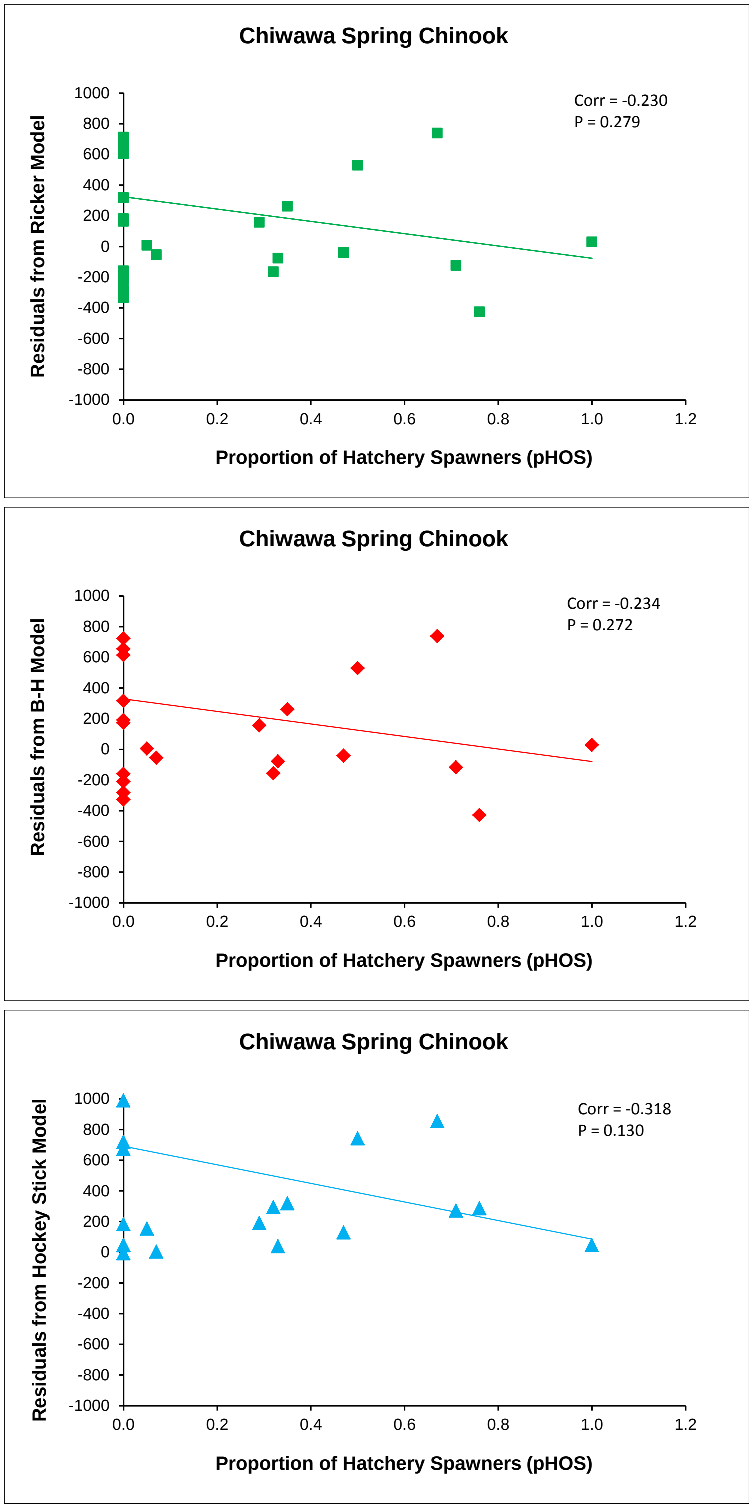

Figure 24. Association between the proportion of spawners that are made up of hatchery adults (pHOS) and the residuals from Ricker, Beverton-Holt (B-H), and smooth hockey stick stock-recruitment models. The Pearson correlation coefficient (Corr) and its P-value (P) are shown in the figures.

Comparison to Standards

In those cases in which suitable reference populations are not available and there are no pre-supplementation data, the investigator is left with comparing population parameters to relevant standards. Standards can include performance of natural-origin fish in similar environments (a type of reference condition), mitigation requirements, quantitative objectives of the program, Biological Assessment and Management Plan (BAMP) values, or other appropriate standards. An example of a statistical hypothesis would be:

Ho: Productivity (Recruits/Spawner) of the supplemented population ≥ standard productivity.

Ha: Productivity (Recruits/Spawner) of the supplemented population < standard productivity.

For these analyses to be useful, the standards must be based on biological reality. Statistical procedures such as one-sample t-tests, quantile tests, or randomization tests could be used to test the hypotheses.

Conclusions and Recommendations

Hatcheries are an important component of fish production within the Upper Columbia Basin. The goal of some of these programs is to supplement natural production in declining populations. The supplementation programs generally use both hatchery and natural (spawned and reared in nature from either wild or hatchery parents) adults for hatchery broodstock. These programs are designed to supplement natural populations by increasing natural reproduction while preventing the establishment of a domesticated hatchery stock. Thus, the programs should increase total spawning escapement and NORs, and not reduce the productivity of the natural population. Measuring the success of these programs is challenging and expensive.

In this paper, we described methods that can be used to determine if supplementation programs are achieving some of their goals. This paper focused on the use of reference populations to determine if the supplementation programs increase total spawning escapement, NORs, and maintain or increase productivities. In some cases, suitable reference populations may not be available (e.g., we found no suitable reference populations for Upper Columbia steelhead and sockeye). In these cases, alternative methods are needed to assess supplementation effects. We also described these alternative methods in this paper.

Identification of Reference Populations

Finding suitable reference populations that match well with supplemented populations is a difficult and time-consuming process. Our three-step selection process included identification of populations with similar life-history characteristics, few or no hatchery spawners, a long time series of accurate abundance and productivity estimates, and similar freshwater habitat impairments and out-of-basin effects. Those populations that met these criteria (or most of the criteria) were then examined for their relationship with the supplemented population (in this case, the Chiwawa spring Chinook population). Several criteria were scored, including pNOS, correlation, trend, and effect size.

Reference populations with total weighed scores of 81 or greater were selected as suitable reference populations.

This selection process provided a valuable framework for selecting suitable reference populations for supplemented populations. Interestingly, we found that a given reference population may match well with one parameter of the supplemented population (e.g., spawning escapement), but not for all parameters (e.g., not NORs or productivity). The reason for this may be related to errors in the estimation of population parameters and/or differential factors limiting population parameters of supplemented and reference populations. Therefore, depending on the parameter analyzed, a different suite of reference populations may be needed.

An important assumption in the use of reference populations is that the supplemented and reference populations that tracked each other before supplementation would continue to track each other in the absence of supplementation. Given that the reference populations did not match the Chiwawa population on all criteria examined, and some reference populations tracked the Chiwawa population more poorly than others, there may be some uncertainty as to whether differences observed between the supplemented and reference populations during the supplementation period are associated with the hatchery program, or other unaccounted factors. For example, any large-scale change (man-made or natural) within the reference or supplemented population could affect our ability to assess the effectiveness of the supplementation program.

To account for some of these uncontrollable factors, we recommend the use of a "causal-comparative" approach to strengthen the certainty of our inferences. This approach relies on correlative data to try and make a case for causal inference. We recommend that the following state variables be measured and tracked within the supplemented and reference populations: mean annual precipitation, total and riparian forest cover, road density, impervious surface, and alluvium. These variables can be used to describe differences in water temperatures at different life stages (pre-spawning, egg incubation, and summer rearing) and substrate characteristics, including fine sediments and embeddedness. These state variables can be used to help explain possible changes in spawner abundance, NORs, and productivity that are independent of supplementation. In addition, the use of multiple reference streams reduces the possibility that man-made changes to a single reference stream will influence the interpretation of the results.

Analyses with Reference Populations

Using reference populations, we evaluated the effects of supplementation on natural-log transformed and untransformed total spawning escapement, NORs, and productivity by comparing trends, analyzing mean differences, ratios, and rates, and comparing stock-recruitment curves and their parameters. For trend analysis, we compared the slopes of the trends between each supplemented/reference pair before and during supplementation. If the hatchery program is successfully supplementing the natural population, trends in spawner abundance and NORs should deviate significantly during the supplementation period (i.e., the slope of the supplemented population should be greater than the slopes of the reference populations during the supplementation period), but not during the pre-supplementation period. For productivity, the slope of the supplemented population, relative to the reference population, should increase or remain the same.

Because trend analysis only tests the slopes of the trend lines, it does not test for differences in elevations of the trend lines, additional analyses were needed to determine if supplementation increased spawner abundance, NORs, and productivity of the target population without changing the slopes of the trend lines. To do this, we derived three different response variables using natural-log transformed and untransformed spawner abundance, NORs, and productivity data. The first derived variable included difference scores, which were calculated as the difference between paired treatment and reference data (T-R). The second included ratios, which were calculated as the ratio of paired treatment and reference data (T/R). Finally, we calculated the differences in annual changes in paired treatment and reference population data (ΔT-ΔR). If the hatchery program is successfully supplementing the natural population, the mean difference or ratio score of paired spawner abundance data and NORs during the supplementation period should be greater than the pre-supplementation period. For productivity, the mean difference or ratio score during the supplementation period should be equal to or higher than the pre-supplementation period.

As a final set of analyses, we compared the stock-recruitment curves of the supplemented population (using stock and recruitment data only from the supplementation period) to the reference populations (using all available stock and recruitment data). Specifically, we tested whether the regression parameters were equal between the supplemented population and the reference populations, and whether the fitted curves coincided between populations. Here, we were most interested in comparing the productivity parameters in the models.

Surprisingly, these different analyses yielded similar results when they were applied to the Chiwawa spring Chinook and reference population data. Trend analysis was unable to detect a significant difference in trends between the supplemented and reference populations during the supplementation period. Even though we measured an increasing trend in spawner abundance, NORs, and productivity in the supplemented population during the supplementation period, these same parameters trended upward in the reference populations. Likewise, we were unable to detect a significant supplementation effect using difference scores, ratios, and differences in annual changes. However, we found the results from analysis of mean differences of annual change difficult to interpret and they may be insensitive to treatment effects. A simpler analysis, which is also easier to interpret, is to use trend analysis. Finally, comparing stock-recruitment curves and their parameters did not provide strong evidence that supplementation has affected the productivity of the natural population.

Based on these results, we do not recommend using difference scores of annual change (ΔT-ΔR), nor do we recommend comparing stock-recruitment curves and their parameters. As noted above, difference scores of annual change are difficult to interpret and may be redundant with trend analysis. Testing stock-recruitment curves and their parameters appears redundant with testing differences in productivity using difference scores or ratios. In addition, the analyses are computer intensive and do not appear to be very sensitive to changes.

There was little difference in results using difference scores and ratios. It appears that ratios may be more sensitive to change than difference scores (e.g., we found significant differences in some comparisons using ratios but not with difference scores), but ratios can be more difficult to interpret than difference scores. Nevertheless, we recommend the use of ratios in future analyses.

Correcting for Density Dependence and Carrying Capacity

The analyses described so far assumed that the density of spawners or recruits did not affect the survival and productivity of fish. However, without controlling for density effects, productivity of the population would continue to decline with increasing abundance. This scenario could occur in supplementation programs that increase the number of spawners, and could result in lower productivities relative to reference populations. In addition, lower productivities may be caused by differential environmental carrying capacities rather than the capacity of the supplemented fish to produce offspring. Therefore, we described two different methods for deriving density-corrected estimates of productivity. The first controlled the effects of density on productivity by partitioning observed productivities into density-independent and density-dependent productivity. These productivities were then combined in a single test. The second method corrected for differences in carrying capacities between the supplemented and reference populations. This was accomplished by calculating the percent saturation of NORs, which was estimated as the ratio of observed NORs to the maximum number of NORs that the habitat could support.

We fit Ricker, Beverton-Holt, and smooth hockey stick models to stock and recruitment data to estimate the maximum number of NORs (NORs at carrying capacity) and the maximum number of spawners needed to produce maximum NORs. We fit models to the supplemented and reference populations. Using information-theoretic criterion and evaluating the precision of estimated parameters, we found that the smooth hockey stick model provided the best estimates of maximum NORs and spawners. We used these modeled values to estimate density-independent and density-dependent productivities, and saturation of NORs.

Statistical analyses, using difference scores and ratios of adjusted Chiwawa spring Chinook productivity data, found no significant effects of supplementation on the productivity of the supplemented population. Indeed, the results from correcting for density dependence were similar to those without correcting for density dependence. This is in part because the abundance of the supplemented and reference populations has been below their respective carrying capacities in most years. This was clearly demonstrated in the analyses of NORs corrected for carrying capacity. In the supplemented population, the mean fraction of the carrying capacity filled with NORs decreased significantly during the supplementation period. In other words, the carrying capacity was filled with more NORs during the pre-supplementation period than during the supplementation period, which is contrary to the goal of supplementation. By comparison, two of the reference populations showed a similar decrease in saturation, while the other two reference populations actually increased in saturation. Analyzing the saturation scores using BACI-design analyses indicated that two of the four pairings differed significantly. That is, the percent saturation of the supplemented population decreased significantly relative to two reference populations.

Because productivity can be affected by the abundance of spawners and recruits, we recommend that future analyses comparing supplemented and reference populations adjust for density-dependent effects and differential carrying capacities. Although we detected only slight differences between adjusted and unadjusted results, as supplemented stocks recover, it will become more important to adjust productivities to account for density dependence. Importantly, the analyses using percent saturation placed NORs in the context of the carrying capacity of the environment. This will help managers determine if supplementation programs are filling or over-filling the capacity of the habitat with NORs.

As we noted earlier, analyses using productivities adjusted for density dependence assume that there is a spawner abundance at which density-independent effects end and density-dependent effects begin. In reality, density-dependent effects occur at low spawning abundance and intensify as spawning abundance increases. We did not account for these increasing density-dependent effects at lower spawner abundances. This is an area that needs additional attention.

Analyses without Reference Populations

Because of the rigorous criteria we used to select reference populations, it is likely that reference populations may not exist for making comparisons with supplemented populations. For example, we used the criteria described in this paper to identify reference populations for supplemented steelhead and sockeye populations in the Upper Columbia Basin. We were unsuccessful in identifying any suitable reference populations. Therefore, in the absence of suitable reference populations, it is important to have alternative methods for assessing supplementation effects. We described three different types of analyses one can use to assess supplementation effects in the absence of reference populations. They include before-after comparisons, correlation analysis, and comparisons to standards.

Before-after analyses compare population metrics before supplementation with those during supplementation. In this case, data collected before supplementation represent the reference condition. The assumption is that population trajectories measured during the pre-supplementation period would continue in the absence of supplementation. We compared trends in spawner abundance, NORs, and productivity before and after supplementation. In addition, we compared mean scores in these three parameters before and after supplementation. Finally, we attempted to compare stock-recruitment parameters before and after supplementation. The hypotheses examined were that the spawner abundance and NORs would be greater during the supplementation period, and that productivities would not decline during the supplementation period.

Trend analysis indicated that the all three Chiwawa spring Chinook population parameters trended downward during the pre-supplementation period, but trended upward during supplementation. On the other hand, mean spawner abundance and NORs were lower during the supplementation period than during the pre-supplementation period. Mean productivities increased, but not significantly, during the supplementation period. We were unable to compare pre- and post-supplementation stock-recruitment curves because we were unable to fit stock-recruitment models to the pre-supplementation data.

We used correlation analyses to determine if productivity was associated with the proportion of hatchery-origin fish that spawn naturally on the spawning grounds (pHOS). Because the association between productivity and pHOS can be confounded with spawner abundance (density dependent effects), we also used correlation to assess the association between pHOS and the residuals from stock-recruitment relationships. A significant negative association may suggest that hatchery-origin spawners are not as productive as natural-origin spawners. The analysis indicated that the productivity of Chiwawa spring Chinook increased with increasing pHOS, but the association was not significant. In contrast, there was a negative association between pHOS and the stock-recruitment residuals, but again the association was not significant.

In concert, the before-after comparisons and correlation analyses do not provide conclusive evidence that the supplementation program has increased spawner abundance and NORs, or that it has significantly reduced the productivity of the supplemented population. Although increasing the number of hatchery fish on the spawning grounds appears to reduce NORs and productivity, mean productivity actually increased during the supplementation period compared to the pre-supplementation period.

It is important to note that relying on only one set of analysis could result in drawing a wrong conclusion. For example, if we had only conducted trend analysis, we may have concluded wrongly that the Chiwawa spring Chinook supplementation program significantly increased spawner abundance, NORs, and productivity in the supplemented population. The analysis of mean scores and correlations indicates that the supplementation program has not increased spawner abundance or NORs in the supplemented population. Therefore, in the absence of suitable reference populations, we recommend that analyses include the evaluation of trends, means scores, and correlations. By conducting more than one set of analyses, one can use weight-of-evidence to assess the effects of supplementation programs.

Under the scenario that there are no reference populations or pre-supplementation data, one is left with comparing population parameters to relevant standards. These standards could come from mitigation requirements, quantitative objectives, or published or unpublished standards. One could also use correlation to evaluate the association between productivity (adjusted for density dependence) and pHOS, but this requires a wide range in pHOS values to be most meaningful. A more extreme approach, which probably would not gain much traction with managers, is to shutoff the supplementation program for some time and then evaluate the effects of the program in a before-after design. The Entiat spring Chinook hatchery program provides a unique opportunity to evaluate this type of management decision.

Some Concerns and Limitations

No matter how hard we try to explain different sources of variation in population data, we are limited by the quality of the data. Teasing out the effects of supplementation requires long time series of population data. Because funding levels and methods change over time, the quality (i.e., accuracy and precision) of the data also changes over time. Importantly, the population parameters examined in this paper (spawner abundance, NORs, and productivity) are rarely measured directly in the field. That is, other population metrics, such as numbers of redds, number of fish counted at weirs or dams, scales, tags, etc., are sampled in the field. These metrics are then used to calculate spawner abundance[10], NORs, and productivity, often based on assumptions about fish/redd, pre-spawning loss, marking rates, and sampling rates. This has a tendency to increase the variability in the data independent of supplementation programs. In our studies, we can only control sampling within the supplemented populations, and even that is limited by available funding. We have no control over the sampling within reference populations. Thus, we have to assume that sampling within the reference populations will continue and that sampling effort will remain comparable to that in the supplemented populations.

In our analyses, we included both the Entiat and Little Wenatchee populations as references for the Chiwawa population. In the analyses, we treated them as equivalent to the other reference populations. That is, the statistical procedures used to compare the supplemented population to each reference population were identical. This is appropriate. However, the interpretation of the results must be different when comparing the Entiat and Little Wenatchee to the supplemented population, because they are populations that were influenced by hatchery fish. As noted earlier, the Entiat spring Chinook hatchery program has been discontinued. Therefore, it provides a unique type of reference where the comparison changes from both populations being supplemented to only one population being supplemented. For the Little Wenatchee, nearly all the strays came from the Chiwawa program. Straying should stop or be greatly reduced with the change in water supply to the Chiwawa Rearing Ponds. In sum, one must be careful in how they interpret these test-reference results.

Finally, it is important to point out that for this paper, we conducted 463 statistical tests. Because we set our Type I error rate at 0.05, by random chance alone, we may have incorrectly rejected about 23 null hypotheses. Inasmuch as this work was designed to evaluate different ways to analyze test-reference data, the number of future analyses will be greatly reduced based on the results from this work. However, if the Type I error rate is a concern to managers, researchers can use a lower error rate, such as $\alpha = 0.01$. Another option is to analyze test-reference data graphically. Although this is subjective, there are no statistical analyses and therefore no concerns with violating assumptions of statistical tests, including temporal correlation. We believe researchers should use the statistical procedures recommended in this report to support graphic analysis.

[10] The smooth hockey stick model, which we used to estimate density-dependent correction factors for productivity and NORs, is sensitive to errors in spawner escapement estimates. Therefore, it is important to use accurate and precise estimates of spawner escapement.

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Appendix D

METHODS FOR ESTIMATING HATCHERY REPLACEMENT RATES

Methods for Estimating Hatchery Return Rates (HRRs)

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In this paper, we document the methods used to estimate hatchery replacement rates (HRRs) used in the hatchery evaluation annual report and five year program evaluation review (Hillman et al. 2011). Hatchery replacement rates are used to monitor the productivity of hatchery produced salmon and steelhead from one generation to the next. Increased survival that occurs during early life stages (i.e., egg-to-smolt) must be adequate for hatchery reared fish to overcome the survival disadvantage after release (i.e., smolt-to-adult).

Hatchery replacement rates are based on the release, recovery, and expansion of coded wire tagged (CWT), visual implant elastomer tagged (VIE), and passive integrated transponder tagged (PIT) hatchery fish. CWT's were used to evaluate all hatchery return rates for Chelan's Chinook hatchery programs. Visual implant elastomer tags were used for steelhead and will be explained in a different section of this paper. In the last section, sockeye HRR estimates were developed based on hatchery run reconstruction from Tumwater Dam counts, returning age structure, wild-hatchery ratios, and harvest estimates provided by the Joint Staff report (ODFW and WDFW 2011). PIT-based HRR estimates for steelhead and sockeye have also been generated, although they do not currently appear in the annual reports or five-year analysis. PIT-based HRR estimates have not been reviewed by the HETT and the methods may be modified upon review. For now, the PIT-based HRR method is an introduction to using PIT tags for developing HRR estimates. For steelhead, there are several years of PIT-based HRR estimates to compare with VIE tag estimates. For sockeye, however, there is currently no overlap in PIT tag and hatchery run-reconstruction estimates to provide a comparison.

In objective 4, the hypothesis compares the brood year (BY) performance in adult-to-adult survival of naturally produced and hatchery produced fish (Murdoch and Peven 2005).

Objective 4 Hypothesis:

- Ho: The hatchery replacement rate is greater than or equal to the natural replacement rate for the same year.

Thus, objective 4 is a comparison of the natural replacement rate (NRR) to the hatchery replacement rate (HRR). Table 1 displays guidelines for expected HRR's for Chelan's hatchery programs.

Table 1. Expected hatchery replacement rates (HRR) for stocks raised in the Chelan PUD Hatchery Programs (from Table 6 in Appendix D of Murdoch and Peven 2005).

Program	Number of broodstock	Smolts released	SAR	Adult equivalents	Number of smolts/adult	HRR
Chiwawa Spring Chinook	379	672,000	0.003	2,016	333	5.3
Wenatchee Summer Chinook	492	864,000	0.003	2,592	333	5.3
Similkameen Summer Chinook	328	576,000	0.003	1,728	333	5.3
Methow Summer Chinook	228	400,000	0.003	1,200	333	5.3
Wenatchee Sockeye	260	200,000	0.007	1,400	143	5.4
Wenatchee Steelhead	208	400,000	0.010	4,000	100	19.2

There are two HRR estimates that are identified in the annual report (Hillman et al. 2011). First, there is the number of adult hatchery salmon that survive to return to spawn naturally or may be collected as broodstock. The second is an estimate of the hatchery replacement rate based on hatchery fish that survived to return to spawn plus those that were harvested. In the following sections, we describe the CWT data used to produce hatchery replacement rates for each brood year of spring Chinook released from the Chiwawa River Hatchery. Spring Chinook from the Chiwawa Hatchery are used as an example, although the methods apply to all Chelan's hatchery Chinook programs. The following data were used to estimate HRRs:

1. CWT Release Information (RMIS database)
2. CWT Recovery Data (RMIS database)
3. Broodstock Collection

CWT Release Information

Coded wire tag release information was queried from the Regional Mark Process Center's Regional Mark Information System (RMIS) website (http://www.rmpc.org/) based on unique tag codes released each year from the Chiwawa Hatchery. Table 1 presents coded wire tag information for spring Chinook salmon released from the Chiwawa Hatchery. Coded wire tagged juvenile spring Chinook have been released from the Chiwawa Hatchery since 1989, with the exception of 1995 and 1999 when there was no supplementation program.

Table 1. CWT release information for Chiwawa hatchery spring Chinook. Data queried from Regional Mark Process Center's Regional Mark Information System (RMIS).

Brood Year	Tag Code	Tagged	Untagged	Total Released	Tag Rate
1989	631156	42,707	292	42,999	0.993
1990	634014	49,488	346	49,834	0.993
	634319	3,310	23	3,333	0.993
1991	634335	1,124	20	1,144	0.983
	634646	19,677	325	20,002	0.984
	635952	40,287	705	40,992	0.983
1992	634748	40,766	1,127	41,893	0.973
	634751	42,210	1,010	43,220	0.977
1993	635326	110,963	1,405	112,368	0.987

Brood Year	Tag Code	Tagged	Untagged	Total Released	Tag Rate
	635327	110,353	889	111,242	0.992
1994	635352	27,135	91	27,226	0.997
1995	No Program				
1996	636137	12,767	2,409	15,176	0.841
1997	630740	259,585	6,563	266,148	0.975
1998	631102	71,571	4,335	75,906	0.943
1999	No Program				
2000	630791	46,726	378	47,104	0.992
2001	630876	40,457	158	40,615	0.996
	631448	182,389	2,665	185,054	0.986
	631451	151,283	592	151,875	0.996
2002	631389	145,074	4,594	149,668	0.969

Tag rates for hatchery Chiwawa spring Chinook have ranged from 84% to 99%. The tag rate is the number of tagged fish released divided by the total number of fish released. For example, in brood year 2002 (tag code 631389) there was 145,074 tagged fish released of the total 149,668 fish released (4,594 untagged fish released). For this brood year, the tag rate was 96.9% (145,074/149,668 = 0.969). The tag rate is used to account for the number of untagged hatchery fish.

CWT Recovery Data

Coded wire tags can be recovered in ocean and freshwater fisheries (harvest), from volunteer and non-volunteer hatchery locations (broodstock collection), and from spawning ground surveys. Table 2 presents an example of brood year recoveries (BY 1998) that were used to produce HRR estimates. Recoveries are separated into harvest and hatchery/spawning locations. We used the PSC fishery and recovery location descriptions to help define the type of recovery. Similar to stray estimation, we designated categories to define the fate of each fish.

The RMIS database provided an observed and estimated number of CWT fish recovered at each location (Table 2). The observed number is simply the number of fish recovered with a CWT. The estimated number of CWT's is derived from an extrapolation of the observed number based on a sampling rate. The purpose of expanding the observed number of CWT's to an estimated number is to account for the portion of the catch not sampled. In some instances, the RMIS database did not provide an estimated number for CWT's recovered (e.g., Foreign Research Vessel). In such instances, we used the observed number.

Table 2. Recoveries of coded wire tagged spring Chinook salmon from brood year 1998 (tag code 631102) released from the Chiwawa Hatchery in 2000.

Recovery Year	PSC Fishery	Recovery Location	Fate	Number of CWT's		Tag Rate Expansion	
				Observed	Estimated	Actual	Rounded
2000	Foreign Research Vessel	High Seas 2 49N 127 W	Harvest	1	1	1.06	1
2000	Foreign Research Vessel	High Seas 3 54N 133 W	Harvest	1	1	1.06	1
2002	Columbia River Gillnet	Col R Tongue Pt Post	Harvest	1	2	2.12	2
2002	Columbia River Gillnet	Col R Zone 2 Net	Harvest	2	5	5.30	5
2002	Columbia River Gillnet	Youngs Bay Net Area	Harvest	1	3	3.18	3
2002	Ocean Troll (non treaty)	SWTR 023-000	Harvest	1	2	2.12	2
2002	Columbia River Sport	Col R OR Sport Sec 1	Harvest	6	29	30.76	31
2002	Columbia River Sport	Col R OR Sport Sec 2	Harvest	2	12	12.73	13
2002	Columbia River Sport	Col R OR Sport Sec 4	Harvest	1	6	6.36	6
2002	Columbia River Sport	Col R OR Sport Sec 10	Harvest	2	12	12.73	13
2002	Columbia River Sport	Col R WN Sport Sec 1	Harvest	4	24	25.45	25
2002	Freshwater Sport	Icicle Creek 45.0474	Harvest	1	17	18.03	18
2002	Columbia River Gillnet	Bonneville Pool Net	Harvest	5	13	13.79	14
2002	Columbia River Gillnet	John Day Pool Net	Harvest	4	11	11.67	12
2002	Columbia River Gillnet	The Dalles Pool Net	Harvest	3	11	11.67	12
2002	Freshwater Net	Priest Rapids E LAD	Harvest	4	4	4.24	4
2002	Freshwater Net	Vernita Bar (36)	Harvest	3	3	3.18	3
2003	Columbia River Gillnet	Col R Zone 2 Net	Harvest	1	2	2.12	2
2003	Ocean Troll (non treaty)	AK M 1 NE 109-61	Harvest	1	3	3.18	3
2003	Ocean Troll (non treaty)	NTR 035-000	Harvest	1	1	1.06	1
2003	Ocean Troll (non treaty)	Newport Troll 3	Harvest	1	1	1.06	1
2003	Columbia River Sport	Col R OR Sport Sec 1	Harvest	1	5	5.30	5
2003	Columbia River Sport	Col R OR Sport Sec 2	Harvest	3	14	14.85	15
2003	Columbia River Gillnet	The Dalles Pool Net	Harvest	1	2	2.12	2
Harvest Total							**194**
2001	Hatchery	Chiwawa Hatchery	Hatchery Homing	4	4	4.2	4
2002	Hatchery	Dryd Dam+Tum FCF+Chiw.	Hatchery Homing	47	55	58.3	58
2003	Hatchery	Dryd Dam+Tum FCF+Chiw.	Hatchery Homing	43	44	46.7	47
2001	Spawning Ground	Chiwawa + Chikamin	Natural Homing	11	26	27.6	28
2001	Spawning Ground	Nason Creek 45.0888	Natural Straying	5	8	8.5	8
2001	Spawning Ground	Wenatchee River 45.0030	Natural Straying	1	2	2.1	2
2002	Spawning Ground	Chiwawa River 45.0759	Natural Homing	109	410	434.8	435
2002	Spawning Ground	White River 45.1116	Natural Straying	3	10	10.6	11
2002	Spawning Ground	Entiat River 46.0042	Natural Straying	5	27	28.6	29
2002	Spawning Ground	Icicle Creek 45.0474	Natural Straying	2	9	9.5	10
2002	Spawning Ground	Little Wenatchee 450985	Natural Straying	5	14	14.8	15
2002	Spawning Ground	Wenatchee River 45.0030	Natural Straying	14	41	43.5	43
2002	Spawning Ground	Nason Creek 45.0888	Natural Straying	82	164	173.9	174
2003	Spawning Ground	Nason Creek 45.0888	Natural Straying	5	11	11.7	12
2003	Spawning Ground	Wenatchee River 45.0030	Natural Straying	5	24	25.5	25
2003	Spawning Ground	Chiwawa River 45.0759	Natural Homing	20	85	90.1	90
Hatchery and Spawning Ground Total							**991**
Total Recoveries:							**1,185**

We used the tag rate specific to each tag code to expand the estimated recoveries to account for the untagged portion of hatchery fish. To expand by tag rate, we divided the estimated recoveries by the appropriate tag rate. For example, there was an estimated 85 fish recovered in the Chiwawa River in 2003 that was expanded to 90 fish (85/0.943 = 90 fish) (Table 2). Expanding by tag rate creates decimal fish values (actual) that we rounded off to whole numbers before summing across different recovery locations or years (Table 2). Recoveries for each brood year are summed to estimate the total number of hatchery fish that returned to spawn or were harvested.

Chinook HRR Estimates

The CWT recovery information was summarized based on brood year and on the assigned fate categories to evaluate HRR estimates with and without harvest included (Table 3). The hatchery return rate was estimated as the sum of returning adults divided by the number of broodstock collected, less any fish released. For example, the two HRR estimates produced for brood year 2000 were 7.38 (without harvest 354/48 = 7.38) and 7.85 (with harvest 377/48 = 7.85). To better understand HRR values, a hatchery replacement rate less than one indicates that adult hatchery returns for a brood year did not replace the parent broodstock population, while a replacement rate greater than one suggests that the returning adults more than replaced their parent broodstock population. The average replacement rate for the fourteen years evaluated was 6.47 (without harvest) and exceeded the guideline of 5.3.

Table 3. CWT recovery data and broodstock collection used to produce estimates of hatchery replacement rates for Chiwawa River hatchery spring Chinook.

Brood Year	CWT Recoveries			Broodstock Collected	HRR Estimates	
	Harvest	Adult Returns	Total		Harvest Not Included	Harvest Included
1989	24	180	204	28	6.43	7.29
1990	18	1	19	19	0.05	1.00
1991	3	33	36	32	1.03	1.13
1992	1	31	32	113	0.27	0.28
1993	4	282	286	100	2.82	2.86
1994	0	21	21	13	1.62	1.62
1995	No Program					
1996	2	77	79	18	4.28	4.39
1997	377	2,232	2,609	120	18.60	21.74
1998	194	991	1,185	48	20.65	24.69
1999	No Program					
2000	23	354	377	48	7.38	7.85
2001	37	1,808	1,845	382	4.73	4.83
2002	71	709	780	84	8.44	9.29
2003	84	695	779	119	5.84	6.55
2004	472	2,512	2,984	296	8.49	10.08
Average					**6.47**	**7.40**

This methodology was used to develop all HRR estimates for Chelan's hatchery Chinook programs. In the next section we discuss the methods used to establish HRR estimates for Wenatchee hatchery steelhead.

Steelhead HRR Estimates

Steelhead HRR for Wenatchee hatchery steelhead were estimated by the release and recapture of steelhead marked with a visual implant elastomer tag. Visual implant elastomer tags were used on hatchery steelhead smolts from brood years 1998 to 2009 (Table 4). The elastomer was injected under the clear tissue just behind the eye on either the right side or left side of the head. Different colors (green, pink, red, and orange) and injection sites (right-side and left-side) were used to identify different release groups. The combination of scale age analysis and VIE tag color and position determined the brood year of each fish. VIE tag rates for hatchery steelhead have been greater than 90 percent for each brood year, although some individual release groups were less. Adipose fin clips and coded wire tagging have also been used but not with the same consistency and high marking rates as VIE tags. Passive integrated transponder (PIT) tags have also been used recently (2002-2009).

Table 4. Number of hatchery Wenatchee steelhead smolts released, number VIE tagged, and VIE tag rates for each release group.

Brood Year	Release Location	Parental Cross	VIE color/Side	VIE Tag Rate	Number VIE Released	Total Released
1998	Chiwawa River	H x H	Red Left	0.994	52,448	52,765
	Chiwawa River	H x W	Green Left	0.990	36,643	37,013
	Chiwawa River	W x W	Orange Left	0.827	68,062	82,300
	Total			**0.913**	**157,153**	**172,078**
1999	Wenatchee River	H x H	Green Left	0.911	41,311	45,347
	Wenatchee River	H x W	Orange Left	0.927	28,471	30,713
	Chiwawa River	H x H	Red Right	0.936	23,982	25,622
	Chiwawa River	H x W	Green Right	0.936	40,603	43,379
	Chiwawa River	W x W	Orange Right	0.936	28,642	30,600
	Total			**0.928**	**163,009**	**175,661**
2000	Chiwawa River	H x H	Red Left	0.963	32,181	33,417
	Chiwawa River	H x W	Green Left	0.963	55,581	57,716
	Chiwawa River	H x W	Green Right	0.949	45,580	48,029
	Chiwawa River	W x W	Orange Right	0.949	43,158	45,477
	Total			**0.956**	**176,500**	**184,639**
2001	Nason Creek	H x W	Green Right	0.934	70,308	75,276
	Nason Creek	W x W	Orange Right	0.934	44,939	48,115
	Chiwawa River	H x W	Green Left	0.895	82,776	92,487
	Chiwawa River	H x H	Red Left	0.895	107,449	120,055
	Total			**0.909**	**305,472**	**335,933**
2002	Chiwawa River	H x H	Red Left	0.920	143,653	156,145
	Chiwawa River	H x W	Green Left	0.928	31,114	33,528
	Nason Creek	W x W	Orange Right	0.928	104,295	112,387
	Total			**0.924**	**279,062**	**302,060**
2003	Wenatchee River	H x H	Red Left	0.968	113,898	117,663
	Chiwawa River	H x W	Green Left	0.927	177,795	191,796
	Nason Creek	W x W	Orange Right	0.962	62,922	65,408
	Total			**0.946**	**354,615**	**374,867**
2004	Wenatchee River	H x H	Red Left	0.804	31,867	39,636
	Chiwawa River	H x W	Green Left	0.977	150,418	153,959
	Nason Creek	W x W	Pink Right	0.940	94,488	100,519
	Total			**0.941**	**276,773**	**294,114**
2005	Wenatchee River	H x H	Red Left	0.983	102,775	104,552
	Wenatchee River	H x W	Green Left	0.979	186,322	190,319

Brood Year	Release Location	Parental Cross	VIE color/Side	VIE Tag Rate	Number VIE Released	Total Released
	Chiwawa River	H x W	Green Left	0.979	18,243	18,634
	Chiwawa River	W x W	Pink Right	0.969	13,686	14,124
	Nason Creek	W x W	Pink Right	0.969	120,694	124,555
	Total			**0.977**	**441,720**	**452,184**
2006	Wenatchee River	H x W (early)	Green Right	0.918	60,608	66,022
	Wenatchee River	H x W (late)	Green Left	0.935	86,185	92,176
	Chiwawa River	H x W (late)	Green Left	0.935	38,559	41,240
	Chiwawa River	W x W	Pink Right	0.945	7,088	7,500
	Nason Creek	W x W	Pink Right	0.945	87,884	92,999
	Total			**0.935**	**280,324**	**299,937**
2007	Wenatchee River	H x W (early)	Green Right	0.950	61,095	64,310
	Wenatchee River	H x W (late)	Green Left	0.951	92,769	97,549
	Chiwawa River	H x W (late)	Green Left	0.951	40,903	43,011
	Chiwawa River	W x W	Pink Right	0.952	6,689	7,026
	Nason Creek	W x W	Pink Right	0.952	90,244	94,794
	Total			**0.951**	**291,700**	**306,690**
2008	Blackbird Pond	HxW (early)	Green Right	0.910	45,389	49,878
	Wenatchee River	H x W (early)	Green Right	0.910	44,248	48,624
	Wenatchee River	H x W (late)	Green Left	0.908	67,962	74,848
	Chiwawa River	H x W (late)	Green Left	0.908	23,458	25,835
	Chiwawa River	W x W	Pink Right	0.904	23,303	25,778
	Nason Creek	W x W	Pink Right	0.904	92,362	102,170
	Total			**0.907**	**296,722**	**327,133**
2009	Blackbird Pond	H x W (early)	Green Right	0.934	46,932	50,248
	Wenatchee River	H x W (early)	Green Right	0.934	98,293	105,239
	Wenatchee River	H x W (late)	Green Left	0.975	26,922	27,612
	Wenatchee River	H x W (late)	Green Left	0.975	44,299	45,435
	Chiwawa River	H x W (early)	Green Right	0.934	22,262	23,835
	Chiwawa River	H x W (late)	Green Left	0.975	32,221	33,047
	Chiwawa River	H x W (late)	Green Left	0.975	53,021	54,381
	Nason	W x W	Pink Right	0.979	141,983	145,029
	Total			**0.961**	**465,933**	**484,826**

HRR estimates were generated from the number of VIE tagged fish sampled as returning adults at Priest Rapids Dam. WDFW personnel sample from July to October sampling about the middle 80 percent of the run cycle. Sample rates were estimated for each return year to extrapolate for the non-sampled portion of tagged steelhead passing the project. Sample rates have varied from 6 to 11 percent over the years. For each return year, the number of observed fish from a release group is divided by the sample rate to estimate the number of tagged fish that passed Priest Rapids Dam. This estimate is then divided by the tag rate for that release group to estimate the total return for that group. Summing across all age groups and release strategies for a given brood year produces the total hatchery return (Table 5). For example, the 1999 brood year had five release groups with two release locations and three different parental crossings (Table 4). The release group identified by a green VIE tag injected on the left side had seven fish observed at Priest Rapids Dam as 1-salt adult steelhead. The seven steelhead observed during sampling at Priest Rapids Dam were expanded to 118 based on the sample rate (7/0.0594 = 117.8). There were eight additional steelhead estimated for the untagged portion of that release group for a total of 126 (117.9/0.9357 = 125.9). If this process is repeated for the 2-salt and 3-salt returns as provided in the example, the total number of returning hatchery steelhead from that release group is 284 fish.

Brood Year	Release Group	Age at Return	Return Year Sample Rate	Tag Rate	Observed Value	Estimated Value
1999	Wenatchee River (H x H) Green Left	1-Salt	0.0594	0.9357	7	126
		2-Salt	0.0677	0.9357	10	158
		3-Salt	0.1088	0.9357	0	0
				Total Return:	**17**	**284**

Repeating this process for all five of the release groups from brood year 1999 produces a total hatchery return of 1,944 fish (Table 5).

Table 5. Estimated brood year returns for Wenatchee hatchery steelhead from different release groups observed at Priest Rapids Dam and expanded by the return year sample rates (SR) and by VIE release group tag rates.

Brood Year	Release Information	VIE Tag Rate	1-Salt Returns			2-Salt Returns			3-Salt and 2.2 Returns			Total Return
			Obs.	SR	Est.	Obs.	SR	Est.	Obs.	SR	Est.	
1998	Chiwawa (H x H/Red Left)	0.9941	1	0.0927	11	2	0.0594	34	0	0.0677	0	45
	Chiwawa (H x W/Green Left)	0.9895	2	0.0927	22	4	0.0594	68	0	0.0677	0	90
	Chiwawa (W x W/Orange Left)	0.8268	1	0.0927	13	0	0.0594	0	0	0.0677	0	13
												148
1999	Wenatchee (H x H/Green Left)	0.9357	7	0.0594	126	10	0.0677	158	0	0.1088	0	284
	Wenatchee (H x W/Orange Left)	0.9357	9	0.0594	162	11	0.0677	174	0	0.1088	0	336
	Chiwawa (H x H/Red Right)	0.9357	2	0.0594	36	3	0.0677	47	0	0.1088	0	83
	Chiwawa (H x W/Green Right)	0.9106	18	0.0594	333	10	0.0677	162	1	0.1088	10	505
	Chiwawa (W x W/Orange Right)	0.9272	37	0.0594	672	4	0.0677	64	0	0.1088	0	736
												1,944
2000	Chiwawa (H x H/Red Left)	0.9625	3	0.0677	46	4	0.1088	38	1	0.0987	11	95
	Chiwawa (H x W/Green Left)	0.9625	3	0.0677	46	7	0.1088	67	0	0.0987	0	113
	Chiwawa (H x W/Green Right)	0.9494	6	0.0677	93	0	0.1088	0	0	0.0987	0	93
	Chiwawa (W x W/Orange Right)	0.9494	0	0.0677	0	0	0.1088	0	1	0.0987	11	11
												312
2001	Nason (H x W/Green Right)	0.9340	113	0.1088	1,112	55	0.0987	597	0	0.0665	0	1,709
	Nason (W x W/Orange Right)	0.9340	29	0.1088	285	83	0.0987	900	0	0.0665	0	1,186
	Chiwawa (H x W/Green Left)	0.8950	120	0.1088	1,232	140	0.0987	1,585	1	0.0665	17	2,834
	Chiwawa (H x H/Red Left)	0.8950	292	0.1088	2,999	142	0.0987	1,608	0	0.0665	0	4,606
												10,335
2002	Chiwawa (H x H/Red Left)	0.9200	49	0.0987	540	21	0.0665	343	0	0.0866	0	883
	Chiwawa (H x W/Green Left)	0.9280	15	0.0987	164	6	0.0665	97	0	0.0866	0	261
	Nason (W x W/Orange Right)	0.9280	40	0.0987	437	20	0.0665	324	0	0.0866	0	761
												1,905
2003	Wenatchee (H x H/Red Left)	0.9620	8	0.0665	125	7	0.0866	84	0	0.1037	0	209
	Chiwawa (H x W/Green Left)	0.9680	11	0.0665	171	13	0.0866	155	0	0.1037	0	326
	Nason (W x W/Orange Right)	0.9270	13	0.0665	211	16	0.0866	199	1	0.1037	10	421
												956
2004	Wenatchee (H x H/Red Left)	0.9399	17	0.0866	209	5	0.1037	51	0	0.0878	0	260
	Chiwawa (H x W/Green Left)	0.8038	9	0.0866	129	2	0.1037	24	0	0.0878	0	153
	Nason (W x W/Pink Right)	0.9768	51	0.0866	603	10	0.1037	99	1	0.0878	12	713
												1,127
2005	Wenatchee (H x H/Red Left)	0.9690	55	0.1037	547	21	0.0878	247	0	0.0811	0	794
	Wenatchee (H x W/Green Left)	0.9830	146	0.1037	1,432	85	0.0878	985	0	0.0811	0	2,417
	Chiwawa (H x W/Green Left)	0.9790	66	0.1037	650	82	0.0878	954	2	0.0811	25	1629
												4,841
2006	Wenatchee (H x W/Green Right)	0.9180	26	0.0878	323	19	0.0811	255	0	0.0837	0	578

Brood Year	Release Information	VIE Tag Rate	1-Salt Returns			2-Salt Returns			3-Salt and 2.2 Returns			Total Return
			Obs.	SR	Est.	Obs.	SR	Est.	Obs.	SR	Est.	
	Wenatchee (H x W/Green Left)	0.9350	65	0.0878	792	51	0.0811	673	0	0.0837	0	1,464
	Chiwawa (H x W/Green Left	0.9350	0	0.0878	0	0	0.0811	0	0	0.0837	0	0
	Chiwawa (W x W/Pink Right)	0.9450	13	0.0878	157	30	0.0811	392	0	0.0837	0	548
	Nason (W x W/Pink Right)	0.9450	0	0.0878	0	0	0.0811	0	0	0.0837	0	0
												2,590
2007	Wenatchee (H x W/Green Right)	0.9500	144	0.0811	1,869	129	0.0837	1623	0		0	3,492
	Wenatchee (H x W/Green Left)	0.9510	178	0.0811	2,308	136	0.0837	1709	0		0	4,017
	Chiwawa (H x W/Green Left)	0.9510	0	0.0811	0	0	0.0837	0	0		0	0
	Chiwawa (W x W/Pink Right)	0.9520	64	0.0811	829	105	0.0837	1318	0		0	2,147
	Nason (W x W/Pink Right)	0.9520	0	0.0811	0	0	0.0837	0	0		0	0
												9,656

The total estimated brood year returns were then divided by the number of broodstock that were collected (less those released) to produce them to get the hatchery return rates (Table 6). Adjusted HRR's were also estimated for some early years to account for VIE tag loss.

Table 6. Hatchery return rates estimated for Wenatchee hatchery steelhead from VIE tags identified at Priest Rapids Dam, VIE tags adjusted for tag loss, and PIT tags.

Brood Year	Broodstock Collected	Adult Return	HRR	HRR adjusted
1998	78	148	1.89	3.49
1999	125	1,944	15.6	23.3
2000	120	312	2.6	3.3
2001	178	10,335	58.1	63.5
2002	162	1,905	11.8	12.2
2003	155	956	6.2	
2004	140	1,127	8.1	
2005	207	4,841	23.4	
2006	167	2,590	15.5	
2007	150	9,656	64.4	

Steelhead PIT Tag-based HRR Estimates

PIT-based HRR estimates were generated from unique detections of Wenatchee hatchery steelhead detected at projects from Bonneville Dam to Wells Dam. HRR estimates derived from PIT tags provide a comparison to estimates provided by VIE tags for the years available. The total unique number of PIT tags detected were expanded by tag rate, summed and then divided by the number of broodstock collected for that brood year (Table 7). For example, brood year 2002 had 404 and 322 unique detections that were expanded separately based on tag rate and summed for a total of 2,327 fish. The total number of fish was then divided by the number of broodstock collected for an HRR estimate of 14.4 (2,327/162 = 14.4).

Table 7. PIT-based hatchery return rates for Wenatchee steelhead developed from unique PIT tag detections from Bonneville Dam to Wells Dam (BON, MCN, PRD, RIS, RRH, WLS and TUM) combined.

Brood Year	Released	Release Site	Number PIT tagged	Total Released	Tag Rate	Unique Combined Project Detections	Tag Rate Expanded	Total	Broodstock Collected	HRR
2002	2003	Chiwawa	62,007	189,673	0.3269	404	1,236	2,327	162	**14.37**
		Nason	33,154	112,387	0.2950	322	1,092			
2003	2004	Chiwawa	32,588	191,796	0.1699	31	182	808	155	**5.21**
		Nason	29,911	65,408	0.4573	134	293			
		Wenatchee	30,811	117,663	0.2619	87	332			
2004	2005	Chiwawa	29,801	153,959	0.1936	101	522	1,022	140	**7.30**
		Nason	34,823	100,519	0.3464	132	381			
		Wenatchee	30,018	39,636	0.7573	90	119			
2005	2006	Chiwawa	3,292	32,758	0.1005	36	358	4,191	207	**20.25**
		Nason	8,827	124,555	0.0709	89	1,256			
		Wenatchee	17,282	104,552	0.1653	426	2,577			
2006	2007	Chiwawa	4,215	48,740	0.0865	67	775	3,853	167	**23.07**
		Nason	7,383	92,999	0.0794	64	806			
		Wenatchee	16,783	158,198	0.1061	241	2,272			
2007	2008	Chiwawa	3,704	51,613	0.0718	88	1,226	10,805	150	**72.10**
		Nason	8,152	102,170	0.0798	240	3,008			
		Wenatchee	18,044	173,350	0.1041	684	6,571			

The PIT-based HRR estimates comport well with the HRR estimates provided by VIE tags (Figure 1; Table 8). In 2006 and 2007 the PIT-based HRR estimate were larger than the VIE tag estimates. However, it is likely with the PIT-based estimates include some harvest and mortality within the estimate. That is, some of the PIT tag detections at Bonneville or McNary dams may not have been detected at Priest Rapids Dam where VIE hatchery return rates are generate. In the next section, we discuss methods used to produce HRR estimates for Lake Wenatchee hatchery sockeye.

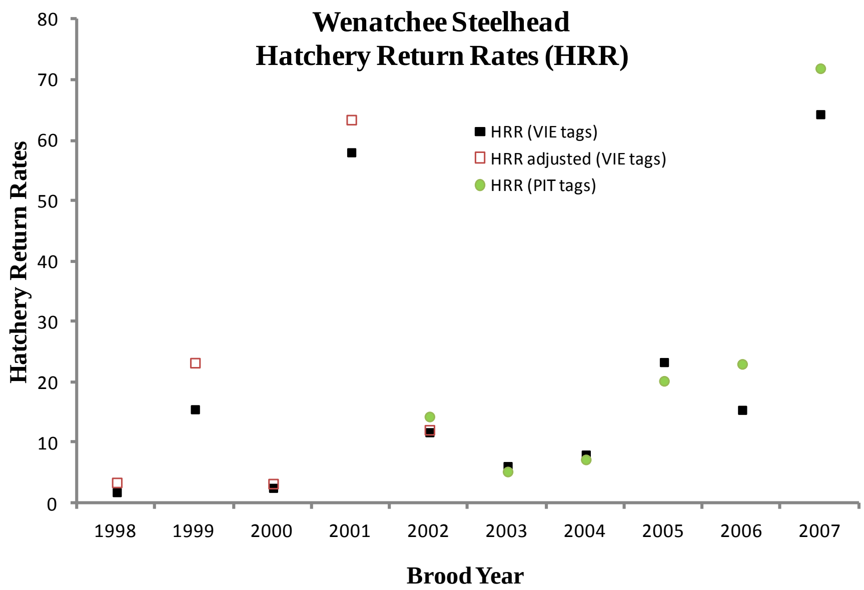

Figure 1. Comparison of hatchery return rates generated from VIE tagged and PIT tagged Wenatchee hatchery steelhead.

Table 8. Comparison of adult returns and hatchery return rates generated from VIE tag estimates at Priest Rapids dam and unique PIT tag detections from Bonneville Dam to Wells Dam (BON, MCN, PRD, RIS, RRH, WLS and TUM) combined.

Brood Year	Broodstock Collected	VIE Tag Estimates			PIT-Tag Estimates	
		Adult Return	HRR	HRR adjusted	Adult Return	PIT-based HRR
2002	162	1,905	11.8	12.2	2,327	14.4
2003	155	956	6.2		808	5.2
2004	140	1,127	8.1		1,022	7.3
2005	207	4,841	23.4		4,191	20.3
2006	167	2,590	15.5		3,853	23.1
2007	150	9,656	64.4		10,805	72.0

Sockeye HRR Estimates without Harvest

Hatchery return rates for sockeye are based on the reconstruction of brood year hatchery returns to Tumwater Dam. For most years, Wenatchee sockeye run size was measured as the count at Tumwater Dam, although some years were unavailable. For those years, the difference in dam counts at Rock Island and Rocky Reach dams were compared to Tumwater Dam counts and adjusted based on linear regression when both data sets were available (1989-1992, 1994, and 1998 to 2007) (Figure 2).

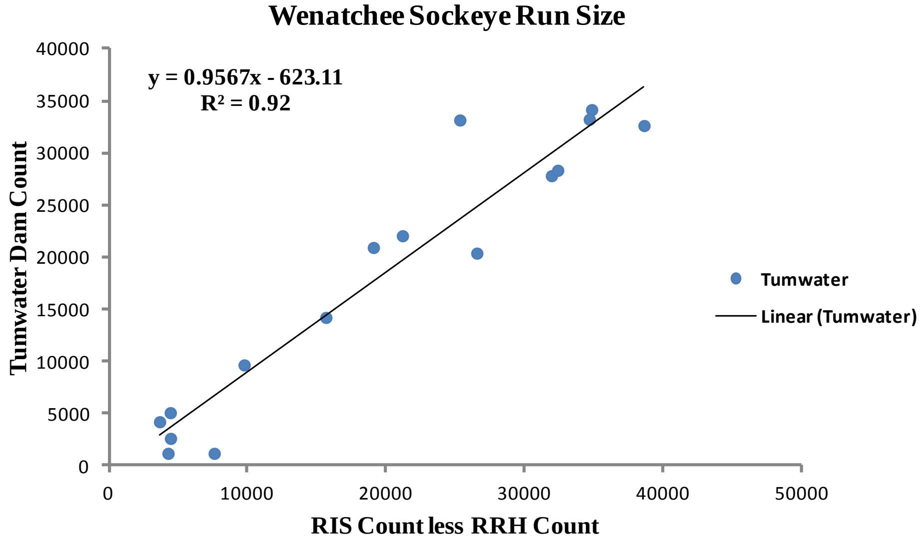

Figure 2. Correlation of Tumwater Dam sockeye salmon counts to the difference in counts of sockeye at Rock Island (RIS) and Rocky Reach (RRH) dams.

Wenatchee sockeye run size for 1993, 1995-1997 were based on the linear regression of:

$$Wenatchee\ Run\ Size\ = 0.9567(RIS_{Count} - RRH_{Count}) - 623.11$$

For example, the Wenatchee sockeye run size for 1997 was estimated as:

$$Wenatchee\ Run\ Size_{1998} = 0.9567(41{,}504 - 30{,}485) - 623.11$$
$$Wenatchee\ Run\ Size_{1998} = 0.9567(11{,}019) - 623.11$$
$$Wenatchee\ Run\ Size_{1998} = 9{,}919$$

The total number of spawners available for each return year was based on the Wenatchee run size, less the number of fish removed for broodstock at Tumwater Dam and those harvested in the Lake Wenatchee recreational fishery (Table 9). The origin of broodstock and harvested fish was known and determined from sampling those fish. For the Wenatchee spawners, the origin was determined from carcass sampling (1996-2003) and monitoring at Tumwater Dam (1993-1995; 2004-2009). Before hatchery fish began returning in 1993, all returning adult sockeye were assumed to be wild. The number of wild and hatchery spawners was determined as the product of total Wenatchee spawners times the wild and hatchery proportions. The total Wenatchee run is the sum of the wild and hatchery spawners plus broodstock. The Wenatchee sockeye run for hatchery fish is the basis for developing HRR estimates that do not include harvest.

Table 9. Wenatchee River sockeye run size, Lake Wenatchee sport harvest, broodstock collected at Tumwater Dam, and wild-hatchery proportions used to determine total Wenatchee sockeye salmon run size without harvest.

Return Year	Wenatchee Run Size	Broodstock Collection		Lake Wenatchee Sport Harvest		Total Wenatchee Spawners	Wild-Hatchery Proportions		Total Wenatchee Run (spawners +broodstock)	
		W	H	W	H		W	H	W	H
1989	22,057	255	0	0	0	21,802	1.000	0.000	22,057	0
1990	34,164	316	0	6,523	0	27,325	1.000	0.000	27,641	0
1991	33,233	233	0	6,311	0	26,689	1.000	0.000	26,922	0
1992	20,369	343	0	3,565	0	16,461	1.000	0.000	16,804	0
1993	35,072	307	0	6,400	639	27,726	0.904	0.096	25,371	2,662
1994	7,595	265	5	0	0	7,325	0.946	0.054	7,194	401
1995	3,657	209	3	0	0	3,445	0.946	0.054	3,468	189
1996	6,800	227	20	0	0	6,553	0.917	0.083	6,236	564
1997	9,919	226	19	0	0	9,674	0.992	0.008	9,823	96
1998	4,204	190	6	0	0	4,008	0.992	0.008	4,166	38
1999	1,172	147	60	0	0	965	0.938	0.062	1,052	120
2000	20,930	195	5	0	0	20,730	0.944	0.056	19,764	1,166
2001	32,633	245	8	3,265	20	29,095	0.972	0.028	28,525	823
2002	27,822	257	0	0	0	27,565	0.993	0.007	27,629	193
2003	5,074	219	0	0	0	4,855	0.988	0.012	5,016	58
2004	33,167	202	0	4,981	429	27,555	0.947	0.053	26,297	1,460
2005	14,218	207	0	0	0	14,011	0.998	0.002	14,190	28
2006	9,658	220	0	0	0	9,438	0.973	0.027	9,403	255
2007	2,607	228	0	0	0	2,379	0.975	0.025	2,548	59
2008	28,340	260	2	4,831	18	23,229	0.996	0.004	23,396	95
2009	16,086	261	3	2,107	122	13,593	0.967	0.033	13,405	452

The hatchery component of the total Wenatchee run can be developed further to determine brood year origin. The age structure for hatchery sockeye from each return year was used to determine the total age of hatchery fish. The age structure of returning hatchery fish was determined from otolith and scale samples collected from a combination of difference sources including carcass sampling, broodstock, and samples collected at Tumwater Dam. Table 10 displays the proportion of each age class for returning hatchery sockeye salmon. The number of fish for each age class was determined by multiplying the Wenatchee hatchery run size by the proportions of each age class for a specific year. For example, the age at return for return year 2000 was estimated as the 1,166 returning hatchery sockeye times the age structure proportions to get 1,146 four year olds (0.983 x 1,166 = 1,146) and 20 five year olds (0.017 x 1,166 = 20).

Table 10. Total hatchery Wenatchee run size and age structure used to determine age at return for Lake Wenatchee hatchery sockeye salmon.

Return Year	Wenatchee Run (hatchery)	Age Structure				Age at Return			
		Age-3	Age-4	Age-5	Age-6	Age-3	Age-4	Age-5	Age-6
1993	2,662	0.000	1.000	0.000	0.000	0	2,662	0	0
1994	401	0.000	0.762	0.238	0.000	0	306	95	0
1995	189	0.000	0.500	0.500	0.000	0	95	95	0
1996	564	0.000	1.000	0.000	0.000	0	564	0	0
1997	96	0.000	0.656	0.344	0.000	0	63	33	0
1998	38	0.000	0.647	0.353	0.000	0	25	13	0
1999	120	0.000	0.813	0.176	0.011	0	98	21	1
2000	1,166	0.000	0.983	0.017	0.000	0	1,146	20	0
2001	823	0.000	0.754	0.246	0.000	0	621	202	0
2002	193	0.000	0.400	0.600	0.000	0	77	116	0
2003	58	0.000	0.500	0.462	0.038	0	29	27	2
2004	1,460	0.007	0.966	0.027	0.000	10	1,410	39	0
2005	28	0.000	0.458	0.542	0.000	0	13	15	0
2006	255	0.016	0.981	0.004	0.000	4	250	1	0
2007	59	0.000	0.475	0.525	0.000	0	28	31	0
2008	95	0.081	0.919	0.000	0.000	8	87	0	0
2009	452	0.033	0.950	0.017	0.000	15	429	8	0

From Table 10, brood year of returning fish was determined as return year less the age of the fish. For instance, the total number of hatchery fish returning from brood year 1989 is shown below.

Return Year	Age at Return	Number of fish
1992	3	0
1993	4	2,662
1994	5	95
1995	6	0
		2,757

Age at return for sockeye can be restructured based on brood year origin to sum brood year returns (Table 11). Hatchery return rates were then estimated as the brood year return divided by the broodstock collected that produced them. For example, the total brood year return for 1989 was 2,757 fish, and they were produced from the 255 sockeye collected as broodstock in 1989. The HRR estimate for brood year 1989 equals 10.81 (2,757/255 = 10.81). Over the sixteen years assessed, only three brood year returns have met the established guideline for an HRR of 5.4. The HRR estimates presented in Table 11 do not include fish harvested in the Lake Wenatchee recreational fishery or in the lower mainstem Columbia River.

Table 11. Hatchery return rates for Lake Wenatchee sockeye salmon determined as the sum of the brood year returns (by age) divided by the number of broodstock collected for that brood year.

Brood Year	Age at Return				Brood Year Return	Broodstock Collected	Hatchery Return Rates (HRRs)
	Age-3	Age-4	Age-5	Age-6			
1989	0	2,662	95	0	2,757	255	10.81
1990	0	306	95	0	401	316	1.27
1991	0	95	0	0	95	233	0.41
1992	0	564	33	0	597	343	1.74
1993	0	63	13	1	77	307	0.25
1994	0	25	21	0	46	270	0.17
1995	0	98	20	0	118	212	0.56
1996	0	1,146	202	0	1,348	247	5.46
1997	0	621	116	2	739	245	3.02
1998	0	77	27	0	104	196	0.53
1999	0	29	39	0	68	207	0.33
2000	0	1,410	15	0	1,425	200	7.13
2001	10	13	1	0	24	253	0.09
2002	0	250	31	0	281	257	1.09
2003	4	28	0	0	32	219	0.15
2004	0	87	8	0	95	202	0.47

Sockeye HRR Estimates with Harvest

Hatchery return rate estimates that include harvest were produced by including sockeye harvested in the mainstem Columbia River fisheries and Lake Wenatchee sport fishery. Table 12 displays harvest estimates for sockeye salmon that were used from the Joint Staff Report on the mainstem Columbia River (ODFW and WDFW 2011). They provided Snake River sockeye harvest, so the remaining harvest contains fish that were destined for the Wenatchee and Okanogan river basins. The Joint Staff used the difference in sockeye salmon dam counts at Rock Island, Rocky Reach, and sometimes Priest Rapids and Wells dams to determine the proportion of escapement associated with each basin (ODFW and WDFW 2011).

The number of Wenatchee sockeye harvested in the mainstem Columbia River was calculated as total harvest less Snake River harvest, times the proportion of Wenatchee escapement. In 2000, there were 3,274 total sockeye harvested in the mainstem Columbia River. The 3,274 fish harvested, less the Snake River harvest of 12 fish, leaves 3,262 sockeye salmon. The proportion of Wenatchee (0.35) escapement that year was then used to estimate the portion of the remaining harvest that can be attributed to Lake Wenatchee sockeye. For the 2000 return year, the mainstem Columbia Wenatchee harvest was estimated as:

$$Mainstem\ Wenatchee\ Harvest = (Tot.Harvest - Snake\ R.Harvest)x(Prop.Wenatchee\ \ Esc.)$$

$$Mainstem\ Wenatchee\ Harvest = (3{,}274 - 12)x(0.35)$$

$$Mainstem\ Wenatchee\ Harvest = 1{,}142$$

Table 12. Estimates of mainstem Columbia River sockeye salmon harvest and proportion of Wenatchee sockeye escapement provided by the Joint Staff Report (ODFW and WDFW 2011) used to determine Lake Wenatchee sockeye salmon harvest.

Return Year	Mainstem Harvest			Snake River Harvest	Okanogan and Wenatchee Harvest	Escapement		Proportion Wenatchee Escapement	Wenatchee Sockeye Mainstem Harvest
	Non-Treaty Harvest	Treaty Harvest	Total			Wenatchee	Okanogan		
1993	64	5,020	5,084	1	5,083	58,307	27,849	0.68	3,456
1994	1	472	473	0	473	10,705	1,666	0.87	412
1995	1	445	446	0	446	4,474	4,892	0.48	214
1996	25	1,414	1,439	0	1,439	7,759	17,701	0.30	432
1997	12	2,046	2,058	1	2,057	14,927	25,754	0.37	761
1998	2	425	427	0	427	5,087	4,669	0.52	222
1999	1	704	705	1	704	4,260	12,388	0.26	183
2000	364	2,910	3,274	12	3,262	32,119	59,944	0.35	1,142
2001	1,688	9,000	10,688	4	10,684	45,104	74,490	0.38	4,060
2002	14	2,564	2,578	4	2,574	35,510	10,659	0.77	1,982
2003	0	1,090	1,090	1	1,089	5,932	28,820	0.17	185
2004	672	4,317	4,989	5	4,984	43,605	77,492	0.36	1,794
2005	0	2,766	2,766	1	2,765	18,993	53,218	0.26	719
2006	1	1,596	1,597	3	1,594	9,756	22,064	0.31	494
2007	0	1,414	1,414	3	1,411	4,439	22,282	0.17	240
2008	821	9,017	9,838	45	9,793	35,491	165,334	0.18	1,763
2009	1,160	9,731	10,891	99	10,792	29,724	134,937	0.18	1,943
2010	242	26,125	26,367	177	26,190	61,420	291,764	0.17	4,452

Estimates of Wenatchee sockeye harvested in the mainstem were then broken down into the number of wild and hatchery fish based on hatchery-wild ratios observed from sampling at Tumwater Dam and on the spawning grounds (Table 13). The total Wenatchee sockeye harvest is then the sum of mainstem Columbia harvest plus the number of sockeye harvested in the Lake Wenatchee sport fishery. The age-structure presented previously in Table 10 was used to estimate the age of harvested hatchery sockeye.

Table 13. Total Wenatchee sockeye salmon harvest assessed from the mainstem harvest times the wild-hatchery proportions, plus the Lake Wenatchee sport harvest.

Return Year	Wenatchee Sockeye Mainstem Harvest	Wild-Hatchery Proportions		Wenatchee Sockeye Mainstem Harvest		Lake Wenatchee Harvest		Total Wenatchee Sockeye Harvest	
		W	H	W	H	W	H	W	H
1993	3,456	0.904	0.096	3,124	332	6,400	639	9,524	971
1994	412	0.946	0.054	390	22	0	0	390	22
1995	214	0.946	0.054	202	12	0	0	202	12
1996	432	0.917	0.083	396	36	0	0	396	36
1997	761	0.992	0.008	755	6	0	0	755	6
1998	222	0.992	0.008	220	2	0	0	220	2
1999	183	0.938	0.062	172	11	0	0	172	11
2000	1,142	0.944	0.056	1,078	64	0	0	1,078	64
2001	4,060	0.972	0.028	3,946	114	3,265	20	7,211	134
2002	1,982	0.993	0.007	1,968	14	0	0	1,968	14
2003	185	0.988	0.012	183	2	0	0	183	2
2004	1,794	0.947	0.053	1,699	95	4,981	429	6,680	524
2005	719	0.998	0.002	718	1	0	0	718	1
2006	494	0.973	0.027	481	13	0	0	481	13
2007	240	0.975	0.025	234	6	0	0	234	6
2008	1,763	0.996	0.004	1,756	7	4,831	18	6,587	25
2009	1,943	0.967	0.033	1,879	64	2,107	122	3,986	186

The age at return of harvested Wenatchee sockeye was determined from the age structure of hatchery fish collected on spawning grounds and broodstock samples times the number of sockeye harvested (Table 14). For example, the 134 sockeye salmon harvested in 2001 consisted of 101 four-year-olds and 33 five-year-old fish.

Return Year	Mainstem Harvest	Lake Wenatchee Sport Harvest	Total Harvest	Age Structure		Number of fish by age	Brood Year Origin
				Age	Proportion		
2001	114	20	134	3	0.000	0	1998
				4	0.754	101	1997
				5	0.246	33	1996
				6	0.000	0	1995
						134	

Table 14. Age at return estimates for Wenatchee hatchery fish harvested in the mainstem Columbia and Lake Wenatchee sport fisheries.

Return Year	Wenatchee Hatchery Harvest	Hatchery Age Structure				Age at Return			
		Age-3	Age-4	Age-5	Age-6	Age-3	Age-4	Age-5	Age-6
1993	971	0.000	1.000	0.000	0.000	0	971	0	0
1994	22	0.000	0.762	0.238	0.000	0	17	5	0
1995	12	0.000	0.500	0.500	0.000	0	6	6	0
1996	36	0.000	1.000	0.000	0.000	0	36	0	0
1997	6	0.000	0.656	0.344	0.000	0	4	2	0
1998	2	0.000	0.647	0.353	0.000	0	1	1	0
1999	11	0.000	0.813	0.176	0.011	0	9	2	0
2000	64	0.000	0.983	0.017	0.000	0	63	1	0
2001	134	0.000	0.754	0.246	0.000	0	101	33	0
2002	14	0.000	0.400	0.600	0.000	0	6	8	0
2003	2	0.000	0.500	0.462	0.038	0	1	1	0
2004	524	0.007	0.966	0.027	0.000	4	506	14	0
2005	1	0.000	0.458	0.542	0.000	0	0	1	0
2006	13	0.016	0.981	0.004	0.000	0	13	0	0
2007	6	0.000	0.475	0.525	0.000	0	3	3	0
2008	25	0.081	0.919	0.000	0.000	2	23	0	0
2009	186	0.033	0.950	0.017	0.000	6	177	3	0

Brood year origin was determined for harvested sockeye based on return year less the age of the fish. Table 15 displays realignment of harvested sockeye from Table 14 fish based on their brood year origin. HRR estimates that include harvest are the sum of brood year returns plus the brood year harvest, divided by the broodstock collected. For the sixteen years assessed, only three brood year returns with harvest included have met the established guideline for an HRR of 5.4.

Table 15. Hatchery return rates for Wenatchee sockeye salmon that include harvest based on the sum of brood year harvest plus brood year return divided by broodstock collected.

Brood Year	Age at Return				Brood Year Harvest	Brood Year Return	Total Brood Year Return (harvest + return)	Broodstock Collected	HRR w/ Harvest
	Age-3	Age-4	Age-5	Age-6					
1989	0	971	5	0	976	2,757	3,734	255	14.64
1990	0	17	6	0	23	401	423	316	1.34
1991	0	6	0	0	6	95	101	233	0.43
1992	0	36	2	0	38	597	635	343	1.85
1993	0	4	1	0	5	77	82	307	0.27
1994	0	1	2	0	3	46	49	270	0.18
1995	0	9	1	0	10	118	128	212	0.60

Brood Year	Age at Return				Brood Year Harvest	Brood Year Return	Total Brood Year Return (harvest + return)	Broodstock Collected	HRR w/ Harvest
	Age-3	Age-4	Age-5	Age-6					
1996	0	63	33	0	96	1,348	1,444	247	5.85
1997	0	101	8	0	109	739	848	245	3.46
1998	0	6	1	0	7	104	111	196	0.57
1999	0	1	14	0	15	68	84	207	0.41
2000	0	506	1	0	507	1,425	1,933	200	9.67
2001	4	0	0	0	4	24	28	253	0.11
2002	0	13	3	0	16	281	297	257	1.16
2003	0	3	0	0	3	32	35	219	0.16
2004	0	23	3	---	26	95	121	202	0.60

Sockeye PIT Tag-based HRR Estimates

PIT-based HRR estimates were also generated from unique detections of Wenatchee hatchery sockeye detected at projects from Bonneville Dam to Wells Dam, including Tumwater Dam. There are two HRR PIT-based estimates provided for sockeye. The first estimate includes only unique detections at Tumwater Dam, reflecting the hatchery return rate for adults back to the upper Wenatchee River. The second estimate includes all unique detections from Bonneville Dam to Wells Dam, including Tumwater Dam. This HRR estimate, unlike the first, would include returning adults not detected at Tumwater Dam (i.e., strays, harvest, prespawn mortality, etc.). PIT-based HRR estimates were not available until brood year 2005 so there are no valid comparisons to estimates derived from hatchery run reconstruction before 2005.

To calculate both HRR estimates from PIT tags, the total unique number of PIT tags detected were expanded by tag rate, summed, and then divided by the number of broodstock collected for that brood year. Table 16 displays HRR estimates of PIT tagged sockeye detected at Tumwater Dam compared to unique detections at all projects combined. Both estimates of hatchery return rates from PIT tags for brood years 2005 and 2006 exceed the established guideline of 5.4. Hatchery return rates based on unique PIT tag detections is a much simpler mark-recapture approach to developing HRR estimates for sockeye than brood year hatchery run reconstruction.

Table 16. PIT-based hatchery return rates for Lake Wenatchee sockeye developed from unique PIT tag detections at Tumwater Dam only and all projects (BON, MCN, PRD, RIS, RRH, WLS, and TUM) combined.

Brood Year	Number PIT tagged	Number Released	Tag Rate	Broodstock Collected	Unique Detection Locations	Number of Unique Detections	Tag Rate Expanded	HRR
2005	14,791	140,542	0.1052	207	Tumwater only	167	1,587	7.67
					All projects	303	2,879	13.91
2006	14,764	225,670	0.0654	220	Tumwater only	440	6,725	30.57
					All projects	648	9,905	45.02
2007	*14,947*	*252,133*	*0.0593*	*228*	*Tumwater only*	*156*	*2,631*	*11.54*

Brood Year	Number PIT tagged	Number Released	Tag Rate	Broodstock Collected	Unique Detection Locations	Number of Unique Detections	Tag Rate Expanded	HRR
					All projects	*303*	*5,111*	*22.42*
2008	*14,858*	*154,772*	*0.0960*	*258*	*Tumwater only*	*6*	*63*	*0.24*
					All projects	*12*	*125*	*0.48*

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Appendix E

METHODS FOR ESTIMATING STRAY RATES

Methods for Estimating Stray Rates

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This paper describes the methods and data used to estimate stray rates for coded wire tagged (CWT) Chinook and PIT-tagged steelhead and sockeye salmon. In this paper, we apply the methods to Wenatchee Summer Chinook, although the methods also apply to Chiwawa Hatchery spring Chinook, Methow and Okanogan summer Chinook, and Turtle Rock Summer Chinook. For steelhead, CWT's have not been routinely used nor are adults recovered on spawning grounds. For steelhead and sockeye, we used the distribution of PIT tag detections to assess brood year stray rates.

In the Chelan Hatchery Evaluation Program, objectives were identified to evaluate the performance of the program. Objective 5 is a comprehensive assessment of returning adult migration behavior. There are three different hypotheses under objective 5 that test if the program is performing within established guidelines:

(1) Stray rates of hatchery fish is less than 5% of the total brood return.

(2) Stray hatchery fish make up less than 5% of the spawning escapement within other independent populations (based on run year).

(3) Stray hatchery fish make up less than 10% of the spawning escapement within non-target spawning areas within the population (based on run year). At this time, this objective applies only to the Chiwawa spring Chinook program.

Chinook stray rates are based on the return, recovery, and expansion of coded wire tagged (CWT) hatchery fish. Coded wire tags can be recovered in ocean and freshwater fisheries (harvest), from volunteer and non-volunteer hatchery locations (broodstock collection), and from spawning ground surveys. For stray rate estimation, we focus on CWT returns to hatcheries and spawning grounds. Coded wire tag information was queried from the Regional Mark Process Center's Regional Mark Information System (RMIS).

For PIT-tagged fish, returning adult information can be queried from either the PIT tag information system (PTAGIS) or Columbia River DART. Data can be extracted to develop detection histories and last observation sites for each tagged fish. We used the last detection observation location as the best indication of migratory behavior. That is, if steelhead or sockeye were last detected in the Wenatchee River basin they were assumed to be homing to their natal stream. Last detections within tributaries outside the Wenatchee River basin were considered strays.

The terms "homing" and "straying" are used to describe adult salmonid migratory behavior; although, the definition of a "stray" is difficult to resolve when returning fish exhibit exploratory or wandering behavior. This behavior can lead to harvest or broodstock collection before their spawning migration is fully expressed (Pastor 2004). Exploratory behavior or wandering (i.e., temporary use of non-natal tributaries) by salmon and steelhead during migration allows some fish to be intercepted for broodstock at dams or in non-natal streams. Because these intercepted fish may not have completed their spawning migration, they should not be considered "strays." We agree with Heard (1991) that a definite conclusion about "homing" and "straying" cannot be made until the fish has spawned. We suggest that PIT tags and CWTs recovered from harvest should not be considered "strays," and therefore should not be used in the calculation of stray rates. Harvested fish are captured before they spawn, which means that their migration behavior has not been fully expressed. We also recognize that PIT tagged stray rates based on last detection do not document that a fish has spawned, but they do offer a reasonable assessment of their migratory behavior.

Hatchery fish can affect hatchery programs and natural production areas when they are used in non-target hatcheries or stray into non-target spawning areas. Therefore, it is important to identify strays that contribute to both natural and hatchery production. As such, we separate the distribution of hatchery returns into two components: (1) hatchery fish that return and contribute to natural production and (2) hatchery fish that return and contribute to hatchery production. The first hypothesis in Objective 5 encompasses both components by examining the performance of returning adult from a specific brood year. For the first hypothesis, we use CWT and PIT tag information to formulate brood year stray rates. The second and third hypotheses consider only the first component by return year into natural production areas. Under the second and third hypotheses, homing and straying are currently only demonstrated by CWT collection of fish on the spawning grounds. With this distinction, homing and straying of hatchery fish can be defined as follows:

1. **Contribution to Natural Production: Hatchery fish that return and spawn in the wild.**

    Natural Homing—Hatchery fish that return and spawn naturally in their natal (target) stream where they were acclimated/released and contribute to the production and gene pool of the local spawning population.

    Natural Straying—Hatchery fish that return and spawn naturally in a non-target stream and contribute to the production and gene pool of that local spawning population.

2. **Contribution to Hatchery Production: Hatchery fish that return and are spawned in a hatchery.**

    Hatchery Homing—Hatchery fish that return to their target stream where they were acclimated/released, but are intercepted and used for broodstock in the hatchery of origin.

    Hatchery Straying—Hatchery fish that are collected (actively or volunteered) and spawned by a hatchery other than its origin. These fish contribute to the production and gene pool of that non-target hatchery program[1].

What follows are brief examples that illustrate how stray rates were estimated for each hypothesis in Chelan's Hatchery Evaluation Program (Hillman et al. 2011).

[1] Quinn (1997) used the term "functional stray" to refer to fish that swim into, and are spawned at a hatchery different than the releasing hatchery.

Brood Year Return Stray Rates

PIT-based Brood Year Stray Rates—Under hypothesis 1, the stray rates of hatchery fish are compared to the established guideline of less than 5% total brood return strays. We use Wenatchee summer Chinook as an example of calculating stray rates for total brood returns based on CWT returns for Chelan's hatchery Chinook programs. We used recent PIT tagged hatchery fish released from 2006 to 2008 to examine the potential of estimating brood year stray rates for Wenatchee steelhead and sockeye salmon. Development of a fairly comprehensive PIT tag detection system (observation sites) in the Upper Columbia allowed us to track the location of adult hatchery returns to many of the tributaries (Wenatchee, Methow, and Entiat) where sockeye and steelhead spawn. Most of the tributary locations were established after 2006. The Okanogan (Zosel Dam) has only recently been included (September 2010) that will assist with potential detections of PIT tagged sockeye straying from Lake Wenatchee. In the first section, we examine PIT-based stray rates for sockeye salmon and steelhead followed by CWT-based stray rates for Chinook salmon.

Table 1 displays the PIT tag release groups that were used to assess stray rates of Wenatchee steelhead and sockeye salmon. We selected brood year 2005 as the first year of evaluation because most of the tributary PIT tag observation sites were available for sockeye and steelhead adult returns. We used adult PIT tag detection histories from return years 2007 to 2011for steelhead and 2008 to 2010 for sockeye. The 2011 adult sockeye migration was incomplete at the time this evaluation was completed.

Table 1. Juvenile PIT tagged steelhead and sockeye release groups used to assess stray rates as returning adults. Release location designations from PTAGIS appear in parentheses.

Program	Brood Year	Release Year	Release Site	Number Released
Steelhead	2005	2006	Chiwawa River (CHIWAR)	4,215
			Nason Creek (NASONC)	7,383
			Wenatchee River (WENATR)	16,783
	2006	2007	Chiwawa River (CHIWAR)	3,704
			Nason Creek (NASONC)	8,152
			Wenatchee River (WENATR)	18,044
	2007	2008	Chiwawa River (CHIWAR)	3,292
			Nason Creek (NASONC)	8,827
			Wenatchee River (WENATR)	17,282
Sockeye	2005	2006	Lake Wenatchee (WENATL)	14,859
	2006	2007	Lake Wenatchee (WENATL)	14,764
	2007	2008	Lake Wenatchee (WENATL)	14,947

For steelhead, we assessed stray rates for brood years 2005 to 2007. We used unique detections of Wenatchee hatchery steelhead at Rock Island, Rocky Reach, and Wells dams combined as a bench mark to assess the number of returning PIT tagged hatchery steelhead and the age at return for each brood year. Detections at these dams showed that most of the PIT tagged hatchery fish returned at two and three years of age (return year-brood year) (Table 2). Two fish were detected within the adult fishways the same year of release and are probably residualized steelhead. These fish were removed from analysis.

Table 2. Number of unique detections for Wenatchee steelhead by brood year and return year at Rock Island (RIS), Rocky Reach (RRH), and Wells (WLS) dams.

Detection Location	Brood Year	Return Year					
		2007	2008	2009	2010	2011	Total
Combined Unique RIS, RRH, WLS dams	2005	169	214	1			384
	2006	1	128	138	3		270
	2007		1	471	302	1	775
Total		**169**	**342**	**610**	**305**	**1**	**1,427**

Table 3 displays the number and percent of last detections for three brood years of Wenatchee hatchery steelhead examined in the Upper Columbia River. For the three brood years examined, more than half of the PIT tagged steelhead were last detected at Rock Island, Rocky Reach, and Wells dams. Higher tributary detection rates were observed for the 2006 and 2007 brood years as more PIT tag observation sites became established.

Table 3. Distribution of last detections for PIT tagged hatchery Wenatchee steelhead for brood years 2005-2007.

Last Detection Location	Brood Year					
	2005		2006		2007	
	Number	Percent	Number	Percent	Number	Percent
Wenatchee River	80	20.7	72	25.9	171	22.0
Entiat River	11	2.8	13	4.7	23	3.0
Methow River	14	3.6	30	10.8	87	11.2
Okanogan River	1	0.3	0	0.0	0	0.0
Other[1]	0	0.0	0	0.0	1	0.1
Tributary Total	**106**	**27.4**	**115**	**41.4**	**282**	**36.3**
Rock Island Dam	44	11.4	21	7.6	72	9.3
Rocky Reach Dam	83	21.4	47	16.9	90	11.6
Wells Dam	154	39.8	95	34.2	333	42.9
Project Total	**281**	**72.6**	**163**	**58.6**	**495**	**63.7**
Combined Total	**387**		**278**		**777**	

[1] One fish from BY 2007 was detected in the Tucannon River.

Brood year stray rates for steelhead were developed from the PIT tagged steelhead that were last detected in tributary streams. We assumed that the last detection in a tributary stream was the river basin selected for spawning. The average tributary distribution shows that about 64% of the hatchery steelhead returned to the Wenatchee Basin (successful homing), while 36% strayed to other natural spawning areas (Table 4). There was only one PIT tagged hatchery fish included in broodstock, likely because most are probably screened out before broodstock selection occurs.

Table 4. PIT tagged based stray rate estimates for hatchery Wenatchee steelhead based on last tributary detections for brood years 2005 to 2007.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2005	80	75.5	0	0.0	26	24.5	0	0.0
2006	71	62.3	1	0.9	43	37.7	0	0.0
2007	171	60.6	0	0.0	111	39.4	0	0.0
Total	***322***	***64.1***	***1***	***0.0***	***180***	***35.9***	***0***	***0.0***

For sockeye salmon, we assessed stray rates for brood years 2005 and 2006. We used detections at Rock Island Dam as a bench mark to assess the number of returning PIT tagged fish and the age at return for each brood year. Detections at Rock Island Dam showed that most of the PIT tagged hatchery fish returned at four years of age (return year-brood year) with 200 in 2009 and 444 in 2010 (Table 4). We expect that a few five-year-old fish have returned in 2011, which should complete the 2006 brood year adult return. There were 655 total PIT tagged sockeye detected for brood years 2005 and 2006. About 95% of the PIT tagged sockeye detected at Rock Island Dam were last detected at observation sites at Wells Dam and in the Wenatchee, Methow, and Entiat rivers. Wells Dam was used for return years 2008 through 2010, because the Zosel Dam site in the Okanogan River did not come online until September 2010. We used the last detections at these locations to assess brood year stray rates.

Table 5. Adult sockeye salmon PIT tag detections at Rock Island Dam for brood years 2005 and 2006 and last detections at observation sites at Wells Dam and in the Wenatchee, Methow, and Entiat rivers.

Detection Location	Brood Year	Return Year			Total
		2008	2009	2010	
Rock Island Dam	2005	6	200	3	209
	2006	0	2	444	446
Total		**6**	**202**	**447**	**655**
Last Detection Locations					
Wenatchee River	2005	6	158	3	167
	2006	0	2	419	421
Methow River	2005	0	0	0	0
	2006	0	0	1	1
Entiat River	2005	0	9	0	9
	2006	0	0	9	9
Wells Dam	2005	0	6	0	6
	2006	0	0	10	10
Total		**6**	**175**	**442**	**623**

Brood year stray rates for sockeye salmon were developed from the PIT tagged sockeye that were last detected in tributary streams and Wells Dam. We assumed that last detections in a river basin indicated the area of spawning. We assumed that last detections at Wells Dam without subsequent detection in the Methow River indicate migration into the Okanogan River system.

The average tributary distribution shows that about 94% of the hatchery fish returned to the Wenatchee Basin (successful homing), while 6% strayed to other natural spawning areas (Table 6). No PIT tagged hatchery fish have been used in hatcheries.

Table 6. PIT tagged based stray rate estimates for Lake Wenatchee hatchery sockeye salmon based on last tributary detections for brood years 2005 and 2006.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2005	167	91.8	0	0.0	15	8.2	0	0.0
2006	421	95.5	0	0.0	20	4.5	0	0.0
Total	***322***	***94.4***	***0***	***0.0***	***35***	***5.6***	***0***	***0.0***

CWT-based brood year stray rates—Brood year strays based on CWTs were used for all of Chelan's Chinook programs. Stray rates are based on the extrapolation of coded wire tags recovered during spawning ground surveys. Table 7 displays coded wire tag information of returning Wenatchee summer Chinook from brood year 1991. These data, along with brood year and spawning escapement information, were used to estimate brood year stray rates. We used PSC Fishery and site location information on recaptured CWT hatchery fish to assign fish to different fate categories. Fish were assigned to either harvest, straying (natural, hatchery), or homing (natural and hatchery). We assumed that fish collected (snout removed and CWT interrogated) for Chinook hatchery production were spawned and used in the program where they were collected.

In the RMIS database, coded wire tags recovered in different locations (observed number) are expanded (estimated number) by the sampling rate for each location. The expanded number can then be adjusted by the tag rate to account for the untagged portion of hatchery fish. To accomplish this, we divided the estimated number by the tag rate to come up with the tagged and untagged number of hatchery fish. For example, in Table 7, eighteen Wenatchee hatchery summer Chinook were estimated to have been harvested in a recreational fishery in the Hanford Reach in 1993. The tag rate for that hatchery release was 0.9920. So, the tag rate expansion estimate is 18.15 (18/0.9920 = 18.15). These expansion estimates are rounded to the nearest whole number, which in this case is eighteen fish. Because of the very high tag rates associated with the 1991 brood year releases there was no difference in the estimated values and tag rate expansion values. If multiple CWT identification tags are used for a single broodstock release, then each estimate is expanded separately by the appropriate tag rate. We used the assigned fate categories to sum different components of straying and homing for brood year 1991.

Table 7. Example information collected on CWT Wenatchee hatchery summer Chinook from brood years 1991 used to determine stray rates.

Return Year	PSC Fishery	Site	Fate	Tag Rate	Obs.	Est.	Tag Rate Expansion	Round
1993	Freshwater Sport	Hanford Reach	Harvest	0.9920	1	18	18.15	18
1994	Mixed Net and Seine	JFN 020-000	Harvest	0.9920	1	4	4.03	4
1994	Hatchery	Wells Dam Sp. Chan.	Hatchery Straying	0.9920	1	1	1.01	1
1994	Mixed Net and Seine	NN 003-460	Harvest	0.9997	1	3	3.00	3
1994	Mixed Net and Seine	NN 003-461	Harvest	0.9997	2	5	5.00	5
1995	Hatchery	Wells Dam Sp. Chan.	Hatchery Straying	0.9920	3	3	3.02	3
1995	Hatchery	Wenatchee River	Hatchery Homing	0.9997	1	1	1.00	1
1996	Ocean Troll	AK M 1 NW 113-81	Harvest	0.9920	1	1	1.01	1
1996	Hatchery	Wells Hatchery	Hatchery Straying	0.9920	1	1	1.01	1
1996	Ocean Troll	AK M 1 NW	Harvest	0.9997	1	3	3.00	3
1996	Ocean Troll	AK M 1 NW 113-41	Harvest	0.9997	1	2	2.00	2
1996	Ocean Sport	AK M 1 03 MSNW	Harvest	0.9997	1	10	10.00	10
1996	Hatchery	Wells Hatchery	Hatchery Straying	0.9997	2	2	2.00	2
1996	Fish Trap	Wells E. Ladder Trap	Hatchery Straying	0.9997	1	1	1.00	1
1997	Ocean Troll	Newport Troll 4	Harvest	0.9997	1	2	2.00	2
1997	Spawning Grounds	Wenatchee River	Natural Homing	0.9997	2	14	14.00	14
Total					**21**	**71**		**71**

Table 8 shows the summarized distribution of homing and straying of Wenatchee hatchery summer Chinook returns for brood years 1989-2004. Overall, the 16-year average distribution shows that about 83% of the hatchery fish returned to the Wenatchee Basin (successful homing), while 17% strayed to other natural spawning areas or other hatchery programs (Table 8). Of those that strayed, about 11% strayed to other spawning grounds and the remaining 5% were collected in other hatchery programs. Based on these data, one would reject the null hypothesis and conclude that on average hatchery fish from the Wenatchee summer Chinook program stray at a rate greater than 5%. It appears that natural straying has increased over time, while hatchery straying has decreased over time (Table 8). These trends are probably related to changes in carcass sampling intensity over time, which is a requirement of the monitoring program, and the decreased use of hatchery fish in broodstock collection programs.

Table 8. Stray rate estimates produced for a 16-year period (1989-2004) of total brood year returns of Wenatchee summer Chinook for the hypothesis: stray rates of hatchery fish is less than 5% of the total brood return.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	1,352	62.9	60	2.8	75	3.5	662	30.8
1990	74	84.1	1	1.1	0	0.0	13	14.8
1991	14	60.9	1	4.3	0	0.0	8	34.8
1992	375	84.8	7	1.6	0	0.0	60	13.6

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1993	67	72.8	9	9.8	4	4.3	12	13.0
1994	890	71.8	205	16.5	56	4.5	88	7.1
1995	748	74.8	139	13.9	42	4.2	71	7.1
1996	261	70.4	42	11.3	53	14.3	15	4.0
1997	3,609	85.6	171	4.1	396	9.4	38	0.9
1998	1,790	78.5	11	0.5	416	18.2	64	2.8
1999	507	79.7	0	0.0	121	19.0	8	1.3
2000	2,745	83.0	0	0.0	526	15.9	37	1.1
2001	521	82.0	0	0.0	105	16.5	9	1.4
2002	1,521	85.3	10	0.6	244	13.7	8	0.4
2003	1,268	89.3	42	3.0	101	7.1	9	0.6
2004	438	83.4	3	0.6	66	12.6	18	3.4
Total	***16,180***	***80.1***	***703***	***3.5***	***2,217***	***11.0***	***1,106***	***5.5***

Stray Rates to Independent Population (based on run year)

For this hypothesis, CWT information was used to determine stray rates to other populations based on run year. No PIT-based estimates for steelhead and sockeye have been produced. We use Wenatchee summer Chinook as an example of estimating stray rates for this hypothesis. Here, the goal is to determine if Wenatchee strays make up less than 5% of the spawning escapement within non-target populations (e.g., the Entiat, Methow, or Okanogan summer Chinook populations).

Similar to the information presented in Table 7, CWT returns are summed across a particular return year for CWT recoveries within non-target populations. The sum of the recoveries are presented in Table 9 to display the number of fish that strayed from the Wenatchee summer Chinook program into other independent summer Chinook populations. To determine the stray rate to other independent populations, we divided the number of strays by the spawning escapement of the population of interest for that return year. For example, in 2003 the spawning escapement of summer Chinook to the Methow River was 3,390 fish. The stray rate of Wenatchee hatchery summer Chinook into the Methow was 0.02 (80/3,390 = 0.023), or about two percent of the spawning escapement. Since 1994, the percentage of Wenatchee strays in the Methow River has made up 4% of the total escapement from 1994 to 2007.

Under this hypothesis, stray rate was calculated based solely on hatchery fish that spawned naturally and were recovered on the spawning grounds within other populations. As shown in Table 9, the fourteen-year average distribution of strays (i.e., total number of strays divided by the total spawning escapement) indicates that hatchery fish from the Wenatchee summer Chinook program made up less than 5% of the spawning escapement of the Methow, Okanogan, and Hanford Reach populations. Wenatchee strays in the Chelan and Entiat rivers were on average at or above the established guideline.

Table 9. Stray rate estimates produced for a 14-year period for Wenatchee hatchery summer Chinook for the hypothesis: stray hatchery fish make up less than 5% of the spawning escapement within other independent populations (based on run year).

Return year	Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	75	1.9	-	-	-	-	-	-
1995	0	0.0	0	0.0	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-
1998	25	3.7	0	0.0	0	0.0	0	0.0	0	0.0
1999	20	2.0	3	0.1	0	0.0	0	0.0	13	0.1
2000	36	3.0	13	0.4	0	0.0	0	0.0	0	0.0
2001	163	5.9	57	0.5	30	3.0	0	0.0	0	0.0
2002	153	3.3	53	0.4	40	6.9	74	14.8	0	0.0
2003	80	2.0	24	0.7	44	10.5	132	19.1	26	0.0
2004	113	5.2	42	0.6	30	7.1	0	0.0	0	0.0
2005	245	9.6	67	0.8	51	11.5	49	13.4	0	0.0
2006	170	6.2	12	0.1	12	2.9	18	3.1	0	0.0
2007	127	9.3	5	0.1	9	4.8	18	7.3	20	0.1
Total	***1,132***	***4.2***	***351***	***0.5***	***216***	***5.0***	***291***	***8.3***	***59***	***0.0***

Stray Rates within Population (based on run year)

For this hypothesis, CWT information was used to determine stray rates within the Wenatchee spring Chinook population based on run year. Similar to the second hypothesis, we used spawning escapement estimates for each non-target spawning location (stream) within the Wenatchee basin to calculate the stray rate for each stream and return year. We only used fish recovered on spawning grounds to estimate stray rate. The goal is to determine if Chiwawa hatchery spring Chinook strays make up less than 10% of the spawning escapement within non-target spawning areas within the Wenatchee Basin (e.g., Nason Creek, White River, Wenatchee River, and Little Wenatchee River). At this time, this hypothesis refers only to the Chiwawa spring Chinook hatchery program.

Table 10 displays the distribution of stray returns of hatchery fish from the Chiwawa spring Chinook program to non-target spawning areas in the Wenatchee Basin from 1992 to 2009. The analysis indicated that Chiwawa hatchery fish, on average, made up more than 10% of the spawning escapement in Nason Creek, Upper Wenatchee River, White River, and Little Wenatchee River (Table 10). In general, annual stray rates tended to increase over the period of record. This may reflect increased sampling effort over the more recent years.

Table 10. Stray rate estimates produced for an 18-year period of Chiwawa spring Chinook returns for the hypothesis: stray hatchery fish make up less than 10% of the spawning escapement within non-target spawning areas within the population (based on run year).

Return year	Nason Creek		Icicle Creek		Peshastin Creek		Upper Wenatchee		White River		Little Wenatchee	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1992	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1993	61	12.4	0	0.0	0	0.0	34	18.0	7	4.8	0	0.0
1994	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1995	0	0.0	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0
1996	25	30.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1997	55	45.1	8	11.0	0	0.0	0	0.0	0	0.0	0	0.0
1998	3	4.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	45	16.7	0	0.0	0	0.0	31	31.0	0	0.0	6	27.3
2001	211	35.3	0	0.0	0	0.0	271	77.7	46	39.0	52	31.3
2002	188	31.2	10	2.0	0	0.0	60	45.8	14	16.3	21	24.4
2003	14	6.9	0	0.0	0	0.0	30	51.7	0	0.0	0	0.0
2004	139	27.4	0	0.0	0	0.0	54	39.1	6	9.1	0	0.0
2005	252	72.6	7	50.0	0	0.0	256	99.6	106	68.4	65	56.5
2006	131	48.3	13	14.4	0	0.0	28	58.3	9	16.4	12	32.4
2007	303	65.4	0	0.0	0	0.0	37	67.3	7	7.6	6	5.9
2008	381	67.4	48	23.4	29	78.4	259	85.8	30	57.7	52	81.3
2009	289	54.1	8	9.2	0	0.0	16	100.0	73	42.2	56	44.8
Total	***2,097***	***38.8***	***94***	***5.4***	***29***	***3.3***	***1,078***	***60.4***	***298***	***25.5***	***270***	***25.4***

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Appendix F

GENETIC DIVERSITY OF WENATCHEE SUMMER STEELHEAD

Examining the Genetic Structure of Wenatchee Basin Steelhead and Evaluating the Effects of the Supplementation Program

Developed for

Chelan County PUD

and the

Rock Island Habitat Conservation Plan Hatchery Committee

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Table of Contents

Executive Summary

In 1997, Wenatchee River summer steelhead, as part of the upper Columbia River evolutionarily significant unit (ESU), were listed as threatened under the Endangered Species Act (ESA). To address concerns about effects of hatchery supplementation, the hatchery program for hatchery produced (HOR) summer steelhead to be planted in the Wenatchee River changed from using mixed ancestry broodstock collected in the Columbia River to using Wenatchee River broodstock collected in the Wenatchee River. Three monitoring and evaluation (M&E) indicators were developed to measure the genetic effects of hatchery production on wild fish populations. To address these indicators, temporal collections of tissue samples from Wenatchee River hatchery-produced (HOR) and natural origin (NOR) adults captured and sampled at Dryden and Tumwater dams and from NOR juveniles from three Wenatchee River tributaries and the Entiat River were surveyed for genetic variation with 132 genetic (SNPs) markers. Peshastin Creek (a Wenatchee River tributary) and the Entiat River served as no-hatchery-outplant controls, meaning they have stopped receiving HOR juvenile outplants. As per the M&E plan, we interrogated these data for the presence or absence of spatial and temporal trends in allele frequencies, genetic distances, and effective population size.

Allele frequencies – Changes to the summer steelhead hatchery supplementation program had no detectable effect on genetic diversity of wild populations. On average, HOR adults had higher minor allele frequencies (MAF) than NOR adults, which may simply reflect the mixed ancestry of HOR adults. Both HOR and NOR adults had MAF similar to juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants. This suggests that the hatchery program has had little effect on allele frequencies since broodstock sources changed in 1998.

Genetic distances – As intended, interbreeding of Wenatchee River HOR and NOR adults reduced the genetic differences between Wells Hatchery HOR adults and Wenatchee River NOR adults observed in the first few years after changing the broodstock collection protocol. Though there were detectable genetic differences between HOR and HOR adults, the magnitude of that difference declined over time. HOR adults were genetically quite different from NOR adults and juveniles based on pair-wise F_{ST} and principal components analysis (PCA), most likely because of the much smaller effective population size (N_b) in the hatchery population (see below). Pair-wise F_{ST} estimates and genetic distances between HOR and NOR adults collected the same year declined over time suggesting that the interbreeding of HOR and

NOR adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year (the year fish were hatched, determined using scale-based age estimates) were inconclusive because of limitations of the data.

Effective population size (N_b) – Although the effective population size of the Wenatchee River hatchery summer steelhead program was consistently small, it does not appear to have caused a reduction in the effective population size of wild populations. On average, estimates of N_b were much lower and varied less for HOR adults than for NOR adults and juveniles. Estimates of N_b for HOR adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1997. There was no indication that this had any effect on N_b in NOR adults and juveniles; N_b estimates for NOR adults and juveniles were, on average, higher and varied considerably over the time period covered by our dataset (1998 – 2010) and showed no temporal trend.

Introduction

The National Marine Fisheries Service (NMFS) recognizes 15 Evolutionary Significant Units (ESU) for west coast steelhead (*Oncorhynchus mykiss*). The Upper Columbia ESU, which contains steelhead in the Wenatchee Basin, was listed as endangered under the Endangered Species Act (ESA) in 1997. Included in this listing were the Wells hatchery steelhead (program initiated in the late 1960s) that originated from a mixed group of native steelhead and are considered to be genetically similar to natural spawning populations above Wells Dam. Juvenile steelhead from Wells Fish Hatchery was the primary stock released into the Wenatchee River (Murdoch et al. 2003). The 1998 steelhead status review identified several areas of concern for this ESU including the risk of genetic homogenization due to hatchery practices and the high proportion (65% for the Wenatchee River) of hatchery fish present on the spawning grounds (Good et al. 2005). The Biological Review Team (BRT) further identified the relationship between the resident and anadromous forms of *O. mykiss* and possible changes in the population structure ('genetic heritage of the naturally spawning fish') in the basin as two areas requiring additional study. Furthermore, the West Coast Steelhead BRT (2003) recommended that stocks in the Wenatchee, Entiat, and Methow rivers, within the Upper Columbia ESU, be managed as separate populations.

A review of the presence of resident *O. mykiss* in the Upper Columbia ESU (Good et al. 2005) shows that rainbow trout are relatively abundant in upper Columbia River tributaries currently accessible to steelhead as well as in upriver tributaries unavailable to anadromous access by Chief Joseph and Grand Coulee dams (Kostow 2003). U.S. Fish and Wildlife Service (USFWS) biologists surveyed the abundance of trout and steelhead juveniles in the Wenatchee, Entiat, and Methow river drainages in the mid-1980s and found adult trout (defined as those with fork length > 20 cm) in all basins (Mullan et al. 1992). The results also supported the hypothesis that resident *O. mykiss* are more abundant in tributary or mainstem areas upstream of the areas used by steelhead for rearing. No samples of rainbow trout from the Wenatchee were available for this study.

In addition to the mixed ancestry Wells Hatchery steelhead, Skamania Hatchery (Washougal River steelhead ancestry) steelhead were also released into the Wenatchee River basin for several years in the late 1980s (L. Brown, Washington Dept. of Fish and Wildlife [WDFW], personal communication). In 1996, broodstock for the Wenatchee River steelhead program were collected from Priest Rapids Dam and Dryden (rkm 24.9) and Tumwater (rkm 52.6) dams on the Wenatchee River. Because of the ESA listing, broodstock collection after 1996 was restricted to the Wenatchee River in an effort to develop a localized broodstock (Murdoch et al. 2003). Thus, starting in 1998, all juvenile steelhead released into the

Wenatchee River and Wenatchee River tributaries were offspring of only Wenatchee River captured broodstock.

In response to the need for evaluation of the supplementation program, both a monitoring and evaluation plan (Murdoch and Peven 2005) and the associated analytical framework (Hays et al. 2006) were developed for the Habitat Conservation Plans Hatchery Committee through the joint effort of the fishery co-managers (Confederated Tribes of the Colville Reservation [CCT], NMFS, USFWS, WDFW, and Yakama Nation [YN]) and Chelan County, Douglas County, and Grant County Public Utility Districts (PUD). These reports outline 10 objectives to be applied to various species assessing the impacts of hatchery operations mitigating the operation of Rock Island and Rocky Reach Dams. This report pertains to Wenatchee River basin steelhead (*O. mykiss*) and the steelhead supplementation program as addressed by objective 3, specifically the first three evaluation indicators.

> **Objective 3:** Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.
>
> **3.1 Allele Frequency**
>
> **3.2 Genetic Distances Between Populations**
>
> **3.3 Effective Spawning Population**

To address these evaluation indicators the WDFW Molecular Genetics Lab (MGL) obtained pertinent tissue collections and samples, surveyed genetic variation with SNP markers using our standard laboratory protocols, and calculated the relevant genetic metrics and statistics. We used collections from both the Entiat River and Wenatchee River basins. Both have received hatchery plants from non-local stocks [i.e. Entiat was stocked with both Wenatchee and Wells program juveniles averaging 12K and 18K respectively during 1995-2001, and Wenatchee received on average 177K juveniles from the Wells program during 1995-2001; (Good et al. 2005)], and both have all or some part of the basin designated as natural production “reference” drainage – no hatchery outplanting (i.e., the entire Entiat Basin, and Peshastin Creek in the Wenatchee River basin) (Good et al. 2005).

Materials and methods

Sample collections

To address objectives 3.1 through 3.3, we obtained samples from hatchery (HOR, adipose fin clipped) and natural origin (NOR, adipose fin intact) adult summer steelhead captured at Dryden or Tumwater diversion dams in the summer and fall of 1997 through 2009 (excepting 2004 and 2005; Table 1). All or some fraction of these fish was later used as hatchery broodstock the calendar year following the sampling year. In order to keep things simple we have reported years as the spawning year, i.e., the calendar year the fish were spawned, not the calendar year they were captured.

To address objective 3.2, it was necessary to have samples from natural origin fish from each of the spawning populations in the basin. It is difficult to obtain adult samples from known spawning populations due to the life history and behavior of steelhead, without tributary weirs or some other blocking method of collection. The NOR adult samples used as broodstock collected from Dryden and Tumwater Dams were a mixed collection representing all of the spawning populations located upstream. Therefore to determine population substructure within the basin we obtained collections of juvenile fish from smolt traps located within tributaries representing three major populations in the basin and from the Entiat River (Chiwawa River, Nason Creek, and Peshastin Creek; Table 2). We also obtained two collections of juvenile fish caught in a smolt trap in the lower Wenatchee River. These, like the NOR adult collections, were a mixed collection presumably representing all populations located upstream. Fin tissue was taken from each fish and preserved in 95% ethanol.

Sample processing

Fin tissue samples were processed for 1468 HOR and NOR adult steelhead broodstock (Table 1) and for 1542 juvenile *O. mykiss* from the Wenatchee and Entiat Rivers (Table 2). Samples were genotyped at 152 single nucleotide polymorphism loci (SNPs, Tables 3, 4). We originally proposed to use microsatellites, but WDFW MGL and other regional genetic laboratories (Columbia River Inter-Tribal Fish Commission [CRITFC], Idaho Fish and Game [IDFG], USFWS) are moving toward using SNPs and they provide the same kinds of information with faster processing. Twenty SNP loci were developed to discriminate among trout species; 14 distinguish *O. mykiss* from coastal cutthroat trout (*O. clarkii clarkii*) and westslope cutthroat (*O. clarkii lewisi*), and 6 distinguish steelhead and coastal cutthroat from westslope cutthroat (Table 4). The remaining 132 SNP loci were developed to be used for population structure, parentage assignment, or other population genetic studies of *O. mykiss* (Table 3). These markers comprised the current standard set of SNP markers used for genetic studies of *O. mykiss* at WDFW MGL.

We used Qiagen DNEasy ® kits (Qiagen Inc., Valencia, CA), following the recommended protocol for animal tissues, to extract and isolate DNA from fin tissue. SNP genotypes were obtained through PCR and visualization on Fluidigm EP1 integrated fluidic circuits (chips). Protocols followed Fluidigm's recommendations for TaqMan SNP assays as follows: Samples were pre-amplified by Specific Target Amplification (STA) following Fluidigm's recommended protocol with one modification. The 152 assays were pooled to a concentration of 0.2X and mixed with 2X Qiagen Multiplexing Kit (Qiagen, Inc., Valencia CA), instead of TaqMan PreAmp Master Mix (Applied Biosystems), to a volume of 3.75µl, to which 1.25µl of unquantified sample DNA was added for a total reaction volume of 5µl. Pre-amp PCR was conducted on a MJ Research or Applied Biosystems thermal cycler using the following profile: 95°C for 15 min followed by 14 cycles of 95°C for 15 sec and 60°C for 4 minutes. Post-PCR reactions were diluted with 20µl dH_2O to a final volume of 25µl.

Specific SNP locus PCRs were conducted on the Fluidigm chips. Assay loading mixture contained 1X Assay Loading Reagent (Fluidigm), 2.5X ROX Reference Dye (Invetrogen) and 10X custom TaqMan Assay (Applied Biosystems); sample loading mixture contains 1X TaqMan Universal PCR Master Mix (Applied Biosystems), 0.05X AmpliTaq Gold DNA polymerase (Applied Biosystems), 1X GT sampling loading reagent (Fluidigm) and 2.1 µL template DNA. Four µL assay loading mix and 5 µL sample loading mix were pipetted onto the chip and loaded by the IFC loader (Fluidigm). PCR was conducted on a Fluidigm thermal cycler using a two step profile. Initial mix thermal profile was 70°C for 30min, 25°C for 5 min, 52.3° for 10 sec, 50.1°C for 1 min 50sec, 98°C for 5 sec, 96°C for 9 min 55 sec, 96°C for 15 sec, 58.6°C for 8 sec, and 60.1°C for 43 sec. Amplification thermal profile was 40 cycles of 58.6°C for 10 sec, 96°C for 5 sec, 58.6°C for 8 sec and 60.1°C for 43 sec with a final hold at 20°C.

The SNP assays were visualized on the Fluidigm EP1 machine using the BioMark data collection software and analyzed using Fluidigm SNP genotyping analysis software. To ensure all SNP markers were being scored accurately and consistently, all data were scored by two researchers and scores of each researcher were compared. Disputed scores were called missing data (i.e., no genotype).

Evaluation of loci

A two-tailed exact test of Hardy–Weinberg equilibrium (HWE) was performed for each locus in each collection or population using the Markov Chain method implemented in GENEPOP v4.1 (dememorization number 1000, 100 batches, 1000 iterations per batch; Raymond and Rousset 1995; Rousset 2008). Significance of probability values was adjusted for multiple tests using false discovery rate (Verhoeven et al. 2005). F_{IS}, a measure of the fractional reduction in heterozygosity due to inbreeding in individuals within a subpopulation and an additional indicator of scoring issues, was calculated according to Weir and Cockerham (1984) using GENEPOP v4.1. Allele frequencies were calculated using CONVERT v1.0 (Glaubitz 2004). Expected and observed heterozygosities were calculated using GDA v1.1 (Lewis and Zaykin 2001).

Allele frequencies, genetic distances and population differentiation

To evaluate Q1 of Objective 3.1 and 3.2, we evaluated trends and patterns in allele frequencies, genetic distances and population differentiation. To test for temporal patterns in allele frequencies, we compared sample or spawn year to two diversity metrics, allele frequency and observed heterozygosity, from each adult and juvenile collection. Each SNP locus had only one or two alleles, so we used the minor allele frequency (MAF) of each SNP locus for each adult collection and averaged across loci. We also calculated the average observed heterozygosity (Ho) for each SNP locus within each adult and juvenile collection. We examined the presence or absence of a temporal trend in average allele frequency and observed heterozygosity with logistic regression analysis in R (R Development Core Team 2009).

To partition genetic variance into temporal, spatial (juvenile) and origin (adult) fractions, we performed hierarchical analysis of molecular variance (AMOVA) using ARLEQUIN v3.0 (Excoffier et al. 2005) with 1,000 permutations. We performed this analysis separately for juvenile and adult collections. Juveniles were grouped by sampling location (tributary) and adults were grouped by origin (HOR or NOR). To estimate the magnitude of genetic differences among temporal and spatial collections we calculated pairwise F_{ST} estimates among collections using FSTAT (Goudet 1995) with 1000 permutations. Statistical significance was adjusted using false discovery rate (Verhoeven et al. 2005).

To evaluate the temporal changes in genetic relationships, we compared spawn year to within spawn year pairwise F_{ST} estimates between NOR and NOR adults using beta regression (Simas and Rocha 2010). We used beta regression because the dependent variable was bound by zero and one but not binomial. Analysis was performed in R (package "betareg", Cribari-Neto and Zeileis 2010), with a loglog link.

We used principal component analyses (PCA) to explore the relationship between the covariation among the SNP loci within each collection and genetic differentiation between HOR and NOR collections, and to determine if the degree of differentiation has changed with time. Since each SNP is represented by only two alleles, only one allele per SNP is necessary to fully describe the covariation among all SNPs. We used MATLAB® scripts (2007a, The Mathworks, Natlick, MA) to calculate the principal components from SNP allele frequencies using only the major allele (1-MAF) for each SNP. We defined the major allele as the allele with the higher mean frequency across all collections, regardless of its status within any individual collection. We conducted three PCA analyses using: (1) all adult samples, aggregated based on origin (HOR versus NOR) and spawn year (i.e., the year the adult fish were used as broodstock) (N = 1437, 22 collections), (2) same as #1, but with the addition of all juvenile samples (N = 2938, 37 collections), and (3) only those adults samples with available age information (Mike Hughes, WDFW, personal communication) aggregated based on origin, and spawn year or brood year (i.e., the year the fish were hatched) (N = 1313, 20 spawn-year or 25 brood-year collections).

Molecular differentiation between HOR and NOR adults within a year was calculated based on principal component scores using Euclidian distances. We calculated pair-wise Euclidian distances between HOR and NOR fish within a spawn year or brood year using the first three principal components, and standardized each distance by subtracting from it the mean Euclidian distance calculated across all pair-wise distances. We used Mahalanobis distances to calculate the variation among HOR and NOR collections (calculated separately), again using the first three principal components. Here, we calculated Mahalanobis distances as the Euclidian distances between each collection and the centroid of all collections (HOR and NOR combined), but the Euclidian distances are scaled based on the dispersion of collections around the centroid (i.e., the variance). Euclidian and Mahalanobis distances were calculated using MATLAB scripts.

Effective spawning population

To evaluate Q1 of Objective 3.3, we estimated N_e using the single-sample linkage disequilibrium methods implemented in the program LDNE (Waples and Do 2008). This method requires that you input the P_{crit} value, the minimum frequency at which alleles were included in the analysis, since results can be biased depending on this setting (Waples and Do 2010). SNP markers typically have only one or two alleles; if one of two alleles is excluded based on its frequency in the collection it essentially excludes the locus, reducing the overall dataset. Therefore, we used P_{crit} values ranging from 0.1 to 0.001 to evaluate whether trends in N_e changed given which loci were used. Confidence intervals were calculated using a jackknife procedure.

We calculated an estimate of N_e for all adult and juvenile collections individually. However, the intention of an integrated hatchery program such as the Wenatchee River steelhead hatchery program is that HOR and NOR fish are integrated and progress as a single population through intentional interbreeding in the hatchery and presumed natural interbreeding in the wild. Thus, we also combined annual HOR and NOR collections to calculate an overall N_e estimate as has been done in other genetic monitoring and evaluation analyses (e.g., Small et al. 2007, [Chinook salmon, *O. tshawytscha*]).

Estimates of N_e from linkage refer to the generations that produced the sample. To calculate the ratio of effective population size to census size (N_e/N), we obtained the number of fish spawned in the hatchery (1993 through 2006, i.e., those that produced the adipose fin clipped adults that returned to spawn in the Wenatchee River 1998 through 2010) and the estimated escapement of fish spawning naturally (HOR and NOR separately) for the same time period. Estimates of census population size in spawning tributaries was obtained by multiplying the fraction of redds counted within tributaries (Chad Herring ,WDFW, unpublished data) by the total Wenatchee River census population estimate (Andrew Murdoch, WDFW, unpublished data). To calculate N_e/N, we performed two analyses. First, for adults, we assumed a five year generation time for natural origin adults and a four year generation time for hatchery origin adults and divided the N_e estimate by the census population estimate from four or five years earlier. For juveniles, we assumed an age at outmigration of two years and divided the N_e estimates by the estimate of census population size for the appropriate tributary. Second, we used available adult age data to parse individuals into cohorts originating in brood years (rather than spawn years) and then used LDNE to estimate N_e from cohort collections. We performed both analyses to make full use of all available data; age data were not available for many adults, and because of variable survival and sampling not all cohorts had sufficient numbers of HOR and NOR adults. According to Luikart et al. (2010), estimates produced using linkage disequilibrium should be interpreted as something between effective population size (N_e) and the effective number of breeders (N_b). Using cohorts, the estimate produced by LDNE is clearly an estimate of N_b rather than N_e. In order to keep things simple, we have referred to all estimates as N_b.

Results and Discussion

Collections and samples received

From 1468 samples from HOR and NOR adult steelhead broodstock, 1437 produced sufficient genetic data for further analysis (Table 1). From 1542 samples from NOR juvenile steelhead from Wenatchee River tributaries and the Entiat River, 1501 produced sufficient genetic data for further analysis and were genetically identified as *O. mykiss* (Table 2). Samples genetically identified as *O. clarki* (2 samples from the Chiwawa River, 1 from the Entiat River) or *O. clarki*/*O. mykiss* hybrids (4 – lower Wenatchee River, 4 – Nason Creek, 4 – Chiwawa River, and 1 – Entiat River) were omitted from further analysis.

Evaluation of loci

Three loci showed deviations from HWE in 10 or more of 37 Wenatchee steelhead collections before correcting for multiple tests (AOmy016, AOmy051, AOmy252, Table A1) indicating possible scoring issues. These loci were omitted from further analysis. Nine of the remaining loci were monomorphic or nearly monomorphic in all collections (average MAF < 0.1, AOmy023, AOmy028, AOmy123, AOmy129, AOmy132, AOmy209, AOmy229, AOmy270, AOmy271, Table A1) contributing little or nothing to analytical power. These loci were also omitted from further analysis. No genetic data was available for collection 10FD due to poor PCR amplification at locus AOmy213 for the entire collection. AOmy213 had a relatively low MAF in most collections so rather than re-processing this collection at this locus or running different sets of loci for different tests, we omitted this locus from further analysis. Only six tests of deviation from HWE were significant after correcting for 4348 tests using false discovery rate. Two of these tests were in loci already omitted. The remaining four tests were spread among the remaining loci, indicating no more loci needed to be omitted from further analysis.

Objective 3.1, 3.2 – Allele frequencies and Genetic distances

Allele frequencies

Average MAF of SNP loci ranged from 0.00 to 0.60 in HOR adult collections and from 0.00 to 0.61 in NOR adult collections (Table A1). Observed heterozygosity ranged from 0.00 to 0.75 in HOR adult collections and from 0.01 to 0.67 in NOR adult collections. Juvenile collections produced similar ranges of MAF and Ho (Table A1). Average MAF and Ho of HOR adult collections appeared to be greater than those of natural origin collections. However, logistic regression analysis indicated there was no significant temporal trend in either diversity statistic (Figure 1). Similarly, there was no consistent temporal trend in MAF or Ho of juvenile collections (Figure 2). Both the Chiwawa River and Nason Creek, the two tributaries that currently still receive hatchery juvenile outplants, both appeared to have declining allele frequencies, but neither was statistically significant ($P > 0.90$). However, the power to detect significant trends was limited by the small sample sizes (n = 3 sample years).

Analysis of Molecular Variance

Analysis of molecular variance (AMOVA) of adult collections (i.e., temporal and origin structure) indicated most of the genetic variance was among individuals or among individuals within populations (99.04%). Most of the remaining variance was temporal variation within hatchery and natural origin groups (0.61%) with the remaining variation from origin (0.35%). AMOVA of juvenile collections (i.e., spatial structure) indicated most of the genetic variance was among individuals (98.44%) or among individuals within populations (0.94%). Most of the remaining variance existed among temporal collections within tributary collections (0.37%) with the smallest fraction as among tributary variance (0.24%). Thus, overall, there was more variability among years than among tributaries or origins, but no trend in the temporal variability.

Pair-wise F_{ST} estimates

HOR adults were genetically different that NOR adults as estimated by F_{ST} (full pair-wise table in Table A2, all pair-wise F_{ST} estimates with *P*-values ≤ 0.05 before correcting for multiple tests were significantly different from zero after correcting for multiple tests using false discovery rate). On average, HOR adult collections were as different from one another (mean F_{ST} = 0.011) as they were from NOR adult collections among years (mean F_{ST} = 0.009) or from NOR adult collections within years (mean F_{ST} = 0.010). Among year comparisons of NOR adult collections were, on average, nearly an order of magnitude lower (mean = 0.002). These patterns held whether spawn year or brood year (data not shown) was used to group individuals. Over time, within spawn year pair-wise F_{ST} estimates between HOR and NOR adults declined over time (β = -0.014, *P* = 0.0185; Figure 3), suggesting that the integration of hatchery and wild fish is slowly genetically homogenizing the groups. That relationship disappeared when adults were grouped by brood year (i.e., comparing fish produced the same year) and all brood years were used (β = -0.009, *P* = 0.615, data not shown). However, when the dataset was restricted to just those brood years when all typical (age at maturation frequency among all years > 0.10) age classes were present in the dataset (HOR = age 3, 4; NOR = age 4, 5, 6; brood years 1996-1998, 2004-2005) a non-significant (*P* = 0.278) negative relationship (β = -0.12) of F_{ST} and brood year was apparent. When the data were further restricted to just the years after the hatchery program changed to only collecting broodstock in the Wenatchee River (brood years 1998, 2004-2005), the slope was also negative (β = -0.09), but the relationship was not statistically significant (*P* = 0.962).

Within tributary among sample year pair-wise comparisons of juvenile collections were, on average, only very slightly smaller than comparisons among tributaries (0.005 vs. 0.006, respectively, Table 5, all pair-wise F_{ST} estimates with *P*-values ≤ 0.05 before correcting for multiple tests were significantly different from zero after correcting for multiple tests using false discovery rate). Nason Creek and Peshastin Creek on average showed higher among sample year F_{ST} estimates (0.010 and 0.007, respectively) than the Chiwawa or Entiat Rivers (0.004 and 0.002, respectively). The pair-wise comparison of the two collections of lower Wenatchee River smolts, presumably a mix of Chiwawa, Nason, Peshastin smolts and smolts from other spawning tributaries, was an order of magnitude smaller (F_{ST} = 0.0002), and not significantly different than zero (Table 5). There was no temporal trend in pair-wise comparisons of juvenile collections. However with, at most, four annual collections, detecting any temporal trend was unlikely. We also had no collections from years prior to 1998 (the first year of new hatchery program broodstock collecting protocols) with which to compare contemporary data, nor could we find any reports or papers containing pre-hatchery-program-change genetic comparisons among Wenatchee River tributary populations, making it impossible to determine whether or not changing the hatchery program has had any effect at all on population structure. However, these data will be useful for future studies.

Principal Components

Each principal component analysis (Figures 4, 5) indicated that the genetic structure among HOR collections differed from that among NOR collections, and that this difference has decreased with time. When adult fish were aggregated based on origin and spawn-year, there was a clear differentiation between HOR and NOR adult collections along PC 1, and a separation among HOR collections, differentiating the early spawn-years (1998 – 2003) from the later spawn-years (2004 – 2010) along PC 2 and PC 3, respectively (Figure 4). The pair-wise genetic distances between HOR and NOR collections from the same spawn year (i.e., the HOR and NOR fish used as broodstock within the same year) decreased from the largest distance in 1998 to small distances in 2009 and 2010, although the smallest distance occurred in 2004 (Figure 4, top right). That is, within hatchery broodstock, the genetic difference between HOR and NOR fish decreased, on average, from 1998 to 2010, and the decrease appeared to be a mutual convergence of NOR fish shifting right along PC 1 and HOR fish shifting downward along PC 2 and PC 3. This increasing similarity in adult fish mirrored that seen in within year pair-wise F_{ST} estimates between HOR and NOR adults which also declined over time (Figure 3).

Overall, there was considerably more genetic variation among the HOR collections than there was among the NOR collections with average Mahalanobis distances (distance between each collection and the overall centroid [0,0,0]) among the HOR and NOR collections being 4.2 and 1.5, respectively. Since each NOR collection was generally composed of 3-4 brood-years, while HOR collections rarely were composed of more than two brood-years, we attributed the lower year-to-year genetic variability of the NOR broodstock to the greater homogenizing effect of including four or more brood-years compared with only two brood years for the HOR broodstock.

Including the 15 juvenile collections, along with the 22 adult collections, did not materially alter the principal component structure (Figure 6), although the total genetic variation accounted for by the three principal components decreased from 44% using only the adults to 33% when juveniles were included. For the most-part, the juvenile fish appeared intermediate between HOR and NOR fish, but there was greater overlap in principal component scores (and therefore greater genetic similarity) of the juvenile and NOR collections, than of the juvenile and HOR collections. The average Euclidian distance between the juvenile and HOR collections was 0.49, compared to 0.23 between the juvenile and NOR collections, which was no different than 0.23 and 0.22 for the within juvenile and NOR collections, respectively.

By using the available adult age data, we were able to compare the genetic differentiation among the same set of fish when they are aggregated by origin (hatchery versus natural) and brood-year (year fish were hatched) with aggregates based on origin and spawn-year (year adult fish were spawned). A brood-year analysis compares within a year the genetic diversity generated from hatchery broodstock with that naturally produced in the spawning grounds. A spawn-year analysis compares the HOR and NOR genetic diversity that was mixed among cohorts of the parental generations. The same basic pattern of genetic structure that we have seen in spawn-year analyses (Figure 4, Figure 6, and the right side of Figure 5) also occurred in the brood-year analysis (left side of Figure 5). That is, from Figure 5 we saw (1) that HOR and NOR fish were differentiated from each other; (2) there was considerably more genetic variation (temporal variation) among the hatchery-origin collections than there was among the natural-origin collections (for brood-year, Mahalanobis distances = 5.18 and 0.75, respectively; for spawn-year, Mahalanobis distances = 4.25 and 1.25, respectively), and (3) that the genetic distances between HOR and NOR collections were lower in the more recent brood- and spawn-years, than in the earlier brood- and spawn-years (Figure 7; R^2 = 0.41 or 41%, $P < 0.05$). This indicated that the HOR and NOR fish used as broodstock in 2010 were more similar to each other than they were at the inception of the new hatchery program.

The relationship between genetic distance and brood-year was not the same as the relationship between genetic distance and spawn-year. For brood-year, although the slope was negative (i.e., trending downward or decreased differentiation with time) and the two most-recent brood years (2005-2006) showed relatively small HOR and NOR adult differentiation, the negative slope was not significantly different from zero and the regression accounted for only 7% of the variation. This was likely the result of insufficient sampling of certain age classes from many brood years (especially from NOR adults) due to two un-processed sample years (2005 and 2006).

Objective 3.3 – Effective spawning population

There was no difference in the temporal trends in estimates of N_b with P_{crit} set from 0.1 to 0.001 (Figure 8, data not shown for all collections), so we have reported only results with $P_{crit} = 0.001$, i.e., the full genetic dataset. Using either spawn-year or brood year, estimates of NOR adult N_b were higher and varied more than those of HOR adults (Figures 9, 10), concordant with the PCA analysis. Estimates for HOR adults ranged from 17 to 174 (by spawn year, mean = 65) or from 6 to 130 (by brood year, mean = 39). Estimates for NOR adults ranged from 36 to 982 (by spawn year, mean = 405) or from 59 to 2966 (by brood year, mean = 645). Many N_b estimates for NOR adults had confidence intervals extending to infinity on the upper bound. This reflected the difficulty in obtaining precise estimates of N_b for large populations (Waples and Do 2010).

Estimates of N_b for HOR steelhead dropped by approximately half from 1994, when broodstock were still collected at Wells Hatchery, to 1998, when the program used Wenatchee River trapped adults only, suggesting an effect of changing broodstock collection practices, which began in 1997 (Figures 8, 9). Since 1997, the hatchery population N_b remained at a relatively stable lower level (Figures 8, 9, and 10). There was no obvious change in N_b for NOR steelhead since 1993; the N_b estimate for 1993 was the largest, however the confidence interval overlapped estimates from many other years. The temporal trend in N_b estimates from combined collections mirrored those of the HOR collections alone, though estimates using combined collections were slightly larger (Figure 11).

As with N_b estimates, estimates of the ratio of N_b/N for NOR adults varied more than those of HOR adults (Figures 12, 13). However, using spawn year, i.e., mixtures of cohorts, the average N_b/N ratio for HOR adults was equal to that of NOR adults (mean N_b/N = 0.26), whereas when using brood year, the average N_b/N ratio for NOR adults was double that of HOR adults (NOR average =0.40, HOR average = 0.20). This is likely a consequence of the homogenizing effect of mixed cohorts. Estimates of N_b for HOR adults using spawn year were close to those estimated using brood year because of the lower diversity in age at maturation, whereas for NOR, grouping by brood year produces different estimates than when grouping by spawn year because of higher diversity in age at maturation. Regardless of which estimate was used, there was no temporal trend in N_b/N for either NOR or HOR adults.

Summary

On average, HOR adults had higher minor allele frequencies (MAF) than NOR adults, and both had similar MAF as juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants suggesting that the hatchery program has had little effect on allele frequencies since 1998.

HOR adults were genetically quite different from NOR adults and juveniles based on pair-wise F_{ST} and principal components analysis (PCA), most likely because of the much smaller effective population size (N_b) in the hatchery population. Pair-wise F_{ST} estimates and genetic distances between HOR and NOR adults collected the same year declined over time suggesting that the interbreeding of HOR and NOR adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year (the year fish were hatched, determined using scale-based age estimates) were inconclusive because of limitations of the data.

On average, estimates of N_b were much lower and varied less for HOR adults than for NOR adults and juveniles. Estimates of N_b for HOR adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1997. There was no indication that this had any effect on N_b in NOR adults and juveniles; N_b estimates for NOR adults and juveniles were, on average, higher and varied considerably over the time period covered by our dataset (1998 – 2010) and showed no temporal trend. Small N_b sizes increase the risk of loss of genetic diversity due to inbreeding and random effects (genetic drift). The N_b of the hatchery component of the population may be increased by spawning more families, using specific mating designs, and minimizing variance in reproductive success. However, given the apparent lack of effects overall, changes to the hatchery protocol may not be necessary.

Overall, hatchery practices appear to have had little effect on natural origin Wenatchee summer steelhead neutral genetic diversity or N_b. We cannot accurately assess their effects on population structure at this time. However, it is interesting to note that when juvenile collections are analyzed separately from adult collections, Peshastin Creek, which has received fewer hatchery outplants in the past and is currently a refuge from hatchery outplants, is genetically different than other tributaries and the Entiat River (data not shown). On the other hand, the Entiat River, which is also a refuge from hatchery outplants and is not a tributary of the Wenatchee River, is genetically very similar to Nason Creek and the Chiwawa River, both Wenatchee River tributaries. This suggests, though it does not conclude, that within basin population structure may have existed before summer steelhead hatchery production began in the upper Columbia River and that the population structure was eliminated by hatchery influence long before 1998.

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Figures

Figure 1. Observed average minor allele frequencies (MAF) and observed heterozygosities (Ho) of 119 SNP loci from 11 annual collections of hatchery-produced (HOR) and natural origin (NOR) adult steelhead from the Wenatchee River. Trend lines are from a logistic regression. Note the X axis does not cross the Y axis at the origin. Neither the slopes nor the intercepts were statistically significant.

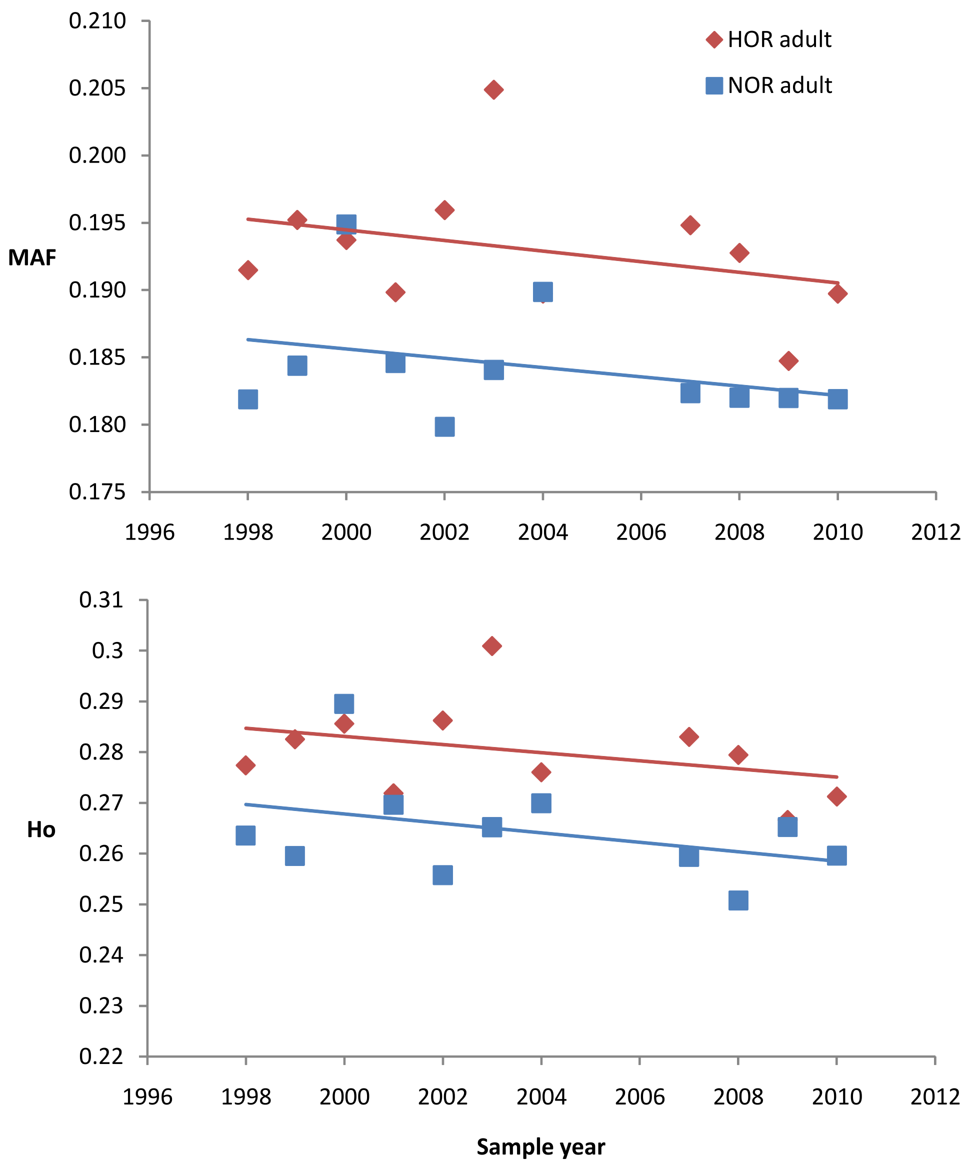


Figure 2. Observed average minor allele frequencies (MAF) and observed heterozygosities (Ho) of 119 SNP loci from 15 collections of natural origin juvenile steelhead from Wenatchee River tributaries, the lower Wenatchee River and the Entiat River. There were no consistent temporal trends in MAF or Ho in these collections.

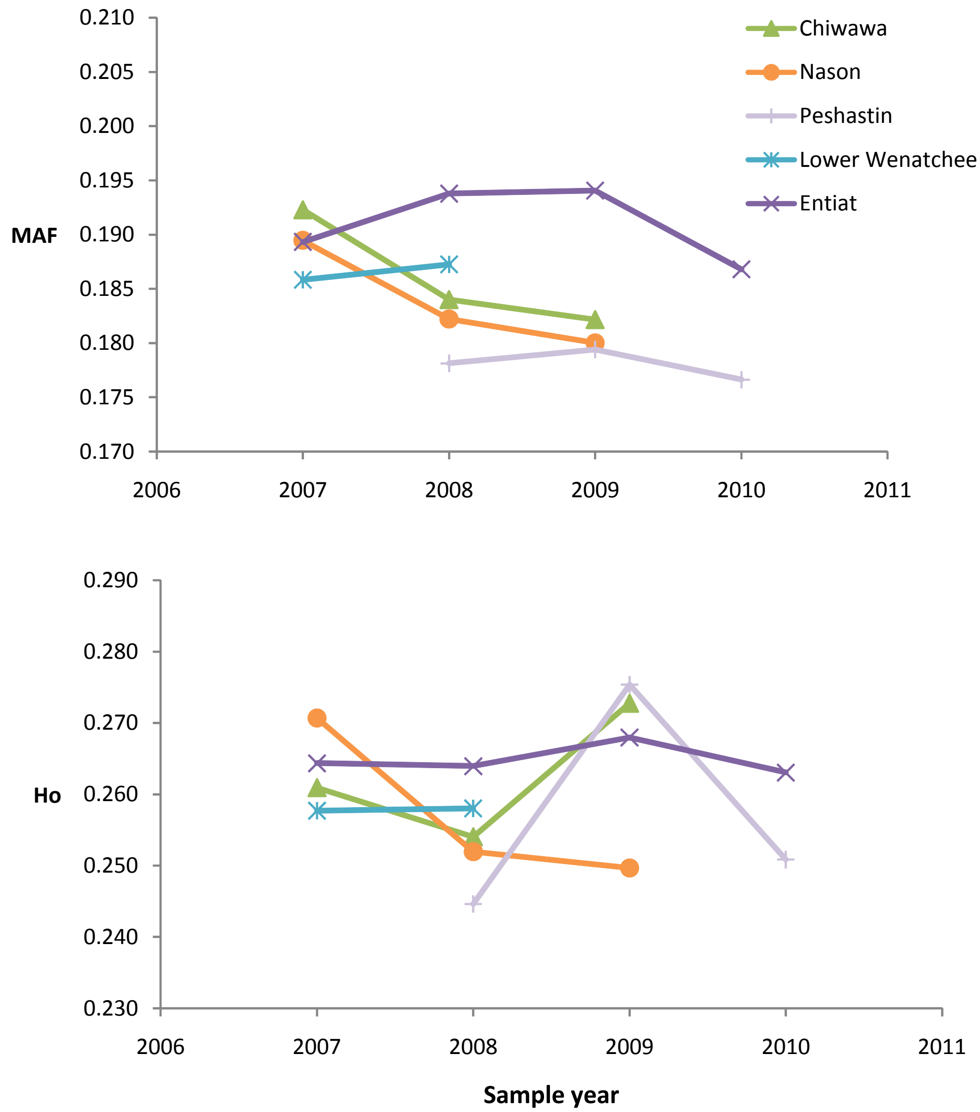


Figure 3. The relationship of time with pairwise F_{ST} estimates between hatchery-produced (adipose fin clipped) and natural origin (unclipped) adults of the same sample year. The line is the prediction based on beta regression.

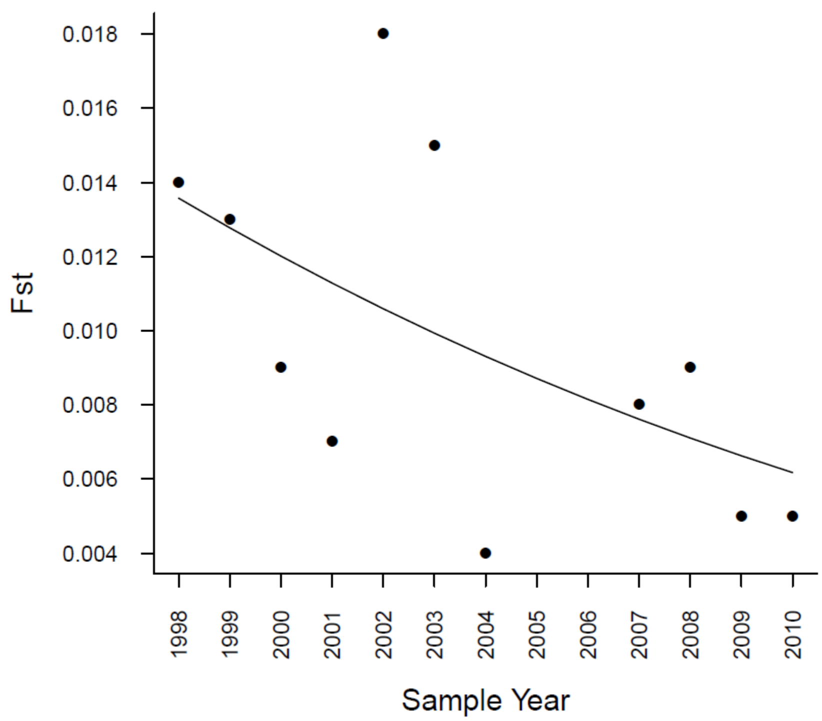


Figure 4. Principal component (PC) 1 versus 2 (top left), PC 1 versus 3 (bottom left), and PC 2 versus 3 (bottom right) based on an analysis using all adults aggregated into origin and spawn-year collections. Natural-origin spawn-years are shown in italicized typeface. The percentage within the label of each axis convey the percent of total genetic variance that is accounted for by that axis. Taken together, the three principal components account for 44% of the total SNP variation. Top right shows pairwise Euclidian distances versus spawn-year, with zero distance equal to average distance across all pairwise distances. Blue line is least-squares fit with $R^2 = 0.45$.

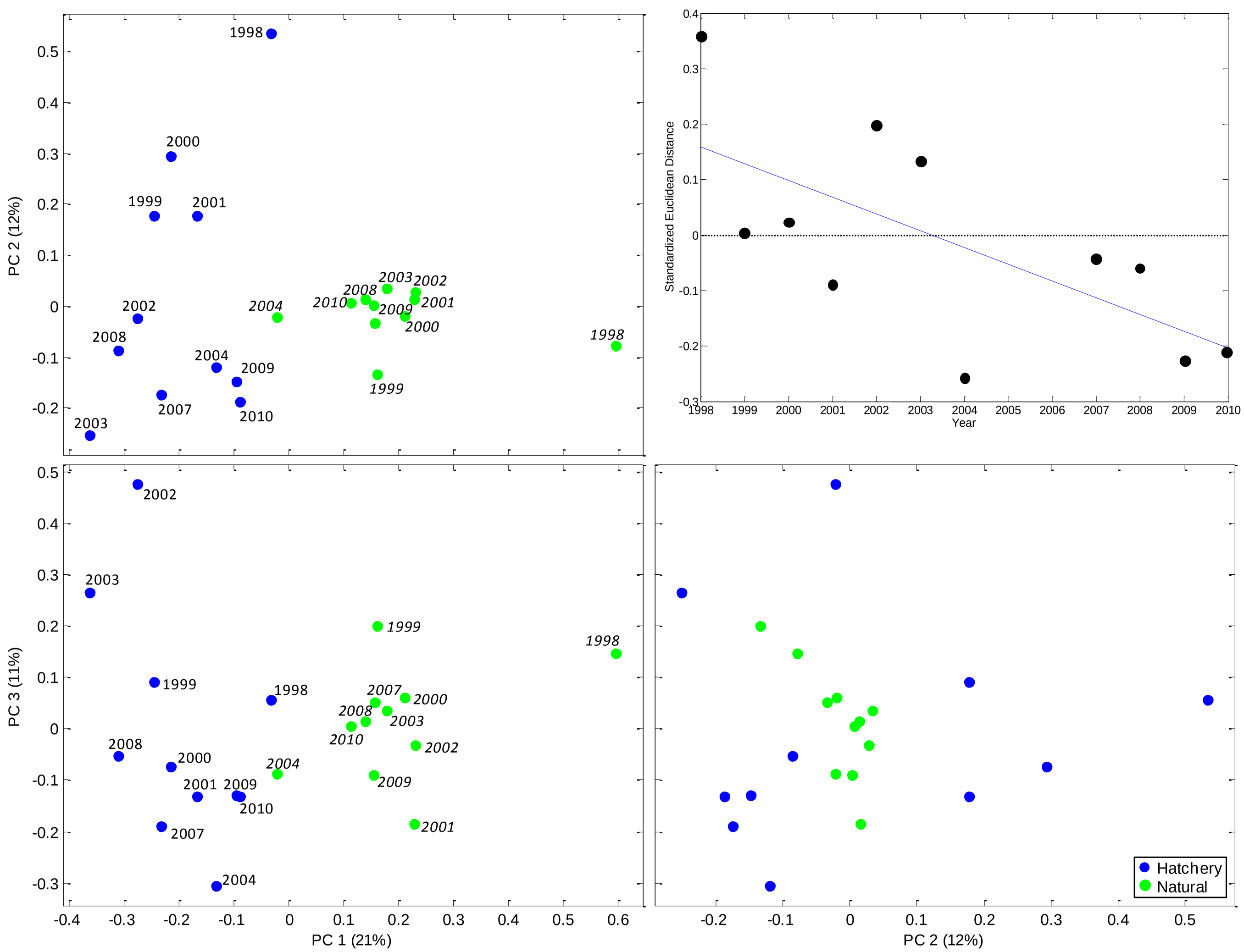


Figure 5. Principal components (PC) 1 versus 2 (top) and 3 (bottom) for adults aggregated into brood-year (BY; left) and spawn-year (SY; right). Spawn-year analysis is the same as in Figure x1, except fewer individuals per collection were included (see methods). Note that for the SY analysis here PC 2 and 3 are similar to PC 3 and 2, respectively, in Figure x1. Only BY1995 (earliest year with paired hatchery-natural data), BY2000 (extreme PC 1 score), and BY2006 (latest year with paired hatchery-natural data) are labeled. Hatchery- and natural-origin individuals from BY1995, BY2000, and BY2006, returned to spawn (spawn-year) in 1999 (hatchery)/1999-2001 (natural), 2003-2004 (hatchery)/2004 and 2007 (natural), and 2009-2010 (hatchery)/2010 (natural), respectively. These years are labeled in the upper right figure. Only 4 year-old BY 2006 natural-origin fish are represented in the SY 2010 collection.

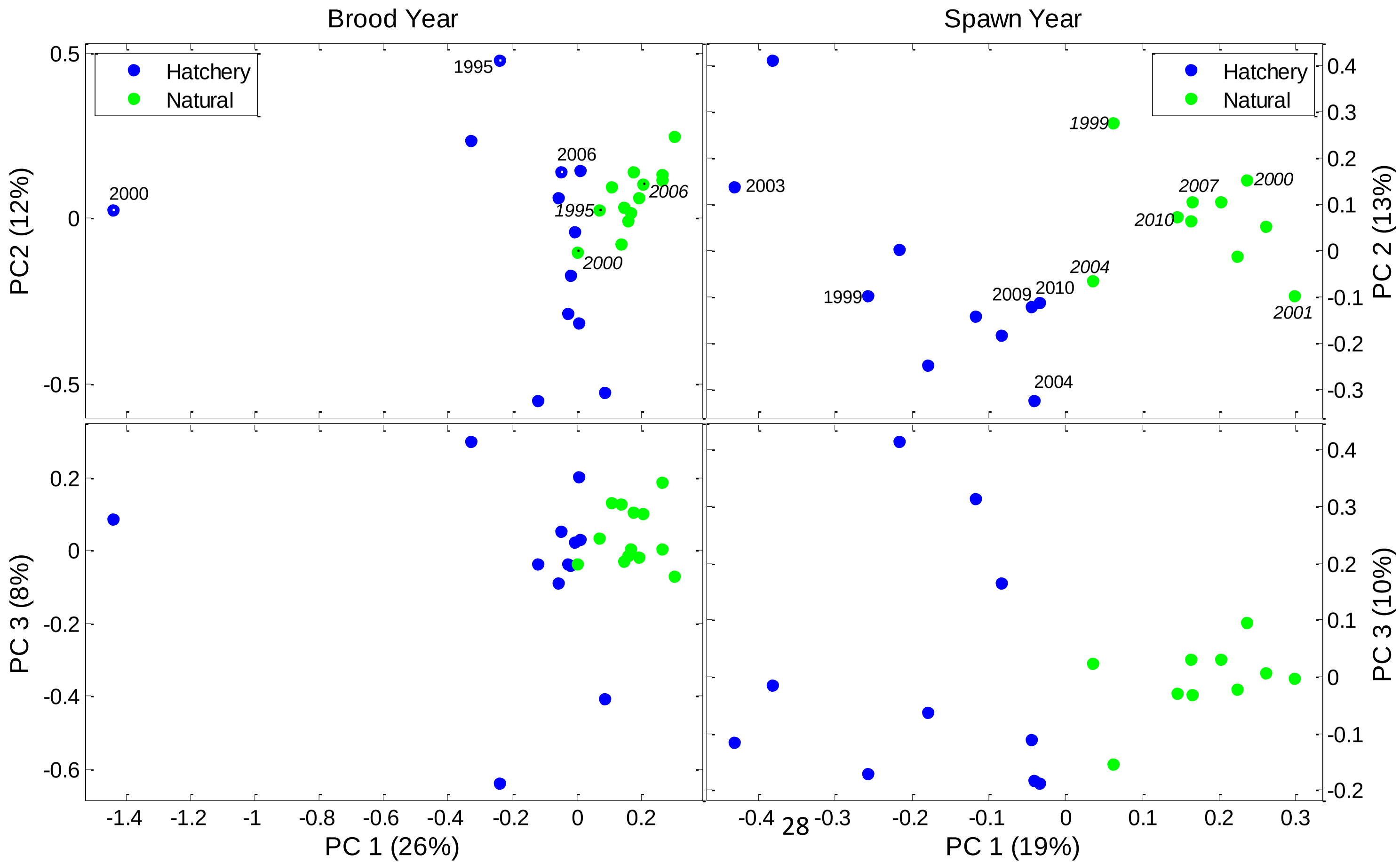


Figure 6. Principal component (PC) 1 versus 2 (top) and PC 1 versus 3 (bottom) based on an analysis using all adult and juvenile fish aggregated into age (juvenile versus adult), origin (hatchery versus adult) and spawn-year collections.

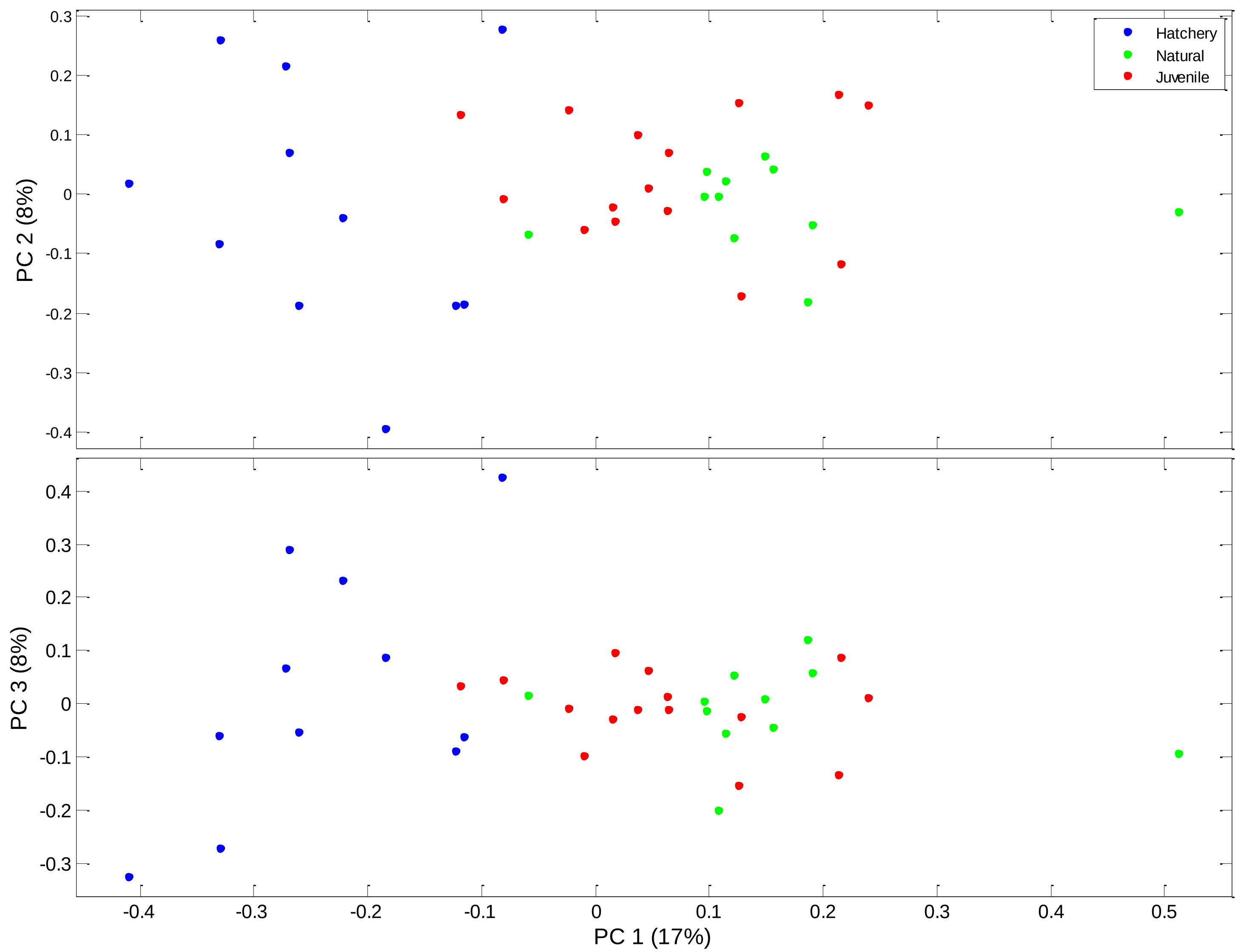


Figure 7. Pairwise Euclidian distances versus brood-year (top) and spawn-year (bottom), with zero distance equal to average distance across all pairwise distances. Blue lines are least-squares fits, which is not significant (slope = 0) for brood-year, but significant (slope > 0) for spawn-year.

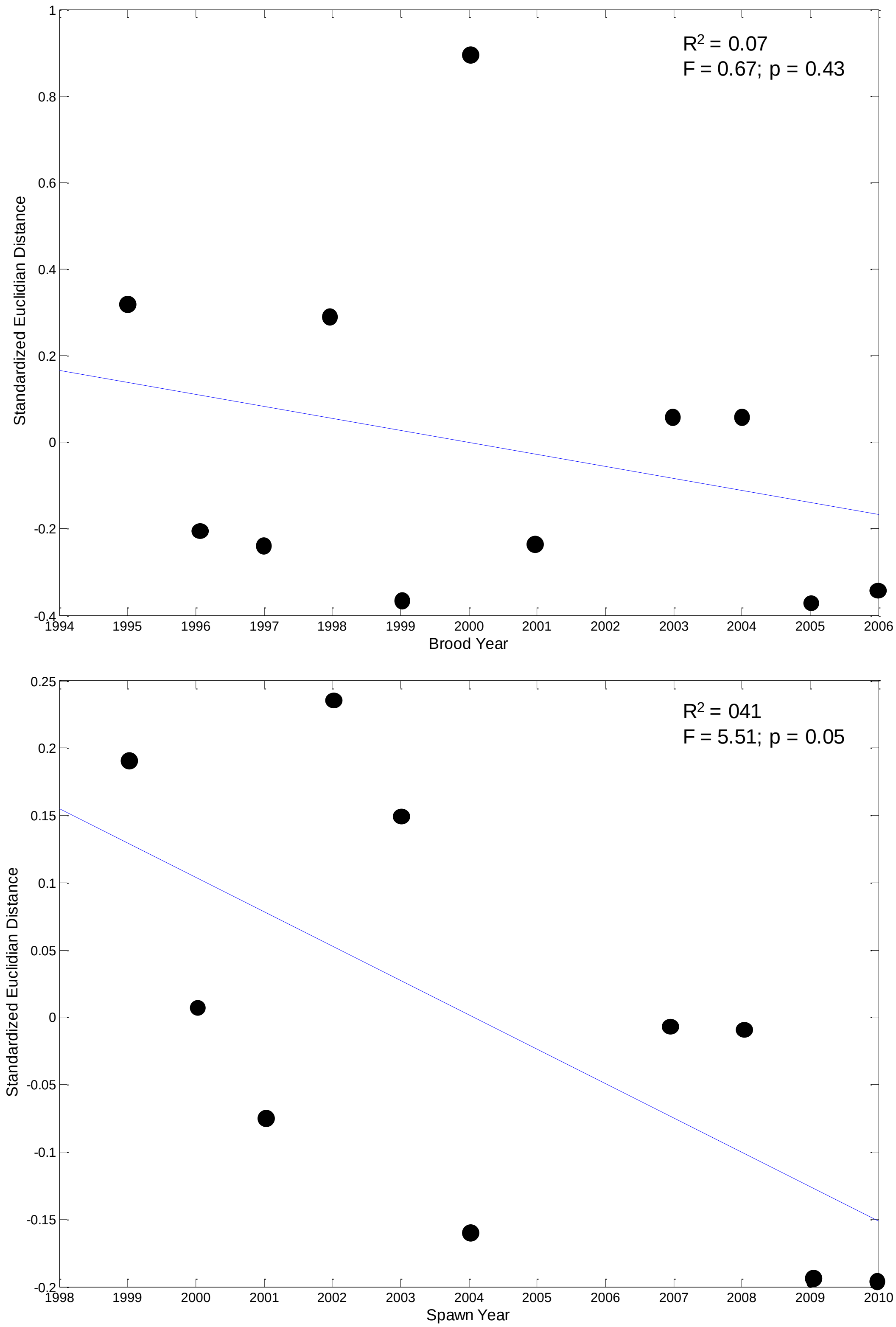


Figure 8. Effective population size estimates (N_b) from Wenatchee River adult hatchery-produced steelhead annual collections calculated using single sample methods implemented in the program LDNE (Waples and Do 2008). Each line connects annual estimates of N_b estimated with a different value of P_{crit}, the smallest allelic proportion allowed during analysis. With SNP data, omitting an allele omits the locus. Estimates of N_b changed very little when P_{crit} varied from 0.1 to 0.001. Setting P_{crit} = 0.001 forced the use of all available loci.

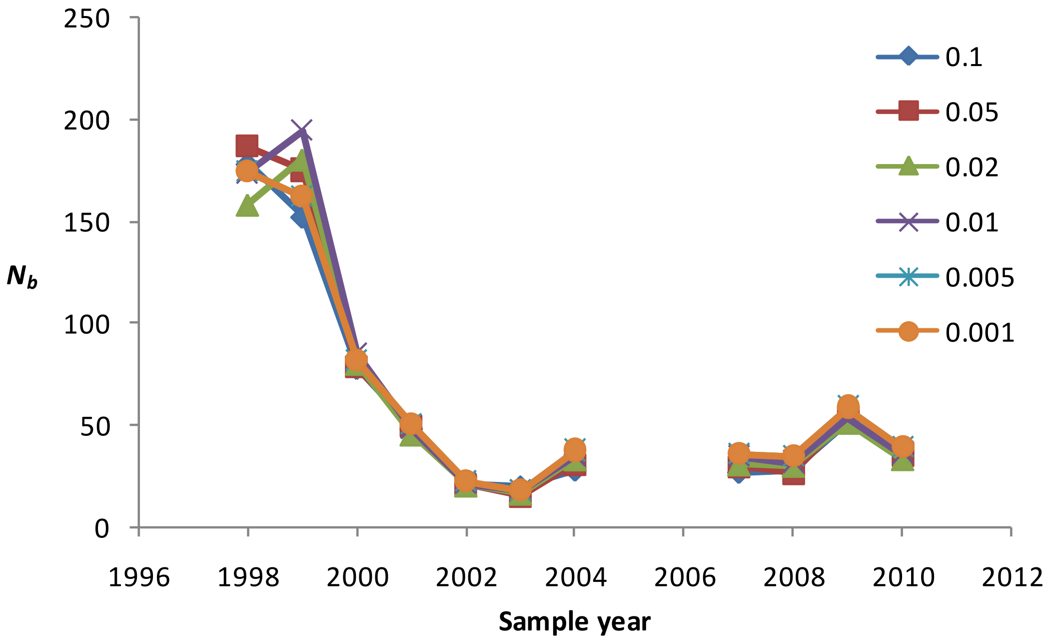


Figure 9. Estimates of Wenatchee River steelhead effective number of breeders (N_b) estimated using the single sample methods incorporated in the program LDNE (Waples and Do 2008). Estimates of N_b refer to parental (and even grantparental) generations. N_b data were plotted against their estimated parental brood year. We assumed a 5 year generation time for natural origin adults (NOR), a 4 year generation time for hatchery-produced adults (HOR) and an age of smolt outmigration of age 2 for smolt collections from Wenatchee River tributaries (Chiwawa River, Nason Creek, Peshastin Creek), the lower Wenatchee River, and the Entiat River. Bars represent the 95% confidence interval estimated by jackknife procedure. Bars that exceed the upper limit of the Y axis are labeled with the upper bound (Inf. = infinity).

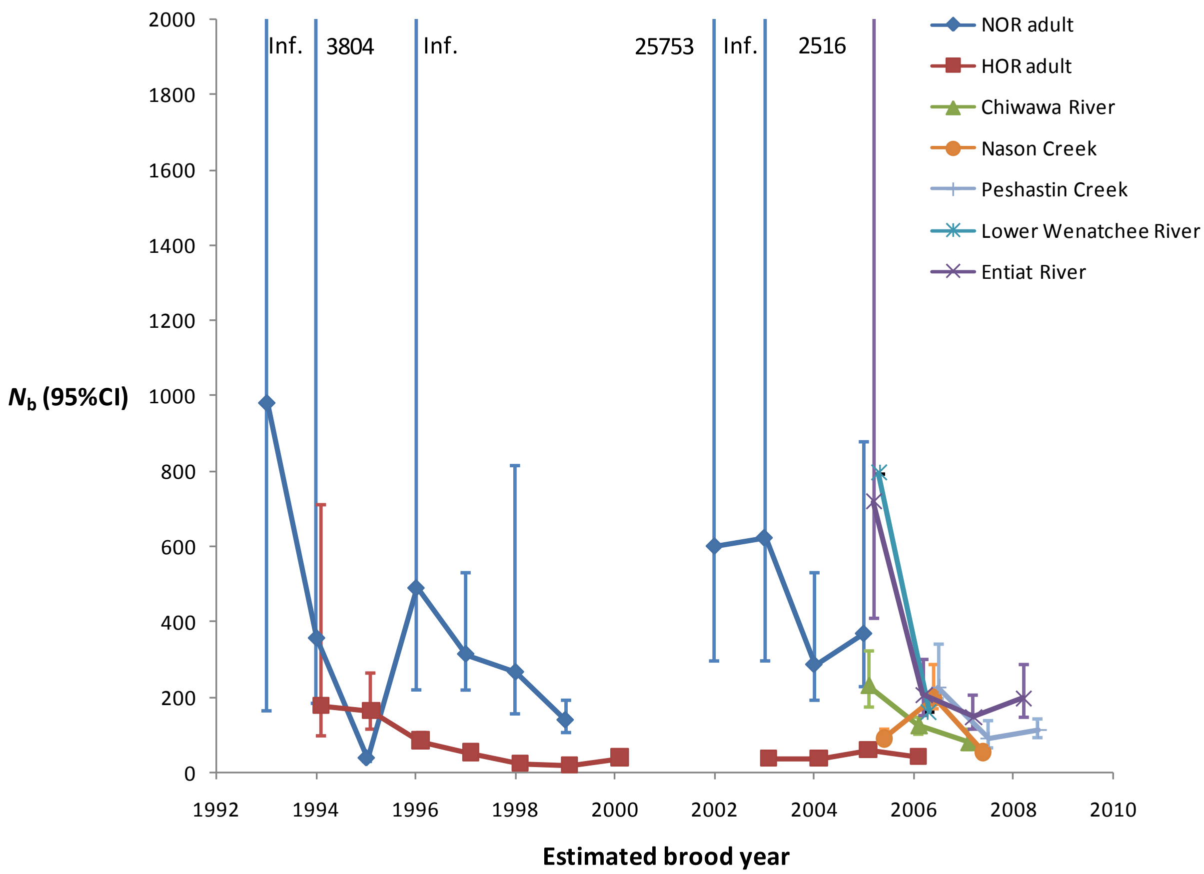


Figure 10. Estimates of N_b for collections of hatchery-produced (HOR) and natural origin (NOR) Wenatchee River summer steelhead grouped by brood year rather than spawn year. Brood year was estimated using scale-based age data. Error bars that extend past the top of the chart are all bounded by infinity.

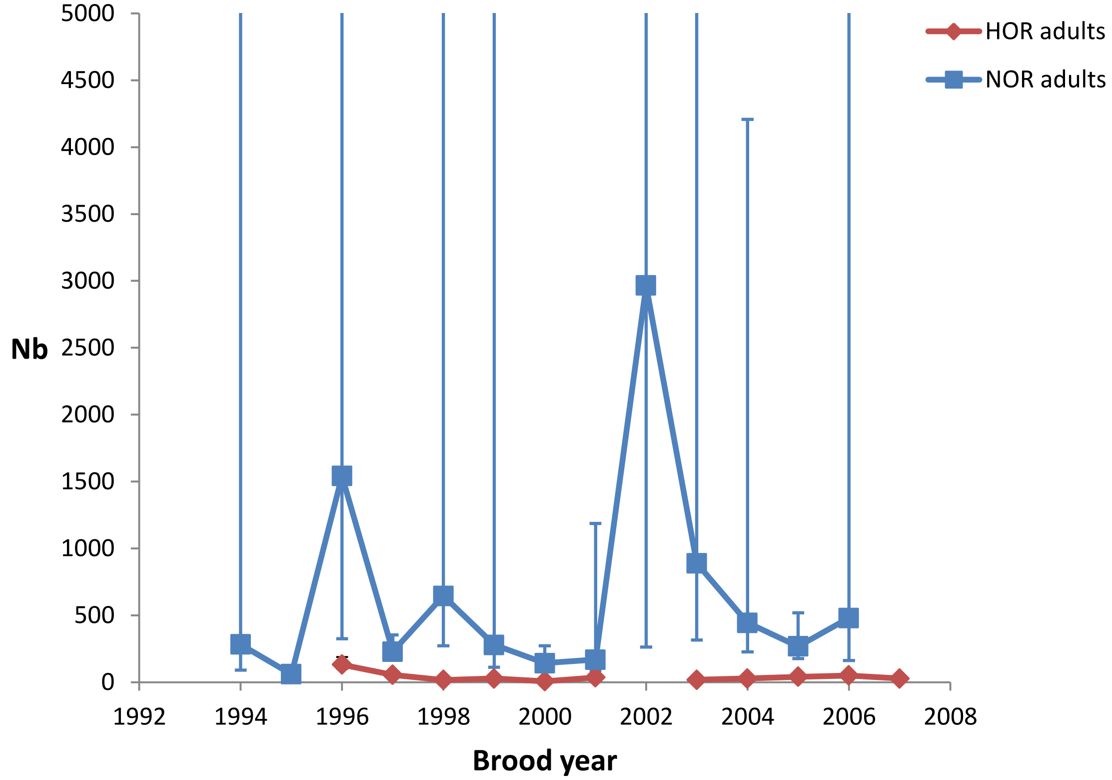


Figure 11. Estimates of N_b for combined annual adult hatchery-produced (HOR) and natural origin (NOR) steelhead and for HOR adults alone. The temporal patterns are similar, though estimates from combined collections are larger than those from HOR collections alone.

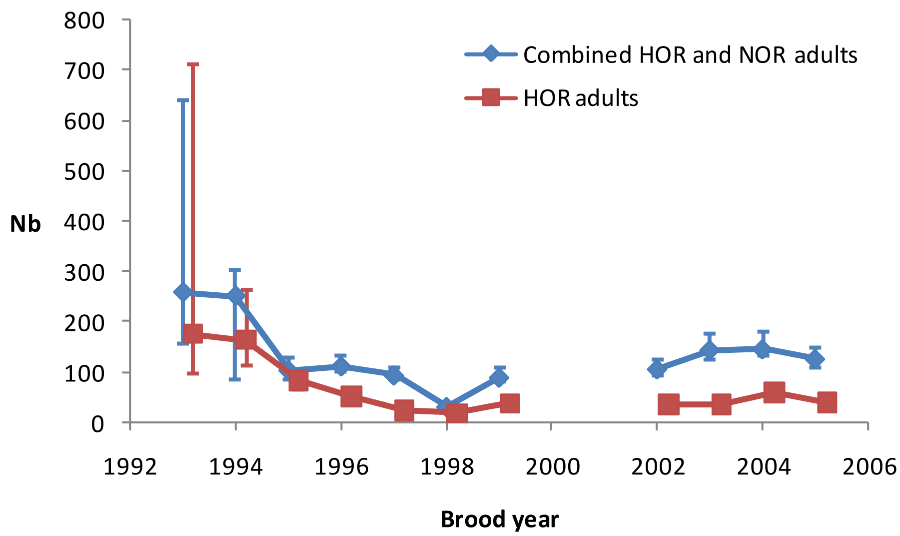


Figure 12. N_b/N ratios for hatchery-produced (HOR) and natural origin (NOR) adult Wenatchee River summer steelhead grouped by spawn year. The average N_b/N ratios are not different, though in later years NOR adults appear to have lower N_b/N ratios.

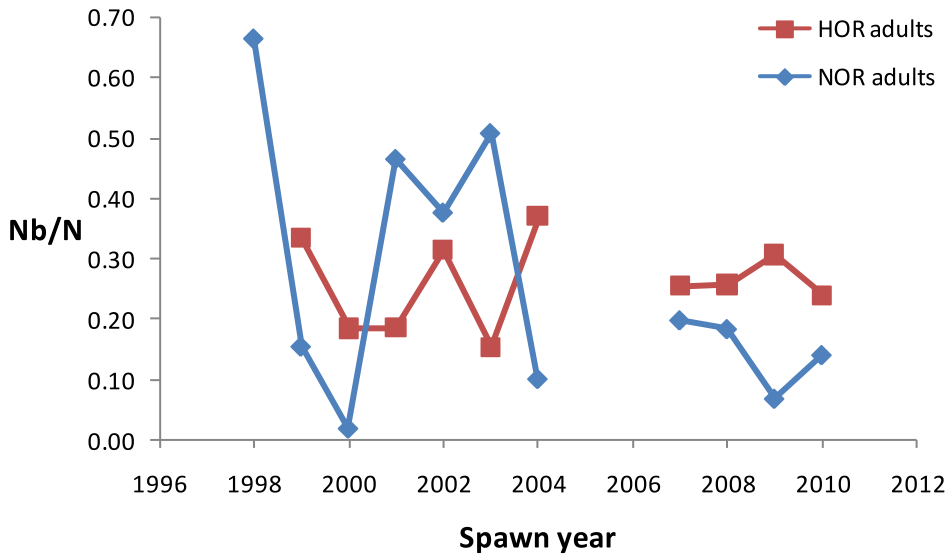
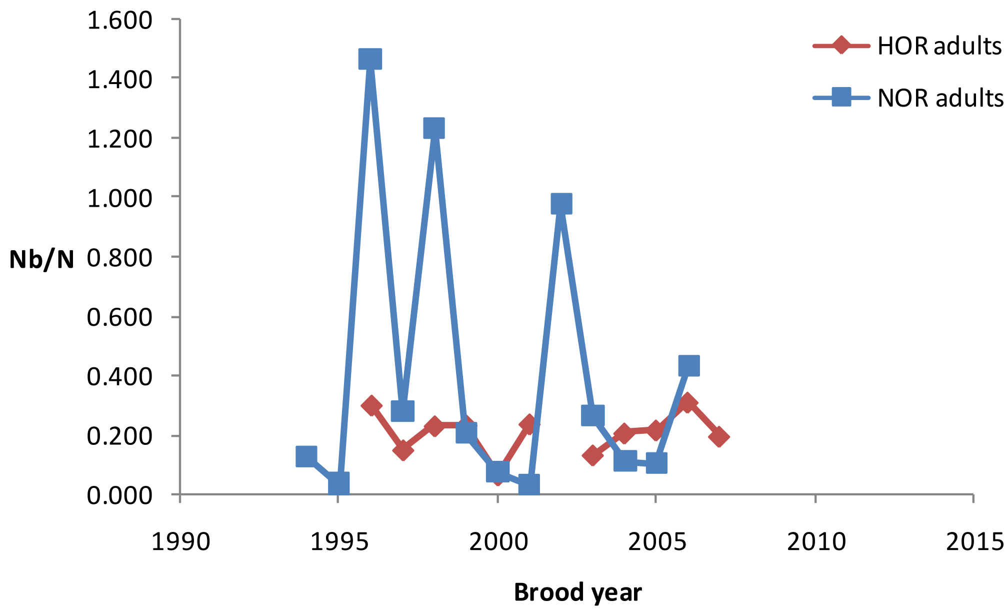


Figure 13. N_b/N ratios for hatchery-produced (HOR) and natural origin (NOR) adult Wenatchee River summer steelhead collections with individuals grouped in brood years rather than spawn years. Individual brood year was estimated using scale-based age data.



Tables

Table 1. Samples of adult steelhead collected for Wenatchee Program broodstock and used for genetic monitoring and evaluation.

Origin	Sampling Location	Year spawned	WDFW Collection code	Samples (N)	Unused Samples[a]
Hatchery	Dryden/Tumwater Dams	1998	98AE	32	4
		1999	98LJ	62	2
		2000	99NE	60	5
		2001	00DQ	99	1
		2002	01MS	64	
		2003	02NP	89	
		2004	03KW	61	
		2007	06CW	64	1
		2008	08AG	56	
		2009	09AV	74	
		2010	10FE	76	1
			Total	737	14
Natural	Dryden/Tumwater Dams	1998	98AF	30	5
		1999	99AA	51	1
		2000	99ND	33	3
		2001	00DP	50	
		2002	01MR	95	
		2003	02NO	50	
		2004	03KV	71	3
		2007	06CX	74	
		2008	08AF	74	1
		2009	09AU	82	2
		2010	10FD	90	2
			Total	700	17

[a]Samples were not used if they had incomplete (≤ 80% or 95 of 119 loci) or duplicate genotypes.

Table 2. Samples of natural origin juvenile steelhead and rainbow trout collected from four Wenatchee basin rivers or creeks and the Entiat River.

Sampling Location	Collection Year	WDFW Collection Code	Samples (N)	Unused samples[a]
Chiwawa River	2007	07AO	127	5
	2008	08CG	143	1
	2009	09NF	35	2
Entiat River	2007	07AL	134	4
	2008	08CI	82	4
	2009	09NC	74	1
	2010	10OX	82	1
Lower Wenatchee River	2007	07AM	139	5
	2008	08CE	98	2
Nason Creek	2007	07AN	81	4
	2008	08CF	133	6
	2009	09NG	103	2
Peshastin Creek	2008	08CH	142	2
	2009	09NE	34	1
	2010	10OY	94	1
		Total	1501	41

[a]Samples were not used if they were genetically identified as cutthroat trout or cutthroat/rainbow trout hybrids, or if they had incomplete (≤ 80% or 95 of 119 loci) or duplicate genotypes.

Table 3. List of 132 general use, diploid single nucleotide polymorphic (SNP) loci genotyped in Wenatchee River basin and Entiat River steelhead.

WDFW Name	Locus Name	Allele 1	Allele 2	Reference
AOmy005	Omy_aspAT-123	T	C	(Campbell et al. 2009)
AOmy014	Omy_e1-147	G	T	(Sprowles et al. 2006)
AOmy015	Omy_gdh-271	C	T	(Campbell et al. 2009)
AOmy016	Omy_GH1P1_2	C	T	(Aguilar and Garza 2008)
AOmy021	Omy_LDHB-2_e5	T	C	(Aguilar and Garza 2008)
AOmy023	Omy_MYC_2	T	C	(Aguilar and Garza 2008)
AOmy027	Omy_nkef-241	C	A	(Campbell et al. 2009)
AOmy028	Omy_nramp-146	G	A	(Campbell et al. 2009)
AOmy047	Omy_u07-79-166	G	T	WDFW - S. Young unpubl.
AOmy051	Omy_121713-115	T	A	(Abadía-Cardoso et al. 2011)
AOmy056	Omy_128693-455	T	C	(Abadía-Cardoso et al. 2011)
AOmy059	Omy_187760-385	A	T	(Abadía-Cardoso et al. 2011)
AOmy061	Omy_96222-125	T	C	(Abadía-Cardoso et al. 2011)
AOmy062	Omy_97077-73	T	A	(Abadía-Cardoso et al. 2011)
AOmy063	Omy_97660-230	C	G	(Abadía-Cardoso et al. 2011)
AOmy065	Omy_97954-618	C	T	(Abadía-Cardoso et al. 2011)
AOmy067	Omy_aromat-280	A	T	WSU - J. DeKoning unpubl.
AOmy068	Omy_arp-630	G	A	(Campbell et al. 2009)
AOmy071	Omy_cd59-206	C	T	WSU - J. DeKoning unpubl.
AOmy073	Omy_colla1-525	C	T	WSU - J. DeKoning unpubl.
AOmy079	Omy_g12-82	T	C	WSU - J. DeKoning unpubl.
AOmy081	Omy_gh-475	C	T	(Campbell et al. 2009)
AOmy082	Omy_gsdf-291	T	C	WSU - J. DeKoning unpubl.
AOmy089	Omy_hsp90BA-193	C	T	(Campbell and Narum 2009)
AOmy094	Omy_inos-97	C	A	WSU - J. DeKoning unpubl.
AOmy095	Omy_mapK3-103	A	T	CRITFC - N. Campbell unpubl.
AOmy096	Omy_mcsf-268	T	C	WSU - J. DeKoning unpubl.

AOmy100	Omy_nach-200	A	T	WSU - J. DeKoning unpubl.
AOmy107	Omy_Ots249-227	C	T	(Campbell et al. 2009)
AOmy108	Omy_oxct-85	A	T	WSU - J. DeKoning unpubl.
AOmy110	Omy_star-206	A	G	WSU - J. DeKoning unpubl.
AOmy111	Omy_stat3-273	G	Deletion	WSU - J. DeKoning unpubl.
AOmy113	Omy_tlr3-377	C	T	WSU - J. DeKoning unpubl.
AOmy117	Omy_u09-52-284	T	G	WDFW - S. Young unpubl.
AOmy118	Omy_u09-53-469	T	C	WDFW - S. Young unpubl.
AOmy120	Omy_u09-54.311	C	T	WDFW - S. Young unpubl.
AOmy123	Omy_u09-55-233	A	G	WDFW - S. Young unpubl.
AOmy125	Omy_u09-56-119	T	C	WDFW - S. Young unpubl.
AOmy129	Omy_BAMBI4.238	T	C	WDFW - S. Young unpubl.
AOmy132	Omy_G3PD_2.246	C	T	WDFW - S. Young unpubl.
AOmy134	Omy_Il-1b-028	T	C	WDFW - S. Young unpubl.
AOmy137	Omy_u09-61.043	A	T	WDFW - S. Young unpubl.
AOmy151	Omy_p53-262	T	A	CRITFC - N. Campbell unpubl.
AOmy173	BH2VHSVip10	C	T	Pascal & Hansen unpubl.
AOmy174	OMS00003	T	G	(Sánchez et al. 2009)
AOmy176	OMS00013	A	G	(Sánchez et al. 2009)
AOmy177	OMS00018	T	G	(Sánchez et al. 2009)
AOmy179	OMS00041	G	C	(Sánchez et al. 2009)
AOmy181	OMS00052	T	G	(Sánchez et al. 2009)
AOmy182	OMS00053	T	C	(Sánchez et al. 2009)
AOmy183	OMS00056	T	C	(Sánchez et al. 2009)
AOmy184	OMS00057	T	G	(Sánchez et al. 2009)
AOmy185	OMS00061	T	C	(Sánchez et al. 2009)
AOmy186	OMS00062	T	C	(Sánchez et al. 2009)
AOmy187	OMS00064	T	G	(Sánchez et al. 2009)
AOmy189	OMS00071	A	G	(Sánchez et al. 2009)
AOmy190	OMS00072	A	G	(Sánchez et al. 2009)

AOmy191	OMS00078	T	C	(Sánchez et al. 2009)
AOmy192	OMS00087	A	G	(Sánchez et al. 2009)
AOmy193	OMS00089	A	G	(Sánchez et al. 2009)
AOmy194	OMS00090	T	C	(Sánchez et al. 2009)
AOmy195	OMS00092	A	C	(Sánchez et al. 2009)
AOmy196	OMS00094	T	G	(Sánchez et al. 2009)
AOmy197	OMS00103	A	T	(Sánchez et al. 2009)
AOmy198	OMS00105	T	G	(Sánchez et al. 2009)
AOmy199	OMS00112	A	T	(Sánchez et al. 2009)
AOmy200	OMS00116	T	A	(Sánchez et al. 2009)
AOmy201	OMS00118	T	G	(Sánchez et al. 2009)
AOmy202	OMS00119	A	T	(Sánchez et al. 2009)
AOmy203	OMS00120	A	G	(Sánchez et al. 2009)
AOmy204	OMS00121	T	C	(Sánchez et al. 2009)
AOmy205	OMS00127	T	G	(Sánchez et al. 2009)
AOmy206	OMS00128	T	G	(Sánchez et al. 2009)
AOmy207	OMS00132	A	T	(Sánchez et al. 2009)
AOmy208	OMS00133	A	G	(Sánchez et al. 2009)
AOmy209	OMS00134	A	G	(Sánchez et al. 2009)
AOmy210	OMS00153	T	G	(Sánchez et al. 2009)
AOmy211	OMS00154	A	T	(Sánchez et al. 2009)
AOmy212	OMS00156	A	T	(Sánchez et al. 2009)
AOmy213	OMS00164	T	G	(Sánchez et al. 2009)
AOmy215	OMS00175	T	C	(Sánchez et al. 2009)
AOmy216	OMS00176	T	G	(Sánchez et al. 2009)
AOmy218	OMS00180	T	G	(Sánchez et al. 2009)
AOmy220	Omy_1004	A	T	(Hansen et al. 2011)
AOmy221	Omy_101554-306	T	C	(Abadía-Cardoso et al. 2011)
AOmy222	Omy_101832-195	A	C	(Abadía-Cardoso et al. 2011)
AOmy223	Omy_101993-189	A	T	(Abadía-Cardoso et al. 2011)

AOmy225	Omy_102505-102	A	G	(Abadía-Cardoso et al. 2011)
AOmy226	Omy_102867-443	T	G	(Abadía-Cardoso et al. 2011)
AOmy227	Omy_103705-558	T	C	(Abadía-Cardoso et al. 2011)
AOmy228	Omy_104519-624	T	C	(Abadía-Cardoso et al. 2011)
AOmy229	Omy_104569-114	A	C	(Abadía-Cardoso et al. 2011)
AOmy230	Omy_105075-162	T	G	(Abadía-Cardoso et al. 2011)
AOmy231	Omy_105385-406	T	C	(Abadía-Cardoso et al. 2011)
AOmy232	Omy_105714-265	C	T	(Abadía-Cardoso et al. 2011)
AOmy233	Omy_107031-704	C	T	(Abadía-Cardoso et al. 2011)
AOmy234	Omy_107285-69	C	G	(Abadía-Cardoso et al. 2011)
AOmy235	Omy_107336-170	C	G	(Abadía-Cardoso et al. 2011)
AOmy238	Omy_108007-193	A	G	(Abadía-Cardoso et al. 2011)
AOmy239	Omy_109243-222	A	C	(Abadía-Cardoso et al. 2011)
AOmy240	Omy_109525-403	A	G	(Abadía-Cardoso et al. 2011)
AOmy241	Omy_110064-419	T	G	(Abadía-Cardoso et al. 2011)
AOmy242	Omy_110078-294	A	G	(Abadía-Cardoso et al. 2011)
AOmy243	Omy_110362-585	G	A	(Abadía-Cardoso et al. 2011)
AOmy244	Omy_110689-148	A	C	(Abadía-Cardoso et al. 2011)
AOmy245	Omy_111005-159	C	T	(Abadía-Cardoso et al. 2011)
AOmy246	Omy_111084-526	A	C	(Abadía-Cardoso et al. 2011)
AOmy247	Omy_111383-51	C	T	(Abadía-Cardoso et al. 2011)
AOmy248	Omy_111666-301	T	A	(Abadía-Cardoso et al. 2011)
AOmy249	Omy_112301-202	T	G	(Abadía-Cardoso et al. 2011)
AOmy250	Omy_112820-82	G	A	(Abadía-Cardoso et al. 2011)
AOmy252	Omy_114976-223	T	G	(Abadía-Cardoso et al. 2011)
AOmy253	Omy_116733-349	C	T	(Abadía-Cardoso et al. 2011)
AOmy254	Omy_116938-264	A	G	(Abadía-Cardoso et al. 2011)
AOmy255	Omy_117259-96	T	C	(Abadía-Cardoso et al. 2011)
AOmy256	Omy_117286-374	A	T	(Abadía-Cardoso et al. 2011)
AOmy257	Omy_117370-400	A	G	(Abadía-Cardoso et al. 2011)

AOmy258	Omy_117540-259	T	G	(Abadía-Cardoso et al. 2011)
AOmy260	Omy_117815-81	C	T	(Abadía-Cardoso et al. 2011)
AOmy261	Omy_118175-396	T	A	(Abadía-Cardoso et al. 2011)
AOmy262	Omy_118205-116	A	G	(Abadía-Cardoso et al. 2011)
AOmy263	Omy_118654-91	A	G	(Abadía-Cardoso et al. 2011)
AOmy265	Omy_120255-332	A	T	(Abadía-Cardoso et al. 2011)
AOmy266	Omy_128996-481	T	G	(Abadía-Cardoso et al. 2011)
AOmy267	Omy_129870-756	C	T	(Abadía-Cardoso et al. 2011)
AOmy268	Omy_131460-646	C	T	(Abadía-Cardoso et al. 2011)
AOmy269	Omy_98683-165	A	C	(Abadía-Cardoso et al. 2011)
AOmy270	Omy_cyp17-153	C	T	WSU - J. DeKoning unpubl.
AOmy271	Omy_ftzf1-217	A	T	WSU - J. DeKoning unpubl.
AOmy272	Omy_GHSR-121	T	C	CRITFC - N. Campbell unpubl.
AOmy273	Omy_metA-161	T	G	CRITFC - N. Campbell unpubl.
AOmy274	Omy_UBA3b	A	T	(Hansen et al. 2011)

Primer and probe sequences for unpublished loci available by request.

Table 4. List of 20 species identification single nucleotide polymorphic (SNP) loci genotyped in Wenatchee River basin and Entiat River steelhead.

		Expected genotype			
WDFW Name	Locus Name	*O. mykiss*	*O. clarkii clarkii*	*O. clarkii lewisi*	Reference
ASpI001	Ocl_Okerca	T	C	C	(McGlauflin et al. 2010)
ASpI002	Ocl_Oku202	A	C	C	(McGlauflin et al. 2010)
ASpI003	Ocl_Oku211	G	T	T	(McGlauflin et al. 2010)
ASpI004	Ocl_Oku216	C	C	A	(McGlauflin et al. 2010)
ASpI005	Ocl_Oku217	C	C	A	(McGlauflin et al. 2010)
ASpI006	Ocl_SsaHM5	A	A	G	(McGlauflin et al. 2010)
ASpI007	Ocl_u800	T	C	C	(McGlauflin et al. 2010)
ASpI008	Ocl_u801	A	T	T	(McGlauflin et al. 2010)
ASpI009	Ocl_u802	C	C	T	(McGlauflin et al. 2010)
ASpI010	Ocl_u803	C	T	T	(McGlauflin et al. 2010)
ASpI011	Ocl_u804	G	G	C	(McGlauflin et al. 2010)
ASpI012	Omy_B9_228	A	A	C	(Finger et al. 2009)
ASpI013	Omy_CTDL1_243	C	A	A	(Finger et al. 2009)
ASpI014	Omy_F5_136	C	G	G	(Finger et al. 2009)
ASpI016	Omy_myclarp404-111	T	G	G	CRITFC - S. Narum - unpubl.
ASpI017	Omy_myclgh1043-156	C	T	T	CRITFC - S. Narum - unpubl.
ASpI018	Omy_Omyclmk436-96	A	C	C	CRITFC - S. Narum - unpubl.
ASpI019	Omy_RAG11_280	T	A	A	(Sprowles et al. 2006)
ASpI020	Omy_URO_302	T	C	C	(Finger et al. 2009)
ASpI021	Omy_BAC-F5.238	C	G	G	WDFW - S. Young unpubl.

Primer and probe sequences for unpublished loci available by request.

Table 5. Pairwise F_{ST} estimates for collections from Wenatchee River tributaries and the Entiat River (below diagonal) and associated bootstrap estimated *P*-values (above diagonal).

		Chiwawa River			Nason Creek			Peshastin Creek			Lower Wenatchee River		Entiat River			
Population	Year	2007	2008	2009	2007	2008	2009	2008	2009	2010	2007	2008	2007	2008	2009	2010
Chiwawa	2007		**0.000**	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.001**	**0.001**	**0.000**	**0.001**	**0.000**	**0.000**
River	2008	0.004		**0.004**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	2009	0.004	0.003		**0.000**	**0.001**	0.061	**0.000**	**0.001**	**0.000**	0.086	**0.050**	**0.022**	0.108	**0.005**	**0.045**
Nason	2007	0.011	0.010	0.007		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Creek	2008	0.007	0.007	0.005	0.009		**0.003**	**0.000**	**0.002**	**0.000**	0.079	**0.000**	**0.001**	**0.000**	**0.000**	**0.000**
	2009	0.007	0.007	0.003	0.014	0.006		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Peshastin	2008	0.010	0.011	0.008	0.013	0.010	0.013		**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Creek	2009	0.005	0.005	0.006	0.010	0.007	0.008	0.003		**0.002**	**0.002**	**0.047**	**0.028**	**0.004**	**0.005**	**0.001**
	2010	0.010	0.011	0.008	0.015	0.008	0.011	0.003	0.003		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Lower Wenatchee	2007	0.003	0.003	0.000	0.005	0.008	0.007	0.009	0.010	0.008		0.112	**0.020**	**0.012**	**0.002**	**0.017**
River	2008	0.002	0.005	0.002	0.003	0.004	0.005	0.007	0.009	0.006	0.000		**0.049**	0.459	**0.047**	**0.002**
Entiat	2007	0.005	0.006	0.002	0.005	0.006	0.005	0.005	0.007	0.006	0.001	0.002		0.451	0.173	**0.000**
River	2008	0.004	0.004	0.000	0.007	0.005	0.007	0.008	0.009	0.011	0.002	0.001	0.000		0.644	**0.002**
	2009	0.005	0.006	0.002	0.003	-0.001	0.003	0.002	0.003	0.004	0.003	0.002	0.002	0.000		**0.028**
	2010	0.005	0.006	0.003	0.006	0.004	0.006	0.006	0.008	0.009	0.002	0.003	0.003	0.003	0.002	

P-values in bold were significant at $\alpha = 0.05$ after correcting for multiple tests using false discovery rate.

Appendix G

GENETIC DIVERSITY OF WENATCHEE SOCKEYE SALMON

Assessing the Genetic Diversity of Lake Wenatchee Sockeye Salmon And Evaluating The Effectiveness Of Its Supportive Hatchery Supplementation Program

Developed for

Chelan County PUD

and the

Habitat Conservation Plan's Hatchery Committee

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Executive Summary

Nine spawning populations of sockeye (*Oncorhynchus nerka*) salmon have been identified in Washington, including stocks in the Lake Wenatchee basin (SaSI 5800) (Washington Department of Fisheries et al. 1993). Lake Wenatchee sockeye are classified as an Evolutionary Significant Unit (ESU), and consists of sockeye salmon that spawn primarily in tributaries above Lake Wenatchee (the White River, Napeequa River, and Little Wenatchee Rivers). Since 1990, the Wenatchee Sockeye Program has released juveniles into Lake Wenatchee to supplement natural production of sockeye salmon in the basin. The program's broodstock are predominantly natural-origin sockeye adults returning to the Wenatchee River captured at Tumwater Dam (Rkm 52.0), where a net-pen system is used to house both maturing adults and juveniles prior to release into Lake Wenatchee to over-winter.

Previous genetic studies have generally found a lack of concordance between population genetic relationships and their geographic distributions. These studies indicate that the nearest geographic neighbors of sockeye salmon populations are not necessarily the most genetically similar. Specifically for the Columbia River Basin, sockeye from Lake Wenatchee, Okanogan River, and Redfish Lake may be more closely related to a population from outside the Columbia River (depending on marker used) then to each other.

In this study we investigated the temporal and spatial genetic structure of Lake Wenatchee sockeye collections, without regard to sockeye populations outside of the Lake Wenatchee area. Our primary objective here was to determine if the Wenatchee Sockeye Program affected the natural Lake Wenatchee sockeye population. More specifically, we were tasked to determine if the genetic composition of Lake Wenatchee sockeye population had been altered by a supplementation program that was based on the artificial propagation of a small subset of that population. Using microsatellite DNA allele frequencies, we investigated population differentiation between temporally replicated collections of natural-origin Lake Wenatchee sockeye and program broodstock. We analyzed thirteen collections of Lake Wenatchee sockeye (Table 1), eight temporally replicated collections of natural-origin Lake Wenatchee sockeye (N=786) and five temporally replicated collections of Wenatchee Sockeye Program broodstock (N=248). Paired natural – broodstock collections were available from years 2000, 2001, 2004, 2006, and 2007.

Conclusions

We observed that allele frequency distributions were consistent over time, irrespective of collection origin, resulting in small and statistically insignificant measures of genetic differentiation among collections. We interpreted these results to indicate no year-to-year differences in allele frequencies among natural-origin or broodstock collections. Furthermore, there were no observed difference between pre- and post-supplementation collections. Therefore, we accepted our null hypothesis that the allele frequencies of the broodstock collections equaled the allele frequencies of the natural collections, which

equaled the allele frequency of the donor population. Given the small differences in genetic composition among collections, the genetic model for estimating N_e produced estimates with extremely large variances, preventing the observation of any trend in N_e.

Introduction

A report titled "Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Hatchery Programs" was prepared July 2005 by Andrew Murdoch and Chuck Peven for the Chelan PUD Habitat Conservation Plan's Hatchery Committee. This report outlined 10 objectives to be applied to various species assessing the impact (positive or negative) of hatchery operations mitigating the operation of Rock Island Dam. This current study pertains only to Lake Wenatchee sockeye and objective 3:

> *Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.*

In order to evaluate cause and effect of hatchery supplementation, WDFW Molecular Genetics Lab surveyed genetic variation of Lake Wenatchee sockeye. The conceptual approach for this project follows that of a parallel study regarding the Wenatchee River spring Chinook supplementation program (Blankenship et al. 2007). We determined the genetic diversity present in the Lake Wenatchee sockeye population by analyzing temporally replicated collections spanning 1989 – 2007, which included collections from before and following the inception of the Wenatchee Sockeye Program. Documenting the genetic composition of the Lake Wenatchee sockeye population is necessary to assess the effect of the hatchery program on the Lake Wenatchee population. In addition, this work provides a genetic baseline for future projects requiring genetic data. See study objectives below for specific details about how this project addresses Murdoch and Peven (2005) objective 3.

Lake Wenatchee Sockeye Salmon

Nine spawning populations of sockeye (*Oncorhynchus nerka*) salmon have been identified in Washington (Washington Department of Fisheries et al. 1993): 1) Baker

River, 2) Ozette Lake, 3) Lake Pleasant, 4) Quinault Lake, and 5) Okanogan River (classified as native stock); 6) Cedar River (classified as non-native stock); 7) Lake Wenatchee, classified as mixed stock); 8) Lake Washington/Lake Sammamish tributaries; and 9) Lake Washington beach spawners (classified as unknown origin). Chapman et al. (1995) listed four additional spawning aggregations of sockeye salmon that appear consistently in Columbia River tributaries: the Methow, Entiat, and Similkameen Rivers; and Icicle Creek in the Wenatchee River drainage.

Located in north central Washington, the Wenatchee River basin drains a portion of the eastern slope of the Cascade Mountains, including high mountainous regions of the Cascade crest. The headwater area of the Wenatchee River is Lake Wenatchee, a typical low productivity oligotrophic or ultra-oligotrophic sockeye salmon nursery lake (Allen and Meekin 1980, Mullan 1986, Chapman et al. 1995). Sockeye salmon bound for Lake Wenatchee enter the Columbia River in April and May and arrive at Lake Wenatchee in late July to early August (Chapman et al. 1995; Washington Department of Fisheries et al. 1993). The run timing of Lake Wenatchee sockeye salmon, classified as an Evolutionary Significant Unit (ESU), appears to have become earlier by 6 - 30 days during the past 70 years (Chapman et al. 1995; Quinn and Adams 1996). Additionally, scale pattern analysis suggests Wenatchee sockeye migrate past Bonneville Dam earlier than the sockeye bound for the Okanogan River (Fryer and Schwartzberg 1994). The Wenatchee population spawns from mid-September through October in the Little Wenatchee, White, and Napeequa Rivers above Lake Wenatchee (Washington Department of Fisheries et al. 1993), peaking in late September (Chapman et al. 1995). Limited beach spawning is believed to occur in Lake Wenatchee (L. Lavoy pers. com.; Mullan 1986), although Gangmark and Fulton (1952) reported two lakeshore seepage areas in Lake Wenatchee that were used by spawning sockeye salmon. Sockeye salmon fry enter Lake Wenatchee between March and May (Dawson et al. 1973), and typically rear in the lake for one year before leaving as smolts (Gustafson et al. 1997; Peven 1987).

Both the physical properties of the habitat and ecological/biological factors of the sockeye populations differ between the Lake Wenatchee ESU and the geographically proximate Okanogan ESU. For example: 1) Different limnology is encountered by sockeye salmon in Lakes Wenatchee and Osoyoos; 2) Lake Wenatchee sockeye predominantly return at ages four and five (a near absence of 3-year-olds), where a large percentage of 3-year-olds return to the Okanogan population; and 3) the apparent one month separation in juvenile outmigration-timing between Okanogan- and Wenatchee-origin fish (Gustafson et al. 1997 and references therein).

Sockeye Artificial Propagation In Lake Wenatchee

The construction of Grand Coulee Dam completely blocked fish passage to the upper Columbia River, and 85% of sockeye salmon passing Rock Island Dam between 1935 and 1936 were estimated to be from natural stocks bound for areas up-river to Grand Coulee Dam (Mullan 1986; Washington Department of Fisheries et al. 1938). To compensate for loss of habitat resulting from Grand Coulee Dam, the federal government initiated the Grand Coulee Fish-Maintenance Project (GCFMP) in 1939 to maintain fish runs in the Columbia River above Rock Island Dam. Between 1939 and 1943, all sockeye salmon entering the mid-Columbia River were trapped at Rock Island Dam, and over 32,000 mixed Lake Wenatchee, Okanogan River, and Arrow Lake adult sockeye salmon were released into Lake Wenatchee (Gustafson et al. 1997 Appendix Table D-2). In addition to adult relocation, between 1941 and 1969 over 52.8 million fry descended from original spawners collected at Rock Island and Bonneville Dams, were released into Lake Wenatchee (Gustafson et al. 1997 Appendix Table D-2).

No releases of artificially-reared sockeye salmon occurred in the Wenatchee watershed during the years 1970 to 1989 (Gustafson et al. 1997 Appendix Table D-2). Since 1990, the Wenatchee Sockeye Program has released juveniles into Lake Wenatchee to supplement natural production of sockeye salmon in the basin. Sockeye adults returning to the Wenatchee River are captured at Tumwater Dam (Rkm 52.0) and transferred to Lake Wenatchee net pens until mature. The Wenatchee Sockeye Program goals are 260 adults with an equal sex ratio, <10% hatchery-origin returns (identified by coded wire tags), and the adults removed for broodstock account for <10% of the run size. Fish are spawned at Lake Wenatchee and their gametes are taken to Rock Island Fish Hatchery

Complex (i.e., Eastbank) for fertilization and incubation. Fry are returned to the Lake Wenatchee net -pens after they are large enough to be coded wire tagged, and are housed in the pens until fall (one year after spawning), when they are liberated into the lake to over-winter. For brood years 1991 – 2004 an average of 218,683 (std. dev. = 71,090) pen-reared Lake Wenatchee-origin juvenile sockeye salmon have been released yearly into Lake Wenatchee.

Previous Genetic Studies

Protein (allozyme) variation – Surveying genetic variation at 12 allozyme loci, Utter et al. (1984) reported moderate population structure among 16 sockeye collections from southeast Alaska through the Columbia River Basin, including Okanogan and Wenatchee stocks, with an apparent genetic association between upper Fraser River and Columbia River sockeye salmon. Winans et al. (1996) surveyed variation at 55 allozyme loci for 25 sockeye salmon and two kokanee collections from 21 sites in Washington, Idaho, and British Columbia, and reported the lowest level of allozyme variability of any species of Pacific salmon and a highest level of inter-population differentiation. Furthermore, these authors reported that there was no clear relationship between geographic and genetic differentiation among the populations within there study. Other studies corroborate the results of Winans et al. (1996), finding a lack of discernible geographic patterning for sockeye salmon populations in British Columbia, Alaska, and Kamchatka (Varnavskaya et al. 1994, Wood et al. 1994, Wood 1995). These studies indicate that the nearest geographic neighbors of sockeye salmon populations are not necessarily the most genetically similar, which contrasts with the other Pacific salmon species that exhibit concordance between geographic and genetic differentiation (Utter et al. 1989, Winans et al. 1994, Shaklee et al. 1991). As part of the comprehensive status review of west coast sockeye salmon (Gustafson et al. 1997), NMFS biologists collected new allozyme genetic information for 17 sockeye salmon populations and one kokanee population in Washington and combined these data for analysis with the existing Pacific Northwest sockeye salmon and kokanee data from Winans et al. (1996). Results of the updated study were consistent with Winans et al. (1996), with no clear concordance between geographic and genetic distances. Sockeye salmon from Lake Wenatchee, Redfish Lake, Ozette Lake, and Lake Pleasant are very distinct from other collections in the study, and Columbia River populations were not necessarily most closely related to each other. Gustafson et al. (1997) also examined between-year variability within a collection location and found low levels of statistical significance among the five Lake Wenatchee collections included in the study (For 10 pair-wise comparisons using sum-G test, five were statistically significant). Lake Wenatchee brood year 1987 accounted for three of the significant comparisons, which were driven by unusually high frequencies of two allozyme alleles (ALAT*95 and ALAT*108) (Winans et al. 1996). Nevertheless, Gustafson et al. (1997) conclude that, in general, temporal variation at a locale was considerably less than between-locale variation.

Nucleic acid variation - Beacham et al. (1995) reported levels of variation in nuclear DNA of *O. nerka* using minisatellite probes. They analyzed 10 collections, including a sample from Lake Wenatchee. Cluster analysis showed the Lake Wenatchee sample was different from all the other collections, including those from the Columbia River. Using a similar molecular technique, Thorgaard et al. (1995) examined the use of multi-locus DNA fingerprinting (i.e., banding patterns) to discriminate among 14 sockeye salmon and kokanee populations. Dendrograms based on analysis of banding patterns produced different genetic affinity groups depending on the probes used. While none of the five DNA probes showed a close relationship between Lake Wenatchee and Okanogan River sockeye salmon, if information from all probes were combined, *O. nerka* from Redfish Lake, Wenatchee, and Okanogan were separate from kokanee of Oregon and Idaho and a sockeye salmon sample from the mid-Fraser River.

Study Objective

We documented temporal variation in genetic diversity (i.e., heterozygosity and allelic diversity), and investigated population differentiation between temporally replicated collections of natural-origin Lake Wenatchee sockeye and program broodstock, using microsatellite DNA allele frequencies. Temporally replicated collections from the same location can also be used to estimate effective population size (N_e). If populations are "ideal", the census size of a population is equal to the "genetic size" of the population.

Yet, numerous factors lower the “genetic size” below census, such as, non-equal sex ratios, changes in population size, and variance in the numbers of offspring produced from parent pairs. N_e is thought to be between 0.10 and 0.33 of the estimated census size (Bartley et al. 1992; RS Waples pers. comm.), although numerous observations differ from this general rule. N_e can be calculated directly from demographic data, or inferred from observed differences in genetic variance over time. Essentially, when calculated from genetic data, N_e is the estimated size of an “ideal” population that accounts for the genetic diversity changes observed, irrespective of abundance.

We will address the hypotheses associated with Objective 3 in Murdock and Peven (2005) using the following four specific tasks:

Task 1 - Document the observed genetic diversity.

Task 2 - Test for population differentiation among Lake Wenatchee collections and the associated supplementation program.

Task 2 was designed to address two hypotheses listed as part of Objective 3 in Murdoch and Peven (2005):

- Ho: Allele frequency $_{\text{Hatchery}}$ = Allele frequency $_{\text{Naturally produced}}$ = Allele frequency $_{\text{Donor pop}}$.
- Ho: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations $_{\text{Year y}}$

Murdoch and Peven (2005) proposed these two hypotheses to help evaluate supplementation programs through a “Conceptual Process” (Figure 5 in Murdoch and Peven 2005). There are two components to the first hypothesis, which must be considered separately for Lake Wenatchee sockeye. The first component involves comparisons between natural-origin populations from Lake Wenatchee to determine if there have been changes in allele frequencies through time starting with the donor population. Documenting a change does not necessarily indicate that the supplementation program has directly affected the natural-origin fish, as additional tests would be necessary to support that hypothesis. The intent of the second component is to determine if the hatchery produced populations have the same genetic composition as the naturally produced populations.

Task 3 - Calculate N_e using the temporal method for multiple samples from the same location to document trend.

Task 4 - Compare N_e estimates with trend in census size for Lake Wenatchee sockeye.

Methods and Materials

Sampling

Thirteen collections of Lake Wenatchee sockeye were analyzed, eight temporally replicated collections of natural Lake Wenatchee sockeye (N=786) and five temporally replicated collections of Wenatchee Sockeye Program broodstock (N=248) (Table 1). Paired natural – broodstock collections were available from years 2000, 2001, 2004, 2006, and 2007 (Table 1). All collections were made at Tumwater Dam on the Wenatchee River. Note that collections classified as broodstock were predominantly natural-origin sockeye. A majority of the genetic samples were from dried scales. The tissue collections from 2006 and 2007 were fin clips stored immediately in ethanol after collection. DNA was extracted from stored tissue using Nucleospin 96 Tissue following the manufacturer's standard protocol (Macherey-Nagel, Easton, PA, U.S.A.).

Laboratory Analysis

Polymerase chain reaction (PCR) amplification was performed using 17 fluorescently end-labeled microsatellite marker loci, *One* 2 (Scribner et al 1996) *One* 100, 101, 102, 105, 108, 110, 114, and 115 (Olsen et al. 2000), *Omm* 1130, 1135, 1139, 1142, 1070, and 1085 (Rexroad et al. 2001), *Ots* 3M (Banks et al. 1999) and *Ots* 103 (Small et al. 1998). PCR reaction volumes were 10 μL, with the reaction variables being 2 μL 5x PCR buffer (Promega), 0.6 μL $MgCl_2$ (1.5 mM) (Promega), 0.2 μL 10 mM dNTP mix (Promega), and 0.1 μL *Go Taq* DNA polymerase (Promega). Loci were amplified as part of multiplexed sets, so primer molarities and annealing temperatures varied. Multiplex one had an annealing temperature of 55°C, and used 0.09 Molar (M) *One* 108, 0.06 M *One* 110, and 0.11 M *One* 100. Multiplex two had an annealing temperature of 53°C, and used 0.08 M *One* 102, 0.1 M *One* 114, and 0.05 M *One* 115. Multiplex three had an annealing temperature of 55°C, and used 0.08 M *One* 105 and 0.07 M *Ots* 103. Multiplex four had an annealing temperature of 53°C, and used 0.09 M *Omm* 1135 and 0.08 M *Omm* 1139. Multiplex five had an annealing temperature of 60°C, and used 0.2 M *Omm* 1085, 0.09 M *Omm* 1070, and 0.05 M *Ots* 3M. Multiplex six had an annealing temperature of 48°C, and used 0.06 M *One* 2, 0.08 M *Omm* 1142, and 0.08 M *Omm* 1130. *One* 101 was run in isolation with a primer molarity of 0.06. Thermal cycling was conducted on either PTC200 (MJ Research) or GeneAmp 9700 thermal cyclers as follows: 94°C (2 min); 30 cycles of 94°C for 15 sec., 30 sec. annealing, and 72°C for 1 min.; a final 72°C extension and then a 10°C hold. PCR products were visualized by denaturing polyacrylamide gel electrophoresis on an ABI 3730 automated capillary analyzer (Applied Biosystems). Fragment analysis was completed using GeneMapper 3.7 (Applied Biosystems).

Genetic data analysis

Assessing within collection genetic diversity - Heterozygosity measurements were reported using Nei's (1987) unbiased gene diversity formula (i.e., expected heterozygosity) and Hedrick's (1983) formula for observed heterozygosity. Both tests were implemented using the microsatellite toolkit (Park 2001). For each locus and collection FSTAT version 2.9.3.2 (Goudet 1995) was used to assess Hardy-Weinberg equilibrium, where deviations from the neutral expectation of random associations among alleles were calculated using a randomization procedure. Alleles were randomized among individuals within collections (4160 randomizations for this dataset) and the F_{IS} (Weir and Cockerham 1984) calculated for the randomized datasets were compared to the observed F_{IS} to obtain an unbiased estimation of the probability that the null hypothesis was true. The 5% nominal level of statistical significance was adjusted for multiple tests (Rice 1989). Genotypic linkage disequilibrium was calculated following Weir (1979) using GENETIX version 4.05 (Belkhir et al. 1996). Statistical significance of linkage disequilibrium results was assessed using a permutation procedure implemented in GENETIX for each locus by locus combination within each collection.

Assessing among collection genetic differentiation - The temporal stability of allele frequencies was assessed by the randomization chi-square test implemented in FSTAT version 2.9.3.2 (Goudet 1995). Multi-locus genotypes were randomized between collections. The G-statistic for observed data was compared to G-statistic distributions from randomized datasets (i.e., null distribution of no differentiation between collections). Population differentiation was also investigated using pairwise estimates of F_{ST}. Multi-locus estimates of pairwise F_{ST}, estimated by a "weighted" analysis of variance (Weir and Cockerham, 1984), were calculated using GENETIX version 4.05 (Belkhir et al.1996). F_{ST} was used to quantify population structure, the deviation from statistical expectations (i.e., excess homozygosity) due to non-random mating between populations. To determine if the observed F_{ST} estimate was consistent with statistically expectations of no population structure, a permutation test was implemented in GENETIX (1000 permutations).

Effective population size (N_e) – Estimates of the effective population size were obtained using a multi-collection temporal method (Waples 1990a). The temporal method assumes that cohorts are used, but we did not decompose the collection year samples into their respective cohorts using age data. Therefore, N_e estimates that pertain to individual year classes of breeders are not valid; however the harmonic mean over all samples will estimate an N_e that pertains to the time period from which the collections are derived. Comparing samples from years *i* and *j*, Waples' (1990a) temporal method estimates the effective number of breeders ($\hat{N}_{b(i,j)}$) according to:

$$\hat{N}_{b(i,j)} = \frac{b}{2(\hat{F} - 1/\tilde{S}_{i,j})}$$

The standardized variance in allele frequency ($\hat{F}$) is calculated according to Pollack (1983). The parameter b is calculated analytically from age structure information and the number of years between samples (Tajima 1992). The age-at-maturity information required to calculate b was obtained from ecological data (Hillman et al. 2007). The harmonic mean of sample sizes from years *i* and *j* is $\tilde{S}_{i,j}$. The harmonic mean over all pairwise estimates of $\hat{N}_{b(i,j)}$ is $\tilde{N}_b$. SALMONNb (Waples et al. 2007) was used to calculate $\tilde{N}_b$.

Results and Discussion

In this section we combine our presentation and interpretations of the genetic analyses. Additionally, this section is organized based on the task list presented in the study plan.

Task 1 - Document the observed genetic diversity.

Substantial genetic diversity was observed over all Lake Wenatchee sockeye collections analyzed (Table 1), with heterozygosity estimates over all loci having a mean of 0.79. Genetic diversity was consistent with expected Hardy-Weinberg random mating genotypic proportions for all collections. The F_{IS} observed for each collection was not statistically significant given the distribution of F_{IS} generated using a randomization procedure. Additionally, there were no statistically significant associations observed between alleles across loci (i.e., linkage equilibrium) (data not shown). We concluded from these results that the genetic data from each collection was consistent with statistical expectations for random association of alleles within and between loci. In other words, each collection represents samples from a single gene pool (i.e., populations), and the genetic diversity observed has no detectable technical artifacts or evidence of natural selection.

Task 2 - Test for differentiation among Lake Wenatchee collections and the associated supplementation program.

We explicitly tested the hypothesis of no significant differentiation within natural-origin or broodstock collections from Lake Wenatchee using a randomization chi-square test. The null hypothesis for these tests was that the allele frequencies from two different populations were drawn from the same underlying distribution. We show the results for the pairwise comparisons among eight temporally replicated natural-origin collections from Lake Wenatchee (28 pairwise tests), and report all tests were non-significant (Table 2A). Similarly, for five temporally replicated broodstock collections, 10 of 10 pairwise tests were non-significant (Table 2B). We also tested if natural-origin and broodstock collections were differentiated from each other over time, and report that 40 of 40 tests were non-significant (Table 2C). The nominal level of statistical significance ($\alpha = 0.05$) was adjusted for multiple comparisons using strict Bonferroni correction (Rice 1989). Yet, there are perhaps slight differences between paired natural-broodstock collections. Note that the p-values for comparisons regarding 2006 and 2007 paired collections are lower than for comparisons regarding 2000, 2001, and 2004. The small sample sizes for broodstock collections in 2006 and 2007 may not have been random samples from the Lake Wenatchee sockeye population.

Given the consistencies observed for allele frequency distributions over time, metrics of population structure were expected to be small. This was the case, as the estimated F_{ST} over all thirteen collections was 0.0003. This observed value fell within the distribution of F_{ST} values expected if there were no population structure present (permutation test p-value 0.12). Analysis of the paired natural-broodstock collections corroborated this result. Pairwise estimates of F_{ST} were 0.000 for years 2000, 2001, 2004, and 2007, and 0.002 for 2006. All five estimates were non-significant. Essentially, all 13 sockeye collections could be considered samples from the same population. Given these results, it is valid to combine all collections for statistical analysis. Therefore, we did not calculate genetic distances among any collections, as it is inappropriate to estimate distances that are effectively zero.

Conclusions

We interpret these data to indicate that there appears to be no significant year-to-year differences in allele frequencies among natural-origin or broodstock collections, nor are there observed differences between collections pre- and post-supplementation. As a result, we accept the null hypothesis that the allele frequencies of the broodstock collections equal the allele frequencies of the natural collections, which equals the allele frequency of the donor population. Furthermore, the observed genetic variance that can be attributed to among collection differences was negligible.

Task 3 - Calculate N_e using the temporal method for multiple samples from the same location to document trend.

The fundamental parameter for inferring N_e using genetic data is the standardized variance in allele frequency ($\hat{F}$) (Pollack 1983). Methods estimate N_e from observed changes in $\hat{F}$ over temporally replicated collections from the same location. Yet, as previously shown, there were no statistically significant differences detected in allele frequencies. The underlying model for estimating N_e produced estimates with extremely large variances, given small temporal differences in $\hat{F}$, which rendered any trend in N_e unobservable. Table 3 shows N_e estimates calculated using temporally replicated natural collections.

Task 4 - Compare N_e estimates with trend in census size for Lake Wenatchee sockeye.

See Task 3

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Table 1 Lake Wenatchee sockeye collections analyzed. MNA is the mean number of alleles per locus, Hz is unbiased heterozygosity, Obs Hz is observed heterozygosity, and HW is the p-value of the null hypothesis of random association of alleles (i.e., Hardy – Weinberg equilibrium). For reference, the nominal level of statistical significance at $\alpha = 0.05$ is 0.0002 after correction for multiple tests.

Year	Collection Code	Tissue Type	Source	N	MNA	Hz	Obs Hz	HW
1989	89[1]	Scales	Natural	96	14.35	0.792	0.791	0.424
1990	90[1]	Scales	Natural	96	13.19	0.793	0.779	0.131
2000	00AAE	Scales	Broodstock	96	12.31	0.787	0.776	0.213
2000	00[1]	Scales	Natural	96	11.76	0.801	0.826	0.868
2001	01AAS	Scales	Broodstock	53	9.47	0.788	0.793	0.392
2001	01[1]	Scales	Natural	96	14.35	0.786	0.794	0.456
2002	02[1]	Scales	Natural	96	14.53	0.794	0.777	0.780
2004	04[1]	Scales	Natural	96	14.65	0.798	0.803	0.704
2004	04AAV	Scales	Broodstock	43	14.35	0.796	0.795	0.051
2006	06CN	Tissue	Broodstock	38	14.59	0.793	0.785	0.688
2006	06CO	Tissue	Natural	96	14.53	0.806	0.803	0.408
2007	07EE	Tissue	Broodstock	18	14.00	0.790	0.790	0.221
2007	07EF	Tissue	Natural	96	14.35	0.789	0.800	0.347

[1] Samples taken from scale cards provided by Jeff Fryer (CRITFC)

Table 2 Allelic differentiation for Lake Wenatchee sockeye collections. A single analysis tested (pairwise) the allelic differentiation between all thirteen collections; however p-values for G-statistics are partitioned in the table by A) natural-origin, B) broodstock, and C) natural versus broodstock. Underlined values are for paired natural-broodstock collections from the same year. For reference, the nominal level of statistical significance at $\alpha = 0.05$ is 0.0006 after correction for multiple tests. No significant values were observed.

A) Natural-Origin Collections

	89	90	00	01	02	04	06CO	07EF
89		0.257	0.359	0.531	0.331	0.127	0.031	0.263
90			0.953	0.148	0.753	0.903	0.077	0.283
00				0.328	0.527	0.607	0.604	0.400
01					0.209	0.081	0.127	0.093
02						0.085	0.707	0.235
04							0.312	0.577
06CO								0.435
07EF								

B) Broodstock Collections

	00AAE	01AAS	04AAV	06CN	07EE
00AAE		0.189	0.090	0.008	0.058
01AAS			0.122	0.020	0.116
04AAV				0.008	0.031
06CN					0.326
07EE					

C) Natural vs. Broodstock

	89	90	00	01	02	04	06CO	07EF
00AAE	0.027	0.309	<u>0.572</u>	0.018	0.041	0.012	0.093	0.040
01AAS	0.115	0.471	0.160	<u>0.219</u>	0.519	0.049	0.654	0.133
04AAV	0.136	0.219	0.210	0.423	0.208	<u>0.328</u>	0.037	0.153
06CN	0.029	0.004	0.053	0.007	0.022	0.004	<u>0.019</u>	0.001
07EE	0.099	0.229	0.053	0.015	0.093	0.178	0.090	<u>0.037</u>

Table 3 Estimation of N_e for temporally replicated natural-original sockeye collections. Above the diagonal are pairwise estimates of N_e, where negative values mean sampling variance can account for genetic variance observed (i.e., genetic drift unnecessary). Below the diagonal are variances for pairwise estimates of N_e. Absent variance values (denoted by **-**) were too large for SalmonNb to display.

Collection	89	90	00	01	02	04	06CO	07EF
89		-3936.6	-1414	-2636.3	671.4	1871.1	1066.1	1951.2
90	2.59E+09		-1490.3	3649.1	-31144	-6808.4	817.6	93190.2
00	1.40E+09	4.45E+09		-592.2	-6842.2	-667.1	-1736.9	-1350.1
01	1.21E+09	1.47E+09	2.33E+09		977.1	6160.4	387.8	2531.5
02	1.91E+09	1.33E+09	1.16E+09	2.29E+09		1495.6	-848.5	3213.6
04	2.21E+09	3.62E+09	4.08E+09	1.27E+09	1.14E+09		896.6	2155.3
06CO	1.34E+09	1.39E+09	1.73E+09	**-**	4.51E+09	1.2E+09		3278.6
07EF	2.15E+09	1.51E+09	1.18E+09	1.68E+09	**-**	1.36E+09	2.65E+09	

Appendix H

GENETIC DIVERSITY OF CHIWAWA RIVER SPRING CHINOOK SALMON

Assessing the Genetic Diversity of Natural Chiwawa River Spring Chinook Salmon and Evaluating the Effectiveness of its Supportive Hatchery Supplementation Program

Developed for

Chelan County PUD

and the

Habitat Conservation Plan's Hatchery Committee

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Table of Contents

Executive Summary

The main objective of this study was to determine the potential impacts of the Chiwawa River Supplementation Program on natural spring Chinook in the upper Wenatchee system. We did this by investigating population differentiation between temporally replicated Chiwawa River natural and hatchery samples from the Wenatchee River watershed using microsatellite DNA allele frequencies and the statistical assignment of individual fish to specific populations. Additionally, to assess the genetic effect of the hatchery program, we investigated the relationship between census and effective population sizes using collections obtained before and after the supplementation program. In this summary, we briefly describe the salient results contained within this report; however, each "Task" within the Results/Discussion section below contains extended coverage for each topic along with an expanded interpretation of each result.

Overall, we observed substantial genetic diversity within collections, with heterozygosities equal to roughly 80%, over thirteen microsatellite markers. Microsatellite allele frequencies among temporally replicated collections from the same population (i.e., location) were variable, resulting in significant genetic differentiation among these collections. However, these difference are likely the result of salmon life history in this area, as four-year-old Chinook comprise a majority of returns each year. That is, the genetic tests are detecting the differences of contributing parents from each cohort, rather than a hatchery effect.

Analysis of Chiwawa River Collections

To assess the multiple competing hypotheses regarding population differentiation within and among Chiwawa River collections, we found it necessary to organized the Chiwawa genetic data into three data sets: (1) fish origin (hatchery versus natural), (2) spawning location (hatchery broodstock versus in-river (natural) spawners), and (3) four "treatment" groups (1. hatchery-origin hatchery broodstock, 2. hatchery-origin natural spawner, 3. natural-origin natural spawner, and 4. natural-origin hatchery broodstock). We conducted separate analyses using each of the three data sets, with each analysis

touching on some aspect of the components necessary to move through the Conceptual Process outlined by Murdoch and Peven (2005).

Origin Dataset – We report that allele frequencies within and between natural- and hatchery-origin collections are significantly different, but there does not appear to be a robust signal indicating that the recent natural-origin collections have diverged greatly from the pre- or early post-supplementation collections. Genetic drift will occur in all populations, but does not appear to be a major factor affecting allele frequencies within the Chiwawa collections.

Spawning Location Dataset – There are significant allele frequency differences within and between hatchery broodstock and natural spawner collections. However, in recent years the allele frequency differences between the hatchery broodstock and natural spawner collections have declined. Furthermore, based on linkage disequilibrium, there is a genetic signal that is consistent with increasing homogenization of allele frequencies within hatchery broodstock collections, but a similar homogenization within the natural spawner collection is not apparent. These data suggest that there exists consistent year-to-year variation in allele frequencies among hatchery and natural spawning collections, but there is a trend toward homogenization of the allele frequencies of the natural- and hatchery-origin fish that compose the hatchery broodstock.

Four Treatment dataset – Although there are signals of allelic differentiation among Chiwawa River collections, there are no robust signs that these collections are substantially different from each other. We used two different analyses to measure the degree of genetic variation that exists among individuals and collections within the Chiwawa River. First, we conducted a principal component analysis using all Chiwawa samples with complete genotypes (i.e., no missing alleles from any locus). Although the first two principal component axes account for only 10.5% of the total molecular variance, a substantially greater portion of that variance is among individual fish, regardless of their identity, rather than among hatchery and natural collections. The variances in principal component scores among individuals are 11 and 13 times greater than the variance in scores among collections.

Secondly, using an Analysis of Molecular Variance (AMOVA), we were able to determine how best to group populations, with "best" being defined as that grouping that accounts for the greatest proportion of among group (i.e., population) variance. Furthermore, by partitioning molecular variance into different hierarchical components, we are able to determine what level accounts for the majority of the molecular variance. The AMOVA results clearly show that nearly all molecular variation, no matter how the data are organized, resides within a collection. The percentage of total molecular variance occurring within collections ranged from 99.68% to 99.74%. These results indicate that the significant differences among collections of Chiwawa fish account for less than one percent of the total molecular variance, and these differences cannot be attributed to fish origin or spawning location.

Effective Population Size (N_e)

The contemporary estimate of N_e calculated using genetic data combined for Chiwawa natural-origin spawners (NOS) and hatchery-origin spawners (HOS) Chinook is N_e=386.8, which is slightly larger than the pre-hatchery N_e we estimated using demographic data from 1989 – 1992. Additionally, the N_e /N ratio calculated using 386.8 for N_e and the arithmetic mean yearly census of NOS and HOS Chinook from 1989 – 2005 for N is 0.40. These results suggest the N_e has not declined during the period of Chiwawa Hatchery Supplementation Program operation.

Analysis Of Upper Wenatchee Tributary Collections

We compared genetic data for spring Chinook collected from the major spawning aggregates of the Wenatchee River. We observed significant differences in allele frequencies among temporally replicated collections within populations, and among populations within the upper Wenatchee. However, these differences account for a very small portion of the overall molecular variance, and these populations overall are very similar to each other. Of all the populations within the Wenatchee River, the White River appears to be the most distinct. Yet, this distinction is more a matter of detail than of large significance, as the median F_{ST} between White River collections and all other collections (except the Little Wenatchee collection; see Results/Discussion) is less than 1.5% among population variance. We consider the implications of these results in the Conclusion section that follows the Results/Discussion section. Additionally, there is no evidence that the Chiwawa River Supplementation Program has changed the allele frequencies in the Nason Creek and White River populations, despite the presence of hatchery-origin fish in both these systems.

Introduction

Murdoch and Peven (2005) outlined 10 objectives to assess the impact (positive or negative) of hatchery operations mitigating the operation of Rock Island Dam. Two objectives relate to monitoring the genetic integrity of populations:

Objective 3: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Objective 5: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

This study addresses Objective 3 (above), and documents analyses and results WDFW completed for populations of spring Chinook (*Oncorhynchus tshawytscha*) in the Wenatchee River watershed. This study was not intended to specifically address Objective 5 (above); however, genetic data provide results relevant to Objective 5. The critical component of Objective 3 is to determine if hatchery supplementation has effected change. Furthermore, change in this context means altering census size and/or genetic marker allele frequencies; we did not attempt to measure changes in fitness. Perhaps a more meaningful rewording of Objective 3 is, "Did the hatchery supplementation program succeed at increasing the census size of a target population while leaving genetic integrity intact?" In order to evaluate cause and effect of hatchery supplementation, we surveyed and compared genetic variation in samples collected before and after potential effects from the Chiwawa Hatchery Supplementation Program. Samples were acquired from the primary spawning aggregates in the upper Wenatchee River watershed: Nason Creek, Little Wenatchee River, White River, and Chiwawa River. Hatchery samples were acquired from programs that could potentially affect genetic composition of Wenatchee stocks, the integrated Chiwawa River stock (local stock), Leavenworth National Fish Hatchery spring Chinook (Carson Stock – non local), and Entiat NFH (Carson Stock – non local). Additionally, the genetic markers used were the Genetic Analysis of Pacific Salmonids (GAPS) (Seeb et al. in review) standardized microsatellites, so all data from the Wenatchee study will be available for inclusion in the GAPS Chinook coastwide microsatellite baseline.

History of Artificial Propagation

Artificial propagation in the upper Columbia River began in 1899 when hatcheries were constructed on the Wenatchee and Methow rivers (Mullan 1987). These initial operations were small, with the Tumwater Hatchery on the Wenatchee River releasing several hundred thousand fry, and the Methow River hatchery producing few Chinook salmon before it was closed in 1913 (Craig and Suomela 1941, Nelson and Bodle 1990). The Leavenworth State Hatchery operated in the Wenatchee River Basin between 1913 and 1931 using eggs from non-native stocks (Willamette River spring-run and lower Columbia Chinook hatchery fall-run). These early attempts at hatchery production were largely unsuccessful for spring-run Chinook (WDF 1934). Between 1931 and 1939, no Chinook salmon hatcheries were in operation above Rock Island Dam (Rkm 730).

In 1938, the last salmon was allowed to pass upstream through the uncompleted Grand Coulee Dam (Rkm 959). To mitigate the loss of habitat, adult Chinook salmon were trapped, under the auspices of the Grand Coulee Fish Maintenance Project (GCFMP), at Rock Island Dam beginning in May 1939, and relocated into three of the remaining accessible tributaries to the upper Columbia River: the Wenatchee, Entiat, and Methow Rivers. GCFMP transfers continued through the autumn of 1943. Spring- and summer/fall-run fish were differentiated at Rock Island Dam based on a 9 July cutoff date for Chinook arrivals at Rock Island Dam (Fish and Hanavan 1948). Spring-run adults collected at Rock Island Dam (pre 9 July fish) were either transported to Nason Creek on the Wenatchee River to spawn naturally (1939-43), or to the newly constructed Leavenworth NFH (1940) for holding and subsequent spawning (1940-43). Eggs were incubated on site or transferred to the Entiat NFH (1941) and Winthrop NFH (1941). In 1944 spring-run adults were allowed to freely pass Rock Island Dam. The GCFMP did not differentiate among late-run stocks (post 9 July fish) passing Rock Island Dam. Late-run offspring reared at the Leavenworth NFH, Entiat NFH, and Winthrop NFHs were an amalgamation of summer and fall upper Columbia River populations (Fish and Hanavan 1948). Late-run fish were transplanted into the upper and lower Wenatchee, Methow, and Entiat Rivers.

After 1943, the Winthrop NFH continued to use local spring-run Chinook for hatchery production, while the other NFHs largely focused on summer-run Chinook salmon. Renewed emphasis on spring run production in the mid-1970s saw the inclusion of local and non-local eggs (Carson NFH stock, Klickitat River stock, and Cowlitz River stock) to the NFHs. In the early 1980s, imports of non-native eggs were reduced significantly, and thereafter the Leavenworth, Entiat, and Winthrop NFHs have relied on adults returning to their facilities for their egg needs (Chapman et al. 1995). Regarding late-run Chinook, due to the variety of methods employed to collect broodstock at dams, hatcheries, or the result of juvenile introductions into various areas, Chinook populations and runs (i.e., summer and fall) have been mixed considerably in the upper Columbia system over the past five decades (reviewed in Chapman et al. 1994).

Washington Department of Fish and Wildlife (WDFW) operates two facilities producing spring-run Chinook, the Methow Fish Hatchery (MFH) owned by Douglas County PUD that began operation in 1992 and Eastbank Fish Hatchery (EFH) owned by Chelan County PUD that began operation in 1989. Both programs were designed to implement supplementation (supportive breeding) programs for naturally spawning populations on the Methow and Wenatchee Rivers, respectively (Chapman et al. 1995). As part of the Rock Island Mitigation Agreement between Chelan County Public Utility District and the fishery management parties (RISPA 1989), a supplementation (supportive breeding) program was initiated in 1989 on the Chiwawa River to mitigate smolt mortality resulting from the operation of Rock Island Hydroelectric Project. EFH uses broodstock collected at a weir on the Chiwawa River, although in recent years hatchery fish have been collected at Tumwater Dam. Similarly, the MFHC uses returning adults collected at weirs on the Methow River and its tributaries, the Twisp and Chewuch Rivers (Chapman et al. 1995; Bugert 1998). Although low run size and trap efficiency has resulted in most broodstock being collected from the hatchery outfall or in some years Wells Dam, progeny produced from these programs are reared at and released from satellite sites on the tributaries where the adults were collected. Numerous other facilities have reared spring-run Chinook salmon on an intermittent basis.

Previous Genetic Studies – Population differentiation

Waples et al. (1991a) examined 21 polymorphic allozyme loci in samples from 44 populations of Chinook salmon in the Columbia River Basin. These authors reported three major clusters of Columbia River Basin Chinook salmon: 1) Snake River spring- and summer-run Chinook salmon, and mid and upper Columbia River spring-run Chinook salmon, 2) Willamette River spring-run Chinook salmon, 3) mid and upper Columbia River fall- and summer-run Chinook salmon, Snake River fall-run Chinook salmon, and lower Columbia River fall- and spring-run Chinook salmon. Utter et al. (1995) examined allele frequency variability at 36 allozyme loci in samples of 16 upper Columbia River Chinook populations. Utter et al. (1995) indicated that spring-run populations were distinct from summer- and fall-run populations, where the average genetic distance between spring-run and late-run Chinook were about eight times the average of genetic distances between samples within each group. Additionally, allele frequency differences among spring-run populations were considerably greater than that among summer- and fall-run populations in the upper Columbia River. Utter et al. (1995) also reported hatchery populations of spring-run Chinook salmon were genetically distinct from natural spring-run populations, but hatchery populations of fall-run Chinook salmon were not genetically distinct from natural fall-run populations.

As part of an evaluation of the relative reproductive success for the Chiwawa River supplementation program, Murdoch et al. (2006), used eleven microsatellite loci to assess population differentiation among spring Chinook salmon population samples in the upper Wenatchee River. Murdoch et al. (2006) reported a >99% accuracy of correctly identifying spring-run and fall-run Chinook from the Wenatchee River. They also reported slight, but significantly different genetic variation among wild spring populations and between wild and hatchery stocks. Yet, since the spring-run populations are genetically similar, identifying individuals genetically from the upper tributaries of the Wenatchee River was difficult. This result is exemplified in their individual assignment results, where < 8% of spring-run individuals, hatchery or wild, were correctly assigned using their criterion of an LOD (log of odds) score greater than 2. Murdoch et al. (2006) also reported contemporary natural spring Chinook show heterozygote deficit and low linkage disequilibrium (LD), while contemporary hatchery spring Chinook show heterozygote excess and high LD.

Williamson et al. (submitted) have continued the work of Murdoch et al. (2006) by analyzing Chiwawa River demographic data from 1989 – 2005 to estimate the proportions of recruits that were produced by Chinook with hatchery or wild origin. In an "ideal" population, the genetic size (i.e., effective size or N_e) and the census size are equal; however various demographic factors such as unequal sex ratios and variance in reproductive success among individuals reduces the genetic size below the census size. It is generally thought that the genetic size is approximately 10-33% the census size (Bartley et al. 1992; RS Waples pers. comm.), although values have been reported outside this range (Araki et al. 2007; Arden and Kapuscinski 2003; Heath et al. 2002). Despite being difficult to estimate, the effective population size in many respects is a more important parameter to know than census size, because N_e determines how genetic diversity is distributed within populations and how the forces of evolution (i.e., forces that change genetic diversity over time) will affect the genetic variation present.

Williamson et al. (submitted) used demographic data to 1) investigate the effect of unequal sex ratio on genetic diversity, 2) investigate the effect of variation in reproductive success on genetic diversity, 3) investigate the effect of fluctuations in population size on genetic diversity, and 4) estimate the effective population size, using the inbreeding method (Ryman and Laikre 1991). Most importantly, they use demographic data from 1989 – 2000 to assess the impact of the Chiwawa Hatchery Supplementation Program on the effective population size of natural-origin Chiwawa River spring Chinook. They estimate that the N_e of naturally spawning Chiwawa Chinook (i.e., both hatchery- and wild-origin fish on the spawning grounds) from 1989 –

1992 was N_e = 2683 and in 1997 – 2000 was N_e = 989. They compare spawning ground N_e to estimates calculated from combined broodstock and naturally spawning Chinook demographic data. The combined inbreeding N_e estimate from 1989 – 1992 was N_e = 147 and in 1997 – 2000 was N_e = 490. Williamson et al. (submitted) argue that since the combined N_e estimate is lower than the naturally spawning estimate, the supplementation program has had a negative impact on the Chiwawa River N_e.

Williamson et al. (submitted) also present genetic data for Chinook recovered on spawning grounds in upper Wenatchee River tributaries in 2004 and 2005. These genetic data are derived from the Murdoch et al. (2006) study. They compare samples collected from Chiwawa River (i.e., hatchery and wild), White River, Nason Creek, and Leavenworth Hatchery. Additionally, they include a 1994 Chiwawa River wild smolt sample for comparison with the 2004 brood year. Williamson et al. (submitted) report statistically significant genetic differentiation among Chiwawa River, White River and Nason Creek. Additionally, they report that the 1994 and 2004 Chiwawa River wild samples are not statistically different, but the 2004 Chiwawa wild and hatchery collections are statistically different.

Study Objectives

This study investigated within and among population genetic diversity to assess the effect of the Chiwawa Hatchery's supplemental program on the natural Chiwawa River spring Chinook population. Differences among temporal population samples, the census size, heterozygosity, and allelic diversity were documented. We investigated population differentiation between the Chiwawa River natural and hatchery samples, and among all temporally replicated samples from the Wenatchee River watershed using microsatellite DNA allele frequencies and the statistical assignment of individual fish to specific populations. To assess the genetic effect of the hatchery program, correlation between census and effective population sizes were investigated using temporally replicated samples obtained before and after the supplementation program operation. To address the hypotheses associated with Objective 3 in Murdock and Peven (2005) we developed eleven specific “Tasks” (Blankenship and Murdoch 2006), to which we analyzed specific genetic data. We present the results from these analyses specific to each individual Task.

Methods and Materials

Tissue collection and DNA extraction

We analyzed thirty-two population collections of adult spring Chinook salmon (*Oncorhynchus tshawytscha*) obtained from the Wenatchee River between 1989 and 2006 (Table 1). Nine collections of natural Chinook adults from the Chiwawa River (n=501), and nine collections of Chiwawa Hatchery Chinook (n=595) were collected at a weir located in the lower Chiwawa River. The 1993 and 1994 Chiwawa Hatchery samples are smolt samples from the 1991 and 1992 hatchery brood years, respectively. Additional samples were collected from upper Wenatchee River tributaries, White River, Little Wenatchee River, and Nason Creek. Six collections of natural White River Chinook (n=179), one collection from the Little Wenatchee (n=19), and six collections from Nason Creek (n=268) were obtained. Single collections were obtained for Chinook spawning in the mainstem Wenatchee River and Leavenworth National Fish Hatchery. An additional out-of-basin collection from Entiat River was also included in the analysis. Samples collected in 1992 or earlier are scale samples. All other samples were either fin clips or operculum punches, stored immediately in ethanol after collection. DNA was extracted from stored tissue using Nucleospin 96 Tissue following the manufacturer’s standard protocol (Macherey-Nagel, Easton, PA, U.S.A.).

Laboratory analysis

We performed polymerase chain reaction (PCR) amplification on each fish sample using the 13 fluorescently end-labeled microsatellite marker loci standardized as part of the GAPS project (Seeb et al. in review). GAPS genetic loci are: *Ogo*2, *Ogo*4 (Olsen et al. 1998); *Oki*100 (unpublished); *Omm*1080 (Rexroad et al. 2001); *Ots*201b (unpublished); *Ots*208b, *Ots*211, *Ots*212, and *Ots*213 (Grieg et al. 2003); *Ots*3M, *Ots*9 (Banks et al.

1999); *Ots*G474 (Williamson et al. 2002); *Ssa*408 (Cairney et al. 2000). PCR reaction volumes were 10 µL, and contained 1 µL 10x PCR buffer (Promega), 1.0 µL MgCl2 (1.5 mM final) (Promega), 0.2 µL 10 mM dNTP mix (Promega), and 0.1 units/mL Taq DNA polymerase (Promega). Loci were amplified as part of multiplexed sets, so primer molarities and annealing temperatures varied. Multiplex one had an annealing temperature of 50°C, and used 0.37 Molar (M) *Oki*100, 0.35 M *Ots*201b, and 0.20 M *Ots*208b, and 0.20 M *Ssa*408. Multiplex two had an annealing temperature of 63°C, and used 0.10 M *Ogo*2, and 0.25 M of a non-GAPS locus (*Ssa* 197). Multiplex three had an annealing temperature of 56°C, and used 0.18 M *Ogo*4, 0.18 M *Ots*213, and 0.16 M *Ots*G474. Multiplex four had an annealing temperature of 53°C, and used 0.26 M *Omm*1080, and 0.12 M *Ots*3M. Multiplex five had an annealing temperature of 60°C, and used 0.30 M *Ots*212, 0.20 M *Ots*211, and 0.10 M *Ots*9. Thermal cycling was conducted on either a PTC200 thermal cycler (MJ Research) or GeneAmp 9700 (Applied Biosystems) as follows: 95°C (2 min); 30 cycles of 95°C for 30 sec., 30 sec. annealing, and 72°C for 30 sec.; a final 72°C extension and then a 10°C hold. PCR products were visualized by electrophoresis on an ABI 3730 automated capillary analyzer (Applied Biosystems). Fragment analysis was completed using GeneMapper 3.7 (Applied Biosystems). Standardization of genetic data to GAPS allele standards was conducted following Seeb et al. (in review).

Genetic data analysis

Assessing within population genetic diversity - Heterozygosity measurements are reported using Nei's (1987) unbiased gene diversity formula (i.e., expected heterozygosity) and Hedrick's (1983) formula for observed heterozygosity. Both tests are implemented using the microsatellite toolkit (Park 2001). We used GENEPOP version 3.4 (Raymond and Rousset 1995) to assess Hardy-Weinberg equilibrium (HWE), where deviations from the neutral expectation of random associations among alleles are calculated using a Markov chain method (5000 iterations in this study) to obtain unbiased estimates of Fisher's exact test. Global estimates of F_{IS} according to Weir and Cockerham (1984) were calculated using GENEPOP version 3.4. Genotypic linkage disequilibrium was calculated following Weir (1979) using GENEPOP version 3.4.

Linkage results for population collections are reported as the proportion of pairwise (locus by locus) tests that are significant (alpha = 0.01). Linkage disequilibrium is considered statistically significant if more than 5% of the pairwise tests based on permutation are significant for a collection.

Within- and among-population genetic differentiation – The temporal stability of allele frequencies within populations, and pairwise differences in allele frequencies among populations were assessed using several different procedures. First, we tested for differences in allele frequencies among populations defined in Table 1 using a randomization chi-square test implemented in GENEPOP version 3.4 (Raymond and Rousset 1995). This procedure tests for differences between pairs of populations where alleles are randomized between the populations (i.e., genic test). The null hypothesis for this test is that the allele frequency distributions between two populations are the same. A low p-value should be interpreted as the allele frequency distributions being compared are unlikely to be samples drawn from the same underlying distribution.

Second, to graphically describe allele frequency differences among populations we conducted a nonmetric multidimensional scaling analysis using allele-sharing distance matrices from two different data sets. Pairwise allele-sharing distances are calculated as 1 – (mean over all loci of the sums of the minima of the relative frequencies of each allele common to a pair of populations). To calculate the allele-sharing distances for each pair of populations we used PowerMarker v3.25 (Liu and Muse 2005). Nonmetric multidimensional scaling is a technique designed to construct an n-dimensional "map" of populations, given a set of pairwise distances between populations (Manly 1986). The output from this analysis is a set of coordinates along n-axes, with the coordinates specific to the number of n-dimensions selected. To simplify our analysis we selected a 2-dimensional analysis to represent the relative positions of each population in a typical bivariate plot. The goodness of fit between the original allele-sharing distances and the pairwise distances between all populations along the 2-dimensional plot is measured by a "stress" statistic. Kruskal (in Rohlf 2002) developed a five-tier guide for evaluating stress levels, ranging from a perfect fit (stress=0) to a poor fit (stress=0.40). We conducted the nonmetric multidimensional scaling analysis for one data set containing Chiwawa natural- and hatchery-origin collections, and another data set containing Chiwawa broodstock and in-river spawner collections. We used the mdscale module in MATLAB R2006b (The Mathworks 2006) to generate the nonmetric multidimensional scaling coordinates.

We examined the geographic and temporal structure of populations in the upper Wenatchee (Chiwawa River, Nason Creek, and White River, only) using a series of analyses of molecular variance (AMOVAs). Here, we defined an AMOVA as an analysis of variance of allele frequencies, as originally designed by Cockerham (1969), but implemented in Arlequin v2.1 (Schneider et al. 2000). These analyses permit populations to be aggregated into groups, and molecular variance is then partitioned into within collections, among collections, but within groups, and among group components. With this approach, we were able to determine how best to group populations, with "best" being defined as that grouping that accounts for the greatest proportion of among group variance. Furthermore, by partitioning molecular variance into three different hierarchical components, we are able to determine what level accounts for the majority of the molecular variance.

Finally, we explored the partitioning of molecular variance between among-individuals and among-populations using a principal component analysis and multi-locus estimates of pairwise F_{ST}, estimated by a "weighted" analysis of variance (Weir and Cockerham, 1984). Principal component analysis is a data-reduction technique whereby the correlation structure among variables can be used to combine variables into a series of multivariate components, with each original variable receiving a weighted value for each component based on its correlation with that component. Here, we used a program written by Warheit in MATLAB R2006b (The Mathworks 2006) that treats each allele for each locus as a single variable (13 loci = 26 alleles or variables), and these 26 "variables" were arranged into 26 components, with each component accounting for a decreasing amount of molecular variance. Estimates of F_{ST} were calculated using GENETIX version 4.05 (Belkhir et al.1996). To determine if the F_{ST} estimates were statistically different from random (i.e., no structure), 1000 permutations were implemented in GENETIX version 4.05 (Belkhir et al.1996).

Effective population size (N_e) – Estimates of the effective population size were obtained using two methods, a multi-collection temporal method (Waples 1990), and a single-collection method (Waples 2006) using linkage disequilibrium data. The temporal method assumes that cohorts are used, but we did not decompose the collection year samples into their respective cohorts using age data. Therefore, N_e estimates that pertain to individual year classes of breeders are not valid; however the harmonic mean over all samples will estimate the contemporary N_e. Comparing samples from years *i* and *j*, Waples' (1990) temporal method estimates the effective number of breeders ($\hat{N}_{b(i,j)}$) according to:

$$\hat{N}_{b(i,j)} = \frac{b}{2(\hat{F} - 1/\hat{S}_{i,j})}$$

The standardized variance in allele frequency ($\hat{F}$) is calculated according to Pollack (1983). The parameter b is calculated analytically from age structure information and the number of years between samples (Tajima 1992). The age-at-maturity information required to calculate b was obtained from Murdoch et al. (2006) for this analysis. They observed for Chiwawa Hatchery Chinook that 8.6% matured at age 2, 4% at age 3, 87% at age 4, and 0.4% at age 5. For Chiwawa natural Chinook, Murdoch et al. (2006) observed that 1.8% matured at age 3, 81.6% at age 4, and 16.7% at age 5. The harmonic mean of sample sizes from years *i* and *j* is $\tilde{S}_{i,j}$. Over all pairwise comparisons the harmonic mean of all $\hat{N}_{b(i,j)}$ is $\tilde{N}_b$, the contemporary estimate of the effective population size (N_e). SALMONNb (Waples et al. 2007) was used to calculate $\tilde{N}_b$. As suggested by authors, alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

The method of Waples (2006) uses linkage disequilibrium (i.e., mean squared correlation of allele frequencies at different gene loci) as a means of estimating effective population size (N_e) from a single sample. While this method is biased in some cases where N_e /N ratio is less the 0.1 and the sample size is less than the true N_e, it has been shown to produce comparable results to the temporal method. Burrows' delta method is used to estimate LD, and a bias corrected estimate of N_e is calculated after eliminating alleles with frequency less than 0.05. This test was implemented using LDN_e (Do and Waples unpublished). In age-structured species, N_e estimates based on LD are best interpreted as the effective number of breeders (N_b) that produced the sample (Waples 2006). N_b should be multiplied by the mean generation length (i.e., 4 in this case) to obtain an overall estimate of N_e based on an N_b estimate. We analyzed collections categorized by spawning location (i.e., hatchery broodstock or in-river) and did not analyze collections categorized by origin (i.e., hatchery or natural). Waples' (2006) method estimates N_e from observed LD, therefore the corresponding N_e estimates for the hatchery collections would be low and the estimates for the natural collections would be high. Yet, since the supplementation program is integrated, and hatchery fish can spawn naturally, we feel it inappropriate to analyze the hatchery and natural samples as if they were separate, which would essentially partition all the LD into the hatchery samples.

Each collection has an N_b estimate and an associated confidence interval. If the confidence interval includes infinity, it means that sampling error accounts for all the LD observed (i.e., empirical LD is less than expected LD). The usual interpretation is that there is no evidence for any disequilibrium caused by genetic drift in a finite number of parents. Since the LD method estimates the number of breeders that contributed to the sample being analyzed, in order to calculate an N_e /N ratio, the appropriate census size must be used. The census size used to derive a ratio was the estimate four years prior to the collection analyzed using LD, which assumed a strict four-year-old lifecycle, although the observed proportion of four-year-olds was approximately 85% each year. The census numbers (Table 2) used to calculate the ratios for Chiwawa broodstock and in-river spawners were combined NOS (natural-origin spawners) and HOS (hatchery-origin spawners) census estimates.

Individual assignment – A population baseline file was constructed containing all 1704 individual Chinook from 34 population collections (Table 1; Chiwawa origin data set plus all samples from other populations). All individuals in the baseline had geneotypes that included nine or more loci. Individual Chinook were assigned to their most likely population of origin based on the partial Bayesian criteria of Rannala and Mountain (1997), using a "jack-knife" procedure, where each individual to be assigned was removed from the baseline prior to the calculation of population likelihoods. This procedure was implemented in a program written by Warheit in MATLAB R2006b (The Mathworks 2006). Two assignment criteria were used, 1) the population with the largest posterior probability for an individual was the "most-likely" population of origin (i.e., all individuals assigned to a collection), and 2) an assignment was consider valid only if the posterior probability was greater than or equal to 0.9. Please note that while the analysis used 34 population collections to assign Rannala and Mountain likelihoods for each individual, these likelihoods were aggregated based on "population" (i.e., Chiwawa, Nason, White, and so on) and posterior probabilities were calculated for population location, rather than individual collections.

Results and Discussion

In this section we combine our presentation and interpretations of the genetic analyses. Additionally, this section will be organized based on the task list presented in the study plan. Overall conclusions are provided following this section.

Task 1: Determine trend in census size for Chiwawa River spring Chinook.

Census data from 1989 – 2005 are provided in Table 2 for the Chiwawa Hatchery broodstock and spring Chinook present in the Chiwawa River. The demographic data for naturally spawning Chinook are based on redd sampling and carcass surveys, while broodstock data are based on Chiwawa hatchery records. As the supplementation program is integrated by design, we also present the proportion of natural-origin broodstock (pNOB) incorporated into the hatchery, in addition to the number of natural-origin (NOS) and hatchery-origin (HOS) spawners present in Chiwawa River. The census size fluctuated yearly, and a general reduction in census size was observed in the mid to late 1990's. This trend was apparent in both the broodstock and in the river. The arithmetic mean census size from 1989 – 2005 for the Chiwawa Hatchery (i.e., broodstock) was N=87.5 per year. The arithmetic mean census size from 1989 – 2005 for the Chiwawa River (i.e., NOS and HOS combined) was N=961.9 per year. For collection years when adult Chiwawa hatchery-origin fish would have been absent in the Chiwawa River (1989 – 1992), the arithmetic mean of natural Chiwawa Chinook census size is N=962.7. We will use this number as the baseline census size to assess if census size has changed. We used two different values for the contemporary census size in the Chiwawa River, NOS only and NOS + HOS. Additionally, we used collection years 2002 – 2005 for the contemporary NOS and HOS estimates, as these are the most recent data and the number of years included for estimation is the same as the pre-hatchery estimate above (i.e., four years). For NOS only, the arithmetic mean census size from 2002 – 2005 was N=536.0. For total census size (i.e., NOS and HOS combined), the arithmetic mean census size from 2002 – 2005 was N=1324.0. For the demographic data presented here, the contemporary census size is larger than the census estimate derived from the years prior to hatchery operation.

<u>Task 2:</u> Document the observed genetic diversity.

Genetic Diversity Categorized By Origin

For Chiwawa River collections categorized by origin (Table 1A), substantial genetic diversity was observed, with heterozygosity estimates over all loci, having a mean of 0.80. Genetic diversity was consistent with expected Hardy-Weinberg random mating genotypic proportions for ten of the eighteen collections. Eight of the nine Chiwawa natural collections were consistent with HWE, and two of nine Chiwawa Hatchery collections were consistent with HWE. F_{IS} is observed to be slight for all Chiwawa population collections, suggesting individuals within collections do not show excessive homozygosity.

The deviations from HWE observed were generally associated with hatchery collections. The two smolt collections (i.e., 1993 and 1994) showed significant deviations from HWE, which may be a function of non-random hatchery practices involving the contributing natural-origin parental broodstocks (i.e., 1991 and 1992 cohort). Deviations from HWE in the remaining hatchery collections may be the result of few individuals being represented in the broodstock (see below).

Additionally, linkage disequilibrium (LD) was also common for Chiwawa hatchery-origin collections and minimal for Chiwawa natural-origin collections. The random association of alleles between loci (i.e., linkage equilibrium) is expected under ideal conditions. LD is observed when particular genotypes are encountered more than expected by chance. Laboratory artifacts (e.g. null alleles) or physical linkage of loci on the same chromosome can cause LD, but the LD we observed was not associated with certain locus combinations, which you would expect if either artifacts or physical linkage were the cause of LD. LD was observed for seven of the nine hatchery-origin collections. As with the deviations from HWE, the high LD in the 1993 and 1994 hatchery-origin collections may be a result of non-random hatchery practices. The substantial LD observed in the hatchery-origin adult collections (collection years 2000, 2001, 2004, and 2006) might be the result of small parental broodstock sizes contributing to those returning adults. During the mid 1990's, the Chiwawa broodstock size was low, with zero individuals collected in 1995 and 1999; so fewer individuals would be contributing to the hatchery adult returns than the natural. This idea is corroborated by the lower LD observed for the 2005 hatchery-origin collection, which had a contributing parental broodstock size in 2001 (i.e., the major contributing parental generation) approximately eight times as large as the previous few collection years (Table 2). LD reappears in the 2006 Chiwawa hatchery-origin collection, which had a contributing parental broodstock size (i.e., for the most-part, the 2002 hatchery brood year) five times lower (Table 2) than that of the 2005 collection.

While seven of nine hatchery-origin collections showed significant LD, only one natural origin collection showed LD, and for this collection, only 10% of the loci-pairs were in disequilibrium (Table 1). The fact that LD predominated in the hatchery samples, suggests that variance in reproductive success (i.e., overrepresentation of particular parents) is higher in the hatchery-origin than in natural-origin collections.

Genetic Diversity Categorized By Spawning Location

For upper Wenatchee River collections categorized by spawning location (Table 1B), substantial genetic diversity was observed, with heterozygosity estimates over all loci, having a mean of 0.79 and ranging from a low of 0.69 (1993 White River) to 0.85 (1993 Little Wenatchee). Genetic diversity was consistent with HWE for nineteen of twenty-nine population collections. For the collections that departed from HWE, seven were from the Chiwawa River, one was from Leavenworth Hatchery, one was the Wenatchee mainstem collection of hatchery-origin – naturally spawning fish, and one was from the White River. F_{IS} is observed to be slight for all population collections except the 1993 White River collection (10% heterozygote deficit) (Table 1B). Collections deviating with HWE generally correlated with collections having high LD. Twelve population collections showed a proportion of pairwise linkage disequilibrium tests (across all loci) greater than 5% (Table 1B), eight of which were Chiwawa collections.

Starting in 1996, spawning location collections are composed of both natural- and hatchery-origin samples. The LD seen in the later spawning location collections may be caused by an admixing effect (i.e., mixing two populations), where random mating has not had the chance to freely associate alleles into genotypes. Interestingly, there appears to be a trend of reducing LD through time within the broodstock collections (Table 1B), which suggests that a “homogenizing” effect is taking place within the Chiwawa River. This observation is discussed more fully in Task 3 below.

Task 3: Test for population differentiation among collections within the Chiwawa River and associated supplementation program.

Introduction

Task 3 was designed to address two hypotheses listed as part of Objective 3 in Murdoch and Peven (2005):

- Ho: Allele frequency $_{\text{Hatchery}}$ = Allele frequency $_{\text{Naturally produced}}$ = Allele frequency $_{\text{Donor pop}}$.
- Ho: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations $_{\text{Year y}}$

Murdoch and Peven (2005) proposed these two hypotheses to help evaluate the Chiwawa supplementation program through the "Conceptual Process" (Figure 5 in Murdoch and Peven 2005; repeated here as Figure 1). There are two components to the first hypothesis, which must be considered separately. The first component involves comparisons between natural-origin populations in the Chiwawa to determine if there have been changes in allele frequencies or genetic distances, through time starting with the donor population. Documenting a change does not necessarily indicate that the supplementation program has directly affected the natural origin fish, as additional tests would be necessary to support that hypothesis. The intent of the second component is to determine if the hatchery produced populations have the same genetic composition as the naturally produced populations.

Although on the surface these two components and their associated comparisons may appear simple, from a hypothesis-testing perspective the analyses are complicated by the fact that natural-origin fish may have had hatchery-origin parents, and hatchery-origin fish may have had natural-origin parents. As such, we organized the Chiwawa genetic data into three data sets: (1) fish origin (hatchery versus natural), (2) spawning location (hatchery broodstock versus in-river (natural) spawners), and (3) four "treatment" groups (1. hatchery-origin hatchery broodstock, 2. hatchery-origin natural spawner, 3. natural-origin natural spawner, and 4. natural-origin hatchery broodstock). We conducted separate analyses using each of the three data sets, with each analysis touching on some aspect of the components necessary to move through the Conceptual Process (Figure 1).

Hatchery- Versus Natural-Origin

We address the following questions with the origin data set:

1. Are there changes in allele frequencies and allele sharing distances in the natural-origin collections from pre-supplementation to today?
2. Are there changes in allele frequencies and allele sharing distances in the hatchery-origin collections from early supplementation to today?
3. Are there significant differences in allele frequencies and large allele sharing distances between hatchery- and natural-origin adults from a collection year, and has this pattern changed through time?

Genic Differentiation Tests – We explicitly tested the hypothesis of no significant differentiation within natural- or hatchery-origin collections from the Chiwawa River using a randomization chi-square test. We show the results for the pairwise comparisons among natural-origin collections from the Chiwawa River populations in the first block of the second page of Table 3. Ten of the 36 (28%) pairwise comparisons have highly significant allele frequency differences, while only 12 of the 36 comparisons (33%) showed no significant differences. Eight of these 12 comparisons involved the 1996 collection, which included only eight samples and therefore provided little power to differentiate allele frequencies. If we exclude the 1996 collection, only 14% of the pairwise comparisons showed no significant differences, and here all but one of these comparisons involved the 1989 collection. The 1989 collection appeared to be the least differentiated collection in the natural-origin data set in that all pairwise comparisons were either not significant, or only mildly significant at the nominal critical value. No comparisons involving the 1989 collection were significant using a Bonferroni-corrected critical value, and 1989 is the only natural-origin collection in our data set that can be classified as “pre-supplementation.”

We can interpret these results to indicate that although there appears to be significant year-to-year differences in allele frequencies among post-supplementation collections, the allele frequencies between each post-supplementation collection and the 1989 pre-supplementation collection are not greatly different. However, the level of differentiation does increase from the early post-supplementation years to the more recent years (2001, 2004-2006), although the statistical level of this significance never exceeds the Bonferroni-corrected critical value. Finally, sample sizes were also small for the 1989 collection (n = 36) and we cannot eliminate a reduction in power as a contributing factor for the lack of significance for these tests.

As with the hatchery-origin collections, most pairwise comparisons of allele frequencies between hatchery-origin samples were significant (Table 3, first page, upper block). Out of the 36 pairwise comparisons, all but three are significant at some level, and most comparisons are highly significant. Similar to the natural-origin analysis, the non-significant results were limited to comparisons involving the 1996, which included only eight samples.

As a result of this analysis *we reject the hypothesis that there was no significant differentiation among natural- or hatchery-origin collections from the Chiwawa River*. Furthermore, the allele frequencies of the hatchery-origin collections are significantly different from those of natural-origin collections (Table 3, first page, second block). For those fish collected in the same year, allele frequencies are significantly different between hatchery- and natural-origin collections, although in 2005 the level of significance was below the Bonferroni critical value (Table 3). The next step is to examine the pattern of allelic differentiation to discover first if there is a trend among the data, and second, if this trend suggests that the allele frequency differences among Chiwawa River natural-origin fish collections has been affected by the hatchery-origin fish.

Allele-sharing and Nonmetric Multidimensional Scaling – We constructed a pairwise allele-sharing distance matrix for all hatchery- and natural-origin collections from the Chiwawa River and subjected this matrix to a nonmetric multidimensional scaling analysis, restricting the analysis to two dimensions (Figure 2). The stress statistic for this analysis is 0.09, a value Kruskal (in Rohlf 2002) listed as a good to excellent fit between the actual allele-sharing distances and the Euclidean (straight-line) distances in the plot.

In other words, Figure 2 is a good visual representation of the allele sharing distance matrix; collections with a high percentage of alleles shared will be closer to each other than collections with a lower percentage of alleles shared.

With the exception of the two outlier years (1996 and 1998) the Chiwawa natural-origin collections form a tight cluster indicating an overall common set of shared alleles among these collections. Even if we ignore the 1996 and 1998 hatchery-origin collections, there appears to be a greater variance in shared alleles among the Chiwawa hatchery-origin collections than the natural-origin collections (Figure 2). In fact, the median percentage of alleles shared among the Chiwawa natural-origin collections is 76% compared with 69% alleles shared among the Chiwawa hatchery-origin collections.

Also, there appears to be a convergence in allele sharing distances (i.e., a decrease in allele frequency differences) between the hatchery- and natural-origin fish from the late 1980s/early 1990s to 2006. The series of red arrows in Figure 2 represent the progression of change in hatchery-origin allele sharing distances from 1996 (first adult hatchery origin fish in our analysis) to 2006 and this progression is decidedly in the direction of the natural-origin cluster. However, the most recent natural-origin collections (2001, 2004-2006) appear to have pulled closer to the hatchery-origin collections, compared with the 1989 natural-origin collection (note the close proximity of the 2000 and 1989 natural-origin collections). Nevertheless, the cluster of natural-origin collections adjacent to the hatchery-origin collections in Figure 2 also includes the 1993 natural-origin collection. Qualitatively, it appears that the initial hatchery-origin and natural-origin collections were more different from each other in terms of the percentage of shared alleles than are the most recent hatchery- and natural-origin collections. This may have been a result of a non-random sample of natural-origin fish that was used as broodstock in the initial years of the supplementation program (see discussion in Task 2 concerning deviations from HWE and linkage disequilibrium).

That being said, we do need to emphasize that Figure 2 is dominated by five outlier collections (two each from the 1996 and 1998 collections, and the 1994 smolt collection).

The 1996 and 1998 collections are characterized by small samples sizes, and the 1994 smolt collection has nearly all pairs of loci in linkage disequilibrium (Table 1). If we eliminate these five outlier groups, both the hatchery- and natural-origin collections form a relatively tight cluster. Excluding the five outliers, the median percentage of shared alleles among all pairwise combinations of Chiwawa hatchery versus Chiwawa natural collections is 76%. This compares with a median pairwise percentage of 79% among only Chiwawa natural-origin collections. That is, there are nearly as many alleles shared between the hatchery-origin and natural-origin collections as there are among the natural-origin collections themselves. There is also a narrowing of differences between natural- and hatchery-origin fish from the same collection years from 1993 (76% shared alleles) through 2006 (83% shared alleles).

If allelic differentiation among collections is a function of genetic drift, we would expect a positive correlation between the number of years between two collections and the allele sharing distance. That is, if genetic drift is the primary cause of allele frequency differences between two collections, the greater the number of years between the two collections the larger the allele-sharing distance. For both the natural- and hatchery-origin collections we examined the relationship between the number of years between a pair of collections and the collections' allele-sharing distance (Figure 3). Although the relationship between time interval and allele distance appears to be a positive function in the natural collections, the slope of the regression line is 0.0017, and is not significantly different from zero. Furthermore, the correlation coefficient (r^2) equals 0.1068, which means that the time interval between collections accounts for only 10% of the pairwise differences in allelic distance. The hatchery-origin collections do show a significantly positive slope (0.0037; $p = 0.0254$) and a regression coefficient nearly three times greater than that for the natural-origin collections. However, the correlation coefficient is still relatively small ($r^2 = 0.3290$), indicating that the time interval between collections accounts for one-third of the pairwise differences in allelic distance. The results suggest that if genetic drift is a factor in allelic differentiation between collections, it is only a minor factor, and appears to have affected the hatchery-origin collections more than the natural-origin collections.

If four-year-old fish dominate each collection year, we would expect a closer relationship among collections that are spaced at intervals of four years. The average percentage of alleles shared between two natural-origin collections that are separated by four years or a multiple of four years is 81%, compared with 78% for natural-origin collections separated by years that are not divisible by four. Likewise, for hatchery-origin collections the average percentage of alleles shared is 80% and 75% for collections separated by years divisible and not divisible by four, respectively. Although the percent differences described above are relatively small, they are consistent with the idea that allelic differences between collections are a function of year-to-year variability among different cohorts of four year-old fish.

Summary – The allele frequencies within and between natural- and hatchery-origin collections are significantly different, but there does not appear to be a robust signal indicating that the recent natural-origin collections have diverged greatly from the pre- or early post-supplementation collections. Genetic drift will occur in all populations, but does not appear to be a major factor with the Chiwawa collections. We propose that the differences among collections are a function of differences in allele frequencies among cohorts of the four year-old fish that dominate each collection.

Hatchery Broodstock Versus Natural (In-River) Spawners

We address the following questions with the spawner data set:

1. Are there changes in allele frequencies and allele sharing distances in the natural spawning collections from pre-supplementation to today?
2. Are there changes in allele frequencies and allele sharing distances in the hatchery broodstock collections from early supplementation to today?
3. Are there significant differences in allele frequencies and large allele sharing distances between hatchery and natural spawning adults from a collection year, and has this pattern changed through time?

Genic Differentiation Tests – For the most part there are significant differences in allele frequencies among collections for both the hatchery broodstock and natural spawners (Table 4), and these differences are consistent with the origin data set (Table 3). There are four collection years with paired samples (2001, 2004-2006) where we can compare allele frequency differences between the hatchery broodstock and natural spawners, within the same year. The 2001 hatchery broodstock and natural spawner collections have significantly different allele frequencies, but the level of significance decreased from 2001 to 2004, and become non-significant in 2005 and 2006 (Table 4). This indicates that by 2005, the hatchery broodstock and natural spawners collections were effectively sampling from the same population of fish. Additionally, the percentage of alleles shared between the hatchery broodstock and the natural spawners increased from 76% in 2001 to 86% in 2006 (allele sharing distance matrix, not shown). From this analysis, we conclude that although there are year-to-year differences in allele frequencies within the natural and hatchery spawner collections, *there appears to be a convergence of allele frequencies within collection-year, between the natural and hatchery spawner populations*.

Linkage Disequilibrium – Linkage disequilibrium is the correlation of alleles between two loci, and can occur for several reasons. If two loci are physically linked on the same chromosome, than alleles from each of these loci should be correlated. However, linkage between two loci can occur as a result of population bottlenecks, small population sizes, and natural selection. If any of these conditions had occurred or were occurring within the Chiwawa River system, we would expect to find substantial linkage disequilibrium in many or perhaps all Chiwawa collections. However, many Chiwawa collections, especially the natural-origin collections, do not show linkage disequilibrium (Table 1), and it would appear that the linkage disequilibrium within certain Chiwawa collections is not a function of the processes listed above. Linkage disequilibrium can also result if the collection is composed of an admixture. That is, if two or more reproductively isolated populations are combined into a single collection, the collection will show linkage disequilibrium. Each broodstock and natural spawning collection is composed of natural- and hatchery-origin fish. If these hatchery- and natural-origin fish are drawn from the same population, the spawning collections should not show substantial linkage disequilibrium. However, if the hatchery- and natural-origin fish are from different populations (i.e., full hatchery – natural integration has not been achieved), the spawning collections should show substantial linkage disequilibrium.

There are only three Chiwawa spawning collections that are not composed of both hatchery- and natural-origin samples: 1989 (natural-origin, natural spawner), 1993 (natural-origin, hatchery broodstock), and 2001 (natural-origin, natural spawner). Of the 10 spawning collections with both hatchery- and natural-origin fish, seven show significant linkage disequilibrium. Two of the three collections that did not show linkage disequilibrium are the 1996 and 1998 hatchery broodstock collections, which are composed of only seven natural- and six hatchery-origin fish, and two natural- and 19 hatchery-origin fish, respectively. Within the hatchery broodstock collections with linkage disequilibrium, the percent of loci pairs showing linkage decreased from 32% in 2000 to 13% in 2001 and 2004, to only 1% and 5% in 2005 and 2006, respectively (Table 1). If the homogenization of allele frequencies of natural- and hatchery-origin fish was increasing from 2000 to 2006, we would expect a decrease in linkage disequilibrium among the broodstock collections. This is what occurred within the hatchery broodstock collections, but did not occur within the natural spawner collections, where the percent of loci pairs showing linkage was 18% in 2004, 6% in 2005, and 10% in 2006 (Table 1). Furthermore, the 2001 natural spawner collection, with no hatchery-origin component showed linkage disequilibrium with 9% of loci pairs.

There is no correlation between percent of loci pairs showing linkage disequilibrium and percent of broodstock composed of hatchery-origin fish ($r^2 = 0.0045$). Furthermore, the natural spawner and hatchery broodstock collections were each composed of roughly the same average percentage of hatchery-origin fish (57% and 53%, respectively). If the decrease in linkage disequilibrium among the hatchery broodstock collections from 2000 to 2006 was a result of a homogenization of allele frequencies of natural- and hatchery-origin fish in the broodstock, the same degree of homogenization did not occur within the natural spawner collections. This would occur if natural- and hatchery-origin fish spawning within the river remain segregated, either by habitat or by fish behavior.

Summary – As with the origin data set, there are significant allele frequency differences within and between hatchery broodstock and natural spawner collections. However, in recent years the allele frequency differences between the hatchery broodstock and natural spawner collections has declined. Furthermore, based on linkage disequilibrium, there is a genetic signal that is consistent with increasing homogenization of allele frequencies within hatchery broodstock collections, but a similar homogenization within the natural spawner collection is not apparent. These data suggest that there exists consistent year-to-year variation in allele frequencies among hatchery and natural spawning collections, but there is a trend toward homogenization of the allele frequencies of the natural- and hatchery-origin fish that compose the hatchery broodstock.

Four Treatment Groups

Analyses of genetic differences between hatchery (broodstock) and natural spawner collections is confounded by the fact that each these two groups are composed of fish of natural- and hatchery-origin. To understand the effects of hatchery supplementation on *natural-origin fish that spawn naturally*, we needed to divide the Chiwawa data set into four mutually exclusive groups: (1) hatchery-origin hatchery broodstock, (2) hatchery-origin natural spawner, (3) natural-origin hatchery broodstock, and (4) natural-origin natural spawner, with each group consisting of multiple collection years, for a total of 25 different groups.

Allele-sharing and Nonmetric Multidimensional Scaling –As with previous analyses discussed above, we constructed a pairwise allele-sharing distance matrix for all collections from each of these treatment groups and subjected this matrix to a nonmetric multidimensional scaling analysis, restricting the analysis to two dimensions. Figure 4 shows that five outlier groups dominate the allele-sharing distances within this data set. These outlier groups are also present in Figure 2, as discussed above, and Figure 2 and 4 resemble each other because the same fish are included in each analysis. The difference between Figures 2 and 4 is that in Figure 4 the fish are grouped into collection year and the four treatment groups, rather than collection year and two treatment groups (hatchery- versus natural-origin).

Figure 4 does not provide useful resolution of the groups within the polygon, because the outlier groups dominate the allele sharing distances. We removed the five outlier groups from Figure 4, recalculated the allele sharing distances and subjected this new matrix to a multidimensional scaling analysis (Figure 5). Figure 5 shows separation among the 2001, 2004-2006 collections, but this separation does not necessarily indicate that within-year collections are more similar to each other than any collection is to a collection from another year. For example, the 2006 natural-origin natural spawner and the 2005 natural-origin hatchery broodstock collections share 81% alleles, while the 2006 natural-origin natural spawner and 2006 hatchery-origin hatchery broodstock collections share 75% alleles. There does not appear to be any discernable pattern of change in allele-sharing distance among the collections relevant to pre- or post-supplementation. Although the 1989 pre-supplementation natural-origin collection appears distinct (Figure 5), the 1993 natural-origin hatchery broodstock collection appears quite similar to the 2005 and 2006 natural-origin collections (Figure 5). The 1993 natural-origin hatchery broodstock collection, although not technically pre-supplementation, is composed of fish whose ancestry cannot be traced to any Chiwawa hatchery fish. Therefore, there is no clear pattern of allele sharing change from pre-supplementation to recent collections.

There does appear to be some change in the average percentage of alleles shared within the 2001 to 2006 collections, with an increase from 74% in 2001 and 2004 to 78% and 79% in 2005 and 2006, respectively. The results provided by this analysis are consistent with the results presented in the origin and spawner data sets. That is, there are allele frequency and allele sharing differences among the collections, but analyses do not strongly suggest that these differences are a function of the supplementation program. Furthermore, there is also a weak signal that the hatchery and natural collections within the most recent years are more similar to each other than in the previous years.

Overall Genetic Variance – Although there are signals of allelic differentiation among Chiwawa River collections, there are no robust signs that these collections are substantially different from each other. We used two different analyses to measure the degree of genetic variation that exists among individuals and collections within the Chiwawa River. First, we conducted a principal component analysis using all Chiwawa samples with complete genotypes (i.e., no missing alleles from any locus). Although the first two principal component axes account for only 10.5% of the total molecular variance, a substantially greater portion of that variance is among individual fish, regardless of their identity, rather than among hatchery and natural collections (Figure 6). The variances in principal component scores among individuals are 11 and 13 times greater than the variance in scores among collections, along the first and second axes, respectively.

Second, we conducted a series of analyses of molecular variance (AMOVA) to ascertain the percentage of molecular variance that could be attributed to differences among collections. We organized these analyses to test also for differences in the hierarchical structure of the data. That is, we tested for differences among collections using the following framework:

- No organizational structure – all 25 origin-spawner collections considered separately
- Origin-spawner collections organized into 10 collection year groups
- Origin-spawner collections organized into 2 breeding location groups (hatchery versus natural)
- Origin-spawner collections organized into 2 origin groups (hatchery versus natural)
- Origin-spawner collections organized into the 4 origin-spawner groups

It is clear from this analysis that nearly all molecular variation, no matter how the data are organized, resides within a collection (Table 5). The percentage of total molecular variance occurring within collections ranged from 99.68% to 99.74%. The among group variance component was limited to less than 0.26% and in all organizational structures, except “no structure,” the among group percentage was not significantly greater than zero. Furthermore, none of the organizational structures provided better resolution than “no structure” in terms of accounting for molecular variance within the data set. *These results indicate that if there are significant differences among collections of Chiwawa fish, these differences account for less than one percent of the total molecular variance, and these differences cannot be attributed to fish origin or spawning location.*

Summary and Conclusions

We reject the null hypothesis that the allele frequencies of the hatchery collections equal the allele frequencies of the natural collections, which equals the allele frequency of the donor population. Furthermore, because the allele-sharing distances are not consistent within and among collections years, we also reject the second stated hypothesis discussed above. However, there is an extremely small amount of genetic variance that can be attributed to among collection differences. The allelic differentiation that does exist among collections does not appear to be a function of fish origin, spawning location, genetic drift, or collection year. Figure 5 and related statistics does suggest that hatchery and natural collections in 2005 and 2006 are more similar to each other than previous years’ collections, and this would be expected in a successful integrated hatchery supplementation program.

Since each of these collection years are generally composed of four-year-old fish, the differentiation among these collections for the most part is differentiation among specific cohorts. The slightly greater percentage of alleles shared among collections that are separated in time by multiples of four years, compared with collections that are not separated in time as such, suggests that cohort differences may be the most important factor accounting for differences in allele frequencies among collections.

<u>Task 4:</u> Develop a model of genetic drift.

See Task 3

<u>Task 5:</u> Analyze spring Chinook population samples from the Chiwawa River and Chiwawa Hatchery from multiple generations.

See Task 3

<u>Task 6:</u> Analyze among population differences for upper Wenatchee spring Chinook.

Supplementation of the Chiwawa River spring Chinook population may affect populations within the Wenatchee River watershed other than the Chiwawa River stock. If the stray rate for Chiwawa hatchery-origin fish is greater than that for natural-origin fish, an increase in gene flow from the Chiwawa population into other populations may result. If this gene flow is high enough, Chiwawa River fish may alter the genetic structure of these other populations. Records from field observations indicate that hatchery-origin fish are present in all major spawning aggregates (A.R Murdoch, unpublished data), and these fish are successfully reproducing (Blankenship et al 2006). The intent of this task is to investigate if there have been changes to the genetic structure of the spring Chinook stocks within upper Wenatchee tributaries during the past 15-20 years, and if changes have occurred, are they a function of the Chiwawa River Supplementation Program? Therefore, we ask the following two questions:

1. Are allele frequencies within populations in the upper Wenatchee stable through time? That is, is there significant allelic differentiation among collections within upper Wenatchee populations?
2. Are the recent collections from the upper Wenatchee populations more similar to the Chiwawa population than earlier collections from the same populations?

For this task we analyzed natural spawning collections from the White River (natural-origin), Little Wenatchee River (natural-origin), Nason Creek (natural-origin), and

Wenatchee mainstem (hatchery-origin), and hatchery collections from Leavenworth NFH and Entiat River NFH (Table 1). We also included in the analysis the natural- and hatchery-origin collections from the Chiwawa River. There are no repeated collections from Leavenworth, Entiat, Little Wenatchee, and Wenatchee mainstem (Table 1), so for many of the analyses we have limited our discussion to the Chiwawa River, White River, and Nason Creek collections. Furthermore, genetic structure of the Little Wenatchee collection, which consisted of only 19 samples, was unexpectedly quite different from the other collections. For example, the F_{ST} statistic measures the percent of total molecular variation that can be attributed to differences between populations. The median F_{ST} for all pairwise combinations of collections from all populations, except Little Wenatchee (33 populations, 528 individual F_{ST} statistics) equals 0.010 (1%), with a range of 0.000 to 0.037 (Table 6). The median F_{ST} for the Little Wenatchee paired with all other collections (33 individual F_{ST} statistics) equals 0.106 (10.6%), with a range of 0.074 to 0.121. The ten-fold increase in the F_{ST} statistic indicates that either the Little Wenatchee spring Chinook is unique among the upper Wenatchee River stocks, or this 1993 collection is somehow aberrant. Therefore, we exclude the Little Wenatchee collection from many other analyses.

Population Differentiation – Table 3 provides the levels of significance for all pairwise genic differentiation tests. Most between-collection comparisons are highly significant, with no pattern of increasing or decreasing differentiation with time, and no differences when comparisons are made with Chiwawa hatchery- versus Chiwawa natural-origin fish. For example, excluding the outlier 1996 and 1998 Chiwawa hatchery- and natural-origin collections, Nason Creek showed highly significant allele frequency differences between the Chiwawa hatchery- and natural-origin collections at 100% and 86% of the comparisons, respectively. The same comparisons with the White River produced 100% and 93% highly significant allele frequency comparisons, respectively. Allele frequencies between Nason Creek and White River were likewise differentiated from each other.

The collection allele frequencies within the upper Wenatchee system are significantly different, and these differences do not appear to change as a function of time (Table 3). Nason Creek shows greater within-population year-to-year variation in allele frequencies than does the White River, with 47% of the pairwise comparisons showing highly significant differences, compared with only 13% for the White River. However, the 2005 and 2006 collections from the White River appear to be somewhat more differentiated from not only each other, but from the earlier collections from the White River.

Despite the high degree of temporal and spatial structure suggested by the genic differentiation tests, as described above for within-Chiwawa analysis (Task 3), most of the genetic variation within this data set occurs within populations, rather than between populations (Table 6). The F_{ST} values for most population comparisons are between 0.01 and 0.02, indicating 1% to 2% among-population variance, with the remaining 98% to 99% variance occurring within populations. The White River shows the highest median F_{ST} among the natural-origin collections, equal to 0.014, compared with 0.009 for both the Nason Creek and Chiwawa natural-origin collections. The median F_{ST} for the Chiwawa hatchery-origin collections (0.012) was higher than that for the Chiwawa natural-origin collections.

Table 7 summarizes the information from the F_{ST} analyses, under five different temporal and spatial scenarios. Under all scenarios, over 99% of the molecular variance is within populations. There is significantly greater spatial structure among populations ("Origin") in 2005 and 2006 than from 1989 to 1996. That is, there appears to be more spatial structure among the Chiwawa hatchery-origin, Chiwawa natural-origin, White River, and Nason Creek now, than in 1989 to 1996, despite the potential homogenizing and cumulative effect of hatchery strays. However, we stress that the amount of molecular variance associated with the among population differences, despite being significantly greater than 0.00%, is limited to only 0.43%.

Allele-sharing and Nonmetric Multidimensional Scaling – As in the Chiwawa River data discussed above, we constructed an allele-sharing distance matrix and then subjected that matrix to a multidimensional scaling analysis (Figure 7). Consistent with all previously discussed multidimensional scaling analyses, the 1996 and 1998 adult, and the 1994 smolt collections are outliers. There is clear separation between the White River collections and all other natural-origin and Chiwawa hatchery-origin collections, indicating that there are more alleles shared among the Nason Creek and Chiwawa collections, than with the White River collections. Furthermore, there is a slight separation between the Chiwawa natural-origin natural spawner collections and Nason Creek collections, suggesting different groups of shared alleles between these populations. There is more variation in the allele-sharing distances among collections involved with the Chiwawa hatchery (origin or broodstock) than any of the natural-origin collections, even if we exclude the 1994, 1996, and 1998 collections. This suggests that there is more year-to-year variation in the composition of hatchery-origin and hatchery broodstock than within natural-origin populations throughout the upper Wenatchee. All Wenatchee mainstem fish are hatchery-origin, and if these fish are from the Chiwawa Supplementation Program (rather than from Leavenworth), it is not unexpected that this collection would be plotted within the Chiwawa polygon (Figure 7).

Assignment of Individual to Populations – Finally, we conducted individual assignment tests whereby we assigned each individual fish to a population, based on a procedure developed by Rannala and Mountain (1997) (Table 8 and 9). Individual fish may be correctly assigned to the population from which they were collected, or incorrectly assigned to a different population. Incorrect assignments may occur if the fish is an actual migrant (i.e., source population different from population where collected), or because the genotype for that fish matches more closely with a population different from its source. If there are many individuals from a population incorrectly assigned to populations other than its source population, that original population is either unreal (i.e., an admixture), or there is considerable gene flow between that population and other populations. Furthermore, in assigning individuals to populations, we can either accept the assignment with the highest probability, regardless of how low that probability may be, or we can establish a more stringent criterion, such as to not accept an assignment unless the posterior probability is equal to or greater than 0.90. This value is roughly equal to having the likelihood of the most-likely population equal to 10 times that of the second most-likely population.

We provide a summary of the assignments in Tables 8 and 9. On average, nearly 50% of the fish are assigned incorrectly if we accept all assignments (Table 8), but the incorrect assignment rate drops to roughly 10% when we accept only those assignments with probabilities greater than 0.90. However, with this more stringent criterion, nearly 64% of the fish go unassigned. These results indicate that the allele frequency distributions for these populations are very similar, and it would be very difficult to assign an individual fish of unknown origin to the correct population. If all fish are assigned, there is a 50% chance, overall, of a correct assignment. If you accept only those assignment with the 0.90 criterion, nearly two-thirds of the fish would be unassigned, but there is a 90% chance of correctly assigning those fish that are indeed assigned.

Of all the populations in the data set, there are fewer errors associated with assigning fish to the White River. If all fish are assigned (Table 8), 72% of those fish assigned to the White River, are actually from the White River (115 fish out of a total of 159 fish assigned to the White River). This compares to a rate of only 52% and 53% for Nason Creek and Chiwawa natural-origin, respectively, and 60% for the Chiwawa hatchery-origin collections. With the 0.90 criterion (Table 9), 89% of the fish assigned to the White River, are actually from the White River, compared with 70% and 65% for Nason Creek and Chiwawa natural origin, respectively, and 81% for the Chiwawa hatchery origin.

When all fish are assigned, most of the incorrectly assigned fish from Nason Creek and White River are assigned to Chiwawa River, at roughly equal frequencies to the hatchery- and natural-origin populations. Incorrectly assigned fish to other populations occur at a slightly higher rate in Nason Creek than in the White River. However, when only those fish meeting the 0.90 criterion are assigned (Table 9), incorrectly assigned fish from Nason Creek are distributed among White and Chiwawa Rivers, as well as Leavenworth NFH, and the Entiat NFH. Mis-assignment to the Chiwawa hatchery-origin was the highest among the Nason Creek collections, equal to nearly 14%. This contrasts with the White River where mis-assignments do not exceed 7% anywhere, and there is a roughly even distribution of mis-assignments among Nason Creek and Chiwawa River collections.

Summary and Conclusions – There is little geographic or temporal structure among populations within the upper Wenatchee systems. Among population molecular variance is limited to 1% or less. The little variance that can be attributed to among populations indicates that the White River is more differentiated from the Chiwawa and Nason populations than these populations are from each other. Furthermore, although we cannot rule out a hatchery effect on the Nason Creek and White River populations, there is no indication there has been any temporal changes in allele frequencies within these populations that can be attributed directly to the Chiwawa River Supplementation Program. In fact, Table 7 weakly suggests that there is more differentiation among these populations now, than there was before or at the early stages of Chiwawa supplementation.

Therefore, returning to our two original questions, there are significant differences in allele frequencies among collections within populations, and among populations within the upper Wenatchee spring Chinook stocks. However, these differences account for a very small portion of the overall molecular variance, and these populations overall are very similar to each other. There is no evidence that the Chiwawa River Supplementation Program has changed the allele frequencies in the Nason Creek and White River populations, despite the presence of hatchery-origin fish in both these systems. Finally, of all the populations within the Wenatchee River, the White River appears to be the most distinct. Yet, this distinction is more a matter of detail than of large significance, as the median F_{ST} between White River collections and all other collections (except the Little Wenatchee) is less than 1.5% among population variance.

<u>Task 7:</u> Calculate the inbreeding effective population size using demographic data for each sample year, and document the ratio of census to effective size.

This analysis was completed by Williamson et al. (submitted).

<u>Task 8:</u> Calculate LD N_b using genetic data for each sample year, and document the ratio of census to effective size.

We report N_e estimated for the Chiwawa River collections based on the bias correction method of Waples (2006) implemented in LDNe (Do and Waples unpublished). N_e estimates based on LD are best interpreted as the effective number of breeders (N_b) that produced the sample (Waples 2006).

For collections categorized by spawning location (i.e., hatchery broodstock or natural), estimates of N_b are shown in Table 10. Considering the hatchery broodstock, N_b estimates range from 30.4 (1996) to 274.3 (2005). To obtain N_e /N ratios, the N_b estimate is multiplied by four (i.e., mean generation length) and divided by the total in river (i.e., NOS [natural-origin spawners] plus HOS [hatchery-origin spawners]) census data from four years prior (i.e., major cohort; see Table 2). The observed N_e /N ratios for the broodstock collections range from 11% to 54% of the census estimate, excluding the 2000 collection which is 106%. A ratio greater than one is possible under special circumstances, and certain artificial mating schemes within hatcheries can inflate N_e above N; yet, it is unknown if this is the case for this collection. While no direct comparisons are possible, the N_b estimates reported by Williamson et al. (submitted) for Chiwawa broodstock collections from 2000 – 2003 are similar in magnitude to our estimates. For Chiwawa natural spawner collections, the N_b estimates range from 5.2 (1989) to 231.5 (2005), with observed N_e /N ratios of 22% - 48% of the census estimate.

Task 9: Calculate N_b using the temporal method for multiple samples from the same location.

Estimates of effective number of breeders (N_b) derived from Waples' (1990) temporal method are shown in Tables 11-13. Eight collection years were used for the Chiwawa broodstock collections (Table 11). The harmonic mean of all pairwise estimates of N_b ($\tilde{N}_b$) was 269.4. This estimate is the contemporary N_e for Chiwawa broodstock collections. For the five collection years of Chiwawa in-river spawners (Table 12), the estimated $\tilde{N}_b$ = 224.2. This estimate is the contemporary N_e for Chiwawa River natural spawner collections. Since the Chiwawa Supplementation Program is integrated by design, we also performed another estimation of N_e using composite hatchery and natural samples. There are paired samples from 2004-2006. We combined genetic data for hatchery (HOS) and natural (NOS) origin fish from 2004 – 2006 to create a single Chiwawa River natural spawner sample for each year. The three composite samples from 2004 – 2006 were then analyzed using the temporal method (Table 13), resulting in a $\tilde{N}_b$ = 386.8. This estimate is the contemporary N_e for Chiwawa River.

Williamson et al. (submitted) estimated N_e using Waples' (1990) temporal method for Chinook captured in 2004 and 2005, and used age data to decompose brood years into consecutive cohorts from 2000 – 2003. They report for Chiwawa broodstock a $\tilde{N}_b$ = 50.4. This estimate is not similar to our Chiwawa broodstock estimate. However, if we analyze the hatchery-origin Chinook only, our estimate is $\tilde{N}_b$ = 80.1 for collection years 1989 – 2006 (data not shown). Williamson et al. (submitted) report for Chiwawa naturally spawning Chinook a $\tilde{N}_b$ = 242.7, which is slightly higher than our estimate for in-river spawners from 1989 – 2006, but lower than our estimate from combined NOS and HOS Chinook from 2004 – 2006 collection years.

<u>Task 10:</u> Use available data and the Ryman-Laikre and Wang-Ryman models to determine the expected change of N_e for natural spring Chinook salmon in the Wenatchee River due to hatchery operation.

N_e is generally thought to be between 0.10 and 0.33 of the estimated census size (Bartley et al. 1992; RS Waples pers. comm.). We used this range to generate an estimate of N_e for Chiwawa natural spawners prior to hatchery operation. For brood years 1989 – 1992, the arithmetic mean census size was N=962.7 (Table 2), resulting in an estimated N_e ranging from 96.3 – 317.7. The contemporary estimate of N_e calculated using genetic data for the Chiwawa in-river spawners is N_e=224.2 (Table 12), falling in the middle of the pre-hatchery range. The N_e /N ratio calculated using 224.2 and the arithmetic census of NOS Chinook from 1989 – 2005 is 0.42. A more appropriate contemporary N_e to compare with the pre-hatchery estimate (i.e., 96.3 – 317.7) is the combined NOS and HOS estimate from natural spawners, since the supplementation program is integrated. As discussed above, the contemporary estimate of N_e calculated using genetic data for Chiwawa NOS and HOS Chinook is N_e=386.8 (Table 13), which is slightly larger than the pre-hatchery range, suggesting the N_e has not declined during the period of hatchery operation. The N_e /N ratio calculated using 386.8 and the arithmetic census of NOS and HOS Chinook from 1989 – 2005 is 0.40. These results suggest the Chiwawa Hatchery Supplementation Program has not resulted in a smaller N_e for the natural spawners from the Chiwawa River.

Williamson et al. (submitted) argued that since their combined (i.e., broodstock and natural) N_e estimate was lower than the naturally spawning estimate, the supplementation program likely had a negative impact on the Chiwawa River N_e. We disagree with this interpretation of these data. Since the natural spawning component is mixed hatchery and natural ancestry, the N_e estimates from natural spawning data are the results that bear on possible hatchery impacts. The census data show the population declined in the mid 1990's and rebounded by 2000 (Table 2). This trend is reflected in the N_e results, as shown above, and Williamson et al. (submitted) clearly show in their Table 4 the N_e was lower in 2000 (N_e = 989) than it was in 1992 (N_e = 2683). Yet, the important comparison they make in our view was the natural spawning N_e versus the natural only component N_e (i.e., hypothetically excluding hatchery program). Williamson et al. (submitted) report the 1989 – 1992 N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) was essentially the same as the natural only component estimate, 2683 and 2776, respectively. This result is not surprising since no HOS fish were present between 1989 – 1992. They also report that the 1997 – 2000 N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) was N_e =989, while the natural-origin estimate of N_e in 1997 – 2000 was N_e = 629. Since the natural-origin estimate of 629 is lower than 989, the N_e estimate from all in-river spawners, we argue that their analysis of demographic data show the N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) is larger only if the hatchery Chinook in the river are ignored.

Task 11: Use individual assignment methods to determine the power of self-assignment for upper Wenatchee River tributaries.

See "Assignment of Individual to Populations" in Task 6

Conclusions

Has the Chiwawa Hatchery Supplementation Program succeeded at increasing the census size of the target population while leaving genetic integrity intact? This is an important question, as hatcheries can impact natural populations by reducing overall genetic diversity (Ryman and Laikre 1991), reducing the fitness of the natural populations through relaxation of selection or inadvertent positive selection of traits advantageous in the hatchery (Ford 2002; Lynch and O'Hely 2001), and by reducing the reproductive success of natural populations (McLean et al. 2003). The census data presented here show that the current natural spawning census size is similar to the pre-supplementation census size. Despite large numbers of hatchery-origin fish on the Chiwawa River spawning grounds, the genetic diversity of the natural-origin collections appear unaffected by the supplementation program; heterozygosities are high, and contemporary N_e is similar (perhaps slightly higher) than pre-supplementation N_e. We did find significant year-to-year differences in allele frequencies in both the origin and spawner datasets, but these differences do not appear to be related to fish origin, spawning area, or genetic drift. However, we do suggest that cohort differences may be the most important factor accounting for differences in allele frequencies among collections.

The main objective of this study was to determine the potential impacts of the hatchery program on natural spring Chinook in the upper Wenatchee system. We did this by analyzing temporally replicated collections from the Chiwawa River, and by comparing genetic diversity prior to the presumed effect of the Chiwawa Hatchery Supplementation Program, with contemporary collections. We report that the genetic diversity present in the Chiwawa River is unchanged (allowing for differences among cohorts) from 1989 – 2006, and the contemporary estimate of the effective population size (N_e) using genetic data is approximately the same as the N_e estimate extrapolated from 1989 – 1992 census data (i.e., pre-hatchery collection years). We observed substantial genetic diversity, with heterozygosities ~80% over thirteen microsatellite markers. Yet, temporal variation in allele frequencies was the norm among temporal collections from the same populations (i.e., location). The genetic differentiation of replicated collections from the same population is likely the result of salmon life history in this area, as four-year-old Chinook comprise a majority of returns each year. The genetic tests are detecting the differences of contributing parents for each cohort. An important point related to the temporal variation, is that the hatchery broodstock is composed in part of the natural origin Chinook from the Chiwawa River. When we compared the genetic data (within a collection year) for Chinook brought into the hatchery as broodstock with the Chinook that remained in the river (years 2001, 2004 – 2006), there was a trend of decreasing statistical differences in allele frequencies from 2001 to 2004, and no differences were detected for 2005 and 2006. While the replicated collections may have detectable differences in allele frequencies, those differences reflect actual differences in cohorts, not the result of hatchery operations, and the hatchery broodstock collection method captures the differences in returning Chiwawa River spring adults each year. We conclude from these results that the genetic diversity of natural spring Chiwawa Chinook has been maintained during the Chiwawa Hatchery Supplementation Program.

We observe slight, but statistically significant population differentiation between Chiwawa River, White River, and Nason Creek collections. Murdoch et al (2006) and Williamson et al. (submitted) also observed population differentiation between Chiwawa River, White River, and Nason Creek collections. Yet, 99.3% of the genetic variation observed was within samples, very little variance could be attributed to population differences (i.e., population structure). The AMOVA analysis and poor individual assignment results suggest the occurrence of gene flow among Wenatchee River locations or a very recent divergence of these groups. While Murdoch et al. 2006 did not perform an AMOVA analysis, their F_{ST} results provide comparable data to our among-population results. Murdoch et al. 2006 report F_{ST} ranging from 2%-3% for pairwise comparisons between of Chiwawa, White, and Nason River collections. Since F_{ST} is an estimate of among-sample variance, these results also imply a majority of the genetic variance (i.e., 97%-98%) resides within collections. To provide further context for the magnitude of these variance estimates, we present the among-group data from Murdoch et al. 2006 comparing summer-run and spring-run Chinook from the Wenatchee River. They report that approximately 91% of observed genetic variance is within-collection for comparisons between collections of summer- and spring-run Chinook. Ultimately, the information provided by this and other reports will be incorporated into the management process for Wenatchee River Chinook. However, we would like to emphasize that the application of these genetic data to management is more about the goals related to the distribution of genetic diversity in the future than specific data values reported. If Chinook are collected at Tumwater Dam instead of within the upper Wenatchee River tributaries, a vast majority of the genetic variation present in the basin would be captured, although any differences among tributaries would be mixed. Alternatively, management policies could be crafted to promote and maintain the among-group genetic diversity that genetic studies consistently observe to be non-zero within the Wenatchee River.

We agree with Murdoch et al. (2006) that it appears hatchery Chinook are not contributing to reproduction in proportion to their abundance. Additionally, if the total census size (i.e., NOS and HOS combined) within the Chiwawa River does not continue to increase, genetic diversity may decline within this system, given the smaller N_e within the hatchery-origin collections compared with the natural-origin collections.

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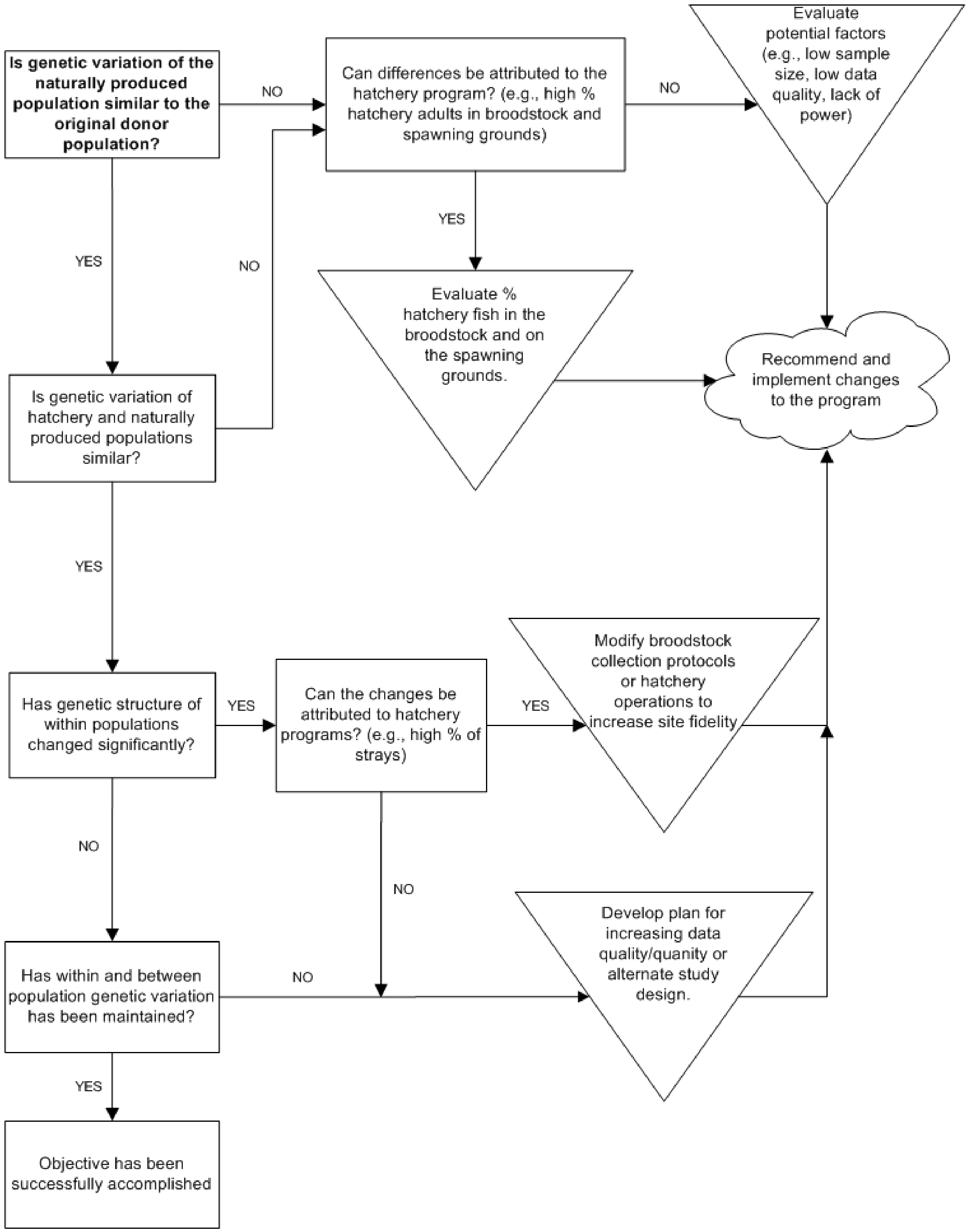

Figure 1. Conceptual process for evaluating potential changes in genetic variation in the Chiwawa naturally produced populations as a result of the supplementation hatchery programs (From Murdoch and Peven 2005).

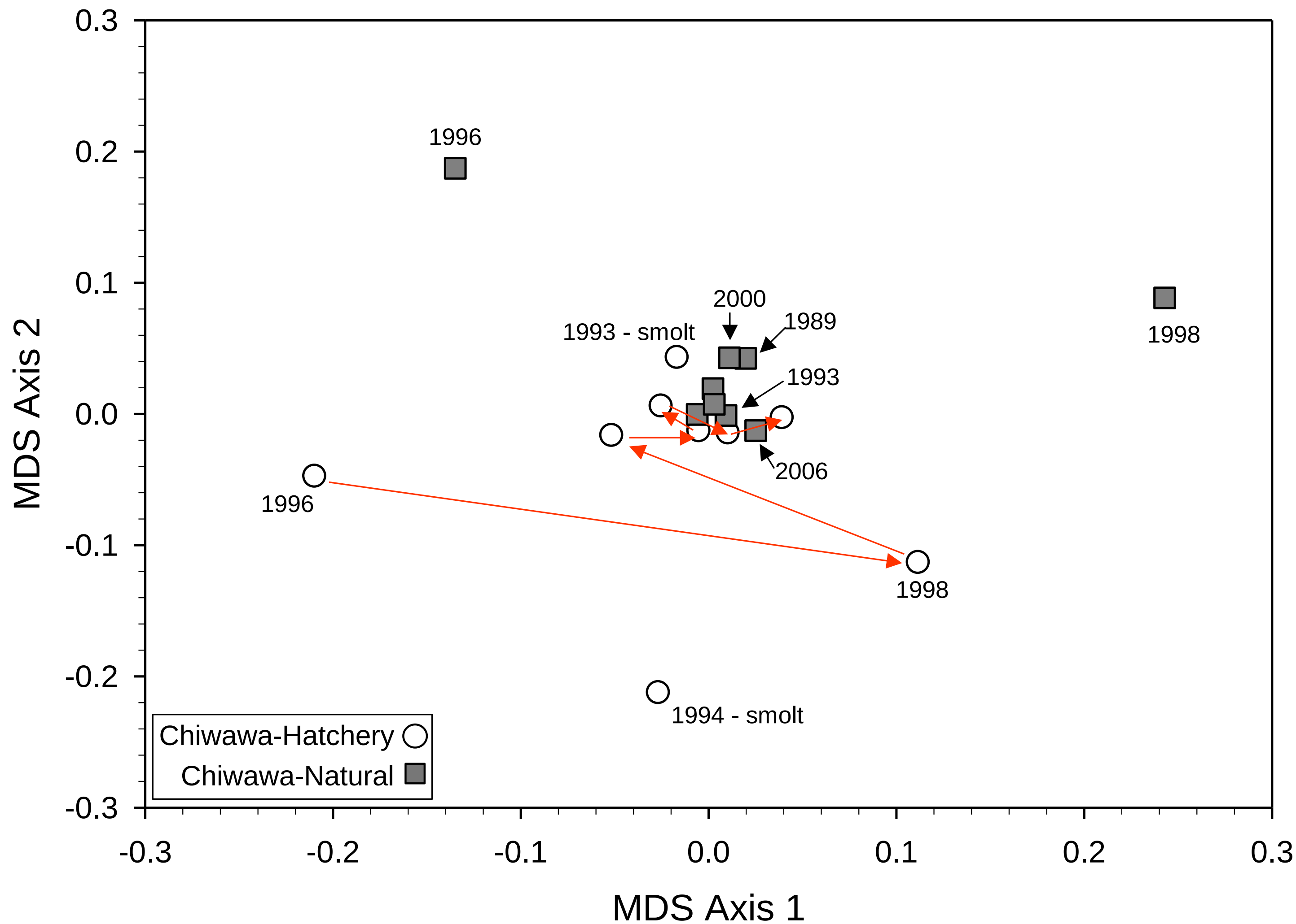

Figure 2. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa data set organized by fish origin (i.e., hatchery versus natural). The red arrows connect consecutive hatchery-origin collections starting with the first adult collection (1996) and ending with the 2006 collection (see Table 1 for collection years).

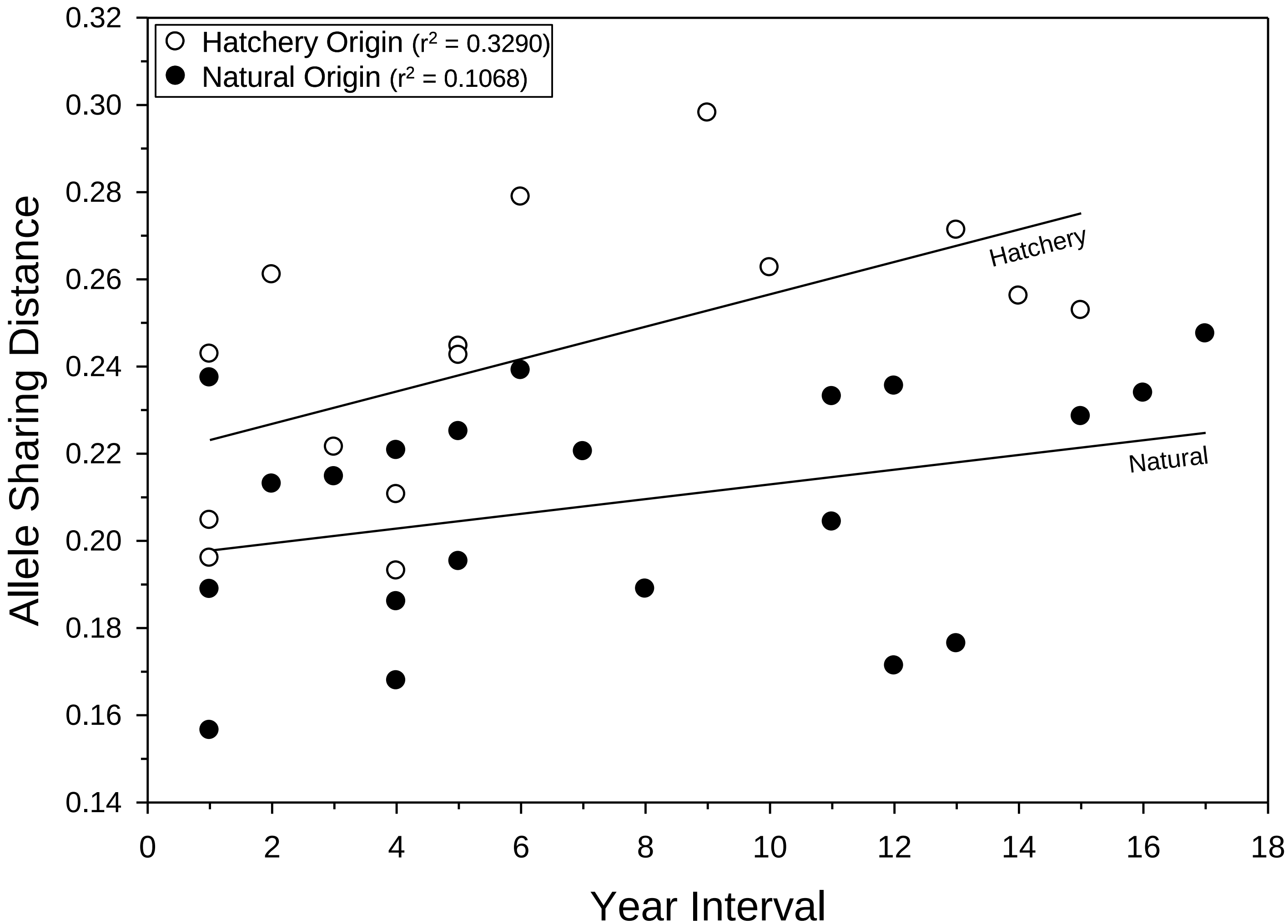

Figure 3. Relationships between the time interval in years and allele sharing distances, with each circle representing the pairwise relationship between two Chiwawa collections. Separate regression lines for the natural- and hatchery-origin collections. The slope for the natural-origin collection is not significantly different from zero (p=0.1483), while the slope for hatchery-origin collection is significantly greater than zero (p=0.0254) indicating a positive relationship between time interval and allele sharing distance.

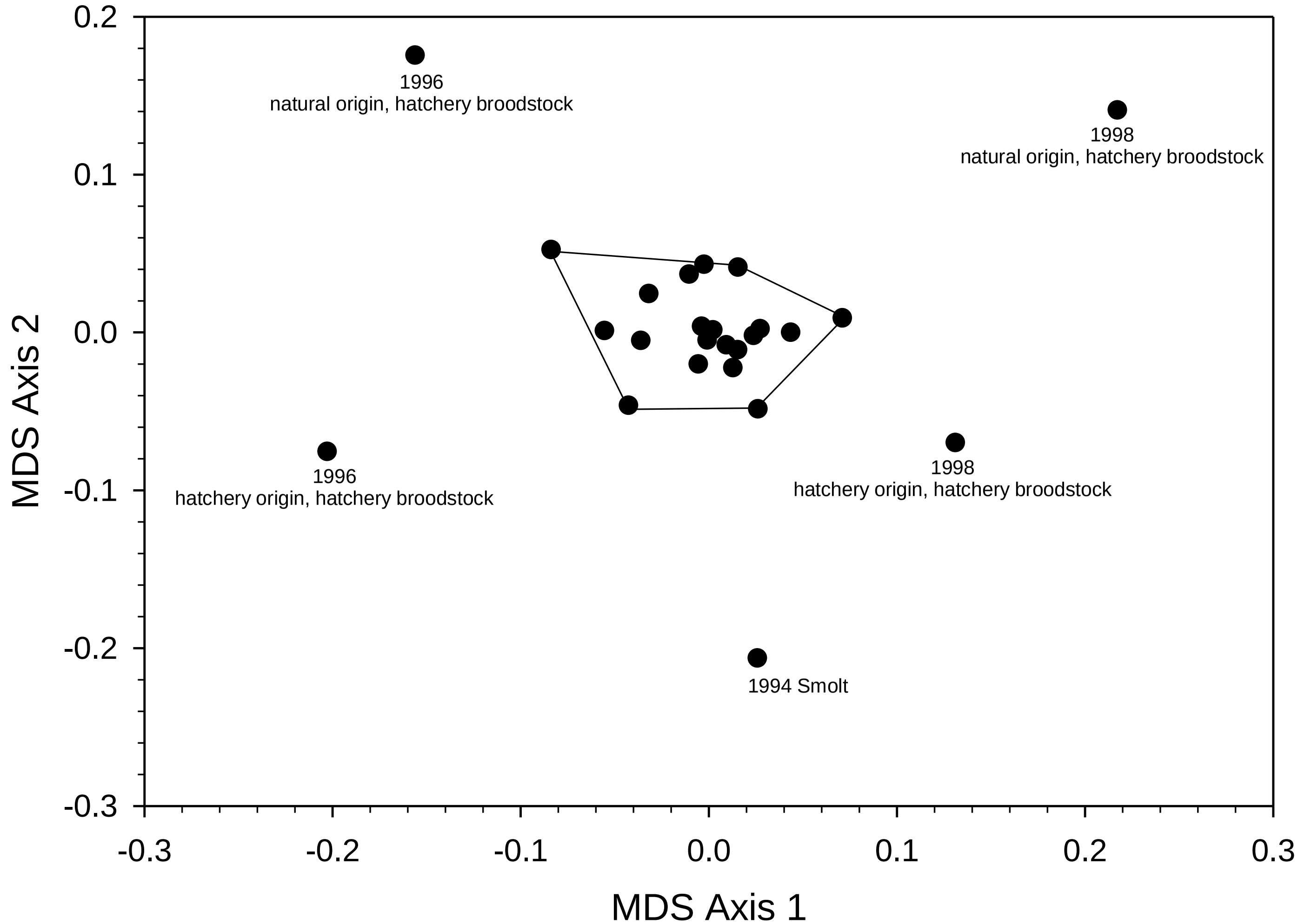

Figure 4. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa data set organized by four treatment groups, as discussed in the text. Each circle represents a single collection within each of the four treatment groups, and the polygon encloses all groups that are not outliers. Each outlier group is specifically labeled.

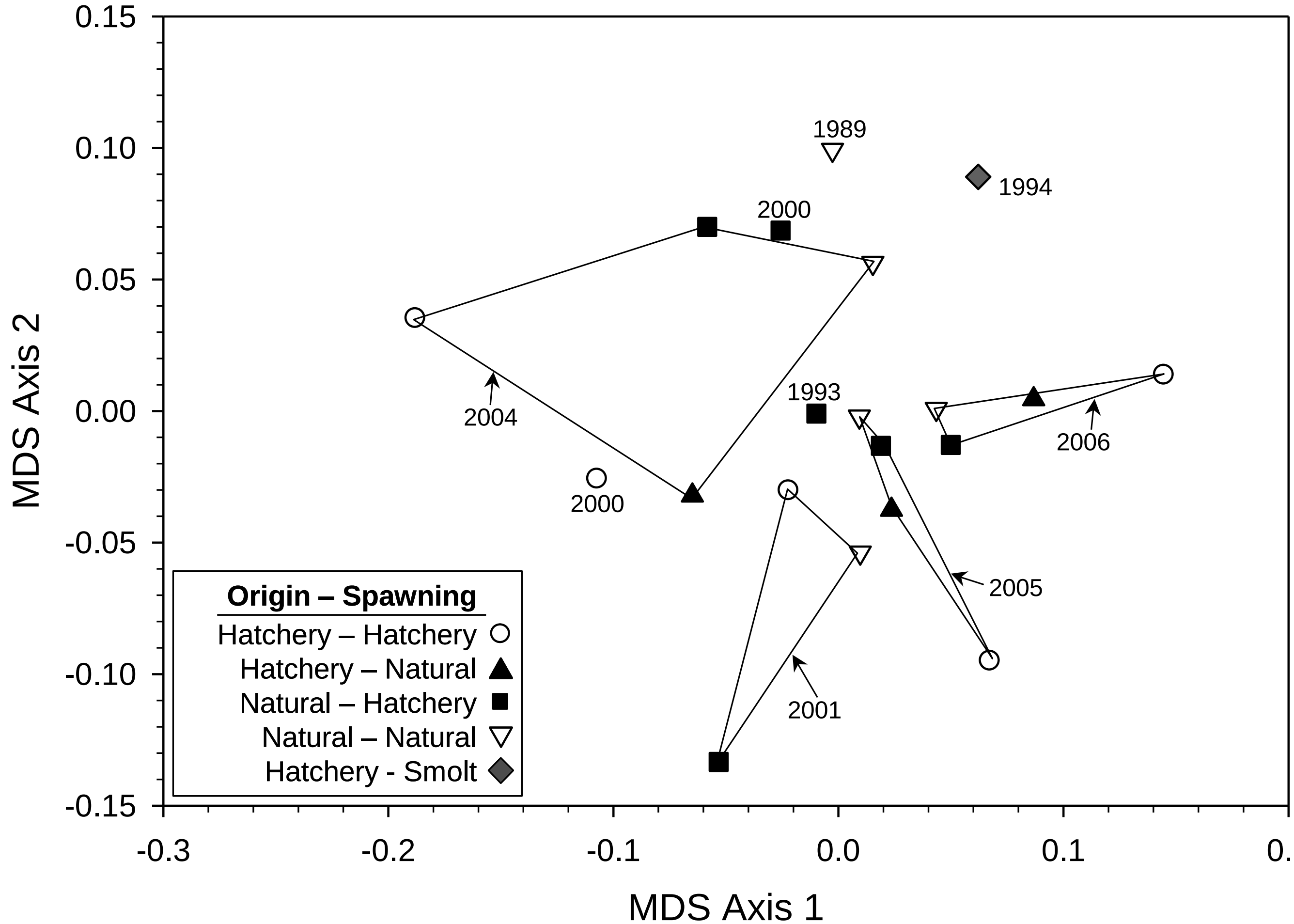

Figure 5. As in Figure 4, but allele-sharing distance matrix recalculated without the five outlier groups shown in Figure 4. Polygons group together treatment groups from the same collection year. Dates associated with symbols also refer to collection year. Collection years 2004-2006 included all four treatment groups, while collection year 2001 did not include a hatchery-origin natural spawner group. Legend is read as follows: Open circles refer to hatchery-origin hatchery spawner group, while filled box refers to natural-origin hatchery spawner group, and so on.

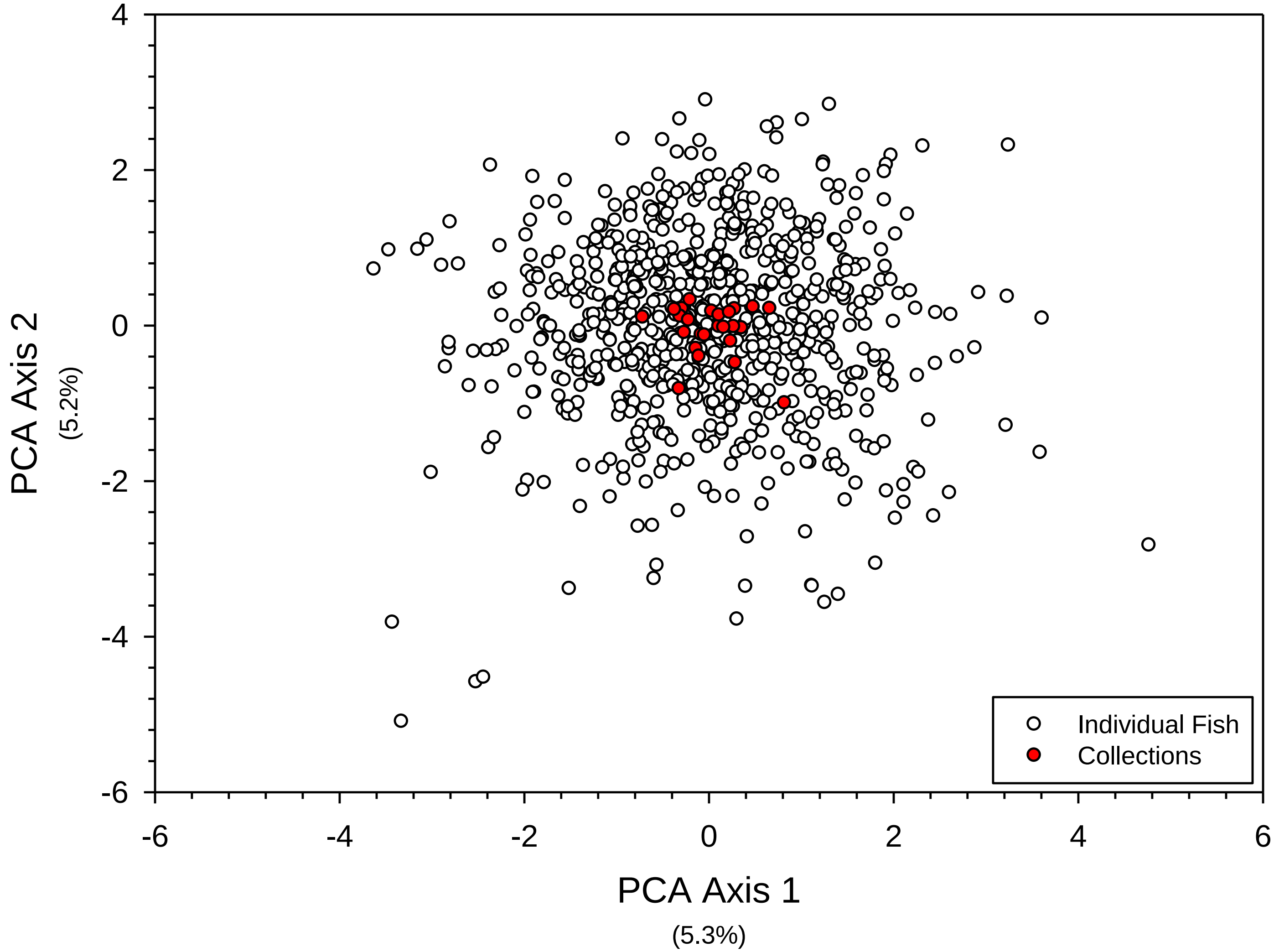

Figure 6. Principal component (PC) analysis of individual fish from the Chiwawa River. Only fish with complete microsatellite genotypes were included in the analysis (n = 757). Open circles are the PC scores for individual fish, and the filled circles are the centroids (bivariate means) for each of the 25 groups discussed in the text. PC axes 1 and 2 account for only 10.5% of the total molecular variance.

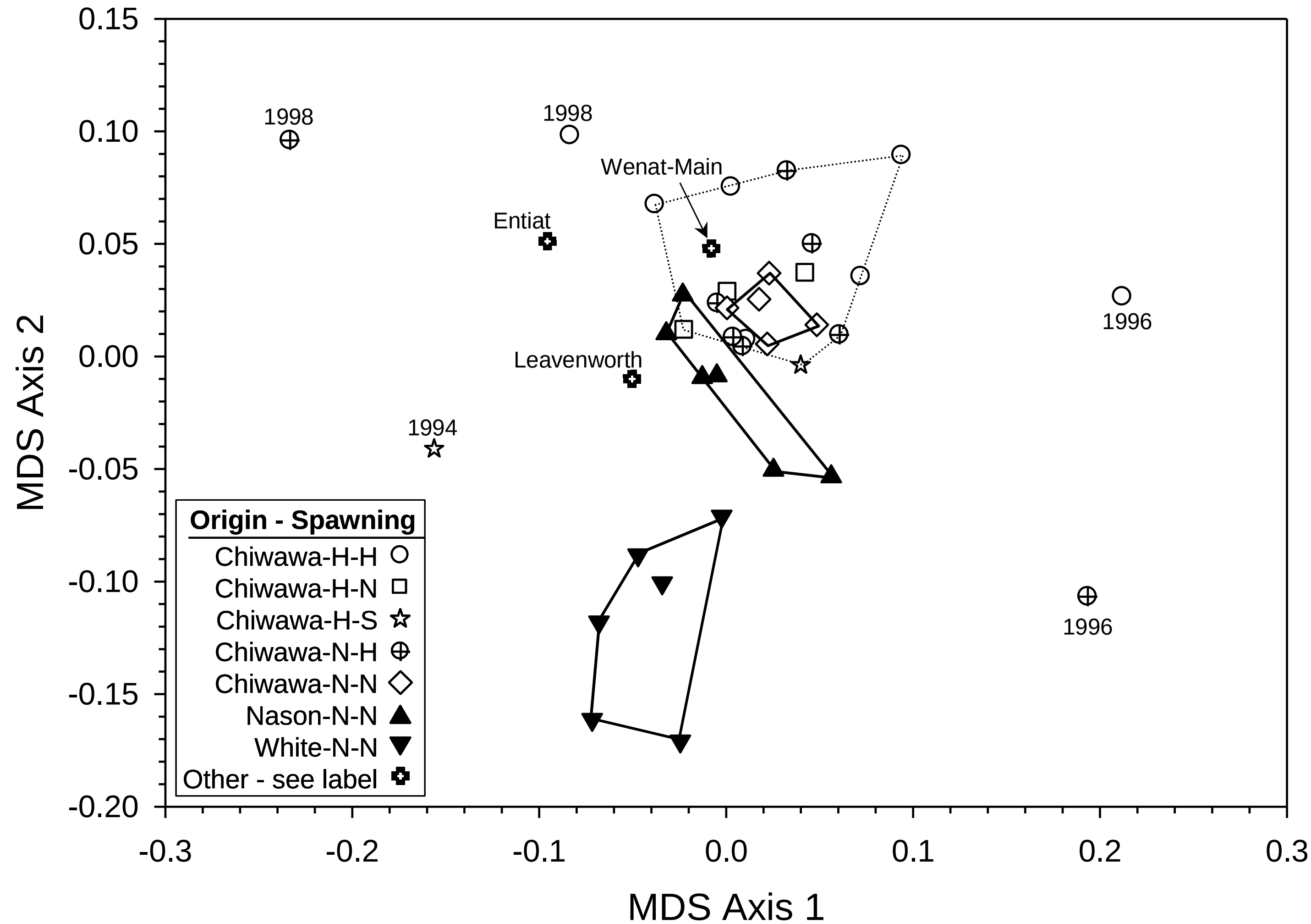

Figure 7. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa origin data set and all other non-Chiwawa collections, except Little Wenatchee River. Legend is read with abbreviations beginning with origin and then spawning location. H=hatchery, N=natural, and S=smolts. Polygons with solid lines enclose the natural-origin natural spawner collections from each population (i.e., river). The polygon with the dotted lines enclose all Chiwawa collections, except for the five outlier collections, as discussed in text.

Table 1 Summary of within population genetic data. Chiwawa collection data are summarized in A) by origin of the sample (i.e., clipped vs. non-clipped). All collection data are summarized in B) by spawning location (i.e., hatchery broodstock or on spawning grounds). Hz is heterozygosity, HWE is the statistical significance of deviations from Hardy-Weinberg expectations (* = 0.05, ** = 0.01, and *** = 0.001), LD is the proportion of pairwise locus tests (across all populations) exhibiting linkage disequilibrium (bolded values are statistically significant), and the last column is mean number of alleles per locus.

Collection	Sample size	Gene Diversity	Observed Hz	HWE	F_{IS}	LD	Mean # Alleles
A) Origin							
1993 Chiwawa Hatchery	95	0.77	0.79	***	-0.02	**0.86**	14.00
1994 Chiwawa Hatchery	95	0.76	0.77	***	-0.01	**0.91**	11.38
1996 Chiwawa Hatchery	8	0.75	0.81	-	-0.01	0.00	8.23
1998 Chiwawa Hatchery	27	0.81	0.82	-	0.00	0.04	12.62
2000 Chiwawa Hatchery	43	0.75	0.78	***	-0.01	**0.19**	12.46
2001 Chiwawa Hatchery	69	0.77	0.80	***	-0.02	**0.14**	15.31
2004 Chiwawa Hatchery	72	0.77	0.77	***	0.01	**0.45**	15.92
2005 Chiwawa Hatchery	91	0.79	0.82	*	-0.03	**0.05**	16.15
2006 Chiwawa Hatchery	95	0.80	0.84	***	-0.05	**0.49**	15.85
1989 Chiwawa Natural	36	0.76	0.78	-	0.01	0.00	12.77
1993 Chiwawa Natural	62	0.78	0.81	-	-0.02	0.04	15.85
1996 Chiwawa Natural	8	0.72	0.78	-	-0.02	0.00	7.54
1998 Chiwawa Natural	10	0.78	0.84	-	0.00	0.00	8.23
2000 Chiwawa Natural	39	0.78	0.79	***	0.00	**0.10**	14.00
2001 Chiwawa Natural	75	0.78	0.80	-	-0.03	0.03	15.31
2004 Chiwawa Natural	85	0.78	0.77	-	0.02	0.01	15.77
2005 Chiwawa Natural	90	0.79	0.79	-	0.01	0.01	16.15
2006 Chiwawa Natural	96	0.80	0.81	-	-0.01	0.01	16.46

Table 1 Within population genetic data analysis summary continued.

Collection	Sample size	Gene Diversity	Observed Hz	HW	F_{IS}	LD	Mean # Alleles
B) Spawning Location							
1993 Chiwawa Broodstock	62	0.78	0.81	-	-0.02	0.00	15.85
1996 Chiwawa Broodstock	16	0.75	0.79	-	-0.02	0.00	10.92
1998 Chiwawa Broodstock	37	0.82	0.83	-	0.00	0.01	14.38
2000 Chiwawa Broodstock	82	0.78	0.78	***	0.00	**0.32**	15.62
2001 Chiwawa Broodstock	89	0.78	0.80	*	-0.02	**0.13**	15.77
2004 Chiwawa Broodstock	61	0.77	0.76	*	0.02	**0.13**	14.92
2005 Chiwawa Broodstock	75	0.79	0.78	*	0.02	0.01	15.85
2006 Chiwawa Broodstock	89	0.80	0.83	-	-0.03	**0.05**	16.46
1989 Chiwawa River	36	0.76	0.78	-	0.01	0.00	12.77
2001 Chiwawa River	55	0.78	0.80	-	-0.02	**0.09**	14.00
2004 Chiwawa River	96	0.78	0.78	*	0.01	**0.18**	17.23
2005 Chiwawa River	106	0.79	0.82	*	-0.02	**0.06**	16.69
2006 Chiwawa River	102	0.80	0.83	***	-0.03	**0.10**	16.77
1989 White River	48	0.75	0.75	-	0.01	0.01	12.85
1991 White River	19	0.76	0.76	-	0.03	0.00	10.92
1992 White River	22	0.75	0.79	-	-0.02	0.01	11.00
1993 White River	21	0.75	0.69	*	0.10	0.00	10.15
2005 White River	29	0.75	0.77	-	-0.01	0.03	12.23
2006 White River	40	0.76	0.76	-	0.01	0.04	13.38

Table 1 Within population genetic data analysis summary continued.

Collection	Sample size	Gene Diversity	Observed Hz	HW	F_{IS}	LD	Mean # Alleles
1993 Little Wenatchee R.	19	0.84	0.85	-	0.02	0.00	11.23
1993 Nason Creek	45	0.78	0.80	-	-0.01	0.01	13.77
2000 Nason Creek	51	0.76	0.78	-	-0.02	**0.13**	13.92
2001 Nason Creek	41	0.79	0.81	-	-0.01	**0.08**	14.23
2004 Nason Creek	38	0.76	0.76	-	0.02	0.03	13.23
2005 Nason Creek	45	0.78	0.82	-	-0.04	0.03	14.92
2006 Nason Creek	48	0.80	0.82	-	-0.01	0.00	15.77
2001 Wenatchee River	32	0.79	0.80	*	0.00	0.04	12.85
2000 Leavenworth NFH	73	0.80	0.82	*	-0.02	**0.15**	16.23
1997 Entiat NFH	37	0.81	0.83	-	-0.01	**0.06**	14.38

Table 2 Demographic data for Chiwawa Hatchery and Chiwawa natural spring Chinook salmon. BS is census size of hatchery broodstock, pNOB is the proportion of hatchery broodstock of natural origin, NOS is the census size of natural-origin spawners present in Chiwawa River, HOS is the census size of hatchery-origin spawners present in Chiwawa River, Total is NOS and HOS combined, and pNOS is the proportion of spawners present in Chiwawa River of natural origin.

	Hatchery		In River			
Brood Year	BS	pNOB	NOS	HOS	Total	pNOS
1989	28	1	1392	0	1392	1.00
1990	18	1	775	0	775	1.00
1991	32	1	585	0	585	1.00
1992	78	1	1099	0	1099	1.00
1993	94	1	677	491	1168	0.58
1994	11	0.64	190	90	280	0.68
1995	0	0	8	50	58	0.14
1996	18	0.44	131	51	182	0.72
1997	111	0.29	210	179	389	0.54
1998	47	0.28	134	45	178	0.75
1999	0	0	119	13	132	0.90
2000	30	0.3	378	310	688	0.55
2001	371	0.3	1280	2850	4130	0.31
2002	71	0.28	694	919	1613	0.43
2003	94	0.44	380	223	603	0.63
2004	215	0.39	820	788	1608	0.51
2005	270	0.33	250	1222	1472	0.17

Table 3 Levels of significance for pairwise tests of genic differentiation among all hatchery- and natural-origin collections used in this analysis. HS = highly significant (P < 0.000095; the Bonferroni corrected p-value for an alpha = 0.05); * = P < 0.05 (nominal critical value for most statistical test); - = P > 0.05 (not significant). A significant result between pairs of populations indicates that the allele frequencies between the pair are significantly different. Results are read by comparing the collections along the rows to collections along columns. The top block for each section is a symmetric matrix, as it compares collections within the same group.

		Chiwawa – Hatchery Origin								
		1993	**1994**	**1996**	**1998**	**2000**	**2001**	**2004**	**2005**	**2006**
Chiwawa – Hat. Origin	**1993**		HS	*	HS	HS	HS	HS	HS	HS
	1994	HS		HS	HS	HS	HS	HS	HS	HS
	1996	*	HS		*	-	*	-	-	*
	1998	HS	HS	*		HS	HS	HS	HS	HS
	2000	HS	HS	-	HS		HS	*	HS	HS
	2001	HS	HS	*	HS	HS		HS	*	HS
	2004	HS	HS	-	HS	*	HS		HS	HS
	2005	HS	HS	-	HS	HS	*	HS		HS
	2006	HS	HS	*	HS	HS	HS	HS	HS	
Chiwawa – Natural Origin	**1989**	HS	HS	-	HS	HS	*	HS	HS	HS
	1993	HS	HS	-	HS	HS	-	HS	*	HS
	1996	*	HS	-	*	-	-	-	-	-
	1998	HS	HS	-	-	HS	*	*	*	-
	2000	HS	HS	-	HS	HS	HS	*	HS	HS
	2001	HS	HS	-	HS	HS	HS	HS	*	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	*	HS	*	HS
	2006	HS	HS	-	*	HS	HS	HS	HS	HS
Nason	**1996**	HS	HS	-	HS	HS	HS	HS	HS	HS
	2000	HS	HS	*	HS	HS	HS	HS	HS	HS
	2001	HS	HS	-	HS	HS	HS	HS	HS	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	HS	HS	HS	HS
	2006	HS	HS	-	*	HS	HS	HS	HS	HS
White	**1989**	HS	HS	HS	HS	HS	HS	HS	HS	HS
	1991	HS	HS	-	HS	HS	HS	HS	HS	HS
	1992	HS	HS	*	HS	HS	HS	HS	HS	HS
	1993	HS	HS	*	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	HS	HS	HS	HS
	2006	HS	HS	HS	HS	HS	HS	HS	HS	HS
Other	**Wen-M**	HS	HS	*	HS	HS	*	*	-	HS
	Leaven	HS	HS	*	HS	HS	HS	HS	HS	HS
	Entiat	HS	HS	*	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		Chiwawa – Natural Origin								
		1989	**1993**	**1996**	**1998**	**2000**	**2001**	**2004**	**2005**	**2006**
Chiwawa – Natural Origin	**1989**		-	-	-	-	*	*	*	*
	1993	-		-	*	*	*	HS	*	HS
	1996	-	-		-	-	-	-	-	-
	1998	-	*	-		*	*	HS	*	*
	2000	-	*	-	*		HS	-	HS	HS
	2001	*	*	-	*	HS		HS	*	HS
	2004	*	HS	-	HS	-	HS		HS	HS
	2005	*	*	-	*	HS	*	HS		*
	2006	*	HS	-	*	HS	HS	HS	*	
Nason	**1996**	*	*	-	*	*	HS	HS	HS	HS
	2000	HS	HS	HS	HS	HS	HS	HS	HS	HS
	2001	HS	*	-	*	HS	HS	HS	HS	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	*	*	-	*	HS	HS	HS	HS	HS
	2006	HS	HS	-	-	HS	HS	HS	HS	HS
White	**1989**	HS	HS	*	HS	HS	HS	HS	HS	HS
	1991	HS	HS	*	-	HS	HS	HS	HS	HS
	1992	HS	HS	-	*	HS	HS	HS	HS	HS
	1993	HS	*	-	*	HS	HS	HS	HS	HS
	2005	HS	*	*	*	HS	HS	HS	*	HS
	2006	HS	HS	*	HS	HS	HS	HS	HS	HS
Other	**Wen-M**	*	-	-	-	*	*	HS	*	*
	Leaven	HS	HS	*	*	HS	HS	HS	HS	HS
	Entiat	HS	HS	*	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		Nason					
		1996	2000	2001	2004	2005	2006
Nason	1996		HS	-	HS	-	*
	2000	HS		HS	HS	HS	HS
	2001	-	HS		*	-	*
	2004	HS	HS	*		*	HS
	2005	-	HS	-	*		-
	2006	*	HS	*	HS	-	
White	1989	HS	HS	HS	HS	HS	HS
	1991	*	HS	HS	HS	*	*
	1992	HS	HS	HS	HS	HS	HS
	1993	*	HS	HS	HS	HS	HS
	2005	*	HS	HS	HS	HS	HS
	2006	HS	HS	HS	HS	HS	HS
Other	Wen-M	HS	HS	HS	HS	*	HS
	Leaven	HS	HS	HS	HS	HS	HS
	Entiat	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		White						Other		
		1989	1991	1992	1993	2005	2006	Wen-M 2001	Leaven 2000	Entiat 1997
White	1989		-	*	-	HS	HS	HS	HS	HS
	1991	-		-	-	*	*	*	HS	HS
	1992	*	-		-	*	*	HS	HS	HS
	1993	-	-	-		*	*	HS	HS	HS
	2005	HS	*	*	*		*	HS	HS	HS
	2006	HS	*	*	*	*		HS	HS	HS
Other	Wen-M	HS	*	HS	HS	HS	HS		HS	HS
	Leaven	HS	HS	HS	HS	HS	HS	HS		HS
	Entiat	HS	HS	HS	HS	HS	HS	HS	HS	

Table 4 Probabilities (above diagonal) and levels of significance (below diagonal) for pairwise tests of genic differentiation among all Chiwawa hatchery broodstock and Chiwawa natural spawner collections used in this analysis. HS = highly significant (P < 0.000476; the Bonferroni corrected p-value for an alpha = 0.05); * = P < 0.05 (nominal critical value for most statistical test); - = P > 0.05 (considered not significant). A significant result between pairs of populations indicates that the allele frequencies between the pair are significantly different. Pairwise comparisons between the hatchery broodstock and natural spawner collections from 2001, 2004, 2005, and 2006, respectively, are highlighted.

		Smolt		Hatchery Broodstock								Natural Spawners				
		1993	1994	1993	1996	1998	2000	2001	2004	2005	2006	1989	2001	2004	2005	2006
Smolt	1993		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	1994	HS		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hatchery Broodstock	1993	HS	HS		0.9155	0.0000	0.0073	0.3647	0.0003	0.0694	0.0000	0.2220	0.0039	0.0008	0.0095	0.0000
	1996	HS	HS	-		0.0151	0.8388	0.0452	0.4916	0.3189	0.0716	0.5591	0.0759	0.8101	0.2364	0.0786
	1998	HS	HS	HS	*		0.0000	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000	0.0000	0.0000	0.0005
	2000	HS	HS	*	-	HS		0.0000	0.4720	0.0000	0.0000	0.0036	0.0000	0.0712	0.0000	0.0000
	2001	HS	HS	-	*	HS	HS		0.0000	0.0059	0.0000	0.0003	0.0000	0.0000	0.0126	0.0000
	2004	HS	HS	*	-	HS	-	HS		0.0000	0.0000	0.0001	0.0000	0.0012	0.0000	0.0000
	2005	HS	HS	-	-	HS	HS	*	HS		0.0005	0.0024	0.0137	0.0025	0.7782	0.0018
	2006	HS	HS	HS	-	*	HS	HS	HS	*		0.0000	0.0000	0.0000	0.0000	0.5770
Natural Spawners	1989	HS	HS	-	-	HS	*	*	HS	*	HS		0.0023	0.0317	0.0000	0.0003
	2001	HS	HS	*	-	HS	HS	HS	HS	*	HS	*		0.0000	0.2641	0.0000
	2004	HS	HS	*	-	HS	-	HS	*	*	HS	*	HS		0.0000	0.0000
	2005	HS	HS	*	-	HS	HS	*	HS	-	HS	HS	-	HS		0.0000
	2006	HS	HS	HS	-	*	HS	HS	HS	*	-	*	HS	HS	HS	

Table 5 Analysis of molecular variance (AMOVA) for the Chiwawa collections, showing the partition of molecular variance into (1) within collections, (2) among collections but within group, and (3) among group components. Each column in the table represents a separate analysis testing for differences under a different spatial or temporal hypothesis. The different analyses are grouped together in a single table for comparisons. The values within the table are percentages and the parenthetical values are P-values, or probabilities, associated with that percentage. P-values greater than 0.05 indicate that the percentage is not significantly different from zero. For example, when collections are organized by hatchery- versus natural-origin ("Origin" – fourth column), 0.11% of the molecular variance is attributed to among group (i.e., hatchery- versus natural-origin), which is not significantly different from zero. No collections (first column) indicates no organization or grouping among all collections, and the among-group percentage is equal to the F_{ST} for the entire data set.

	No Structure	Collection Year	Spawning Location	Origin	Origin-Spawning Location
Among Groups	0.26 (0.00)	0.20 (0.43)	0.05 (0.48)	0.11 (0.15)	0.11 (0.06)
Among collections - Within groups	-	0.08 (0.003)	0.24 (0.00)	0.21 (0.00)	0.18 (0.06)
Within collections	99.74 (0.00)	99.72 (0.00)	99.71 (0.00)	99.68 (0.00)	99.71 (0.00)

Table 6 F_{ST} values for all pairwise combinations of populations. Each F_{ST} is the median value for all pairwise combinations of collections within each population (the number of collections within each population is shown parenthetically next to each population name on each row). For example, the F_{ST} for the Chiwawa hatchery versus the White River (0.019) is the median value of 54 pairwise comparisons. The bold values along the center diagonal are the median F_{ST} values within each collection. For those populations with only one collection, the diagonal value was set at 0.000.

	Chiwawa-Hatchery	Chiwawa-Natural	Entiat	Leaven-worth	Nason	Wenatchee-main	White	Little Wenatchee
Chiwawa-Hatchery (9)	**0.013**	0.008	0.016	0.012	0.011	0.005	0.019	0.111
Chiwawa-Natural (9)		**0.003**	0.012	0.011	0.007	0.003	0.014	0.105
Entiat (1)			**0.000**	0.005	0.010	0.008	0.019	0.078
Leavenworth (1)				**0.000**	0.007	0.008	0.014	0.092
Nason (6)					**0.006**	0.008	0.015	0.099
Wenatchee-main (1)						**0.000**	0.012	0.098
White (6)							**0.005**	0.113
Little Wenatchee (1)								**0.000**

Table 7 As in Table 5, except data includes Chiwawa hatchery- and natural-origin, Nason Creek, and White River collections

	All Years	All Years	1989-1996	2005-2006	2005-2006
	No Structure	Origin	Origin	Origin	Collection Year
Among Groups	0.28 (0.00)	0.33 (0.00)	-0.07 (0.67)	0.43 (0.01)	-0.06 (0.57)
Among Collections - Within groups	-	0.04 (0.00)	0.22 (0.00)	0.25 (0.00)	0.64 (0.00)
Within Collections	99.72	99.63	99.85	99.32	99.41

Table 8 Individual assignment results reported are the numbers of individuals assigned to each population using the partial Bayesian criteria of Rannala and Mountain (1997) and a "jack-knife" procedure (see Methods). The population with the highest posterior probability is considered the stock of origin (i.e., no unassigned individuals). Individuals from each population are assigned to specific populations (along rows). Bold values indicate correct assignment back to population of origin. Individuals assigned to a population are read down columns. For example, of the 595 individuals from Chiwawa hatchery origin, 134 individuals were assigned to Chiwawa natural origin (reading across). Of the 511 individuals assigned to Chiwawa natural origin (reading down), 60 were from Nason Creek.

Population	**Total**	**Unassigned**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1) Chiwawa Hatchery	595	0	**371**	134	2	16	0	45	15	12
2) Chiwawa Natural	501	0	156	**269**	4	5	0	42	9	16
3) Entiat	37	0	4	5	**13**	8	0	6	1	0
4) Leavenworth	73	0	9	8	3	**33**	0	17	0	3
5) Little Wenatchee	19	0	0	0	0	0	**19**	0	0	0
6) Nason	268	0	49	60	5	11	0	**131**	1	11
7) Wenatchee Mainstem	32	0	12	9	0	1	0	2	**6**	2
8) White	179	0	22	26	0	2	0	13	1	**115**
TOTAL	1704	0	623	511	27	76	19	256	33	159

Table 9 As in Table 8, except the posterior probability from the partial Bayesian criteria of Rannala and Mountain (1997) must be 0.90 or greater, to be assigned to a population. Those individuals with posterior probabilities less than 0.90 are unassigned.

Aggregate	Total	Unassigned	1	2	3	4	5	6	7	8
1) Chiwawa Hatchery	595	332	**214**	31	1	4	0	10	3	0
2) Chiwawa Natural	501	375	30	**82**	0	1	0	5	2	6
3) Entiat	37	24	1	1	**5**	4	0	2	0	0
4) Leavenworth	73	51	0	1	1	**19**	0	1	0	0
5) Little Wenatchee	19	2	0	0	0	0	**17**	0	0	0
6) Nason	268	188	11	6	2	5	0	**53**	0	3
7) Wenatchee Mainstem	32	23	4	3	0	0	0	0	**2**	0
8) White	179	92	4	3	0	1	0	5	1	**73**
TOTAL	1704	1087	264	127	9	34	17	76	8	82

Table 10 Estimates of N_e based on bias correction method of Waples (2006) implemented in LDNe (Do and Waples unpublished). Collections are categorized by spawning location. Sample size is the harmonic mean of the sample size, 95% CI is the confidence interval calculated using Waples' (2006) equation 12, and Major Cohort assumes that each collection is 100% four-year-olds.

	Sample size	Estimated N_b	95% CI	Major Cohort	Census	N_e/N
1993 Chiwawa Broodstock	58.4	103.1	77.0 - 149.7	1989	1392	0.30
1996 Chiwawa Broodstock	15.5	30.4	19.6 - 58.1	1992	1099	0.11
1998 Chiwawa Broodstock	33.4	37.7	29.8 - 49.7	1994	280	0.54
2000 Chiwawa Broodstock	77.8	48.4	41.4 - 57.2	1996	182	1.06
2001 Chiwawa Broodstock	80.4	49.6	42.2 - 59.2	1997	389	0.51
2004 Chiwawa Broodstock	56.6	48.1	39.0 - 60.9	2000	688	0.28
2005 Chiwawa Broodstock	73	274.3	148.9 - 1131.8	2001	4130	0.27
2006 Chiwawa Broodstock	88.4	198.3	136.1 - 340.5	2002	1613	0.49
1989 Chiwawa River	26.6	5.2	3.9 - 6.3	1985		
2001 Chiwawa River	46.7	38.6	31.0 - 49.3	1997	389	0.40
2004 Chiwawa River	88.5	82.6	67.3 - 104.4	2000	688	0.48
2005 Chiwawa River	104.2	231.5	161.8 - 382.7	2001	4130	0.22
2006 Chiwawa River	101.1	107.3	87.2 - 136	2002	1613	0.27

Table 11 Summary of output from program SALMONNb and data for eight Chiwawa broodstock collections from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	1993	1996	1998	2000	2001	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):								
1993	-	24.5	42.5	66.4	67.2	57.2	64.6	70.3
1996	82	-	21.2	25.8	26.0	24.4	25.6	26.4
1998	80	81	-	46.7	47.2	42.0	45.8	48.4
2000	80	82	84	-	78.6	65.2	75.1	82.7
2001	73	77	81	76	-	66.0	76.2	84.2
2004	77	81	75	76	78	-	63.5	69.0
2005	71	75	82	73	73	69	-	80.0
2006	81	80	84	75	74	75	72	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):								
1993	-	-742.7	406.9	1240.8	-5432.0	829.8	808.9	729.0
1996	22491.2	-	110.4	-1786.5	765.9	162.8	824.7	382.7
1998	10910.4	67299.1	-	101.8	237.1	69.6	307.0	140.0
2000	6910.0	742895.8	19122.7	-	490.6	1498.2	706.9	201.6
2001	49318.3	21402.8	9754.2	6126.6	-	307.8	82.0	362.5
2004	8338.4	257267.7	24283.0	145043.4	7095.7	-	269.7	140.1
2005	31511.8	22242.5	10015.8	6596.6	114931.1	8240.4	-	599.6
2006	6223.8	43935.2	73518.7	10152.5	5885.3	12827.0	6370.8	-

$\tilde{N}_b = 269.4$

Table 12 Summary of output from program SALMONNb and data for five Chiwawa in-river spawner collections from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	1989	2001	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):					
1989	-	33.3	40.2	41.7	42.2
2001	72	-	60.5	63.9	63.3
2004	72	77	-	95.3	94.0
2005	69	72	75	-	102.5
2006	76	76	77	78	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):					
1989	-	118.4	299.0	143.3	165.3
2001	40378.8	-	181.7	-1537.3	153.5
2004	10455.2	7265.5	-	387.1	329.4
2005	20923.6	68660.6	5040.7	-	356.8
2006	16227.2	8886.9	3802.0	4522.8	-

$\tilde{N}_b = 224.2$

Table 13 Summary of output from program SALMONNb and data for three brood years that combined Chiwawa natural- and hatchery-origin samples from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):			
2004	-	162	164.3
2005	77	-	188.2
2006	76	75	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):			
2004	-	611.3	210.8
2005	9351.5	-	727.5
2006	14965.5	8673.9	-

$\tilde{N}_b$ = 386.8

Appendix I

GENETIC DIVERSITY OF UPPER COLUMBIA SUMMER CHINOOK SALMON

Genetic Structure of upper Columbia River Summer Chinook and Evaluation of the Effects of Supplementation Programs

by

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Abstract

We investigated genetic relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin. Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – MEOK stock, and Wells Hatchery were also included in the analysis. Samples of natural- and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has had any impacts to the genetic structure of these populations. We also calculated the effective number of breeders for collection locations of natural- and hatchery-origin summer Chinook from 1993 and 2008. In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been

spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Introduction

The National Marine Fisheries Service (NMFS) recognizes 15 Evolutionary Significant Units (ESU) for Chinook salmon (*Oncorhynchus tshawytscha*) (Myers et al. 1998). The summer Chinook from the upper Columbia River are included in the Upper Columbia River Summer- and Fall-Run ESU, which encompasses all late-run (summer and fall), ocean-type Chinook salmon from the mainstem Columbia River and its tributaries (excluding the Snake River) between Chief Joseph and McNary Dams (Waknitz et al. 1995). Waknitz et al. (1995) concluded that due to high total abundance this ESU was not likely to become at risk from extinction. Yet, a majority of natural spawning activity was in the vicinity of Hanford Reach, and it was unclear whether natural production was self-sustaining given the vast summer Chinook artificial propagation efforts (Waknitz et al. 1995). Additionally, the Biological Review Team expressed concern about potential consequences to genetic and life-history traits from an increasing contribution of hatchery fish to total spawning escapement (Waknitz et al. 1995).

Artificial propagation of ocean-type Chinook from the middle/upper Columbia has been continuous since the implementation of the Grand Coulee Fish Maintenance Project (GCFMP) in 1939 (Myers et al. 1998). The US Fish and Wildlife Service established three hatchery programs for summer/fall Chinook during the GCFMP, Leavenworth NFH, Entiat NFH, and Winthrop NFH. The Washington Department of Fisheries (now Washington Department of Fish and Wildlife) followed with hatchery programs at Rocky Reach (1964), Wells Dam (1967), Priest Rapids (1974), and Eastbank (1990) facilities. Currently, only Leavenworth NFH and Winthrop NFH are not producing summer/fall Chinook. Entiat NFH has resumed production of summer/fall Chinook (Wells FH Stock) in 2009 and released their first yearling summer Chinook smolts in 2010. Since

1941, over 200 million ocean-type Chinook salmon have been released into the middle Columbia River Basin (Myers et al. 1998). Initially, the hatchery programs differentiated between early returning fish (i.e., stream-type) and later returning fish (i.e., ocean-type), but no distinction was made regarding the “summer” and “fall” components of the ocean-type stocks (Waknitz et al. 1995). Therefore, all Chinook salmon now migrating above Rock Island Dam descend from not only a mixture between different stocks from the basin, but also a mixture between the endemic summer and fall life histories. While hatchery protocols have been modified of late to maintain discreet summer and fall Chinook hatchery stocks (Utter et al. 1995; see also HGMP), physical evidence and genetic data suggests that summer and fall Chinook may have become homogenized. During the 1970’s and 80’s, given coded-wire tag recoveries, summer-run Chinook originating from above Rock Island Dam were believed to have spawned extensively with Hanford Reach and Priest Rapids Hatchery fish (Chapman 1994). Stuehrenberg et al. (1995) reported that 10% of their radio tagged summer Chinook were occupying typical fall-run spawning habitat on the mainstem Columbia river, and 25% of fall fish released from Priest Rapids were recovered as summers at (or above) Wells Hatchery. Genetic data reported by Marshall et al. (1995) and Waknitz et al. (1995) corroborate these observations, as genetic distances observed between summer and fall Chinook within the Upper Columbia River Summer- and Fall-Run ESU were essentially zero.

In response to the need for evaluation of the supplementation hatchery programs, both a monitoring and evaluation plan (DCPUD 2005; Murdoch and Peven 2005) and the associated analytical framework (Hays et al. 2006) were developed for the Habitat Conservation Plan’s Hatchery Committee through the joint effort of the fishery co-managers (CCT, NMFS, USFWS, WDFW, and YN) and Chelan County and Douglas County PUDs. These reports outline 10 objectives to be applied to various species assessing the impacts of hatchery operations mitigating the operation of Wells, Rocky Reach, and Rock Island hydroelectric projects. The present monitoring and evaluation study plan differs in scope from previous monitoring and evaluation projects proposed by WDFW Molecular Genetics Lab, in that it does not investigate a single watershed, but instead will encompass all summer Chinook stocks from the upper Columbia River including the three supplementation (Wenatchee, Methow, and Okanogan) and the harvest augmentation program (Wells summer Chinook). The objectives of this study were to determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery programs.

Materials and Methods

Collections

A total of 2,416 summer Chinook were collected from tributaries in the upper Columbia River basin and were analyzed (Table 1). Two collections of natural-origin summer Chinook from 1993 (prior to the supplementation program) were taken from the Wenatchee River Basin and were compared to collections of hatchery and natural-origin from 2006 and 2008 that were post-supplementation. Two pre-supplementation collections from the Methow River (1991 and 1993) were compared to post-supplementation collections from 2006 and 2008. Three pre-supplementation collections from the Okanogan River Basin (1991, 1992, and 1993) were compared with post-supplementation collections from 2006 and 2008. A collection of natural-origin summer Chinook from the Chelan River was also analyzed. Additionally, hatchery collections from Eastbank Hatchery (Wenatchee and MEOK stock) and Wells Hatchery were analyzed and compared to the in-river collections. Summer Chinook data (provided by the USFWS) from the Entiat River was also used for comparison. Lastly, data from eight collections of fall Chinook was compared to the collections of summer Chinook.

Laboratory Analyses

All laboratory analyses were conducted at the WDFW Genetics Laboratory in Olympia, Washington. Genomic DNA was extracted by digesting a small piece of fin tissue using the nucleospin tissue kits obtained from Macherey-Nagel following the recommended conditions in the user manual. Extracted DNA was eluted with a final volume of 100 µL.

Genotype information was generated using thirteen microsatellite markers following standard laboratory protocols and analysis methods. Descriptions of the loci assessed in this study and polymerase chain reaction (PCR) conditions are given in Table 2. PCR reactions were run with a thermal profile consisting of: denaturation at 95^{o}C for 3 min, denaturation at 95^{o}C for 15 sec, anneal for 30 sec at the appropriate temperature for each locus (Table 2), extension at 72^{o}C for 1 min, repeat cycle (steps 2-4), final extension at 72^{o}C for 30 minutes. PCR products were then processed with an ABI-3730 DNA Analyzer. Genotypes were visualized with a known size standard (GS500LIZ 3730) using GENEMAPPER 3.7 software. Alleles were binned in GENEMAPPER using the standardized allele sizes established for the Chinook GAPS dataset (Seeb et al. 2007).

Within-collection Statistical Analyses

Allele frequencies were calculated with CONVERT (version 1.3, Glaubitz 2003). Hardy-Weinberg proportions for all loci within each collection were calculated using GENEPOP (version 3.4, Raymond and Rousset 1995). Heterozygosity (observed and expected) was computed for each collection group using GDA (Lewis and Zaykin 2001).

Allelic richness and F_{IS} (Weir and Cockerham 1984) inbreeding coefficient were calculated using FSTAT (version 2.9.3.2, Goudet 2001). Linkage disequilibrium for each pair of loci in each collection was calculated using GENEPOP v 3.4 (10,000 dememorizations, 100 batches, and 5,000 iterations per batch). Pairwise estimates of genetic differentiation between collection groups were calculated using GENEPOP (version 3.4, Raymond and Rousset 1995). Statistical significance for the tests of Hardy-Weinberg proportions, linkage disequilibrium, and genotypic differentiation was evaluated using a Bonferroni correction of p-values to account for multiple, simultaneous tests (Rice 1989).

Between-collection Statistical Analyses

Pairwise F_{ST} estimates were computed to examine population structure among collections using GENETIX (version 4.03, Belkhir et al. 2001). This estimate uses allelic frequency data and departures from expected heterozygosity to assess differences between pairs of populations.

We used PHYLIP (version 3.5c, Felsenstein 1993) to calculate Cavalli-Sforza and Edwards (1967) pairwise chord distances between collections. Bootstrap calculations were performed using SEQBOOT followed by calculations of genetic distance using GENDIST. The NEIGHBOR-JOINING method of Saitou and Nei (1987) was used to generate the dendrograms and CONSENSE to generate a final consensus tree from the 1,000 replicates. The dendrogram generated in PHYLIP was plotted as an unrooted radial tree using TREEVIEW (version 1.6.6, Page 1996).

Effective Number of Breeders

The effective number of breeders (N_b) was estimated for pre- and post-supplementation program collections (where possible) to investigate whether hatchery programs had affected that genetic metric over the operational period. Wang (2009) derived an equation for effective size (N_e) as a function of the frequency of nested full-sib and half-sib families in a random collection of individuals.

$$\frac{1}{N_e} = \frac{1+3\alpha}{4}\left(Q_1 + Q_2 + 2Q_3\right) - \frac{\alpha}{2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right) \qquad \text{(equation 10)}$$

Where α is a measure of the deviation of genotype frequencies from Hardy-Weinberg expectation (equivalent to Wright's (1969) F_{IS}), Q_i are the probabilities that a pair of offspring are paternal half sibs, maternal half sibs, or full sibs, respectively, and N_1 and N_2 are the number of male and female parents that generation, respectively. Genetic parameters (i.e., sibship distributions) were estimated for summer Chinook collections using algorithms implemented in COLONY (Jones and Wang 2009). To be clear, Wang's (2009) method as implemented here will estimate N_b, given multi-locus genotypes from each collection were partitioned by brood year for this analysis. To obtain an estimate of N_e each N_b value must be multiplied by the mean generation time of that population.

Results

Collections

A total of 2,350 individuals from 32 collections of temporally replicated samples (six locations) were analyzed (Table 1). Temporally replicated collections of hatchery and natural-origin samples were from the Wenatchee, Methow, and Okanogan Rivers. Temporally replicated hatchery-origin summer Chinook were from Wells Hatchery, Eastbank Hatchery - Wenatchee stock, and Eastbank Hatchery - Methow/Okanogan (MEOK) stock. A total of 232 of those individuals were excluded from any analyses because they failed to amplify at nine or more loci. Data for remaining 2,118 individuals were analyzed to assess differences between temporally replicated natural- and hatchery-origin summer Chinook for each location and to compare the differences among the different collection locations. Summer Chinook data from the temporally replicated collection locations were then combined and compared to fall Chinook data from the GAPS v.3.0 dataset.

Statistical Analyses

The population statistics (Hardy-Weinberg equilibrium and F_{IS}) calculated for each of the 32 temporally replicated collection locations were consistent with neutral expectations (i.e., no associations among alleles). Three collections did have a single locus that did not meet expectations (Wenatchee hatchery-origin 2006, Wells hatchery 2006, and Okanogan hatchery-origin 2009). Based on these results we suggest the collections represented randomly breeding groups and were not comprised of mixtures of individuals from different genetic source populations.

Population differentiation was assessed for each of the temporally replicated collections from within each location (Table 3). This analysis revealed the only significant difference observed within a collection location pertained to the collection from 1993 Okanogan River natural-origin samples. Because of the significant difference of this collection to the other temporal replicates it was not included in further analyses.

Given the absence of genetic differentiation observed among the temporally replicated collections, the 32 collections from the Wenatchee, Methow, and Okanogan River were combined to form three location-specific collections for analysis. Population differentiation metrics were compared among the composite Wenatchee, Methow, and Okanogan collections and eight other location-specific collections (11 locations total). Comparing all collections, there were a total of 39 significant genic test comparisons out of a total 496 (Table 4). Thirty-eight of the 39 statistically significant pairwise differences pertained to the Okanogan River and 2006 Wells Hatchery collections (Table 4). F_{ST} results are described further below.

Within-collection genetic metrics were estimated for the 11 location-specific collections of summer Chinook from the upper Columbia River, in addition to eight collections of fall Chinook (Table 1). The population statistics (Hardy-Weinberg equilibrium and F_{IS}) calculated for these collections of summer and fall

Chinook were also consistent with neutral expectations. The collection from Lyons Ferry Hatchery had one locus that did not meet expectations and the collections from Crab Creek and Marion Drain both had three loci that did not meet expectations.

The hatchery collections in general had a higher percentage of significantly linked loci; however the observed genetic diversity were similar for the natural and hatchery-origin collections. Analysis of allelic richness was based on 11 individuals per collection, the minimum number of individuals across all collections with complete multilocus genotypes. The largest number of linked loci occurred in the Crab Creek, Entiat River, and Okanogan natural-origin collections. Allelic richness was on average lower in the collections of summer Chinook (10.7) collections in comparison to the collections of fall Chinook (11.0).

Pairwise F_{ST} (Table 4) estimates revealed low levels of differentiation, where all observed F_{ST} values between the collections of summer Chinook were lower than 0.0096. There were 15 out of 28 comparisons between collections of summer Chinook that were significantly different from zero and occurred primarily from comparisons of the Okanogan River (hatchery and natural-origin) and Wells Hatchery to all other collections. The collection of Eastbank Hatchery – MEOK stock was differentiated from the Wenatchee River natural-origin and Entiat River collections. The collection from the Chelan River had a small sample size of 23 individuals and only differentiated from the Eastbank Hatchery – MEOK stock. F_{ST} estimates regarding pairwise comparisons between each of four fall Chinook collection locations (Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River) to all other collections were significantly different from zero (Table 5). Pairwise comparisons for three other fall Chinook collections (Hanford Reach, lower Yakima River, and Umatilla River) to the collections of summer Chinook were significantly different from zero (Table 6). The only fall Chinook collection that was not significantly differentiated from all of the summer Chinook was Priest Rapids.

The relative genetic relationships among the test groups were assessed using the consensus clustering analysis (Figure 1). Statistical support for the dendrogram topology (i.e., tree shape) was low regarding the branching that separated the collections of summer Chinook from the upper Columbia River. The collections of fall Chinook; however were supported with bootstrap support over 76% with the exception of three collections (lower Yakima River, Crab Creek, and Umatilla River). In other words, 760 of the 1000 bootstrap replicates supported the placement of the node separating summer and fall collections. The collection from the Chelan River had bootstrap support of 68%; however the sample size for that collections was small (N = 23). Even though the bootstrap support was low among the collections of summer Chinook there was concordance between geography and genetic distance.

Where comparisons were possible between pre- and post-supplementation program collections, the effective number of breeders (N_b) estimated to have comprised those collections were slightly lower for contemporary (2008) collections; however in all cases the 95% confidence intervals overlapped between historical and contemporary collections, suggesting statistical equivalency. Regarding Wenatchee River collections, the point estimates of N_b ranged from 134 (08FU) to 190 (93DD), where all collections had overlapping confidence intervals (Table 7). The upper bound of the 1989 brood year for collection 93DD was very large, suggesting the sample size was insufficient for properly inferring the sibship distribution within the collection. Comparing the Okanogan natural collections 93ED and 08GA, the estimated N_b were 142 (CI 102 – 203) and 127 (CI 92 – 180), respectively. For the Eastbank Hatchery MEOK stock comparisons, the N_b estimated for the 93DF collection was 171 (CI 129 – 229), as compared to the 166 (CI 126 – 226) estimated for collection 08MO. In all cases, the estimated N_b can be converted to effective population size (N_e) by multiplying the estimate by the mean generation time.

Discussion

The collections of summer Chinook populations from the upper Columbia River are of interest because census sizes are reduced below historic levels and are the subject of mitigation and supplementation hatchery programs. Concern over the impacts of hatchery supplementation programs on the genetic integrity of natural-origin populations led to our primary objective, which was to evaluate genetic metrics for temporally replicated collections of summer Chinook in the upper Columbia River pre and post hatchery supplementation. A similar analysis by Kassler and Dean (2010) was conducted on spring Chinook in the Tucannon River to evaluate the effects of a supplementation and captive brood program on natural-origin stocks. Additionally, upper Columbia River spring Chinook supplementation programs (Blankenship et al. 2007; Small et al. 2007), spring and fall Chinook populations in the Yakima Basin (Kassler et al. 2008), and a potentially unique population of fall Chinook in Crab Creek (Small et al. 2010) have been evaluated. In the present analysis of summer Chinook populations, collections of pre- and post- supplementation summer Chinook were collected from the Wenatchee River, Methow River, and Okanogan River Basins and analyzed to determine if the genetic profile has changed as a result of the supplementation program. Analysis was then conducted on the collections of summer run to compare the fall run Chinook collections in the upper Columbia River basin.

Allozyme analyses of these three summer run Chinook stocks in the upper Columbia River have identified that each stock was distinct, with a closer relationship detected between the Wenatchee and Methow Rivers (WDF and WDW 1993, Marshall 2002). Wenatchee summer Chinook are thought to be a mixture of native summer Chinook and Chinook from the Grand Coulee Fish Maintenance Project (GCFMP). The goal of the GCFMP project between 1939 and 1943 was to trap migrating Chinook salmon at Rock Island dam (75 miles below Grand Coulee) and homogenize the populations, which reduced the genetic uniqueness of the distinct tributary populations present in the upper Columbia River.

We found allele frequencies for individual temporally replicated hatchery- and natural-origin collection locations of adult summer Chinook were not significantly different from that expected of a single underlying population, except for one collection (1993 Okanogan natural-origin; Table 3). This collection was differentiated to the Okanogan collections in 2006 and 2008; however it was not differentiated from the collection in 1992. The Okanogan collection from 1992 was also not differentiated to any other collection; therefore the difference in the collection from Okanogan 1993 was likely not an indication of genetic change from pre supplementation to post supplementation. The collection was however dropped from further analyses so as to not confuse interpretation of results. The lack of allelic differentiation observed among the temporally replicated collections was interpreted as the genetic metrics from each location in the early 1990's did not differ from the samples collected in 2008. Spanning a few generations, allele frequencies are not expected to change for large populations at genetic equilibrium. In contrast, changes in allele frequencies of small populations may occur due to the stochastic sampling of genes from one generation to the next (i.e., genetic drift).

A second round of analyses was conducted to evaluate the genetic relationships of the summer run collections (temporal collections were combined) with data from the Entiat River, Chelan River, and eight collections of fall Chinook. Assessment of the relationship between the summer run collections in comparison to each other provided very little evidence of genetic differentiation between these collections. While population differentiation did show some significant differences between the Okanogan River and Wells Hatchery collections, all of the pairwise F_{ST} values were below 0.003. Meaning that a very small proportion of the observed genetic variation could be attributed to restrictions in gene flow (i.e., population structure)

The comparison of the hatchery-origin collections revealed a lack of differentiation between the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – MEOK stock, and the Wells Hatchery (with exception of the 2006 collection). The genetic similarity or low level of genetic differentiation among these stocks suggests that there has been an integration of natural- and hatchery-origin summer Chinook in the upper Columbia River or a lack of ancestral genetic difference. The difference of the 2006 Wells Hatchery collection to the other collections is most likely a result of sampling effect because of the lack of differentiation among the stocks in the basin. If the 2006 collection had been mixed from different sources of summer Chinook there would not be a detectable level of differentiation as was seen with the 2006 sample.

The analyses to compare summer and fall Chinook collections provided some understanding on the genetic relationships of Chinook with different run timings in the upper Columbia River basin. Historically, the hatchery programs in the upper Columbia River were separated into groups of the early returning fish (i.e., stream-type) and later returning fish (i.e., ocean-type), but the programs did not sort individuals identified as "summer" or "fall" stocks (Waknitz et al. 1995). Now all Chinook salmon that are migrating above Rock Island Dam descend from a mixture of different stocks from the upper Columbia River basin, but also a mixture between the endemic summer and fall life histories.

Small et al. (2010) conducted an analysis on summer run and fall run Chinook in the upper Columbia River and concluded that Crab Creek Chinook in the upper Columbia River were genetically distinct to all other fall and summer run Chinook stocks that were analyzed. They did note a departure from Hardy Weinberg expectation as a result of a null allele at the microsatellite locus *Ogo-4* and a higher linkage disequilibrium value due to the inclusion of family groups in one of their samples. Kassler et al. (2008) found differentiation among spring and fall Chinook populations in the Yakima River.

The tests of pairwise F_{ST} indicated a very low level of genetic differentiation (less than one percent difference) between collections of summer-run Chinook and fall-run Chinook. The range of pairwise F_{ST} values for comparisons between the summer run and fall run collections was 0.0016 – 0.0248. The larger values from the range were associated to the collections from Crab Creek, Lyons Ferry Hatchery, and Marion Drain. Studies by Kassler et al. (2008) and Small et al. (2010) have documented differences among the populations of these collections to others within the upper Columbia River basin. The low pairwise F_{ST} values between Priest Rapids and Hanford Reach collections and the summer run collections were not surprising because summer-run Chinook originating from above Rock Island Dam were believed to have spawned extensively with Hanford Reach and Priest Rapids Hatchery fish during the 1970's and 80's (Chapman 1994). The lack of differentiation among the summer and fall stocks in the Columbia River was also identified by Utter et al. (1995) and the HGMP where they state physical evidence and genetic data suggests that summer and fall Chinook may have become homogenized.

Despite low levels of statistical bootstrap support for dendrogram topology (i.e., tree shape), there was concordance observed between geographic location and the genetic relationships among the summer and fall Chinook populations. The collections from the Okanogan (hatchery and natural-origin) did separate out with collections from Wells Dam Hatchery, Entiat River, and Eastbank Hatchery – MEOK stock, and were next to a group of the Methow and Wenatchee collections. The fall Chinook populations are also separated to the summer collections and the position of all but three of these collections (lower Yakima River, Crab Creek, and Umatilla River) were statistically supported. The geographic proximity of the fall collections seemed to follow the observed pattern in this dendrogram. The relationship of the Snake River and Lyons Ferry Hatchery in proximity to the collection from Marion Drain was not surprising while the relationship between Priest Rapids and Hanford Reach was easily a result of the stocking practices of fall Chinook in the 1970 and 1980's.

A secondary objective of this study was to determine if the effective population size of upper Columbia River summer Chinook populations had changed over time due to supplementation efforts. We observed that the number of effective breeders in the collections from 1993 and 2008 has not changed thus providing reason to believe that the genetic diversity of summer Chinook in the upper Columbia River has not been altered through the supplementation program.

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Table 1. Samples of adult hatchery- and natural-origin summer and fall Chinook that were analyzed from the upper Columbia River. Total number of individuals that were analyzed / individuals with data for 9 or more loci that were included in the analysis. Collection statistics (allelic richness, linkage disequilibrium (before and after Bonferroni correction), F_{IS}, heterozygosity (H_O and H_E)) and p-values for deviations from Hardy-Weinberg equilibrium (HWE). P-values were defined as significant after implementation of Bonferroni correction for multiple tests (Rice 1989).

WDFW GSI code[a]	Collection location	N =	Allelic Richness[b]	Linkage Disequilibrium[c]	F_{IS} (p-value)[d]	H_O	H_E
93DD	Wenatchee River upstream of Tumwater Dam - natural origin	51 / 45					
93DE	Wenatchee River downstream of Tumwater Dam - natural origin	88 / 88					
06CQ	Wenatchee River upstream of Tumwater Dam - natural origin	95 / 86					
06CR	Wenatchee River downstream of Tumwater Dam - natural origin	95 / 82					
08FV	Wenatchee River upstream of Tumwater Dam - natural origin	95 / 82					
08FW	Wenatchee River downstream of Tumwater Dam - natural origin	95 / 87					
	Wenatchee River - Natural origin combined	**519 / 470**	**10.7**	**17 / 4**	**0.001 (0.403)**	**0.8504**	**0.8513**
06CP	Wenatchee River - hatchery origin	95 / 70					
08FU	Wenatchee River - hatchery origin	95 / 83					
	Wenatchee River - Hatchery origin combined	**190 / 153**	**10.6**	**18 / 6**	**0.018 (0.013)**	**0.8409**	**0.8561**
93EC	Methow River - natural origin	27 / 27					
06CT	Methow River - natural origin	95 / 90					
08FY	Methow River - natural origin	95 / 88					
09CO	Methow River - natural origin	91 / 80					
	Methow River - Natural origin combined	**308 / 285**	**10.7**	**4 / 1**	**0.006 (0.160)**	**0.8506**	**0.8554**
06CS	Methow River - hatchery origin	14 / 8					
08FX	Methow River - hatchery origin	21 / 18					
09CP	Methow River - hatchery origin	19 / 18					
	Methow River - Hatchery origin combined	**54 / 44**	**10.8**	**11 / 2**	**-0.003 (0.593)**	**0.8553**	**0.8523**

Table 1 continued.

92FM	Okanogan River - natural origin	49 / 46					
93ED*	Okanogan River - natural origin	103 / 87					
06CV	Okanogan River - natural origin	95 / 88					
08GA	Okanogan River - natural origin	95 / 92					
09CN	Okanogan River - natural origin	133 / 126					
	Okanogan River - Natural origin combined	**475 / 439**	**10.8**	**9 / 4**	**0.003 (0.304)**	**0.8563**	**0.8596**
* - not included in the combined dataset							
06CU	Okanogan River - hatchery origin	58 / 49					
08FZ	Okanogan River - hatchery origin	19 / 18					
09CM	Okanogan River - hatchery origin	117 / 107					
	Okanogan River - hatchery origin combined	**194 / 174**	**10.8**	**31 / 10**	**-0.011 (0.920)**	**0.8678**	**0.8586**
91FL	Wells Hatchery	68 / 42					
92FK	Wells Hatchery	25 / 23					
93DG	Wells Hatchery	11 / 9					
06DM	Wells Hatchery	95 / 91					
08HY	Wells Hatchery	95 / 91					
	Wells Hatchery combined	**294 / 256**	**10.7**	**8 / 3**	**-0.001 (0.529)**	**0.8670**	**0.8665**
08MN	**Eastbank Hatchery - Wenatchee River stock**	**95 / 90**	**10.7**	**6 / 1**	**0.020 (0.024)**	**0.8326**	**0.8498**
92FO	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	36 / 33					
93DF	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	90 / 86					
08MO	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	95 / 88					
	Eastbank Hatchery - MEOK stock combined	**221 / 207**	**10.7**	**2 / 0**	**-0.005 (0.782)**	**0.8647**	**0.8604**
		2,350 / 2,118					

Table 1 continued.

06KN	**Chelan River**	**70 / 23**	**10.3**	**11 / 0**	**0.027 (0.118)**	**0.8334**	**0.8556**
Data provided by USFWS							
	Entiat River - summer Chinook	**190**	**10.9**	**33 / 10**	**0.008 (0.119)**	**0.8553**	**0.8625**
Data from Small et al. (2010)							
08EH	Crab Creek	108					
09AZ	Crab Creek	291					
	Crab Creek	**399**	**10.5**	**35 / 14**	**0.018 (0.000)**	**0.8519**	**0.8676**
GAPS v.3.0 data							
	Priest Rapids Hatchery - fall Chinook	**81**	**11.1**	**3 / 2**	**0.015 (0.079)**	**0.8591**	**0.8723**
	Hanford Reach - fall Chinook	**220**	**11.3**	**4 / 0**	**0.010 (0.068)**	**0.8661**	**0.8746**
	Umatilla - fall Chinook	**96**	**11.2**	**17 / 6**	**-0.003 (0.623)**	**0.8719**	**0.8693**
	lower Yakima River - fall Chinook	**103**	**11.0**	**3 / 1**	**0.000 (0.511)**	**0.8724**	**0.8721**
	Marion Drain - fall Chinook	**190**	**10.8**	**9 / 4**	**0.022 (0.001)**	**0.8586**	**0.8782**
	Lyons Ferry Hatchery - fall Chinook	**186**	**10.6**	**7 / 4**	**0.013 (0.033)**	**0.8527**	**0.8641**
	Snake River - fall Chinook	**521**	**11.1**	**0 / 0**	**-0.001 (0.634)**	**0.8720**	**0.8708**
		NA / 2,009					

[a] - Year that samples were collected is identifed by the two numbers in the WDFW GSI code

[b] - based on a minimum of 11 diploid individuals

[c] - adjusted alpha p-value = 0.0006

[d] - adjusted alpha p-value = 0.0002

Table 2. PCR conditions and microsatellite locus information (number alleles/locus and allele size range) for multiplexed loci used for the analysis of Chinook. Also included are the observed and expected heterozygosity (H_o and H_e) for each locus.

PCR Conditions			Locus statistics		Heterozygosity		
Poolplex	Locus	Dye Label	# Alleles/ Locus	Allele Size Range (bp)	H_o	H_e	References
Ots-M	*Ots-201b*	blue	49	137 - 334	0.9474	0.9544	Unpublished
	Ots-208b	yellow	56	154 - 378	0.9523	0.9672	Greig et al. 2003
	Ssa-408	red	32	184 - 308	0.9177	0.9214	Cairney et al. 2000
Ots-N	*Ogo-2*	red	22	206 - 260	0.8526	0.8673	Olsen et al. 1998
Ots-O	*Ogo-4*	blue	20	128 - 170	0.6694	0.7028	Olsen et al. 1998
	Ots-213	yellow	45	178 - 370	0.9430	0.9525	Greig et al. 2003
	Ots-G474	red	16	152 - 212	0.6816	0.6838	Williamson et al. 2002
Ots-R	*Ots-3M*	blue	15	128 - 158	0.7854	0.7938	Banks et al. 1999
	Omm-1080	green	54	162 - 374	0.9517	0.9670	Rexroad et al. 2001
Ots-S	*Ots-9*	red	9	99 - 115	0.6531	0.6543	Banks et al. 1999
	Ots-212	blue	33	123 - 251	0.9205	0.9360	Greig et al. 2003
Ots-T	*Oki-100*	blue	50	164 - 361	0.9500	0.9567	Unpublished
	Ots-211	red	34	188 - 327	0.9325	0.9414	Greig et al. 2003

Table 3. Tests of population differentiation for temporal collections of summer Chinook from natural and hatchery-origin populations in the upper Columbia River. P-values that are highlighted grey are significantly different after Bonferroni correction (Rice 1989). Adjusted alpha p-value was 0.0001 . The H and W in the collection identifier is for wild or hatchery-origin and the two digit number identifes the year samples were collected.

Wenatchee River

	WenW93U	WenW93D	WenH06	WenW06U	WenW06D	WenH08	WenW08U	WenW08D
WenW93U	****							
WenW93D	0.0162	****						
WenH06	0.0033	0.0102	****					
WenW06U	0.3039	0.1642	0.4795	****				
WenW06D	0.0261	0.0160	0.0678	0.5300	****			
WenH08	0.1126	0.0708	0.0073	0.4359	0.0893	****		
WenW08U	0.2115	0.1148	0.4191	0.7243	0.3830	0.8856	****	
WenW08D	0.1915	0.0014	0.7047	0.4928	0.1671	0.7755	0.7665	****

D - collection was downstream of Tumwater Dam; U - collection was upstream of Tumwater Dam

Methow River

	MetW93	MetH06	MetW06	MetH08	MetW08	MetW09	MetH09
MetW93	****						
MetH06	0.3962	****					
MetW06	0.5481	0.4688	****				
MetH08	0.1408	0.1192	0.2052	****			
MetW08	0.8219	0.8937	0.6156	0.3779	****		
MetW09	0.2564	0.4282	0.2502	0.0328	0.7309	****	
MetH09	0.1543	0.5678	0.0547	0.0017	0.0098	0.0073	****

Okanogan River

	OkanW92	OkanW93	OkanH06	OkanW06	OkanH08	OkanW08	OkanH09	OkanW09
OkanW92	****							
OkanW93	0.0066	****						
OkanH06	0.0193	0.0000	****					
OkanW06	0.2843	0.0082	0.0031	****				
OkanH08	0.1290	0.1106	0.0652	0.7329	****			
OkanW08	0.0106	0.0029	0.0082	0.4075	0.7396	****		
OkanH09	0.0187	0.0001	0.0094	0.0551	0.2214	0.0281	****	
OkanW09	0.0527	0.0000	0.0024	0.7130	0.0262	0.0065	0.0002	****

Table 3 continued.

Wells Dam Hatchery

	Wells91	Wells92	Wells93	Wells06	Wells08
Wells91	****				
Wells92	0.5863	****			
Wells93	0.0490	0.0784	****		
Wells06	0.0089	0.0100	0.0542	****	
Wells08	0.0819	0.1088	0.2552	0.0256	****

Eastbank Hatchery - Wenatchee and MEOK stocks

	EBHWen08	EBHME92	EBHME93	EBHME08
EBHWen08	****			
EBHME92	0.8681	****		
EBHME93	0.0251	0.8661	****	
EBHME08	0.0086	0.9563	0.1895	****

Table 4. F_{ST} pairwise comparisons and genotypic tests of differentiation for hatchery- and natural-origin summer Chinook from the upper Columbia River. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

	Wenatchee Hatchery	Wenatchee Natural	Methow Hatchery	Methow Natural	Okanogan Hatchery	Okanogan Natural	Wells Hatchery	Eastbank Wenatchee stock	Eastbank MEOK stock	Entiat River	Chelan River
Wenatchee Hatchery	****	**0.0000**	**0.0011**	**0.0000**	**0.0013**	**0.0010**	0.0015	**0.0004**	**0.0007**	**0.0004**	**0.0072**
Wenatchee Natural	**0.4351**	****	**0.0016**	**0.0000**	0.0014	0.0016	0.0024	**0.0006**	0.0012	0.0009	**0.0068**
Methow Hatchery	**0.3800**	**0.0205**	****	**0.0012**	0.0029	**0.0008**	**0.0027**	**0.0014**	**0.0022**	**0.0019**	**0.0078**
Methow Natural	**0.2237**	**0.6566**	**0.1502**	****	**0.0011**	0.0011	0.0013	**0.0007**	**0.0007**	**0.0008**	**0.0053**
Okanogan Hatchery	0.0001	0.0000	**0.0364**	**0.0008**	****	**0.0010**	**0.0014**	0.0029	**0.0000**	**0.0007**	**0.0055**
Okanogan Natural	0.0000	0.0000	**0.1755**	0.0000	**0.0003**	****	0.0016	0.0023	**0.0005**	**0.0008**	**0.0049**
Wells Hatchery	0.0000	0.0000	**0.0129**	0.0000	0.0000	0.0000	****	0.0036	**0.0006**	**0.0008**	**0.0041**
Eastbank Wenatchee	**0.5261**	**0.4102**	**0.1215**	**0.8404**	**0.0015**	0.0000	0.0000	****	**0.0018**	0.0030	0.0096
Eastbank MEOK stock	**0.0485**	0.0000	**0.4246**	**0.0009**	**0.5786**	**0.0051**	0.0000	**0.0065**	****	**0.0005**	**0.0039**
Entiat River	**0.0565**	0.0000	**0.1795**	**0.0044**	**0.0005**	0.0000	**0.0032**	**0.0039**	**0.0042**	****	**0.0052**
Chelan River	**0.0091**	**0.0026**	**0.0182**	**0.0156**	**0.0048**	**0.0030**	**0.0066**	**0.0059**	**0.0493**	**0.0617**	****

Table 5. F_{ST} pairwise comparisons and genotypic tests of differentiation for fall Chinook. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

	Crab Creek	Hanford Reach Fall	Lyons Ferry Hatchery Fall	lower Yakima River Fall	Marion Drain Fall	Priest Rapids Fall	Umatilla River Fall	Snake River Fall
Crab Creek	****	0.0087	0.0134	0.0079	0.0143	0.0107	0.0073	0.0097
Hanford Reach Fall	0.0000	****	0.0077	**0.0000**	0.0064	**0.0000**	**0.0000**	0.0022
Lyons Ferry Hatchery Fall	0.0000	0.0000	****	0.0063	0.0074	0.0092	0.0062	0.0029
lower Yakima River Fall	0.0000	**0.4140**	0.0000	****	0.0054	**0.0000**	**0.0000**	0.0018
Marion Drain Fall	0.0000	0.0000	0.0000	0.0000	****	0.0067	0.0061	0.0060
Priest Rapids Fall	0.0000	**0.0695**	0.0000	**0.0083**	0.0000	****	**0.0000**	0.0027
Umatilla River Fall	0.0000	**0.4879**	0.0000	**0.4896**	0.0000	**0.2539**	****	0.0011
Snake River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	****

Table 6. F_{ST} pairwise comparisons and genotypic tests of differentiation for hatchery- and natural-origin summer Chinook from the upper Columbia River and fall Chinook. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

Population Differentiation

	Wenatchee Hatchery	Wenatchee Natural	Methow Hatchery	Methow Natural	Okanogan Hatchery	Okanogan Natural	Wells Hatchery	Eastbank Wenatchee stock	Eastbank MEOK stock	Entiat River	Chelan River
Crab Creek	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hanford Reach Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0349**
Lyons Ferry Hatchery Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lower Yakima River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0074**
Marion Drain Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Priest Rapids Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0642**
Umatilla River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0579**
Snake River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 6 continued.

Pairwise F_{ST}

	Crab Creek	Hanford Reach Fall	Ferry Hatchery	Yakima River	Marion Drain Fall	Priest Rapids Fall	Umatilla River Fall	Snake River Fall
Wenatchee Hatchery	0.0158	0.0054	0.0180	0.0056	0.0153	**0.0025**	0.0053	0.0103
Wenatchee Natural	0.0162	0.0059	0.0185	0.0063	0.0157	0.0030	0.0059	0.0102
Methow Hatchery	0.0191	0.0104	0.0248	0.0095	0.0220	0.0069	0.0107	0.0165
Methow Natural	0.0148	0.0057	0.0182	0.0051	0.0148	0.0033	0.0055	0.0101
Okanogan Hatchery	0.0146	0.0041	0.0166	0.0042	0.0151	**0.0016**	0.0041	0.0082
Okanogan Natural	0.0163	0.0064	0.0187	0.0062	0.0170	0.0035	0.0068	0.0113
Wells Hatchery	0.0120	0.0051	0.0135	0.0044	0.0120	0.0028	0.0046	0.0077
Wenatchee stock	0.0184	0.0073	0.0203	0.0074	0.0167	0.0047	0.0084	0.0128
Eastbank MEOK stock	0.0128	0.0036	0.0143	0.0038	0.0135	**0.0019**	0.0038	0.0079
Entiat River	0.0147	0.0059	0.0176	0.0057	0.0156	0.0028	0.0056	0.0100
Chelan River	0.0074	**0.0046**	0.0110	**0.0040**	0.0160	**0.0047**	**0.0035**	0.0072

Table 7. Effective number of breeders per brood year with the largest number of samples of summer Chinook in the upper Columbia River. Brood years with sample size less than 19 individuals (shown in bold type) were not analyzed with exception of the 2008 Wells Hatchery collection. A comparison could not be made between an early and late collection from Wells Hatchery.

WDFW Code	Collection Location	Sample Size	Nb =	CI95(L) =	CI95(U) =
93DD[A]	Wenatchee Natural - upstream	23 / 19	152 / 190	77 / 87	616 / 2,147,483,647
08FV	Wenatchee Natural - upstream	56	162	112	249
93DE[A]	Wenatchee Natural - downstream	39 / 34	145 / 152	94 / 95	256 / 302
08FW	Wenatchee Natural - downstream	67	140	105	199
08FU	Wenatchee Hatchery	60	134	90	213
93EC[A]	Methow Natural	**10 / 15**	---	---	---
08FY	Methow Natural	62	150	106	218
08FX	Methow Hatchery	**9**	---	---	---
93ED	Okanogan Natural	69	142	102	203
08GA	Okanogan Natural	59	127	92	180
08FZ	Okanogan Hatchery	**16**	---	---	---
93DG	Wells Hatchery	**6**	---	---	---
08HY[B]	Wells Hatchery	24 / 39	---	---	---
08MN	Eastbank Hatchery - Wenatchee	88	190	144	263
93DF	Eastbank Hatchery - MEOK	84	171	129	229
08MO	Eastbank Hatchery - MEOK	88	166	126	226

[A] - calculations were made for samples from brood year 1988 / brood year 1989

[B] - samples were collected from brood year 2003 / brood year 2004

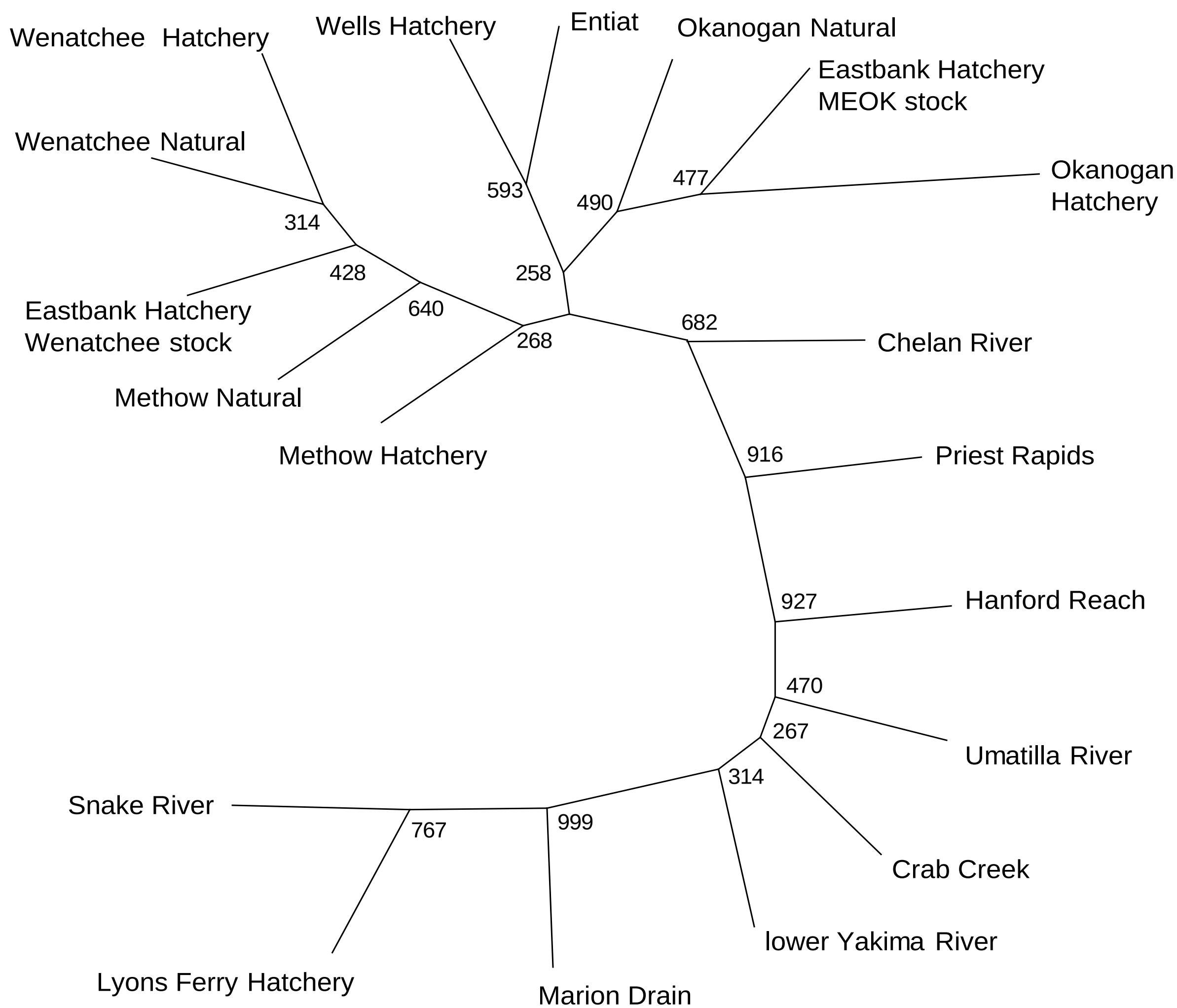

Figure 1. Relationship of natural- and hatchery-origin Chinook collections from the upper Columbia River basin using Cavalli-Sforza and Edwards (1967) chord distance. Bootstrap values are shown at each node.

APPENDIX N
CHELAN COUNTY PUD HATCHERY MONITORING AND EVALUATION WORK PLAN 2013

CHELAN COUNTY PUD HATCHERY MONITORING AND EVALUATION WORK PLAN 2013

FINAL

Prepared by:

Lance Keller and Josh Murauskas

December 2012

Table of Contents

Figures and Tables

1.0 ***INTRODUCTION***

The Habitat Conservation Plan (HCP) specifies that a monitoring and evaluation plan will be developed for the hatchery program. The approach to monitoring the hatchery programs was guided by the "*Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Programs*" (Murdoch and Peven 2005). The Hatchery Evaluation Technical Team (HETT) developed an "*Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs*" (Hays et al. 2006), which directs the analyses of hypotheses developed under the conceptual approach. Most of the analyses outlined in the Analytical Framework paper will be conducted after the fifth year of monitoring.

The purpose of this document is to define the tasks associated with the approved scope of work to implement Chelan PUD's (CPUD's) hatchery monitoring and evaluation (M&E) plan for 2013. The annual Monitoring and Evaluation report, summarizing data obtained through implementation of the work plan, will be finalized July 1, 2012. For each year the Plan is implemented, this will be done the previous year, as specified in Murdoch and Peven (2005). The work described in this plan has ESA coverage provided by ESA permits 1196, 1347, and 1395. These permits allow for changes to monitoring or research protocols with the caveat that such modifications are approved by NMFS prior to implementing those changes.

1.1 ***DATA FLOW AND ANALYSIS***

Data collection and analysis is paramount to understanding whether the hatchery program is meeting the goals and objectives that have been developed (Murdoch and Peven 2005). The following structure ensures that the data flow and analysis is efficient, robust, and can be used by the HCP HC to make informed decisions.

In 2013, the District, WDFW, BioAnalysts, CCT, and the Yakama Nation will be collecting data consistent with Murdoch and Peven (2005) and other tasks that may be identified by the HCP HC. The contracts that the District is entering into with these entities states that the information collected will be entered into summary spreadsheets and sent to the District Coordinator on a monthly basis.The spreadsheets will be examined by the District Coordinator for completeness and qualifying information. If there are questions concerning the information, the District Coordinator will contact the entity and rectify any problems.

After the information is deemed complete, it will be sent to BioAnalysts and a subcommittee of the HC, the Hatchery Effectiveness Technical Team (HETT). The raw data will be provided to the HCP HC if requested. BioAnalysts will then employ the methods for analyzing the information that is developed by the HETT, or the Hatchery Committee or other contractor assigned to collect data. BioAnalysts will send a monthly report back to the HCP HC, which will then evaluate the information and comment if necessary. BioAnalysts will incorporate appropriate comments from the HCP HC and finalize the monthly summary report.

The HETT generally will meet monthly to discuss data completeness, any qualifications that should be considered during analysis, and all aspects related to the data compilation and analysis of the information collected for the District's hatchery program. In addition, the HETT will address any assignments from the HCP HC and make recommendations to the HC. The HETT will meet to ensure the following issues are addressed if requested by the HC:

- Coordinate (at a minimum) the forms used to report field data, and the form of the final delivered information and any other issues relevant to the collection and use of the data. Coordination may also occur outside of HETT among the entities involved with data collection.
- Ensure all qualifying information[1] from the field is known.
- Ensure at the end of the field season completeness of the data and coordination of the final report.
- A year-end meeting may be held by HETT to assess the efficiency of the data sharing and analysis process describe above. The HETT, or other entities collecting data, will report to the Hatchery Committee on their findings and recommendations.

Meetings will also be held by entities collecting data or the Hatchery Committee to ensure that the objectives noted above continue to be addressed and to discuss any changes to the collection or analysis processes that may have occurred. The meetings should occur as follows:

- Prior to the beginning of the data collection season.
- At the beginning of the smolt data collection and steelhead spawning ground survey period.
- At the beginning of the remaining spawning ground survey periods.
- At the end of the field season to ensure completeness of the data and coordinate the final report.

The development of a yearly report will go through a similar review process as outlined above for the monthly reporting. Figure 1, on the next page, diagrams the proposed flow of information. Table 1 depicts which tasks are being performed by entity and objective. The task numbers refer to the appendices within Murdoch and Peven (2005). At the end of this implementation plan, attached as Appendix 1, is the analytical framework document to evaluate the District's hatchery programs.

[1] During the course of a field season it is anticipated that issues will arise that should be noted when reporting and analyzing the information collected.

Proposed Hatchery M&E Data Flow and Analysis

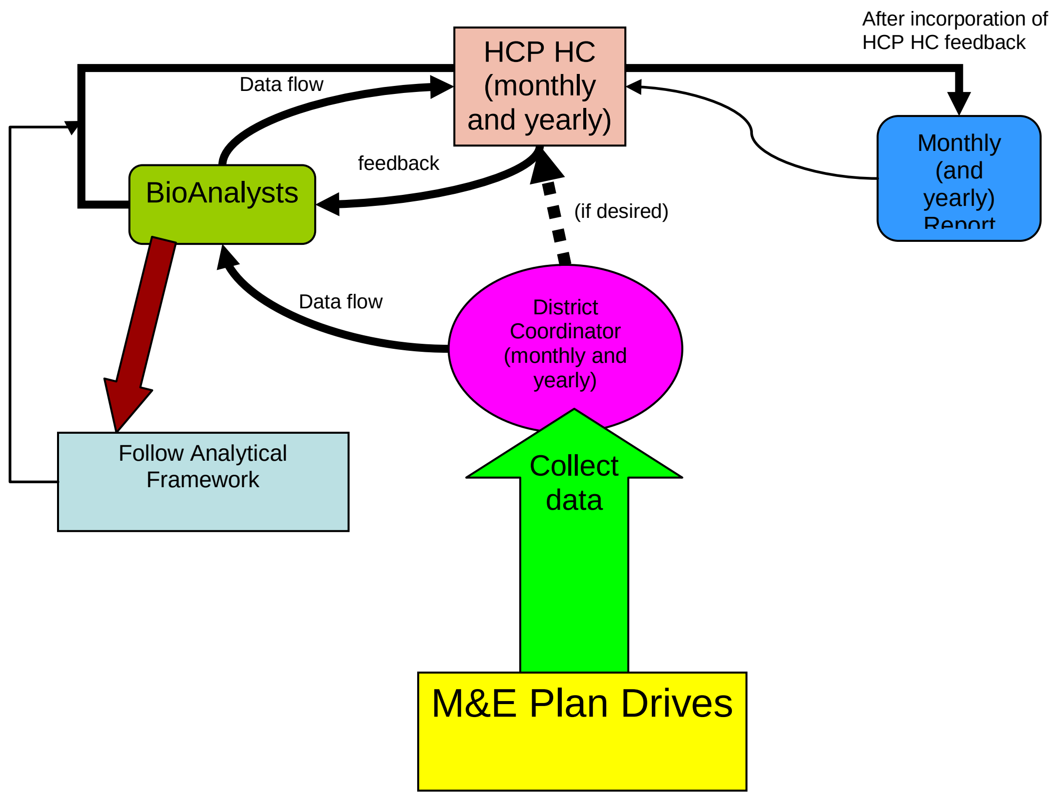

Figure 1: Diagrammatic view of data flow, subsequent analysis, and report review.

Table 1: Tasks by entity performing the tasks. The task and page numbers refer to the appendices within Murdoch and Peven (2005).

Objective	Hypothesis	Wenatchee spring Chinook	Wenatchee summer Chinook	Wenatchee Sockeye	Wenatchee Steelhead	Methow summer Chinook	Okanogan summer Chinook
1	**Hypothesis:** *Relative increase in spawners of supplemented stream is greater than non supplemented stream* **Methods:** Spawn Survey and Analysis	**WDFW, CPUD** Tasks: 7-1, 7-2 (p 88,89) **BioA** Tasks; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**CPUD** Tasks: 7-1, 7-2, 7-3, 7-4 (p 88-90) **BioA** Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**CPUD** Tasks: 7-1, (p 88) **BioA** Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**WDFW** Tasks: 7-1, 7-3, (p 88-90) **BioA** Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks:7-2, 7-7 through 7-9 (p 88-92)	**CCT** All Okanogan River Basin summer Chinook M&E activities will be conducted by CCT.[2]
1,2,3,4	**Hypothesis:** *NRR of supplemented stream is equal to that of non supplemented stream* **Methods:** Data Analysis	**BioA** Tasks: 8-1 through 8-4 (p 94, 95)	**BioA** Tasks: 8-1 through 8-4 (p 94, 95)	**BioA** Tasks: 8-1 through 8-4 (p 94, 95)	**BioA** Tasks: 8-1 through 8-4 (p 94, 95)	**BioA** Tasks: 8-1 through 8-4 (p 94, 95)	
2	**Hypothesis:** *Run timing, spawn timing, and redd distribution of supplemented fish is equal to that of naturally produced fish* **Methods:** Carcass survey/ broodstock collection/spawning survey/analysis	**WDFW** Tasks: 7-5, 7-7 (a and b), 7-8 (p 91,92); Tasks: 1-2 through 1-5 (p. 72, 73), 2-1 (p 74) **BioA** Tasks: 7-10 (p 93); and others as outlined above)	**CPUD** Tasks: 7-5, 7-7 (a and b), 7-8 (p 91,92) **WDFW** Tasks: 1-2 through 1-5 (p. 72, 73), 2-1 (p 74) **BioA** Tasks: 7-10 (p 93); and others as outlined above) **YN** Task: 1-4 (p 72, 73)	**CPUD** Tasks: 7-5, 7-7 (a and b), 7-8 (p 91,92) **WDFW** Tasks: 1-2 through 1-5 (p. 72, 73), 2-1 (p 74) **BioA** Tasks: 7-10 (p 93); and others as outlined above)	**WDFW** Tasks: 7-5, 7-7 (a and b), 7-8 (p 91,92) Tasks: 1-2 through 1-5 (p. 72, 73), 2-1 (p 74) **BioA** Tasks: 7-10 (p 93); and others as outlined above) **YN** Task: 1-4 (p 72, 73)	**WDFW** Tasks: 1-2 through 1-5 (p. 72, 73), 2-1 (p 74) **BioA** Tasks: 7-5, 7-7 (a and b), 7-8 (p 91,92) Tasks: 7-10 (p 93); and others as outlined above)	
3	**Hypothesis:** *No loss of within or between genetic variability; Size and age at maturity of hatchery fish is equal to that of naturally produced fish* **Methods:** Genetic monitoring	**WDFW** All tasks associated with Appendix H (p 96-99; except task 11)	**WDFW** All tasks associated with Appendix H (p 96-99; except task 11)	**WDFW** All tasks associated with Appendix H (p 96-99; except task 11)	**WDFW** All tasks associated with Appendix H (p 96-99; except task 11)	**WDFW** All tasks associated with Appendix H (p 96-99; except task 11)	

[2] Details of the CCT M&E plan are still under development. For planning purposes it is assumed that the activities performed in 2013 by the CCT will be consistent with objectives set forth in Murdoch and Peven (2005).

Objective	Hypothesis	Wenatchee spring Chinook	Wenatchee summer Chinook	Wenatchee Sockeye	Wenatchee Steelhead	Methow summer Chinook	Okanogan summer Chinook
3	**Hypothesis:** *Effective population size of supplemented stream increases in relation to spawning population* **Methods**: Genetic monitoring	**WDFW** Task 11, Appendix H (p 99, 100)	**WDFW** Task 11, Appendix H (p 99, 100)	**WDFW** Task 11, Appendix H (p 99, 100)	**WDFW** Task 11, Appendix H (p 99, 100)	**WDFW** Task 11, Appendix H (p 99, 100)	**CCT** All Okanogan River Basin summer Chinook M&E activities will be conducted by CCT.
4	**Hypothesis**: *HRR is greater than NRR* *HRR is equal or greater than expected value* **Methods:** Data Analysis	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	
5	***Hypothesis:*** *Stray rates of hatchery fish are less than 5%.* ***Methods:*** Spawning surveys/broodstock collection/PIT tag conversion rates/potentially other information as available	**BioA** Tasks: information from the relevant tasks outlined in Appendices B, C, D, and F	**BioA** Tasks: information from the relevant tasks outlined in Appendices B, C, D, and F	**BioA** Tasks: information from the relevant tasks outlined in Appendices B, C, D, and F	**BioA** Tasks: information from the relevant tasks outlined in Appendices B, C, D, and F	**BioA** Tasks: information from the relevant tasks outlined in Appendices B, C, D, and F	
6	**Hypothesis:** *Hatchery fish are released at programmed number and size* **Methods:** Monitoring and "real-time" reporting of hatchery operations	**WDFW** Tasks: 2-4 (p 74-76) Tasks: 5-1, 5-2, 5-4a and b (p 80, 81)	**WDFW** Tasks: 2-4 (p 74-76) Tasks: 5-1, 5-2, 5-4a and b (p 80, 81)	**WDFW** Tasks: 2-4 (p 74-76) Tasks: 5-1, 5-2, 5-4a and b (p 80, 81)	**WDFW** Tasks: 2-4 (p 74-76) Tasks: 5-1, 5-2, 5-4a and b (p 80, 81)	**WDFW** Tasks: 2-4 (p 74-76) Tasks: 5-1, 5-2, 5-4a and b (p 80, 81)	
7	**Hypothesis:** *Supplemented streams have equal ratio of smolts/redd than non*	**WDFW** Tasks 6-1 through 6-6 (p 83-85)	**WDFW** Tasks 6-1 through 6-6 (p 83-85)	**WDFW** Tasks 6-1 through 6-6 (p 83-85)	**WDFW** Tasks 6-1 through 6-6 (p 83-85)	**WDFW** Tasks 6-1 through 6-6 (p 83-85)[3]	

Objective	Hypothesis	Wenatchee spring Chinook	Wenatchee summer Chinook	Wenatchee Sockeye	Wenatchee Steelhead	Methow summer Chinook	Okanogan summer Chinook
	supplemented streams **Methods**: Smolt trapping/snorkel surveys/analysis	**BioA** Snorkel surveys consistent with previous years, as referenced in task 7-3 (p 86) Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92) Tasks: 7-1 through 7-3 (p 86, 87)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**BioA** Tasks: ensure 5-1b and 5-4d are consistently calculated, 5-5 through 5-7 (p 80-82) Ensure tasks 6-3-2 through 6-5 are calculated consistently (p 85) Tasks: 7-1 through 7-3 (p 86, 87) Tasks: 7-3-3 (c-e), 7-4-4 through 7-4-6; ensure 7-7 through 7-9 calculated consistently (p 89-92)	**CCT** All Okanogan River Basin summer Chinook M&E activities will be conducted by CCT.
8	***Hypothesis:*** *Harvest of hatchery fish is at or below the desired level to meet program goals* ***Methods:*** *Creel census*					**WDFW** Task: 5-4 c and d (p 81) Methodology outlined in separate document	

Outlined below are the schedules, locations, and general methodology of the tasks associated with implementing the M&E plan. These tasks are outlined by the eight objectives from Murdoch and Peven (2005). Detailed methodologies are provided in the appendices of Murdoch and Peven (2005).

1.2 ***PIT TAGGING NATURALLY PRODUCED FISH***

Naturally produced juvenile spring Chinook will be PIT tagged after being captured at the Chiwawa River smolt trap (≥4,000). Naturally produced juvenile steelhead were historically tagged at the Chiwawa, Nason, upper Wenatchee, and lower Wenatchee smolt traps, though annual sample sizes averaged only ~200 fish across all locations and failed to provide smolt or smolt to adult survival rates with acceptable precision (if any).

WDFW, CPUD, DPUD, USFWS, and YN have standardized their PIT tagging protocols for wild juvenile salmonids captured at screw traps. In doing so, we are also coordinating the activities between agencies for the capture and tagging of these fish such that efficient basin-wide approaches to tagging can be developed. For example, the current model has a single tagging crew working the majority of fish capture sites to standardize the tagging process and reduce cost. A standardized protocol was developed in 2006. This collaboration is fostering the coordination of data management and communication between agencies to facilitate analysis and assessment of Upper Columbia River fisheries management programs. Most importantly, the coordination with ongoing RME activities is allowing the deployment of in-stream PIT-tag detection antenna arrays in conjunction with current trapping and proposed tagging activities. The deployment of in-stream PIT-tag detection will maximize the information gathered from each tag deployed (in both hatchery and wild fish) by expanding the potential analysis beyond mainstem-based survival, transit, and return metrics.

On the White and Little Wenatchee rivers, CPUD and WDFW have installed additional arrays to detect natural and hatchery-origin adult sockeye returns, as well as juvenile steelhead and Chinook. These arrays are operational and are will provide return data for the 2013 Work Plan.

Information will be downloaded from remote arrays on roughly a weekly basis throughout the year. Data downloading will be conducted by WDFW and will be uploaded to PTAGIS. In 2009, the ISEMP arrays and CPUD White and Little Wenatchee river arrays were added to the PTAGIS system and PIT tag detection data are accessible through PTAGIS. Other local efforts may include development of other data sharing efforts and these will be evaluated by the HC prior to the PUD committing to use them.

PIT tagging of naturally produced fish may provide information on assessing survival for all life stages; (objectives 1 and 7 in Murdoch and Peven 2005) and straying (objective 5 in Murdoch and Peven 2005). PIT tagging of naturally produced fish is specified within Appendix E, Task 7 of Murdoch and Peven (2005). Subsequent analyses of seven years of tagging efforts have indicated which efforts provide viable data for comparisons. Additional detail will be outlined under each objective below.

The following tasks will be displayed by objective and not by entity performing the work.

2.0 *OBJECTIVE 1*

Determine if supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference stream) and the changes in the natural replacement rate (NRR) of the supplemented population is similar to that of the non-supplemented population.

2.1 *PIT TAGGING HATCHERY AND NATURALLY-PRODUCED FISH*

Under Objective 1, the main metric that will be derived will be natural replacement rate, or the rate at which naturally produced fish replace themselves (i.e., adult-to-adult survival or [Natural Origin Return (NOR)]/spawner). In the Upper Columbia River, two important components of adult-to-adult survival are smolt-to-smolt and smolt-to-adult survival rates. Large annual variation in either of these two life stages can result in vastly different estimates of adult returns. PIT tags provide a useful tool for estimating survival rates. Tags are inserted in juveniles during outmigration and detected during emigration and upon return as adults. Comparisons can be made between streams or between naturally and hatchery produced fish. Without tagged fish, the estimation of natural replacement rate will rely on less direct methods that could introduce a higher incidence of bias. More specifically, these estimates can be used to validate or compare against estimates derived from smolt traps.

2.2 *SPAWNING GROUND COUNTS*

2.2.1 Wenatchee and Chelan Summer/Fall Chinook

Summer Chinook redds will be enumerated from the onset of spawning (mid-September) through the end of spawning in November. Summer/fall Chinook spawn in the entire mainstem of the Wenatchee River, from the mouth to the lake (Table 4) and in the Chelan River (near the confluence with the Columbia). This work will be conducted by Chelan PUD in the summer and fall of 2013.

Table **2**: Designated survey reaches for summer Chinook spawning grounds on the Wenatchee River.

Code	Reach	River mile
W1	**Mouth to Sleepy Hollow Br**	**0.0-3.5**
W2	**Sleepy Hollow Br to L. Cashmere Br**	**3.5-9.5**
W3	**L. Cashmere Br to Dryden Dam**	**9.5-17.5**
W4	**Dryden Dam to Peshastin Br**	**17.5-20.0**
W5	**Peshastin Br to Leavenworth Br**	**20.0-23.9**
W6	**Leavenworth Br to Icicle Rd Br**	**23.9-26.4**
W7	**Icicle Rd Br to Tumwater Dam**	**26.4-30.9**
W8	**Tumwater Dam to Tumwater Br**	**30.9-35.6**
W9	**Tumwater Br to Chiwawa River**	**35.6-48.4**
W10	**Chiwawa River to Lake Wenatchee**	**48.4-54.2**

Chinook spawning ground surveys are conducted by foot, raft, or canoe. The most appropriate survey method selected for a given stream reach is based on stream size, flow, and density of spawners. Because of the broad stream width and high spawner densities, individual summer Chinook redds are not flagged. Each reach is surveyed approximately once per week, beginning the last week in September and ending the second-third week of November.

Peak and total redd count methodologies are used during the summer Chinook surveys (see Appendix F of Murdoch and Peven 2005 for more detail). A peak count is conducted by counting all visible redds (new and old) observed within a reach from week to week. The objective of the peak redd count methodology is to capture the apex of spawning activity over an entire spawning season. This apex occurs at different times between reaches during the season, (i.e., spawning begins sooner in the upstream reaches compared to the downstream reaches). The sum of all apex counts for the entire river is the peak redd count for the year. Peak counts provide an index of spawning. When comparing historic redd counts in the Wenatchee River with previous years, peak counts are needed.

A total redd count is conducted by counting or mapping only new or recently constructed redds within an area. Each new redd is drawn or mapped on aerial photos and enumerated. The objective of the total redd count methodology is to capture 1) "early" redds that may fade over time due to siltation or algae growth, 2) redds that become disfigured by superimposition (when new redds are constructed on top of previously existing redds), and 3) redds that become erased resulting from freshets. The total redd count methodology is more accurate than the peak redd count methodology, because the peak count methodology only accounts for visible redds each week during the survey season. For example, summer Chinook redds that were visible during the first week of spawning may not be visible during the third week; those redds would be missed in the third and subsequent redd counts. Using the total count methodology, the redds in the first week would be mapped and accounted for in subsequent weeks, even though they may fade at some point during future surveys.

Since it is not feasible to map all new redds within the entire river, an expansion is used to estimate a total count for the entire Wenatchee River. To account for the different spawning substrate types in the mainstem Wenatchee River, the river was delineated into ten distinct reaches (Table 5). Within each of these reaches, index areas have been identified as being representative areas of spawning activity. Peak counts are performed within each total reach as previously described, while mapping new redds only occurs within the index areas. Immediately after peak spawning within each index area, naïve observers survey all index and non-index areas within each respective reach. An expansion rate for non-index areas is developed based on the ratio of visible to mapped redds for each reach (i.e., each reach has its own expansion factor). The sum of the index and non-index expanded counts is an estimate of the total redds for that reach. Additional details are provided in Appendix F of Murdoch and Peven (2005).

In 2013-14, CPUD will also be monitoring the numbers of summer Chinook spawners in Icicle Creek, Nason Creek and the Chiwawa River. This summer chinook monitoring may be coordinated or re-distributed among other entities also performing spawning surveys for other species in the Icicle, Nason or Chiwawa rivers.

Table 3: Index (Mapping) Areas on the Wenatchee River.

Reach	Reach description	Distance (miles)	Mapping index area within reach
1	Sleepy Hollow Br to River Mouth	3.5	Sleepy Hollow Br to River Bend
2	Cashmere Br to Sleepy Hollow Br	6	Cashmere Br 2 to Old Monitor Br.
3	Dryden Dam to Cashmere Br	8	Dryden Dam to Williams Canyon
4	Peshastin Br to Dryden Dam	2.5	Peshastin Br to Dryden Dam
5	Leavenworth Br to Peshastin Br	3.9	Leavenworth Br to Irrigation Flume
6	Icicle Rd Br to Leavenworth Br	2.5	Icicle Mouth to Boat Takeout
7	Tumwater Dam to Icicle Rd Br	4.5	Penstock Br to Icicle Rd Br
8	Tumwater Br to Tumwater Dam	4.7	Tumwater Br to Swiftwater Campground
9	Old Plain Br to Tumwater Br	12.8	RR Tunnel to Swing Pool
10	Lake Wenatchee to Old Plain Br	5.8	Bridge to Swamp

2.2.2 Methow, and Okanogan Summer/Fall Chinook

BioAnalysts will perform summer Chinook spawning ground surveys in the Methow subbasins. These surveys will begin in late-September and continue through mid-November. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity. The CCT will conduct summer Chinook spawning ground surveys in the Okanagan basin.

Spawning ground surveys will be conducted via foot, raft, and from aircraft beginning late September and continuing until spawning has ended (usually mid-November). Frequency of surveys will vary depending on method. For ground counts (foot and raft), surveys will be conducted weekly; aerial surveys will be conducted intermittently with weekly surveys conducted during the peak spawning period (Table 6). During aerial surveys, one observer will report the numbers and locations of redds on topographic maps and the other will use a hand counter and record total number of redds within each sampling reach. Aerial surveys on the Methow River will not be conducted because past work has demonstrated that ground counts are more accurate than aerial surveys (Miller and Hillman 1998). Aerial surveys combined with weekly ground surveys will provide sufficient information to adequately describe the numbers, location, and time of spawning.

Table 4: Aerial and ground surveys scheduled for monitoring the abundance and distribution of summer Chinook salmon. Shaded portions indicate peak spawning periods.

Summer Chinook Salmon	**September**				**October**				**November**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Ground Surveys				X	X	X	X	X	X	X		
Aerial Surveys				X		X	X	X		X		

Ground surveys will be used to provide more accurate counts and a complete census of Chinook redds within their spawning distribution. Observers will float or walk through sampling reaches and record the location and numbers of redds each week. Observers will record the following information in field notebooks: date, sampling reach, water temperature, RKm, and a drawing of the habitat units where redds are located. Different symbols will be used for complete, incomplete, and test redds. Each redd will be given a unique number and its location will be recorded on a 7.5-minute topographic map.

To maintain consistency over time, at least one observer will survey the same stream reach on successive dates. Surveyor's tape may be used in some locations to mark redds and reduce the possibility of recounting older redds. In areas where numerous salmon spawn, surveyors will construct detailed maps of the river and use the cell-area method (Hamilton and Bergersen 1984) to identify the number of redds within each cell. Cells will be bounded by noticeable landmarks along the banks (e.g., bridges or trees) or at stream habitat boundaries (e.g., transitions between pools and riffles). The number of redds in each cell can then be recorded in the corresponding grid on the map. When possible, observers will estimate the number of redds in a large disturbed area by counting females that defend nests. It is assumed that the area or territory defended by a female is one redd and each female produces only one redd.

All major spawning areas within the Methow and Okanogan subbasins will be surveyed (Table 7). The appropriate summary analysis and reporting (with additional requirements) will remain consistent with previous years.

Table 5: Historical reach descriptions for summer Chinook spawning and carcass surveys in the Methow and Okanogan subbasins.

River	Reach	Code	RM
Methow	Mouth to Methow Bridge	M1	0.0-14.78
	Methow Bridge to Carlton Bridge	M2	14.78-27.17
	Carlton Bridge to Twisp Bridge	M3	27.17-39.55
	Twisp Bridge to MVID	M4	39.55-44.85
	MVID to Winthrop Bridge	M5	44.85-49.80
	Winthrop Bridge to Hatchery Dam	M6	49.80-51.55
Okanogan	Mouth to Mallot Bridge	O1	0.00-16.90
	Mallot Bridge to Okanogan Bridge	O2	16.90-26.05
	Okanogan Bridge to Omak Bridge	O3	26.05-30.70
	Omak Bridge to Riverside Bridge	O4	30.70-40.65
	Riverside Bridge to Tonasket Bridge	O5	40.65-56.82
	Tonasket Bridge to Zosel Dam	O6	56.82-77.35
Similkameen	Mouth to Oroville Bridge	S1	0.00-5.00
	Oroville Bridge to Enloe Dam	S2	5.00-8.85

2.2.3 *Wenatchee Spring Chinook*

WDFW will conduct spawning ground surveys for Wenatchee spring Chinook upstream of Tumwater Dam (Table 7.1) beginning in early August and continuing through September. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity. CPUD will conduct spawning and carcass surveys in Icicle and Peshastin Creeks.

Spawning ground surveys will be conducted via foot or raft, beginning in early August (prior to onset of spawning) and continuing until spawning has ended (end of September). Total ground counts will be conducted in historical spring Chinook spawning ground reaches (Table 4). Surveys will be consistent with methodologies detailed in Appendix F of Murdoch and Peven (2005). Surveys will be conducted at minimum, once a week; however, during periods of peak spawning, one and two person crews will survey each stream reach a minimum of twice a week. Each redd will be assigned a unique GPS waypoint, marked with surveyors flagging attached to nearby vegetation, and recorded in a field notebook. Each flag will be labeled with the appropriate reach and redd number, date, redd location, and the surveyor’s initials.

Table 6: Description of survey reaches for spring Chinook redds and carcasses in the Wenatchee Basin.

Stream	Code	Reach	River mile (RM)
Chiwawa River	C1	Mouth to Grouse Creek	0.0-11.7
	C2	Grouse Creek to Rock Creek	11.7-19.3
	C3	Rock Creek to Schaefer Creek	19.3-22.4
	C4	Schaefer Creek to Atkinson Flats	22.4-25.6
	C5	Atkinson Flats to Maple Creek	25.6-27.0
	C6	Maple Creek to Trinity	27.0-30.3
Rock Creek	R1	Mouth to End	0.0-0.5
Chikamin Creek	K1	Mouth to End	0.0-0.5
Nason Creek	N1	Mouth to Kahler Creek Bridge	0.0-3.9
	N2	Kahler Creek Bridge to Hwy 2 Bridge	3.9-8.3
	N3	Hwy 2 Bridge to Lower RR Bridge	8.3-13.2
	N4	Lower RR Bridge to Whitepine Creek	13.2-15.4
Little Wenatchee River	L2	Old Fish Weir to Lost Creek	2.7-5.2
	L3	Lost Creek to Rainy Creek	5.2-9.2
	L4	Rainy Creek to Falls	9.2-Falls
White River	H2	Sears Creek Bridge to Napeequa River	6.4-11.0
	H3	Napeequa River to Grasshopper Meadows	11.0-12.9
Napeequa River	Q1	Mouth to End	0.0-1.0
Panther Creek	T1	Mouth to End	0.0-0.7
Wenatchee River	W9	Tumwater Bridge to Chiwawa River	35.6-48.4
	W10	Chiwawa River to Lake Wenatchee	48.4-54.2
Icicle Creek	I1	Mouth to Boulder Block	0.0-4.0
Peshastin Creek	P1	Mouth to Camas Creek	0.0-5.9
	P2	Camas Creek to Mouth of Scotty Creek	5.9-16.3
Ingalls Creek	D1	Mouth to Trailhead	0.0-1.0

2.2.4 Wenatchee Sockeye

Sockeye escapement will be enumerated in the White River and Little Wenatchee using PIT tag detection arrays deployed in the tributaries. Carcass surveys will be conducted in both tributaries, with area-under-the-curve (AUC) calculations only being carried out for the Little Wenatchee. WDFW will operate the PIT-tag arrays and CPUD will conduct the redd counts. Data from the arrays will be uploaded to PTAGIS for subsequent analysis by CPUD. CPUD will also calculate the AUC escapement estimate from spawning ground surveys.

Table 7: Designated survey reaches for spawning ground areas on the Wenatchee, Little Wenatchee, White, and Nepeequa rivers for all sockeye.

Survey Section	River Mile
Little Wenatchee River	
Mouth to Old Fish Weir	0 – 2.7
Old Fish Weir to Lost Creek	2.7 – 5.2
Lost Creek to Rainey Creek	5.2 – 9.2
Rainey Creek to End	9.2 – End
White River	
Mouth to Sears Creek Bridge	0 – 6.4
Sears Creek Bridge to Napeequa River	6.4 – 11.0
Napeequa River to Grasshopper Meadows	11.0 – 12.9
Grasshopper Meadows to Falls	12.9 – 14.3
Napeequa River	
Mouth to End	0 - End

2.2.5 Wenatchee Steelhead

WDFW will conduct spawning ground surveys for Wenatchee summer steelhead beginning in early March and continuing through June. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

Spawning ground surveys will be conducted via foot or boat, beginning in early March and continuing until spawning has ended (as determined by WDFW) or river conditions (high muddy water) make it impossible to continue. Frequency of index area surveys will be weekly. All major spawning areas within the Wenatchee Basin will be surveyed (Table 8). Survey methodology (i.e., total redd counts based on expanding counts within the index areas), appropriate summary analysis, and reporting will remain consistent with previous years (e.g., see Tonseth 2006). A detailed description of the methodologies and relevant tasks (Task 7-3, 7-8, 7-9, and 7-10) can be found in Murdoch and Peven (2005). Survey efforts will primarily be concentrated in the upper Wenatchee basin because most returning adult hatchery fish were released as juveniles above Tumwater Dam. Peshastin Creek will be included in the surveys because it has been identified as a major steelhead spawning tributary. Steelhead spawning information for other tributaries not surveyed under this plan will be available through the ISEMP.

Table 8: Wenatchee subbasin spawning ground survey reaches and corresponding index areas for steelhead. Non-index areas are those areas that fall between or within the surveys reach that are not included in the index area.

Stream	Code	Reach	Index/reference area
Wenatchee River	W2	Sleepy Hollow Br. to Lower Cashmere Br.	Monitor boat ramp to Cashmere boat ramp
	W6	Leavenworth Bridge to Icicle Road Bridge	Leavenworth boat ramp to Icicle River
	W8	Tumwater Dam to Tumwater Bridge	Swiftwater boat ramp to Tumwater Bridge
	W9	Tumwater Bridge to Plain	Tumwater Bridge to Plain
	W10	Plain to Lake Wenatchee	Chiwawa pump station to Lake Wenatchee
Peshastin Creek	P1	Mouth to Camas Creek	Kings Bridge to Camas Creek
	P2A	Camas Creek to mouth of Scotty Creek	Ingalls Creek to Ruby Creek
	P2	Camas Creek to mouth of Scotty Creek	FR7320 to mouth of Shaser Cr.
Ingalls Creek	D1	Mouth to Trailhead RM 1.0	Mouth to Trailhead RM 1.0
	D2	Trailhead to Wilderness Boundary RM 1.5	Trailhead to Wilderness Boundary RM 1.5
Chiwawa River	C1	Mouth to Grouse Creek	Mouth to Road 62 Bridge RM 6.4
	C2	Grouse Creek to Rock Creek	Chikamin Creek to Log jam
Clear Creek	V1	Mouth to HWY 22	Mouth to HWY 22
	V2	HWY 22 to Lower culvert RM 2.0	HWY 22 to Lower culvert
Nason Creek	N1	Mouth to Kahler Creek Bridge	Mouth to Swamp Creek
	N3	HWY 2 Bridge to Lower R.R. Bridge	Highway 2 Bridge to Merrit Bridge
	N4	Lower R.R. Bridge to Whitepine Creek	Rayrock to Church camp
Icicle River	I1	Mouth to Hatchery	Mouth to Boulder Block
Little Wenatchee River	L2	Mouth to Lost Creek	Fish Weir to Lost Creek
	L3	Lost Creek to Rainy Creek Bridge	Lost Creek to Rainy Creek Bridge
White River	H2	Sears Cr. Bridge to Napeequa River	Riprap bank to Napeequa River
	H3	Napeequa River to mouth of Panther Creek	Napeequa River to Grasshopper Meadows.
Napeequa River	Q1	Mouth to RM 1.0	Mouth to RM 1.0

Total redd counts will be obtained by following the methods described in Murdoch and Peven (2005). Selected index areas, defined as likely spawning areas, will be surveyed at most, once a week. Redds are either individually flagged or in the case of localized mass spawning, mapped and numbered sequentially. When the end of spawning within an index area is thought to be nearly complete, a naïve observer will survey the index area to determine the number of redds still visible at the end of the spawning season. The unbiased proportion of redds (i.e., no previous knowledge of redd location and number) visible during this survey will be used as an expansion factor for non-index areas. Each index area expansion factor will be calculated by dividing the number of visible redds in the index during the survey by the total number of redds in the index area.

All non-index areas associated with each index area will also be surveyed near the end of spawning (i.e., ideally the same day in which the expansion factor was calculated). The total estimated number of redds in non-index areas will be calculated by dividing the number of redds found in the non-index area by the expansion factor for the corresponding index area. The reach total redd count will be calculated by combining the estimated number of redds in the non-index and the index area. An estimate of the total number of redds in each tributary will be calculated summing the reach totals.

2.3 ***PROTOCOLS FOR SPAWNING GROUND SURVEYS:***

2.3.1 Peak Counts-Summer Chinook Surveys

Upon arrival at the survey reach:

1) Turn on the GPS and after gaining satellite contact, verify the coordinates of the start or upstream point of the survey reach.
2) Use photographs as a secondary means to verify start point of the survey reach.
3) Record stream/river name, surveyor name(s), date, section, temperature (Celsius), and start time on a data card.
4) Mark start of the reach with flagging on the first survey of the year and replace if necessary during the survey season.
5) Search for redds as you move downstream.
6) Locate and evaluate redds, i.e., presence of a definite "pocket" and mound, clean gravel/cobble (algae/silt removed by spawning female), presence of spawning fish, position in stream (e.g., upstream end of a riffle), etc.
7) Using a tally counter, keep track of the number of redds (new and old) as you progress through each river section. **NOTE*:*** If a "scratch" or small patch of clean cobble/gravel is present (i.e. what appears to be the start of a redd), classify as a "test" redd. *Do not include in the redd count*.
8) At the end point of each section, record the redd count on the data card.
9) Re-set counters for next section, if applicable.
10) Refer to GPS to verify the end or downstream point of the survey reach; use photographs as a secondary means to verify the end point.
11) Mark end of the reach with flagging on the first survey of the year and replace if necessary during the survey season.
12) Repeat steps 1 through 11 for each reach surveyed in a day.
13) Repeat steps 1 through 12 for each survey day.
14) At the end of each day, tally up redd counts for each reach and write the total number on the data card.

2.3.2 Total Counts-Summer Chinook Surveys

The earliest spawning activity must be observed for the total redd count to be successful. Otherwise, these early redds could be missed if fading or superimposition occurs over a short time frame. Based on historical spawning ground data, surveyors should plan surveys in advance of the earliest, historical spawning activity.

1) Prior to the survey, obtain the series of maps for the river reach to be surveyed. If the maps are on Rite-in-the-Rain paper, take a sufficient number of colored lead pencils to map redds; if the maps are laminated, take a sufficient number of colored grease pencils to map redds.
2) Upon arrival at the "index" reach, turn on the GPS and after gaining satellite contact, verify the coordinates of the start or upstream point of the survey reach.
3) Use photographs as a secondary means to verify start point of the "index" reach.
4) Record stream/river name, surveyor name(s), date, section name, temperature (Celsius), and start time on a data card.
5) Mark start of the reach with flagging on the first survey of the year and replace if necessary during the survey season.
6) Survey for redds as you move downstream.
7) Locate and evaluate new redds, i.e., presence of a definite "pocket" and mound, clean gravel/cobble (algae/silt removed by spawning female), presence of spawning fish, position in stream (e.g. upstream end of a riffle), etc.
8) When redds are located, use the detailed maps to estimate the location and map the redd(s) in each section. The surveyor who is rowing must do his/her best to hold the raft in position so that the observer has sufficient time to evaluate the location and map the redd(s). "Complete" redds are depicted as a circle with an "x" in the middle. **NOTE:** If a "scratch" or small patch of clean cobble/gravel is present (i.e., what appears to be the start of a redd), classify as a "test" redd and map as an "incomplete" redd. Incomplete redds are depicted by a "x" only.
9) Repeat steps 2 through 8 for each reach surveyed in a day.
10) Repeat steps 1 through 9 for each survey day.
11) At the end of each day, following the survey, make copies of the original maps and keep them in a safe location at the shop. Continue to use the original maps in the field on subsequent surveys.
12) At the end of each day, complete a data sheet with date, reach name, number of old redds, number of new redds, and color of pencil used during the survey. **NOTE:** Use a different pencil color for each complete survey of the river. The surveyors will be able to determine when new redds were mapped on subsequent surveys based on the color used for a particular day.

2.4 *CARCASS SURVEYS*

2.4.1 Wenatchee Basin Carcass Surveys

Chelan PUD will conduct salmon carcass surveys for Wenatchee sockeye, Wenatchee summer Chinook, and Wenatchee spring Chinook beginning in August with spring Chinook and ending in November with summer Chinook consistent with Tasks 7-5,7-7 a, 7-7b, and 7-8 in Appendix F in Murdoch and Peven (2005). Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

WDFW will conduct carcass surveys on selected rivers from target populations and collect biological data from a representative sample (i.e., 20%) of the spawners as determined by spawner abundance and distribution (typically 100% of the carcasses encountered with exception of sockeye). Biological data will include collection of scale samples for age analysis, length measurements (POH and FKL), gender, egg voidance, and a check for tags or marks. DNA samples (five-hole punches from operculum) will be collected as needed to address different objectives. In order to ensure the carcass sample is representative, Chelan County PUD staff will provide redd abundance and distribution data to the WDFW at the beginning or end of the survey week. Chelan County PUD will also conduct spawning ground and carcass surveys on Peshastin and Icicle creeks. Biological data to be collected will include but not limited to those as outlined in Task 7-5b and 7-5c in Appendix F in Murdoch and Peven (2005). Descriptions of historical reaches surveyed by WDFW for spring Chinook (Table 9), summer Chinook (Table 10) and sockeye (Table 11) are listed below.

Table 9: Historical reach descriptions for spring Chinook carcass surveys in the Wenatchee Basin conducted by WDFW.

Stream	Reach	Code	Rivermile
Chiwawa River	Mouth to Grouse Creek	C1	0.0 - 11.7
	Grouse Creek to Rock Creek C.G.	C2	11.7 - 19.3
	Rock Cr. C.G. to Schaefer Cr. C.G.	C3	19.3 - 22.4
	Schaefer Creek C.G. to Atkinson Flats	C4	22.4 - 25.6
	Atkinson Flats to Maple Creek	C5	25.6 - 27.0
	Maple Creek to Trinity	C6	27.0 - 30.3
Little Wenatchee River	Old fish weir to Lost Creek	L2	2.7 - 5.2
	Lost Creek to Rainy Creek	L3	5.2 - 9.2
	Rainy Creek to Falls	L4	9.2 - Falls
Napeequa River	Mouth to End	Q1	0.0 - 1.0
Nason Creek	Mouth to Kahler Cr. Bridge	N1	0.0 - 3.9
	Kahler Cr. Bridge to Hwy.2 Bridge	N2	3.9 - 8.3
	Hwy.2 Bridge to Lower R.R.Bridge	N3	8.3 - 13.2
	Lower R.R. Bridge to Whitepine Cr.	N4	13.2 - 15.4
Panther Creek	Mouth to end	T1	0.0 - 0.75

Stream	Reach	Code	Rivermile
White River	Napeequa R. to Grasshopper Mdws.	H3	11.0 - 12.9
	Grasshopper Mdws. to Falls	H4	12.9 - 14.3
Wenatchee River	Tumwater Dam to Tumwater Bridge	W8	30.9 - 35.6
	Tumwater Bridge to Chiwawa River	W9	35.6 - 48.4
	Chiwawa River to Lake Wenatchee	W10	48.4 - 54.2
Chikamin Creek	Mouth to end	K1	0.0 - 0.5
Rock Creek	Mouth to end	R1	0.0 - 0.5
Big Meadow Creek	Mouth to Culvert	F1	0.0 - 0.5

Table 10: Historical reach descriptions for summer Chinook carcass surveys in the Wenatchee Basin.

Stream	Reach	Code	Rivermile
Wenatchee River	Mouth to Sleepy Hollow Bridge	W1	0.0 - 3.5
	Sleepy Hollow Br. to L. Cashmere Br.	W2	3.5 - 9.5
	L. Cashmere Br. to Dryden Dam	W3	9.5 - 17.5
	Dryden Dam to Peshastin Bridge	W4	17.5 - 20.0
	Peshastin Bridge to Leavenworth Bridge	W5	20.0 - 23.9
	Leavenworth Br. to Icicle Rd. Br.	W6	23.9 - 26.4
	Icicle Rd. Bridge to Tumwater Dam	W7	26.4 - 30.9
	Tumwater Dam to Tumwater Bridge	W8	30.9 - 35.6
	Tumwater Bridge to Chiwawa River	W9	35.6 - 48.4
	Chiwawa River to Lake Wenatchee	W10	48.4 - 54.2

Table 11**: Historical reach descriptions for sockeye carcass surveys in the Wenatchee Basin**

Stream	Reach	Code	Rivermile
Little Wenatchee River	Old fish weir to Lost Creek	L2	2.7 - 5.2
	Lost Creek to Rainy Creek	L3	5.2 - 9.2
	Rainy Creek to falls	L4	9.2 - Falls
Napeequa River	Mouth to End	Q1	0.0 - 1.0
White River	Mouth to Sears Cr. Bridge	H1	0.0 - 6.4
	Sears Cr. Bridge to Napeequa River	H2	6.4 - 11.0
	Napeequa R. to Grasshopper Mdws.	H3	11.0 - 12.9
	Grasshopper Mdws. to Falls	H4	12.9 - 14.3

2.4.2 Okanogan and Methow Basin Carcass Surveys

BioAnalysts will conduct summer Chinook carcass surveys in the Chelan and Methow subbasins beginning in September and ending in November, consistent with Tasks 7-5,7-7 a, 7-7b, and 7-8 in Appendix F in Murdoch and Peven (2005). The CCT will conduct summer Chinook carcass surveys in the Okanogan subbasin. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

BioAnalysts will conduct carcass surveys on the Chelan, Methow, Okanogan, and Similkameen, rivers and collect biological data from a representative sample (i.e., 20%) of spawners as determined by spawner abundance and distribution (typically 100% of the carcasses encountered in the Chelan, Methow and Okanogan, but not the Similkameen). Biological data to be collected will include but are not limited to those outlined in Task 7-5b and 7-5c in Appendix F in Murdoch and Peven (2005). Biological data will include collection of scale samples for age analysis, length measurements (POH and FKL), gender, egg voidance, and a check for tags or marks. DNA samples (five-hole punches from operculum) will be collected as needed to address different objectives. These data will be used to assess length-at-age, size-at-age, egg voidance, origin (hatchery or naturally produced), stray rates, and genetics. All carcass surveys will be conducted within the historical reaches (described in Table 7).

3.0 *OBJECTIVE 2*

Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

3.1 *DETERMINING RUN TIMING, SPAWN TIMING, AND SPAWNING DISTRIBUTION OF NATURAL AND HATCHERY FISH*

Artificially propagated fish should mimic natural origin fish in both run and spawn (maturation) timing. Adult collection protocols are designed to ensure appropriate representation of run timing in the broodstock. Maturation of hatchery and natural origin fish will be monitored in the broodstock and secondarily on the spawning grounds. Observed differences in these indicators would suggest that program methodologies be evaluated. Differences in redd distributions will be evaluated based the location that carcasses were recovered during spawning ground surveys. Alternatively, depending on the hatchery program and tributary, a more precise, although more labor intensive, indicator for redd distribution would involve determining the origin of actively spawning fish. Through the placement of a network of detection arrays, PIT tagging will add resolution to other measures of run and spawn timing as well as spawner distribution efforts,

3.2 *PIT TAGGING HATCHERY AND NATURALLY PRODUCED FISH*

PIT tagged returning adults can provide much needed information related to migration timing. As adult detection locations at dams and tributaries come online PIT data may provide information not only for migration timing, but spawn timing and distribution within or outside the Wenatchee Basin.

Information collected under other objectives (e.g., from carcass surveys, spawn timing, and distribution) will be used to assess whether this objective is successfully being implemented. Please refer to Section 5.0 Objective 4, and Table 15 therein for specific numbers of hatchery and natural origin species to be tagged.

4.0 *OBJECTIVE 3*

Determine if genetic diversity, population structure, and effective population size have changed in naturally spawning populations as a result of hatchery programs. Additionally, determine if hatchery programs have caused changes in the phenotypic characteristics of natural populations.

4.1 *GENETIC SAMPLING AND PHENOTYPIC CHARACTERISTICS*

Genotypes of hatchery and naturally produced populations will be sampled and monitored based upon the schedule outlined in Appendix H of the CPUD M&E Plan (Murdoch and Peven 2005). Priority of analysis will be based upon recovery needs and or relative risk a hatchery program may have on the naturally produced population as determined by the HCP Hatchery Committee. In 2012-13, Wenatchee summer Chinook are scheduled for genetic analyses consistent with Objective 3. Steelhead may also be evaluated, but this effort is expected to be a component of a larger reproductive success study that will be developed and approved by the HC outside of this workplan. The status of previous genetic studies is summarized in the 2007 M&E Final Report, but generally, spring Chinook and sockeye have been analyzed.

Differences in phenotypic characteristics that may arise as a result of hatchery programs (i.e., domestication) will be measured using historical (i.e., prior to current hatchery programs) and recent data collected from wild and hatchery broodstock or carcasses recovered on the spawning grounds. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

Specific methodologies related to DNA extraction and genetic analysis is available from the WDFW Genetics Lab and was not included in the M&E Plan. Appendix H of the M&E Plan outlines the methodology used in accomplishing this objective. Historical donor population samples (i.e., DNA collected from tissue or scales samples collected before hatchery programs) will be used to establish a genetic baseline for comparing against samples collected from current hatchery and naturally produced fish.

Data for monitoring phenotypic characteristics (i.e., age at maturity and size at maturity) will be collected annually as part of the broodstock collection protocol (Appendix B in Murdoch and Peven 2005). Broodstock for all programs are not collected randomly from the run at large with respect to sex, origin, or age. However, broodstock collection does provide a unique opportunity to collect data from a random sample from the run at large (i.e., those fish collected and passed upstream). Broodstock collection sites are located near or below a majority of the spawning locations (Table 12). All fish trapped or a random sample depending on the stock will be sampled to determine origin, age, and size. Based on broodstock collection protocols approved by the HC, WDFW and/or YN will collect biological data (i.e., species, sex, origin, marks or tags, scales, fork length, and POH) from fish trapped but not collected for broodstock. Collecting these data would ensure that a representative sample (including broodstock) from the run at large has been collected from all target populations.

Table 12: Broodstock collection locations for stock assessment and phenotypic characterization of hatchery and naturally produced fish.

Stock	Primary location	Secondary location
Chiwawa spring Chinook	Chiwawa Weir	Tumwater Dam
Wenatchee steelhead	Dryden Dam	Tumwater Dam
Wenatchee summer Chinook	Dryden Dam	Tumwater Dam
Methow summer Chinook *	Wells Dam	NA
Okanogan summer Chinook	Purse Seine	Wells Dam

* Methow summer Chinook activities funded through sharing agreement with Grant PUD (Carlton Program).

Genotypic data will be examined with a suite of tests to gather basic population information. For each sample we will test for Hardy-Weinberg equilibrium (genotypic proportions expected in a randomly mating population) and linkage disequilibrium using a computer program such as GENEPOP (Raymond and Rousset 1995). We will conduct several tests to evaluate differentiation among samples, such as genic and genotypic differentiation tests. Sample allele frequency divergence will be tested with pairwise "Fst" tests using a computer program such as FSTAT (Goudet 1995). Genetic distances (based on allele frequencies) calculated between all possible sample pairs will be evaluated using the computer program PHYLIP (Felsenstein 1993) to produce relational topologies, such as dendrograms or other "trees". We will use genetic distance measures in a correspondence analysis to produce three-dimensional plots using the computer program GENETIX (Belkhir et al. 2002). We will also assess the degree of differentiation among samples using the program STRUCTURE (Pritchard et al. 2000).

4.1.1 Adult Sampling at Wells, Dryden, and Tumwater dams

Data for monitoring run timing (Objective 2) and phenotypic characteristics (i.e., age and size at maturity) will be collected annually by WDFW or other contractor, as part of the broodstock collection protocol (Appendix B in Murdoch and Peven 2005). Broodstock for all programs are not collected randomly from the run at large with respect to sex, origin, or age. However, broodstock collection does provide a unique opportunity to collect data from a random sample from the run at large (i.e., those fish collected and passed upstream). Historically, information related to the spawning population was derived from broodstock, carcasses, or a combination of both. Recent data suggests that these methods are biased and additional sampling at broodstock collection sites is required (Zhou 2002). All steelhead not taken for broodstock will be sampled to determine origin, age, and size. From a random sample of summer Chinook and sockeye, we will collect data regarding origin, age, and size. Collecting these data would ensure that a representative sample from the run at large has been collected from all target populations. Spring Chinook stock assessment activities for Upper Wenatchee River Basin populations are currently being conducted at Tumwater Dam as part of the Spring Chinook Reproductive Success study.

4.1.2 Wenatchee Sockeye Stock Assessment

Beginning the third week of July through the third week of August, WDFW will randomly sample sockeye salmon captured at Tumwater Dam. Adults will be PIT-tagged to estimate spawning escapement and run-timing in conjunction with spawning ground surveys in the Little

Wenatchee River and carcass recovery on the Little Wenatchee, White, and Napequa rivers. If requested, a small tissue sample may be taken for genetic analysis.

4.1.3 Steelhead Stock Assessment-Dryden Dam

A comprehensive Wenatchee steelhead stock assessment throughout the run helps to address parts of these objectives. Systematic sampling of steelhead at Dryden Dam will provide an unbiased estimate of stock composition that will include fish origin, run-timing, age-at-maturity, and length-at-age for NORs and HORs from three potential parental crosses (HxH, HxW, and WxW).

Beginning the first week of July, WDFW will randomly sample summer steelhead captured at the Dryden Dam right and left bank trapping facilities. Summer steelhead run composition sampling will be conducted in conjunction with steelhead broodstock collection activities as outlined in the broodstock protocol (Appendix B in Murdoch and Peven 2005). Broodstock collected as part of the stock assessment will be PIT tagged in the pelvic girdle. This will ensure that broodstock can be included in the run timing analyses relative to age, size, and origin.

Beginning the first week of September and continuing through the end of November, the YN will sample all steelhead captured at the Dryden Dam facility that are not retained for broodstock. All steelhead sampled will be anaesthetized and examined for the presence of elastomer, coded-wire tags, and PIT tags. Steelhead not previously PIT tagged will be PIT tagged in the pelvic girdle. Data collected from each fish will include gender (for determination of sex ratio and spawning escapement), scales-for-age analysis (5 scales from each side), fork length and post-orbital to hypural length in centimetres, and origin (hatchery release group or natural). If requested, a small tissue sample may be taken for genetic analysis. Fish will be allowed to fully recover from the anaesthesia prior to release into the Wenatchee River.

4.1.4 Summer Chinook Stock Assessment-Dryden Dam

Beginning the first week of July through the end of August, WDFW will randomly sample summer Chinook salmon captured at the Dryden Dam right and left bank trapping facilities. Summer Chinook run composition sampling will be conducted in conjunction with summer Chinook broodstock collection activities as outlined in the broodstock protocol (Appendix B in Murdoch and Peven 2005). Broodstock collected as part of the stock assessment will be PIT tagged in the dorsal sinus. This will ensure that broodstock can be included in the run timing analyses relative to age and origin. WDFW may pursue broodstock collection earlier than July 1, however, this would be subject to Committee approval and must be authorized in Section 10 permit 1347. Currently, permit 1347 does not allow summer Chinook collection prior to July 1.

From the first week of September through the end of November, the YN will randomly sample summer Chinook salmon captured at the Dryden Dam left and right bank trapping facilities. Summer Chinook run composition sampling at Dryden Dam will be conducted in coordination with WDFW and consistent with steelhead broodstock collection activities. For consistency and to avoid biasing results late in the run, the proportions of summer Chinook sampled by YN will be determined by the proportions sampled by WDFW during July and August. Coordination of stock assessment activities between the two agencies will ensure that sampling methods are applied consistently.

All summer Chinook sampled will be anaesthetized and examined for the presence of marks or tags. Data collected from each fish will include gender (for determination of sex ratio and spawning escapement), scales-for-age analysis (5 from each side), fork length and post-orbital to hypural length in centimetres, and origin (hatchery release group or natural). If requested, a small tissue sample may be taken for genetic analysis. Fish will be allowed to fully recover from the anaesthesia prior to release into the Wenatchee River.

5.0 *OBJECTIVE 4*

Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate) is greater than the natural adult-to-adult survival (i.e., natural replacement rate) and equal to or greater than the program specific HRR expected value based on survival rates listed in the BAMP (1998).

5.1 *PIT TAGGING HATCHERY AND NATURALLY PRODUCED FISH*

Under objective 4, the rate at which hatchery fish return will be compared to both the naturally produced return rate. As such, CPUD will PIT tag and release hatchery fish (For ESA coverage descriptions, see Amended Permit 1196, Section A: Intentional Take; and Permit 1395, Section A: Intentional Take. The take proposed in this M&E workplan will also be approved by the NMFS Hatchery Committee representative through review and approval of this workplan). PIT tagging will occur on the following stocks and release locations presented in Table 13. By releasing spring Chinook and steelhead in the same streams that are proposed for tagging naturally produced fish, a direct comparison can be made within the supplemented and non-supplemented components of the subpopulations. Information collected under other objectives will be used to assess whether this objective is being met.

Table 13: Number of hatchery and naturally produced fish proposed for PIT tagging in 2013.

Species		Release location	Number tagged	
			Hatchery	Naturally Produced[1]
Spring Chinook		Chiwawa	5,000	≥ 4,000
Steelhead		Wenatchee Basin (CHIP Raceway)	10,000	N/A
		Wenatchee Basin (CHIP Reuse)	5,000	

* Additional PIT tagging may take place, consistent with HC-approved studies.

6.0 *OBJECTIVE 5*

Determine if the stray rate of hatchery plan species is below the acceptable levels to maintain genetic variation between stocks.

6.1 *CODED-WIRE TAGGING*

Except for steelhead, all hatchery fish released from the CPUD hatchery program are coded-wire tagged (CWT). As such, recovery of CWTs in various fisheries, hatcheries and on spawning grounds will be the primary tool for calculating stray rates.

6.2 *PIT TAGGING HATCHERY AND NATURALLY PRODUCED FISH*

Tagging both hatchery and naturally produced juveniles may enable us to better evaluate straying of adults. PIT tagging hatchery and naturally produced fish may help the HCP HC to determine if water-source modifications are decreasing the current rate of straying. By PIT tagging naturally produced fish, the HCP HC may be able to determine the fidelity of naturally produced fish, and compare that to the rates observed for hatchery fish. Please refer to section 5.1 and Table 13 above for the numbers of hatchery and natural origin tagged fish.

Information collected under other objectives will be used to assess whether this objective is being met.

7.0 *OBJECTIVE 6*

Determine if hatchery fish were released at the programmed size and number.

WDFW will conduct activities consistent with Tasks 2, 3, and 4 in Appendix C and Task 5-1, 5-2, and 5-4a and 5-4b of Appendix D in Murdoch and Peven (2005) as it relates to spawning operations, monitoring growth and health during rearing (including determining life stage survival rates), and determine if broodstock collections and in-hatchery survival was adequate to achieve number and size at release goals. The HCP outlines the number of fish from each program that are to be released. The length, weight, and coefficient of variation targets for each species and program are described in Table 3 of Appendix C in Murdoch and Peven (2005). The programmed size and number of fish for each program will be compared to actual values at release each year. The number of broodstock collected and the assumptions (i.e., sex ratio, fecundity, and survival) in the broodstock collection protocol are important components that need to be considered. A programs failure to meet the HCP standards (e.g., over or under program goals) will be evaluated taking into account the number of broodstock and other assumptions. WDFW Monitoring and Evaluation staff, in coordination with WDFW Fish Management staff will monitor broodstock collection activities as specified in Task 1-2 through 1-5 of Appendix B in Murdoch and Peven (2005). The size of juvenile fish will be compared using a representative sample collected immediately prior to release. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

The number and size of fish released will be calculated according to methodologies outlined in Appendix C of Murdoch and Peven (2005). An annual review of size and number of fish from each program will be compared to those values defined in the HCP. If release targets are not achieved then causation will be determined and recommendations will be made based upon the results of the evaluation. A review of the broodstock protocols will occur every five years (or more frequently if necessary).

8.0 *OBJECTIVE 7*

Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of smolts per redd) of supplemented streams when compared to non-supplemented streams.

8.1 *PIT TAGGING HATCHERY AND NATURALLY PRODUCED FISH*

The primary metric that will be estimated in objective 7 is freshwater productivity (i.e., smolt per redd). This will be accomplished in part by understanding the composition of hatchery and naturally produced fish on the spawning grounds. PIT tagged juveniles (hatchery and naturally produced) that survive as adults to the spawning grounds will be detected migrating into or out of selected tributaries and enable us to determine spawner composition (e.g., steelhead).

To estimate smolt-to-smolt, and smolt-to-adult survival rates, both hatchery and naturally produced fish may be PIT tagged and tracked throughout their life history.

The tagging effort may provide the District the ability to estimate both natural and hatchery return rates, which may aid in the evaluation of many of the objectives from Murdoch and Peven (2005). WDFW will be conducting PIT tagging in 2013 using the following protocols that are based on standard procedures followed throughout the region.

8.1.1 Protocols for PIT tagging:

1) Setup prior to tagging

a) Customize header information at start of season – save as a template header.
b) Open a PIT tag file for the tagging session with appropriate header info.
c) Complete computer set for compatibility, checking all technical components for proper operational use (digitizer board, portable reader/scanner, multiport, computer, and digitizer pen).
d) Fill fish handling isolation tanks/pans with fresh river water to appropriate levels, add MS-222 anesthetic (1.8 ml mixed solution per gallon of water) and a dash of pro-poly aqua fish conditioner (*mixed solution: 200 g Finquel per gallon water*).
e) Load PIT tag syringe needles with PIT tags (one pit-tag per needle); load enough sterile needles with tags for 100 fish.
f) A typical batch with one person tagging and one person digitizing would be approximately 10 fish.
g) Flush fecal matter from recovery/release buckets prior to beginning a tagging session.

h) Fill post tagging recovery/release buckets with fresh river water and make sure water is constantly running through pipe/pipes and into the recovery/release buckets.

2) Tagging Session procedures

a) The fish handler anesthetizing the fish to be tagged should dipnet with a sanctuary net, approximately 10 fish out of the holding tank and immediately place these fish into the pre-tagging anesthesia vessel. This is done properly by gently sliding the fish out of the dipnet and into the anesthesia.
b) Once the anesthetized fish begin showing signs of sedation (turning or rolling onto their sides), the fish need to be moved by aquarium nets into the tagging station vessels. The fish should be sedated enough to handle without excessive squirming.
c) The people tagging the fish then pick up fish by hand. The fish are gently rolled or turned upside down with the head of the fish facing towards the tagger. If you are right handed the fish would be in your left hand and the syringe needle with tag would be in your right hand.
d) The proper technique for tagging is to insert the needle at approximately a 45-degree angle perpendicular to the fish body just below the tip of the right pectoral fin.
e) Once the tip of the needle has broken the surface of the skin the needle should be inserted only far enough to insert the tag (about ¼ of an inch). The plunger on the syringe is then pushed forward to insert the tag. Immediately after tag insertion has occurred gently pull the needle out of the fish. Tagging demonstrations and the pit tag marking procedures manual will clarify any questions prior to actual study tagging.
f) Gently rub the incision to close the incision and insure the tag is fully inserted into the fish.
g) After the fish has been tagged the tagger immediately places the fish into the isolation pan for the person running the digitizer.
h) The used PIT tag needle, which is only used for one fish at a time, is then placed in a container of 60 – 70% isopropyl alcohol for a minimum of 10 minutes for sterilization and disinfecting purposes. The needle is actually stuck in a piece of foam that is soaked in the alcohol. The foam helps remove scales and any other residue from the tagging.
i) The digitizer person then takes the tagged fish and scans it through the portable tag scanner until the tag code registers on the computer screen. The fish is then placed on the digitizer board and fork length is taken. The species, stock of fish, and other pertinent characteristics may be programmed into the repeating comments or entered manually using the digitizer pen and digitizing board. Training will occur in demonstrations prior to and during fish studies**.** After the fish has been tagged and the digitizer has collected all pertinent data, the digitizer will place the fish in a bucket.
j) Avoid overlap between tagging batches as overlap may lead to fish being left in anesthesia for an extended period of time. All fish in a tagging batch should be sent to the recovery tanks prior to starting a new tagging batch. No fish should be left in anesthesia more than 5 minutes for the whole PIT tagging process. Avoid anesthetizing fish more than once.
k) When all the fish have been tagged, digitized, and are in the recovery/release buckets the PIT tag file may be closed.

l) Between tagging batches, needles that have been disinfected with alcohol need to be taken out of the alcohol, shaken out, and left to dry for a few minutes before loading new tags into the needles.
m) The fish handler bringing the fish into the tagging area from the holding tank needs to have good communication with the tagger and digitizer person at their station in order to keep a constant flow to this process to prevent overloads of fish or lag time between batches.
n) PIT tag needles should be changed whenever a dull needle is identified or after the needles have been used to tag 10-15 fish.
o) River water used in the initial anesthesia tank/pan for the initial knockdown of fish before tagging will be drained after each tagging batch. This is necessary because of dilution caused by sanctuary nets adding more water to the pan with each consecutive batch.
p) River water in all fish handling pans will be changed every 10 minutes due to potential increases in temperature. The standard of 10 minutes is a maximum; it may be necessary to change water more frequently as air temperature increases.
q) After each tagging session, all equipment (nets, boards, tagging and recovery vessels, etc.) is sanitized with a strong solution of iodine.

3) <u>Before Release of Fish to the River</u>

a) The recovery/release holding buckets need to be visually inspected for mortalities. If any mortalities are found they need to be removed from the tanks, recorded on the data sheets and taken back to the tagging sites for file editing. All shed tags need to be removed from the release buckets by using a turkey baster.
b) All shed tags or tags removed from mortalities need to be taken to the tagging sites, scanned and removed from the tagging file.
c) The proper release date and time will be entered in the proper file (Pacific Standard Time). Release temperature will also be updated and entered.
d) The file(s) should be correct now, export and validate the file, save the file to a disk, and the file is ready to be sent to PTAGIS.

8.1.2 <u>Juvenile Emigration Monitoring</u>

WDFW will install and operate rotary smolt traps in locations downstream from major spawning areas (Table 14) that allow for operation throughout the emigration period. Additionally they will collect daily environmental and biological data relative to each trapping location, conduct mark-recapture trails for target species to develop discharge/trap-efficiency linear-regression models to estimate daily trap efficiency, and estimate a daily migration population as outlined in tasks 6-1 through 6-4 in Appendix E of Murdoch and Peven (2005). Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

Identical methodologies used in calculating smolt production estimates are important when comparing supplemented and non-supplemented populations, as well as smolt production estimates with similar levels of precision. However, equally important is identical methodologies used in estimating the number of redds. Coordination among trap operators and spawning ground surveyors will be extremely important to ensure protocols, assumptions, and potential biases are similar.

Table 14: Population and location of smolt traps that may be used in examining the influence of hatchery fish on freshwater productivity. Some traps may be used for multiple species/populations in the table below.

Population	Status	Smolt trap	Size	Agency
Chiwawa spring Chinook	Treatment	Chiwawa	1 - 8 ft trap	WDFW
Wenatchee sockeye	Treatment	Upper Wen.	2 – 5 ft traps	WDFW
Wenatchee summer Chinook	Treatment	Lower Wen.	2 – 8 ft traps	WDFW
Wenatchee steelhead	Treatment	Lower Wen.	2 – 8 ft traps	WDFW
Chiwawa steelhead	Treatment	Chiwawa	1 - 8 ft trap	WDFW

Procedures for this objective are outlined in Appendix E of the M & E Plan. Juvenile monitoring requires an extensive trapping period (February to December, Table 15) over many successive generations due to the diverse life history of spring Chinook (subyearling and yearling emigrants) and summer steelhead. Random scale samples will be collected for all stocks with multiple age class smolts in order to calculate the number of smolts produced from each brood year.

At a minimum, fish are removed from the trap every morning (or more often based on run size, capture rate, and density within the live box) and placed in an anesthetic solution of MS-222. Fish are identified to species and counted. Non-target species will be allowed to fully recover in fresh water prior to being released in an area of calm water downstream from the smolt trap. Target species will be held in separate live boxes when needed for mark/recapture efficiency trials conducted in the evening.

Fish will be measured to the nearest millimeter (fork length, FL) and weight to the nearest 0.1 g. A Fulton type condition factor $[(W/FL^3) \times 1.0^5]$ is calculated for all target species. The degree of smoltification (parr, transitional, or smolt) is assessed by visual examination. Juvenile spring Chinook and steelhead will be classified as parr if parr marks are distinct, transitional if parr marks are not distinct, and smolts if parr marks are not visible and the fish exhibit a silvery appearance.

Mark/recapture efficiency trials will be conducted throughout the trapping season. The frequency of mark/recapture trials is dependent on the number of fish captured and the river discharge. These trials will be conducted over the widest range of discharge possible (interval depends on trap location). Fish for mark/recapture trials will be marked by clipping the tip of either the upper or lower lobe of the caudal fin. Chinook fry (e.g., FL < 50 mm) used in mark/recapture trials will be dyed using a Bismark brown solution. Fish will be placed in a live pen to recover for at least 8 h before being transported to the release site upstream of the trap. Marked fish will be distributed evenly on both sides of the river in pools or in calm pockets of water around boulders. Marked fish will be released between 1800 h and 2000 h. All recaptures of marked fish typically occur within 48 h after each trial. Emigration estimates will be calculated using estimated daily trap efficiencies derived from the regression formula using trap efficiency (dependent variable) and discharge (independent variable). Detailed methodologies and formulas used in calculating smolt production estimates are provided in Appendix E in Murdoch and Peven (2005).

Table 15: Schedule of activities for smolt monitoring programs in the Wenatchee Basin (D= data collection; A = data analysis).

Target population	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wenatchee steelhead	A	D	D	D	D	D	D	D	A	A	A	A
Chiwawa spring Chinook	A	D	D	D	D	D	D	D	D	D	D	A
Wenatchee summer Chinook	A	D	D	D	D	D	D	D	A	A	A	A

8.2 *SNORKEL SURVEYS*

BioAnalysts will use underwater observations (snorkeling) to estimate the abundance and distribution of juvenile spring Chinook within the Chiwawa subbasin during the month of August. Numbers of juvenile Chinook within specific reaches of the Chiwawa River will be compared to numbers of juvenile Chinook within matched reference areas in Nason Creek and the Little Wenatchee River. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

BioAnalysts' approach is consistent with the work that has been done in the Chiwawa subbasin during the past 14 years (see Hillman and Miller 2002 as referenced under Task 7-3a of Appendix E in Murdoch and Peven 2005). BioAnalysts will assess the abundance, distribution, habitat use, and total number of age-0 Chinook salmon in the basin during August using a stratified-random sampling design and direct underwater observations. In addition, BioAnalysts will estimate the abundance, distribution, habitat use, and size structure of other salmonids within the Chiwawa subbasin and reference areas.

Sampling will occur within randomly selected sites (habitat units) within each geomorphic stratum. Measurements needed to estimate water surface areas (lengths and widths) and water volumes (lengths, widths, and depths) will be taken at all habitat units of each habitat type. Snorkeling will occur on clear days between 1000 and 1800 hours. During snorkel surveys one to four observers (depending on stream width and water clarity) will estimate fish numbers in randomly selected sites. Snorkel methods will follow those described by Thurow (1994) and Dolloff et al. (1996).

Fish species will be grouped based on age and size. BioAnalysts will divide juvenile Chinook salmon into age-0 (<4 inches) and 1+ (≥4 inches) age groups, steelhead/rainbow into ages 0 (<4 inches), 1+ (4-8 inches), and those larger than 8 inches (in). Bull trout will be divided into two total-length size classes: juveniles (2-8 in) and adults (>8 in). For each bull trout observed, observers we will estimate its length and assign it to one of the size classes. Precision and accuracy will be repeatedly tested by having observers estimate under water the lengths of objects (e.g., sticks) of known size.

The following equations (Hillman et al. 1992) will be used to adjust snorkel counts of juvenile Chinook salmon and steelhead/rainbow for water temperatures recorded at each sampling site:

$Log_{10}N_t = Log_{10}N_s - 0.1t + 1.85$ (Chinook salmon),

$Log_{10}N_t = Log_{10}N_s - 0.2t + 1.85$ (age-0 steelhead/rainbow), and

$Log_{10}N_t = Log_{10}N_s - 0.1t + 2.01$ (age-1+ steelhead/rainbow),

where N_t is the population estimate, N_s is the snorkel count, and t is water temperature (^oC). There are no adjustments available for steelhead/rainbow larger than 8 inches or for bull trout.

For each habitat type within a stratum, mean density of salmon and trout will be calculated as the ratio of mean numbers to mean area sampled. There will be no estimate of variance for mean densities because there is no equation that calculates variance of ratios of two random variables (i.e., fish numbers and area sampled) if sample sizes are small (here, sample size refers to the number of habitat units sampled within a given habitat type). Total numbers of fish per habitat type within a stratum will be calculated as the product of mean density of fish in a given habitat type times total area of that habitat type within the stratum. Total numbers of fish in the Chiwawa River basin will be estimated as the sum of all population numbers per habitat type in state type/reach strata. Variances and percent errors (based on 95% confidence interval) for total numbers of fish will be calculated with equations for ratio estimation in stratified-random sampling designs described in Cochran (1977, pg. 150-172).

9.0 *OBJECTIVE 8*

Determine if harvest opportunities have been provided using hatchery returning adults where appropriate (e.g. Turtle Rock Program).

In years when the expected returns of hatchery adults are above the levels required to meet natural escapement and program goals (i.e., broodstock), surplus fish may be available for harvest. In years when harvest within the upper Columbia Basin does occur, WDFW will conduct statistically valid creel surveys in order to estimate the number of hatchery fish harvested. Harvest of returning adults is the goal of some programs (e.g., Turtle Rock summer Chinook) and ancillary benefits of other programs (e.g., Wenatchee and MEOK summer Chinook). Contribution to fisheries whether incidental or directed will be monitored using CWT recoveries on a brood year basis. Target harvest rates have not been outlined in the M & E Plan. Hence, a qualitative assessment of the contribution rates of hatchery fish to fisheries versus broodstock or spawning grounds will be used to determine if the objective has been met.

One approach, based on the goal of the hatchery program, is to compare CWT recoveries by recovery location (i.e., broodstock, fisheries, or spawning grounds). For example, a majority of the CWT recoveries for harvest augmentation programs should occur in fisheries. Conversely, supplementation programs should have a majority of the CWT recoveries occur on the spawning grounds. Monthly updates will summarize activities and results and will be sent to the District Coordinator within 10 days following the month of activity.

9.1 *CREEL CENSUS*

Robust statistically valid creel programs will be conducted for all sport fisheries in the Upper Columbia River to estimate harvest of hatchery fish from Chelan County PUD funded hatchery programs (Task 5-4c, and 5-4d of Appendix D in Murdoch and Peven 2005 and Appendix 2 in this report). Creel survey programs will be designed and implemented by WDFW Fish Management staff. Creel surveys in the Upper Columbia River are also an important component in calculating the HRR (Objective 4), because most CWT recoveries occur within the Upper Columbia River, the exception being summer Chinook. Significant time lags in reporting CWT recovery data to the Regional Marking Information System (RMIS) database requires a continual re-querying of recovery data until the number of estimated fish does not change. The number of fish and proportion by brood year for CWT recoveries will be summarized in several categories (Table 16).

Table 16: Categories for CWT recoveries of hatchery fish released from Chelan County PUD funded programs.

Category	Estimated number of fish (%)		
Broodstock	Total	Target stream	Nontarget streams
Spawning ground	Total	Target stream	Nontarget streams
Fisheries	Total	Commercial	Sport
Commercial	Ocean	Columbia River Treaty	Columbia River non-Treaty
Sport	Ocean	Columbia River	Terminal

9.2 *STATISTICAL ANALYSIS*

Variance estimates from the RMIS databases are currently not available. Harvest data will be summarized and a qualitative analysis with respect to program objectives will be conducted and reported.

10.0 *DATA ANALYSIS*

All analyses will follow the methods described in the analytical framework document (Hays et al. 2006), which is appended to this work plan as Appendix 1. Data analyses may be conducted by the entities performing the work described in this Plan (i.e., Chelan PUD, WDFW, Bioanalysts) or other contractors.

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APPENDIX O
MONITORING AND EVALUATION OF THE CHELAN COUNTY PUD HATCHERY PROGRAMS, 2011 ANNUAL REPORT

MONITORING AND EVALUATION OF THE CHELAN COUNTY PUD HATCHERY PROGRAMS

2011 ANNUAL REPORT

June 1, 2012

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TABLE OF CONTENTS

PREFACE

This annual report is the result of coordinated field efforts conducted by Washington Department of Fish and Wildlife (WDFW), the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), Chelan County Public Utility District (Chelan PUD), and BioAnalysts, Inc. An extensive amount of work was conducted in 2006 through 2011 to collect the data needed to monitor the effects of the Chelan County PUD Hatchery Programs. This work was directed and coordinated by the Habitat Conservation Plan (HCP) Hatchery Committee, consisting of the following members: Bill Gale, U.S. Fish and Wildlife Service (USFWS); Rob Jones and Craig Busack, National Marine Fisheries Service (NMFS); Joe Miller, Josh Murauskas, and Alene Underwood, Chelan County PUD; Tom Scribner and Keely Murdoch, the Yakama Nation; Mike Tonseth, WDFW; Kirk Truscott, Confederated Tribes of the Colville Reservation (Colville Tribes), and Mike Schiewe, Anchor QEA (Chair).

The approach to monitoring the hatchery programs was guided by the "*Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Programs*" (Murdoch and Peven 2005). Technical aspects of the monitoring and evaluation program were developed by the Hatchery Evaluation Technical Team (HETT), which consists of the following scientists: Carmen Andonaegui, Anchor QEA; Matt Cooper, USFWS; Steve Hays, Chelan PUD; Tracy Hillman, BioAnalysts; Tom Kahler, Douglas PUD; Russell Langshaw, Grant PUD; Greg Mackey, Douglas PUD; Joe Miller, Chelan PUD; Josh Murauskas, Chelan PUD, Andrew Murdoch, WDFW; Keely Murdoch, Yakama Nation; and Todd Pearsons, Grant PUD. The HETT developed an "*Analytical Framework for Monitoring and Evaluating PUD Hatchery Programs*" (Hays et al. 2006), which directs the analyses of hypotheses developed under the conceptual approach. Most of the analyses outlined in the Analytical Framework paper will be conducted in the five-year comprehensive reports.

Most of the work reported in this paper was funded by Chelan PUD. Bonneville Power Administration purchased the Passive Integrated Transponder (PIT) tags that were used to mark juvenile Chinook and steelhead captured in tributaries. This is the sixth annual report written under the direction of the HCP.

"I often say that when you can measure something and express it in numbers, you know something about it. When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science, whatever it may be."

Lord Kelvin

SECTION 1: INTRODUCTION

Chelan PUD implements hatchery programs as part of two Habitat Conservation Plan (HCP) agreements related to the operation of Rocky Reach and Rock Island Hydroelectric Projects. The HCPs define the goal of achieving no net impact to spring Chinook, summer/fall Chinook, sockeye salmon, steelhead, and coho salmon affected by the operation of these projects. The two HCPs identify general program objectives as "*contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest*." The fish resource management agencies initially developed the following general goal statements for each hatchery program, which were adopted by the Hatchery Committee:

(1) Support the recovery of ESA listed species by increasing the abundance of natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.

Includes the Wenatchee spring Chinook, Wenatchee summer steelhead, and Methow spring Chinook programs.

(2) Increase the abundance of the natural adult population of unlisted plan species, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity. In addition, provide harvest opportunities in years when spawning escapement is sufficient to support harvest.

Includes the Wenatchee sockeye, Wenatchee summer/fall Chinook, Methow summer/fall Chinook, Okanogan summer/fall Chinook, and Okanogan sockeye programs.

(3) Provide salmon for harvest and increase harvest opportunities, while segregating returning adults from natural tributary spawning populations.

Includes the Turtle Rock summer/fall Chinook program.

Thus, there are two different types of artificial propagation strategies that address the different goals of the program: supplementation and harvest augmentation. The supplementation programs primarily focus on increasing the natural production of fish in tributaries. A fundamental assumption of this strategy is that hatchery fish returning to the spawning grounds are "reproductively similar" to naturally produced fish. The second program type, harvest augmentation, focuses on increasing harvest opportunities. This is accomplished by releasing hatchery fish directly into the Columbia River with the intent that returning adults remain segregated from the naturally spawning populations in tributaries.

Monitoring is needed to determine if the programs are performing properly. The HCP Hatchery Committee adopted a monitoring and evaluation (M&E) approach that will guide the assessment of the hatchery programs. The approach, developed by Murdoch and Peven (2005), identified the following objectives:

(1) Determine if supplementation programs have increased the number of naturally spawning and naturally produced adults of the target population relative to a non-supplemented population (i.e., reference stream) and the changes in the natural

replacement rate (NRR) of the supplemented population is similar to that of the non-supplemented population.

(2) Determine if the run timing, spawn timing, and spawning distribution of both the natural and hatchery components of the target population are similar.

(3) Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

(4) Determine if the hatchery adult-to-adult survival (i.e., hatchery replacement rate or HRR) is greater than the natural adult-to-adult survival (i.e., natural replacement rate or NRR) and equal to or greater than the program-specific HRR expected value based on estimated survival rates listed in Appendix D in Murdoch and Peven(2005).

(5) Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

(6) Determine if hatchery fish were released at the programmed size and number.

(7) Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams.

(8) Determine if harvest opportunities have been provided using hatchery returning adults where appropriate (e.g., Turtle Rock program).

Two additional objectives that were not explicit in the goals specified above but were included in the M&E approach because they relate to goals and concerns of all artificial production programs include:

(9) Determine whether bacterial kidney disease (BKD) management actions lower the prevalence of disease in hatchery fish and subsequently in the naturally spawning population. In addition, when feasible, assess the transfer of *Renibacterium salmoninarum* (Rs) infection at various life stages from hatchery fish to naturally produced fish.

(10) Determine if the release of hatchery fish impact non-target taxa of concern (NTTOC) within acceptable limits.

Attending each objective is one or more testable hypotheses (see Murdoch and Peven 2005). Each hypothesis will be tested statistically following the routines identified in Hays et al. (2006). Most of these analytical routines will be conducted at the end of five-year monitoring blocks, as outlined in the M&E plan (Murdoch and Peven 2005; Hays et al. 2006).

Throughout each five-year monitoring period, annual reports will be generated that describe the M&E data collected during a specific year. This is the sixth annual report developed under the direction of the M&E guidance approach (Murdoch and Peven 2005). The purpose of this report is to describe monitoring activities conducted in 2011. Activities included broodstock collection, collection of life-history information, within hatchery spawning and rearing activities, juvenile monitoring within streams, and redd and carcass surveys. Data from reference areas are not included in this annual report (reference data are in the five-year reports). To the extent currently possible, we have included information collected before 2011.

This report is divided into several sections, each representing a different species or stock (i.e., steelhead, sockeye salmon, spring Chinook, and summer Chinook). For all species we provide broodstock information; hatchery rearing history, release data, and survival estimates; disease information; juvenile migration and productivity estimates; redd counts, distribution, and spawn timing; spawning escapements; and life-history characteristics. For salmon species, we also provide information on carcasses.

Finally, we end each section by addressing compliance issues with ESA/HCP mandates. For each Chelan PUD Hatchery Program, WDFW and the PUD are authorized annual take of ESA-listed spring Chinook and steelhead through Section 10 of the Endangered Species Act (ESA), including:

1. ESA Section 10(a)(1)(A) Permit No. 1395, which authorizes the annual take of adult and juvenile endangered upper Columbia River (UCR) spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs for the enhancement of UCR steelhead. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, monitoring and evaluation activities, and management of adult returns related to UCR steelhead artificial propagation programs in the UCR region (NMFS 2003a).
2. ESA Section 10(a)(1)(A) Permit No. 1196, which authorizes the annual take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead associated with implementing artificial propagation programs for the enhancement of UCR spring Chinook. The authorization includes takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities supporting UCR spring Chinook artificial propagation programs in the UCR region (NMFS 2004).
3. ESA Section 10(a)(1)(A) Permit No. 1347, which authorizes the annual incidental take of adult and juvenile endangered UCR spring Chinook and endangered UCR steelhead through actions associated with implementing artificial propagation programs for the enhancement of non-listed anadromous fish populations in the UCR. The authorization includes incidental takes associated with adult broodstock collection, hatchery operations, juvenile fish releases, and monitoring and evaluation activities associated with non-listed summer Chinook, fall Chinook, and sockeye salmon artificial propagation programs in the UCR region (NMFS 2003b).

SECTION 2: SUMMARY OF METHODS

Sampling in 2011 followed the methods and protocols described in Murdoch and Peven (2005). In this section we only briefly review the methods and protocols. More detailed information can be found in Murdoch and Peven (2005).

2.1 Broodstock Collection and Sampling

Methods for collecting broodstock are described in the Annual Broodstock Collection Protocols (Appendix A in WDFW 2011). Methods for sampling broodstock are described in Appendices A and B in Murdoch and Peven (2005). Generally, broodstock were collected over the migration period (to the extent allowed in ESA-permit provisions) in proportion to their temporal occurrence at collection sites, with in-season adjustments dictated by 2011 run timing and trapping success relative to achieving weekly and annual collection objectives. Pre-season weekly collection objectives are shown in Table 2.1 and assumptions associated with broodstock trapping are provided in Table 2.2.

Table 2.1. Weekly collection objectives for steelhead, sockeye, and Chinook in 2011.

Collection week beginning day	Chiwawa Spring Chinook[a]		Wild Wenatchee Summer Chinook	Wild ME/OK Summer Chinook	Wenatchee Steelhead		Wild Wenatchee Sockeye[b]	
	Hatchery	Wild			Hatchery	Wild	Male	Female
5 June		2						
12 June	2	6						
19 June	4	15						
26 June	7	13	40	89				
3 Jun	8	11	54	84	1	1	24	24
10 Jul	14	10	54	80	1	1	55	55
17 Jul	24	11	80	69	2	2	30	30
24 Jul	25	7	90	59	2	2	9	9
31 Jul	8	3	60	43	3	3		
7 Aug			60	40	4	4		
17 Aug			33	25	4	4		
21 Aug			18	23	4	4		
28 Aug				9	4	4		
4 Sep				6	4	4		
11 Sep					4	4		
18 Sep					4	4		
25 Sep					7	7		
2 Oct					10	9		
9 Oct					5	5		
16 Oct					5	4		
23 Oct					2	2		
Total	**92**	**76**	**489**	**527**	**66**	**64**	**118**	**118**

[a] Collection quota based on 1999-2010 average cumulative Tumwater Dam spring Chinook passage (WDFW unpublished data) and pre-season broodstock collection objectives.

[b] Collection targeted equal numbers of males and females.

Table 2.2. Biological and trapping assumptions associated with collecting broodstock for the Chelan PUD Hatchery Programs (from Appendix A in Murdoch and Peven 2005).

Assumptions	Wenatchee Steelhead	Wenatchee Sockeye	Chiwawa Spring Chinook	Wenatchee Summer Chinook	ME/OK Summer Chinook
Production level	400,000 yearling smolts	200,000 subyearlings	672,000 yearling smolts	864,000 yearling smolts	976,000 yearling smolts
Broodstock required	208 adults (not to exceed 33% of population)	260 adults (not to exceed 33% of population)	379 adults (not to exceed 33% of population)	492 adults (not to exceed 33% of the population)	556 adults (not to exceed 33% of the population)
Trapping period	7 July – 12 Nov	7 July – 28 Aug	1 May – 12 Sep	7 Jul – 12 Sep	7 Jul – 15 Sep
# days/week	5	3	4	5	3
# hours/day	24	16	24	24	16
Broodstock composition	50% wild; 50% WxW and/or HxW	100% wild	Sliding scale; minimum 33% wild (depends on the number of wild fish)	100% wild	100% wild
Trapping site	Dryden Dam (Tumwater will be used if weekly quota not achieved at Dryden Dam)	Tumwater Dam	Tumwater Dam (hatchery fish only) and the Chiwawa Weir (both hatchery and wild fish)	Dryden Dam (Tumwater will be used if weekly quota not achieved at Dryden Dam)	Wells Dam east ladder

Several biological parameters were measured during broodstock collection at adult collection sites. Those parameters included the date and start and stop time of trapping; number of each species collected for broodstock; origin, size, and sex of trapped fish; age from scale analysis; and pre-spawn mortality. For each species, trap efficiency, extraction rate, and trap operation effectiveness were estimated following procedures in Appendix B in Murdoch and Peven (2006). In addition, a representative sample of most species trapped but not taken for broodstock were sampled for origin, sex, age, and size (stock assessment). All steelhead trapped were sampled.

2.2 Within Hatchery Monitoring

Methods for monitoring hatchery activities are described in Appendix C in Murdoch and Peven (2005). Biological information collected from all spawned adult fish included age at maturity, length at maturity, spawn timing, and fecundity of females. In addition, all fish were checked for tags and females were sampled for disease.

Throughout the rearing period in the hatchery, fish were sampled for growth, health, and survival. Each month, lengths and weights were collected from a sample of fish and rearing density indices were calculated. In addition, fish were examined monthly for health problems following standard fish health monitoring practices for hatcheries. Various life-stage survivals were estimated for each hatchery stock. These estimates were then compared to the "standard" survival rates identified in Table 2.3 to provide insight as to how well the hatchery operations were performing. Failure to achieve a survival standard could indicate a problem with some part of the hatchery program. However, failure to meet a standard may not be indicative of the overall success of the program to meet the goals identified in Section 1.

Table 2.3. Standard life-stage survival rates for fish reared within the Chelan PUD hatchery programs (from Appendix C in Murdoch and Peven 2005).

Life stage	Standard survival rate (%)
Collection-to-spawning (females)	90
Collection-to-spawning (males)	85
Unfertilized egg-to-eyed	92
Unfertilized egg-to-ponding	98
30 d after ponding	97
100 d after ponding	93
Ponding-to-release	90
Transport-to-release	95
Unfertilized egg-to-release	81

Nearly all hatchery fish from each stock were marked (adipose fin clip) or tagged (coded-wire tag or elastomer tag). Different combinations of marks and tags were used depending on the stock. In addition, Chelan PUD personnel PIT tagged about 5,100 juvenile hatchery spring Chinook in June and about 30,300 steelhead (10,101 steelhead in the Chiwawa Circular Pond and 20,220 in Blackbird Pond) during September. They also tagged about 5,103 juvenile sockeye in late June. No summer Chinook were PIT tagged in 2011. PIT tags will be used to estimate migration timing and survival rates (e.g., smolt-to-adult) outside the hatchery.

Lastly, the size and number of fish released were assessed and compared to programmed production levels. The goal of the program is that numbers released and their sizes should fall within 10% of the programmed targets identified in Table 2.4. However, because of constraints due to run size and proportions of wild and hatchery adults, production levels may not be met every year.

Table 2.4. Targets for fish released from the Chelan PUD hatchery programs; CV = coefficient of variation (from Appendix C in Murdoch and Peven 2005).

Hatchery stock	Release targets	Size targets		
		Fork length (CV)	Weight (g)	Fish/pound
Wenatchee Summer Chinook	864,000	176 (9.0)	45.4	10
Okanogan Summer Chinook	576,000	176 (9.0)	45.4	10
Methow Summer Chinook	400,000	176 (9.0)	45.4	10
Turtle Rock Summer Chinook (yearlings)	200,000	176 (9.0)	45.4	10
Turtle Rock Summer Chinook (subyearlings)	1,620,000	112 (9.0)	11.4	40
Chiwawa Spring Chinook	672,000	176 (9.0)	37.8	12
Wenatchee Sockeye	200,000	133 (9.0)	22.7	20
Wenatchee Steelhead	400,000	198 (9.0)	75.6	6

2.3 Juvenile Sampling

Juvenile sampling within streams included operation of rotary smolt traps, snorkel observations, and PIT tagging. Methods for sampling juvenile fish are described in Appendix E in Murdoch and Peven (2005).

A smolt trap was located on the Wenatchee River about 0.5 km downstream from the mouth of Lake Wenatchee (Upper Wenatchee Trap) and in the Chiwawa River about 1 km upstream from the mouth (Chiwawa Trap). All traps operated throughout the smolt migration period. The Chiwawa Trap operated throughout most of the year (March through November), but not during icing or extreme high flow conditions. The following data were collected at each trap site: water temperature, discharge, number and identification of all species captured, degree of smoltification for anadromous fish, presence of marks and tags, size (fork lengths and weights), and scales from steelhead and sockeye salmon smolts. Trap efficiencies at each trap site were estimated by using mark-recapture trials conducted over a wide range of discharges. Linear regression models relating discharge and trap efficiencies were developed to estimate daily trap efficiencies during periods when no mark-recapture trials were conducted. The total number of fish migrating past the trap each day was estimated as the quotient of the daily number of fish captured and the estimated daily trap efficiency. Summing the daily totals resulted in the total emigration estimate.

Snorkel observations were used to estimate the number of juvenile spring Chinook salmon, juvenile rainbow/steelhead, and bull trout within the Chiwawa River Basin. The focus of the study was on juvenile spring Chinook salmon. Sampling followed a stratified random design with proportional allocation of sites among strata. Strata were identified based on unique combinations of geology, land type, valley bottom type, stream state condition, and habitat types. A total of 187 randomly selected sites were surveyed during August (Table 2.5). Counts of fish within each sampling site were adjusted based on detection efficiencies, which were related to water temperature. That is, non-linear models that described relationships between water temperatures and detection efficiencies (Hillman et al. 1992) were used to estimate total numbers of fish within sampling sites. These numbers were then converted to densities by dividing total fish numbers by the wetted surface area and water volume of sample sites. Total numbers within a stratum were estimated as the product of fish densities times the total wetted surface or water volume for the stratum. The sum of fish numbers across strata resulted in the total number of fish within the basin. The calculation of total numbers, densities, and degrees of certainty are fully explained in Hillman and Miller (2004).

Working in collaboration with the Comparative Survival Study (CSS) funded by Bonneville Power Administration (BPA), crews PIT tagged juvenile wild Chinook, wild and hatchery steelhead, and wild sockeye salmon collected at the Upper Wenatchee and Chiwawa smolt traps. The proposed number of wild spring Chinook and steelhead to be tagged at each location is provided in Table 2.6. The goal of this work was to better understand the life-history characteristics of fish in the Wenatchee Basin and to estimate SARs. This in turn improves the ability to detect potential effects of the hatchery program on wild fish.

Table 2.5. Location of strata and numbers of randomly sampled sites within each stratum that were sampled in the Chiwawa River Basin in 2011.

Reach/stratum	River kilometers (RKm)	Number of randomly selected sites
Chiwawa River		
1	0.0-6.1	11
2	6.1-8.9	5
3	8.9-12.7	8
4	12.7-14.3	6
5	14.3-17.4	5
6	17.4-19.0	6
7	19.0-32.2	27
8	32.2-40.9	23
9	40.9-46.4	11
10	46.4-50.1	10
Phelps Creek		
1	0.0-0.6	1
Chikamin Creek (includes Minnow Creek)		
1	0.0-1.5	28
Rock Creek		
1	0.0-1.2	11
Peven Creek (unnamed stream on USGS map)		
1	0.0-0.1	1
Big Meadow Creek		
1	0.0-1.6	7
Alder Creek		
1	0.0-0.1	4
Brush Creek		
1	0.0-0.1	2
Clear Creek		
1	0.0-0.1	3

Table 2.6. Number of wild spring Chinook and steelhead proposed for tagging at different locations within the Wenatchee Basin, 2011.

Sampling location	Target sample size	
	Wild spring Chinook	Wild steelhead
Chiwawa Trap	2,500-8,000	500-2,000
Upper Wenatchee Trap	500-1,000	50-250
Total	**3,000-9,000**	**550-2,250**

Survival rates for various juvenile life-stages were calculated based on estimates of seeding levels (total egg deposition), numbers of parr, numbers of emigrants, and numbers of smolts. Total egg deposition was estimated as the product of the number of redds counted in the basin times the mean fecundity of female spawners. Fecundity was estimated from females collected for broodstock using an electronic egg counter. Numbers of emigrants and smolts were estimated at trapping sites and numbers of parr were estimated using snorkel observations only in the Chiwawa Basin. Survival estimates could not be calculated for some stocks (e.g., summer Chinook) because specific life-stage abundance estimates were lacking.

2.4 Spawning/Carcass Surveys

Methods for conducting carcass and spawning ground surveys are detailed in Appendix F in Murdoch and Peven (2005). Information collected during spawning surveys included spawn timing, redd distribution, and redd abundance. Data collected during carcass surveys included sex, size (fork length and postorbital-to-hypural length), scales for aging[1], degree of egg voidance, DNA samples, and identification of marks or tags. The sampling goal for carcasses was 20% of the spawning population. Crews also conducted snorkel surveys to assess the incidence of precocial fish spawning naturally in streams.

Both redd and carcass surveys were conducted in reaches that encompassed the spawning distribution of most populations. Steelhead surveys were the exception. These surveys were conducted within major spawning areas in the basin and therefore may not capture the entire spawning distribution of the population. Steelhead surveys were conducted during March through June in reaches and index areas described in Table 2.7. Total redd counts were estimated by expanding counts within non-index areas by expansion factors developed within index areas.

[1] In this report we use two methods of describing age. One is termed the "European Method." This method has two digits, separated by a period. The first digit represents the number of winters the fish spent in freshwater before migrating to the sea. The second digit indicates the number of winters the fish spent in the ocean. For example, a fish designated as 1.2 spent one winter in freshwater and two in the ocean. A fish designated as 0.3 migrated to the ocean in its first year and spent three winters in the ocean. The other method describes the total age of the fish (egg-to-spawning adult, i.e., gravel-to-gravel), so fish demarcated as 0.3 or 1.2 are considered 4-year-olds, from the same brood.

Table 2.7. Description of reaches and index areas surveyed for steelhead redds in the Wenatchee Basin.

Stream	Code	Reach	Index/reference area
Wenatchee River	W2	Sleepy Hollow Br to L. Cashmere Br	Monitor Boat Rmp to Cashmere Boat Rmp
	W6	Leavenworth Br to Icicle Rd Br	Leavenworth Boat Ramp to Icicle Ck
	W8	Tumwater Dam to Tumwater Br	Swift Boat Ramp to Tumwater Br
	W9	Tumwater Br to Chiwawa R	Tumwater Br to Plain
	W10	Chiwawa R to Lk Wenatchee	Chiwawa Pump St. to Lk Wenatchee
Peshastin Creek	P1	Mouth to Camas Cr	Kings Br to Camas Cr
	P2A	Camas Cr to Mouth of Scotty Cr	Ingalls Cr to Ruby Cr
	P2	Camas Cr to Mouth of Scotty Cr	FR7620 to Shaser Cr
Ingalls Creek	D1	Mouth to Trailhead RM 1	Mouth to Trailhead RM 1
	D2	Trailhead to Wilderness Bd RM 1.5	Trailhead to Wilderness Bd RM 1.5
Chiwawa River	C1	Mouth to Grouse Cr	Mouth to Rd 62 Br RM 6.4
	C2	Grouse Cr to Rock Cr	Chikamin Cr to Log Jam
Clear Creek	V1	Mouth to Hwy 22	Mouth to Hwy 22
	V2	Hwy 22 to Lower Culvert RM 2	Hwy 22 to Lower Culvert
Nason Creek	N1	Mouth to Kahler Cr Br	Mouth to Swamp Cr
	N3	Hwy 2 Br to Lower RR Br	Hwy 2 Br to Merrit Br
	N4	Lower RR Br to Whitepine Cr	Rayrock to Church Camp
Icicle River	I1	Mouth to Hatchery	Mouth to Boulder Block
Little Wenatchee	L2	Mouth to Lost Cr	Old Fish Weir to Lost Cr
	L3	Lost Cr to Rainy Cr Br	Lost Cr to Rainy Cr Br
White River	H2	Sears Cr Br to Napeequa R	Riprap Bank to Napeequa R
	H3	Napeequa R to Mouth of Panther Cr	Napeequa R to Grasshopper Meadows
Napeequa River	Q1	Mouth to RM 1	Mouth to RM1

Spring Chinook redd and carcass surveys were conducted during August through September in the Chiwawa River (including Rock and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), upper Wenatchee River, Little Wenatchee River, and the White River (including the Napeequa River and Panther Creek). Survey reaches for spring Chinook are described in Table 2.8.

Table 2.8. Description of reaches surveyed for spring Chinook redds and carcasses in the Wenatchee Basin.

Stream	Code	Reach	River mile (RM)
Chiwawa River	C1	Mouth to Grouse Creek	0.0-11.7
	C2	Grouse Creek to Rock Creek	11.7-19.3
	C3	Rock Creek to Schaefer Creek	19.3-22.4
	C4	Schaefer Creek to Atkinson Flats	22.4-25.6
	C5	Atkinson Flats to Maple Creek	25.6-27.0
	C6	Maple Creek to Trinity	27.0-30.3
Rock Creek	R1	Mouth to End	0.0-0.5
Chikamin Creek	K1	Mouth to End	0.0-0.5
Nason Creek	N1	Mouth to Kahler Creek Bridge	0.0-3.9
	N2	Kahler Creek Bridge to Hwy 2 Bridge	3.9-8.3
	N3	Hwy 2 Bridge to Lower RR Bridge	8.3-13.2
	N4	Lower RR Bridge to Whitepine Creek	13.2-15.4
Little Wenatchee River	L2	Old Fish Weir to Lost Creek	2.7-5.2
	L3	Lost Creek to Rainy Creek	5.2-9.2
	L4	Rainy Creek to Falls	9.2-Falls
White River	H2	Sears Creek Bridge to Napeequa River	6.4-11.0
	H3	Napeequa River to Grasshopper Meadows	11.0-12.9
Napeequa River	Q1	Mouth to End	0.0-1.0
Panther Creek	T1	Mouth to End	0.0-0.7
Wenatchee River	W8	Tumwater Dam to Tumwater Bridge	30.9-35.6
	W9	Tumwater Bridge to Chiwawa River	35.6-48.4
	W10	Chiwawa River to Lake Wenatchee	48.4-54.2
Icicle Creek	I1	Mouth to Boulder Block	0.0-4.0
Peshastin Creek	P1	Mouth to Camas Creek	0.0-5.9
	P2	Camas Creek to Mouth of Scotty Creek	5.9-16.3
Ingalls Creek	D1	Mouth to Trailhead	0.0-1.0

Surveys for live sockeye and carcass were conducted during August through October in the Little Wenatchee River. No sockeye redds were counted in 2011. Live fish counts were used to estimate spawning escapements using the area-under-the-curve (AUC) method. Mark-recapture methods were used to estimate the spawning escapement of sockeye in the White River Basin.

Table 2.9. Description of reaches surveyed for sockeye salmon carcasses and live fish in the Wenatchee Basin.

Stream	Code	Reach	River mile (RM)
Little Wenatchee River	L1	Mouth to Old Fish Weir	0.0-2.7
	L2	Old Fish Weir to Lost Creek	2.7-5.2
	L3	Lost Creek to Rainy Creek	5.2-9.2
White River	H1	Mouth to Sears Creek Bridge	0.0-6.4
	H2	Sears Creek Bridge to Napeequa River	6.4-11.0
	H3	Napeequa River to Grasshopper Meadows	11.0-12.9
Napeequa River	Q1	Mouth to End	0.0-1.0

Wenatchee summer Chinook redd and carcass surveys were conducted during September through November within ten reaches on the Wenatchee River (Table 2.10). Peak redd counts and map redd counts were estimated in the Wenatchee River. Map redd counts were conducted only within index areas, not throughout the entire river. The total number of redds within the Wenatchee River was estimated by expanding peak counts based on map counts. This method is described in Appendix F in Murdoch and Peven (2005).

Table 2.10. Description of reaches and index areas surveyed for summer Chinook redds in the Wenatchee Basin.

Code	Reach	River mile	Index/reference area (RM)
W1	Mouth to Sleepy Hollow Br	0.0-3.3	River Bend to Sleepy Hollow Br (1.7-3.3)
W2	Sleepy Hollow Br to L. Cashmere Br	3.3-9.5	L. Cashmere Br to Old Monitor Br (7.1-9.5)
W3	L. Cashmere Br to Dryden Dam	9.5-17.8	Williams Canyon to Dryden Dam (15.5-17.8)
W4	Dryden Dam to Peshastin Br	17.8-20.0	Dryden Dam to Peshastin Br (17.8-20.0)
W5	Peshastin Br to Leavenworth Br	20.0-23.9	Irrigation Flume to Leavenworth Br (22.8-23.9)
W6	Leavenworth Br to Icicle Rd Br	23.9-26.4	Icicle to Boat Takeout (24.5-25.6)
W7	Icicle Rd Br to Tumwater Dam	26.4-30.9	Icicle Br to Penstock Br (26.4-28.7)
W8	Tumwater Dam to Tumwater Br	30.9-35.6	Swiftwater Campgd to Tumwater Br (33.5-35.6)
W9	Tumwater Br to Chiwawa River	35.6-47.9	Swing Pool to Railroad Tunnel (36.7-39.3)
W10	Chiwawa River to Lake Wenatchee	47.9-54.2	Swamp to Bridge (52.7-53.6)

Summer Chinook redd and carcass surveys were also conducted in the Methow, Okanogan, Similkameen, and Chelan rivers during September through November. Total (map) redd counts were conducted in these rivers. Table 2.11 describes the survey reaches in these rivers.

Table 2.11. Description of reaches surveyed for summer Chinook redds and carcasses on the Methow, Okanogan, and Similkameen rivers.

Stream	Code	Reach	River mile (RM)
Methow River	M1	Mouth to Methow Bridge	0.0-14.8
	M2	Methow Bridge to Carlton Bridge	14.8-27.2
	M3	Carlton Bridge to Twisp Bridge	27.2-39.6
	M4	Twisp Bridge to MVID	39.6-44.9
	M5	MVID to Winthrop Bridge	44.9-49.8
	M6	Winthrop Bridge to Hatchery Dam	49.8-51.6
Okanogan River	O1	Mouth to Mallot Bridge	0.0-16.9
	O2	Mallot Bridge to Okanogan Bridge	16.9-26.1
	O3	Okanogan Bridge to Omak Bridge	26.1-30.7
	O4	Omak Bridge to Riverside Bridge	30.7-40.7
	O5	Riverside Bridge to Tonasket Bridge	40.7-56.8
	O6	Tonasket Bridge to Zosel Dam	56.8-77.4
Similkameen River	S1	Driscoll Channel to Oroville Bridge	0.0-1.8
	S2	Oroville Bridge to Enloe Dam	1.8-5.7

Except for sockeye, total spawning escapements for each population were estimated as the product of total number of redds times the ratio of fish per redd for a specific stock. Fish per redd ratios were estimated as the ratio of males to females sampled at broodstock collection sites and monitoring sites. Total spawning escapement for sockeye salmon in the Little Wenatchee River was estimated using the AUC approach (where escapement = [AUC/redd residence time] x observer efficiency). This method relied on weekly counts of live sockeye and assumed a redd residence time of 11 days (from Hyatt et al. 2006) and an observer efficiency of 100%.[2] In addition, sockeye escapement was estimated using mark-recapture methods. Adult sockeye were PIT tagged at Tumwater Dam and Bonneville Dam[3] and detected in the Little Wenatchee and White rivers with stationary PIT-tag interrogators.

Derived metrics calculated from carcass surveys, broodstock sampling, stock assessments, and harvest records included proportion of hatchery spawners, stray rates, age-at-maturity, length-at-age, smolt-to-adult survival (SAR), hatchery replacement rates (HRR), harvest rates, and natural replacement rates (NRR). The expected SARs and HRRs for different stocks raised in the Chelan PUD hatchery programs are provided in Table 2.12. Methods for calculating these variables are described in Appendices D, F, and G in Murdoch and Peven (2005) and in "White Papers" developed by the Hatchery Evaluation Technical Team (HETT) (see Appendices in Hillman et al. 2012).

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[2] It is unlikely that observer efficiency is 100%. Thus, spawning escapements based on AUC may be biased.

[3] Adult sockeye that were tagged at Bonneville Dam and detected at Tumwater Dam were included in the mark-recapture analyses.

Table 2.12. Expected smolt-to-adult (SAR) and hatchery replacement rates (HRR) for stocks raised in the Chelan PUD Hatchery Programs (from Table 6 in Appendix D in Murdoch and Peven 2005).

Program	Number of broodstock	Smolts released	SAR	Adult equivalents	Number of smolts/adult	HRR
Chiwawa Spring Chinook	379	672,000	0.003	2,016	333	5.3
Wenatchee Summer Chinook	492	864,000	0.003	2,592	333	5.3
Similkameen Summer Chinook	328	576,000	0.003	1,728	333	5.3
Methow Summer Chinook	228	400,000	0.003	1,200	333	5.3
Wenatchee Sockeye	260	200,000	0.007	1,400	143	5.4
Wenatchee Steelhead	208	400,000	0.010	4,000	100	19.2

Derived data that rely on CWTs (e.g., HRR, SAR, stray rates, etc.) are five or more years behind release information because of the lag time for returning adult fish to enter the fishery and spawning grounds, and the processing of tags. Consequently, complete information on rates and ratios based on CWTs is generally only available for years before 2006.

SECTION 3: WENATCHEE STEELHEAD

3.1 Broodstock Sampling

This section focuses on results from sampling 2010 and 2011 brood years of Wenatchee steelhead, which were collected at Dryden and Tumwater dams. The 2010 brood begins the tracking of the life cycle of steelhead released in 2011. The 2011 brood is included because juveniles from this brood are still maintained within the hatchery.

Origin of Broodstock

A total of 211 Wenatchee steelhead from the 2009 return (2010 brood) were collected at Dryden and Tumwater dams (Table 3.1). About 50% of these were natural-origin (adipose fin present, no CWT, and no elastomer tags) fish and the remaining 50% were hatchery-origin (elastomer tagged and/or adipose fin absent) adults. Origin was determined by analyzing scales and/or otoliths. The total number of steelhead spawned from the 2010 brood was 171 adults (56% natural-origin and 44% hatchery-origin).

A total of 208 steelhead were collected from the 2010 return (2011 brood) at Dryden and Tumwater dams; 104 (50%) natural-origin (adipose fin present, no CWT, and no elastomer tags) and 104 (50%) hatchery-origin (elastomer tagged and/or adipose fin absent) adults. A total of 161 steelhead were spawned; 57% were natural-origin fish and 43% were hatchery fish (Table 3.1). Origin was confirmed by sampling scales and/or otoliths.

Table 3.1. Numbers of wild and hatchery steelhead collected for broodstock, numbers that died before spawning, and numbers of steelhead spawned, 1998-2011. Unknown origin fish (i.e., undetermined by scale analysis, no elastomer, CWT, or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program or were immature fish killed at spawning.

Brood year	Wild steelhead					Hatchery steelhead					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
1998	35	0	0	35	0	43	4	2	37	0	72
1999	58	5	1	52	0	67	1	2	64	0	116
2000	39	2	1	36	0	101	9	12	60	20	96
2001	64	5	8	51	0	114	5	6	103	0	154
2002	99	0	1	96	2	113	1	0	64	48	160
2003	63	10	4	49	0	92	2	0	90	0	139
2004	85	3	0	75	7	132	1	0	61	70	136
2005	95	8	0	87	0	114	7	1	104	2	191
2006	101	5	0	93	3	98	0	0	69	29	162
2007	79	0	2	76	1	97	0	14	58	25	134
2008	104	0	3	77	22	107	0	28	54	25	131
2009	101	2	0	86	13	107	1	4	73	29	159
2010	106	1	1	96	8	105	2	23	75	5	171
2011	104	8	1	91	4	104	13	2	70	0	161
Average	***81***	***4***	***2***	***71***	***4***	***100***	***3***	***2***	***70***	***18***	***142***

Age/Length Data

Broodstock ages were determined from examination of scales and/or otoliths. For the 2010 return, both natural-origin and hatchery steelhead consisted primarily of 1-salt adults (Table 3.2). For the 2011 return, both hatchery and natural-origin steelhead consisted primarily of 2-salt adults (Table 3.2).

Table 3.2. Percent of hatchery and wild steelhead of different ages (saltwater ages) collected from broodstock, 1998-2011.

Return year	Origin	Saltwater age		
		1	2	3
1998	Wild	39.4	60.6	0.0
	Hatchery	20.9	79.1	0.0
1999	Wild	50.0	48.3	1.7
	Hatchery	81.8	18.2	0.0
2000	Wild	56.4	43.6	0.0
	Hatchery	67.9	32.1	0.0
2001	Wild	51.7	48.3	0.0
	Hatchery	14.9	85.1	0.0
2002	Wild	55.6	44.4	0.0
	Hatchery	94.6	5.4	0.0
2003	Wild	13.1	85.3	1.6
	Hatchery	29.4	70.6	0.0
2004	Wild	94.8	5.2	0.0
	Hatchery	95.2	4.8	0.0
2005	Wild	22.1	77.9	0.0
	Hatchery	20.5	79.5	0.0
2006	Wild	28.7	71.3	0.0
	Hatchery	60.3	39.7	0.0
2007	Wild	40.3	59.3	0.0
	Hatchery	62.1	37.9	0.0
2008	Wild	65.4	33.7	0.9
	Hatchery	88.8	11.2	0.0
2009	Wild	39.8	57.8	2.4
	Hatchery	23.4	76.6	0.0
2010	Wild	65.2	33.7	1.1
	Hatchery	76.5	23.5	0.0
2011	Wild	27.5	72.5	0.0
	Hatchery	36.0	64.0	0.0
Average	***Wild***	***46.4***	***53.0***	***0.6***
	Hatchery	***55.2***	***44.8***	***0.0***

There was little difference between mean lengths of hatchery and natural-origin steelhead for both the 2010 and 2011 return years (Table 3.3). Natural-origin fish were on average 1 to 3 cm larger than hatchery-origin fish of the same age.

Table 3.3. Mean fork length (cm) at age (saltwater ages) of hatchery and wild steelhead collected from broodstock, 1998-2011; N = sample size and SD = 1 standard deviation.

Return year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1998	Wild	63	15	4	79	20	5	-	0	-
	Hatchery	61	9	4	73	34	4	-	0	-
1999	Wild	65	29	5	74	28	5	77	1	-
	Hatchery	62	54	4	73	12	4	-	0	-
2000	Wild	64	22	3	74	17	5	-	0	-
	Hatchery	60	57	3	71	27	4	-	0	-
2001	Wild	61	33	6	77	31	5	-	0	-
	Hatchery	62	17	4	72	97	4	-	0	-
2002	Wild	64	55	4	77	44	4	-	0	-
	Hatchery	63	106	4	73	6	4	-	0	-
2003	Wild	69	8	6	77	52	5	91	1	-
	Hatchery	66	27	4	75	65	4	-	0	-
2004	Wild	63	73	6	78	4	2	-	0	-
	Hatchery	61	59	3	73	3	1	-	0	-
2005	Wild	59	21	4	74	74	5	-	0	-
	Hatchery	59	23	4	72	89	4	-	0	-
2006	Wild	63	27	5	75	67	6	-	0	-
	Hatchery	61	41	4	72	27	5	-	0	-
2007	Wild	64	31	6	76	46	5	-	0	-
	Hatchery	60	60	4	71	36	5	-	0	-
2008	Wild	64	68	4	77	35	4	80	1	-
	Hatchery	60	95	4	72	12	2	-	0	-
2009	Wild	65	33	5	76	48	6	81	2	0
	Hatchery	63	18	4	75	59	5	-	-	-
2010	Wild	64	60	5	74	31	5	76	1	-
	Hatchery	61	53	5	73	23	5	-	-	-
2011	Wild	62	28	5	76	74	5	-	0	-
	Hatchery	60	36	4	74	64	4	-	0	-

Sex Ratios

Male steelhead in the 2010 return made up about 53% of the adults collected, resulting in an overall male to female ratio of 1.11:1.00 (Table 3.4). For the 2011 return, males made up about 45% of the adults collected, resulting in an overall male to female ratio of 0.82:1.00. On average (1998-2011), the sex ratio is slightly less than the 1:1 ratio assumed in the broodstock protocol (Table 3.4).

Table 3.4. Numbers of male and female wild and hatchery steelhead collected for broodstock, 1998-2011. Ratios of males to females are also provided.

Return year	Number of wild steelhead			Number of hatchery steelhead			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1998	13	22	0.59:1.00	15	28	0.54:1.00	0.56:1.00
1999	22	36	0.61:1.00	35	32	1.09:1.00	0.84:1.00
2000	18	21	0.86:1.00	60	41	1.46:1.00	1.26:1.00
2001	38	26	1.46:1.00	40	74	0.54:1.00	0.78:1.00
2002	32	67	0.48:1.00	81	32	2.53:1.00	1.14:1.00
2003	19	44	0.43:1.00	44	48	0.92:1.00	0.68:1.0
2004	43	42	1.02:1.00	90	42	2.14:1.00	1.58:1.00
2005	36	59	0.61:1.00	46	68	0.68:1.00	0.65:1.00
2006	38	63	0.60:1.00	47	51	0.92:1.00	0.75:1.00
2007	36	43	0.84:1.00	49	48	1.02:1.00	0.93:1.00
2008	61	43	1.42:1.00	68	39	1.74:1.00	1.57:1.00
2009	44	57	0.77:1.00	54	53	1.02:1.00	0.89:1.00
2010	49	57	0.86:1.00	62	43	1.44:1.00	1.11:1.00
2011	44	60	0.73:1.00	50	54	0.93:1.00	0.82:1.00
Total	***493***	***640***	***0.77:1.00***	***741***	***653***	***1.13:1.00***	***0.95:1.00***

Fecundity

Fecundities for Wenatchee steelhead returning in 2010 and 2011 averaged 5,442 and 5,811 eggs per female, respectively, which were similar to the overall average (Table 3.5). Mean fecundities for the 2010 and 2011 returns were at or greater than the 5,678 eggs per female assumed in the broodstock protocol.

Table 3.5. Mean fecundity of wild, hatchery, and all female steelhead collected for broodstock, 1998-2011.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1998	6,202	5,558	5,924
1999	5,691	5,186	5,424
2000	5,858	5,729	5,781
2001	5,951	6,359	6,270
2002	5,776	5,262	5,626

Return year	Mean fecundity		
	Wild	Hatchery	Total
2003	6,561	6,666	6,621
2004	5,118	5,353	5,238
2005	5,545	6,061	5,832
2006	5,688	5,251	5,492
2007	5,840	5,485	5,660
2008	5,693	5,153	5,433
2009	6,199	6,586	6,408
2010	5,458	5,423	5,442
2011	6,276	6,100	6,203
Average	***5,847***	***5,727***	***5,811***

3.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 493,827 eggs are required to meet the program release goal of 400,000 smolts. Between 1998 and 2011, the egg take goal was reached 57% of the time (Table 3.6).

Table 3.6. Numbers of eggs taken from steelhead broodstock, 1998-2011.

Brood year	Number of eggs taken
1998	224,315
1999	303,083
2000	280,872
2001	549,464
2002	503,030
2003	532,708
2004	408,538
2005	672,667
2006	546,382
2007	462,662
2008	439,980
2009	633,229
2010	499,499
2011	522,049
Average	***469,891***

Number of acclimation days

Juvenile steelhead were transferred from Chelan FH to Turtle Rock FH in December 2010 and from Eastbank FH to Turtle Rock FH in November 2010. At Turtle Rock FH, juvenile steelhead were reared on Columbia River water (range, 148-181 d) before being trucked and released into the Wenatchee River and tributaries. In April 2011, a small group of early HxH steelhead were transferred to Black Bird Pond near Leavenworth for acclimation on Wenatchee River water. Fish were acclimated for 37 d before a volitional release was initiated on 11 May.

Juvenile Wenatchee steelhead at the Chiwawa Ponds were acclimated and reared on Wenatchee River water. In the past, Wenatchee steelhead were reared on Columbia River water from January through April before being trucked and released into the Wenatchee Basin (Table 3.7).

Table 3.7. Water source and mean acclimation period for Wenatchee steelhead, brood years 1998-2010.

Brood year	Release year	Parental origin	Water source	Number of Days
1998	1999	H x H	Wenatchee/Chiwawa	36
		H x W	Wenatchee/Chiwawa	36
		W x W	Wenatchee/Chiwawa	36
1999	2000	H x H	Wenatchee/Chiwawa	138
		H x W	Wenatchee/Chiwawa	138
		W x W	Wenatchee/Chiwawa	138
		H x W	Eastbank	0
		W x W	Eastbank	0
2000	2001	H x H	Wenatchee/Chiwawa	122
		H x W	Wenatchee/Chiwawa	122
		H x W	Wenatchee/Chiwawa	122
		W x W	Wenatchee/Chiwawa	122
2001	2002	H x H	Columbia	92
		H x H	Wenatchee/Chiwawa	63
		H x W	Columbia	92
		H x W	Wenatchee/Chiwawa	63
		W x W	Columbia	153
2002	2003	H x H	Columbia	98
		H x W	Columbia	98
		W x W	Columbia	117
2003	2004	H x H	Columbia	88
		H x W	Wenatchee/Chiwawa	84
		W x W	Columbia	148
2004	2005	H x H	Columbia	160
		H x W	Columbia	160

Brood year	Release year	Parental origin	Water source	Number of Days
		W x W	Columbia	160
2005	2006	H x H	Columbia	116
		H x W	Columbia	113
		W x W	Columbia	141
2006	2007	Early H x W	Columbia	111
		Late H x W	Columbia	112
		W x W	Columbia	148
2007	2008	Early H x W	Columbia	94-95
		Late H x W	Columbia	91-93
		W x W	Columbia	138
2008	2009	Early H x W	Columbia	120-121
		Early H x W	Columbia/Wenatchee	120-121/28-95
		Late H x W	Columbia	114-115
		W x W	Columbia	152-153
2009	2010	Early H x W	Columbia	93-94
		Early H x W	Columbia/Wenatchee	99-111
		Early H x W	Wenatchee	31-129
		Late H x W	Columbia	84-87
		W x W	Columbia/Nason	118-120/28
2010	2011	H x H	Wenatchee	188-192
		H x H	Wenatchee	37-87
		H x H	Columbia	181
		W x W	Columbia	148-149
		W x W	Columbia/Nason	113-114/42-101
		W x W	Columbia	148-149

Release Information

Numbers released

The release of 2010 brood Wenatchee steelhead achieved 89% of the 400,000 target goal with about 354,314 fish released into the Wenatchee and Chiwawa rivers and Nason Creek (Table 3.8). Distribution of juvenile steelhead released in each of the three subbasins was determined by the mean proportion of steelhead redds in each basin. About 31.3% and 22.9% of the steelhead were released in Nason Creek and the Chiwawa River, respectively. The balance of the program was split between the Wenatchee River downstream from Tumwater Dam (12.7%) and the Wenatchee River upstream from the dam (33.0%).

Table 3.8. Numbers of steelhead smolts released from the hatchery, brood years 1998-2010. The release target for steelhead is 400,000 smolts.

Brood year	Release year	Number of smolts
1998	1999	172,078
1999	2000	175,701
2000	2001	184,639
2001	2002	335,933
2002	2003	302,060
2003	2004	374,867
2004	2005	294,114
2005	2006	452,184
2006	2007	299,937
2007	2008	306,690
2008	2009	327,143
2009	2010	484,772
2010	2011	354,314
Average		***312,649***

Numbers elastomer tagged

Wenatchee hatchery steelhead from the 2010 brood were marked with elastomer tags in the clear tissue posterior of the eye to denote parental origin. About 46% of the juveniles released were also adipose fin clipped (Table 9).

Table 3.9. Release location and marking scheme for the 1998-2010 brood Wenatchee steelhead.

Brood year	Release location	Parental origin	Proportion Ad-clip	VIE color/side	Tag rate	Number released
1998	Chiwawa River	H x H	0.000	Red Left	0.994	52,765
	Chiwawa River	H x W	0.000	Green Left	0.990	37,013
	Chiwawa River	W x W	0.000	Orange Left	0.827	82,300
1999	Wenatchee River	H x H	0.000	Green Left	0.911	45,347
	Wenatchee River	H x W	0.000	Orange Left	0.927	30,713
	Chiwawa River	H x H	0.000	Red Right	0.936	25,622
	Chiwawa River	H x W	0.000	Green Right	0.936	43,379
	Chiwawa River	W x W	0.000	Orange Right	0.936	30,600
2000	Chiwawa River	H x H	0.000	Red Left	0.963	33,417
	Chiwawa River	H x W	0.000	Green Left	0.963	57,716
	Chiwawa River	H x W	0.000	Green Right	0.949	48,029
	Chiwawa River	W x W	0.000	Orange Right	0.949	45,477

Brood year	Release location	Parental origin	Proportion Ad-clip	VIE color/side	Tag rate	Number released
2001	Nason Creek	H x W	0.000	Green Right	0.934	75,276
	Nason Creek	W x W	0.000	Orange Right	0.934	48,115
	Chiwawa River	H x W	0.000	Green Left	0.895	92,487
	Chiwawa River	H x H	0.000	Red Left	0.895	120,055
2002	Chiwawa River	H x H	0.000	Red Left	0.920	156,145
	Chiwawa River	H x W	0.000	Green Left	0.928	33,528
	Nason Creek	W x W	0.000	Orange Right	0.928	112,387
2003	Wenatchee River	H x H	0.000	Red Left	0.968	117,663
	Chiwawa River	H x W	0.000	Green Left	0.927	191,796
	Nason Creek	W x W	0.000	Orange Right	0.962	65,408
2004	Wenatchee River	H x H	0.500	Red Left	0.804	39,636
	Chiwawa River	H x W	0.000	Green Left	0.977	153,959
	Nason Creek	W x W	0.000	Pink Right	0.940	100,519
2005	Wenatchee River	H x H	1.000	Red Left	0.983	104,552
	Wenatchee River	H x W	0.616	Green Left	0.979	190,319
	Chiwawa River	H x W	0.616	Green Left	0.979	18,634
	Chiwawa River	W x W	0.000	Pink Right	0.969	14,124
	Nason Creek	W x W	0.000	Pink Right	0.969	124,555
2006	Wenatchee River	H x W (early)	1.000	Green Right	0.918	66,022
	Wenatchee River	H x W (late)	0.671	Green Left	0.935	92,176
	Chiwawa River	H x W (late)	0.671	Green Left	0.935	41,240
	Chiwawa River	W x W	0.000	Pink Right	0.945	7,500
	Nason Creek	W x W	0.000	Pink Right	0.945	92,999
2007	Wenatchee River	H x W (early)	0.967	Green Right	0.950	64,310
	Wenatchee River	H x W (late)	0.586	Green Left	0.951	97,549
	Chiwawa River	H x W (late)	0.586	Green Left	0.951	43,011
	Chiwawa River	W x W	0.000	Pink Right	0.952	7,026
	Nason Creek	W x W	0.000	Pink Right	0.952	94,794
2008	Blackbird Pond	HxW (early)	0.917	Green Right	0.910	49,878
	Wenatchee River	H x W (early)	0.917	Green Right	0.910	48,624
	Wenatchee River	H x W (late)	0.595	Green Left	0.908	74,848
	Chiwawa River	H x W (late)	0.595	Green Left	0.908	25,835
	Chiwawa River	W x W	0.000	Pink Right	0.904	25,778

Brood year	Release location	Parental origin	Proportion Ad-clip	VIE color/side	Tag rate	Number released
	Nason Creek	W x W	0.000	Pink Right	0.904	102,170
2009	Blackbird Pond	H x W (early)	0.969	Green Right	0.934	50,248
	Wenatchee River	H x W (early)	0.969	Green Right	0.934	105,239
	Wenatchee River	H x W (late)	0.973	Green Left	0.975	27,612
	Wenatchee River	H x W (late)	0.000	Green Left	0.975	45,435
	Chiwawa River	H x W (early)	0.969	Green Right	0.934	23,835
	Chiwawa River	H x W (late)	0.973	Green Left	0.975	33,047
	Chiwawa River	H x W (late)	0.000	Green Left	0.975	54,381
	Nason	W x W	0.000	Pink Right	0.979	145,029
2010	Wenatchee River	H x H	0.994	-	.0984	24,838
	Wenatchee River	H x H	0.994	-	0.984	45,000
	Wenatchee River	H x H	0.994	-	0.984	92,113
	Chiwawa River	W x W	0.000	Pink Right	0.917	81,174
	Nason River	W x W	0.000	Pink R/Pink L	0.884	20,000
	Nason River	W x W	0.000	Pink Right	0.917	91,189

Numbers PIT tagged

Table 3.10 summarizes the number of hatchery steelhead of different parental origins that have been PIT-tagged and released into the Wenatchee Basin.

Table 3.10. Summary of PIT-tagging activities for Wenatchee hatchery steelhead, brood years 2006-2010.

Brood year	Release location	Parental origin	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2006	Wenatchee River	H x W (early)	10,035	479	24	9,533
	Wenatchee/Chiwawa rivers	H x W (late)	10,031	922	20	9,089
	Chiwawa River/Nason Creek	W x W	10,019	152	352	9,515
2007	Wenatchee River	H x W (early)	10,052	22	10	9,820
	Wenatchee/Chiwawa rivers	H x W (late)	10,063	73	78	9,912
	Chiwawa River/Nason Creek	W x W	10,051	55	1	9,982
2008	Wenatchee River	H x W (early)	10,101	59	15	10,027
	Wenatchee/Chiwawa rivers	H x W (late)	10,104	106	17	9,981
	Chiwawa River/Nason Creek	W x W	10,101	159	80	9,862
2009	Wenatchee/Chiwawa rivers	H x W (early)	10,114	574	11	9,529

Brood year	Release location	Parental origin	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
	Wenatchee (Blackbird)	H x W (early)	8,100	0	0	8,100
	Wenatchee/Chiwawa rivers	H x W (late)	10,115	271	11	9,833
	Chiwawa pilot	H x W (early)	10,107	532	103	9,472
	Chiwawa River/Nason Creek	W x W	10,101	38	3	10,060
	Wenatchee River	HxH	10,100	624	21	9,455
	Chiwawa River/Nason Creek	WxW	10,100	206	0	9,894
	Wenatchee (Blackbird)	HxH	10,101	235	8	9,858
	Wenatchee River	HxH	10,100	46	28	10,026

2011 Brood Wenatchee (Chiwawa Circular Pond) Summer Steelhead—A total of 10,101 Wenatchee summer steelhead were tagged at Eastbank Hatchery on 20-23 September 2011. These fish were tagged in raceway #8. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 101 mm in length and 11.0 g at time of tagging.

At the end of February 2012, a total of 114 steelhead have died and 30 others have shed their tags. This leaves a total of 9,957 tagged summer steelhead alive in the Chiwawa circular ponds at the end of the month.

2011 Brood Wenatchee (Chiwawa Raceway) Summer Steelhead—A total of 20,220 Wenatchee summer steelhead were tagged at the Chelan Hatchery on 6-9 October 2011. These fish were tagged in raceway #1. Fish were not fed during tagging or for two days before and after tagging. Fish averaged 105 mm in length and 12.0 g at time of tagging.

At the end of January 2011, a total of 99 steelhead have died and 13 others have shed their tags. This leaves a total of 20,108 tagged summer steelhead alive at the Chiwawa facility at the end of the month.

Fish size and condition at release

With the exception of the Blackbird Pond and Rolfhing Pond releases, all 2010 brood steelhead were trucked and released as yearling smolts in May of 2011. The other two groups mentioned above were released volitionally beginning 2 May. All three parental groups did not meet the length target and only the early HxW group met or exceeded the weight target. All groups except for the early HxW group met the fish per pound release target. All three groups exceeded the target for coefficient of variation (CV) for fork length (Table 3.11).

Table 3.11. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of steelhead smolts released from the hatchery, brood years 1998-2010. Size targets are provided in the last row of the table.

Brood year	Release year	Parental origin	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
1998	1999	H x H	201	11.1	92.3	5
		H x W	190	12.8	76.9	6
		W x W	173	12.0	55.3	8
1999	2000	H x H	181	8.9	70.6	6
		H x W	187	7.2	75.3	6
		W x W	184	11.3	71.5	6
2000	2001	H x H	218	15.2	122.4	4
		H x W	209	10.6	107.5	4
		W x W	205	10.7	100.9	5
2001	2002	H x H	179	17.4	67.0	7
		H x W	192	15.6	82.8	6
		W x W	206	11.6	102.6	4
2002	2003	H x H	194	13.1	83.0	6
		H x W	191	13.0	77.4	6
		W x W	180	19.1	70.3	7
2003	2004	H x H	191	14.4	73.1	6
		H x W	199	12.9	83.9	5
		W x W	200	11.1	90.1	5
2004	2005	H x H	204	11.3	87.2	6
		H x W	202	13.5	71.9	5
		W x W	198	12.4	76.6	6
2005	2006	H x H	215	12.6	116.6	4
		H x W	198	11.8	86.3	5
		W x W	189	15.4	55.3	6
2006	2007	H x H (early)	213	12.1	109.6	4
		H x W (late)	186	11.8	68.3	7
		W x W	178	11.1	58.6	8
2007	2008	H x W (early)	192	17.4	77.1	6
		H x W (late)	179	19.3	63.8	7
		W x W	183	12.3	62.8	7
2008	2009	H x W (early)	184	11.6	68.0	7
		H x W (late)	186	11.6	73.5	6
		W x W	181	13.0	59.7	8

Brood year	Release year	Parental origin	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
2009	2010	H x W (early)	197	11.3	84.2	5
		H x W (late)	192	11.1	72.7	6
		W x W	190	9.6	70.5	6
2010	2011	H x H	183	14.1	68.9	4
		W x W	188	10.5	68.1	7
Targets			***198***	***9.0***	***75.6***	***6***

Survival Estimates

Overall survival of Wenatchee steelhead from green (unfertilized) egg to release was below the standard set for the program. This is due in part because of poor eyed egg-to-ponding, the 30 day after ponding, 100 day after ponding, and ponding to release survivals (Table 3.12). The Wenatchee steelhead program, from its inception, has experienced highly variable fertilization rates. It is unknown at this time what mechanisms may be influencing stock performance at these stages.

Table 3.12. Hatchery life-stage survival rates (%) for steelhead, brood years 1998-2010. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1998	92.0	100.0	85.5	91.7	99.2	98.8	97.8	99.9	76.7
1999	91.2	100.0	66.9	93.0	95.9	94.9	93.1	99.7	58.0
2000	83.9	96.2	77.6	86.7	99.3	98.9	97.7	99.5	65.7
2001	90.0	100.0	73.0	91.8	99.1	97.8	91.3	99.7	61.1
2002	99.0	100.0	69.2	93.1	95.9	94.4	89.6	89.6	60.0
2003	87.0	96.8	86.3	83.8	97.2	94.8	97.6	85.3	70.4
2004	97.6	98.5	83.4	93.7	97.8	94.1	92.2	99.9	72.0
2005	91.3	95.1	81.3	92.1	95.6	91.8	89.7	99.6	67.2
2006	99.1	95.3	73.2	85.4	95.4	94.6	87.8	98.5	54.9
2007	100.0	100.0	80.3	92.0	95.7	92.7	89.8	99.1	66.3
2008	100.0	100.0	87.1	88.4	99.0	97.4	96.6	99.5	74.4
2009	97.3	100.0	89.0	97.2	96.0	95.2	88.6	96.6	76.6
2010	96.7	100.0	93.8	93.9	91.0	86.2	80.6	96.0	70.9
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

3.3 Disease Monitoring

Rearing of the 2010 brood Wenatchee summer steelhead was typical to previous years with fish being held on Chelan spring water, Eastbank well water, and Columbia River water before being released directly into Nason Creek and the Chiwawa and Wenatchee rivers. No significant disease-related mortality events occurred in the 2010 brood steelhead.

3.4 Natural Juvenile Productivity

During 2011, juvenile steelhead were sampled at the Upper Wenatchee and Chiwawa traps and counted during snorkel surveys within the Chiwawa Basin. Because the snorkel surveys targeted juvenile Chinook salmon, the entire distribution of juvenile steelhead in the Chiwawa Basin was not surveyed. Therefore, the parr numbers presented below represent a minimum estimate.

Parr Estimates

A total of 39,446 (±5.0%) age-0 (<100 mm) and 14,903 (±10.0%) age-1+ (100-200 mm)[4] steelhead/rainbow were estimated in the Chiwawa Basin in August 2011 (Table 3.13 and 3.14). During the survey period 1992-2011, numbers of age-0 and 1+ steelhead/rainbow have ranged from 1,410 to 45,727 and 2,533 to 22,128, respectively, in the Chiwawa Basin (Table 3.13 and 3.14; Figure 3.1). Numbers of all fish counted in the Chiwawa Basin are reported in Appendix A.

Juvenile steelhead/rainbow were distributed primarily throughout the lower seven reaches of the Chiwawa River (downstream from Rock Creek). Their densities were highest in the lower portions of the river and in tributaries. Age-0 steelhead/rainbow most often used riffle and multiple channel habitats in the Chiwawa River, although they also associated with woody debris in pool and glide habitat. In tributaries they were generally most abundant in small pools. Those that were observed in riffles selected stations in quiet water behind small and large boulders or occupied stations in quiet water along the stream margin. In pool and multiple-channel habitats, age-0 steelhead/rainbow used the same kinds of habitat as age-0 Chinook.

Age-1+ steelhead/rainbow most often used pool, riffle, and multiple-channel habitats. Those that used pools were usually in deeper water than subyearling steelhead/rainbow and Chinook. Like age-0 steelhead/rainbow, age-1+ steelhead/rainbow selected stations in quiet water behind boulders in riffles, but the two age groups rarely occurred together. Age-1+ steelhead/rainbow appeared to use deeper and faster water than did subyearling steelhead/rainbow.

Table 3.13. Total numbers of age-0 steelhead/rainbow trout estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2011; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	4,927	NS	NS	NS	NS	NS	NS	NS	NS	**4,927**
1993	3,463	0	356	185	NS	NS	NS	NS	NS	**4,004**
1994	953	0	256	24	0	177	0	0	0	**1,410**
1995	6,005	0	744	90	0	371	40	107	0	**7,357**
1996	3,244	0	71	40	0	763	127	0	0	**4,245**
1997	6,959	224	84	324	0	1,124	58	50	0	**8,823**
1998	2,972	22	280	96	113	397	18	22	0	**3,921**
1999	5,060	20	253	189	0	255	34	27	0	**5,838**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**

4 A steelhead/rainbow trout larger than 200 mm (8 in) was considered a resident trout.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
2001	35,759	192	1,449	1,826	0	6,345	156	0	0	**45,727**
2002	12,137	0	2,252	889	0	4,948	277	18	0	**20,521**
2003	9,911	296	996	1,166	96	5,366	73	116	0	**18,020**
2004	8,464	110	583	113	40	957	35	78	0	**10,380**
2005	4,852	120	2,931	477	45	2,973	65	0	0	**11,463**
2006	10,669	21	858	872	34	3,647	73	71	0	**16,245**
2007	8,442	53	2,137	348	11	2,955	65	28	34	**14,073**
2008	9,863	0	2,260	859	0	1,987	57	168	36	**15,230**
2009	13,231	0	1,183	449	0	2,062	170	67	17	**17,179**
2010	17,572	0	2,870	1,478	5	2,843	182	35	33	**25,018**
2011	35,825	0	1,503	804	0	1,066	56	152	40	**39,446**
Average	***10,543***	***59***	***1,170***	***568***	***20***	***2,249***	***87***	***55***	***9***	***14,412***

Table 3.14. Total numbers of age-1+ steelhead/rainbow trout estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2011; NS = not sampled.

Sample Year	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Unnamed Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	2,533	NS	NS	NS	NS	NS	NS	NS	NS	**2,533**
1993	2,530	0	228	102	NS	NS	NS	NS	NS	**2,860**
1994	4,972	0	476	296	5	107	0	0	0	**5,856**
1995	8,769	0	494	71	0	183	0	0	0	**9,517**
1996	11,381	0	6	27	0	435	0	0	0	**11,849**
1997	6,574	160	0	105	0	66	0	0	0	**6,905**
1998	10,403	0	133	49	0	0	0	0	0	**10,585**
1999	21,779	0	68	201	0	82	0	0	0	**22,130**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	9,368	16	186	407	0	646	0	0	0	**10,623**
2002	7,200	0	199	165	0	1,526	0	0	0	**9,090**
2003	4,745	362	426	599	0	47	0	0	0	**6,179**
2004	7,700	107	209	0	0	174	0	0	0	**8,190**
2005	4,624	63	957	257	0	287	0	0	0	**6,188**
2006	7,538	76	748	1,186	0	985	0	0	0	**10,533**
2007	6,976	0	945	96	0	431	0	0	0	**8,448**
2008	8,317	0	1,168	298	0	793	0	0	0	**10,576**
2009	4,998	16	320	102	0	167	21	0	5	**5,629**
2010	8,324	32	366	393	0	780	21	0	0	**9,616**
2011	13,329	0	415	470	0	689	0	0	0	**14,903**
Average	***8,003***	***46***	***408***	***268***	***0***	***435***	***2***	***0***	***0***	***9,064***

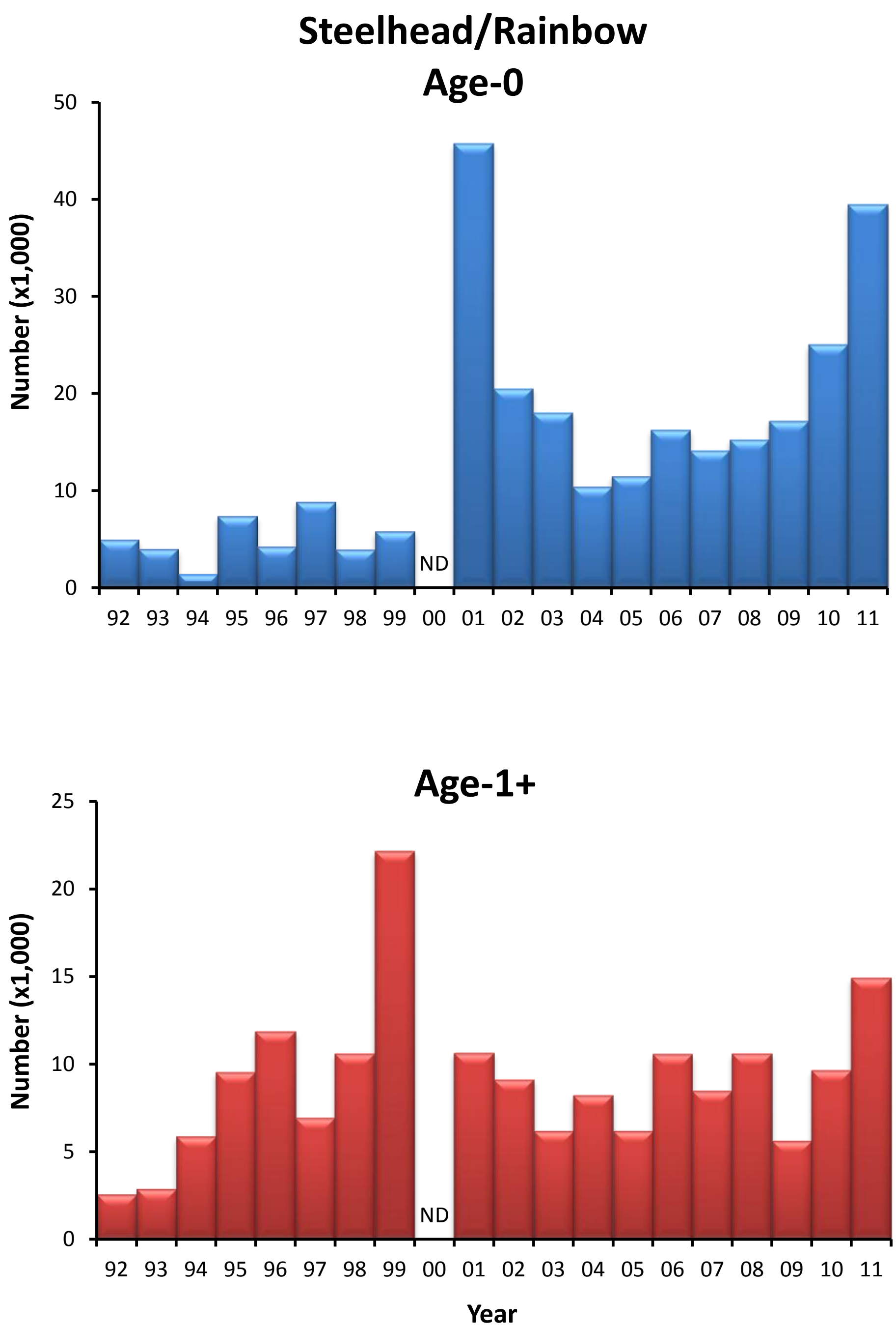

Figure 3.1. Numbers of subyearling and yearling steelhead/rainbow trout within the Chiwawa River Basin in August 1992-2011; ND = no data.

Emigrant and Smolt Estimates

Numbers of steelhead smolts and emigrants were estimated at the Upper Wenatchee and Chiwawa traps in 2011.

Chiwawa Trap

The Chiwawa Trap operated between 8 March and 30 November 2011. During that time period the trap was inoperable for 20 days because of high river flows, debris, snow/ice, or mechanical failure. The trap operated in two different positions depending on stream flow; lower position at flows greater than 12 m^3/s and an upper position at flows less than 12 m^3/s. Monthly captures of all fish collected at the Chiwawa Trap are reported in Appendix B.

A total of 195 wild steelhead/rainbow smolts, 8,250 hatchery smolts, and 981 wild parr were captured at the Chiwawa Trap. Nearly all (99%) of the hatchery smolts were collected in May, while most (93%) of the wild steelhead smolts were captured during April and May (Figure 3.2). Although steelhead/rainbow parr emigrated throughout the sampling period, most emigrated during May through June and in September (Figure 3.2). No mark-recapture efficiency trials were conducted with steelhead/rainbow at the Chiwawa Trap to estimate total population sizes.

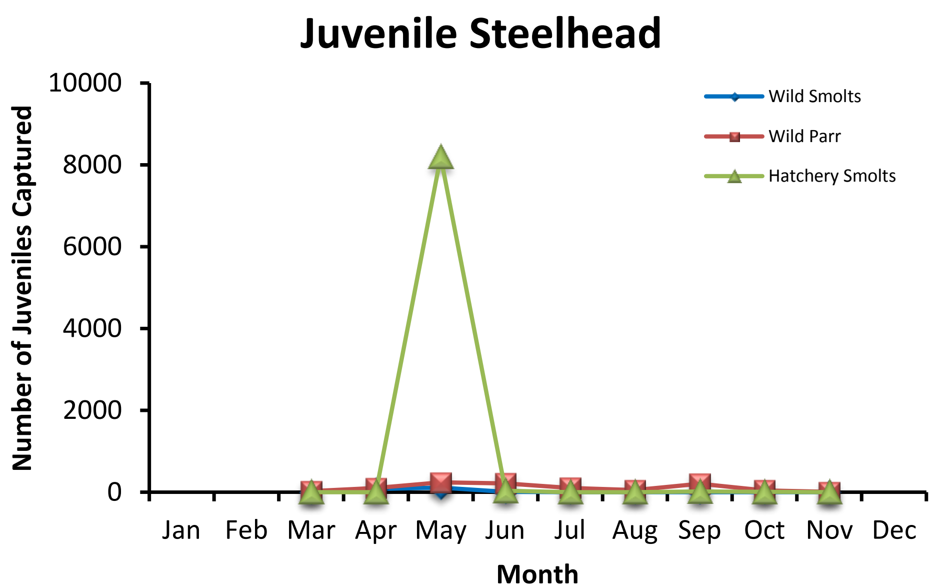

Figure 3.2. Monthly captures of wild smolts, wild parr, and hatchery smolt steelhead/rainbow at the Chiwawa Trap, 2011.

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 4 March and 1 July 2011. During the five-month sampling period, a total of eight wild steelhead/rainbow smolts, 376 hatchery smolts, and 127 wild parr were captured at the Upper Wenatchee Trap. Monthly captures of all fish collected at the Upper Wenatchee Trap are reported in Appendix B.

PIT Tagging Activities

As part of the Comparative Survival Study (CSS), a total of 1,095 juvenile steelhead/rainbow trout (1,094 wild and one hatchery) were PIT tagged and released in 2011 at the Chiwawa and Upper Wenatchee traps (Table 3.15a). Most of these were tagged at the Chiwawa Trap. Few were tagged and released at the Upper Wenatchee trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 3.15a. Numbers of wild and hatchery steelhead/rainbow trout that were captured, tagged, and released at different trapping locations within the Wenatchee Basin, 2011. Numbers of fish that died or shed tags are also given.

Sampling Location	Species and Life Stage	Number held	Number of recaptures	Number tagged	Number died	Shed Tags	Total released	Percent mortality
Chiwawa Trap	Wild Steelhead/Rainbow	1,048	3	1,016	4	0	1,012	0.38
	Hatchery Steelhead/Rainbow	1	0	1	0	0	1	0.00
	Total	**1,049**	**3**	**1,017**	**4**	**0**	**1,013**	**0.38**
Upper Wenatchee Trap	Wild Steelhead/Rainbow	93	5	82	0	0	82	0.00
	Hatchery Steelhead/Rainbow	14	14	0	0	0	0	0.00
	Total		**19**	**82**	**0**	**0**	**82**	**0.00**
Total:	**Wild Steelhead/Rainbow**	**1,141**	**8**	**1,098**	**4**	**0**	**1,094**	**0.35**
	Hatchery Steelhead/Rainbow	**15**	**14**	**1**	**0**	**0**	**1**	**0.00**
Grand Total:		**1,156**	**22**	**1,099**	**4**	**0**	**1,095**	**0.34**

Numbers of steelhead/rainbow PIT-tagged and released as part of CSS during the period 2006-2011 are shown in Table 3.15b.

Table 3.15b. Summary of the numbers of wild and hatchery steelhead/rainbow trout that were tagged and released at different locations within the Wenatchee Basin, 2006-2011.

Sampling Location	Species and Life Stage	Numbers of PIT-tagged steelhead/rainbow released					
		2006	2007	2008	2009	2010	2011
Chiwawa Trap	Wild Steelhead/Rainbow	1,366	832	1,431	1,127	930	1,012
	Hatchery Steelhead/Rainbow	0	3	2	1	2	1
	Total	**1,366**	**835**	**1,433**	**1,128**	**932**	**1,013**
Chiwawa Remote	Wild Steelhead/Rainbow	33	167	94	35	99	0
	Hatchery Steelhead/Rainbow	1	47	35	43	64	0
	Total	**34**	**214**	**129**	**78**	**163**	**0**
Upper Wenatchee Trap	Wild Steelhead/Rainbow	21	37	24	46	69	82
	Hatchery Steelhead/Rainbow	0	0	0	0	0	0
	Total	**21**	**37**	**24**	**46**	**69**	**82**
Nason Creek Remote	Wild Steelhead/Rainbow	174	452	255	459	318	0
	Hatchery Steelhead/Rainbow	26	75	87	197	32	0
	Total	**200**	**527**	**342**	**656**	**350**	**0**
Upper Wenatchee Remote	Wild Steelhead/Rainbow	413	1,001	21	7	30	0
	Hatchery Steelhead/Rainbow	2	64	26	23	9	0
	Total	**415**	**1,065**	**47**	**30**	**39**	**0**
Middle Wenatchee Remote	Wild Steelhead/Rainbow	0	0	981	867	1,517	0
	Hatchery Steelhead/Rainbow	0	0	11	5	57	0
	Total	**0**	**0**	**992**	**872**	**1,574**	**0**

Sampling Location	Species and Life Stage	Numbers of PIT-tagged steelhead/rainbow released					
		2006	2007	2008	2009	2010	2011
Lower Wenatchee Remote	Wild Steelhead/Rainbow	0	0	102	69	0	0
	Hatchery Steelhead/Rainbow	0	0	10	9	0	0
	Total	**0**	**0**	**112**	**78**	**0**	**0**
Peshastin Creek Remote	Wild Steelhead/Rainbow	0	0	0	92	307	0
	Hatchery Steelhead/Rainbow	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**92**	**307**	**0**
Lower Wenatchee Trap	Wild Steelhead/Rainbow	131	461	285	227	465	0
	Hatchery Steelhead/Rainbow	0	0	0	1	0	0
	Total	**131**	**461**	**285**	**228**	**465**	**0**
Total:	**Wild Steelhead/Rainbow**	**2,138**	**2,950**	**3,193**	**2,928**	**3,735**	**1,094**
	Hatchery Steelhead/Rainbow	**29**	**189**	**171**	**278**	**164**	**1**
Grand Total:		**2,167**	**3,139**	**3,364**	**3,206**	**3,899**	**1,095**

3.5 Spawning Surveys

Surveys for steelhead redds were conducted during March through May, 2011, in the Wenatchee River (including Beaver and Chiwaukum creeks), Chiwawa River (including Meadow, Alder, and Clear creeks), Nason Creek (including White Pine, Roaring, and an un-named stream), Icicle Creek, Peshastin Creek (including Mill, Ingalls, Tronsen, Scotty, Shaser, and Schafer creeks), and the White River (including the Napeequa River and Panther Creek). Surveys were conducted in both index and non-index areas throughout the Wenatchee Basin (see Appendix D for more details).

Redd Counts

A total of 932 steelhead redds were estimated in the Wenatchee Basin in 2011 (Table 3.16). This is about a 4% decrease over the estimate in 2010 (see Appendix D). Most spawning occurred in the Wenatchee River (34.7%), Nason Creek (25.2%), and Icicle Creek (19.3%) (Table 3.16; Figure 3.3). Peshastin Creek contained 12.3% of all redds in the Wenatchee Basin. The Little Wenatchee River contained 0.2% of the steelhead redds in the Wenatchee Basin. No redds were detected in the White River in 2011. The number of redds estimated in the Chiwawa Basin was just above the average for that area.

Table 3.16. Numbers of steelhead redds estimated within different streams/watersheds within the Wenatchee Basin, 2001-2011; NS = not sampled. Redd counts beginning in 2004 have been conducted within the same areas and with the same methods. Therefore, comparing redd numbers before 2004 with estimates since may not be valid.

Survey year	Number of steelhead redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River[a]	Icicle	Peshastin	Total
2001	25	27	NS	NS	116	19	NS	**187**
2002	80	80	1	0	315	27	NS	**503**

Survey year	Number of steelhead redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River[a]	Icicle	Peshastin	Total
2003	64	121	5	3	248	16	15	**472**
2004	62	127	0	0	151	23	34	**397**
2005	162	412	0	2	459	8	97	**1,140**
2006	19	77	NS	0	191	41	67	**395**
2007	11	78	0	1	46	6	17	**159**
2008	11	88	NS	1	100	37	49	**286**
2009	75	126	0	0	327	102	32	**662**
2010	74	270	4	3	380	120	118	**969**
2011	77	235	2	0	323	180	115	**932**
Average[b]	***61***	***177***	***1***	***1***	***247***	***65***	***66***	***932***

[a] Includes redds in Beaver and Chiwaukum creeks.
[b] The average is based on estimates from 2004 to present.

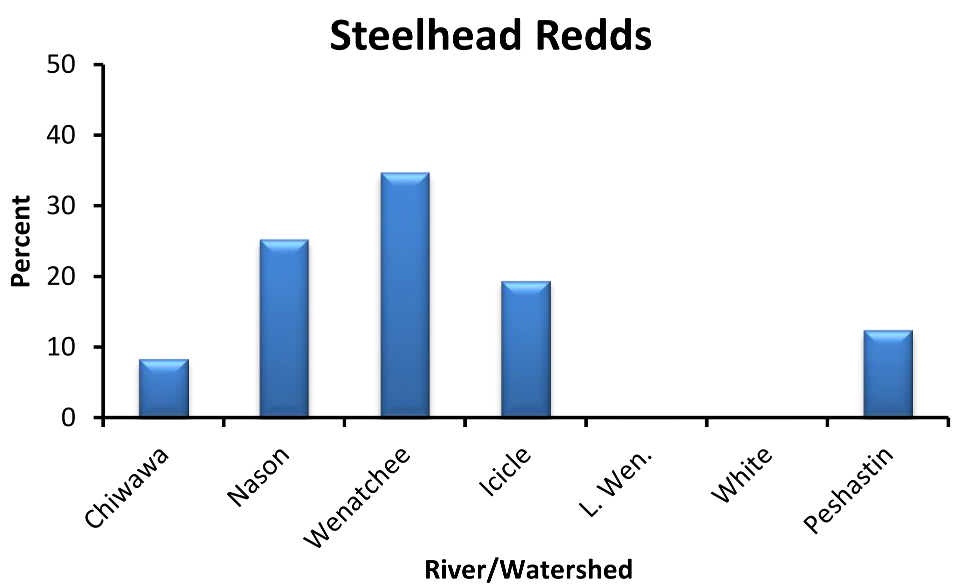

Figure 3.3. Percent of the total number of steelhead redds counted in different streams/watersheds within the Wenatchee Basin during March through May, 2011.

Redd Distribution

Steelhead redds were not evenly distributed among reaches within survey streams in 2011 (Table 3.17). Most of the spawning in the Chiwawa Basin occurred in Reach 1. The number of redds observed in Chikamin Creek and Clear Creek were 2 and 11, respectively. In addition, a single redd was observed in Alder Creek. No redds were observed in Big Meadow and Rock creeks.

All of the spawning in the Nason Creek Basin occurred in Nason Creek, primarily in Reach 3. No spawning was observed in the tributaries. Most spawning activity in the Peshastin Creek Basin was confined to Peshastin Creek proper, while two redds were observed in Tronsen Creek.

About 46% of the spawning in the Wenatchee River occurred upstream from Tumwater Dam (Table 3.17).

Table 3.17. Numbers and percentages of steelhead redds counted within different streams/watersheds within the Wenatchee Basin during March through May, 2011.

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
Chiwawa	Chiwawa 1 (C1)	63	81.8
	Rock Creek	0	0.0
	Chikamin Creek	2	2.6
	Meadow Creek	0	0.0
	Alder Creek	1	1.3
	Clear Creek	11	14.3
	Total	**77**	**100.0**
Nason	Nason 1 (N1)	33	14.0
	Nason 2 (N2)	71	30.2
	Nason 3 (N3)	108	46.0
	Nason 4 (N4)	23	9.8
	White Pine Creek	0	0.0
	Un-named Creek	0	0.0
	Roaring Creek	0	0.0
	Total	**235**	**100.0**
White	White 2 (H2)	0	0.0
	White 3 (H3)	0	0.0
	Panther Creek	0	0.0
	Naqeequa River (Q1)	0	0.0
	Total	**0**	**100.0**
Icicle	Icicle (I1)	180	100.0
	Total	**180**	**100.0**
Peshastin	Peshastin 1 (P1)	103	89.6
	Peshastin 2 (P2)	10	8.7
	Mill Creek	0	0.0
	Ingalls Creek	0	0.0
	Tronsen Creek	2	1.7
	Scotty Creek	0	0.0
	Shaser Creek	0	0.0
	Schafer Creek	0	0.0
	Total	**115**	**100.0**
Wenatchee	Wenatchee 1 (W1)	8	2.5
	Wenatchee 2 (W2)	53	16.4
	Wenatchee 3 (W3)	3	0.9
	Wenatchee 4 (W4)	0	0.0

Stream/watershed	Reach	Number of redds	Percent of redds within stream/watershed
	Wenatchee 5 (W5)	0	0.0
	Wenatchee 6 (W6)	109	33.8
	Wenatchee 7 (W7)	0	0.0
	Wenatchee 8 (W8)	3	0.9
	Wenatchee 9 (W9)	78	24.1
	Wenatchee 10 (W10)	66	20.4
	Beaver Creek	2	0.6
	Chiwaukum Creek	1	0.3
	Total	**323**	**100.0**

Spawn Timing

Steelhead began spawning during the third week of March in Icicle Creek and the Wenatchee River, and the first week of April in Peshastin Creek. In Nason Creek, a small number of redds were documented in the first and second weeks of March with the majority of spawning commencing the first week of April. Spawning activity appeared to begin once the mean daily stream temperature reached ~4.4^{o}C and was observed in water temperatures ranging from 2.6 - 9.0^{o}C. Steelhead spawning peaked in Icicle Creek the second week of April. Peak spawning occurred the third week in April and the fourth week in April in Nason Creek and Peshastin Creek, respectively. Spawning activity in the mainstem Wenatchee River peaked the first week of May (Figure 3.4).

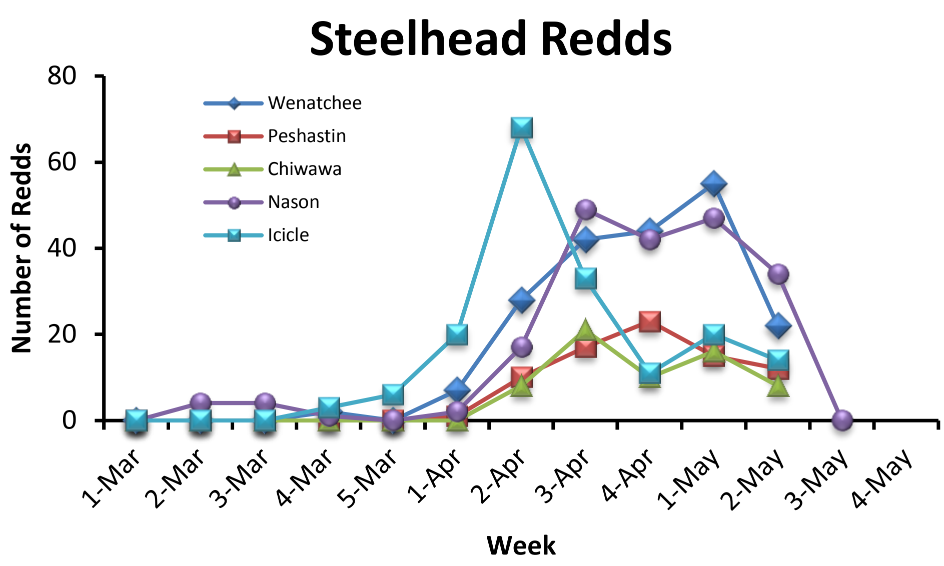

Figure 3.4. Numbers of steelhead redds counted during different weeks in different index areas within the Wenatchee Basin, March through May 2011.

Spawning Escapement

Spawning escapement for steelhead upstream from Tumwater Dam was calculated as the number of redds (upstream from the dam) times the fish per redd ratio (based on sex ratios estimated at Tumwater Dam using video surveillance). The estimated fish per redd ratio for steelhead in 2011 was 1.79 (Table 3.18). Multiplying this ratio by the total number of redds upstream from the dam resulted in a total spawning escapement of 823 steelhead (Table 3.18). This means that of the 1,130 steelhead counted at Tumwater, about 73% of them were estimated to have spawned upstream from the dam. This estimate was higher than the average of 50%.

The low estimated spawning escapement in 2011 may have resulted from the difficult survey conditions that biologists experienced in that year. That is, poor survey conditions may have obscured redds and high spring flows prevented post-peak surveys to be conducted in some areas. The effect of other factors, such as pre-spawning mortality, fallback, and illegal harvest remain unknown.

Table 3.18. Numbers of steelhead counted at Tumwater Dam, fish/redd estimates (based on male-to-female ratios estimated at Tumwater Dam), numbers of steelhead redds counted upstream from Tumwater Dam, total spawning escapement upstream from Tumwater Dam (estimated as the total number of redds times the fish/redd ratio), and the proportion of the Tumwater Dam count that made up the spawning escapement.

Survey year	Total count at Tumwater Dam	Fish/redd	Number of redds			Spawning escapement	Proportion of Tumwater count that spawned
			Index area	Non-index area	Total redds		
2001	820	2.08	118	19	137	285	0.35
2002	1,720	2.68	296	179	475	1,273	0.74
2003	1,810	1.60	353	88	441	706	0.39
2004	1,869	2.21	277	92	369	815	0.44
2005	2,650	1.61	828	136	964	1,552	0.59
2006	1,053	2.05	192	34	226	463	0.44
2007	657	1.94	105	29	134	260	0.40
2008	1,328	2.81	124	35	159	447	0.34
2009	1,781	1.83	284	107	931	716	0.40
2010	2,270	2.33	546	95	641	1,494	0.66
2011	1,130	1.79	427	33	460	823	0.73
***Average*[a]**	***1,592***	***2.07***	***348***	***70***	***486***	***821***	***0.50***

[a] The average is based on estimates from 2004 to present.

3.6 Life History Monitoring

Life history characteristics of steelhead were assessed by examining fish collected at broodstock collection sites, examining videotape at Tumwater Dam, and by reviewing tagging data and fisheries statistics. Some statistics could not be calculated at this time because few fish have been tagged with CWTs. All steelhead released from the hatchery received elastomer tags and about 30,300 were PIT tagged. With the placement of remote PIT tag detectors in spawning streams in

2007 and 2008, statistics such as origin on spawning grounds, stray rates, and SARs can be estimated more accurately in the future.

Migration Timing

Sampling at Tumwater Dam indicates that steelhead migrate throughout the year; however, the migration distribution is bimodal, indicating that steelhead migrate past Tumwater Dam in two pulses: one pulse during summer-autumn the year before spawning and another during winter-spring the year of spawning (Figure 3.5). Most steelhead passed Tumwater Dam during July through October and April. The highest proportion of both wild and hatchery fish migrated during October.

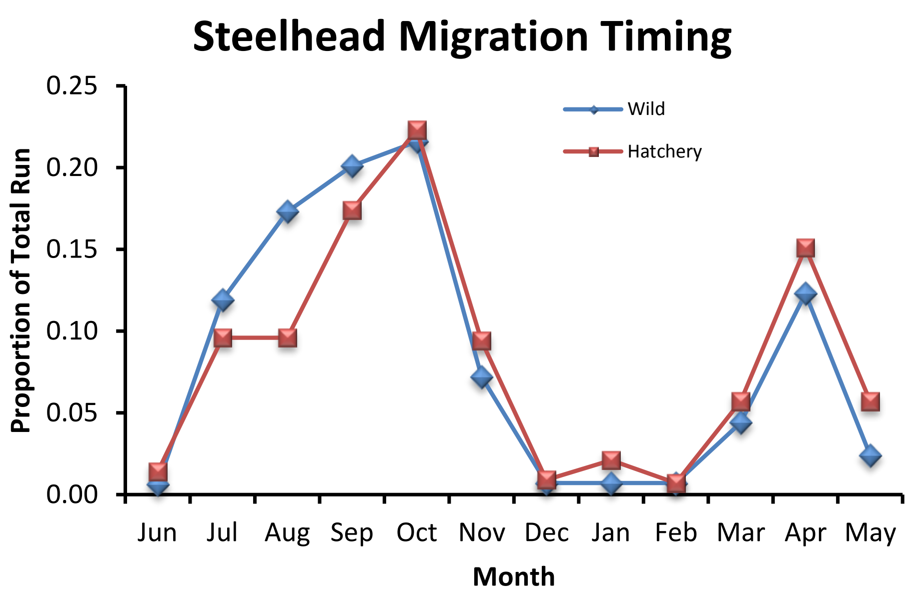

Figure 3.5. Proportion of wild and hatchery steelhead sampled at Tumwater Dam for the combined brood years of 1999-2011.

Because the migration of steelhead is bimodal, we estimated migration statistics separately for each migration pulse (i.e., summer-autumn migration and winter-spring migration). That is, we compared migration statistics for wild and hatchery steelhead passing Tumwater Dam during the summer-autumn period independent of those for the winter-spring migration period. We estimated the week and month that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during the two migration periods. We also estimated the mean weekly and monthly migration timing for wild and hatchery steelhead.

Overall, there was little difference in migration timing of wild and hatchery fish enumerated at Tumwater Dam (Table 3.19a and b; Figure 3.5). For both the summer-autumn and winter-spring migration periods, wild and hatchery steelhead arrived at the dam during the same week and month. The mean and median migration timing for wild and hatchery steelhead were also similar. However, at the tail end of both migration periods, on average, wild steelhead appeared to end their migration about one week earlier than hatchery steelhead.

Table 3.19a. The week that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during their summer-autumn migration (June through December) and during their winter-spring migration (January through May), 1999-2011. The average week is also provided for both migration periods. Migration timing is based on video sampling at Tumwater. The presence of eroded fins and/or missing adipose fins was used to distinguish hatchery fish from wild fish during video monitoring at Tumwater Dam. Estimates also include steelhead collected for broodstock.

Spawn year	Origin	Steelhead Migration Time (week)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
1999	Wild	27	32	47	35	81	12	16	17	15	29
	Hatchery	25	31	47	34	47	12	16	18	15	27
2000	Wild	31	36	41	36	238	11	14	18	14	40
	Hatchery	31	34	41	36	194	12	14	16	14	69
2001	Wild	29	34	41	35	391	13	15	17	15	84
	Hatchery	30	38	41	36	227	12	16	17	15	156
2002	Wild	29	39	46	38	810	13	14	17	14	181
	Hatchery	35	42	46	41	610	12	15	18	15	124
2003	Wild	30	33	40	35	731	3	9	16	9	193
	Hatchery	30	35	51	37	372	3	9	15	9	538
2004	Wild	30	40	45	39	644	13	16	18	16	222
	Hatchery	29	40	44	38	677	11	17	19	16	361
2005	Wild	30	39	43	38	986	10	15	17	15	206
	Hatchery	27	38	42	36	1,112	12	16	18	15	377
2006	Wild	29	40	43	39	428	12	15	17	15	191
	Hatchery	29	41	43	39	334	4	13	16	12	181
2007	Wild	30	36	41	35	277	11	17	17	15	108
	Hatchery	29	38	43	36	90	11	17	18	16	214
2008	Wild	30	38	43	38	397	13	15	18	16	123
	Hatchery	33	41	45	40	554	14	18	19	17	311
2009	Wild	30	37	46	37	338	13	15	19	15	87
	Hatchery	29	35	46	36	1,133	13	16	19	16	229
2010	Wild	31	37	45	38	648	11	15	18	15	171
	Hatchery	31	40	45	40	1,207	12	16	19	16	309
2011	Wild	29	36	44	36	797	13	17	19	17	118
	Hatchery	31	39	45	39	991	15	18	19	18	240
Average	***Wild***	***30***	***37***	***43***	***37***	***520***	***11***	***15***	***18***	***15***	***135***
	Hatchery	***30***	***38***	***45***	***38***	***581***	***11***	***15***	***18***	***15***	***241***

Table 3.19b. The month that 10%, 50% (median), and 90% of the wild and hatchery steelhead passed Tumwater Dam during their summer-autumn migration (June through December) and during their winter-spring migration (January through May), 1999-2011. The average month is also provided for both migration periods. Migration timing is based on video sampling at Tumwater. The presence of eroded fins and/or missing adipose fins was used to distinguish hatchery fish from wild fish during video monitoring at Tumwater Dam. Estimates also include steelhead collected for broodstock.

Spawn year	Origin	Steelhead Migration Time (month)									
		Summer-Autumn Migration (Jun-Dec)					Winter-Spring Migration (Jan-May)				
		10%	50%	90%	Mean	Sample size	10%	50%	90%	Mean	Sample size
1999	Wild	7	8	11	8	81	3	4	4	4	29
	Hatchery	6	8	11	8	47	3	4	4	4	27
2000	Wild	8	9	10	9	238	3	4	5	4	40
	Hatchery	8	8	10	9	194	3	4	4	4	69
2001	Wild	7	8	10	8	391	3	4	4	4	84
	Hatchery	7	9	10	9	227	3	4	4	4	156
2002	Wild	7	9	11	9	810	3	4	4	4	181
	Hatchery	9	10	11	10	610	3	4	5	4	124
2003	Wild	7	8	10	8	731	1	3	4	3	193
	Hatchery	7	8	12	9	372	1	3	4	2	538
2004	Wild	7	10	11	9	644	3	4	4	4	222
	Hatchery	7	10	10	9	677	3	4	5	4	361
2005	Wild	7	9	10	9	986	3	4	4	4	206
	Hatchery	7	9	10	9	1,112	3	4	5	4	377
2006	Wild	7	10	10	10	428	3	4	4	4	191
	Hatchery	7	10	10	9	334	1	3	4	3	181
2007	Wild	7	9	10	9	277	3	4	4	4	108
	Hatchery	7	9	10	9	90	3	4	5	4	214
2008	Wild	7	9	10	9	397	3	4	5	4	123
	Hatchery	8	10	11	10	554	4	4	5	4	311
2009	Wild	7	9	11	9	338	3	4	5	4	87
	Hatchery	7	8	11	9	1,133	3	4	5	4	229
2010	Wild	8	9	11	9	648	3	4	5	4	171
	Hatchery	8	10	11	10	1,207	3	4	5	4	309
2011	Wild	7	9	11	9	797	4	4	5	4	118
	Hatchery	8	9	11	9	991	4	5	5	5	240
Average	***Wild***	***7***	***9***	***10***	***9***	***520***	***3***	***4***	***4***	***4***	***135***
	Hatchery	***7***	***9***	***11***	***9***	***581***	***3***	***4***	***5***	***4***	***241***

Age at Maturity

Nearly all steelhead broodstock collected at Tumwater and Dryden dams lived in saltwater 1 to 2 years (saltwater age) (Table 3.20; Figure 3.6). Very few saltwater age-3 fish returned and those that did were wild fish. On average, there was a difference between the saltwater age at return of wild and hatchery fish. A greater number of wild fish returned as saltwater age-2 fish than did hatchery fish. In contrast, a greater number of hatchery fish returned as saltwater-1 fish than did wild fish.

Table 3.20. Proportions of wild and hatchery steelhead broodstock of different ages collected at Tumwater and Dryden dams, 1998-2011. Age represents the number of years the fish lived in salt water.

Sample year	Origin	Saltwater age			Sample size
		1	2	3	
1998	Wild	0.39	0.61	0.00	35
	Hatchery	0.21	0.79	0.00	43
1999	Wild	0.50	0.48	0.02	58
	Hatchery	0.82	0.18	0.00	67
2000	Wild	0.56	0.44	0.00	39
	Hatchery	0.68	0.32	0.00	101
2001	Wild	0.52	0.48	0.00	64
	Hatchery	0.15	0.85	0.00	114
2002	Wild	0.56	0.44	0.00	99
	Hatchery	0.95	0.05	0.00	113
2003	Wild	0.13	0.85	0.02	63
	Hatchery	0.29	0.71	0.00	92
2004	Wild	0.95	0.05	0.00	85
	Hatchery	0.95	0.05	0.00	132
2005	Wild	0.22	0.78	0.00	95
	Hatchery	0.21	0.79	0.00	114
2006	Wild	0.29	0.71	0.00	101
	Hatchery	0.60	0.40	0.00	98
2007	Wild	0.40	0.59	0.00	79
	Hatchery	0.62	0.38	0.00	97
2008	Wild	0.65	0.34	0.01	104
	Hatchery	0.89	0.11	0.00	107
2009	Wild	0.40	0.58	0.20	83
	Hatchery	0.23	0.77	0.0	77
2010	Wild	0.65	0.34	0.01	92
	Hatchery	0.77	0.23	0.00	98
2011	Wild	0.28	0.73	0.00	102
	Hatchery	0.36	0.64	0.00	100
Average	***Wild***	***0.46***	***0.53***	***0.01***	***79***

Sample year	Origin	Saltwater age			Sample size
		1	2	3	
	Hatchery	***0.55***	***0.45***	***0.00***	***97***

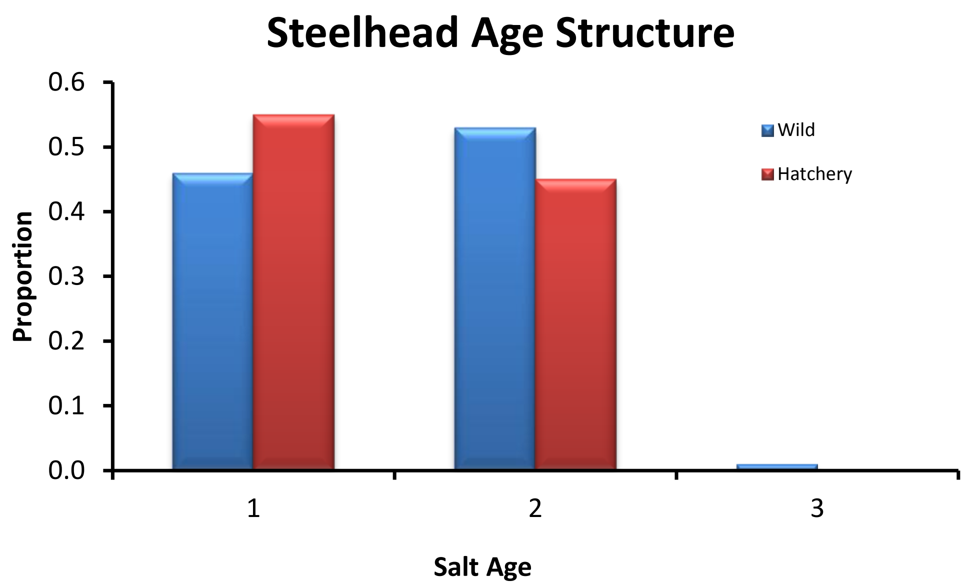

Figure 3.6. Proportions of wild and hatchery steelhead of different saltwater ages sampled at Tumwater Dam for the combined years 1998-2011.

Size at Maturity

On average, hatchery steelhead collected at Tumwater and Dryden dams were about 3-4 cm smaller than wild steelhead (Table 3.21). This may be related to the fact that more wild steelhead return as saltwater age-2 fish than hatchery steelhead.

Table 3.21. Mean fork length (cm) at age (saltwater ages) of hatchery and wild steelhead collected from broodstock, 1998-2011; N = sample size and SD = 1 standard deviation.

Return year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1998	Wild	63	15	4	79	20	5	-	0	-
	Hatchery	61	9	4	73	34	4	-	0	-
1999	Wild	65	29	5	74	28	5	77	1	-
	Hatchery	62	54	4	73	12	4	-	0	-
2000	Wild	64	22	3	74	17	5	-	0	-
	Hatchery	60	57	3	71	27	4	-	0	-
2001	Wild	61	33	6	77	31	5	-	0	-
	Hatchery	62	17	4	72	97	4	-	0	-
2002	Wild	64	55	4	77	44	4	-	0	-

Return year	Origin	Steelhead fork length (cm)								
		1-Salt			2-Salt			3-Salt		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	63	106	4	73	6	4	-	0	-
2003	Wild	69	8	6	77	52	5	91	1	-
	Hatchery	66	27	4	75	65	4	-	0	-
2004	Wild	63	73	6	78	4	2	-	0	-
	Hatchery	61	59	3	73	3	1	-	0	-
2005	Wild	59	21	4	74	74	5	-	0	-
	Hatchery	59	23	4	72	89	4	-	0	-
2006	Wild	63	27	5	75	67	6	-	0	-
	Hatchery	61	41	4	72	27	5	-	0	-
2007	Wild	64	31	6	76	46	5	-	0	-
	Hatchery	60	60	4	71	36	5	-	0	-
2008	Wild	64	68	4	77	35	4	80	2	-
	Hatchery	60	95	4	72	12	2	-	0	-
2009	Wild	65	33	5	76	48	6	81	2	0
	Hatchery	63	18	4	75	59	5	-	0	-
2010	Wild	64	60	5	74	31	5	76	1	-
	Hatchery	61	53	5	73	23	5	-	0	-
2011	Wild	62	28	5	76	74	5	-	0	-
	Hatchery	60	36	4	74	64	4	-	0	-
Average	Wild	64	36	5	76	41	5	81	1	0
	Hatchery	61	47	4	73	40	4	-	0	-

Contribution to Fisheries

Nearly all harvest on Wenatchee steelhead occurs within the Columbia basin. Harvest rates on steelhead in the Lower Columbia River fisheries (both tribal and non-tribal) are generally less than 5-10% (NMFS 2004). WDFW regulates steelhead harvest in the Upper Columbia. Under certain conditions, WDFW may allow a harvest on hatchery steelhead (adipose fin clipped fish). The intent is to reduce the number of hatchery steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of wild steelhead in spawning populations.

Origin on Spawning Grounds

At this time, origin of steelhead (wild or hatchery) on spawning grounds cannot be determined precisely. However, based on scales collected during steelhead run composition sampling at Dryden Dam in 2009 (2010 spawners), naturally produced steelhead made up about 23% of the escapement. More precise estimates of wild and hatchery spawners within tributaries can be generated after remote PIT tag detectors are installed within spawning tributaries.

Straying

Stray rates of Wenatchee steelhead can be estimated by examining the locations where PIT-tagged hatchery steelhead were last detected. PIT tagging of steelhead began with brood year 2005, which allows estimation of stray rates by brood return. These data only provide estimates for brood years 2005 through 2007, because later brood years are still rearing in the ocean. The target for brood year stray rates should be less than 5%.

Based on PIT-tag analyses, on average, about 34% of the hatchery steelhead returns were last detected in streams outside the Wenatchee Basin (Table 3.22). The numbers in Table 3.22 should be considered rough estimates because they are not based on confirmed spawning (only last detections) and the numbers have not been adjusted for detection efficiencies, which currently do not exist for most PIT-tag detection arrays in tributaries. What these data do indicate is that large numbers of hatchery steelhead from the Wenatchee program have wandered or strayed into the Entiat and Methow rivers, and also into the Tucannon River. Most (about 70%) of the strays were detected in the Methow River.

Table 3.22. Number and percent of hatchery-origin Wenatchee steelhead that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005 to 2007. Estimates were based on last detections of PIT-tagged hatchery steelhead. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	80	75.5	0	0.0	26	24.5	0	0.0
2006	71	62.3	1	0.9	43	37.7	0	0.0
2007	171	60.6	0	0.0	111	39.4	0	0.0
Average	***107***	***66.1***	***0***	***0.3***	***60***	***33.9***	***0***	***0.0***

At this time, we cannot estimate among population stray rates by return year, because we have no estimates of detection efficiencies for PIT-tag interrogation sites within different tributaries. These data are needed to estimate the total number of Wenatchee steelhead that stray into areas outside the Wenatchee Basin. Finally, for the same reason, we cannot evaluate within population stray rates.

Genetics

Genetic studies were conducted to determine the potential effects of the Wenatchee Supplementation Program on natural-origin summer steelhead in the Wenatchee Basin (Seamons et al. 2012; the entire report is appended as Appendix E). Temporal collections of tissue samples from Wenatchee hatchery-produced and natural-origin adults sampled at Dryden and Tumwater dams and from natural-origin juveniles from three Wenatchee River tributaries and the Entiat River were surveyed for genetic variation with 132 genetic (single nucleotide polymorphism loci; SNPs) markers. Peshastin Creek and the Entiat River served as no-hatchery-outplant controls. Genetic data were interrogated for the presence or absence of spatial and temporal trends in allele frequencies, genetic distances, and effective population size.

Allele Frequencies—Changes to the summer steelhead hatchery supplementation program had no detectable effect on genetic diversity of wild populations. On average, hatchery-origin adults had higher minor allele frequencies (MAF) than natural-origin adults, which may simply reflect the mixed ancestry of hatchery adults. Both hatchery and natural-origin adults had MAF similar to juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants. This suggests that the hatchery program has had little effect on allele frequencies since broodstock sources changed in 1998 from mixed-ancestry broodstock collected in the Columbia River to using broodstock collected in the Wenatchee River.

Genetic Distances—As intended, interbreeding of Wenatchee River hatchery and natural-origin adults reduced the genetic differences between Wells Hatchery adults and Wenatchee River natural-origin adults observed in the first few years after changing the broodstock collection protocol. Although there were detectable genetic differences between hatchery and natural-origin adults, the magnitude of that difference declined over time. Hatchery adults were genetically different from natural-origin adults and juveniles based on pair-wise F_{ST} and principal components analysis, most likely because of the smaller effective population size (N_b) in the hatchery population (see below). Pair-wise F_{ST} estimates and genetic distances between hatchery and natural-origin adults collected the same year declined over time suggesting that the interbreeding of hatchery and natural-origin adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year were inconclusive because of limitations in the data.

Effective Population Size—Although the effective population size of the Wenatchee River hatchery steelhead program was consistently small, it does not appear to have caused a reduction in the effective population size of wild populations. On average, estimates of N_b were much lower and varied less for hatchery adults than for natural-origin adults and juveniles. Estimates of N_b for hatchery adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1998. There was no indication that this had any effect on N_b in natural-origin adults and juveniles; N_b estimates for natural-origin adults and juveniles were, on average, higher and varied considerably over the 1998-2010 time period and showed no temporal trend.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 2001-2011, the PNI was equal to or less than 0.59 (Table 3.23). This indicates that the hatchery environment has a greater influence on adaptation of Wenatchee steelhead than does the natural environment.

Table 3.23. Proportionate natural influence (PNI) of the Wenatchee steelhead supplementation program for brood years 2001-2011. PNI was calculated as the proportion of naturally produced steelhead in the hatchery broodstock (pNOB) divided by the proportion of hatchery steelhead on the spawning grounds (pHOS) plus pNOB. NOS = number of natural-origin steelhead on the spawning grounds; HOS = number of hatchery-origin steelhead on the spawning grounds; NOB = number of natural-origin steelhead collected for broodstock; and HOB = number of hatchery-origin steelhead included in hatchery broodstock.

Brood year	Spawners[a]			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2001	158	127	0.45	51	103	0.33	0.43
2002	731	542	0.43	96	64	0.60	0.59
2003	356	350	0.50	49	90	0.35	0.42
2004	371	444	0.55	75	61	0.55	0.50
2005	690	862	0.56	87	104	0.46	0.45
2006	253	210	0.45	93	69	0.57	0.56
2007	145	115	0.44	76	58	0.57	0.56
2008	168	279	0.62	77	54	0.59	0.48
2009	171	545	0.76	86	73	0.57	0.24
2010	524	970	0.65	96	75	0.56	0.46
2011	351	472	0.57	91	70	0.57	0.50
Average	***356***	***447***	***0.54***	***80***	***75***	***0.52***	***0.49***

[a] Proportions of natural-origin and hatchery-origin spawners were determined from video tape at Tumwater Dam. Therefore, these PNI estimates are appropriate for steelhead spawning upstream from Tumwater Dam. They may not represent PNI for steelhead spawning downstream from Tumwater Dam.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). For brood years 1998-2004, NRR for summer steelhead in the Wenatchee Basin averaged 0.90 (range, 0.13-3.10) if harvested fish were included in the estimate (Table 3.24).

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 19.2 (the calculated target value in Murdoch and Peven 2005). In nearly all years, HRRs were greater than NRRs (Table 3.24). HRRs exceeded the estimated target value of 19.2 in one of the seven years.

Table 3.24. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR with harvest) for summer steelhead in the Wenatchee Basin, brood years 1998-2004.

Brood year	Broodstock Collected	Spawning Escapement	Harvest included			
			HOR	NOR	HRR	NRR
1998	78	602	148	1,867	1.89	3.10
1999	125	343	1,944	334	15.55	0.97
2000	120	1,030	312	878	2.60	0.85

Brood year	Broodstock Collected	Spawning Escapement	Harvest included			
			HOR	NOR	HRR	NRR
2001	178	1,655	10,335	1,085	58.06	0.66
2002	162	5,000	1,905	662	11.76	0.13
2003	155	2,598	956	689	6.17	0.27
2004	140	2,948	1,127	969	8.05	0.33
Average	***137***	***2,025***	***2,390***	***926***	***14.87***	***0.90***

Smolt-to-Adult Survivals

Smolt-to-adult ratios (SARs) are calculated as the number of returning hatchery adults divided by the number of tagged hatchery smolts released. SARs are generally based on CWT returns. However, Wenatchee steelhead have not been extensively tagged with CWTs. Therefore, elastomer-tagged fish were used to estimate SARs from release to capture at Priest Rapids Dam.

SARs (not adjusted for tag loss) for Wenatchee steelhead ranged from 0.0009 to 0.0308 (mean = 0.0075) for brood years 1996-2005 (Table 3.25).

Table 3.25. Smolt-to-adult ratios (SARs) for Wenatchee hatchery steelhead, 1996-2005. Estimates were based on elastomer tags recaptured at Priest Rapids Dam. SARs were not adjusted for tag loss after release.

Brood year	Number of tagged smolts released	SAR
1996	348,693	0.0034
1997	429,422	0.0041
1998	172,078	0.0009
1999	175,661	0.0111
2000	184,639	0.0017
2001	335,933	0.0308
2002	302,060	0.0063
2003	374,867	0.0025
2004	294,114	0.0038
2005	452,184	0.0107
Average	***306,965***	***0.0075***

3.7 ESA/HCP Compliance

Broodstock Collection

Collection of brood year 2010 broodstock for Wenatchee steelhead at Tumwater and Dryden dams began on 7 July and ended on 20 October 2009 and represented a slightly shortened collection duration from the 1 July to 12 November collection period identified in the 2010 broodstock collection protocol. The broodstock collection protocols specified a total collection of 208 steelhead, including 104 natural-origin steelhead. Actual broodstock collection totaled 211 steelhead collected at Tumwater and Dryden dams, including 106 natural-origin fish (102% of the total collection). The total number and proportion of natural-origin steelhead in the broodstock were more than the 104 and slightly above the 50% values identified in the 2010 protocol and ESA Permit 1395, respectively.

About 207 and 945 steelhead were handled and released at Dryden Dam and Tumwater Dam, respectively, during brood year 2010 Wenatchee steelhead broodstock collection. These fish were released because the weekly quota for hatchery or wild steelhead had been attained, but not both, or because they were non-target (red/green VIE tagged), or they were unidentifiable hatchery-origin steelhead. All steelhead released were allowed to fully recover from the anesthesia and released immediately upstream from the trap sites.

In addition to steelhead encountered at Dryden Dam during steelhead broodstock collection, 59 spring Chinook salmon were captured and released unharmed immediately upstream from the trap facility. Consistent with ESA Section 10 Permit 1395 impact minimization measures, all ESA species handled at this site were subject of water-to-water transfers.

Hatchery Rearing and Release

The 2010 brood Wenatchee steelhead reared throughout all life-stages without significant mortality (defined as >10% population mortality associated with a single event). However, the 2010 brood had poor fertilization to eyed-egg and ponding-to-release survival resulting in an unfertilized-to-release survival of 70.9%, which was less than the program target of 81% (see Section 3.2).

Juvenile rearing occurred at four separate facilities including Eastbank Fish Hatchery, Chelan Falls Fish Hatchery, Turtle Rock Fish Hatchery, and Chiwawa Ponds. Multiple facilities were used to take advantage of variable water temperatures to manipulate growth of juveniles from different parental crosses. Typically, wild steelhead spawn later than their hatchery cohort and are therefore reared at Chelan Falls Fish Hatchery on warmer water to accelerate their growth so they achieve a size at release similar to HxH and HxW parental cross progeny reared on cooler water at Eastbank Fish Hatchery. All parental cross groups received final rearing at Turtle Rock Fish Hatchery on Columbia River surface water before direct release (scatter planting) in the Wenatchee River basin with the exception of one test group (24,000 fish) at Chiwawa being over-winter acclimated on a circular re-use system.

The 2010 brood steelhead smolt release in the Wenatchee Basin totaled 354,314 smolts, representing about 89% of the program target of 400,000 smolts identified in the Rocky Reach and Rock Island Dam HCPs and in ESA Section 10 Permit 1395. As specified in ESA Section 10 Permit 1395, all steelhead smolts released were externally marked or tagged and a representative number were PIT tagged (see Section 3.2).

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January 2011 through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1395, the permit holders are authorized a direct take of 20% of the emigrating steelhead population and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild steelhead population (smolt trap expansion) and hatchery juvenile steelhead population estimate (hatchery release data) for the Wenatchee Basin, the reported steelhead encounters during the 2011 emigration complied with take provisions in the Section 10 permit and are detailed in Table 3.26. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1395 Section B.

Table 3.26. Estimated take of Upper Columbia River steelhead resulting from juvenile emigration monitoring in the Wenatchee Basin, 2011. NA = not available.

Trap location	Population estimate				Number trapped				Total	Take allowed by Permit
	Wild	Hatchery[b]	Parr	Fry	Wild	Hatchery	Parr	Fry		
Chiwawa Trap										
Population	NA	81,174	NA	NA	195	8,250	981	242	9,668	
Encounter rate	NA	NA	NA	NA	NA	0.1016	NA	NA	0.1171	0.20
Mortality [b]	NA	NA	NA	NA	0	0	8	2	10	
Mortality rate	NA	NA	NA	NA	0.0000	0.0000	0.0082	0.0083	0.0010	0.02
Upper Wenatchee Trap										
Population	NA	111,189	NA	NA	135	376	127	1	639	
Encounter rate	NA	NA	NA	NA	NA	0.0034	NA	NA	0.0057	0.20
Mortality [b]	NA	NA	NA	NA	0	3	0	0	3	
Mortality rate	NA	NA	NA	NA	0.0000	0.0080	0.0000	0.0000	0.0047	0.02
Lower Wenatchee Trap										
Population	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Encounter rate	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.20
Mortality [b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Mortality rate	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02
Wenatchee Basin Total										
Population	NA	354,314	NA	NA	330	8,626	1,108	243	10,307	
Encounter rate	NA	NA	NA	NA	NA	0.0243	NA	NA	0.0290	0.20
Mortality [b]	NA	NA	NA	NA	0	3	8	2	13	
Mortality rate	NA	NA	NA	NA	0.0000	0.0003	0.0072	0.0082	0.0013	0.02

[a] 2010 smolt release data for the Wenatchee basin.

[b] Mortality includes trapping and PIT tag mortalities.

Spawning Surveys

Steelhead spawning ground surveys were conducted in the Wenatchee Basin during 2011, as authorized by ESA Section 10 Permit No. 1395. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Stock Assessment at Priest Rapids Dam

Upper Columbia River steelhead stock assessment sampling at Priest Rapids Dam (PRD) is authorized through ESA Section 10 Permit No. 1395 (NMFS 2003). Permit authorizations include interception and biological sampling of up to 10% of the Upper Columbia River steelhead passing PRD to determine upriver adult population size, estimate hatchery to wild ratios, determine age-class contribution, and evaluate the need for managing hatchery steelhead consistent with ESA recovery objectives, which include fully seeding spawning habitat with naturally produced Upper Columbia River steelhead supplemented with artificially propagated enhancement steelhead (NMFS 2003). The 2010-2011 run-cycle report (BY 2010) for stock assessment sampling at Priest Rapids Dam was compiled under provisions of ESA Section 10 Permit 1395. Data and reporting information are included in Appendix G.

SECTION 4: WENATCHEE SOCKEYE SALMON

4.1 Broodstock Sampling

This section focuses on results from sampling 2009 and 2010 Wenatchee sockeye broodstock, which were collected at Tumwater Dam. The 2009 brood begins the tracking of the life cycle of sockeye that were released as parr into Lake Wenatchee in 2010 and some of which began smolt migrations in 2011. The 2010 brood is included because juveniles from this brood were released as parr in the lake in 2011. Complete information is not currently available for the 2011 brood (this information will be provided in the 2012 annual report). Collection of sockeye broodstock targets naturally produced fish and equal numbers of male and female fish.

Origin of Broodstock

The 2009 broodstock consisted of naturally produced Wenatchee sockeye collected at Tumwater Dam between 11 July and 21 August 2009 (Table 4.1). A total of 239 naturally produced sockeye were spawned. The 2010 broodstock consisted of naturally produced sockeye salmon collected at Tumwater Dam between 15 July and 15 August 2010 (Table 4.1). A total of 198 naturally produced sockeye were spawned.

Table 4.1. Numbers of wild and hatchery sockeye salmon collected for broodstock, numbers that died before spawning, and numbers of sockeye spawned, 1989-2010. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes sockeye that died of natural causes typically near the end of spawning and were not needed for the program, surplus sockeye killed at spawning, sockeye that died but were not recovered from the net pens, and sockeye that may have jumped out of the net pens.

Brood year	Wild sockeye					Hatchery sockeye					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
1989	299	93	47	115	44	0	0	0	0	0	115
1990	333	7	7	302	17	0	0	0	0	0	302
1991	357	18	16	199	124	0	0	0	0	0	199
1992	362	18	5	320	19	0	0	0	0	0	320
1993	307	79	21	207	0	0	0	0	0	0	207
1994	329	15	9	236	69	5	0	0	5	0	241
1995	218	5	7	194	12	3	0	0	3	0	197
1996	291	2	0	225	64	20	0	0	0	20	225
1997	283	12	3	192	76	19	0	0	19	0	211
1998	225	37	25	122	41	6	0	0	6	0	128
1999	90	7	1	79	3	60	0	0	60	0	139
2000	256	19	1	170	66	5	0	0	5	0	175
2001	252	27	10	200	15	8	1	0	7	0	207
2002	257	0	1	256	0	0	0	0	0	0	256
2003	261	12	9	198	42	0	0	0	0	0	198
2004	211	13	12	177	9	0	0	0	0	0	177
2005	243	29	12	166	36	0	0	0	0	0	166
2006	260	2	4	214	40	0	0	0	0	0	214

Brood year	Wild sockeye					Hatchery sockeye					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
2007	248	15	3	210	20	0	0	0	0	0	210
2008	258	4	11	243	0	2	0	0	2	0	245
2009	258	5	14	239	0	3	0	3	0	0	239
2010	256	3	0	198	55	0	0	0	0	0	256
Average	***266***	***19***	***10***	***203***	***34***	***6***	***0***	***0***	***5***	***1***	***210***

Age/Length Data

Ages of sockeye were determined from scales and otoliths collected from broodstock. The 2009 return was comprised primarily of age-4 returning adults (78.5%; Table 4.2). Age-5 sockeye made up 21.5% of the 2009 return. The 2010 return consisted primarily of age-4 adults (67.4%; Table 4.2). Age-5 sockeye made up 32.6% of the 2010 return.

Table 4.2. Percent of hatchery and wild sockeye salmon of different ages (total age) collected from broodstock, 1994-2010.

Return year	Origin	Total age		
		4	5	6
1994	Wild	57.3	41.7	1.0
	Hatchery	40.0	60.0	0.0
1995	Wild	77.3	20.7	2.0
	Hatchery	66.7	33.3	0.0
1996	Wild	65.8	34.2	0.0
	Hatchery	0.0	0.0	0.0
1997	Wild	86.5	13.5	0.0
	Hatchery	57.9	42.1	0.0
1998	Wild	9.9	88.6	1.5
	Hatchery	66.7	33.3	0.0
1999	Wild	21.8	74.7	3.5
	Hatchery	90.0	8.3	1.7
2000	Wild	97.7	2.3	0.0
	Hatchery	100.0	0.0	0.0
2001	Wild	69.9	29.6	0.5
	Hatchery	71.4	28.6	0.0
2002	Wild	31.6	67.6	0.8
	Hatchery	0.0	0.0	0.0
2003	Wild	2.6	90.5	6.9
	Hatchery	0.0	0.0	0.0
2004	Wild	97.5	2.0	0.5
	Hatchery	0.0	0.0	0.0
2005	Wild	74.2	25.8	0.0

Return year	Origin	Total age		
		4	5	6
	Hatchery	0.0	0.0	0.0
2006	Wild	34.0	65.5	0.5
	Hatchery	0.0	0.0	0.0
2007	Wild	1.9	88.4	9.7
	Hatchery	0.0	0.0	0.0
2008	Wild	95.0	4.0	1.0
	Hatchery	100.0	0.0	0.0
2009	Wild	78.5	21.5	0.0
	Hatchery	100.0	0.0	0.0
2010	Wild	67.4	32.6	0.0
	Hatchery	0.0	0.0	0.0
Average	***Wild***	***57.0***	***41.4***	***1.6***
	Hatchery	***40.7***	***12.1***	***0.1***

Lengths of sockeye for the 2009 and 2010 return years are provided in Table 4.3. Lengths of age-4 and 5 sockeye sampled in 2010 averaged 56 and 57 cm, respectively.

Table 4.3. Mean fork length (cm) at age (total age) of hatchery and wild sockeye salmon collected for broodstock, 1994-2010; SD = 1 standard deviation.

Return year	Origin	Sockeye fork length (cm)								
		Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
1994	Wild	56	125	3	55	91	3	54	2	3
	Hatchery	57	2	1	56	3	1	-	0	-
1995	Wild	51	153	2	55	41	4	54	4	5
	Hatchery	53	2	4	59	1	-	-	0	-
1996	Wild	52	146	4	53	76	3	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-
1997	Wild	50	166	3	53	26	5	-	0	-
	Hatchery	54	11	4	59	8	2	-	0	-
1998	Wild	51	13	4	55	117	3	53	2	3
	Hatchery	52	4	2	55	2	8	-	0	-
1999	Wild	52	19	4	50	65	4	56	3	1
	Hatchery	50	54	3	56	5	4	56	1	-
2000	Wild	52	167	2	54	4	3	-	0	-
	Hatchery	54	5	1	-	0	-	-	0	-
2001	Wild	54	151	3	56	65	4	58	1	-
	Hatchery	51	5	5	55	2	4	-	0	-
2002	Wild	54	77	2	56	165	4	57	2	0

Return year	Origin	Sockeye fork length (cm)								
		Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	-	0	-	-	0	-
2003	Wild	54	5	4	60	172	2	60	13	4
	Hatchery	-	0	-	-	0	-	-	0	-
2004	Wild	53	192	3	56	4	3	63	1	-
	Hatchery	-	0	-	-	0	-	-	0	-
2005	Wild	51	132	3	57	46	4	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-
2006	Wild	52	70	3	56	135	4	54	2	3
	Hatchery	-	0	-	-	0	-	-	0	-
2007	Wild	57	4	2	58	182	5	58	20	5
	Hatchery	-	0	-	-	0	-	-	0	-
2008	Wild	52	245	3	52	11	3	62	2	6
	Hatchery	53	2	3	-	-	-	-	-	-
2009	Wild	54	197	3	59	54	4	-	-	-
	Hatchery	54	2	1	-	-	-	-	-	-
2010	Wild	56	130	2	57	63	4	-	-	-
	Hatchery	-	-	-	-	-	-	-	-	-

Sex Ratios

Male sockeye in the 2009 return made up about 51% of the adults collected, resulting in an overall male to female ratio of 1.04:1.00 (Table 4.4). In 2010, males made up about 49.6% of the adults collected, resulting in an overall male to female ratio of 0.98:1.00. Ratios for both years were near the 1:1 ratio target in the broodstock protocol.

Table 4.4. Numbers of male and female wild and hatchery sockeye collected for broodstock, 1989-2010. Ratios of males to females are also provided.

Return year	Number of wild sockeye			Number of hatchery sockeye			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	162	137	1.18:1.00	0	0	-	1.18:1.00
1990	177	156	1.13:1.00	0	0	-	1.13:1.00
1991	260	97	2.68:1.00	0	0	-	2.68:1.00
1992	180	182	0.99:1.00	0	0	-	0.99:1.00
1993	130	177	0.73:1.00	0	0	-	0.73:1.00
1994	162	167	0.97:1.00	1	4	0.25:1.00	0.95:1.00
1995	102	116	0.88:1.00	1	2	0.50:1.00	0.87:1.00
1996	150	161	0.93:1.00	0	0	-	0.93:1.00
1997	139	144	0.97:1.00	10	9	1.11:1.00	0.97:1.00
1998	115	110	1.05:1.00	2	4	0.50:1.00	1.03:1.00

Return year	Number of wild sockeye			Number of hatchery sockeye			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1999	22	68	0.32:1.00	37	23	1.61:1.00	0.65:1.00
2000	155	101	1.53:1.00	3	2	1.50:1.00	1.53:1.00
2001	114	138	0.83:1.00	4	4	1.00:1.00	0.83:1.00
2002	128	129	0.99:1.00	0	0	-	0.99:1.00
2003	161	100	1.61:1.00	0	0	-	1.61:1.00
2004	108	103	1.05:1.00	0	0	-	1.05:1.00
2005	130	113	1.15:1.00	0	0	-	1.15:1.00
2006	130	130	1.00:1.00	0	0	-	1.00:1.00
2007	127	121	1.05:1.00	0	0	-	1.05:1.00
2008	127	131	0.97:1.00	1	1	1.00:1.00	0.97:1.00
2009	133	125	1.06:1.00	0	3	0.00:1.00	1.04:1.00
2010	127	129	0.98:1.00	0	0	-	0.98:1.00
Total	***3039***	***2835***	***1.07:1.00***	***59***	***52***	***1.13:1.00***	***1.07:1.00***

Fecundity

Fecundities for the 2009 and 2010 returns of sockeye salmon averaged 2,459 and 2,782 eggs per female, respectively (Table 4.5). The lower mean fecundity for the 2009 return was likely because of the strong age-4 component in the return. Fecundities for this program between 1989 and 2006 are based upon the total (pooled) number of eyed eggs divided by the number of females spawned. For brood years 2007 to present, mean fecundities were derived from individual fecundities.

Table 4.5. Mean fecundity of female sockeye salmon collected for broodstock, 1989-2010. Fecundities were determined from pooled egg lots and were not identified for individual females.

Return year	Mean fecundity
1989	2,344
1990	2,225
1991	2,598
1992	2,341
1993	2,340
1994	2,798
1995	2,295
1996	2,664
1997	2,447
1998	2,813
1999	2,319
2000	2,673
2001	2,960
2002	2,856

Return year	Mean fecundity
2003	3,511
2004	2,505
2005	2,718
2006	2,656
2007	3,115
2008	2,555
2009	2,459
2010	2,782
Average	***2,635***

4.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 246,914 eggs are required to meet the program release goal of 200,000 smolts. From 1989 to 2010, the egg take goal was reached in 65% of the years (Table 4.6). The number of eggs taken in 2011 was above the egg take target by 18%.

Table 4.6. Numbers of eggs taken from sockeye broodstock, 1989-2011.

Return year	Number of eggs taken
1989	133,600
1990	326,267
1991	231,254
1992	381,561
1993	231,700
1994	338,562
1995	247,900
1996	314,390
1997	254,459
1998	163,278
1999	190,732
2000	227,234
2001	301,925
2002	356,982
2003	319,470
2004	225,499
2005	211,985
2006	292,136

Return year	Number of eggs taken
2007	302,363
2008	316,476
2009	304,963
2010	278,171
2011	291,046
Average	***271,389***

Number of acclimation days

Wenatchee sockeye have only been acclimated on Lake Wenatchee water. For brood years 1989 through 1998, unfed fry were transferred from Eastbank FH to Lake Wenatchee Net Pens until release (Table 4.7). For brood years 1999 to present, juvenile sockeye were reared at Eastbank Fish Hatchery until July in an effort to increase growth before release.

Table 4.7. Water source and mean acclimation period for Wenatchee sockeye, brood years 1989-2009.

Brood year	Release year	Transfer date	Release date	Number of Days	Water source
1989	1990	5-Apr	24-Oct	202	Lake Wenatchee
1990	1991	10-Apr	19-Oct	192	Lake Wenatchee
1991	1992	1-Apr	20-Oct	202	Lake Wenatchee
1992	1993	5-Apr	7-Sep	155	Lake Wenatchee
		5-Apr	26-Oct	204	Lake Wenatchee
1993	1994	5-Apr	1-Sep	149	Lake Wenatchee
		5-Apr	17-Oct	195	Lake Wenatchee
1994	1995	4-Apr	15-Sep	164	Lake Wenatchee
		4-Apr	23-Oct	202	Lake Wenatchee
1995	1996	4-Apr	25-Oct	204	Lake Wenatchee
1996	1997	4-Apr	22-Oct	201	Lake Wenatchee
1997	1998	1-Apr	9-Nov	222	Lake Wenatchee
1998	1999	1-Apr	29-Oct	211	Lake Wenatchee
1999	2000	25-Jul	28-Aug	34	Lake Wenatchee
		26-Jul	1-Nov	98	Lake Wenatchee
2000	2001	2-Jul	27-Aug	56	Lake Wenatchee
		3-Jul	27-Sep	86	Lake Wenatchee
2001	2002	15-Jul	28-Aug	44	Lake Wenatchee
		16-Jul	22-Sep	68	Lake Wenatchee
2002	2003	30-Jun	25-Aug	56	Lake Wenatchee
		1-Jul	22-Oct	113	Lake Wenatchee

Brood year	Release year	Transfer date	Release date	Number of Days	Water source
2003	2004	6-Jul	25-Aug	50	Lake Wenatchee
		7-Jul	3-Nov	119	Lake Wenatchee
2004	2005	5-Jul	29-Aug	55	Lake Wenatchee
		6-Jul	2-Nov	120	Lake Wenatchee
2005	2006	11-Jul	30-Oct	111	Lake Wenatchee
2006	2007	9-10 Jul	31-Oct	113-114	Lake Wenatchee
2007	2008	7-8 Jul	29-Oct	113-114	Lake Wenatchee
2008	2009	21-Jul	28-Oct	100	Lake Wenatchee
2009	2010	19-20, 23-Jul	27-Oct	97-101	Lake Wenatchee

Release Information

Numbers released

The 2010 Wenatchee sockeye program achieved 121.6% of the 200,000 target goal with about 243,260 fish being released (Table 4.8).

Table 4.8. Total number of sockeye parr released and numbers of released fish with CWTs and PIT tags for brood years 1989-2010. The release target for sockeye is 200,000 fish.

Brood year	Release year	CWT mark rate	Number of released fish with PIT tags	Number released
1989	1990	Not marked	0	108,400
1990	1991	0.9308	0	270,802
1991	1992	0.8940	0	167,523
1992	1993	0.9240	0	340,597
1993	1994	0.7278	0	190,443
1994	1995	0.8869	0	252,859
1995[a]	1996	1.0000	0	150,808
1996[a]	1997	0.9680	0	284,630
1997[a]	1998	0.9642	0	197,195
1998[a]	1999	0.8713	0	121,344
1999	2000	0.9527	0	167,955
2000	2001	0.9558	0	190,174
2001	2002	0.9911	0	200,938
2002	2003	0.9306	0	315,783
2003	2004	0.9291	0	240,459
2004	2005	0.8995	0	172,923
2005	2006	0.9811	14,791	140,542
2006	2007	0.9735	14,764	225,670

Brood year	Release year	CWT mark rate	Number of released fish with PIT tags	Number released
2007	2008	0.9863	14,947	252,133
2008	2009	0.9576	14,858	154,772
2009	2010	0.9847	14,486	227,743
2010	2011	0.9564	5,039	243,260
Average		***0.9364***	***13,883[b]***	***209,862***

[a] These groups were only adipose fin clipped.
[b] Average is based on brood years 2005 to present.

Numbers tagged

About 96% of the hatchery sockeye released in 2011 were CWT and adipose fin clipped (Table 4.8). In addition, a total of 5,103 juvenile sockeye were PIT tagged at the Eastbank Hatchery during 6-8 June. These fish were transported to the Lake Wenatchee net pens in July and released into the lake on 26 October 2011. At the time of release, a total of 49 fish had died and 15 others had shed their tags. Thus, the total number of PIT-tagged sockeye released into the lake was 5,039 (Table 4.8).

Fish size and condition at release

The 2009 brood sockeye were released as parr in 2010 and emigrated as yearling smolts in spring of 2011. Size at release was 7.5% and 65% of the fork length and weight goals, respectively. The 2009 brood year was close to the target CV for length at 98.9% (Table 4.9).

Table 4.9. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of sockeye released, brood years 1989-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1990	128	-	18.2	25
1990	1991	131	-	18.9	24
1991	1992	117	3.0	20.6	22
1992	1993	73	6.8	4.2	44
1993	1994	103	-	13.6	40
1994	1995	75	6.1	4.5	38
1995	1996	137	8.2	14.7	30
1996	1997	107	5.6	15.1	30
1997	1998	122	6.1	21.3	21
1998	1999	112	5.4	17.0	27
1999	2000	94	9.5	9.5	48
		134	11.5	31.3	15
2000	2001	123	6.5	22.3	20

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
		146	8.4	26.0	12
2001	2002	118	7.4	20.7	22
		135	7.3	30.5	15
2002	2003	73	5.6	4.4	104
		118	7.7	13.7	23
		145	9.4	38.6	13
2003	2004	79	4.6	4.8	96
		118	5.9	17.0	26
		158	8.1	44.3	10
2004	2005	116	4.5	17.2	18
		151	7.0	39.3	12
2005	2006	149	7.5	43.7	10
2006	2007	138	10.6	32.4	14
2007	2008	137	9.3	33.0	14
2008	2009	138	9.6	34.6	13
2009	2010	143	8.9	35.5	13
Targets		***133***	***9.0***	***22.7***	***20***

Survival Estimates

Overall survival of Wenatchee sockeye from green (unfertilized) egg to release was below the standard set for the program. Survivals for unfertilized-to-eyed egg were below the standard for the program. Because of the highly variable unfertilized-to-eyed egg survivals, studies should be considered that assess the effects of holding adults on warm surface water at Lake Wenatchee on gamete maturation/viability in addition to reducing negative phototactic behavior at swim up (potential influences on survival at the fertilization to ponding stages) (Table 4.10).

Table 4.10. Hatchery life-stage survival rates (%) for sockeye salmon, brood years 1989-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	41.6	100.0	88.1	63.9	99.2	98.9	98.1	65.2	83.0
1990	96.2	99.4	90.8	96.3	99.9	99.2	98.4	98.4	81.1
1991	91.8	94.1	79.2	94.8	99.8	99.3	96.4	96.4	72.4
1992	91.1	98.8	92.3	98.0	99.9	99.8	98.6	98.8	89.2
1993	57.1	99.2	89.2	98.3	99.6	99.1	93.7	93.8	82.2

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1994	89.8	99.2	79.2	96.0	99.5	98.6	98.3	98.2	74.7
1995	97.5	99.1	87.5	95.0	99.0	93.3	73.2	73.2	60.8
1996	99.2	100.0	95.1	98.7	99.7	99.3	96.4	96.5	90.5
1997	92.8	99.3	84.8	97.9	97.9	97.6	95.5	94.9	77.5
1998	75.4	95.5	77.7	98.4	98.6	98.2	97.1	97.2	74.3
1999	92.3	100.0	92.2	97.3	99.6	99.3	98.2	99.7	88.1
2000	84.5	98.1	93.8	97.7	96.7	96.1	91.4	96.8	83.7
2001	75.4	99.2	78.5	97.6	98.0	97.6	86.9	95.1	66.6
2002	100.0	100.0	95.7	97.8	99.6	99.2	94.6	99.8	88.5
2003	91.0	98.1	87.2	96.9	99.0	98.2	94.8	95.5	74.6
2004	88.7	92.6	88.0	93.1	97.9	97.4	93.7	96.1	76.7
2005	98.5	98.5	85.3	94.9	97.8	96.6	95.5	99.2	66.3
2006	95.3	99.1	73.2	85.4	95.4	94.6	87.8	98.5	54.9
2007	88.4	99.2	89.1	98.6	97.0	95.9	94.9	99.0	83.4
2008	97.0	100.0	59.0	88.3	99.1	97.2	93.8	97.4	48.9
2009	95.8	98.3	89.1	94.8	96.9	96.2	88.4	92.3	74.7
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

4.3 Disease Monitoring

Rearing of the 2009 brood sockeye was typical to previous years with fish being held on Lake Wenatchee water in net pens for 100 days before being released directly into the lake. No significant disease-related mortality occurred during the rearing of the 2009 brood sockeye.

4.4 Natural Juvenile Productivity

During 2011, juvenile sockeye salmon were sampled at the Upper Wenatchee trap.

Emigrant and Smolt Estimates

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 4 March and 1 July 2011. During the five-month sampling period, a total of 48,128 wild sockeye and 3,017 hatchery sockeye smolts were captured at the Upper Wenatchee Trap. Based on a pooled daily trap efficiency of 3.3% for wild and 2.4% for hatchery sockeye (based on eight mark-recapture trials), the total number of smolts that emigrated past the trap in 2011 was 1,500,730 (±58,436) wild and 159,089 (±28,150) hatchery sockeye (Table 4.11). This was the fifth brood year since 1999 that all hatchery sockeye parr were released at a similar size and time. Monthly captures of all fish and results of capture efficiency tests at the Upper Wenatchee Trap are reported in Appendix B.

Because of low trap efficiency estimates, calculations of the total number of smolt migrants were overestimated for brood years 2008 and 2009. Numbers of migrants for these brood years were recalculated using the ratio of the overestimate to the actual number of released hatchery fish and applying it to the PIT tag survival rates to McNary Dam. This was done for both hatchery and wild sockeye. Adjusted estimates are reported in Table 4.11.

Table 4.11. Estimated numbers of wild and hatchery sockeye smolts that emigrated from Lake Wenatchee during run years 1997-2011.

Run year	Numbers of sockeye smolts	
	Wild smolts	Hatchery smolts
1997	55,359	28,828
1998	1,447,259	55,985
1999	1,944,966	112,524
2000	985,490	24,684
2001	39,353	94,046
2002	729,716	121,511
2003	5,439,032	140,322
2004	5,771,187	216,023
2005	723,413	122,399
2006	1,266,971	159,500
2007	2,797,313	140,542
2008[a]	549,682	121,843
2009[a]	355,549	119,908
2010[a]	3,958,888	126,326
2011	1,500,730	159,089
Average	***1,837,661***	***116,235***

[a] Estimates refined based on PIT tag survival to McNary Dam.

Age classes of wild sockeye smolts were determined from a length frequency analysis based on scales collected randomly each year since 1997 (Table 4.12). For the available run years, most wild sockeye smolts migrated as age 1+ fish. Only in two years (1997 and 2005) did more smolts migrate as age 2+ fish. Relatively few smolts migrated at age 3+.

Table 4.12. Age structure and estimated number of wild sockeye smolts that emigrated from Lake Wenatchee, 1997-2011.

Run year	Proportion of wild smolts			Total wild emigrants
	Age 1+	Age 2+	Age 3+	
1997	0.075	0.906	0.019	55,359
1998	0.955	0.037	0.008	1,447,259
1999	0.619	0.381	0.000	1,944,966
2000	0.599	0.400	0.001	985,490
2001	0.943	0.051	0.006	39,353
2002	0.961	0.039	0.000	729,716
2003	0.740	0.026	0.000	5,439,032

Run year	Proportion of wild smolts			Total wild emigrants
	Age 1+	Age 2+	Age 3+	
2004	0.929	0.071	0.000	5,771,187
2005	0.230	0.748	0.022	723,413
2006	0.994	0.006	0.000	1,266,971
2007	0.996	0.004	0.000	2,797,313
2008	0.804	0.195	0.001	549,682
2009	0.927	0.073	0.000	355,549
2010	0.963	0.036	0.001	3,958,888
2011*	0.786	0.213	0.001	1,500,730
Average	***0.768***	***0.212***	***0.004***	***1,837,661***

* Ages have not been confirmed with scale analysis.

Freshwater Productivity

Egg-smolt survival estimates for wild sockeye salmon are provided in Table 4.13. Estimates of egg deposition were calculated based on the spawner escapement at Tumwater Dam and the sex ratio and fecundity of the broodstock. Egg-smolt survival rates for brood years 1995-2008 have ranged from 0.012 to 0.212 (mean = 0.088).

Table 4.13. Estimated egg deposition (estimated as mean fecundity times estimated number of females), numbers of smolts, and survival rates for wild Wenatchee sockeye salmon, 1995-2010; NA = not available.

Brood year	Number of females	Mean fecundity	Total eggs	Numbers of wild smolts				Egg-smolt survival
				Age 1+	Age 2+	Age 3+	Total	
1995	2,136	2,295	4,902,120	4,174	53,549	0	57,723	0.012
1996	3,767	2,664	10,035,288	1,382,133	741,032	985	2,124,150	0.212
1997	5,404	2,447	13,223,588	1,203,934	394,196	236	1,598,366	0.121
1998	2,024	2,813	5,693,512	590,309	2,007	0	592,316	0.104
1999	513	2,319	1,189,647	37,110	28,459	0	65,569	0.055
2000	11,413	2,673	30,506,949	701,257	1,414,148	0	2,115,405	0.069
2001	21,685	2,960	64,187,600	4,024,884	409,754	15,915	4,450,553	0.069
2002	17,226	2,856	49,197,456	5,361,433	541,113	0	5,902,546	0.120
2003	2,158	3,511	7,576,738	166,385	7,602	0	173,987	0.023
2004	15,469	2,505	38,749,845	1,259,369	11,189	275	1,270,833	0.033
2005	5,867	2,718	15,946,506	2,786,123	107,243	0	2,893,366	0.181
2006	2,747	2,656	7,296,032	442,164	25,919	1,507	469,590	0.064
2007	2,001	3,115	6,232,804	329,629	142,916	594	473,139	0.076
2008	11,775	2,555	30,084,691	3,814,226	320,567	NA	NA	NA
2009	3,939	2,459	9,684,965	1,179,569	NA	NA	NA	NA
2010	11,918	2,785	33,190,467	NA	NA	NA	NA	NA
Average	***7,503***	***2,708***	***20,481,138***	***1,552,180***	***299,978***	***1,501***	***1,706,734***	***0.088***

Juvenile survival rates for hatchery sockeye salmon are provided in Table 4.14. Release-smolt survival rates for brood years 1995-2009 have ranged from 0.000 to 1.000 (mean = 0.570). Egg-smolt survival rates for the same brood years ranged from 0.000 to 0.710 (mean = 0.294). On average, egg-smolt survival of hatchery sockeye is about three times greater than egg-smolt survival of wild sockeye.

Table 4.14. Juvenile survival rates for hatchery Wenatchee sockeye, brood years 1995-2009.

Brood year	Number of eggs	Number of parr released	Date of release	Estimated number of smolts	Egg-smolt survival	Release-smolt survival
1995	247,900	150,808	10/25/96	28,828	0.116	0.191
1996	314,390	284,630	10/22/97	55,985	0.178	0.197
1997	254,459	197,195	11/9/98	112,524	0.442	0.571
1998	163,278	121,344	10/27/99	24,684	0.151	0.203
1999	190,732	84,466	8/28/00	30,326	0.159	0.359
		83,489	11/1/00	63,720	0.334	0.763
2000	227,234	92,055	8/27/01	30,918	0.136	0.336
		98,119	9/27/01	90,593	0.399	0.923
2001	301,925	96,486	8/28/02	36,484	0.121	0.378
		104,452	9/23/02	103,838	0.344	0.994
2002	356,982	98,509	6/16/03	5,192	0.015	0.053
		104,855	8/25/03	98,412	0.276	0.939
		112,419	10/22/03	112,419	0.315	1.000
2003	319,470	32,755	6/15/04	0	0.000	0.000
		104,879	8/25/04	19,574	0.061	0.187
		102,825	11/3/04	102,825	0.322	1.000
2004	225,499	81,428	8/29/05	159,500	0.707	0.922
		91,495	11/2/05			
2005	211,985	70,386	10/30/06	140,542	0.663	1.000
		70,156	10/30/06			
2006	292,136	225,670	10/31/07	121,843	0.412	0.540
2007	302,363	252,133	10/29/08	119,908	0.397	0.476
2008	316,476	154,772	10/28/09	126,326	0.399	0.813
2009	304,963	227,743	10/27/10	159,089	0.522	0.699

PIT Tagging Activities

No wild juvenile sockeye salmon were PIT tagged and released in 2011 at the Upper Wenatchee Trap. Numbers of wild sockeye salmon PIT-tagged and released as part of the Comparative Survival Study during the period 2006-2011 are shown in Table 4.15. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 4.15. Summary of the numbers of wild sockeye salmon that were tagged and released at different locations within the Wenatchee Basin, 2006-2011.

Sampling Location	Numbers of PIT-tagged sockeye salmon released					
	2006	2007	2008	2009	2010	2011
Upper Wenatchee Trap	0	0	3,165	3,683	10,006	0

4.5 Spawning Surveys

Spawning surveys were conducted in the Little Wenatchee River from 23 August to 6 October 2011. Surveys in 2011 only included counting numbers of live sockeye spawners. The last redd counts were conducted in 2007 (see Appendix H for more details).

Spawn Timing

Sockeye began spawning during the first week of September and peaked around the second week of September (Figure 4.1). Peak spawning was determined using the total number of spawners observed on the spawning grounds in the Little Wenatchee River.

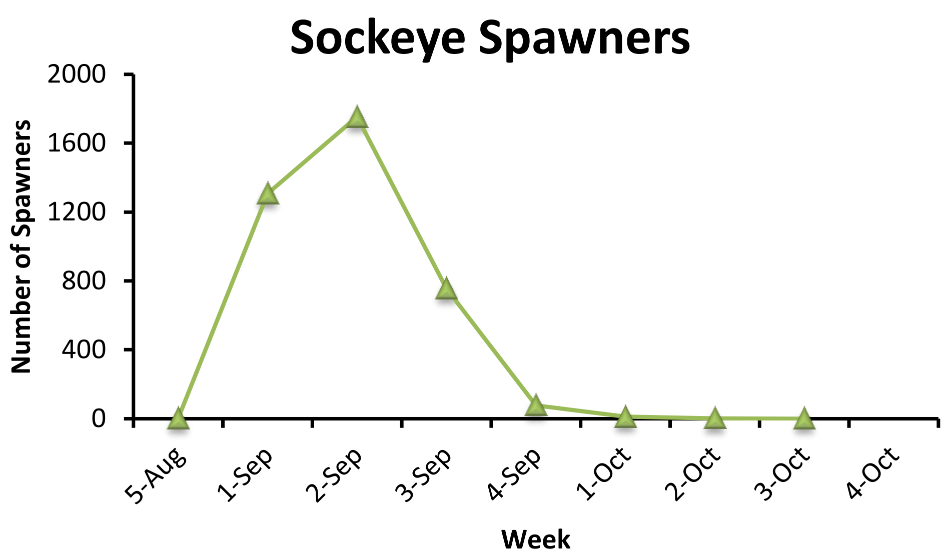

Figure 4.1. Numbers of sockeye spawners counted during different weeks in the Little Wenatchee River, August through October 2011.

Spawning Escapement

Spawning escapement of sockeye salmon in 2011 was estimated using the area-under-the-curve (AUC) method (i.e., escapement = (AUC/redd residence time) x observer efficiency) and mark-recapture methods. AUC relied on weekly counts of live sockeye in the Little Wenatchee River and assumed a redd residence time of 11 days and an observer efficiency of 100%. The mark-recapture method used PIT tags to estimate sockeye spawning escapement (see Appendix H for more details).

Area-under-the-curve

Based on the AUC approach, the estimated total spawning escapement of sockeye in the Wenatchee Basin in 2011 was 17,013 (Table 4.16). About 86% of the escapement spawned in the White River Basin (including the Napeequa River).

Table 4.16. Peak numbers of live spawners and total spawning escapement estimates for sockeye salmon in the Wenatchee Basin, August through October 2011; N/A = not available.

Sampling basin	Peak number of live fish	Spawning escapement
Little Wenatchee	1,753	2,431
White River[a]	N/A	14,582
Total	***N/A***	***17,013***

[a] Spawning escapement in the White River was estimated using a regression model (see Appendix H).

The spawning escapement of 17,013 Wenatchee sockeye is greater than the overall average of 15,249 (Table 4.17).

Table 4.17. Spawning escapements for sockeye salmon in the Wenatchee Basin for return years 1989-2011; NA = not available. Total escapements before 2003 were based on counts at Tumwater Dam.

Return year	Spawning escapement		
	Little Wenatchee	White	Total
1989	NA	NA	**21,802**
1990	NA	NA	**27,325**
1991	NA	NA	**26,689**
1992	NA	NA	**16,461**
1993	NA	NA	**27,726**
1994	NA	NA	**7,330**
1995	NA	NA	**3,448**
1996	NA	NA	**6,573**
1997	NA	NA	**9,693**
1998	NA	NA	**4,014**
1999	NA	NA	**1,025**
2000	NA	NA	**20,735**
2001	NA	NA	**29,103**
2002	NA	NA	**27,565**
2003	NA	NA	**4,855**
2004	NA	NA	**27,556**
2005	NA	NA	**14,011**
2006	574	5,634	**6,208**
2007	150	1,720	**1,870**
2008	3,491	16,757	**20,248**
2009	763	7,004	**7,767**

Return year	Spawning escapement		
	Little Wenatchee	White	Total
2010	2,543	19,157	**21,700**
2011	2,431	14,582	**17,013**
Average	***1,659***	***10,809***	***15,249***

Mark-recapture method

Using mark-recapture methods, the estimated total escapement of sockeye in the Upper Wenatchee Basin in 2011 was 17,013 (Table 4.18). About 86% of the escapement entered the White River Basin (including the Napeequa River).

Table 4.18. Estimated escapement of adult sockeye into the Little Wenatchee and White River basins for return years 2009-2011. Escapement is based on recapture of PIT tagged fish.

Return year	Tumwater Dam count	Recreational harvest	Little Wenatchee escapement	White River escapement	Total spawning escapement
2009	16,034	2,229	576	13,876	14,452
2010	35,821	4,129	2,062	19,542	21,604
2011	18,634	0	2,431	14,582	17,013
Average	***23,496***	***2,119***	***1,690***	***16,000***	***17,690***

4.6 Carcass Surveys

Carcass surveys were conducted in the Little Wenatchee and White (including the Napeequa River) rivers from 7 September to 11 October 2011.

Number sampled

A total of 3,742 sockeye carcasses were sampled during September through October, 2011, in the Wenatchee Basin (Table 4.19). This is higher than the 1993-2011 average of 2,880 carcasses. Most of the carcasses sampled in 2011 were collected in the White River basin (90% or 3,370 carcasses) (Figure 4.2). The remaining 10% were sampled in the Little Wenatchee River (372 carcasses). Because of sampling bias associated with collecting male carcasses, CWTs were only taken from female carcasses.

Table 4.19. Numbers of sockeye carcasses sampled within different streams/watersheds within the Wenatchee Basin, 1989-2011.

Survey year	Numbers of sockeye carcasses			
	Little Wenatchee	White	Napeequa	Total
1993	90	195	0	**285**
1994	121	165	0	**286**
1995	0	56	0	**56**
1996	43	1,387	3	**1,433**
1997	69	1,425	41	**1,535**
1998	61	524	4	**589**

Survey year	Numbers of sockeye carcasses			
	Little Wenatchee	White	Napeequa	Total
1999	40	186	0	**226**
2000	821	5,494	0	**6,315**
2001	650	3,127	0	**3,777**
2002	506	7,258	55	**7,819**
2003	86	1,002	14	**1,102**
2004	625	6,960	138	**7,723**
2005	1	7	0	**8**
2006	101	2,158	38	**2,297**
2007	17	363	3	**383**
2008	476	5,132	125	**5,733**
2009	84	3,103	103	**3,290**
2010	217	7,832	70	**8,119**
2011	372	3,322	48	**3,742**
Average	***231***	***2,616***	***34***	***2,880***

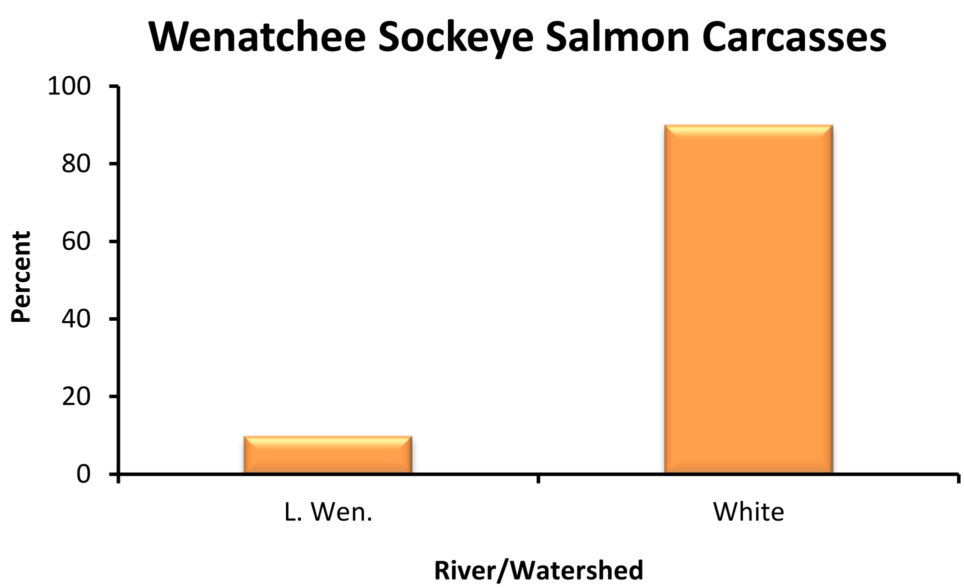

Figure 4.2. Percent of the total number of sockeye carcasses sampled in different streams/watersheds within the Wenatchee Basin during August through October, 2011.

Carcass Distribution and Origin

Sockeye carcasses were not evenly distributed among reaches within survey streams in 2011 (Table 4.20). Carcasses were only found in Reach 2 (Lost Creek to Rainy Creek) on the Little Wenatchee. Most (99%) of the carcasses sampled in the White River Basin were in Reach 2

(Sears Creek Bridge to Napeequa River). About 1% of the carcasses sampled in the White River Basin were in the Napeequa River.

Table 4.20. Numbers of carcasses sampled within different streams/watersheds within the Wenatchee Basin during August through September, 2011.

Stream/watershed	Reach	Total carcasses
Little Wenatchee	Little Wen 1 (L1)	0
	Little Wen 2 (L2)	372
	Little Wen 3 (L3)	0
	Total	**372**
White	White 1 (H1)	0
	White 2 (H2)	3,322
	White 3 (H3)	0
	Napeequa 1 (Q1)	48
	Total	**3,370**
Grand Total		***3,742***

Based on the available data (1993-2011), the largest percentage of both wild and hatchery sockeye spawned in Reach 2 on the White River (Table 4.21 and Figure 4.3). However, a greater percentage of wild fish was found in Reach 2 than hatchery fish. The opposite occurred in Reach 2 on the Little Wenatchee. There, a larger percentage of hatchery fish was found compared to wild fish.

Table 4.21. Numbers of wild and hatchery sockeye carcasses sampled within different reaches in the Wenatchee Basin, 1993-2011. Reach codes are described in Table 2.9.

Survey year	Origin	Numbers of sockeye carcasses					
		Little Wenatchee		White River			Total
		L2	L3	H1	H2	Q1	
1993	Wild	86	0	0	183	0	**269**
	Hatchery	4	0	0	12	0	**16**
1994	Wild	112	0	0	155	0	**267**
	Hatchery	9	0	0	9	0	**18**
1995	Wild	0	0	0	55	0	**55**
	Hatchery	0	0	0	1	0	**1**
1996	Wild	41	0	0	1,299	3	**1,343**
	Hatchery	2	0	0	88	0	**90**
1997	Wild	65	0	0	1,411	40	**1,516**
	Hatchery	4	0	0	11	1	**16**
1998	Wild	61	0	0	515	4	**580**
	Hatchery	0	0	0	9	0	**9**
1999	Wild	30	0	0	164	0	**194**
	Hatchery	10	0	0	22	0	**32**
2000	Wild	694	0	3	5,239	0	**5,936**

Survey year	Origin	Numbers of sockeye carcasses					
		Little Wenatchee		White River			Total
		L2	L3	H1	H2	Q1	
	Hatchery	127	0	0	252	0	**379**
2001	Wild	625	0	0	3,063	0	**3,688**
	Hatchery	25	0	0	64	0	**89**
2002	Wild	504	0	0	7,207	55	**7,766**
	Hatchery	2	0	0	51	0	**53**
2003	Wild	81	0	0	993	14	**1,088**
	Hatchery	5	0	0	9	0	**14**
2004	Wild	606	0	0	6,755	166	**7,527**
	Hatchery	19	0	0	205	22	**246**
2005	Wild	201	0	5	2,966	21	**3,193**
	Hatchery	1	0	0	8	0	**9**
2006	Wild	80	0	0	2,112	36	**2,228**
	Hatchery	21	0	0	46	2	**69**
2007	Wild	17	0	0	346	3	**366**
	Hatchery	0	0	0	17	0	**17**
2008	Wild	472	0	0	5,118	124	**5,714**
	Hatchery	4	0	0	14	1	**19**
2009	Wild	80	0	0	3,084	103	**3,267**
	Hatchery	4	0	0	19	0	**23**
2010	Wild	210	0	0	7,711	69	**7,990**
	Hatchery	7	0	0	121	1	**129**
2011	Wild	266	0	0	3,079	43	**3,388**
	Hatchery	106	0	0	243	5	**354**
Average	***Wild***	***223***	***0***	***0***	***2,708***	***36***	***2,967***
	Hatchery	***18***	***0***	***0***	***63***	***2***	***83***

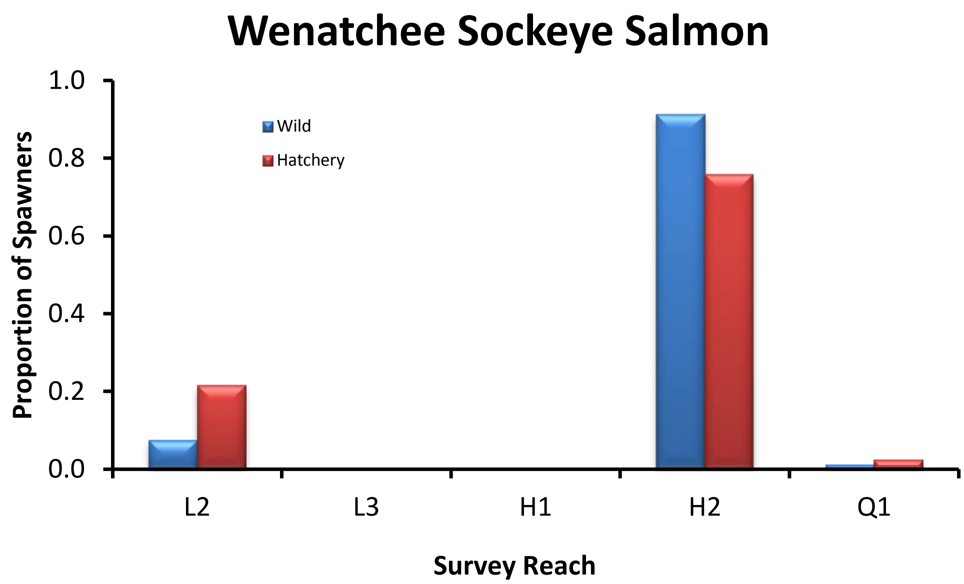

Figure 4.3. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee Basin, pooled data from 1993-2011. Reach codes are described in Table 2.9; L = Little Wenatchee, H = White River, and Q = Napeequa River.

Sampling Rate

The sampling rate of sockeye carcasses differed among basins, with a higher sampling rate in the White than in the Little Wenatchee (Table 4.22). Nevertheless, the overall sampling rate for both basins combined exceeded the target of 20%.

Table 4.22. Numbers of carcasses, estimated spawning escapements (based on AUC), and sampling rates for sockeye salmon in the Wenatchee Basin, 2011.

Sampling basin	Total number of carcasses	Total spawning escapement	Sampling rate
Little Wenatchee	372	2,431	0.15
White	3,370	14,582	0.23
Total	***3,742***	***17,013***	***0.22***

Length Data

Mean lengths (POH, cm) of male and female hatchery sockeye carcasses sampled during surveys in the Wenatchee Basin in 2011 are provided in Table 4.23. In 2011, only hatchery female sockeye were sampled for lengths. Wild sockeye are sampled at Tumwater Dam, not on the spawning grounds.

Table 4.23. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of female hatchery sockeye carcasses sampled in different streams/watersheds in the Wenatchee Basin, 2011; N = number of fish sampled, NA = not available. Wild sockeye were sampled at Tumwater Dam.

Stream/watershed	Male		Female	
	N	Length (cm)	N	Length (cm)
Little Wenatchee River	NA	NA	92	39 (3)
White River	NA	NA	185	40 (3)
Napeequa River	NA	NA	5	41 (2)
Wenatchee River	NA	NA	0	NA
Total	***NA***	***NA***	***282***	***40.0 (2.6)***

4.7 Life History Monitoring

Life history characteristics of Wenatchee sockeye were assessed by examining carcasses on spawning grounds and fish sampled at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

There was little difference in migration timing of hatchery and wild sockeye past Tumwater Dam (Table 4.24a and b; Figure 4.4). On average, early in the run, hatchery and wild sockeye arrived at the dam at about the same time. Toward the end of the migration period, hatchery sockeye tended to arrive at the dam slightly later than did wild sockeye. Most hatchery and wild sockeye migrated upstream past Tumwater Dam during July through early August. The peak migration time for both hatchery and wild sockeye was the last week of July (Figure 4.4).

Table 4.24a. The Julian day and date that 10%, 50% (median), and 90% of the wild and hatchery sockeye salmon passed Tumwater Dam, 1998-2011. The average Julian day and date are also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery sockeye salmon. All sockeye were visually examined during trapping from 2004 to present.

Survey year	Origin	Sockeye Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
1998	Wild	195	14-Jul	201	20-Jul	208	27-Jul	202	21-Jul	4,173
	Hatchery	196	15-Jul	204	23-Jul	220	8-Aug	206	25-Jul	31
1999	Wild	226	14-Aug	233	21-Aug	241	29-Aug	234	22-Aug	908
	Hatchery	228	16-Aug	234	22-Aug	242	30-Aug	235	23-Aug	264
2000	Wild	200	18-Jul	206	24-Jul	213	31-Jul	207	25-Jul	18,390
	Hatchery	199	17-Jul	206	24-Jul	213	31-Jul	206	24-Jul	2,589
2001	Wild	189	8-Jul	194	13-Jul	214	2-Aug	198	17-Jul	32,554
	Hatchery	199	18-Jul	212	31-Jul	240	28-Aug	214	2-Aug	79
2002	Wild	204	23-Jul	208	27-Jul	219	7-Aug	210	29-Jul	27,241
	Hatchery	204	23-Jul	209	28-Jul	222	10-Aug	211	30-Jul	580

Survey year	Origin	Sockeye Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
2003	Wild	194	13-Jul	200	19-Jul	208	27-Jul	201	20-Jul	4,699
	Hatchery	194	13-Jul	201	20-Jul	211	30-Jul	203	22-Jul	375
2004	Wild	191	9-Jul	196	14-Jul	207	25-Jul	198	16-Jul	31,408
	Hatchery	189	7-Jul	194	12-Jul	203	21-Jul	196	14-Jul	1,758
2005	Wild	192	11-Jul	199	18-Jul	227	15-Aug	204	23-Jul	14,176
	Hatchery	187	6-Jul	200	19-Jul	251	8-Sep	212	31-Jul	42
2006	Wild	201	20-Jul	204	23-Jul	214	2-Aug	206	25-Jul	9,151
	Hatchery	202	21-Jul	219	7-Aug	228	16-Aug	215	3-Aug	507
2007	Wild	201	20-Jul	210	29-Jul	227	15-Aug	213	1-Aug	2,542
	Hatchery	205	24-Jul	213	1-Aug	231	19-Aug	216	4-Aug	65
2008	Wild	200	18-Jul	207	25-Jul	219	6-Aug	208	26-Jul	29,229
	Hatchery	201	19-Jul	206	24-Jul	215	2-Aug	208	26-Jul	103
2009	Wild	198	17-Jul	204	23-Jul	213	1-Aug	206	25-Jul	15,552
	Hatchery	199	18-Jul	205	24-Jul	215	3-Aug	207	26-Jul	534
2010	Wild	199	18-Jul	205	24-Jul	220	8-Aug	208	27-Jul	34,519
	Hatchery	200	19-Jul	215	3-Aug	244	1-Sep	218	6-Aug	1,302
2011	Wild	213	1-Aug	216	4-Aug	224	12-Aug	217	5-Aug	17,680
	Hatchery	213	1-Aug	213	1-Aug	231	19-Aug	216	4-Aug	954
Average	Wild	***200***	-	***206***	-	***218***	-	***208***	-	***17,302***
	Hatchery	***201***	-	***209***	-	***226***	-	***212***	-	***656***

Table 4.24b. The week that 10%, 50% (median), and 90% of the wild and hatchery sockeye salmon passed Tumwater Dam, 1998-2011. The average week is also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery sockeye salmon. All sockeye were visually examined during trapping from 2004 to present.

Survey year	Origin	Sockeye Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
1998	Wild	28	29	30	29	4,173
	Hatchery	28	30	32	30	31
1999	Wild	33	34	35	34	908
	Hatchery	33	34	35	34	264
2000	Wild	29	30	31	30	18,390
	Hatchery	29	30	31	30	2,589
2001	Wild	27	28	31	29	32,554
	Hatchery	29	31	35	31	79
2002	Wild	30	30	32	30	27,241

Survey year	Origin	Sockeye Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
	Hatchery	30	30	32	31	580
2003	Wild	28	29	30	29	4,699
	Hatchery	28	29	31	29	375
2004	Wild	28	28	28	29	31,408
	Hatchery	27	28	29	28	1,758
2005	Wild	28	29	33	30	14,176
	Hatchery	27	29	36	31	42
2006	Wild	29	29	31	30	9,151
	Hatchery	29	32	33	31	507
2007	Wild	29	30	33	31	2,542
	Hatchery	30	31	33	31	65
2008	Wild	29	30	32	30	29,229
	Hatchery	29	30	31	30	103
2009	Wild	29	30	31	30	15,552
	Hatchery	29	29	31	30	534
2010	Wild	29	30	32	30	34,519
	Hatchery	29	31	35	32	1,302
2011	Wild	31	31	32	31	17,680
	Hatchery	31	31	33	31	954
Average	Wild	***29***	***30***	***32***	***30***	***17,302***
	Hatchery	***29***	***30***	***33***	***31***	***656***

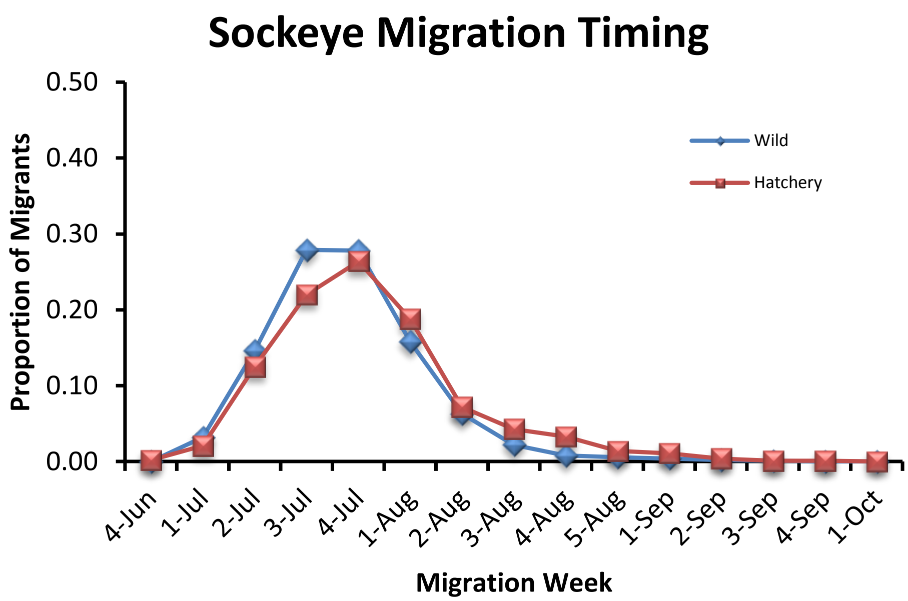

Figure 4.4. Proportion of wild and hatchery sockeye observed (using video) passing Tumwater Dam each week during their migration period late-June through early-October; data were pooled over survey years 1998-2011.

Age at Maturity

Although sample sizes are small, it appears that most wild sockeye returned as age-5 fish, while most hatchery sockeye returned as age-4 fish (Table 4.25; Figure 4.5). Only wild fish have returned at age-6.

Table 4.25. Proportions of wild and hatchery sockeye of different ages (total age) sampled in broodstock and on spawning grounds, 1994-2010.

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
1994	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	0.88	0.13	0.00	0.00	16
1995	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	0.00	1.00	0.00	0.00	1
1996	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	82
1997	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.00	0.77	0.23	0.00	0.00	13
1998	Wild	0.00	0.08	0.85	0.08	0.00	0.00	26
	Hatchery	0.00	0.00	0.64	0.36	0.00	0.00	11
1999	Wild	0.00	0.00	0.18	0.73	0.10	0.00	113
	Hatchery	0.00	0.00	0.65	0.35	0.00	0.00	31
2000	Wild	0.00	0.00	0.00	1.00	0.00	0.00	1

Survey year	Origin	Total age						Sample size
		2	3	4	5	6	7	
	Hatchery	0.00	0.00	0.98	0.02	0.00	0.00	359
2001	Wild	0.00	0.00	0.76	0.24	0.00	0.00	29
	Hatchery	0.00	0.00	0.75	0.25	0.00	0.00	171
2002	Wild	0.00	0.00	0.20	0.80	0.00	0.00	5
	Hatchery	0.00	0.00	0.29	0.71	0.00	0.00	63
2003	Wild	0.00	0.00	0.00	1.00	0.00	0.00	5
	Hatchery	0.00	0.33	0.67	0.00	0.00	0.00	6
2004	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.02	0.93	0.05	0.00	0.00	244
2005	Wild	-	-	-	-	-	-	0
	Hatchery	0.00	0.13	0.75	0.13	0.00	0.00	8
2006	Wild	0.00	0.00	0.34	0.65	0.01	0.00	207
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	65
2007	Wild	0.00	0.00	0.02	0.88	0.10	0.00	206
	Hatchery	0.00	0.00	0.35	0.65	0.00	0.00	17
2008	Wild	0.00	0.00	0.95	0.04	0.01	0.00	258
	Hatchery	0.00	0.08	0.92	0.00	0.00	0.00	12
2009	Wild	0.00	0.00	0.79	0.21	0.00	0.00	251
	Hatchery	0.00	0.00	1.00	0.00	0.00	0.00	2
2010	Wild	0.00	0.00	0.67	0.33	0.00	0.00	193
	Hatchery	0.00	0.00	0.98	0.02	0.00	0.00	130
Average	***Wild***	***0.00***	***0.01***	***0.43***	***0.54***	***0.02***	***0.00***	***76***
	Hatchery	***0.00***	***0.03***	***0.74***	***0.23***	***0.00***	***0.00***	***72***

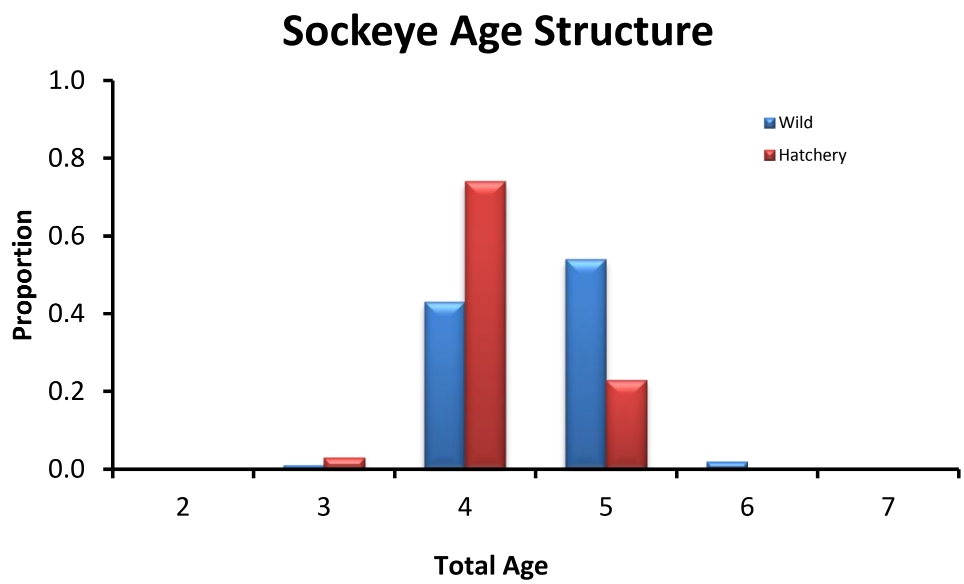

Figure 4.5. Proportions of wild and hatchery sockeye salmon of different total ages sampled at Tumwater Dam and on spawning grounds in the Wenatchee Basin for the combined years 1994-2010.

Size at Maturity

Although sample sizes are small, wild sockeye were larger than hatchery sockeye in 2010 (Table 4.26). This is because more wild sockeye return at age 5, while more hatchery sockeye return at age 4. However, the pooled data indicate that there is little difference in mean sizes of hatchery and wild sockeye salmon sampled in the Wenatchee Basin (Table 4.26). Analyses for the five-year reports will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 4.26. Mean lengths (POH; cm) and variability statistics for wild and hatchery sockeye salmon sampled at Tumwater Dam (broodstock) and on spawning grounds in the Wenatchee Basin, 1994-2010; SD = 1 standard deviation.

Survey year	Origin	Sample size	Sockeye length (POH; cm)			
			Mean	SD	Minimum	Maximum
1994	Wild	0	-	-	-	-
	Hatchery	14	42	3	37	47
1995	Wild	0	-	-	-	-
	Hatchery	1	53	-	53	53
1996	Wild	0	-	-	-	-
	Hatchery	5	51	3	49	55
1997	Wild	6	40	3	38	45
	Hatchery	17	41	3	37	50
1998	Wild	585	43	3	34	50
	Hatchery	20	43	3	40	51
1999	Wild	99	42	3	36	50
	Hatchery	31	41	3	36	47

Survey year	Origin	Sample size	Sockeye length (POH; cm)			
			Mean	SD	Minimum	Maximum
2000	Wild	1	48	-	48	48
	Hatchery	377	40	2	30	49
2001	Wild	29	42	2	38	47
	Hatchery	184	43	3	35	51
2002	Wild	5	42	1	40	43
	Hatchery	52	44	3	37	49
2003	Wild	5	44	4	38	47
	Hatchery	13	42	5	30	48
2004	Wild	0	-	-	-	-
	Hatchery	230	40	3	33	49
2005	Wild	0	-	-	-	-
	Hatchery	8	43	9	35	64
2006	Wild	248	45	4	34	52
	Hatchery	17	41	5	31	48
2007	Wild	248	45	3	32	52
	Hatchery	16	41	5	31	48
2008	Wild	261	52	3	44	66
	Hatchery	20	39	3	30	41
2009	Wild	260	43	3	33	53
	Hatchery	22	41	2	36	46
2010	Wild	200	56	3	48	66
	Hatchery	131	41	2	35	45
Pooled	***Wild***	***115***	***45***	***3***	***32***	***66***
	Hatchery	***68***	***43***	***4***	***30***	***64***

Contribution to Fisheries

The total number of hatchery and wild sockeye captured in different fisheries is provided in Tables 4.27 and 4.28. Harvest on hatchery-origin sockeye has been less than the harvest on wild sockeye.

Table 4.27. Estimated number and percent (in parentheses) of hatchery-origin Wenatchee sockeye captured in different fisheries, 1989-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	0 (0)	279 (30)	4 (0)	639 (69)	922
1990	0 (0)	23 (100)	0 (0)	0 (0)	23
1991	0 (0)	6 (100)	0 (0)	0 (0)	6
1992	0 (0)	37 (97)	1 (3)	0 (0)	38

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1993	0 (0)	3 (100)	0 (0)	0 (0)	3
1994	0 (0)	3 (100)	0 (0)	0 (0)	3
1995	0 (0)	10 (100)	0 (0)	0 (0)	10
1996	0 (0)	59 (81)	9 (12)	5 (7)	73
1997	0 (0)	73 (73)	12 (12)	15 (15)	100
1998	0 (0)	7 (100)	0 (0)	0 (0)	7
1999	0 (0)	3 (20)	0 (0)	12 (80)	15
2000	0 (0)	56 (12)	9 (2)	414 (86)	479
2001	0 (0)	0 (0)	0 (0)	3 (100)	3
2002	0 (0)	16 (100)	0 (0)	0 (0)	16
2003	0 (0)	3 (100)	0 (0)	0 (0)	3
2004	0 (0)	6 (23)	1 (4)	19 (73)	26
2005	0 (0)	5 (30)	7 (4)	126 (66)	190

[a] Includes the Lake Wenatchee fishery.

Table 4.28. Estimated number and percent (in parentheses) of wild Wenatchee sockeye captured in different fisheries, 1989-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	0 (0)	2,189 (31)	26 (0)	4,838 (69)	7,053
1990	0 (0)	189 (100)	0 (0)	0 (0)	189
1991	0 (0)	289 (99)	2 (1)	0 (0)	291
1992	0 (0)	341 (98)	6 (2)	0 (0)	347
1993	0 (0)	689 (99)	4 (1)	0 (0)	693
1994	0 (0)	145 (100)	0 (0)	0 (0)	145
1995	0 (0)	61 (86)	3 (4)	7 (10)	71
1996	0 (0)	1,554 (56)	250 (9)	993 (36)	2,797
1997	0 (0)	3,182 (54)	393 (7)	2,266 (39)	5,841
1998	0 (0)	918 (98)	4 (0)	10 (1)	932
1999	0 (0)	21 (18)	3 (3)	90 (79)	114
2000	0 (0)	1,149 (19)	156 (3)	4,881 (79)	6,186
2001	0 (0)	827 (100)	0 (0)	0 (0)	827
2002	0 (0)	380 (84)	2 (0)	72 (16)	454
2003	0 (0)	135 (26)	10 (2)	382 (72)	527
2004	0 (0)	1,622 (25)	157 (2)	4,786 (73)	6,565
2005	0 (0)	2,405 (44)	170 (3)	2,899 (53)	6,474

[a] Includes the Lake Wenatchee fishery.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. In addition, PIT tagging of hatchery sockeye, which began with brood year 2005, allows estimation of stray rates by brood return. Targets for strays based on return year (recovery year) outside the Wenatchee Basin should be less than 5%. The target for brood year strays should also be less than 5%.

Based on CWTs and brood year analysis, no hatchery-origin Wenatchee sockeye have strayed into non-target spawning areas or hatchery programs (Table 4.29). These data indicate that hatchery-origin Wenatchee sockeye stray at rates less than the target of 5%.

Table 4.29. Number and percent of hatchery-origin Wenatchee sockeye that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs, by brood years 1990-2005. Hatchery-origin sockeye from brood years 1995-1998 were not tagged because of columnaris disease. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target streams		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1990	402	100.0	0	0.0	0	0.0	0	0.0
1991	1	100.0	0	0.0	0	0.0	0	0.0
1992	92	98.9	1	1.1	0	0.0	0	0.0
1993	29	100.0	0	0.0	0	0.0	0	0.0
1994	66	100.0	0	0.0	0	0.0	0	0.0
1995	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-
1999	65	100.0	0	0.0	0	0.0	0	0.0
2000	571	100.0	0	0.0	0	0.0	0	0.0
2001	17	100.0	0	0.0	0	0.0	0	0.0
2002	3	100.0	0	0.0	0	0.0	0	0.0
2003	0	0.0	0	0.0	0	0.0	0	0.0
2004	0	0.0	0	0.0	0	0.0	0	0.0
2005	0	0.0	0	0.0	0	0.0	0	0.0
Total	***1,246***	***99.9***	***1***	***0.1***	***0***	***0.0***	***0***	***0.0***

Based on PIT-tag analyses, on average, about 7% of the hatchery sockeye returns were last detected in streams outside the Wenatchee Basin (Table 4.30). The numbers in Table 4.30 should be considered rough estimates because they are not based on confirmed spawning (only last detections) and the numbers have not been adjusted for detection efficiencies, which currently do not exist for PIT-tag detection arrays in tributaries. What these data do indicate is that some hatchery sockeye from the Wenatchee program have wandered or strayed into the Entiat and

Methow rivers and possibly into the Okanogan system (based on sockeye detected at Wells Dam but not in the Methow River).

Table 4.30. Number and percent of hatchery-origin Wenatchee sockeye that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and hatchery programs for brood years 2005 and 2006. Estimates were based on last detections of PIT-tagged hatchery sockeye. Percent strays should be less than 5%.

Brood Year	Homing				Straying			
	Target streams		Target hatchery		Non-target stream		Non-target hatchery	
	Number	%	Number	%	Number	%	Number	%
2005	167	92	0	0.0	15	8	0	0.0
2006	421	95	0	0.0	20	5	0	0.0
Average	***294***	***94***	***0***	***0.0***	***18***	***7***	***0***	***0.0***

Genetics

Genetic studies were conducted to determine the potential impacts of the Wenatchee sockeye supplementation program on natural-origin sockeye in the upper Wenatchee Basin (Blankenship et al. 2008; the entire report is appended as Appendix I). Specifically, the objective of the study was to determine if the genetic composition of the Lake Wenatchee sockeye population had been altered by the supplementation program, which was based on the artificial propagation of a small subset of the Wenatchee population. Microsatellite DNA allele frequencies were used to differentiate between temporally replicated collections of natural and hatchery-origin sockeye in the Wenatchee Basin. A total of 13 collections of Wenatchee sockeye were analyzed; eight temporally replicated collections of natural-origin sockeye and five temporally replicated collections of hatchery-origin sockeye. Paired natural-hatchery collections were available from return years 2000, 2001, 2004, 2006, and 2007.

Overall, the study showed that allele frequency distributions were consistent over time, regardless of origin, resulting in small, insignificant measures of genetic differentiation among collections. This indicates that there was no year-to-year differences in allele frequencies between natural and hatchery-origin sockeye. In addition, the analyses found no differences between pre- and post-supplementation collections. Thus, it was concluded that the allele frequencies of the broodstock collections equaled the allele frequency of the natural collections.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1989-2010, the PNI has consistently been greater than 0.67 (Table 4.31). This indicates that the natural environment has a greater influence on adaptation of Wenatchee sockeye than does the hatchery environment.

Table 4.31. Proportionate natural influence (PNI) of the Wenatchee sockeye supplementation program for brood years 1989-2010. PNI was calculated as the proportion of naturally produced sockeye in the hatchery broodstock (pNOB) divided by the proportion of hatchery sockeye counted at Tumwater Dam (pHOS) plus pNOB. NOS = number of natural-origin sockeye counted at Tumwater Dam; HOS = number of hatchery-origin sockeye counted at Tumwater Dam; NOB = number of natural-origin sockeye collected for broodstock; and HOB = number of hatchery-origin sockeye included in hatchery broodstock.

Brood year	Spawners[a]			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	21,802	0	0.00	115	0	1.00	1.00
1990	27,325	0	0.00	302	0	1.00	1.00
1991	26,689	0	0.00	199	0	1.00	1.00
1992	16,461	0	0.00	320	0	1.00	1.00
1993	25,064	2,662	0.10	207	0	1.00	0.91
1994	6,929	396	0.05	236	5	0.98	0.95
1995	3,259	186	0.05	194	3	0.98	0.95
1996	6,009	544	0.08	225	0	1.00	0.93
1997	9,597	77	0.01	192	19	0.91	0.99
1998	3,976	32	0.01	122	6	0.95	0.99
1999	905	60	0.06	79	60	0.57	0.90
2000	19,569	1,161	0.06	170	5	0.97	0.94
2001	28,280	815	0.03	200	7	0.97	0.97
2002	27,372	193	0.01	256	0	1.00	0.99
2003	4,797	58	0.01	198	0	1.00	0.99
2004	26,095	1,460	0.05	177	0	1.00	0.95
2005	13,983	28	0.00	166	0	1.00	1.00
2006	9,183	255	0.03	214	0	1.00	0.97
2007	2,320	59	0.02	210	0	1.00	0.98
2008	23,136	93	0.00	243	2	0.99	1.00
2009	13,144	449	0.03	239	0	1.00	0.97
2010	30,357	1,134	0.04	198	0	1.00	0.96
Average	***15,739***	***439***	***0.03***	***203***	***5***	***0.97***	***0.97***

[a] Proportions of natural-origin and hatchery-origin spawners were determined from video tape at Tumwater Dam.

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population. For brood years 1989-2005, NRR in the Wenatchee averaged 1.19 (range, 0.13-4.28) if harvested fish were not included in the estimate and 1.36 (range, 0.14-4.71) if harvested fish were included in the estimate (Table 4.32).

Hatchery replacement rates (HRR) were estimated as hatchery adult-to-adult returns. These rates should be greater than the NRRs and greater than or equal to 5.40 (the calculated target value in Murdoch and Peven 2005). HRRs exceeded NRRs in ten of the 17 years of data, regardless if harvest was or was not included in the estimates (Table 4.32). Hatchery replacement rates for Wenatchee sockeye have equaled or exceeded the estimated target value of 5.40 in only three years regardless if harvest was or was not included in the estimate (Table 4.32).

Table 4.32. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for sockeye salmon in the Wenatchee Basin, 1989-2005.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	255	21,802	2,757	23,616	10.81	1.08	3,680	30,669	14.43	1.41
1990	316	27,325	401	3,509	1.27	0.13	423	3,699	1.34	0.14
1991	233	26,689	95	4,814	0.41	0.18	101	5,105	0.43	0.19
1992	343	16,461	597	5,491	1.74	0.33	635	5,838	1.85	0.35
1993	307	27,726	77	12,224	0.25	0.44	81	12,917	0.26	0.47
1994	265	7,325	46	1,194	0.17	0.16	48	1,340	0.18	0.18
1995	209	3,445	118	839	0.56	0.24	128	912	0.61	0.26
1996	227	6,553	1,348	28,049	5.94	4.28	1,421	30,844	6.26	4.71
1997	226	9,674	739	36,097	3.27	3.73	839	41,938	3.71	4.34
1998	190	4,008	104	16,166	0.55	4.03	111	17,098	0.58	4.27
1999	147	965	68	566	0.46	0.59	83	681	0.56	0.71
2000	195	20,730	1,425	29,082	7.31	1.40	1,905	35,268	9.77	1.70
2001	245	29,095	24	17,242	0.10	0.59	28	18,069	0.11	0.62
2002	257	27,565	281	5,755	1.09	0.21	297	6,211	1.16	0.23
2003	219	4,855	32	2,070	0.15	0.43	35	2,610	0.16	0.54
2004	202	27,555	95	23,798	0.47	0.86	120	30,362	0.59	1.10
2005	207	14,011	437	20,699	2.11	1.48	616	26,173	2.98	1.87
Average	***238***	***16,223***	***508***	***13,601***	***2.16***	***1.19***	***621***	***15,867***	***2.65***	***1.36***

Juvenile-to-Adult Survivals

When possible, both parr-to-adult ratios (PAR) and smolt-to-adult ratios (SAR) were calculated for hatchery sockeye salmon. Ratios were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery parr released or the estimated number of smolts emigrating from Lake Wenatchee. Survival ratios were based on CWT returns, when available, or on the estimated number of hatchery adults recovered on the spawning grounds, in broodstock, and harvested. For the available brood years, PARs have ranged from 0.0001 to 0.0100 for hatchery sockeye salmon and SARs have ranged from 0.0002 to 0.0254 (Table 4.33).

Table 4.33. Parr-to-adult ratios (PAR) and smolt-to-adult ratios (SAR) for Wenatchee hatchery sockeye salmon, brood years 1990-2004; NA = not available.

Brood year	Number of parr released	Number of smolts	Estimated adult recaptures	PAR	SAR
1989	260,400	NA	3,680	0.0141	NA
1990	372,102	NA	423	0.0011	NA
1991	167,523	NA	101	0.0006	NA
1992	340,557	NA	635	0.0019	NA
1993	190,443	NA	81	0.0004	NA
1994	252,859	NA	48	0.0002	NA
1995	150,808	28,828	128	0.0008	0.0044
1996	284,630	55,985	1,421	0.0050	0.0254
1997	197,195	112,524	839	0.0043	0.0075
1998	121,344	24,684	111	0.0009	0.0045
1999	167,955	94,046	83	0.0005	0.0009
2000	190,174	121,511	1,905	0.0100	0.0157
2001	200,938	140,322	28	0.0001	0.0002
2002	315,783	216,023	297	0.0009	0.0014
2003	240,459	122,399	35	0.0001	0.0003
2004	172,923	159,500	120	0.0007	0.0008
Average	***226,631***	***107,582***	***621***	***0.0026***	***0.0061***

4.8 ESA/HCP Compliance

Broodstock Collection

The 2009 sockeye broodstock collections at Tumwater Dam occurred concurrently with the spring Chinook reproductive success monitoring and evaluation activities (BPA Project No. 2003-039-00) and Wenatchee steelhead broodstock collection activities authorized under ESA permits 1196 and 1395, respectively. No ESA-listed spring Chinook or steelhead take occurred during sockeye broodstock collections at Tumwater Dam that were outside those authorized through ESA Section 10 permits 1196 and 1395.

Hatchery Rearing and Release

The 2009 brood Wenatchee sockeye program released 227,743 juveniles, representing 104% of the program production objective production overage allowance in ESA Section 10 Permit 1347.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Smolt and Emigrant Trapping

ESA-listed spring Chinook and steelhead were encountered during operation of the upper Wenatchee trap. ESA takes are reported in the steelhead (Section 3.8) and spring Chinook (Section 5.8) sections and will not be repeated here.

Spawning Surveys

Sockeye spawning ground surveys conducted in the Wenatchee Basin during 2011 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical and extreme caution was used to avoid established redds when wading was required.

SECTION 5: WENATCHEE (CHIWAWA) SPRING CHINOOK

Although this section of the report focuses on results from monitoring the Chiwawa spring Chinook program, information on spring Chinook collected throughout the Wenatchee Basin is also provided.

5.1 Broodstock Sampling

This section focuses on results from sampling 2009-2011 Chiwawa spring Chinook broodstock, which were collected at the Chiwawa weir and at Tumwater Dam. Some information for the 2011 return is not available at this time (e.g., age structure and final origin determination). This information will be provided in the 2012 annual report.

Origin of Broodstock

Hatchery-origin adults made up between 55-57% of the Chiwawa spring Chinook broodstock for return years 2009-2011 (Table 5.1). Hatchery-origin adults were collected at both Tumwater Dam and the Chiwawa weir. In an effort to partially address straying of Chiwawa spring Chinook to other tributaries in the basin, and secondarily to ensure meeting adult collection quotas, hatchery-origin adults were collected to the greatest extent possible at Tumwater Dam. Natural-origin fish were collected only at the Chiwawa weir. Broodstock were trapped at Tumwater Dam and Chiwawa weir from mid-June through August.

Table 5.1. Numbers of wild and hatchery Chiwawa spring Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned, 1989-2011. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program or were surplus fish killed at spawning.

Brood year	Wild spring Chinook					Hatchery spring Chinook					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
1989	28	0	0	28	0	0	0	0	0	0	28
1990	19	1	0	18	0	0	0	0	0	0	18
1991	32	0	5	27	0	0	0	0	0	0	27
1992	113	0	0	78	35	0	0	0	0	0	78
1993	100	3	3	94	0	0	0	0	0	0	94
1994	9	0	1	8	0	4	0	0	4	0	12
1995	No Program										
1996	8	0	0	8	0	10	0	0	10	0	18
1997	37	0	5	32	0	83	1	3	79	0	111
1998	13	0	0	13	0	35	1	0	34	0	47
1999	No Program										
2000	10	0	1	9	0	38	1	16	21	0	30
2001	115	2	0	113	0	267	8	0	259	0	372
2002	21	0	1	20	0	63	1	11	51	0	71
2003	44	1	2	41	0	75	2	20	53	0	94
2004	100	1	16	83	0	196	30	34	132	0	215
2005	98	1	6	91	0	185	3	1	181	0	279

Brood year	Wild spring Chinook					Hatchery spring Chinook					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
2006	95	0	4	91	0	303	0	29	224	50	315
2007	45	1	1	43	0	124	2	18	104	0	147
2008	88	2	3	83	0	241	5	16	220	0	303
2009	113	6	11	96	0	151	3	37	111	0	207
2010	83	0	6	77	0	103	0	5	98	0	175
2011	80	0	0	80	0	101	2	6	93	0	173
***Average*[a]**	***60***	***1***	***3***	***54***	***0***	***94***	***3***	***9***	***80***	***2***	***134***

[a] Origin determinations should be considered preliminary pending scale analyses.

Age/Length Data

Ages were determined from scales and/or coded wire tags (CWT) collected from broodstock. For both the 2009 and 2010 returns, most adults, regardless of origin, were age-4 Chinook (Table 5.2). A larger percentage of the age-5 Chinook were hatchery-origin fish, whereas a larger percentage of the age-3 fish were natural-origin fish.

Table 5.2. Percent of hatchery and wild spring Chinook of different ages (total age) collected from broodstock, 1991-2010.

Return year	Origin	Total age			
		2	3	4	5
1991	Wild	0.0	15.6	59.4	25.0
	Hatchery	0.0	0.0	0.0	0.0
1992	Wild	0.0	0.0	0.0	0.0
	Hatchery	0.0	0.0	0.0	0.0
1993	Wild	0.0	0.0	22.0	78.0
	Hatchery	0.0	0.0	0.0	0.0
1994	Wild	0.0	0.0	28.6	71.4
	Hatchery	0.0	0.0	50.0	50.0
1995	Wild	No program			
	Hatchery				
1996	Wild	0.0	28.6	71.4	0.0
	Hatchery	0.0	50.0	50.0	0.0
1997	Wild	0.0	0.0	87.5	12.5
	Hatchery	0.0	1.2	98.8	0.0
1998	Wild	0.0	0.0	63.6	36.4
	Hatchery	0.0	0.0	62.9	37.1
1999	Wild	No program			
	Hatchery				
2000	Wild	0.0	20.0	70.0	10.0
	Hatchery	0.0	76.3	23.7	0.0
2001	Wild	0.0	2.8	94.4	2.8
	Hatchery	0.0	1.5	98.5	0.0

Return year	Origin	Total age			
		2	3	4	5
2002	Wild	0.0	0.0	66.7	33.3
	Hatchery	0.0	0.0	93.4	6.6
2003	Wild	0.0	27.0	2.7	70.3
	Hatchery	0.0	21.3	5.3	73.3
2004	Wild	1.1	4.3	89.4	5.3
	Hatchery	0.0	36.9	63.1	0.0
2005	Wild	0.0	1.1	84.5	14.4
	Hatchery	0.0	4.3	94.6	1.1
2006	Wild	0.0	1.1	71.1	27.8
	Hatchery	0.0	1.4	81.3	17.3
2007	Wild	2.3	16.3	48.8	32.6
	Hatchery	0.0	27.4	61.5	11.1
2008	Wild	0.0	9.1	75.3	15.6
	Hatchery	0.0	7.9	86.5	5.6
2009	Wild	0.0	8.4	80.0	11.6
	Hatchery	0.0	18.9	77.8	3.3
2010	Wild	0.0	5.4	94.6	0.0
	Hatchery	0.0	1.0	97.0	2.0
Average	***Wild***	***0.0***	***8.0***	***62.0***	***25.0***
	Hatchery	***0.0***	***14.0***	***58.0***	***12.0***

There was little difference in mean lengths between hatchery and natural-origin broodstock of age-4 and 5 Chinook in 2009 and 2010 (Table 5.3). However, for the 2010 returns, there was a large difference in mean lengths for age-3 hatchery (N = 1) and natural-origin (N = 4) fish.

Table 5.3. Mean fork length (cm) at age (total age) of hatchery and wild spring Chinook collected from broodstock, 1991-2010; N = sample size and SD = 1 standard deviation.

Return year	Origin	Spring Chinook fork length (cm)											
		Age-2			Age-3			Age-4			Age-5		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	-	0	-	-	5	-	-	19	-	-	8	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1992	Wild	-	0	-	-	0	-	-	0	-	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	-	0	-	79	22	3	92	78	4
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-
1994	Wild	-	0	-	-	0	-	79	2	3	96	5	6
	Hatchery	-	0	-	-	0	-	82	2	11	91	2	3
1995	Wild	No program											

Return year	Origin	Spring Chinook fork length (cm)											
		Age-2			Age-3			Age-4			Age-5		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery												
1996	Wild	-	0	-	51	2	1	79	5	7	-	0	-
	Hatchery	-	0	-	56	5	4	74	5	6	-	0	-
1997	Wild	-	0	-	-	0	-	80	28	5	99	4	8
	Hatchery	-	0	-	56	1	-	82	82	4	-	0	-
1998	Wild	-	0	-	-	0	-	78	7	13	83	4	18
	Hatchery	-	0	-	-	0	-	77	22	8	93	13	7
1999	Wild	No program											
	Hatchery												
2000	Wild	-	0	-	51	2	3	82	7	4	98	1	-
	Hatchery	-	0	-	58	29	7	79	9	8	-	0	-
2001	Wild	-	0	-	49	3	6	82	101	6	95	3	3
	Hatchery	-	0	-	56	4	7	83	261	5	-	0	-
2002	Wild	-	0	-	-	0	-	79	12	4	96	6	10
	Hatchery	-	0	-	-	0	-	81	57	6	94	4	9
2003	Wild	-	0	-	55	10	5	83	1	-	99	26	6
	Hatchery	-	0	-	59	16	5	86	4	18	96	55	6
2004	Wild	47	1	-	57	4	4	80	84	5	95	5	9
	Hatchery	-	0	-	49	72	6	79	123	6	-	0	-
2005	Wild	-	0	-	49	1	-	80	82	6	96	14	8
	Hatchery	-	0	-	56	8	5	82	175	6	93	2	2
2006	Wild	-	0	-	48	1	-	80	64	7	96	25	5
	Hatchery	-	0	-	49	4	4	80	240	6	95	51	7
2007	Wild	54	1	-	57	7	10	79	21	6	93	14	7
	Hatchery	-	0	-	59	32	8	81	72	6	93	13	6
2008	Wild	-	0	-	54	7	8	82	58	5	93	12	7
	Hatchery	-	0	-	56	20	10	82	218	6	95	14	6
2009	Wild	-	-	-	53	8	6	81	76	4	95	11	5
	Hatchery	-	-	-	56	29	5	82	119	5	94	5	7
2010	Wild	-	-	-	58	4	9	80	70	6	-	0	-
	Hatchery	-	-	-	84	1	-	82	97	5	98	2	5

Sex Ratios

Male spring Chinook in the 2009-2011 return years made up 50%, 51%, and 50%, respectively, of the adults collected. This resulted in overall male to female ratios of 1.00:1.00, 1.02:1.00, and 1.01:1.00, respectively (Table 5.4). For the 2011 return year, natural-origin fish consisted of a slightly lower proportion of males than females, whereas hatchery-origin fish consisted of a slightly higher proportion of males than females (Table 5.4).

Table 5.4. Numbers of male and female wild and hatchery spring Chinook collected for broodstock, 1989-2011. Ratios of males to females are also provided.

Return year	Number of wild spring Chinook			Number of hatchery spring Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	11	17	0.65:1.00	-	-	-	0.65:1.00
1990	7	12	0.58:1.00	-	-	-	0.58:1.00
1991	13	19	0.68:1.00	-	-	-	0.68:1.00
1992	39	39	1.00:1.00	-	-	-	1.00:1.00
1993	50	50	1.00:1.00	-	-	-	1.00:1.00
1994	5	4	1.25:1.00	2	2	1.00:1.00	1.17:1.00
1995	No program						
1996	6	2	3.00:1.00	8	2	4.00:1.00	3.50:1.00
1997	14	23	0.61:1.00	34	49	0.69:1.00	0.67:1.00
1998	9	4	2.25:1.00	18	17	1.06:1.00	1.29:1.00
1999	No program						
2000	5	5	1.00:1.00	32	6	5.33:1.00	3.36:1.00
2001	45	70	0.64:1.00	90	177	0.51:1.00	0.55:1.00
2002	9	12	0.75:1.00	30	33	0.91:1.00	0.87:1.00
2003	28	16	1.75:1.00	42	33	1.27:1.00	1.43:1.00
2004	58	42	1.38:1.00	102	94	1.09:1.00	1.18:1.00
2005	58	40	1.45:1.00	89	96	0.93:1.00	1.08:1.00
2006	49	46	1.07:1.00	123	179	0.69:1.00	0.77:1.00
2007	20	25	0.80:1.00	66	58	1.14:1.00	1.04:1.00
2008	41	47	0.87:1.00	109	132	0.83:1.00	0.84:1.00
2009	53	60	0.88:1.00	79	72	1.10:1.00	1.00:1.00
2010	41	42	0.98:1.00	53	50	1.06:1.00	1.02:1.00
2011	38	42	0.90:1.00	53	48	1.10:1.00	1.01:1.00
Total	***599***	***617***	***0.97:1.00***	***930***	***1048***	***0.88:1.00***	***0.92:1.00***

Fecundity

Mean fecundities for the 2009-2011 returns of spring Chinook ranged from 4,314-4,573 eggs per female (Table 5.5). These fecundities were less than the overall average of 4,703 eggs per female, but were close to the expected fecundity of 4,400 eggs per female assumed in the broodstock protocol. For the three return years, natural-origin Chinook produced more eggs per female than did hatchery-origin fish (Table 5.5). This could be attributed to differences in size and age of hatchery and natural-origin fish described above.

Table 5.5. Mean fecundity of wild, hatchery, and all female spring Chinook collected for broodstock, 1989-2011; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	2,832
1990*	NA	NA	5,024
1991*	NA	NA	4,600
1992*	NA	NA	5,199[a]
1993*	NA	NA	5,249
1994*	NA	NA	5,923
1995	No program		
1996*	NA	NA	4,645
1997	4,752	4,479	4,570
1998	5,157	5,376	5,325
1999	No program		
2000	5,028	5,019	5,023
2001	4,530	4,663	4,624
2002	5,024	4,506	4,654
2003	6,191	5,651	5,844
2004	4,846	4,775	4,799
2005	4,365	4,312	4,327
2006	4,773	4,151	4,324
2007	4,656	4,351	4,441
2008	4,691	4,560	4,592
2009	4,691	4,487	4,573
2010	4,548	4,114	4,314
2011	4,969	3,884	4,385
Average	***4,873***	***4,595***	***4,703***

* Individual fecundities were not tracked with females until 1997.
[a] Estimated as the mean of fecundities two years before and two years after 1992.

5.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 829,630 eggs are required to meet the program release goal of 672,000 smolts. Between 1989 and 2011, the egg take goal was reached in one of those years (Table 5.6). The green egg takes for 2009-2011 brood years were 68%, 46%, and 44% of program goals, respectively.

ESA Permit 1196 sets limits on the percentage of the total run, natural-origin run, and a minimum contribution of natural-origin fish that must be in the broodstock. Applying these criteria to the low total abundance of spring Chinook salmon to the Chiwawa Basin and the low abundance of natural-origin fish returning to the basin has resulted in the program not meeting production goals.

Table 5.6. Numbers of eggs taken from spring Chinook broodstock, 1989-2011.

Return year	Number of eggs taken
1989	45,311
1990	60,287
1991	73,601
1992	111,624
1993	257,208
1994	35,539
1995	No program
1996	18,579
1997	312,182
1998	90,521
1999	No program
2000	55,256
2001	1,099,630
2002	196,186
2003	247,501
2004	538,176
2005	536,490
2006	744,344
2007	359,739
2008	761,821
2009	564,912
2010	383,941
2011	366,244
Average	***326,623***

Number of acclimation days

Early rearing of the 2009 brood Chiwawa spring Chinook was similar to previous years with fish being held on well water before being transferred to Chiwawa Ponds for final acclimation. Beginning in 2006 (2005 brood acclimation), modifications were made to the Chiwawa Fish Hatchery intakes so that Wenatchee River water could be applied to the Chiwawa River intakes during severe cold periods to prevent the formation of frazzle ice. During acclimation of the 2009 brood, fish were acclimated for 224 to 249 days on Chiwawa River water, with 88 of those days containing a small percentage of Wenatchee River water to prevent freezing of hatchery intakes (Table 5.7).

Table 5.7. Number of days spring Chinook broods were acclimated and water source, brood years 1989-2009; NA = not available.

Brood year	Release year	Transfer date	Release date	Number of days and water source		
				Total	Chiwawa	Wenatchee
1989	1991	19-Oct	11-May	204	NA	NA
1990	1992	13-Sep	27-Apr	227	NA	NA
1991	1993	24-Sep	24-Apr	212	NA	NA
1992	1994	30-Sep	20-Apr	202	NA	NA
1993	1995	28-Sep	20-Apr	204	NA	NA
1994	1996	1-Oct	25-Apr	207	NA	NA
1995	1997	No Program				
1996	1998	25-Sep	29-Apr	216	NA	NA
1997	1999	28-Sep	22-Apr	206	NA	NA
1998	2000	27-Sep	24-Apr	210	NA	NA
1999	2001	No Program				
2000	2002	26-Sep	25-Apr	211	NA	NA
2001	2003	22-Oct	1-May	191	NA	NA
2002	2004	25-Sep	2-May	220	NA	NA
2003	2005	30-Sep	3-May	215	NA	NA
		30-Sep	18-Apr-18-May	200	NA	NA
2004	2006	3-Sep	1-May	240	88-104	124
		3-Sep	17-Apr-17-May	226	NA	NA
2005	2007	25-Sep	1-May	217	217	98[a]
		26-Sep	16-Apr-15-May	202-232	202-232	98[a]
2006	2008	24-27-Sep	14-Apr-13-May	231	231	95[a]
2007	2009	1-Oct	15-Apr-13-May	223	223	103[a]
2008	2010	14-15-Sep	14-Apr-12-May	212-241	212-241	129
2009	2011	14-15-Sep	26-Apr-19-May	225-249	225-249	88

[a] Represents the number of days Wenatchee River water was applied to the Chiwawa River intake screen to prevent the formation of frazzle ice.

Release Information

Numbers released

The 2009 brood Chiwawa spring Chinook program achieved 65.3% of the 672,000 target goal with about 438,561 smolts being released volitionally into the Chiwawa River (Table 5.8).

Table 5.8. Numbers of spring Chinook smolts tagged and released from the hatchery, brood years 1989-2009. The release target for Chiwawa spring Chinook is 672,000 smolts.

Brood year	Release year	Type of release	CWT mark rate	Number released that were PIT tagged	Number of smolts released	Total number of smolts released
1989	1991	Volitional	0.9932	0	43,000	43,000
1990	1992	Volitional	0.9931	0	53,170	53,170
1991	1993	Volitional	0.9831	0	62,138	62,138
1992	1994	Volitional	0.9747	0	85,113	85,113
1993	1995	Volitional	0.9892	0	223,610	223,610
1994	1996	Volitional	0.9967	0	27,226	27,226
1995	1997	No program				
1996	1998	Forced	0.8413	0	15,176	15,176
1997	1999	Volitional	0.9753	0	266,148	266,148
1998	2000	Volitional	0.9429	0	75,906	75,906
1999	2001	No program				
2000	2002	Volitional	0.9920	0	47,104	47,104
2001	2003	Forced	0.9961	0	192,490[a]	377,544
		Volitional	0.9856	0	185,054[a]	
2002	2004	Volitional	0.9693	0	149,668	149,668
2003	2005	Forced	0.9783	0	69,907	222,131
		Volitional	0.9743	0	152,224	
2004	2006	Forced	0.9533	0	243,505	494,517
		Volitional	0.9493	0	251,012	
2005	2007	Forced	0.9882	4,993	245,406	494,012
		Volitional	0.9864	4,988	248,606	
2006	2007	Direct	0.0000	0	12,977[b]	612,482
	2008	Volitional	0.9795	9,894	612,482	
2007	2008	Direct	0.0000	0	9,494	305,542
	2009	Volitional	0.9948	10,035	296,048	
2008	2010	Volitional	0.9835	10,006	609,789	609,789
2009	2011	Forced	0.9874	0	241,181	438,561
		Volitional	0.9874	9,412	197,380	

[a] This does not include the 226,456 eyed eggs that were planted in the Chiwawa River.
[b] This high ELISA group was only adipose fin clipped and directly planted into Big Meadow Creek in May.

Numbers tagged

The 2009 brood Chiwawa spring Chinook were 98.7% CWT and adipose fin clipped (Table 5.8).

In 2011, a total of 5,102 spring Chinook from the 2010 brood were PIT tagged at the Eastbank Hatchery during 13-15 June. These fish were transferred to the Chiwawa raceway in September. As of the end of February 2012, a total of 82 tagged fish have died (no fish have shed their tags). This leaves 5,020 tagged spring Chinook alive at the end of February. These fish will be released in the Chiwawa River in spring of 2012. Table 5.9 summarizes the number of hatchery spring Chinook that have been PIT-tagged and released into the Chiwawa River.

Table 5.9. Summary of PIT-tagging activities for Chiwawa hatchery spring Chinook, brood years 2005-2009.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2005	2007	10,063	74	8	9,981[a]
2006	2008	10,055	134	27	9,894
2007	2009	10,112	61	16	10,035
2008	2010	10,101	81	14	10,006
2009	2011	10,101	655	34	9,412

[a] This release consisted of 4,988 tagged Chinook that were released volitionally and 4,993 that were forced released.

Fish size and condition at release

Spring Chinook from the 2009 brood were released as yearling smolts between 26 April and 19 May 2011. Size at release was below the target established for the program. The target CV for fork length was exceeded by 43% (Table 5.10).

Table 5.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of spring Chinook smolts released from the hatchery, brood years 1989-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	147	4.4	37.8	12
1990	1992	137	5.0	32.4	14
1991	1993	135	4.2	30.3	15
1992	1994	133	5.0	28.4	16
1993	1995	136	4.5	30.2	15
1994	1996	139	7.1	34.4	13
1995	1997	No Program			
1996	1998	157	5.3	52.1	9
1997	1999	146	7.2	38.7	12
1998	2000	143	9.1	39.5	12
1999	2001	No Program			
2000	2002	150	6.8	46.7	10

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
2001	2003	142	7.1	37.6	12
2002	2004	146	8.5	40.3	11
2003	2005	167[a]	5.9	59.4	8
		151[b]	7.4	44.2	10
2004	2006	146[a]	6.4	39.1	12
		139[b]	5.7	34.3	13
2005	2007	136[a]	4.6	30.8	15
		129[b]	5.8	26.6	17
2006	2008	124	8.8	23.5	19
2007	2008	70[a]	4.0	3.7	122
	2009	140[b]	11.0	33.6	14
2008	2010	141	107	36.0	13
2009	2011	167	12.9	56.8	8
Targets		***176***	***9.0***	***37.8***	***12***

[a] Forced release group.
[b] Volitional release group.

Survival Estimates

Overall survival of Chiwawa spring Chinook from green (unfertilized) egg to release was slightly below the standard set for the program (Table 5.11). Survival from the eyed egg-to-ponding stage was below program objectives. Pre-spawn survival of adults was above the standard set for the program.

Table 5.11. Hatchery life-stage survival rates (%) for spring Chinook, brood years 1989-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	100.0	100.0	98.0	99.1	99.1	99.0	96.4	99.3	94.8
1990	100.0	85.7	91.8	98.1	99.5	98.9	97.9	99.2	88.2
1991	100.0	100.0	94.4	96.1	99.6	97.9	93.2	95.0	84.4
1992	100.0	100.0	98.4	96.7	99.9	99.9	80.0	80.6	76.2
1993	96.0	98.0	89.7	98.0	99.7	99.3	98.9	99.7	86.9
1994	100.0	100.0	98.6	100.0	99.8	99.4	77.0	78.9	76.6
1995	No program								
1996	100.0	100.0	88.3	100.0	93.8	93.0	89.9	97.7	81.7
1997	98.6	100.0	93.2	95.7	98.3	99.6	95.6	99.3	85.3
1998	95.2	100.0	94.5	99.0	98.5	98.3	89.6	99.1	83.9
1999	No program								
2000	100.0	100.0	91.0	98.1	97.2	96.6	95.4	99.3	85.2
2001	97.6	97.0	88.9	98.1	99.7	99.6	51.3	51.8	34.3

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2002	97.8	100.0	82.1	98.0	97.4	96.7	94.8	99.1	76.3
2003	93.9	100.0	93.2	97.7	99.5	99.3	98.5	98.1	89.7
2004	97.8	82.5	93.3	98.4	98.8	94.3	93.9	97.2	91.9
2005	97.1	100.0	95.9	98.0	99.2	99.0	97.9	99.1	92.1
2006	100.0	100.0	90.1	98.1	99.2	99.0	95.3	97.7	84.2
2007	98.8	97.7	92.9	97.2	99.4	99.0	98.0	99.4	88.5
2008	96.6	99.3	90.8	93.2	97.4	97.1	95.6	97.6	80.0
2009	94.4	97.6	92.5	88.3	97.6	97.4	89.2	92.8	77.6
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

5.3 Disease Monitoring

Results of 2011 adult broodstock bacterial kidney disease (BKD) monitoring indicated that most females (96.6%) had ELISA values less than 0.199. About 88% of females had ELISA values less than 0.120, which would have required about 12% of the progeny to be reared at densities not to exceed 0.06 fish per pound (Table 5.12). As per the HCP Hatchery Committee Agreement, progeny from the four high ELISA females were culled to minimize possible negative effects to the remainder of the program. These progeny represented about 3.6% of the estimated production for the 2011 brood.

Mortalities resulting from external fungal infections began increasing shortly after transfer to the Chiwawa Ponds, presumably from bacterial coldwater disease (BCWD). Two formalin drip treatments failed to control the infection. A Chloramine-T treatment was initiated, which was successful. No significant health issues were encountered for the remainder of juvenile rearing.

Table 5.12. Proportion of bacterial kidney disease (BKD) titer groups for the Chiwawa spring Chinook broodstock, brood years 1996-2011. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1996	0.0000	0.2500	0.2500	0.5000	0.0000	1.0000
1997	0.1176	0.7353	0.0588	0.0882	0.3529	0.6471
1998	0.1176	0.8235	0.0588	0.0000	0.4706	0.5294
1999	No Program					
2000	0.0000	0.9091	0.0909	0.0000	0.1818	0.8182
2001	0.4066	0.5436	0.0373	0.0124	0.6515	0.3485
2002	0.2195	0.6585	0.0732	0.0488	0.5610	0.4390
2003	0.6957	0.1087	0.0652	0.1304	0.7174	0.2826
2004	0.8182	0.1515	0.0227	0.0076	0.8939	0.1061

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
2005	0.9084	0.0916	0.0000	0.0000	0.9695	0.0305
2006	0.7222	0.2556	0.0000	0.0222	0.8444	0.1556
2007	0.5854	0.3415	0.0244	0.0488	0.7073	0.2927
2008	0.8304	0.1520	0.0058	0.0117	0.9357	0.0643
2009	0.7600	0.1840	0.0080	0.0480	0.8480	0.1520
2010	0.8791	0.0769	0.0000	0.0439	0.9451	0.0549
2011	0.7640	0.2022	0.0000	0.0337	0.8764	0.1236
Average	*0.5216*	*0.3656*	*0.0463*	*0.1330*	*0.6637*	*0.3363*

[a] Individual ELISA samples were not collected before the 1996 brood.

5.4 Natural Juvenile Productivity

During 2011, juvenile spring Chinook were sampled at the Upper Wenatchee and Chiwawa traps and counted during snorkel surveys within the Chiwawa Basin.

Parr Estimates

A total of 141,510 (±13%) subyearling and 967 (±28%) yearling spring Chinook were estimated in the Chiwawa River Basin in August 2011 (Table 5.13 and 5.14). During the survey period 1992-2011, numbers of subyearling and yearling Chinook have ranged from 5,815 to 141,510 and 5 to 967, respectively, in the Chiwawa Basin (Table 5.13 and 5.14; Figure 5.1). Numbers of all fish counted in the Chiwawa Basin are reported in Appendix A.

Table 5.13. Total numbers of subyearling spring Chinook estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2011; NS = not sampled.

Sample Year	Number of subyearling spring Chinook								
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
1992	45,483	NS	NS	NS	NS	NS	NS	NS	NS	**45,483**
1993	77,269	0	1,258	586	NS	NS	NS	NS	NS	**79,113**
1994	53,492	0	398	474	68	624	0	0	0	**55,056**
1995	52,775	0	1,346	210	0	683	67	160	0	**55,241**
1996	5,500	0	29	10	0	248	28	0	0	**5,815**
1997	15,438	0	56	92	0	480	0	0	0	**16,066**
1998	65,875	0	1,468	496	57	506	0	13	0	**68,415**
1999	40,051	0	366	592	0	598	22	0	0	**41,629**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	106,753	168	2,077	2,855	354	2,332	78	0	0	**114,617**
2002	117,230	75	8,233	2,953	636	5,021	429	0	297	**134,874**
2003	80,250	4,508	1,570	3,255	118	1,510	22	45	0	**91,278**
2004	43,360	102	717	215	54	637	21	71	0	**45,177**

Sample Year	Number of subyearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Clear Creek	Total
2005	45,999	71	2,092	660	17	792	0	0	0	**49,631**
2006	73,478	113	2,500	1,681	51	1,890	62	127	0	**79,902**
2007	53,863	125	5,235	870	51	538	20	28	22	**60,752**
2008	72,431	214	3,287	4,730	163	1,221	28	255	22	**82,351**
2009	101,085	125	2,486	1,849	14	1,082	29	18	17	**106,705**
2010	117,499	526	4,571	4,052	0	1,449	56	42	25	**128,220**
2011	136,424	64	2,762	1,330	53	581	42	214	40	**141,510**
Average	***68,645***	***338***	***2,247***	***1,495***	***96***	***1,188***	***53***	***57***	***25***	***73,781***

Table 5.14. Total numbers of yearling spring Chinook estimated in different steams in the Chiwawa Basin during snorkel surveys in August 1992-2011; NS = not sampled.

Sample Year	Number of yearling spring Chinook									
	Chiwawa River	Phelps Creek	Chikamin Creek	Rock Creek	Peven Creek	Big Meadow Creek	Alder Creek	Brush Creek	Y Creek	Total
1992	563	NS	NS	NS	NS	NS	NS	NS	NS	**563**
1993	174	0	0	0	NS	NS	NS	NS	NS	**174**
1994	14	0	0	4	0	0	0	0	0	**18**
1995	13	0	0	0	0	0	0	0	0	**13**
1996	22	0	0	0	0	0	0	0	0	**22**
1997	5	0	0	0	0	0	0	0	0	**5**
1998	63	0	0	0	0	0	0	0	0	**63**
1999	41	0	0	0	0	0	0	0	0	**41**
2000	NS	NS	NS	NS	NS	NS	NS	NS	NS	**NS**
2001	66	0	3	0	0	0	0	0	0	**69**
2002	32	0	0	0	0	0	0	0	0	**32**
2003	134	0	0	0	0	0	0	0	0	**134**
2004	14	0	0	0	0	7	0	0	0	**21**
2005	62	0	17	0	0	0	0	0	0	**79**
2006	345	0	0	43	0	0	0	0	0	**388**
2007	41	0	0	0	0	0	0	0	0	**41**
2008	144	0	45	0	0	0	0	0	0	**189**
2009	49	0	0	5	0	0	0	0	0	**54**
2010	207	27	19	38	0	0	0	0	0	**291**
2011	645	0	71	194	0	57	0	0	0	**967**
Average	***139***	***2***	***9***	***16***	***0***	***4***	***0***	***0***	***0***	***167***

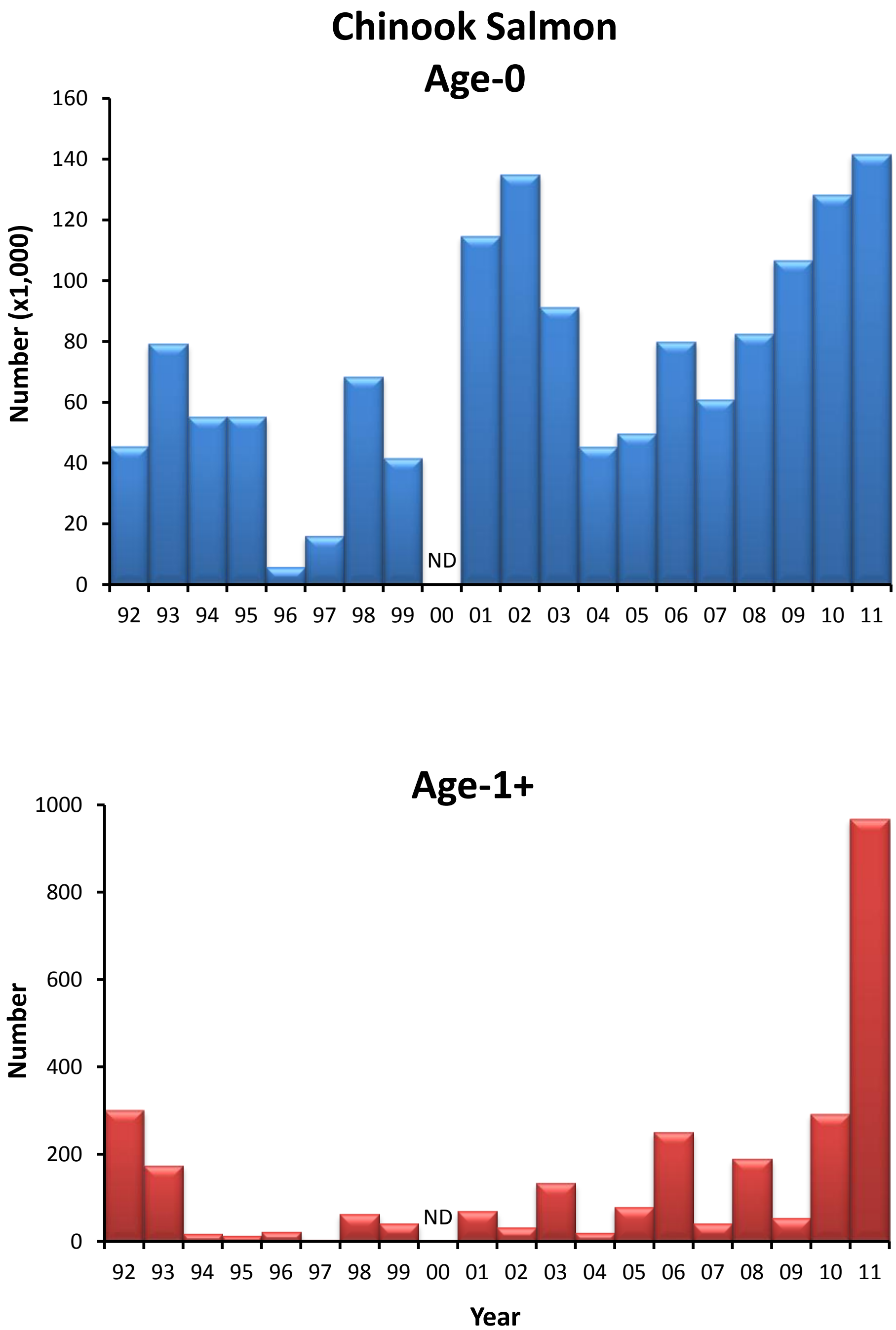

Figure 5.1. Numbers of subyearling and yearling Chinook salmon within the Chiwawa River Basin in August 1992-2011; ND = no data.

Juvenile Chinook were distributed contagiously among reaches in the Chiwawa River. Their densities were highest in the upper portions of the basin, with the highest densities within tributaries. Juvenile Chinook were most abundant in multiple channels and least abundant in glides. Most Chinook associated closely with woody debris in multiple channels. These sites (multiple channels) made up 17% of the total area of the Chiwawa Basin, but they provided habitat for 43% of all subyearling Chinook in the basin in 2011. In contrast, riffles made up 57% of the total area, but provided habitat for only 19% of all juvenile Chinook in the Chiwawa Basin. Pools made up 18% of the total area and provided habitat for 34% of all juvenile Chinook in the basin. Virtually no Chinook used glides that lacked woody debris.

Mean densities of juvenile Chinook in two reaches of the Chiwawa River were generally less than those in corresponding reference areas (Nason Creek and the Little Wenatchee River) (Figure 5.2). Within both the Chiwawa River and its reference areas, pools and multiple channels consistently had the highest densities of juvenile Chinook.

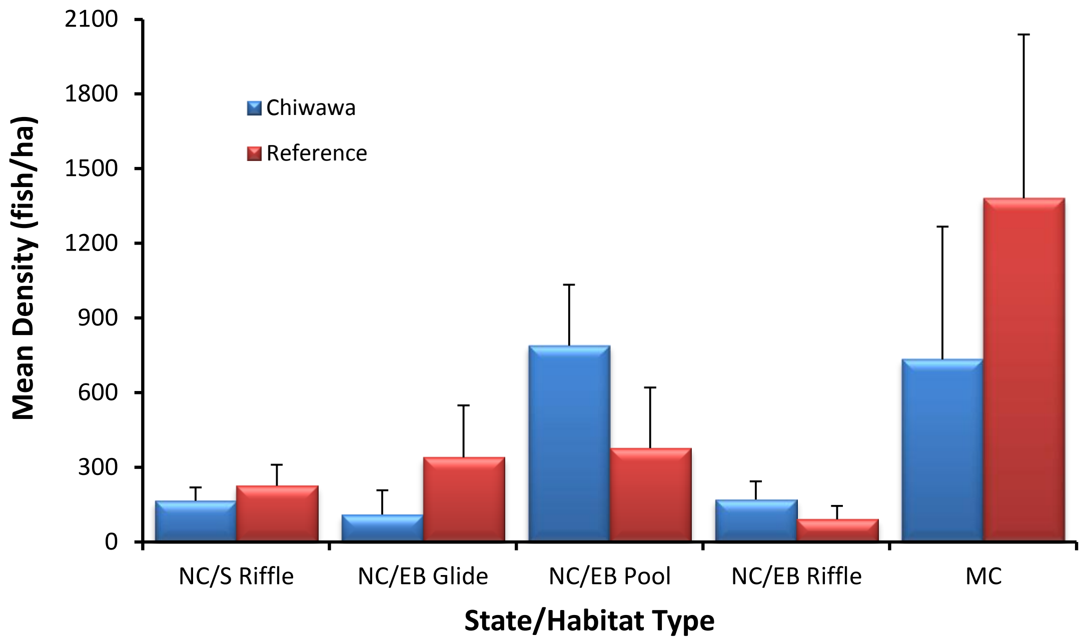

Figure 5.2. Comparison of the 18-year means of subyearling spring Chinook densities within state/habitat types in reaches 3 and 8 of the Chiwawa River and their matched reference areas on Nason Creek and the Little Wenatchee River. NC = natural channel; S = straight channel; EB = eroded banks; MC = multiple channel. There was no sampling in 2000 and no sampling within reference areas in 1992.

Smolt and Emigrant Estimates

Numbers of spring Chinook smolts and emigrants were estimated at the Upper Wenatchee and Chiwawa traps in 2011.

Chiwawa Trap

The Chiwawa Trap operated between 8 March and 29 November 2011. During that time period the trap was inoperable for 20 days because of high river flows, debris, snow/ice, or mechanical failure. The trap operated in two different positions depending on stream flow; lower position at flows greater than 12 m^3/s and an upper position at flows less than 12 m^3/s. Daily trap efficiencies were estimated from two regression models depending on trap position and age class of fish (e.g., subyearling and yearling). The daily number of fish captured was expanded by the estimated trap efficiency to estimate daily total emigration. Monthly captures of all fish and results of mark-recapture efficiency tests at the Chiwawa Trap are reported in Appendix B.

Wild yearling spring Chinook (2009 brood year) were primarily captured from March through June 2011 (Figure 5.3). Based on capture efficiencies estimated from the flow model, the total number of wild yearling Chinook emigrating from the Chiwawa River was 30,959 (±7,386). Combining the total number of subyearling spring Chinook (30,996) that emigrated during the fall of 2010 with the total number of yearling Chinook (30,959) that emigrated during 2011 resulted in a total emigrant estimate of 61,955 spring Chinook for the 2009 brood year (Table 5.15).

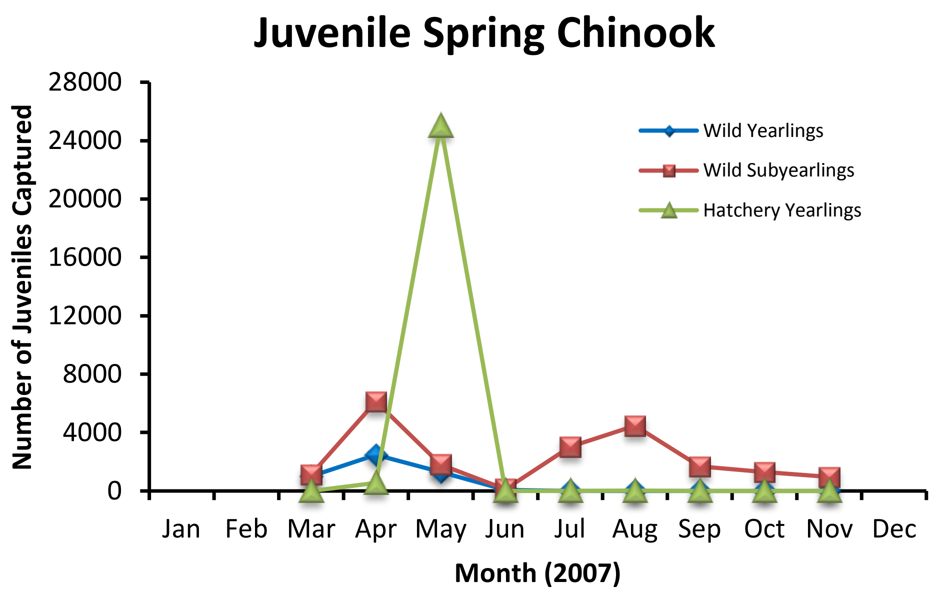

Figure 5.3. Monthly captures of wild subyearling, wild yearling, and hatchery yearling spring Chinook at the Chiwawa Trap, 2011.

Table 5.15. Numbers of redds and juvenile spring Chinook at different life stages in the Chiwawa Basin for brood years 1991-2011; NS = not sampled.

Brood year	Number of redds	Egg deposition	Number of parr	Number of smolts produced within Chiwawa Basin[a]	Total number of smolts[b]	Number of emigrants
1991	104	478,400	45,483[c]	42,525	42,525	NS
1992	302	1,570,098	79,113	39,723	56,763	65,541
1993	106	556,394	55,056	8,662	17,926	22,698
1994	82	485,686	55,240	16,472	22,145	25,067
1995	13	66,248	5,815	3,830	5,230	5,951
1996	23	106,835	16,066	15,475	17,922	19,183
1997	82	374,740	68,415	28,334	39,044	44,562

Brood year	Number of redds	Egg deposition	Number of parr	Number of smolts produced within Chiwawa Basin[a]	Total number of smolts[b]	Number of emigrants
1998	41	218,325	41,629	23,068	24,953	25,923
1999	34	166,090	NS	10,661	13,953	15,649
2000	128	642,944	114,617	40,831	50,634	55,685
2001	1,078	4,984,672	134,874	86,482	389,940	546,266
2002	345	1,605,630	91,278	90,948	152,547	184,279
2003	111	648,684	45,177	16,755	27,897	33,637
2004	241	1,156,559	49,631	72,080	101,172	116,158
2005	332	1,436,564	79,902	69,064	140,737	177,659
2006	297	1,284,228	60,752	45,050	86,579	107,972
2007	283	1,256,803	82,351	25,809	65,539	86,006
2008	689	3,163,888	106,705	35,023	91,229	120,184
2009	421	1,925,233	128,220	30,959	51,417	61,955
2010	502	2,165,628	141,510	-	-	-
Average	***261***	***1,214,682***	***75,353***	***36,934***	***73,587***	***95,243***

[a] The estimated number of smolts (yearlings) that are produced entirely within the Chiwawa Basin. Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-present were calculated with a flow model.
[b] These numbers represent Chiwawa smolts produced within the entire Wenatchee Basin. This assumes that 66% of the subyearling migrants from the Chiwawa Basin survive to smolt in the Wenatchee Basin, regardless of the number of subyearling migrants (i.e., no density dependence). Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-present were calculated with a flow model.
[c] Estimate only includes numbers of Chinook in the Chiwawa River. Tributaries were not sampled at that time.

Wild subyearling spring Chinook (2010 brood year) were captured between 8 March and 29 November 2011. Based on capture efficiencies estimated from the flow model for both the upper trap position and lower position, the total number of wild subyearling (fry and parr) Chinook from the Chiwawa Basin was 172,448 (±19,292). Removing fry from the estimate, a total of 59,305 (±5,983) parr emigrated from the Chiwawa Basin in 2011. Although subyearlings migrated during most months of sampling, the majority (91%) migrated during March, April, May, July, August, and September (Figure 5.3).

Yearling spring Chinook sampled in 2011 averaged 94 mm in length, 8.7 g in weight, and had a mean condition of 1.04 (Table 5.16). These size estimates were similar in comparison to the overall mean of yearling spring Chinook sampled in previous years (overall means: 92 mm, 8.8 g, and condition of 1.07). Subyearling spring Chinook sampled in 2011 at the Chiwawa Trap averaged 73 mm in length, averaged 4.8 g, and had a mean condition of 1.15 (Table 5.16). These sizes were similar to the overall mean of subyearling spring Chinook sampled in previous years (overall means, 74 mm, 4.8 g, and condition of 1.07).

Table 5.16. Mean fork length (mm), weight (g), and condition factor of subyearling and yearling spring Chinook collected in the Chiwawa Trap, 1996-2011. Numbers in parentheses indicate 1 standard deviation.

Sample year	Life stage	Sample size[a]	Mean size		
			Length (mm)	Weight (g)	Condition (K)
1996	Subyearling	514	78 (25)	6.9 (4.2)	1.11 (0.11)
	Yearling	1,589	94 (9)	9.5 (3.0)	1.11 (0.08)
1997	Subyearling	840	86 (8)	7.5 (2.1)	1.16 (0.08)
	Yearling	1,114	100 (7)	10.2 (2.6)	1.02 (0.10)
1998	Subyearling	3,743	82 (11)	6.2 (2.2)	1.08 (0.09)
	Yearling	2,663	97 (7)	10.3 (2.8)	1.12 (0.23)
1999	Subyearling	569	89 (9)	8.5 (2.4)	1.15 (0.07)
	Yearling	3,664	95 (8)	9.6 (3.4)	1.09 (0.19)
2000	Subyearling	1,810	85 (10)	7.4 (2.4)	1.15 (0.10)
	Yearling	1,891	97 (8)	10.5 (5.2)	1.13 (0.07)
2001	Subyearling	4,657	82 (11)	6.6 (3.4)	1.14 (0.09)
	Yearling	2,935	97 (7)	10.5 (2.4)	1.15 (0.08)
2002	Subyearling	6,130	64 (12)	3.0 (1.6)	1.06 (0.10)
	Yearling	1,735	94 (8)	9.0 (2.3)	1.09 (0.08)
2003	Subyearling	3,679	64 (12)	3.2 (1.7)	1.08 (0.10)
	Yearling	2,657	87 (9)	7.2 (3.5)	1.07 (0.10)
2004	Subyearling	2,278	75 (16)	4.3 (2.1)	0.92 (0.16)
	Yearling	1,032	91 (9)	8.5 (2.7)	1.09 (0.10)
2005	Subyearling	2,702	73 (12)	4.6 (2.2)	1.08 (0.09)
	Yearling	803	96 (9)	9.9 (2.8)	1.08 (0.08)
2006	Subyearling	3,462	76 (11)	5.1 (2.0)	1.12 (0.21)
	Yearling	4,645	95 (7)	9.4 (2.3)	1.10 (0.13)
2007	Subyearling	1,718	72 (12)	4.5 (2.1)	1.13 (0.16)
	Yearling	2,245	91 (8)	8.6 (2.5)	1.10 (0.09)
2008	Subyearling	10,443	79 (12)	5.9 (2.3)	1.15 (0.15)
	Yearling	8,792	93 (7)	8.8 (2.1)	1.08 (0.10)
2009	Subyearling	10,536	75 (10)	5.0 (2.2)	0.91 (0.11)
	Yearling	3,630	92 (7)	8.8 (2.1)	0.89 (0.07)
2010	Subyearling	3,888	77 (12)	5.4 (2.3)	1.11 (0.16)
	Yearling	5,799	91 (8)	8.9 (2.2)	1.15 (0.14)
2011	Subyearling	6,870	73 (11)	4.8 (2.2)	1.15 (0.16)
	Yearling	4,734	94 (8)	8.7 (2.2)	1.04 (0.10)
Average	***Subyearling***	***5,064***	***74 (4)***	***4.8 (0.8)***	***1.07 (0.09)***
	Yearling	***3,815***	***92 (3)***	***8.8 (0.7)***	***1.07 (0.07)***

[a] Sample size represents the number of fish that were measured for both length and weight.

Upper Wenatchee Trap

The Upper Wenatchee Trap operated nightly between 4 March and 1 July 2011. During the five-month sampling period, a total of 786 wild yearling Chinook, 109 wild subyearling Chinook, and 292 hatchery yearling Chinook were captured at the Upper Wenatchee Trap. Monthly captures of all fish collected at the Upper Wenatchee Trap are reported in Appendix B.

PIT Tagging Activities

As part of the Comparative Survival Study (CSS), a total of 11,063 wild juvenile Chinook (6,031 subyearling and 5,032 yearlings) were PIT tagged and released in 2011 in the Wenatchee Basin (Table 5.17a). Most of these (94%) were tagged at the Chiwawa trap. See Appendix C for a complete list of all fish captured, tagged, lost, and released.

Table 5.17a. Numbers of wild Chinook that were captured, tagged, and released at different locations within the Wenatchee Basin, 2011. Numbers of fish that died or shed tags are also given.

Sampling Location	Species and Life Stage	Number held	Number of recaptures	Number tagged	Number died	Shed Tags	Total released	Percent mortality
Chiwawa Trap	Wild Subyearling Chinook	6,640	466	6,043	12	1	6,030	0.18
	Wild Yearling Chinook	4,582	193	4,326	7	1	4,318	0.15
	Total	**11,222**	**659**	**10,369**	**19**	**2**	**10,348**	**0.17**
Upper Wenatchee Trap	Wild Subyearling Chinook	1	0	1	0	0	1	0.00
	Wild Yearling Chinook	755	11	717	3	0	714	0.40
	Total	**756**	**11**	**718**	**3**	**0**	**715**	**0.40**
Total:	**Wild Subyearling Chinook**	**6,641**	**466**	**6,044**	**12**	**1**	**6,031**	**0.18**
	Wild Yearling Chinook	**5,337**	**204**	**5,043**	**10**	**1**	**5,032**	**0.19**
Grand Total:		**11,978**	**670**	**11,087**	**22**	**2**	**11,063**	**0.18**

Numbers of wild Chinook salmon PIT-tagged and released as part of CSS during the period 2006-2011 are shown in Table 5.17b.

Table 5.17b. Summary of the numbers of wild Chinook that were tagged and released at different locations within the Wenatchee Basin, 2006-2011.

Sampling Location	Species and Life Stage	Numbers of PIT-tagged Chinook salmon released					
		2006	2007	2008	2009	2010	2011
Chiwawa Trap	Wild Subyearling Chinook	5,130	6,137	8,755	8,765	3,324	6,030
	Wild Yearling Chinook	2,793	4,659	8,397	3,694	6,281	4,318
	Total	**7,923**	**10,796**	**17,152**	**12,459**	**9,605**	**10,348**
Chiwawa Remote	Wild Subyearling Chinook	111	20	43	128	531	0
	Wild Yearling Chinook	0	0	0	3	4	0
	Total	**111**	**20**	**43**	**131**	**535**	**0**
Upper Wenatchee Trap	Wild Subyearling Chinook	0	15	0	37	3	1
	Wild Yearling Chinook	81	1,434	159	296	486	714
	Total	**81**	**1,449**	**159**	**333**	**489**	**715**

Sampling Location	Species and Life Stage	Numbers of PIT-tagged Chinook salmon released					
		2006	2007	2008	2009	2010	2011
Nason Creek Remote[a]	Wild Subyearling Chinook	68	6	4	701	595	0
	Wild Yearling Chinook	1	7	0	13	3	0
	Total	**69**	**13**	**4**	**714**	**598**	**0**
Upper Wenatchee Remote	Wild Subyearling Chinook	0	61	1	0	2	0
	Wild Yearling Chinook	27	0	0	0	0	0
	Total	**27**	**61**	**1**	**0**	**2**	**0**
Middle Wenatchee Remote	Wild Subyearling Chinook	0	0	65	284	233	0
	Wild Yearling Chinook	0	0	0	0	0	0
	Total	**0**	**0**	**65**	**284**	**233**	**0**
Lower Wenatchee Remote	Wild Subyearling Chinook	0	0	0	0	0	0
	Wild Yearling Chinook	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**0**	**0**
Peshastin Creek Remote	Wild Subyearling Chinook	0	0	0	0	1	0
	Wild Yearling Chinook	0	0	0	0	0	0
	Total	**0**	**0**	**0**	**0**	**1**	**0**
Lower Wenatchee Trap	Wild Subyearling Chinook	0	0	2	0	0	0
	Wild Yearling Chinook	522	1,641	506	468	917	0
	Total	**522**	**1,641**	**508**	**468**	**917**	**0**
Total:	**Wild Subyearling Chinook**	**5,309**	**6,239**	**8,870**	**9,915**	**4,689**	**6,031**
	Wild Yearling Chinook	**3,424**	**7,741**	**9,062**	**4,474**	**7,691**	**5,032**
Grand Total:		**8,733**	**13,980**	**17,932**	**14,389**	**12,380**	**11,063**

Freshwater Productivity

Both productivity and survival estimates for different life stages of spring Chinook in the Chiwawa Basin are provided in Table 5.18. Estimates for brood year 2009 fall within the ranges estimated over the period of brood years 1991-2008. During that period, freshwater productivities ranged from 125-1,015 parr/redd, 122-779 smolts/redd, and 147-834 emigrants/redd. Survivals during the same period ranged from 2.7-19.1% for egg-parr, 2.9-16.8% for egg-smolt, and 3.2-18.0% for egg-emigrants. Overwinter survival rates for juvenile spring Chinook within the Chiwawa Basin have ranged from 15.7-100.0%.

Table 5.18. Productivity (fish/redd) and survival (%) estimates for different juvenile life stages of spring Chinook in the Chiwawa Basin for brood years 1991-2010; ND = no data. These estimates were derived from data in Table 5.14.

Brood year	Parr/Redd	Smolts/Redd[a]	Emigrants/ Redd	Egg-Parr (%)	Parr-Smolt[b] (%)	Egg-Smolt[a] (%)	Egg-Emigrant (%)
1991	437	409	ND	9.5	93.5	8.9	ND
1992	262	188	217	5.0	50.2	3.6	4.2
1993	519	169	214	9.9	15.7	3.2	4.1
1994	674	270	306	11.4	29.8	4.6	5.2
1995	447	402	458	8.8	65.9	7.9	9.0
1996	699	779	834	15.0	96.3	16.8	18.0
1997	834	476	543	18.3	41.4	10.4	11.9
1998	1,015	609	632	19.1	55.4	11.4	11.9
1999	ND	410	460	ND	ND	8.4	9.4
2000	895	396	435	17.8	35.6	7.9	8.7
2001	125	362	507	2.7	64.1	7.8	11.0
2002	265	442	534	5.7	99.6	9.5	11.5
2003	407	251	303	7.0	37.1	4.3	5.2
2004	206	420	482	4.3	100.0	8.7	10.0
2005	241	424	535	5.6	86.4	9.8	12.4
2006	205	292	364	4.7	74.2	6.7	8.4
2007	291	232	304	6.6	31.3	5.2	6.8
2008	155	132	174	3.4	32.8	2.9	3.8
2009	305	122	147	6.7	24.1	2.7	3.2
2010	282	-	-	6.5	-	-	-
Average	***435***	***357***	***414***	***8.8***	***57.4***	***7.4***	***8.6***

[a] These estimates include Chiwawa smolts produced within the Wenatchee Basin. This assumes that 66% of the subyearling migrants survive to smolt, regardless of the number of subyearling migrants (i.e., no density dependence). Smolt estimates for brood years 1992-1996 were calculated with a mark-recapture model; brood years 1997-present were calculated with a flow model.

[b] These estimates represent overwinter survival within the Chiwawa Basin. It does not include Chiwawa smolts produced outside the Chiwawa Basin. As noted in footnote *a*, smolts/redd and egg-smolt survival include Chiwawa smolts produced in the Wenatchee Basin.

Seeding level (egg deposition) explained most of the variability in productivity and survival of juvenile spring Chinook in the Chiwawa Basin. That is, for estimates based on "within-Chiwawa-Basin" life stages (e.g., parr and within-Chiwawa-Basin smolts), survival and productivity decreased as seeding levels increased (Figure 5.4). This suggests that density dependence regulates juvenile productivity and survival within the Chiwawa Basin. This form of population regulation is less apparent with total smolts (i.e., Chiwawa smolts produced within the Wenatchee Basin) and total emigrants. However, one would expect the number of emigrants to increases as seeding levels exceed the capacity of the Chiwawa Basin.

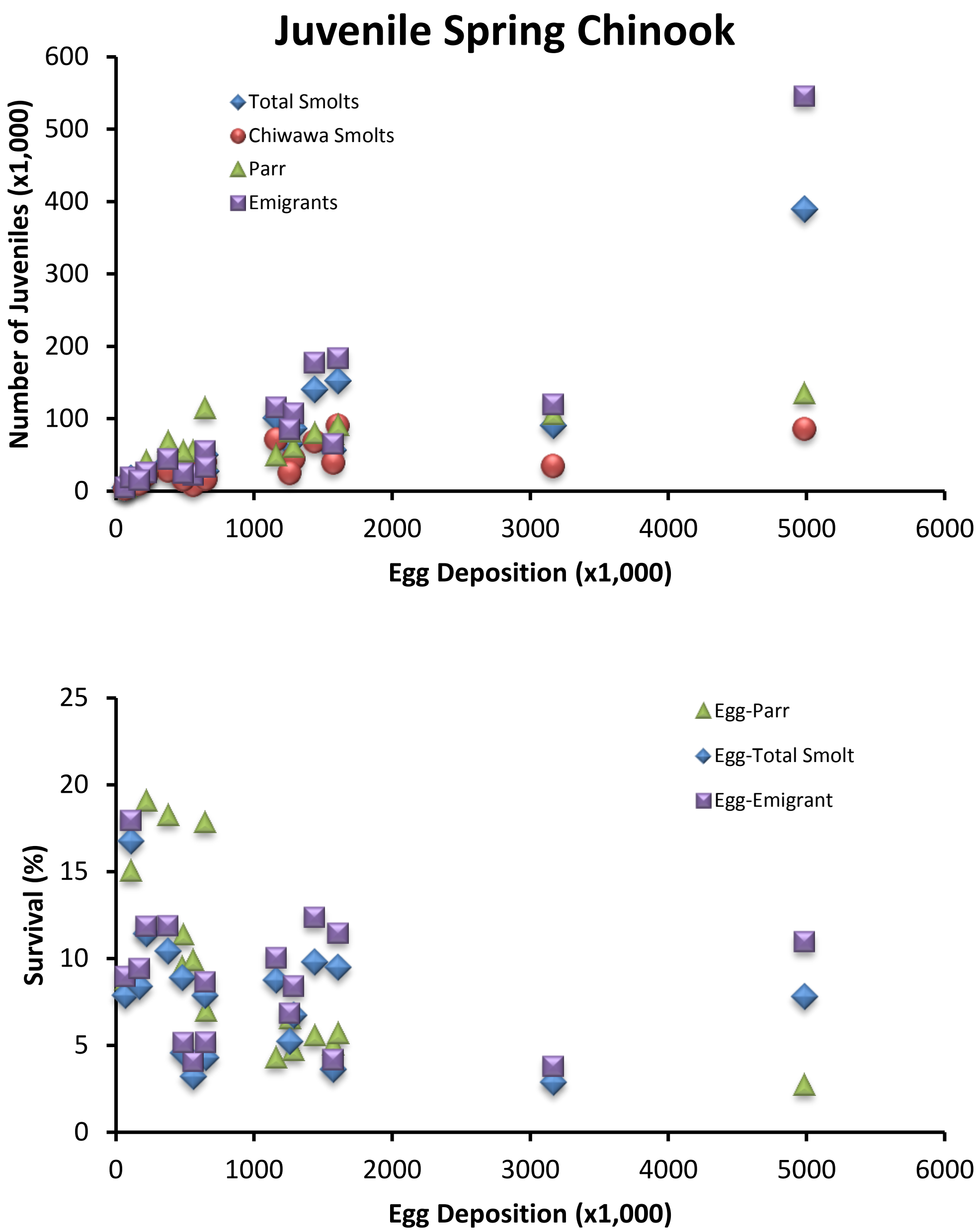

Figure 5.4. Relationships between seeding levels (egg deposition) and juvenile life-stage survivals and productivities for Chiwawa spring Chinook, brood years 1991-2009. Total smolts are Chiwawa smolts produced within and outside the Chiwawa Basin (assumes a 66% survival on subyearling emigrants). Chiwawa smolts are smolts produced only in the Chiwawa Basin.

5.5 Spawning Surveys

Surveys for spring Chinook carcasses were conducted during August through September, 2011, in the Chiwawa River (including Rock, Phelps, Big Meadow, and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek).

Redd Counts

A total of 872 spring Chinook redds were counted in the Wenatchee Basin in 2011 (Table 5.19). This is higher than the average of 576 redds counted during the period 1989-2010 in the Wenatchee Basin. Most spawning occurred in the Chiwawa River (56.4% or 492 redds) (Table 5.19; Figure 5.5). Nason Creek contained 19.5% (170 redds), White River contained 2.3% (20 redds), Little Wenatchee contained 3.4% (30 redds), Icicle contained 14% (122 redds), Peshastin Creek contained 3% (26 redds), and the Upper Wenatchee River 1.4% (12 redds).

Table 5.19. Numbers of spring Chinook redds counted within different streams/watersheds within the Wenatchee Basin, 1989-2011. Redd counts in Peshastin Creek in 2001 and 2002 (*) were elevated because the U.S. Fish and Wildlife Service planted 487 and 350 spring Chinook adults, respectively, into the stream. These counts were not included in the total or average calculations.

Sample year	Number of spring Chinook redds							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
1989	314	98	45	64	94	24	NS	**639**
1990	255	103	30	22	36	50	4	**500**
1991	104	67	18	21	41	40	1	**292**
1992	302	81	35	35	38	37	0	**528**
1993	106	223	61	66	86	53	5	**600**
1994	82	27	7	3	6	15	0	**140**
1995	13	7	0	2	1	9	0	**32**
1996	23	33	3	12	1	12	1	**85**
1997	82	55	8	15	15	33	1	**209**
1998	41	29	8	5	0	11	0	**94**
1999	34	8	3	1	2	6	0	**54**
2000	128	100	9	8	37	68	0	**350**
2001	1,078	374	74	104	218	88	173*	**2,109**
2002	345	294	42	42	64	245	107*	**1,139**
2003	111	83	12	15	24	18	60	**323**
2004	241	169	13	22	46	30	55	**576**
2005	332	193	64	86	143	8	3	**829**
2006	297	152	21	31	27	50	10	**588**
2007	283	101	22	20	12	17	11	**466**
2008	689	336	38	31	180	116	21	**1,411**
2009	421	167	39	54	5	32	15	**733**
2010	502	188	38	33	47	155	5	**968**
2011	492	170	30	20	12	122	26	**872**
Average	***273***	***133***	***27***	***31***	***49***	***54***	***11***	***589***

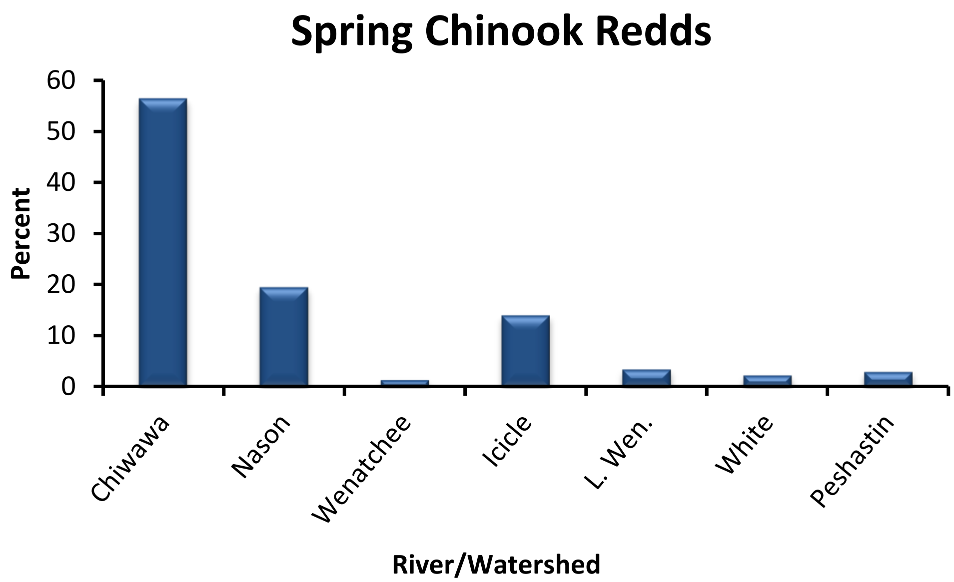

Figure 5.5. Percent of the total number of spring Chinook redds counted in different streams/watersheds within the Wenatchee Basin during August through September, 2011.

Redd Distribution

Spring Chinook redds were not evenly distributed among reaches within survey streams in 2011 (Table 5.20). Most of the spawning in the Chiwawa Basin occurred in Reaches 1 through 6. Over half of all the spawning in the Chiwawa Basin occurred in the lower two reaches (RM 0.0-19.3; from the mouth to Rock Creek). Relatively few fish spawned in Rock and Chikamin creeks. The spatial distribution of redds in Nason Creek was weighted towards Reach 3, having 43% of the Nason Creek redds. In the Little Wenatchee River, 80% of all spawning occurred in Reach 3 (RM 5.2-9.2; Lost Creek to Rainy Creek). On the White River, 95% of the spawning occurred in Reach 3 (RM 11.0-12.9; Napeequa River to Grasshopper Meadows). Fifty percent of all the spawning in the Wenatchee River occurred upstream from the mouth of the Chiwawa River.

Table 5.20. Numbers and proportions of spring Chinook redds counted within different streams/watersheds within the Wenatchee Basin during August through September, 2011.

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
Chiwawa	Chiwawa 1 (C1)	95	0.19
	Chiwawa 2 (C2)	189	0.38
	Chiwawa 3 (C3)	23	0.05
	Chiwawa 4 (C4)	42	0.09
	Chiwawa 5 (C5)	56	0.11
	Chiwawa 6 (C6)	69	0.14
	Phelps 1	1	<0.01
	Rock 1 (R1)	9	0.02
	Chikamin 1 (K1)	8	0.02
	Big Meadow 1	0	0.0

Stream/watershed	Reach	Number of redds	Proportion of redds within stream/watershed
	Total	**492**	**1.00**
Nason	Nason 1 (N1)	37	0.22
	Nason 2 (N2)	31	0.18
	Nason 3 (N3)	73	0.43
	Nason 4 (N4)	29	0.17
	Total	**170**	**1.00**
Little Wenatchee	Little Wen 2 (L2)	6	0.20
	Little Wen 3 (L3)	24	0.80
	Total	**30**	**1.00**
White	White 2 (H2)	0	0.00
	White 3 (H3)	19	0.95
	White 4 (H4)	1	0.05
	Napeequa 1 (Q1)	0	0.00
	Panther 1 (T1)	0	0.00
	Total	**20**	**1.00**
Wenatchee River	Wen 8 (W8)	0	0.00
	Wen 9 (W9)	0	0.00
	Wen 10 (W10)	6	0.50
	Chiwaukum 1	6	0.50
	Total	**12**	**1.00**
Icicle	Icicle 1 (I1)	122	1.00
	Total	**122**	**1.00**
Peshastin	Peshastin 1 (P1)	1	0.04
	Peshastin 2 (P2)	20	0.77
	Ingalls (D1)	5	0.19
	Total	**26**	**1.00**
Grand Total		***872***	***1.00***

Spawn Timing

Spring Chinook began spawning during the second week of August in Nason Creek and the Little Wenatchee River, and the third week in the Chiwawa River, White River, and Wenatchee River (Figure 5.6). Spawning generally peaked the fourth week of August. All spawning was completed by the end of September.

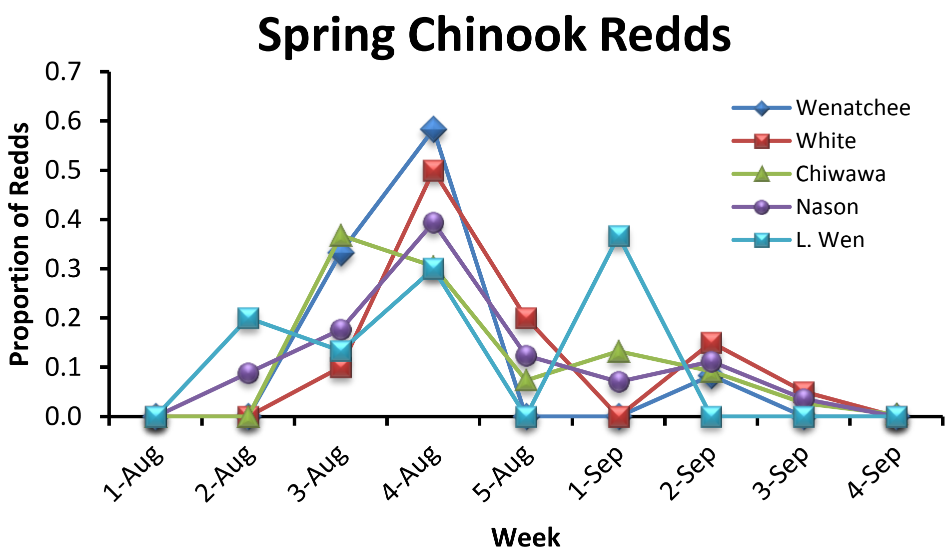

Figure 5.6. Proportion of spring Chinook redds counted during different weeks in different sampling streams within the Wenatchee Basin, August through September 2011.

The temporal distribution of spawning activity in the Chiwawa River in 2011 occurred earlier than the mean 1991-2010 spawning distribution for the Chiwawa (Figure 5.7). The greatest difference in distributions was noted in August.

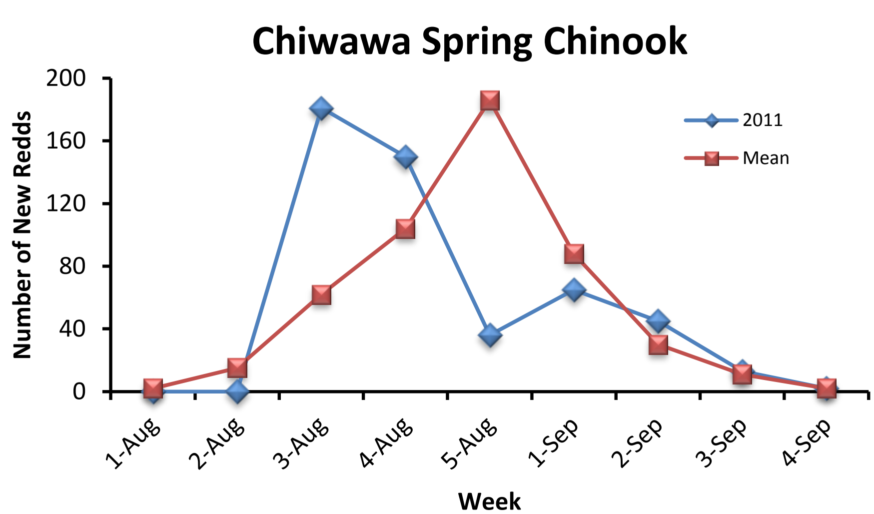

Figure 5.7. Comparison of the number of new spring Chinook redds counted during different weeks in the Chiwawa Basin, August through September, 2011, to the overall average.

Spawning Escapement

Spawning escapement for spring Chinook was calculated as the number of redds times the male-to-female ratio (i.e., fish per redd expansion factor) estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for spring Chinook upstream from Tumwater in 2011 was 4.13 (based on sex ratios estimated at Tumwater Dam). The estimated fish per redd ratio for spring Chinook downstream from Tumwater (Icicle and Peshastin creeks) was 2.66 (derived from broodstock collected at the Leavenworth National Fish Hatchery). Multiplying these ratios by the number of redds counted in the Wenatchee Basin resulted in a total spawning escapement of 3,384 spring Chinook (Table 5.21). The Chiwawa Basin had the highest spawning escapement (2,032 Chinook), while the Upper Wenatchee River had the lowest.

Table 5.21. Number of redds, fish per redd ratios, and total spawning escapement for spring Chinook in the Wenatchee Basin, 2011. Spawning escapement was estimated as the product of redds times fish per redd.

Sampling area	Total number of redds	Fish/redd	Total spawning escapement*
Chiwawa	492	4.13	2,032
Nason	170	4.13	702
Upper Wenatchee River	12	4.13	50
Icicle	122	2.66	325
Little Wenatchee	30	4.13	124
White	20	4.13	83
Peshastin	26	2.66	69
Total	***872***	-	***3,384***

* Spawning escapement estimate is based on total number of redds by stream. If escapement is calculated at the reach scale, then the total escapement may vary from what is shown here because of rounding errors.

The estimated total spawning escapement of 3,384 spring Chinook in 2011 was greater than the overall average of 1,903 spring Chinook (Table 5.22). The escapement in the Chiwawa Basin in 2011 was over twice the escapement in Nason Creek, the second most abundant stream in the Wenatchee Basin (Table 5.22).

Table 5.22. Spawning escapements for spring Chinook in the Wenatchee Basin for return years 1989-2011; NA = not available.

Return year	Upper basin spawning escapement						Lower basin spawning escapement			Total
	Fish/redd	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Fish/redd	Icicle	Peshastin	
1989	2.27	713	222	102	145	213	2.27	54	NA	**1,449**
1990	2.24	571	231	67	49	81	2.24	112	9	**1,120**
1991	2.33	242	156	42	49	96	2.33	93	2	**680**
1992	2.24	676	181	78	78	85	2.24	83	0	**1,181**
1993	2.20	233	491	134	145	189	2.20	117	11	**1,320**
1994	2.24	184	60	16	7	13	2.24	34	0	**314**
1995	2.51	33	18	0	5	3	2.51	23	0	**82**
1996	2.53	58	83	8	30	3	2.53	30	3	**215**
1997	2.22	182	122	18	33	33	2.22	73	2	**463**
1998	2.21	91	64	18	11	0	2.21	24	0	**208**
1999	2.77	94	22	8	3	6	2.77	17	0	**150**
2000	2.70	346	270	24	22	100	2.70	184	0	**946**

Return year	Upper basin spawning escapement						Lower basin spawning escapement			Total
	Fish/redd	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Fish/redd	Icicle	Peshastin	
2001	1.60	1,725	598	118	166	349	1.60	141	277	**3,874**
2002	2.05	707	603	86	86	131	2.05	502	219	**2,334**
2003	2.43	270	202	29	36	58	2.43	44	146	**785**
2004[a]	3.56/3.00	858	507	39	66	138	1.79	54	98	**1,759**
2005	1.80	598	347	115	155	257	1.75	14	5	**1,491**
2006	1.78	529	271	37	55	48	1.80	90	18	**1,048**
2007	4.58	1,296	463	101	92	55	1.86	32	20	**2,059**
2008	1.68	1,158	565	64	52	302	1.77	205	37	**2,383**
2009	3.20	1,347	534	125	173	16	2.72	87	41	**2,323**
2010	2.18	1,094	410	83	72	102	2.72	422	14	**2,197**
2011	4.13	2,032	702	124	83	50	2.66	325	69	**3,384**
Average	***2.68***	***927***	***423***	***73***	***82***	***124***	***2.20***	***163***	***73***	***1,903***

[a] In 2004 the fish/redd expansion estimate of 3.56 was applied to the Chiwawa River only and 3.00 fish/redd for the rest of the upper basin.

5.6 Carcass Surveys

Surveys for spring Chinook carcasses were conducted during August through September, 2011, in the Chiwawa River (including Rock, Phelps, Big Meadow, and Chikamin creeks), Nason Creek, Icicle Creek, Peshastin Creek (including Ingalls Creek), Upper Wenatchee River (including Chiwaukum Creek), Little Wenatchee River, and White River (including the Napeequa River and Panther Creek).

Number sampled

A total of 333 spring Chinook carcasses were sampled during August through September in the Wenatchee Basin (Table 5.23). Most were sampled in the Chiwawa Basin (53% or 177 carcasses) and Nason Creek (29% or 98 carcasses) (Figure 5.8). A total of 40 carcasses were sampled in Icicle Creek, seven in the Little Wenatchee, four in the White River, four in the upper Wenatchee River, and three in Peshastin Creek.

Table 5.23. Numbers of spring Chinook carcasses sampled within different streams/watersheds within the Wenatchee Basin, 1996-2011.

Survey year	Number of spring Chinook carcasses							
	Chiwawa	Nason	Little Wenatchee	White	Wenatchee River	Icicle	Peshastin	Total
1996	22	3	0	2	0	1	0	**28**
1997	13	42	3	8	1	28	1	**96**
1998	24	25	3	2	1	6	0	**61**
1999	15	5	0	0	2	1	0	**23**
2000	122	110	8	1	37	52	0	**330**
2001	751	388	68	74	213	163	63	**1,720**
2002	190	292	30	24	34	91	49	**710**

Survey year	Number of spring Chinook carcasses							
	Chiwawa	**Nason**	**Little Wenatchee**	**White**	**Wenatchee River**	**Icicle**	**Peshastin**	**Total**
2003	70	100	8	8	12	37	42	**277**
2004	178	186	1	13	29	16	40	**463**
2005	391	217	48	52	120	2	0	**830**
2006	241	190	13	25	15	7	0	**491**
2007	250	201	16	13	25	15	6	**526**
2008	386	243	15	13	108	68	5	**838**
2009	240	128	20	19	2	67	2	**478**
2010	193	141	7	11	30	39	2	**423**
2011	177	98	7	4	4	40	3	**333**
Average	***279***	***199***	***21***	***23***	***54***	***50***	***19***	***644***

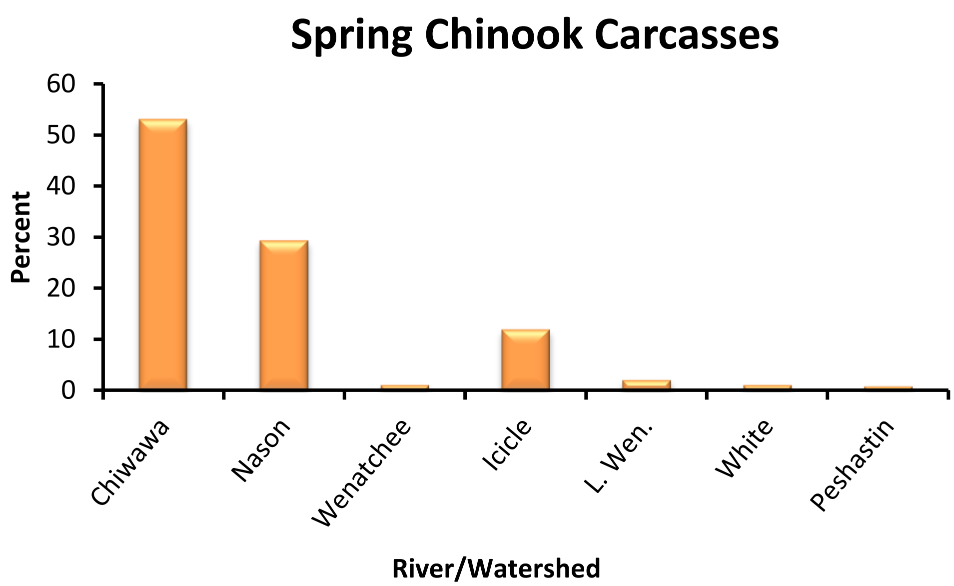

Figure 5.8. Percent of the total number of spring Chinook carcasses sampled in different streams/watersheds within the Wenatchee Basin during August through September, 2011.

Carcass Distribution and Origin

Spring Chinook carcasses were not evenly distributed among reaches within survey streams in 2011 (Table 5.24). Most of the carcasses in the Chiwawa Basin occurred in Reaches 1 and 2 (downstream from Rock Creek). In Nason Creek, most carcasses (31%) were collected in Reach 1 and the fewest (13%) in Reach 4. All of the carcasses in the Little Wenatchee River were sampled in Reach 3 (Lost Creek to Rainy Creek). On the White River, all occurred in Reach 3 (Napeequa River to Grasshopper Meadows). On the Wenatchee River, 75% of the carcasses were found upstream from the confluence of the Chiwawa River and 25% were found below the confluence.

Table 5.24. Numbers and proportions of carcasses sampled within different streams/watersheds within the Wenatchee Basin during August through September, 2011.

Stream/watershed	Reach	Number of carcasses	Proportion of redds within stream/watershed
Chiwawa	Chiwawa 1 (C1)	51	0.29
	Chiwawa 2 (C2)	66	0.37
	Chiwawa 3 (C3)	14	0.08
	Chiwawa 4 (C4)	11	0.06
	Chiwawa 5 (C5)	13	0.07
	Chiwawa 6 (C6)	15	0.08
	Phelps 1	1	0.01
	Rock 1 (R1)	5	0.03
	Chikamin 1 (K1)	1	0.01
	Big Meadow 1	0	0.00
	Total	**177**	**1.00**
Nason	Nason 1 (N1)	30	0.31
	Nason 2 (N2)	23	0.23
	Nason 3 (N3)	32	0.33
	Nason 4 (N4)	13	0.13
	Total	**98**	**1.00**
Little Wenatchee	Little Wen 2 (L2)	0	0.00
	Little Wen 3 (L3)	7	1.00
	Total	**7**	**1.00**
White	White 2 (H2)	0	0.00
	White 3 (H3)	4	1.00
	White 4 (H4)	0	0.00
	Napeequa 1 (Q1)	0	0.00
	Panther 1 (T1)	0	0.00
	Total	**4**	**1.00**
Wenatchee River	Wen 8 (W8)	0	0.00
	Wen 9 (W9)	0	0.00
	Wen 10 (W10)	3	0.75
	Chiwaukum 1	1	0.25
	Total	**4**	**1.00**
Icicle	Icicle 1 (I1)	40	1.00
	Total	**40**	**1.00**
Peshastin	Peshastin 1 (P1)	3	1.00
	Peshastin 2 (P2)	0	0.00
	Ingalls (D1)	0	0.00
Grand Total		**333**	**1.00**

Of the 333 carcasses sampled in 2011, 61% were hatchery fish (Table 5.25; these numbers may change after analysis of CWTs). In the Chiwawa Basin, the spatial distribution of hatchery and wild fish was not equal (Table 5.25). A larger percentage of hatchery fish were found in the lower reaches (C1 and C2; Mouth to Rock Creek) than were wild fish. This general trend was also apparent in the pooled data (Figure 5.9).

Table 5.25. Numbers of wild and hatchery spring Chinook carcasses sampled within different reaches in the Chiwawa Basin, 1993-2011. See Table 2.8 for description of survey reaches.

Survey year	Origin	Survey Reach								Total
		C-1	C-2	C-3	C-4	C-5	C-6	Chikamin	Rock	
1993	Wild	0	0	0	0	0	0	0	0	**0**
	Hatchery	1	0	0	0	0	0	0	0	**1**
1994	Wild	0	6	0	2	0	1	0	0	**9**
	Hatchery	1	1	0	2	0	0	0	0	**4**
1995	Wild	0	0	0	0	0	0	0	0	**0**
	Hatchery	2	3	0	1	0	0	0	0	**6**
1996	Wild	11	1	1	1	0	0	0	0	**14**
	Hatchery	6	0	0	0	0	0	0	0	**6**
1997	Wild	5	2	0	1	0	0	0	0	**8**
	Hatchery	3	1	0	0	0	1	1	3	**9**
1998	Wild	0	3	5	1	2	4	0	0	**15**
	Hatchery	1	3	2	0	1	1	0	0	**8**
1999	Wild	1	8	0	5	0	0	0	0	**14**
	Hatchery	0	0	0	0	1	0	0	0	**1**
2000	Wild	25	27	1	1	1	1	0	0	**56**
	Hatchery	42	12	0	0	0	2	0	0	**56**
2001	Wild	24	57	15	40	16	20	1	3	**176**
	Hatchery	164	284	19	58	14	21	8	0	**568**
2002	Wild	15	11	9	6	7	5	2	0	**55**
	Hatchery	46	40	12	5	1	15	14	4	**137**
2003	Wild	7	13	0	11	3	2	0	0	**36**
	Hatchery	14	14	0	3	1	0	0	0	**32**
2004	Wild	23	48	2	11	7	3	0	1	**95**
	Hatchery	46	21	1	1	1	3	0	2	**75**
2005	Wild	16	36	3	4	3	2	0	0	**64**
	Hatchery	170	132	7	7	4	3	0	1	**324**
2006	Wild	10	17	2	8	4	3	1	0	**45**
	Hatchery	84	75	5	7	6	13	3	3	**196**
2007	Wild	3	20	3	4	4	2	0	0	**36**
	Hatchery	42	113	15	14	16	12	2	0	**214**
2008	Wild	4	24	0	5	4	8	0	0	**45**
	Hatchery	174	121	2	8	15	15	4	1	**340**
2009	Wild	4	22	4	8	4	1	0	3	**46**
	Hatchery	88	69	6	14	7	5	0	5	**194**

Survey year	Origin	Survey Reach								Total
		C-1	C-2	C-3	C-4	C-5	C-6	Chikamin	Rock	
2010	Wild	6	32	7	9	10	3	0	0	**67**
	Hatchery	63	35	2	9	7	5	0	5	**126**
2011	Wild	9	28	10	7	8	6	0	1	**69**
	Hatchery	42	32	4	4	5	10	1	4	**108**
Average	***Wild***	***9***	***19***	***3***	***7***	***4***	***3***	***0***	***0***	***45***
	Hatchery	***52***	***50***	***4***	***7***	***4***	***6***	***2***	***1***	***127***

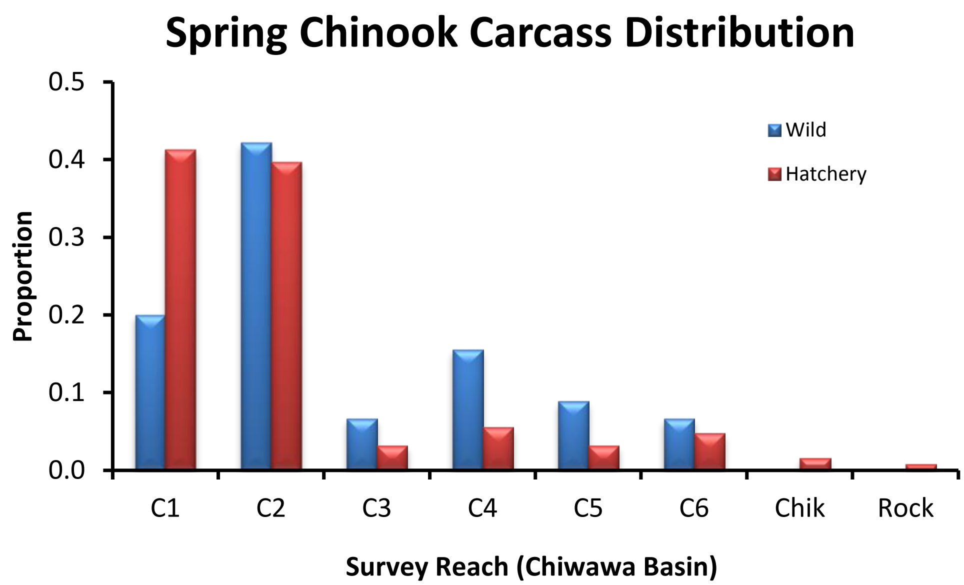

Figure 5.9. Distribution of wild and hatchery produced carcasses in different reaches in the Chiwawa Basin, 1993-2011; Chik = Chikamin Creek and Rock = Rock Creek. Reach codes are described in Table 2.8.

Sampling Rate

Overall, 10% of the estimated total spawning escapement of spring Chinook in the Wenatchee Basin was sampled in 2011 (Table 5.26). Sampling rates among streams/watershed varied from 4 to 14%.

Table 5.26. Number of redds and carcasses, total spawning escapement, and sampling rates for spring Chinook salmon in the Wenatchee Basin, 2011.

Sampling area	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Chiwawa	492	177	2,032	0.09
Nason	170	98	702	0.14
Upper Wenatchee	12	4	50	0.08
Icicle	122	40	325	0.12
Little Wenatchee	30	7	124	0.06

Sampling area	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
White	20	4	83	0.04
Peshastin	26	3	69	0.04
Total	***872***	***333***	***3,384***	***0.10***

Length Data

Mean lengths (POH, cm) of male and female spring Chinook carcasses sampled during surveys in the Wenatchee Basin in 2011 are provided in Table 5.27. The average sizes of males and females sampled in the Wenatchee Basin were 58 and 66 cm, respectively.

Table 5.27. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female spring Chinook carcasses sampled in different streams/watersheds in the Wenatchee Basin, 2011.

Stream/watershed	Mean lengths (cm)	
	Male	Female
Chiwawa	63 (15.4)	67 (7.3)
Nason	53 (13.1)	64 (7.8)
Upper Wenatchee	0 (--)	69 (5.4)
Icicle	58 (15.2)	64 (7.7)
Little Wenatchee	46 (0.7)	61 (5.0)
White	0 (--)	73 (4.8)
Peshastin	48 (17.0)	59 (0.0)
Total	***58 (15.1)***	***66 (7.5)***

5.7 Life History Monitoring

Life history characteristics of spring Chinook were assessed by examining carcasses on spawning grounds and fish collected at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

There was little difference in migration timing of hatchery and wild spring Chinook past Tumwater Dam (Table 5.28a and b; Figure 5.10). On average, early in the migration, wild Chinook arrived at Tumwater Dam slightly earlier than hatchery fish, but by the end of the migration, both were arriving at about the same time. Most hatchery and wild spring Chinook migrated upstream past Tumwater Dam during June and July (Figure 5.10).

Table 5.28a. The Julian day and date that 10%, 50% (median), and 90% of the wild and hatchery spring Chinook salmon passed Tumwater Dam, 1998-2011. The average Julian day and date are also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery spring Chinook. All spring Chinook were visually examined during trapping from 2004 to present.

Survey year	Origin	Spring Chinook Migration Time (days)								Sample size
		10 Percentile		50 Percentile		90 Percentile		Mean		
		Julian	Date	Julian	Date	Julian	Date	Julian	Date	
1998	Wild	156	5-Jun	156	5-Jun	156	5-Jun	156	5-Jun	49
	Hatchery	156	5-Jun	156	5-Jun	156	5-Jun	156	5-Jun	25
1999	Wild	192	11-Jul	207	26-Jul	224	12-Aug	207	26-Jul	173
	Hatchery	200	19-Jul	211	30-Jul	229	18-Aug	213	1-Aug	25
2000	Wild	171	19-Jun	186	4-Jul	194	12-Jul	184	2-Jul	651
	Hatchery	179	27-Jun	189	7-Jul	201	19-Jul	190	8-Jul	357
2001	Wild	154	3-Jun	166	15-Jun	185	4-Jul	167	16-Jun	2,073
	Hatchery	157	6-Jun	169	18-Jun	185	4-Jul	170	19-Jun	4,244
2002	Wild	174	23-Jun	189	8-Jul	204	23-Jul	189	8-Jul	1,033
	Hatchery	178	27-Jun	189	8-Jul	199	18-Jul	189	8-Jul	1,363
2003	Wild	162	11-Jun	181	30-Jun	200	19-Jul	181	30-Jun	919
	Hatchery	157	6-Jun	179	28-Jun	192	11-Jul	178	27-Jun	423
2004	Wild	156	4-Jun	172	20-Jun	189	7-Jul	172	20-Jun	969
	Hatchery	161	9-Jun	177	25-Jun	189	7-Jul	177	25-Jun	1,295
2005	Wild	153	2-Jun	172	21-Jun	193	12-Jul	173	22-Jun	1,038
	Hatchery	153	2-Jun	173	22-Jun	187	6-Jul	172	21-Jun	2,808
2006	Wild	177	26-Jun	184	3-Jul	193	12-Jul	185	7-Jul	577
	Hatchery	178	27-Jun	185	4-Jul	194	13-Jul	186	5-Jul	1,601
2007	Wild	169	18-Jun	185	4-Jul	203	22-Jul	185	4-Jul	351
	Hatchery	174	23-Jun	192	11-Jul	209	28-Jul	192	11-Jul	3,232
2008	Wild	173	21-Jun	188	6-Jul	209	27-Jul	189	7-Jul	634
	Hatchery	177	25-Jun	193	11-Jul	210	28-Jul	193	11-Jul	5,368
2009	Wild	174	23-Jun	186	5-Jul	201	20-Jul	187	6-Jul	1,008
	Hatchery	175	24-Jun	187	6-Jul	202	21-Jul	188	7-Jul	4,106
2010	Wild	173	22-Jun	190	9-Jul	214	2-Aug	191	10-Jul	977
	Hatchery	180	29-Jun	194	13-Jul	213	1-Aug	195	14-Jul	4,450
2011	Wild	183	2-Jul	198	17-Jul	213	1-Aug	198	17-Jul	1,433
	Hatchery	187	6-Jul	200	19-Jul	210	29-Jul	199	18-Jul	4,707
Average	Wild	***169***		***183***		***198***		***183***		***849***
	Hatchery	***172***		***185***		***198***		***186***		***2,429***

Table 5.28b. The week that 10%, 50% (median), and 90% of the wild and hatchery spring Chinook salmon passed Tumwater Dam, 1998-2011. The average week is also provided. Migration timing is based on video sampling at Tumwater. Data for 1998 through 2003 were based on videotapes and broodstock trapping and may not reflect the actual number of hatchery spring Chinook. All spring Chinook were visually examined during trapping from 2004 to present.

Survey year	Origin	Spring Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
1998	Wild	23	23	23	23	49
	Hatchery	23	23	23	23	25
1999	Wild	28	30	32	30	173
	Hatchery	29	31	34	31	25
2000	Wild	24	27	27	27	651
	Hatchery	26	27	29	28	357
2001	Wild	22	24	27	24	2,073
	Hatchery	23	25	27	25	4,244
2002	Wild	25	27	30	27	1,033
	Hatchery	26	27	29	27	1,363
2003	Wild	24	26	29	26	919
	Hatchery	23	26	28	26	423
2004	Wild	23	25	27	25	969
	Hatchery	23	26	27	26	1,295
2005	Wild	22	25	28	25	1,038
	Hatchery	22	25	27	25	2,808
2006	Wild	26	27	28	27	577
	Hatchery	26	27	28	27	1,601
2007	Wild	25	27	29	27	351
	Hatchery	25	28	30	28	3,232
2008	Wild	25	27	30	27	634
	Hatchery	26	28	30	28	5,368
2009	Wild	25	27	29	27	1,008
	Hatchery	25	27	29	27	4,106
2010	Wild	25	28	31	28	977
	Hatchery	26	28	31	28	4,450
2011	Wild	27	29	31	29	1,433
	Hatchery	27	29	30	29	4,707
Average	Wild	***25***	***27***	***29***	***27***	***849***
	Hatchery	***25***	***27***	***29***	***27***	***2,429***

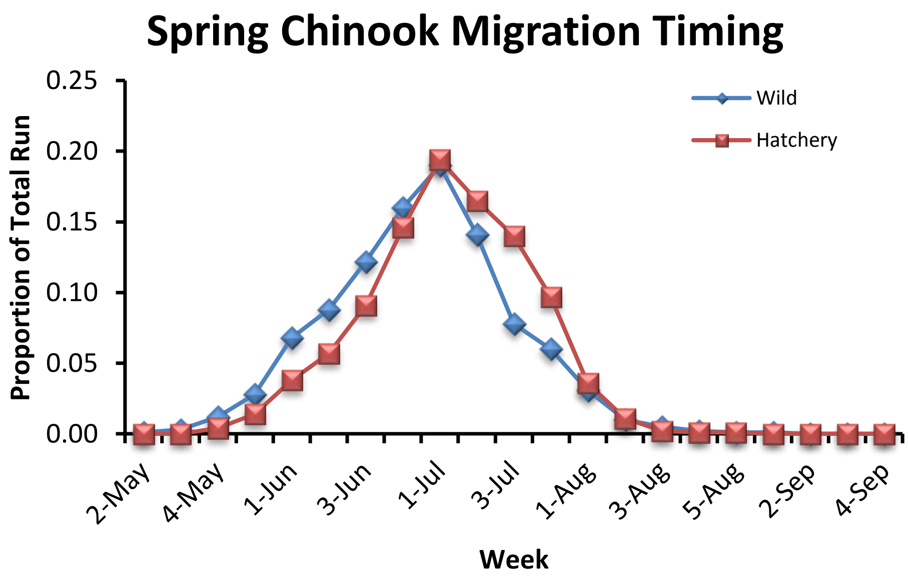

Figure 5.10. Proportion of wild and hatchery spring Chinook observed (using video) passing Tumwater Dam each week during their migration period May through September; data were pooled over survey years 1998-2011.

Age at Maturity

Most of the wild and hatchery spring Chinook sampled during the period 1994-2011 in the Chiwawa Basin were age-4 fish (total age) (Table 5.29; Figure 5.11). On average, hatchery fish made up a higher percentage of age-3 Chinook than did wild fish. In contrast, a higher proportion of age-4 and 5 wild fish returned than did age-4 and 5 hatchery fish. Thus, wild fish tended to return at an older age than hatchery fish.

Table 5.29. Proportions of wild and hatchery spring Chinook of different ages (total age) sampled on spawning grounds in the Chiwawa Basin, 1994-2011.

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
1994	Wild	0.00	0.00	0.33	0.67	0.00	9
	Hatchery	0.00	0.20	0.00	0.80	0.00	5
1995	Wild	0.00	0.00	0.00	0.00	0.00	0
	Hatchery	0.00	0.00	1.00	0.00	0.00	2
1996	Wild	0.00	0.36	0.64	0.00	0.00	14
	Hatchery	0.00	0.83	0.17	0.00	0.00	6
1997	Wild	0.00	0.00	0.75	0.25	0.00	8
	Hatchery	0.00	0.00	1.00	0.00	0.00	9
1998	Wild	0.00	0.00	0.00	1.00	0.00	15
	Hatchery	0.00	0.00	0.13	0.88	0.00	8
1999	Wild	0.00	0.07	0.50	0.43	0.00	14
	Hatchery	0.00	0.00	0.00	1.00	0.00	1

Sample year	Origin	Total age					Sample size
		2	3	4	5	6	
2000	Wild	0.00	0.02	0.95	0.03	0.00	56
	Hatchery	0.00	0.50	0.50	0.00	0.00	52
2001	Wild	0.00	0.01	0.95	0.04	0.00	176
	Hatchery	0.00	0.02	0.98	0.00	0.00	571
2002	Wild	0.00	0.00	0.56	0.44	0.00	55
	Hatchery	0.00	0.00	0.91	0.09	0.00	128
2003	Wild	0.00	0.09	0.00	0.91	0.00	36
	Hatchery	0.00	0.19	0.03	0.78	0.00	32
2004[a]	Wild	0.00	0.02	0.97	0.01	0.00	124
	Hatchery	0.00	0.43	0.57	0.00	0.00	80
2005 [a]	Wild	0.00	0.00	0.85	0.15	0.00	111
	Hatchery	0.00	0.07	0.93	0.00	0.00	656
2006 [a]	Wild	0.01	0.03	0.56	0.40	0.00	86
	Hatchery	0.00	0.16	0.72	0.12	0.00	451
2007 [a]	Wild	0.00	0.09	0.26	0.65	0.00	54
	Hatchery	0.00	0.32	0.61	0.07	0.00	304
2008 [a]	Wild	0.02	0.02	0.80	0.16	0.00	44
	Hatchery	0.00	0.07	0.89	0.04	0.00	339
2009 [a]	Wild	0.00	0.07	0.89	0.04	0.00	118
	Hatchery	0.00	0.17	0.81	0.02	0.00	417
2010 [a]	Wild	0.00	0.00	0.88	0.12	0.00	128
	Hatchery	0.00	0.05	0.94	0.01	0.00	288
2011 [a]	Wild	0.00	0.23	0.41	0.34	0.00	567
	Hatchery	0.00	0.71	0.22	0.08	0.00	1967
Average	***Wild***	***0.00***	***0.10***	***0.64***	***0.25***	***0.00***	***90***
	Hatchery	***0.00***	***0.34***	***0.61***	***0.06***	***0.00***	***295***

[a] These years include carcass and live fish PIT-tag detection data (fish that were sampled both as carcasses and detected as live fish on the spawning grounds were not counted twice). Also origin assignments have been made to fish that were previously identified as fish of unknown origin.

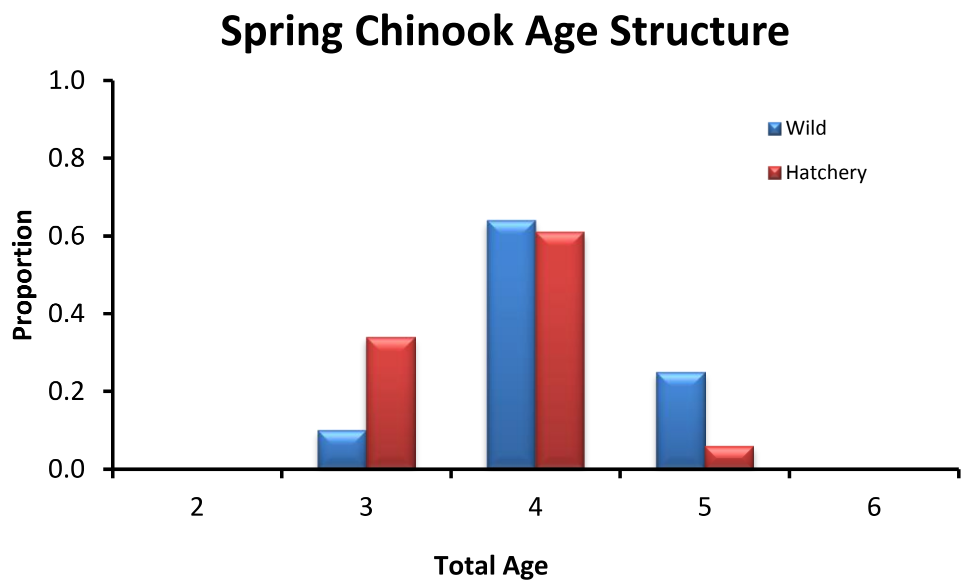

Figure 5.11. Proportions of wild and hatchery spring Chinook of different total ages sampled at the Chiwawa Weir and on spawning grounds in the Chiwawa Basin for the combined years 1994-2011.

Size at Maturity

On average, hatchery and wild spring Chinook of a given age differed slightly in length (Table 5.30). For example, wild age-5 fish were larger on average than the age-5 hatchery fish. In contrast, hatchery age-3 and 4 Chinook were generally larger than age-3 and 4 wild fish.

Table 5.30. Mean lengths (POH in cm; ±1SD) and sample sizes (in parentheses) of different ages (total age) of male and female spring Chinook of wild and hatchery-origin sampled in the Chiwawa Basin, 1994-2011. Brood years 2004-2011 include carcasses and live fish PIT-tag detections. In addition, 2005 and 2006 include fish released at the weir.

Brood year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
1994	3				43 ±0 (1)
	4			62 ±3 (3)	
	5	76 ±0 (1)		73 ±2 (5)	
	6				
1995	3				
	4		61 ±5 (5)		
	5				
	6				
1996	3	45 ±3 (5)	49 ±7 (10)		
	4	69 ±4 (6)	69 ±0 (1)	67 ±8 (2)	
	5				
	6				
1997	3				

Brood year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	4	61 ±1 (2)	68 ±0 (1)	67 ±5 (3)	63 ±3 (8)
	5	67 ±5 (2)			
	6				
1998	3				
	4				54 ±0 (1)
	5	77 ±7 (8)	75 ±4 (4)	74 ±4 (7)	76 ±4 (3)
	6				
1999	3	44 ±0 (1)			
	4	61 ±0 (1)		64 ±3 (6)	
	5	76 ±5 (3)		72 ±5 (3)	66 ±0 (1)
	6				
2000	3		46 ±3 (17)		50 ±7 (3)
	4	60 ±8 (23)	62 ±5 (5)	61 ±5 (26)	62 ±3 (20)
	5	77 ±1 (2)			
	6				
2001	3	37 ±0 (1)	42 ±4 (11)	41 ±0 (1)	60 ±0 (1)
	4	63 ±5 (57)	65 ±5 (151)	62 ±4 (110)	63 ±4 (407)
	5	75 ±5 (2)	83 ±0 (1)	76 ±1 (5)	
	6				
2002	3				
	4	64 ±4 (14)	66 ±5 (46)	60 ±4 (15)	63 ±4 (71)
	5	80 ±6 (13)	75 ±5 (4)	72 ±3 (12)	73 ±6 (6)
	6				
2003	3	45 ±2 (3)	45 ±1 (6)		
	4		63 ±0 (1)		
	5	78 ±5 (12)	74 ±8 (11)	75 ±3 (19)	72 ±5 (14)
	6				
2004	3	42 ±3 (3)	44 ±5 (33)		
	4	63 ±7 (60)	66 ±5 (9)	63 ±4 (59)	63 ±6 (36)
	5			74 ±0 (1)	
	6				
2005	3		43 ±5 (48)		
	4	61 ±5 (32)	65 ±5 (224)	62 ±4 (61)	62 ±4 (382)
	5	74 ±5 (6)	54±0 (1)	71 ±3 (11)	
	6				
2006	3	45 ±3 (3)	43 ±3 (73)		
	4	64 ±3 (7)	62 ±6 (91)	63 ±5 (41)	60 ±4 (227)
	5	74 ±6 (8)	75 ±6 (17)	71 ±4 (26)	71± 4 (37)
	6				
2007	3	39 ±3 (5)	45 ±6 (90)		50 ±3 (7)
	4	60 ±4 (4)	66 ±5 (45)	61 ±4 (10)	63 ±3 (142)

Brood year	Total age	Mean length (cm)			
		Male		Female	
		Wild	Hatchery	Wild	Hatchery
	5	78 ±6 (15)	76 ±5 (8)	74 ±3 (20)	73 ±5 (12)
	6				
2008	3	43 ±0 (1)	44 ±5 (22)		
	4	65 ±4 (9)	64 ±6 (73)	62 ±4 (26)	64 ±4 (229)
	5	65 ±5 (3)	79 ±5 (10)	73 ±3 (4)	72 ±3 (5)
	6				
2009	3	45 ±3 (8)	46 ±6 (68)		65 ±0 (1)
	4	64 ±4 (38)	65 ±5 (136)	63 ±3 (67)	64 ±4 (202)
	5	79 ±0 (1)		72 ±2 (4)	71 ±4 (10)
	6				
2010	3		46 ±4 (11)		65 ±3 (3)
	4	64 ±5 (31)	66 ±5 (74)	64 ±4 (82)	65 ±3 (196)
	5	77 ±4 (6)		73 ±5 (9)	73 ±6 (4)
	6				
2011	3	43 ±4 (133)	44 ±4 (1374)		53 ±4 (17)
	4	62 ±5 (137)	64 ±5 (169)	64 ±3 (94)	64 ±3 (258)
	5	80 ±5 (78)	79 ±4 (85)	75 ±3 (116)	75 ±3 (63)
	6				

Contribution to Fisheries

Nearly all the harvest on hatchery-origin Chiwawa spring Chinook occurs within the Columbia Basin. Ocean catch records (Pacific Fishery Management Council) indicate that virtually no Upper Columbia spring Chinook are taken in ocean fisheries. Most of the harvest on hatchery-origin Chiwawa spring Chinook occurs in the Lower Columbia River fisheries, which are managed by the states and tribes pursuant to management plans developed in *U.S. v Oregon*. The Lower Columbia River fisheries occur during what is referred to in *U.S. v Oregon* as the winter, spring, and summer seasons, which begin in February and ends July 31 of each year. The Tribal fishery occurs upstream from Bonneville Dam, but primarily in Zone 6, the area between Bonneville and McNary dams; the non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam. The non-treaty recreational (sport) fishery occurs in the lower mainstem.

The total number of hatchery-origin spring Chinook captured in different fisheries has been relatively low (Table 5.31). The largest harvests occurred on the 1997, 1998, 2004, and 2005 brood years.

Table 5.31. Estimated number and percent (in parentheses) of hatchery-origin Chiwawa spring Chinook captured in different fisheries, brood years 1989-2005; NP = no hatchery program.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational[a] (sport)	
1989	3 (13)	5 (21)	0 (0)	16 (67)	24
1990	0 (0)	0 (0)	0 (0)	18 (100)	18
1991	0 (0)	3 (100)	0 (0)	0 (0)	3
1992	0 (0)	1 (100)	0 (0)	0 (0)	1
1993	3 (75)	1 (25)	0 (0)	0 (0)	4
1994	0 (0)	0 (0)	0 (0)	0 (0)	0
1995	NP	NP	NP	NP	NP
1996	0 (0)	2 (100)	0 (0)	0 (0)	2
1997	1 (0)	193 (51)	68 (18)	115 (31)	377
1998	9 (5)	47 (24)	12 (6)	126 (65)	194
1999	NP	NP	NP	NP	NP
2000	0 (0)	17 (74)	0 (0)	6 (26)	23
2001	17 (46)	8 (22)	1 (3)	11 (30)	37
2002	12 (17)	11 (15)	22 (31)	26 (37)	71
2003	18 (21)	29 (35)	11 (13)	26 (31)	84
2004	3 (1)	188 (40)	31 (7)	253 (53)	475
2005	6 (5)	31 (24)	18 (14)	74 (57)	129

[a] Includes the Wanapum fishery.

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. Targets for strays based on return year (recovery year) within the Wenatchee Basin should be less than 10% and targets for strays outside the Wenatchee Basin should be less than 5%. The target for brood year stray rates should be less than 5%.

The percentage of the spawning escapement made up of hatchery-origin Chiwawa spring Chinook in non-target spawning areas has been high in some years and exceeded the target of 10% (Table 5.32). Chiwawa spring Chinook have strayed into spawning areas on Nason Creek, the White River, the Little Wenatchee River, and the Upper Wenatchee River. On average, Chiwawa spring Chinook made up the highest percentage of the spawning escapement within Nason Creek and the Upper Wenatchee River. Stray rates of hatchery-origin Chiwawa spring Chinook do not appear to have declined with the change in source water that was implemented in 2006 for the Chiwawa rearing ponds.

Table 5.32. Number (No.) and percent (%) of the spawning escapement in other non-target spawning streams within the Wenatchee Basin that consisted of hatchery-origin Chiwawa spring Chinook, return years 1992-2010. For example, for return year 2001, 35.3% of the spring Chinook spawning escapement in Nason Creek consisted of hatchery-origin Chiwawa spring Chinook. Percent strays should be less than 10%.

Return year	Nason Creek		Icicle Creek		Peshastin Creek		Upper Wenatchee		White River		Little Wenatchee	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1992	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1993	61	12.4	0	0.0	0	0.0	34	18.0	7	4.8	0	0.0
1994	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1995	0	0.0	0	0.0	0	0.0	2	66.7	0	0.0	0	0.0
1996	25	30.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1997	55	45.1	8	11.0	0	0.0	0	0.0	0	0.0	0	0.0
1998	3	4.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	45	16.7	0	0.0	0	0.0	31	31.0	0	0.0	6	27.3
2001	211	35.3	0	0.0	0	0.0	271	77.7	46	39.0	52	31.3
2002	188	31.2	10	2.0	0	0.0	60	45.8	14	16.3	21	24.4
2003	14	6.9	0	0.0	0	0.0	30	51.7	0	0.0	0	0.0
2004	139	27.4	0	0.0	0	0.0	54	39.1	6	9.1	0	0.0
2005	252	72.6	7	50.0	0	0.0	256	99.6	106	68.4	65	56.5
2006	131	48.3	13	14.4	0	0.0	28	58.3	9	16.4	12	32.4
2007	303	65.4	0	0.0	0	0.0	37	67.3	7	7.6	6	5.9
2008	381	67.4	48	23.4	29	78.4	259	85.8	30	57.7	52	81.3
2009	289	54.1	8	9.2	0	0.0	16	100.0	73	42.2	56	44.8
2010	272	66.3	58	13.7	11	78.6	85	83.3	23	31.9	59	71.1
Total	***2,369***	***43.9***	***152***	***8.7***	***40***	***4.6***	***1,078***	***60.4***	***321***	***27.5***	***329***	***30.9***

Hatchery-origin Chiwawa spring Chinook have strayed into the Methow and Entiat basins (Table 5.33). Based on return year analyses, rates of hatchery-origin Chiwawa spring Chinook straying into these populations have been low in most years. Only during return years 2002, 2006, 2008, and 2009 have Chiwawa spring Chinook made up more than 5% of the spawning escapement in the Entiat Basin.

Table 5.33. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Chiwawa spring Chinook, return years 1992-2010. For example, for return year 2002, 9.2% of the spring Chinook spawning escapement in the Entiat Basin consisted of hatchery-origin Chiwawa spring Chinook. Percent strays should be less than 5%. NS = not sampled.

Return year	Methow Basin		Entiat Basin	
	Number	%	Number	%
1992	0	0.0	0	0.0
1993	0	0.0	0	0.0
1994	0	0.0	0	0.0
1995	0	0.0	0	0.0

Return year	Methow Basin		Entiat Basin	
	Number	%	Number	%
1996	NS	NS	0	0.0
1997	0	0.0	0	0.0
1998	NS	NS	0	0.0
1999	0	0.0	0	0.0
2000	0	0.0	1	0.6
2001	0	0.0	1	0.2
2002	0	0.0	34	9.2
2003	0	0.0	6	2.3
2004	0	0.0	0	0.0
2005	10	0.7	15	4.2
2006	8	0.5	27	10.5
2007	9	0.8	4	1.6
2008	12	1.2	61	21.9
2009	9	0.3	15	5.4
2010	10	0.4	18	3.7
Total	***58***	***0.2***	***182***	***4.0***

Based on brood year analyses, on average, about 35% of the hatchery returns have strayed into non-target spawning areas, exceeding the target of 5% (Table 5.34). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-81%. Few (<1%) have strayed into non-target hatchery programs. The change in source water that was implemented in 2006 for the Chiwawa rearing ponds does not appear to have decreased stray rates.

Table 5.34. Number and percent of hatchery-origin Chiwawa spring Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2005. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	74	41.1	1	0.6	102	56.7	3	1.7
1990	0	0.0	1	100.0	0	0.0	0	0.0
1991	29	87.9	0	0.0	2	6.1	2	6.1
1992	2	6.5	4	12.9	25	80.6	0	0.0
1993	134	47.5	82	29.1	63	22.3	3	1.1
1994	4	19.0	14	66.7	3	14.3	0	0.0
1995	No program							
1996	58	75.3	7	9.1	12	15.6	0	0.0
1997	1,242	55.6	298	13.4	687	30.8	5	0.2

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1998	553	55.8	109	11.0	329	33.2	0	0.0
1999	No program							
2000	149	42.1	115	32.5	90	25.4	0	0.0
2001	647	35.8	276	15.3	881	48.7	4	0.2
2002	314	44.3	238	33.6	156	22.0	1	0.1
2003	556	80.0	11	1.6	123	17.7	5	0.7
2004	1,198	47.7	203	8.1	1,091	43.4	19	0.8
2005	819	58.8	139	10.0	425	30.5	10	0.7
Total	***5,779***	***51.1***	***1,498***	***13.2***	***3,989***	***35.2***	***52***	***0.5***

Genetics

Genetic studies were conducted to determine the potential impacts of the Chiwawa Supplementation Program on natural-origin spring Chinook in the upper Wenatchee Basin (Blankenship et al. 2007; the entire report is appended as Appendix J). Microsatellite DNA allele frequencies collected from temporally replicated natural and hatchery-origin spring Chinook were used to statistically assign individual fish to specific demes (locations) within the Wenatchee population. In addition, genetic effects of the hatchery program were assessed by examining relationships between census and effective population sizes (N_e) from samples collected before and after supplementation.

Overall, this work showed that although allele frequencies within and between natural and hatchery-origin spring Chinook were significantly different, there was no evidence (i.e., robust signal) that the difference was the result of the hatchery program. Rather, the differences were more likely the result of life history characteristics. However, there was an increasing trend toward homogenization of the allele frequencies of the natural and hatchery-origin fish that comprised the broodstock, even though there was consistent year-to-year variation in allele frequencies among hatchery and natural-origin fish. In addition, there were no robust signals indicating that hatchery-origin hatchery broodstock, hatchery-origin natural spawners, natural-origin hatchery broodstock, and natural-origin natural spawners were substantially different from each other. Finally, the N_e estimate of 387 was only slightly larger than the pre-hatchery N_e (based on demographic data from 1989-1992), which means that the Chiwawa hatchery program has not reduced the N_e of the Wenatchee spring Chinook population.

Significant differences in allele frequencies were observed within and among major spawning areas in the Upper Wenatchee Basin. However, these differences made up only a very small portion of the overall variation, indicating genetic similarity among the major spawning areas. There was no evidence that the Chiwawa program has changed the genetic structure (allele frequency) of spring Chinook in Nason Creek and the White River, despite the presence of hatchery-origin spawners in both systems.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1989-1994, the PNI was greater than or equal to 0.67, indicating that the natural environment had a greater influence on adaptation of Chiwawa spring Chinook than did the hatchery environment (Table 5.35). Since brood year 1994, however, the PNI has been less than 0.67, indicating that the hatchery environment has a greater influence on adaptation than does the natural environment.

Table 5.35. Proportionate natural influence (PNI) of the Chiwawa spring Chinook supplementation program for brood years 1989-2010. PNI was calculated as the proportion of naturally produced Chinook in the hatchery broodstock (pNOB) divided by the proportion of hatchery Chinook on the spawning grounds (pHOS) plus pNOB. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	713	0	0.00	28	0	1.00	1.00
1990	571	0	0.00	18	0	1.00	1.00
1991	242	0	0.00	27	0	1.00	1.00
1992	676	0	0.00	78	0	1.00	1.00
1993	231	2	0.01	94	0	1.00	0.99
1994	123	61	0.33	8	4	0.67	0.67
1995	0	33	1.00	No Program			
1996	41	17	0.29	8	10	0.44	0.60
1997	60	122	0.67	32	79	0.29	0.30
1998	59	32	0.35	13	34	0.28	0.44
1999	87	7	0.07	No Program			
2000	173	173	0.50	9	21	0.30	0.38
2001	414	1,311	0.76	113	259	0.30	0.28
2002	205	502	0.71	20	51	0.28	0.28
2003	143	127	0.47	41	53	0.44	0.48
2004	582	276	0.32	83	132	0.39	0.55
2005	134	464	0.78	91	181	0.33	0.30
2006	116	413	0.78	91	224	0.29	0.27
2007	192	1,104	0.85	43	104	0.29	0.25

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2008	205	953	0.82	83	220	0.27	0.25
2009	303	1,044	0.78	96	111	0.46	0.37
2010	418	676	0.62	77	98	0.44	0.42
Average	***259***	***333***	***0.46***	***48***	***72***	***0.48***	***0.49***

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). For brood years 1989-2005, NRR for spring Chinook in the Chiwawa averaged 1.15 (range, 0.01-4.40) if harvested fish were not include in the estimate and 1.24 (range, 0.01-4.81) if harvested fish were included in the estimate (Table 5.36). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.30 (the calculated target value in Murdoch and Peven 2005). In nearly all years, HRRs were greater than NRRs, regardless if harvest was or was not included (Table 5.36). HRRs exceeded the estimated target value of 5.3 in seven of the 17 years.

Table 5.36. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for spring Chinook in the Chiwawa Basin, brood years 1989-2005; NP = no hatchery program.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	28	713	180	194	6.43	0.27	204	282	7.29	0.40
1990	19	571	1	34	0.05	0.06	19	40	1.00	0.07
1991	32	242	33	2	1.03	0.01	36	2	1.13	0.01
1992	113	676	31	46	0.27	0.07	32	48	0.28	0.07
1993	100	233	282	159	2.82	0.68	286	163	2.86	0.69
1994	13	184	21	37	1.62	0.20	21	38	1.62	0.21
1995	NP	33	NP	66	NP	2.00	NP	69	NP	2.09
1996	18	58	77	255	4.28	4.40	79	279	4.39	4.81
1997	120	182	2,232	716	18.60	3.93	2,609	794	21.74	4.36
1998	48	91	991	350	20.65	3.85	1,185	373	24.69	4.10
1999	NP	94	NP	10	NP	0.11	NP	11	NP	0.12
2000	48	346	354	699	7.38	2.02	377	733	7.85	2.12
2001	382	1,725	1,808	310	4.73	0.18	1,845	314	4.83	0.18
2002	84	707	709	245	8.44	0.35	780	255	9.29	0.36
2003	119	270	695	113	5.84	0.44	779	121	6.55	0.45

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
2004	296	858	2,511	276	8.48	0.32	2,986	298	10.09	0.35
2005	283	598	1,393	405	4.92	0.68	1,522	418	5.38	0.70
Average	***114***	***446***	***755***	***230***	***6.37***	***1.15***	***851***	***249***	***7.26***	***1.24***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00036 to 0.01562 for hatchery spring Chinook (Table 5.37).

Table 5.37. Smolt-to-adult ratios (SARs) for Chiwawa hatchery spring Chinook, brood years 1989-2005.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	42,707	204	0.00478
1990	52,798	19	0.00036
1991	61,088	36	0.00059
1992	82,976	31	0.00037
1993	221,316	284	0.00128
1994	27,135	21	0.00077
1995	No hatchery program		
1996	12,767	67	0.00525
1997	259,585	2,549	0.00982
1998	71,571	1,118	0.01562
1999	No hatchery program		
2000	46,726	375	0.00803
2001	374,129	1,830	0.00489
2002	145,074	760	0.00524
2003	216,702	763	0.00352
2004	491,987	2,975	0.00605
2005	489,664	1,513	0.00309
Average	***173,082***	***836***	***0.00483***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

5.8 ESA/HCP Compliance

Broodstock Collection

The collection of 2009 Brood Chiwawa River spring Chinook broodstock was consistent with the 2009 Upper Columbia River salmon and steelhead broodstock objectives and site-based broodstock collection protocols. Specifically, broodstock collection targeted hatchery-origin fish at Tumwater Dam and the Chiwawa Weir, while only natural-origin spring Chinook were collected at the Chiwawa Weir. In-season adjustments were made to the number of hatchery and natural-origin spring Chinook collected for broodstock and were based on in-season escapement monitoring at Tumwater Dam and estimated Chiwawa run-escapement.

Broodstock collection at Tumwater Dam began 23 May 2009, concluded on 26 July 2009, and targeted hatchery-origin, coded-wire tagged spring Chinook. Collection was implemented concurrent with trapping, sampling, and tagging associated with the spring Chinook reproductive success study (BPA project No. 2003-039-00). Trapping at the Chiwawa Weir began on 21 June 2009 and concluded on 6 August 2009. Broodstock collection targeted natural-origin spring Chinook and hatchery-origin spring Chinook as needed to attain a minimum 33% natural-origin broodstock and a maximum 33% extraction of the estimated natural-origin return to the Chiwawa River.

The BY 2009 brood collection retained a total of 264 spring Chinook, including 113 natural-origin fish, representing a 43% natural-origin broodstock. The brood successfully met the minimum targeted 33% natural-origin composition.

Both passive (low abundance periods) and active (high abundance periods) trapping were used to collect spring Chinook at Tumwater Dam. During passive trapping, the trap was checked and fish were processed several times per day. At the Chiwawa Weir, the trap was operated passively, checked several times per day, and fish were processed once daily. Trapping at the Chiwawa Weir generally followed a four-up and three-down schedule, and operated only as needed to meet weekly collection objectives consistent with the 2009 collection protocol or as adjusted based on in-season run escapement monitoring and ESA Section 10 Permit 1196 requirements. All spring Chinook, steelhead, and bull trout that were captured were anesthetized with tricaine methanesulfonate (MS-222) and subject to water-to-water transfers during handling. All fish were allowed to fully recover before release.

The estimated escapement of 2009 spring Chinook past Tumwater Dam totaled 5,056 adult and jack spring Chinook (Murdoch et al. 2009). Based on 2009 spawning ground data (redd and carcass surveys), an estimated 258 natural-origin spring Chinook spawned in the Chiwawa River Basin. Assuming the pre-spawn survival of Chiwawa River natural-origin spring Chinook was similar to the at-large population upstream from Tumwater Dam (73%), combined with the 113 natural-origin Chinook extracted for broodstock, the natural-origin escapement to the Chiwawa Basin totaled 466 spring Chinook (i.e., (258/0.73) + 113 = 466). The 2009 broodstock retention of 264 spring Chinook (113 natural-origin and 151 hatchery-origin) represents 14.3% of the estimated 2009 Chiwawa spring Chinook escapement (24% of the wild Chiwawa escapement) to Tumwater Dam and 5.2% of the run escapement of spring Chinook upstream from Tumwater Dam. The estimated broodstock extraction rate of natural-origin Chiwawa spring Chinook and overall extraction of spring Chinook upstream from Tumwater Dam comply with provisions of ESA Permit 1196.

No additional spring Chinook were handled and released as a function of maintaining, at minimum, 33% natural-origin spring Chinook in the broodstock. About 518 bull trout were captured and released. To minimize fallback or impingement on the weir, all spring Chinook and bull trout were released unharmed about 10 km upstream from the weir.

Hatchery Rearing and Release

The rearing and release of 2009 brood Chiwawa spring Chinook was completed without incident. No mortality events occurred that exceeded 10% of the population. Fish were acclimated on Chiwawa River water with regulated amounts of Wenatchee river water to prevent frazzle ice formation during the winter months (see Section 5.2).

The release of 2009 brood Chiwawa spring Chinook smolts totaled 438,561 spring Chinook, representing 65.3% of program objectives and complied with the ESA Section 10 Permit 1196 program level of 672,000 smolts.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January 2011 through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Smolt and Emigrant Trapping

Per ESA Section 10 Permit No. 1196, the permit holders are authorized a direct take of 20% of the emigrating spring Chinook population during juvenile emigration monitoring and a lethal take not to exceed 2% of the fish captured (NMFS 2003). Based on the estimated wild spring Chinook population (smolt trap expansion) and hatchery juvenile spring Chinook population estimate (hatchery release data) for the Wenatchee Basin, the reported spring Chinook encounters during 2011 emigration monitoring complied with take provisions in the Section 10 permit. Spring Chinook encounter and mortality rates for each trap site (including PIT tag mortalities) are detailed in Table 5.38. A single day mortality event at the upper Wenatchee trap where a juvenile holding vessel failed, contributed to the hatchery and subyearling mortality targets to be exceeded. Corrective actions were taken and no additional mortalities occurred. Additionally, juvenile fish captured at the trap locations were handled consistent with provisions in ESA Section 10 Permit 1196, Section B.

Table 5.38. Estimated take of Upper Columbia River spring Chinook resulting from juvenile emigration monitoring in the Wenatchee Basin, 2011.

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Sub-yearling[c]	Wild	Hatchery	Sub-yearling		
Chiwawa Trap								
Population	30,959	438,561	59,305	4,848	25,620	20,561	51,029	
Encounter rate	NA	NA	NA	0.1566	0.0584	0.3467	0.0965	0.20
Mortality[e]	NA	NA	NA	10	109	100	219	

Trap location	Population estimate			Number trapped			Total	Take allowed under Permit
	Wild[a]	Hatchery[b]	Sub-yearling[c]	Wild	Hatchery	Sub-yearling		
Mortality rate	NA	NA	NA	0.0021	0.0043	0.0049	0.0043	0.02
Upper Wenatchee Trap								
Population	NA[d]	112,158	NA[d]	786	292	109	1,187	
Encounter rate	NA	NA	NA	NA	0.0026	NA	0.0105	0.20
Mortality[e]	NA	NA	NA	18	18	5	41	
Mortality rate	NA	NA	NA	0.0229	0.0616	0.0459	0.0345	0.02
Lower Wenatchee Trap								
Population	NA	NA	NA	NA	NA	NA	NA	
Encounter rate	NA	NA	NA	NA	NA	NA	NA	0.20
Mortality[e]	NA	NA	NA	NA	NA	NA	NA	
Mortality rate	NA	NA	NA	NA	NA	NA	NA	0.02
Wenatchee Basin Total								
Population	30,959	550,719	59,305	5,634	25,912	20,670	52,216	
Encounter rate	NA	NA	NA	0.1820	0.0471	0.3485	0.0815	0.20
Mortality[e]	NA	NA	NA	28	127	105	260	
Mortality rate	NA	NA	NA	0.0050	0.0049	0.0050	0.0050	0.02

[a] Smolt population estimate derived from juvenile emigration trap data.

[b] 2008 smolt release data for the Wenatchee Basin.

[c] Based on size, date of capture, and location of capture, subyearling Chinook encountered at the Lower Wenatchee Trap are categorized as summer Chinook.

[d] Insufficient numbers of natural-origin spring Chinook were encountered to derive a population estimate.

[e] Combined trapping and PIT tagging mortality.

Spawning Surveys

Spring Chinook spawning ground surveys were conducted in the Wenatchee Basin during 2011, as authorized by ESA Section 10 Permit 1196. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

Spring Chinook Reproductive Success Study

ESA Section 10 Permit 1196 specifically provides authorization to capture, anesthetize, biologically sample, PIT tag, and release adult spring Chinook at Tumwater Dam for reproductive success studies and general program monitoring. During 2010 through 2011, all spring Chinook passing Tumwater Dam were enumerated, anesthetize, biologically sampled, PIT tagged, and released (not including hatchery-origin Chinook retained for broodstock) as a component of the reproductive success study (BPA Project No. 2003-039-00). Please refer to Ford et al. (2010) and Ford et al. (2011) for complete details on the methods and results of the spring Chinook reproductive success study for 2010 and 2011.

SECTION 6: WENATCHEE SUMMER CHINOOK

6.1 Broodstock Sampling

This section focuses on results from sampling 2009-2010 Wenatchee summer Chinook broodstock, which were collected at Dryden and Tumwater dams. Complete information is not currently available for the 2011 brood (this information will be provided in the 2012 annual report).

Origin of Broodstock

Both the 2009 and 2010 broodstock consisted primarily of natural-origin (adipose fin present) summer Chinook (Table 6.1). In order to meet production goals, hatchery-origin adults were collected in concert with natural-origin fish. About 1% of the 2010 broodstock was comprised of hatchery-origin fish (hatchery-origin was determined by examination of scales and/or CWTs).

Table 6.1. Numbers of wild and hatchery summer Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned in the Wenatchee Basin, 1989-2010. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program and surplus fish killed at spawning.

Brood year	Wild summer Chinook					Hatchery summer Chinook					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
1989	346	29	27	290	0	0	0	0	0	0	290
1990	87	6	24	57	0	0	0	0	0	0	57
1991	128	9	14	105	0	0	0	0	0	0	105
1992	341	48	19	274	0	0	0	0	0	0	274
1993	480	28	46	406	0	44	0	0	44	0	450
1994	363	29	1	333	0	55	1	0	54	0	387
1995	382	15	4	363	0	16	0	0	16	0	378
1996	331	34	34	263	0	3	0	0	3	0	266
1997	225	14	6	205	0	15	1	1	13	0	218
1998	378	40	39	299	0	94	4	12	78	0	377
1999	250	7	1	242	0	238	1	1	236	0	478
2000	298	18	5	275	0	194	7	7	180	0	455
2001	311	41	60	210	0	182	8	38	136	0	346
2002	469	28	32	409	0	13	1	2	10	0	419
2003	488	90	61	337	0	8	1	0	7	0	344
2004	494	24	46	424	0	2	0	0	2	0	426
2005	491	29	19	397	46	3	0	0	3	0	400
2006	483	29	21	433	0	5	1	0	4	0	437
2007	415	53	99	263	0	4	0	1	3	0	266
2008	400	11	11	378	0	72	2	1	69	0	447
2009	482	22	8	452	0	9	1	0	8	0	460
2010	427	14	25	388	0	7	2	0	5	0	393
Average	***367***	***28***	***27***	***309***	***2***	***44***	***1***	***3***	***40***	***0***	***349***

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2009 return consisted primarily of age-4 and age-5 natural-origin Chinook (93%). Age-2 and age-3 natural-origin fish collectively made up 7% of the broodstock. No age-6 fish were included in the broodstock (Table 6.2). Of the hatchery Chinook included in the broodstock, 53% were age-5 fish, with age-3 and 4 comprising 13% and 34%, respectively. About 3% of the hatchery broodstock were age-3 fish.

Broodstock collected from the 2010 return consisted primarily of age-4 and age-5 natural-origin Chinook (93%). Age-2 and age-3 natural-origin fish collectively made up 6% of the broodstock. No age-6 fish were included in the broodstock (Table 6.2). Of the hatchery Chinook included in the broodstock, age-4 and age-5 fish comprised 57% and 43% of the hatchery-origin broodstock collected.

Table 6.2. Percent of hatchery and wild Wenatchee summer Chinook of different ages (total age) collected from broodstock in the Wenatchee Basin, 1991-2010.

Return Year	Origin	Total age				
		2	3	4	5	6
1991	Wild	0.0	4.6	36.8	57.5	1.1
	Hatchery	0.0	0.0	0.0	0.0	0.0
1992	Wild	0.0	2.6	40.4	50.9	6.1
	Hatchery	0.0	0.0	0.0	0.0	0.0
1993	Wild	0.0	1.5	36.0	60.3	2.2
	Hatchery	0.0	0.0	93.0	7.0	0.0
1994	Wild	0.0	1.0	33.7	64.3	1.0
	Hatchery	0.0	0.0	1.9	98.1	0.0
1995	Wild	0.0	3.3	18.9	76.6	1.2
	Hatchery	0.0	0.0	0.0	0.0	100.0
1996	Wild	0.0	4.6	40.1	53.3	2.0
	Hatchery	0.0	0.0	33.3	66.7	0.0
1997	Wild	0.0	2.3	42.6	53.2	1.9
	Hatchery	0.0	26.7	66.7	6.6	0.0
1998	Wild	0.0	5.5	34.8	58.6	1.1
	Hatchery	0.0	5.4	68.5	19.6	6.5
1999	Wild	0.5	1.9	39.0	56.3	2.4
	Hatchery	0.0	1.3	23.2	72.1	2.4
2000	Wild	2.6	6.3	24.6	66.5	0.0
	Hatchery	0.0	23.6	15.2	42.9	18.3
2001	Wild	0.3	16.4	53.9	27.7	1.7
	Hatchery	0.0	6.3	80.6	10.0	3.1
2002	Wild	1.6	8.4	61.1	28.3	0.6

Return Year	Origin	Total age				
		2	3	4	5	6
	Hatchery	0.0	0.0	41.7	58.3	0.0
2003	Wild	0.9	2.8	31.4	64.9	0.0
	Hatchery	0.0	12.5	25.0	62.5	0.0
2004	Wild	0.2	3.6	10.1	84.0	2.1
	Hatchery	0.0	0.0	50.0	50.0	0.0
2005	Wild	0.0	4.3	53.5	35.1	7.1
	Hatchery	0.0	0.0	0.0	100.0	0.0
2006	Wild	1.4	0.9	14.9	81.8	1.0
	Hatchery	0.0	0.0	0.0	80.0	20.0
2007	Wild	3.6	14.9	18.6	46.4	16.5
	Hatchery	0.0	0.0	0.0	100.0	0.0
2008	Wild	0.5	6.3	65.4	26.2	1.6
	Hatchery	0.0	3.0	13.2	69.1	14.7
2009	Wild	1.1	6.3	46.3	46.3	0.0
	Hatchery	0.0	12.5	34.4	53.1	0.0
2010	Wild	0.1	6.3	66.3	26.5	0.0
	Hatchery	0.0	0.0	57.1	42.9	0.0
Average	***Wild***	***0.6***	***5.2***	***38.4***	***53.2***	***2.5***
	Hatchery	***0.0***	***4.6***	***30.2***	***46.9***	***8.3***

Mean lengths of natural-origin summer Chinook of a given age differed little between return years 2009 and 2010 (Table 6.3). Mean lengths of age-2 and 5 Chinook differed between years by about 3 cm and 11 cm, respectively. The few hatchery fish that were included in broodstock were about 11-15 cm smaller than their natural counterparts in the 2010 brood (Table 6.3).

Table 6.3. Mean fork length (cm) at age (total age) of hatchery and wild Wenatchee summer Chinook collected from broodstock in the Wenatchee Basin, 1991-2010; N = sample size and SD = 1 standard deviation.

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	-	0	-	-	4	-	-	32	-	-	50	-	-	1	-
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
1992	Wild	-	0	-	66	3	10	69	46	5	81	58	3	87	7	1
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	68	6	10	84	142	9	98	238	6	100	9	6
	Hatchery	-	0	-	-	0	-	79	41	8	101	3	8	-	0	-
1994	Wild	-	0	-	74	3	5	86	101	8	96	193	7	106	3	7
	Hatchery	-	0	-	-	0	-	75	1	-	90	53	8	-	0	-
1995	Wild	-	0	-	66	11	8	85	64	7	97	255	6	106	4	7

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	91	16	8
1996	Wild	-	0	-	69	14	5	86	121	6	97	161	6	104	6	5
	Hatchery	-	0	-	-	0	-	63	1	-	96	2	4	-	0	-
1997	Wild	-	0	-	54	5	10	85	92	7	98	115	7	97	4	9
	Hatchery	-	0	-	46	4	2	74	10	4	98	1	-	-	0	-
1998	Wild	-	0	-	66	19	9	85	120	7	99	201	7	106	4	7
	Hatchery	-	0	-	53	5	2	77	63	8	95	19	8	98	6	8
1999	Wild	42	1	-	65	4	6	86	83	6	97	120	7	103	5	8
	Hatchery	-	0	-	52	3	6	79	55	7	90	171	6	100	8	6
2000	Wild	43	7	4	60	17	7	84	67	5	98	181	6	-	0	-
	Hatchery	-	0	-	53	47	7	76	29	8	94	83	7	102	35	9
2001	Wild	48	1	-	66	48	7	88	155	7	97	80	6	102	5	3
	Hatchery	-	0	-	51	10	3	75	132	8	91	17	8	100	5	8
2002	Wild	48	7	4	64	37	8	89	270	7	100	125	7	99	3	13
	Hatchery	-	0	-	-	0	-	78	5	8	95	7	5	-	0	-
2003	Wild	41	4	2	58	13	4	87	144	8	100	297	7	-	0	-
	Hatchery	-	0	-	40	1	-	78	2	4	101	5	8	-	0	-
2004	Wild	51	1	-	69	17	5	84	47	8	99	392	6	109	10	7
	Hatchery	-	0	-	-	0	-	84	1	-	108	1	-	-	0	-
2005	Wild	-	0	-	68	20	7	86	247	8	95	162	6	101	33	6
	Hatchery	-	0	-	-	0	-	-	0	-	90	3	9	-	0	-
2006	Wild	44	6	6	63	4	11	88	66	7	99	363	6	96	5	7
	Hatchery	-	0	-	-	0	-	-	0	-	99	4	7	100	1	-
2007	Wild	44	14	5	65	58	7	89	72	8	99	180	7	102	64	6
	Hatchery	-	0	-	-	0	-	-	0	-	90	4	5	-	0	-
2008	Wild	46	2	3	69	24	7	90	247	6	98	99	7	105	6	9
	Hatchery	-	0	-	63	2	14	81	9	7	93	47	6	99	10	5
2009	Wild	48	7	6	70	25	6	89	199	7	101	199	6	-	0	-
	Hatchery	-	0	-	61	4	7	80	11	9	98	17	10	-	0	-
2010	Wild	45	4	4	70	26	9	89	275	7	99	110	6	-	0	-
	Hatchery	-	0	-	-	0	-	74	4	8	88	3	7	-	0	-

Sex Ratios

Male summer Chinook in the 2009 broodstock made up about 50% of the adults collected, resulting in an overall male to female ratio of 1.00:1.00 (Table 6.4.). In 2010, males made up about 53% of the adults collected, resulting in an overall male to female ratio of 1.12:1.00 (Table 6.4). The ratios in 2009 were nearly equal to the 1:1 ratio goal in the broodstock protocol.

Table 6.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock in the Wenatchee Basin, 1989-2010. Ratios of males to females are also provided.

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989	166	180	0.92:1.00	0	0	-	0.92:1.00
1990	45	39	1.15:1.00	0	0	-	1.15:1.00
1991	60	68	0.88:1.00	0	0	-	0.88:1.00
1992	154	187	0.82:1.00	0	0	-	0.82:1.00
1993	208	228	0.91:1.00	35	9	3.89:1.00	1.03:1.00
1994	158	179	0.88:1.00	24	31	0.77:1.00	0.87:1.00
1995	169	213	0.79:1.00	1	15	0.07:1.00	0.75:1.00
1996	150	181	0.83:1.00	2	1	2.00:1.00	0.84:1.00
1997	104	121	0.86:1.00	15	0	-	0.98:1.00
1998	211	167	1.26:1.00	64	30	2.13:1.00	1.40:1.00
1999	130	120	1.08:1.00	108	130	0.83:1.00	0.95:1.00
2000	153	145	1.06:1.00	112	82	1.37:1.00	1.17:1.00
2001	187	124	1.51:1.00	132	50	2.64:1.00	1.83:1.00
2002	266	203	1.31:1.00	5	8	0.63:1.00	1.28:1.00
2003	270	218	1.24:1.00	5	3	1.67:1.00	1.24:1.00
2004	230	264	0.87:1.00	1	1	1.00:1.00	0.87:1.00
2005	291	200	1.46:1.00	2	1	2.00:1.00	1.46:1.00
2006	237	246	0.96:1.00	1	4	0.25:1.00	0.95:1.00
2007	239	176	1.36:1.00	2	2	1.00:1.00	1.35:1.00
2008	208	192	1.08:1.00	29	43	0.67:1.00	1.01:1.00
2009	223	236	0.94:1.00	25	7	3.57:1.00	1.02:1.00
2010	217	198	1.10:1.00	5	2	2.50:1.00	1.12:1.00
Total	***4,076***	***3,885***	***1.05:1.00***	***568***	***419***	***1.36:1.00***	***1.08:1.00***

Fecundity

Fecundities for the 2009 and 2010 returns of summer Chinook averaged 5,291 and 4,963 eggs per female, respectively (Table 6.5). These values are close to the overall average of 5,176 eggs per female. Mean observed fecundities for the 2009 and 2010 returns were near the expected fecundity of 5,000 eggs per female assumed in the broodstock protocol.

Table 6.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock in the Wenatchee Basin, 1989-2010; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	5,280
1990*	NA	NA	5,436
1991*	NA	NA	4,333

Return year	Mean fecundity		
	Wild	Hatchery	Total
1992*	NA	NA	5,307
1993*	NA	NA	5,177
1994*	NA	NA	5,899
1995*	NA	NA	4,402
1996*	NA	NA	4,941
1997	5,385	5,272	5,390
1998	5,393	4,825	5,297
1999	5,036	4,942	4,987
2000	5,464	5,403	5,441
2001	5,280	4,647	5,097
2002	5,502	5,027	5,484
2003	5,357	5,696	5,361
2004	5,372	6,681	5,377
2005	5,045	6,391	5,053
2006	5,126	5,633	5,133
2007	5,124	4,510	5,115
2008	5,147	4,919	5,108
2009	5,308	4,765	5,291
2010	4,971	3,323	4,963
Average	***5,251***	***5,145***	***5,176***

* Individual fecundities were not tracked with females until 1997.

6.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 1,066,667 eggs are required to meet the program release goal of 864,000 smolts. Between 1989 and 2010, the egg take goal was reached in 11 of those years (Table 6.6).

Table 6.6. Numbers of eggs taken from Wenatchee summer Chinook broodstock, 1989-2010.

Return year	Number of eggs taken
1989	829,012
1990	163,109
1991	247,000
1992	827,911
1993	1,133,852
1994	999,364
1995	949,531
1996	756,000

Return year	Number of eggs taken
1997	554,617
1998	854,997
1999	1,182,130
2000	1,113,159
2001	733,882
2002	1,049,255
2003	901,095
2004	1,311,051
2005	883,669
2006	1,190,757
2007	655,201
2008	1,145,330
2009	1,217,028
2010	947,875
Average	***892,992***

Number of acclimation days

The 2009 brood Wenatchee summer Chinook were transferred to Dryden Pond between 15 March and 22 April 2010. These fish received 5-43 days of acclimation on Wenatchee River water before being released on 26 April 2010 (Table 6.7). In recent years, a small proportion of the brood (high ELISA fish) has been reared separately and received no acclimation (i.e., these fish were released directly into the Wenatchee River). These data are not shown in Table 6.7. No such release occurred in 2011.

Table 6.7. Number of days Wenatchee summer Chinook were acclimated at Dryden Pond, brood years 1989-2009. Numbers in parenthesis represents the number of days fish reared at Chiwawa Ponds.

Brood year	Release year	Transfer date	Release date	Number of days
1989	1991	2-Mar	7-May	66
1990	1992	19-Feb	2-May	73
1991	1993	10-Mar	8-May	59
1992	1994	1-Mar	6-May	66
1993	1995	3-Mar	1-May	59
1994	1996	2-Oct	6-May	217 (154)
		5-Mar	6-May	62
1995	1997	16-Oct	8-May	205 (139)
		27-Feb	8-May	70
1996	1998	6-Oct	28-Apr	204 (142)

Brood year	Release year	Transfer date	Release date	Number of days
		25-Feb	28-Apr	62
1997	1999	23-Feb	27-Apr	63
1998	2000	5-Mar	1-May	57
1999	2001	8-Mar	23-Apr	46
2000	2002	1-Mar	6-May	66
2001	2003	19-Feb	23-Apr	63
2002	2004	5-Mar	23-Apr	49
2003	2005	15-Mar	25-Apr	41
2004	2006	25-Mar	27-Apr	33
2005	2007	15-Mar	30-Apr	46
2006	2008	11-14-Mar	28-Apr	45-48
2007	2009	30-31-Mar	29-Apr	29-30
2008	2010	9-12, 15, 22-Mar	28-Apr	38-51
2009	2011	15-18, 21-Mar, 22-Apr	26-Apr	5-43

Release Information

Numbers released

The 2009 Wenatchee summer Chinook program achieved 98% of the 864,000 target goal with about 843,866 fish being released (Table 6.8).

Table 6.8. Numbers of Wenatchee summer Chinook smolts released from the hatchery, 1989-2009. The release target for Wenatchee summer Chinook is 864,000 smolts.

Brood year	Release year	CWT mark rate	Number released with PIT tags	Number of smolts released
1989	1991	0.2013	0	720,000
1990	1992	0.9597	0	124,440
1991	1993	0.9957	0	191,179
1992	1994	0.9645	0	627,331
1993	1995	0.9881	0	900,429
1994	1996	0.9697	0	797,350
1995	1997	0.9725	0	687,439
1996	1998	0.9758	0	600,127
1997	1999	0.9913	0	438,223
1998	2000	0.9869	0	649,612
1999	2001	0.9728	0	1,005,554
2000	2002	0.9723	0	929,496
2001	2003	0.9868	0	604,668

Brood year	Release year	CWT mark rate	Number released with PIT tags	Number of smolts released
2002	2004	0.9644	0	835,645
2003	2005	0.9778	0	653,764
2004	2006	0.9698	0	892,926
2005	2007	0.9596	0	644,182
2006	2008	0.9676	0	51,550[a]
		0.9676	0	899,107
2007	2009	0.9768	0	456,805
2008	2010	0.9664	10,035	888,811
2009	2011	0.9767	29,930	843,866
Average		***0.9393***	***19,983***	***685,284***

[a] Represents high Elisa group planted directly in the Wenatchee River at Leavenworth Boat Launch.

Numbers tagged

The 2009 brood Wenatchee summer Chinook were 97.7% CWT and adipose fin-clipped (Table 6.8).

No juvenile hatchery summer Chinook were PIT tagged in 2011. Table 6.9 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Wenatchee River.

Table 6.9. Summary of PIT-tagging activities for Wenatchee hatchery summer Chinook, brood years 2008-2010.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	10,100	64	1	10,035
2009	2011	10,108 (Control)	140	3	9,965
		10,100 (R1)	129	0	9,971
		10,099 (R2)	105	0	9,994
2010	2012	0	0	0	0

Fish size and condition at release

About 843,866 summer Chinook from the 2009 brood were released from Dryden Pond using an unmonitored volitional method (i.e., volitional without PIT-tag detection equipment in place) on 26 April 2010. Size at release was 86.4% and 85.9% of the target fork length and weight goals, respectively. This brood year achieved 76.7% of the target CV for length (Table 6.10). Since the program began, Wenatchee summer Chinook have not met the target length and CV values. The target weight (fish/pound or FPP) of juvenile fish has been met occasionally.

Table 6.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Wenatchee summer Chinook smolts released from the hatchery, brood years 1989-2009; NA = not available. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (cm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	158	13.7	45.4	10
1990	1992	155	14.2	45.4	10
1991	1993	156	15.5	42.3	11
1992	1994	152	13.1	40.1	10
1993	1995	149	NA	34.9	13
1994	1996	138	NA	21.7	21
1995	1997	149	12.2	42.5	11
1996	1998	151	16.6	43.2	10
1997	1999	154	10.1	42.8	11
1998	2000	166	9.7	53.1	9
1999	2001	137	16.1	29.0	16
2000	2002	148	14.6	37.1	12
2001	2003	148	NA	38.9	12
2002	2004	146	15.1	37.3	14
2003	2005	147	13.2	36.5	12
2004	2006	147	10.7	35.4	13
2005	2007	153	16.3	40.6	11
2006	2008	136	21.5	29.2	16
2007	2009	163	21.6	49.7	9
2008	2010	166	15.0	52.0	9
2009	2011	152	15.9	39.0	12
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of the 2009 brood Wenatchee summer Chinook from green (unfertilized) egg to release was slightly below the standard set for the program in part because of not meeting the ponding-to-release survival standard (Table 6.11).

Table 6.11. Hatchery life-stage survival rates (%) for Wenatchee summer Chinook, brood years 1989-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989	90.0	93.4	90.9	97.0	99.7	99.3	98.5	99.4	86.9
1990	89.7	95.6	80.9	96.6	99.6	99.2	97.7	98.8	76.3
1991	88.2	98.3	86.9	96.1	99.3	98.5	94.9	98.1	77.4

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1992	84.3	92.2	79.8	97.8	99.9	99.9	97.1	98.1	75.8
1993	92.4	95.9	84.2	97.5	99.6	99.3	96.7	98.8	79.4
1994	90.7	95.3	83.7	100	99.2	97.0	95.3	98.4	79.8
1995	94.7	98.2	86.0	100	96.7	96.4	74.9	90.8	72.4
1996	84.6	96.1	84.1	100	97.9	97.7	94.4	97.7	79.4
1997	89.3	98.3	82.6	97.3	97.1	96.9	98.3	98.2	79.0
1998	85.3	94.6	80.9	98.3	99.4	98.6	95.6	99.8	76.0
1999	98.4	98.3	90.4	97.9	98.1	97.9	96.2	99.4	85.1
2000	93.0	96.6	88.3	98.0	99.6	99.3	96.5	98.9	83.5
2001	87.4	91.5	90.6	97.7	99.8	99.6	93.1	93.3	82.4
2002	93.8	94.1	85.1	99.8	98.1	97.6	93.7	96.5	79.6
2003	77.4	85.1	80.5	98.1	99.6	99.1	91.9	93.5	72.6
2004	92.8	97.8	85.7	87.8	99.9	99.6	86.6	92.1	65.1
2005	97.3	89.6	83.5	98.0	99.7	99.4	89.1	99.5	72.9
2006	92.4	95.2	85.6	98.4	99.3	98.4	94.8	97.2	79.8
2007	73.6	97.5	73.7	97.9	99.5	98.7	96.6	99.1	69.7
2008	96.6	97.9	90.4	97.3	99.4	98.7	88.2	89.6	77.6
2009	95.1	95.6	92.0	99.6	97.3	97.3	84.8	98.2	78.1
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

6.3 Disease Monitoring

Rearing of the 2009 brood Wenatchee summer Chinook was similar to previous years with fish being held on well water before being transferred to Dryden Pond for final acclimation in March 2011. Fish were transferred to Dryden pond from 15 March to 22 April. Increased mortality caused by external fungus began to occur during the acclimation period at Dryden pond at which time a formalin treatment was initiated in an attempt to prevent the fungus from proliferating.

Results of the 2011 adult broodstock bacterial kidney disease (BKD) monitoring indicated that most females (99.5%) had ELISA values less than 0.199. About 99.0% of females had ELISA values less than 0.120, which would require about 1.0% of the progeny to be reared at densities not to exceed 0.06 fish per pound (Table 6.12).

Table 6.12. Proportion of bacterial kidney disease (BKD) titer groups for the Wenatchee summer Chinook broodstock, brood years 1997-2011. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1997	0.7714	0.0857	0.0381	0.1048	0.8095	0.1905
1998	0.3067	0.2393	0.1656	0.2883	0.4479	0.5521
1999	0.9590	0.0123	0.0123	0.0164	0.9713	0.0287
2000	0.6268	0.1053	0.1627	0.1053	0.7321	0.2679
2001	0.6513	0.0263	0.0987	0.2237	0.6776	0.3224
2002	0.7868	0.0457	0.0711	0.0964	0.8325	0.1675
2003	0.9825	0.0000	0.0058	0.0117	0.9825	0.0175
2004	0.9593	0.0081	0.0163	0.0163	0.9675	0.0325
2005	0.9833	0.0056	0.0000	0.0111	0.9833	0.0167
2006	0.9134	0.0563	0.0000	0.0303	0.9351	0.0649
2007	0.9535	0.0078	0.0078	0.0310	0.9535	0.0465
2008	0.9868	0.0088	0.0044	0.0000	0.9868	0.0132
2009	0.9957	0.0000	0.0000	0.0043	0.9957	0.0043
2010	0.9897	0.0025	0.0000	0.0025	0.9949	0.0051
2011	0.9585	0.0363	0.0000	0.0052	0.9896	0.0104
Average	*0.8550*	*0.0427*	*0.0389*	*0.0632*	*0.8840*	*0.1160*

[a] Individual ELISA samples were not collected before the 1997 brood.

6.4 Natural Juvenile Productivity

The Lower Wenatchee Trap did not operate in 2011. Therefore, there are no estimates of juvenile summer Chinook emigrants in 2011.

6.5 Spawning Surveys

Surveys for Wenatchee summer Chinook redds were conducted from late 19 September to 4 November, 2011, in the Wenatchee River and Icicle Creek. Both peak counts and total counts (based on expansion factors; Murdoch and Peven 2005) were conducted in the river (see Appendix H for more details).

Redd Counts

A peak count of 2,592 summer Chinook redds was estimated in 2011 based on ground surveys conducted in the Wenatchee River and Icicle Creek (Table 6.13). A total count of 3,078 redds was estimated in 2011 based on expanded peak counts in the Wenatchee Basin (Table 6.13).

Table 6.13. Peak and total numbers of redds counted in the Wenatchee Basin, 1989-2011; NA = not available. Total counts are based on expanded peak counts (see Appendix H for more information).

Survey year	Peak redd count	Total count (peak expansion)
1989	3,331	4,215
1990	2,479	3,103
1991	2,180	2,748
1992	2,328	2,913
1993	2,334	2,953
1994	2,426	3,077
1995	1,872	2,350
1996	1,435	1,814
1997	1,388	1,739
1998	1,660	2,230
1999	2,188	2,738
2000	2,022	2,540
2001	2,857	3,550
2002	5,419	6,836
2003	4,281	5,268
2004	4,003	4,874
2005	2,895	3,538
2006*	7,233	8,896
2007*	1,870	1,970
2008*	2,361	2,800
2009*	2,688	3,441
2010*	2,564	3,261
2011*	2,592	3,078
Average	***2,776***	***3,475***

* Peak and total counts include 68, 13, 23, 21, 11, 11, and 9 redds counted in Icicle Creek in 2006-2011, respectively.

Redd Distribution

Summer Chinook redds were not evenly distributed among reaches within the Wenatchee Basin in 2011 (Table 6.14; Figure 6.1). Most of the spawning occurred upstream from the Leavenworth Bridge in Reaches 6, 9, and 10. The highest density of redds occurred in Reach 6 near the confluence of the Icicle River.

Table 6.14. Peak and total numbers of summer Chinook redds counted in different reaches in the Wenatchee Basin during September through mid-November, 2011. Reach codes are described in Table 2.10.

Survey reach	Peak redd count	Total count (peak expansion)
Wenatchee 1 (W1)	1	1
Wenatchee 2 (W2)	111	127
Wenatchee 3 (W3)	232	254

Survey reach	Peak redd count	Total count (peak expansion)
Wenatchee 4 (W4)	67	75
Wenatchee 5 (W5)	41	25
Wenatchee 6 (W6)	910	1,002
Wenatchee 7 (W7)	214	246
Wenatchee 8 (W8)	182	206
Wenatchee 9 (W9)	475	698
Wenatchee 10 (W10)	350	435
Icicle Creek (I1)	9	9
Totals	***2,592***	***3,078***

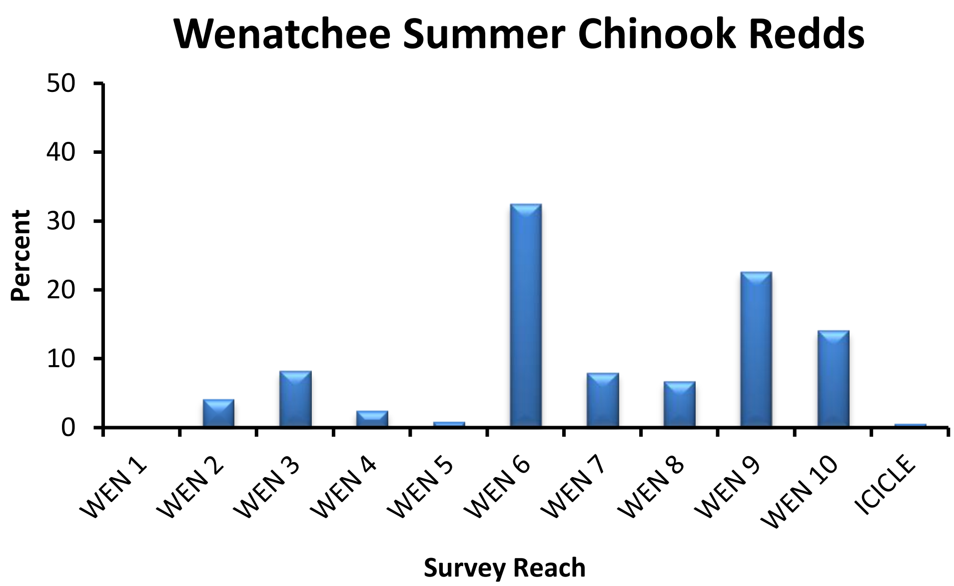

Figure 6.1. Percent of the total number (based on peak expansion) of summer Chinook redds counted in different reaches in the Wenatchee Basin during September through early-November, 2011. Reach codes are described in Table 2.10.

Spawn Timing

In 2011, spawning in the Wenatchee River began during the last week of September, peaked the third week of October, and ended in early November (Figure 6.2).

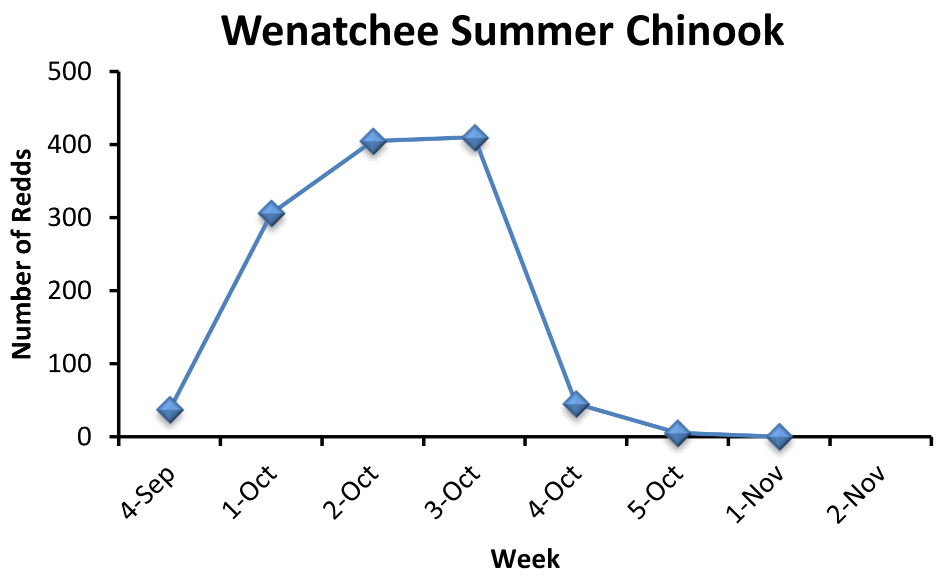

Figure 6.2. Number of new summer Chinook redds counted during different weeks in the Wenatchee River, September through mid-November 2011 (based on mapping counts).

Spawning Escapement

Spawning escapement for Wenatchee summer Chinook was calculated as the total number of redds (expanded peak counts) times the fish per redd ratio estimated from broodstock and fish sampled at adult trapping sites. The estimated fish per redd ratio for summer Chinook in 2011 was 3.20. Multiplying this ratio by the number of redds counted in the Wenatchee Basin resulted in a total spawning escapement of 9,850 summer Chinook (Table 6.15).

Table 6.15. Spawning escapements for summer Chinook in the Wenatchee Basin, return years 1989-2011. Number of redds is based on expanded peak redd counts.

Return year	Fish/Redd	Redds	Total spawning escapement
1989	3.40	4,215	14,331
1990	3.50	3,103	10,861
1991	3.70	2,748	10,168
1992	4.00	2,913	11,652
1993	3.20	2,953	9,450
1994	3.30	3,077	10,154
1995	3.30	2,350	7,755
1996	3.40	1,814	6,168
1997	3.40	1,739	5,913
1998	2.40	2,230	5,352
1999	2.00	2,738	5,476
2000	2.17	2,540	5,512
2001	3.20	3,550	11,360

Return year	Fish/Redd	Redds	Total spawning escapement
2002	2.30	6,836	15,723
2003	2.24	5,268	11,800
2004	2.15	4,874	10,479
2005	2.46	3,538	8,703
2006	2.00	8,896	17,792
2007	2.33	1,970	4,590
2008	2.32	2,800	6,496
2009	2.42	3,441	8,327
2010	2.29	3,261	7,468
2011	3.20	3,078	9,850
Average	***2.81***	***3,475***	***9,364***

6.6 Carcass Surveys

Surveys for Wenatchee summer Chinook carcasses were conducted during late September to mid-November, 2011, in the Wenatchee River and Icicle Creek.

Number sampled

A total of 2,243 summer Chinook carcasses were sampled during October through mid-November in the Wenatchee Basin in 2011 (Table 6.16).

Table 6.16. Numbers of summer Chinook carcasses sampled within each survey reach in the Wenatchee Basin, 1993-2011. Reach codes are described in Table 2.10.

Survey year	Number of summer Chinook carcasses											
	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	Total
1993	61	138	627	12	77	141	202	38	0	0	0	**1,296**
1994	0	6	22	1	17	48	18	47	125	1	0	**285**
1995	0	10	14	0	0	111	49	36	19	0	0	**239**
1996	0	5	67	39	9	190	26	30	41	0	0	**407**
1997	1	44	118	4	28	288	7	71	67	13	0	**641**
1998	6	74	141	3	0	248	28	346	324	59	0	**1,229**
1999	0	160	97	15	31	857	61	133	171	72	0	**1,597**
2000	7	109	165	7	79	651	75	111	159	193	0	**1,556**
2001	0	45	127	26	0	323	33	110	87	81	0	**832**
2002	0	238	170	0	196	809	0	306	520	155	6	**2,400**
2003	6	323	164	61	132	673	56	237	482	47	36	**2,217**
2004	8	141	181	157	158	975	87	312	428	366	5	**2,818**
2005	8	85	106	39	46	707	70	140	353	257	7	**1,818**
2006	22	140	160	64	112	953	435	343	703	658	18	**3,608**
2007	3	15	49	9	26	475	38	38	96	91	8	**848**
2008	10	34	63	36	36	678	47	42	103	143	8	**1,200**

Survey year	Number of summer Chinook carcasses											
	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	Total
2009	11	29	43	32	27	389	16	58	240	175	6	**1,026**
2010	3	31	98	57	122	681	136	49	124	193	15	**1,509**
2011	5	88	126	19	38	1,335	78	45	211	289	9	**2,243**
Average	***8***	***90***	***134***	***31***	***60***	***554***	***77***	***131***	***224***	***147***	***6***	***1,462***

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Wenatchee Basin in 2011 (Table 6.15; Figure 6.3). Most of the carcasses in the Wenatchee Basin were found upstream from the Leavenworth Bridge. The highest percentage of carcasses (60%) was sampled in Reach 6 near the confluence of the Icicle River.

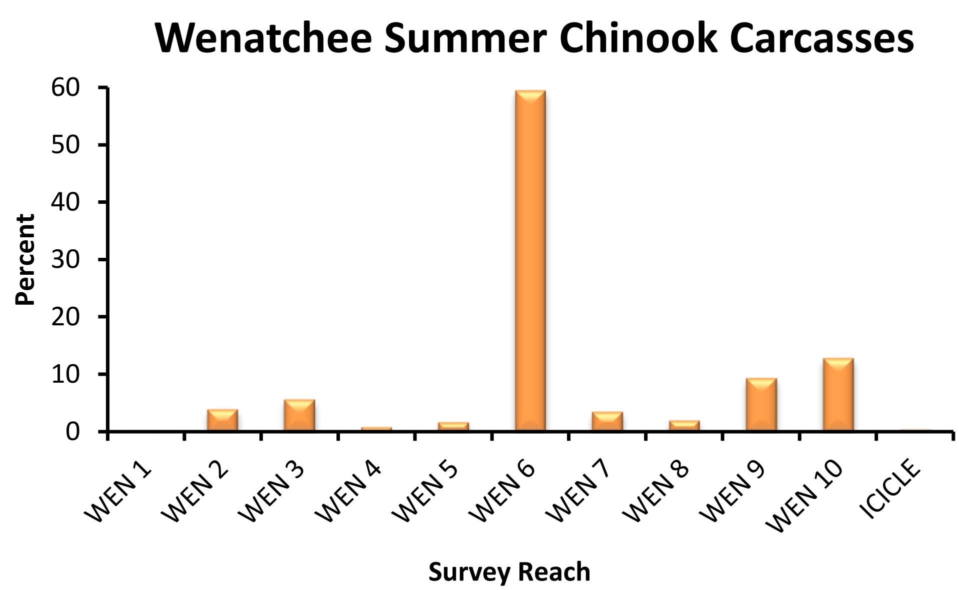

Figure 6.3. Percent of summer Chinook carcasses sampled within different reaches in the Wenatchee Basin during September through mid-November, 2011. Reach codes are described in Table 2.10.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2011 will be available after analysis of CWTs and scales. Based on the available data (1993-2010), most fish, regardless of origin, were found in Reach 6 (Leavenworth Bridge to Icicle Road Bridge) (Table 6.17). However, a larger percentage of hatchery fish were found in that reach than were wild fish (Figure 6.4). In contrast, a larger percentage of wild fish were found in reaches upstream from the Icicle Road Bridge.

Table 6.17. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Wenatchee Basin, 1993-2010.

Survey year	Origin	Survey reach											Total
		W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	Icicle	
1993	Wild	52	133	591	11	77	124	200	37	0	0	0	**1,225**
	Hatchery	9	5	36	1	0	17	2	1	0	0	0	**71**
1994	Wild	0	2	15	1	15	34	18	47	124	1	0	**257**
	Hatchery	0	4	7	0	2	14	0	0	1	0	0	**28**
1995	Wild	0	4	11	0	0	99	49	34	19	0	0	**216**
	Hatchery	0	6	3	0	0	12	0	2	0	0	0	**23**
1996	Wild	0	5	65	37	8	181	26	30	41	0	0	**393**
	Hatchery	0	0	2	2	1	9	0	0	0	0	0	**14**
1997	Wild	1	35	104	4	21	242	7	71	66	13	0	**564**
	Hatchery	0	9	14	0	7	46	0	0	1	0	0	**77**
1998	Wild	6	55	106	2	0	169	25	325	297	56	0	**1,041**
	Hatchery	0	19	35	1	0	79	3	21	27	3	0	**188**
1999	Wild	0	79	55	7	14	525	51	124	155	68	0	**1,078**
	Hatchery	0	81	42	8	17	332	10	9	16	4	0	**519**
2000	Wild	4	68	102	6	51	443	68	100	154	186	0	**1,182**
	Hatchery	3	41	63	1	28	208	7	11	5	7	0	**374**
2001	Wild	0	33	88	4	0	230	29	108	83	78	0	**653**
	Hatchery	0	12	39	22	0	93	4	2	4	3	0	**179**
2002	Wild	0	140	110	0	94	440	0	295	514	150	4	**1,747**
	Hatchery	0	98	60	0	102	369	0	11	6	5	2	**653**
2003	Wild	5	218	118	21	94	425	52	223	445	46	11	**1,658**
	Hatchery	1	105	46	40	38	248	4	14	37	1	25	**559**
2004	Wild	7	108	151	102	97	640	74	282	416	357	0	**2,234**
	Hatchery	1	33	30	55	61	335	13	30	12	9	5	**584**
2005	Wild	4	49	78	24	26	397	66	125	336	243	0	**1,348**
	Hatchery	4	36	28	15	20	310	4	15	17	14	7	**470**
2006	Wild	16	108	133	46	80	753	426	336	700	654	5	**3,257**
	Hatchery	6	32	27	18	32	200	9	7	3	4	13	**351**
2007	Wild	1	9	29	2	16	241	36	37	96	91	3	**561**
	Hatchery	2	6	20	7	10	234	2	1	0	0	5	**287**
2008	Wild	7	17	39	25	21	404	43	35	102	142	2	**869**
	Hatchery	3	17	24	11	15	272	4	7	2	1	6	**130**
2009	Wild	6	22	32	23	20	288	13	55	236	173	5	**873**
	Hatchery	5	7	11	9	7	101	3	3	4	2	1	**153**
2010	Wild	2	22	62	44	64	477	125	47	121	192	0	**1156**
	Hatchery	1	9	36	14	58	204	11	2	3	1	15	**354**
Average	***Wild***	***6***	***62***	***105***	***20***	***39***	***340***	***73***	***128***	***217***	***136***	***2***	***1128***
	Hatchery	***2***	***29***	***29***	***11***	***22***	***171***	***4***	***8***	***8***	***3***	***4***	***279***

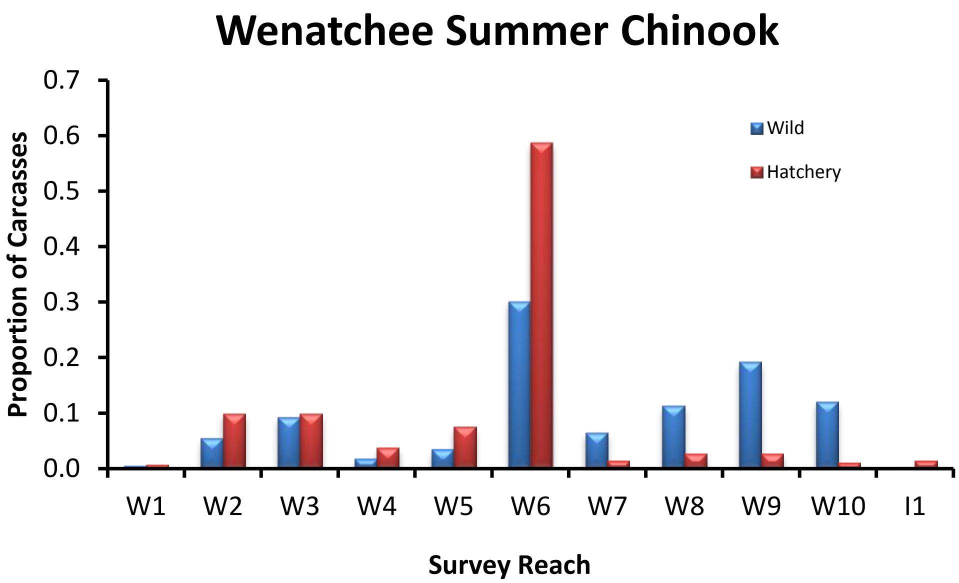

Figure 6.4. Distribution of wild and hatchery produced carcasses in different reaches in the Wenatchee Basin, 1993-2010. Reach codes are described in Table 2.10.

Sampling Rate

If escapement is based on total numbers of redds (based on peak expansion), then about 23% of the total spawning escapement of summer Chinook in the Wenatchee Basin was sampled in 2011 (Table 6.18). Sampling rates among survey reaches varied from 7 to 167%.

Table 6.18. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Wenatchee Basin, 2011.

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Wenatchee 1 (W1)	1	5	3	1.67
Wenatchee 2 (W2)	127	88	406	0.22
Wenatchee 3 (W3)	254	126	813	0.15
Wenatchee 4 (W4)	75	19	240	0.08
Wenatchee 5 (W5)	25	38	80	0.48
Wenatchee 6 (W6)	1,002	1,335	3,206	0.42
Wenatchee 7 (W7)	246	78	787	0.10
Wenatchee 8 (W8)	206	45	659	0.07
Wenatchee 9 (W9)	698	211	2,234	0.09
Wenatchee 10 (W10)	435	289	1,392	0.21
Icicle Creek (I1)	9	9	29	0.31
Total	***3,078***	***2,243***	***9,850***	***0.23***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys in the Wenatchee Basin in 2011 are provided in Table 6.19. The average size of males and females sampled in the Wenatchee basin were 66 cm and 69 cm, respectively.

Table 6.19. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different streams/watersheds in the Wenatchee Basin, 2011.

Stream/watershed	Mean length (cm)	
	Male	Female
Wenatchee 1 (W1)	62.0 (1.4)	67.0 (5.3)
Wenatchee 2 (W2)	66.2 (9.7)	68.8 (5.7)
Wenatchee 3 (W3)	70.0 (13.2)	70.0 (6.2)
Wenatchee 4 (W4)	69.4 (4.9)	71.5 (7.4)
Wenatchee 5 (W5)	64.5 (12.9)	64.1 (8.6)
Wenatchee 6 (W6)	63.3 (10.5)	67.5 (5.8)
Wenatchee 7 (W7)	68.0 (8.3)	65.3 (5.9)
Wenatchee 8 (W8)	67.8 (12.1)	67.1 (6.4)
Wenatchee 9 (W9)	70.3 (9.9)	72.3 (6.1)
Wenatchee 10 (W10)	67.2 (10.1)	71.4 (5.6)
Icicle Creek (I1)	--	66.4 (4.8)
Total	***65.7 (10.9)***	***68.5 (6.2)***

6.7 Life History Monitoring

Life history characteristics of Wenatchee summer Chinook were assessed by examining carcasses on spawning grounds and fish collected or examined at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

Migration timing of hatchery and wild Wenatchee summer Chinook was determined from broodstock data and stock assessment data collected at Dryden Dam. Sampling at Dryden Dam occurs from early July through mid-October. During the early part of the migration, hatchery summer Chinook arrived about one week later than wild Chinook (Table 6.20). This pattern carries through the migration distribution of summer Chinook at Dryden Dam. By the end of the migration, hatchery fish continue to pass Dryden about five weeks after 90% of the wild fish have passed the dam.

Table 6.20. The week that 10%, 50% (median), and 90% of the wild and hatchery summer Chinook salmon passed Dryden Dam, 2007-2011. The average week is also provided. Migration timing is based on collection of summer Chinook broodstock at Dryden Dam.

Survey year	Origin	Wenatchee Summer Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
2007	Wild	28	31	37	31	274
	Hatchery	30	33	41	35	305
2008	Wild	29	31	40	32	219
	Hatchery	32	37	41	37	576
2009	Wild	27	29	41	31	469
	Hatchery	28	34	42	35	382
2010	Wild	30	33	35	32	403
	Hatchery	29	30	33	30	268
2011	Wild	30	31	34	32	293
	Hatchery	32	34	39	35	304
Average	Wild	***28***	***31***	***35***	***32***	***346***
	Hatchery	***29***	***34***	***41***	***35***	***367***

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2010 in the Wenatchee Basin were salt age-3 fish (Table 6.21; Figure 6.5). A higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1, 2, and 3 hatchery fish returned than did salt age-1, 2, and 3 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 6.21. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Wenatchee Basin, 1993-2010.

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1993	Wild	0.02	0.24	0.62	0.12	0.00	1,224
	Hatchery	0.03	0.91	0.03	0.03	0.00	64
1994	Wild	0.02	0.21	0.45	0.32	0.00	257
	Hatchery	0.00	0.14	0.86	0.00	0.00	21
1995	Wild	0.02	0.15	0.65	0.18	0.00	216
	Hatchery	0.00	0.00	0.05	0.95	0.00	21
1996	Wild	0.01	0.25	0.66	0.08	0.00	512
	Hatchery	0.00	0.33	0.33	0.29	0.05	21

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1997	Wild	0.01	0.24	0.57	0.18	0.00	561
	Hatchery	0.05	0.20	0.67	0.08	0.00	75
1998	Wild	0.02	0.23	0.66	0.09	0.00	1,041
	Hatchery	0.03	0.49	0.38	0.10	0.00	187
1999	Wild	0.01	0.34	0.55	0.10	0.00	1,087
	Hatchery	0.01	0.15	0.79	0.05	0.00	510
2000	Wild	0.02	0.20	0.64	0.15	0.00	1,181
	Hatchery	0.07	0.12	0.66	0.15	0.00	343
2001	Wild	0.01	0.16	0.74	0.08	0.00	653
	Hatchery	0.05	0.76	0.14	0.04	0.00	182
2002	Wild	0.00	0.14	0.62	0.24	0.00	1,744
	Hatchery	0.01	0.16	0.80	0.03	0.00	646
2003	Wild	0.01	0.07	0.51	0.41	0.00	1,653
	Hatchery	0.05	0.07	0.75	0.12	0.00	530
2004	Wild	0.00	0.13	0.32	0.54	0.01	2,232
	Hatchery	0.08	0.57	0.25	0.10	0.00	566
2005	Wild	0.00	0.12	0.75	0.13	0.00	1,190
	Hatchery	0.02	0.09	0.86	0.03	0.00	450
2006	Wild	0.00	0.02	0.27	0.71	0.00	2,972
	Hatchery	0.02	0.16	0.24	0.57	0.00	299
2007	Wild	0.01	0.09	0.31	0.53	0.07	480
	Hatchery	0.00	0.15	0.75	0.07	0.03	275
2008	Wild	0.01	0.06	0.76	0.17	0.00	769
	Hatchery	0.02	0.12	0.75	0.11	0.00	332
2009	Wild	0.01	0.07	0.51	0.41	0.00	797
	Hatchery	0.10	0.36	0.49	0.05	0.00	132
2010	Wild	0.01	0.18	0.65	0.16	0.00	1,069
	Hatchery	0.00	0.49	0.46	0.03	0.00	299
Average	***Wild***	***0.01***	***0.14***	***0.53***	***0.32***	***0.00***	***1,091***
	Hatchery	***0.03***	***0.26***	***0.60***	***0.11***	***0.00***	***275***

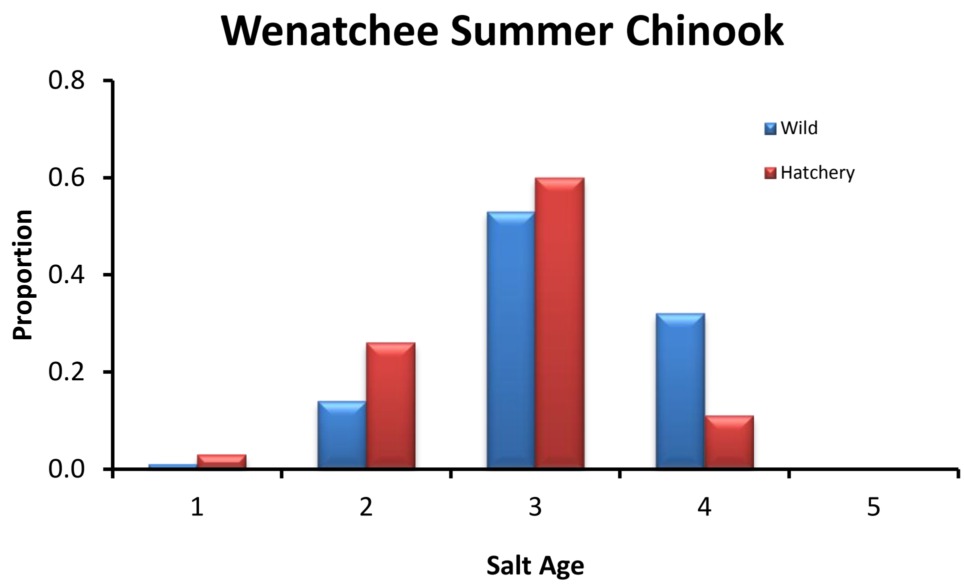

Figure 6.5. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Wenatchee Basin for the combined years 1993-2010.

Size at Maturity

On average, hatchery summer Chinook were about 4 cm smaller than wild summer Chinook sampled in the Wenatchee Basin (Table 6.22). This is interesting given that a slightly higher percentage of hatchery fish returned as age-5 and 6 fish than did wild fish. Analyses for the five-year reports will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 6.22. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Wenatchee Basin, 1993-2010; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	1,344	73	8	33	94
	Hatchery	68	61	9	37	83
1994	Wild	276	73	8	31	89
	Hatchery	25	70	8	54	85
1995	Wild	225	75	7	48	87
	Hatchery	23	74	7	57	85
1996	Wild	210	74	7	43	92
	Hatchery	9	66	12	52	84
1997	Wild	615	74	8	29	99
	Hatchery	78	69	10	29	83
1998	Wild	1,179	73	8	28	97
	Hatchery	188	67	10	37	87
1999	Wild	1,218	72	8	29	95

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
	Hatchery	518	71	8	26	94
2000	Wild	1,302	71	10	24	94
	Hatchery	369	69	11	33	91
2001	Wild	730	70	9	30	93
	Hatchery	179	63	10	28	86
2002	Wild	1,914	72	8	39	94
	Hatchery	653	71	8	34	95
2003	Wild	1,950	74	9	24	105
	Hatchery	546	69	10	26	97
2004	Wild	2,571	72	9	32	98
	Hatchery	580	59	11	25	91
2005	Wild	1,352	69	7	41	92
	Hatchery	469	69	8	39	91
2006	Wild	3,249	74	6	29	99
	Hatchery	350	71	9	35	90
2007	Wild	566	73	9	29	92
	Hatchery	269	70	7	45	87
2008	Wild	836	69	8	29	89
	Hatchery	363	70	9	24	94
2009	Wild	872	71	8	30	94
	Hatchery	153	64	11	32	84
2010	Wild	1,147	68	8	32	92
	Hatchery	351	65	10	25	87
Pooled	***Wild***	***21,556***	***72***	***8***	***24***	***105***
	Hatchery	***5,191***	***68***	***9***	***24***	***97***

Contribution to Fisheries

Most of the harvest on hatchery-origin Wenatchee summer Chinook occurred in the ocean (Table 6.23). Ocean harvest has made up 47% to 100% of all hatchery Wenatchee summer Chinook harvested. Total harvest on early brood years (1990-1996) was lower than for later brood years (1997-2005).

Table 6.23. Estimated number and percent (in parentheses) of hatchery-origin Wenatchee summer Chinook captured in different fisheries, brood years 1989-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	1,510 (51)	1,432 (48)	0 (0)	20 (1)	2,962
1990	30 (100)	0 (0)	0 (0)	0 (0)	30
1991	30 (63)	0 (0)	0 (0)	18 (38)	48
1992	149 (79)	39 (21)	0 (0)	0 (0)	189
1993	40 (62)	25 (38)	0 (0)	0 (0)	65
1994	642 (91)	62 (9)	2 (0)	0 (0)	706
1995	560 (98)	9 (2)	5 (1)	0 (0)	574
1996	195 (96)	3 (1)	0 (0)	6 (3)	204
1997	3,008 (95)	49 (2)	12 (1)	106 (3)	3,175
1998	4,974 (92)	128 (2)	16 (0)	287 (5)	5,405
1999	1,548 (84)	168 (9)	21 (1)	105 (6)	1,842
2000	7,941 (73)	1,248 (11)	447 (4)	1,225 (11)	10,861
2001	1,056 (60)	238 (13)	106 (6)	366 (21)	1,766
2002	1,488 (56)	557 (21)	189 (7)	431 (16)	2,665
2003	819 (50)	484 (29)	89 (5)	257 (16)	1,649
2004	406 (47)	218 (25)	70 (8)	167 (19)	861
2005	1,338 (58)	481 (21)	186 (8)	288 (13)	2,293

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Wenatchee Basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Hatchery-origin Wenatchee summer Chinook have strayed into the Entiat, Chelan, Methow, and Okanogan basins and into the Hanford Reach (Table 6.24). In four different years, Wenatchee summer Chinook strays have made up more than 5% of the spawning escapement in the Chelan Tailrace. They have made up more than 5% of the spawning escapement in the Entiat and Methow basins in five different years. Few have strayed into the Okanogan Basin or into the Hanford Reach.

Table 6.24. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Wenatchee summer Chinook, return years 1994-2008. For example, for return year 2000, 3% of the summer Chinook escapement in the Methow Basin consisted of hatchery-origin Wenatchee summer Chinook. Percent strays should be less than 5%.

Return year	Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	75	1.9	-	-	-	-	-	-
1995	0	0.0	0	0.0	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-
1998	25	3.7	0	0.0	0	0.0	0	0.0	0	0.0
1999	20	2.0	3	0.1	0	0.0	0	0.0	13	0.1
2000	36	3.0	13	0.4	0	0.0	0	0.0	0	0.0
2001	163	5.9	57	0.5	30	3.0	0	0.0	0	0.0
2002	153	3.3	53	0.4	40	6.9	74	14.8	0	0.0
2003	80	2.0	24	0.7	44	10.5	132	19.1	26	0.0
2004	113	5.2	42	0.6	30	7.1	0	0.0	0	0.0
2005	245	9.6	67	0.8	51	11.5	49	13.4	0	0.0
2006	170	6.2	12	0.1	12	2.9	18	3.1	0	0.0
2007	127	9.3	5	0.1	9	4.8	18	7.3	20	0.1
2008	87	4.5	24	0.3	10	2.0	31	9.7	0	0.0
Total	***1,219***	***4.6***	***375***	***0.5***	***226***	***5.2***	***322***	***9.2***	***59***	***0.0***

Based on brood year analyses, on average, about 11% of the hatchery-origin Wenatchee summer Chinook returns have strayed into non-target spawning areas, exceeding the target of 5% (Table 6.25). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-19%. In addition, on average, about 5.2% have strayed into non-target hatchery programs, but straying into non-target programs has declined over time.

Table 6.25. Number and percent of hatchery-origin Wenatchee summer Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2005. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	1,352	62.9	60	2.8	75	3.5	662	30.8
1990	74	84.1	1	1.1	0	0.0	13	14.8
1991	14	60.9	1	4.3	0	0.0	8	34.8
1992	375	84.8	7	1.6	0	0.0	60	13.6
1993	67	72.8	9	9.8	4	4.3	12	13.0
1994	890	71.8	207	16.7	61	4.9	81	6.5

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	748	74.8	139	13.9	48	4.8	65	6.5
1996	261	70.4	42	11.3	53	14.3	15	4.0
1997	3,609	85.6	171	4.1	397	9.4	37	0.9
1998	1,790	78.5	11	0.5	416	18.2	64	2.8
1999	507	79.7	0	0.0	121	19.0	8	1.3
2000	2,745	83.0	0	0.0	526	15.9	37	1.1
2001	521	82.0	0	0.0	105	16.5	9	1.4
2002	1,521	85.3	10	0.6	244	13.7	8	0.4
2003	1,268	88.6	42	2.9	112	7.8	9	0.6
2004	493	84.1	3	0.5	72	12.3	18	3.1
2005	1,069	84.1	3	0.2	180	14.2	19	1.5
Total	***17,304***	***80.3***	***706***	***3.3***	***2,414***	***11.2***	***1,125***	***5.2***

Genetics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix K). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

Except for brood year 1999, the PNI has been greater than 0.67 (Table 6.26). This indicates that the natural environment has a greater influence on adaptation of Wenatchee summer Chinook than does the hatchery environment.

Table 6.26. Proportionate natural influence (PNI) of the Wenatchee summer Chinook supplementation program for brood years 1989-2010. PNI was calculated as the proportion of naturally produced Chinook in the hatchery broodstock (pNOB) divided by the proportion of hatchery Chinook on the spawning grounds (pHOS) plus pNOB. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	14,331	0	0.00	290	0	1.00	1.00
1990	10,861	0	0.00	57	0	1.00	1.00
1991	10,168	0	0.00	105	0	1.00	1.00
1992	11,652	0	0.00	274	0	1.00	1.00
1993	8,810	640	0.07	406	44	0.90	0.93
1994	8,378	1,776	0.17	333	54	0.86	0.83
1995	6,813	942	0.12	363	16	0.96	0.89
1996	5,991	177	0.03	263	3	0.99	0.97
1997	5,381	532	0.09	205	13	0.94	0.91
1998	4,003	1,349	0.25	299	78	0.79	0.76
1999	3,971	1,505	0.27	242	236	0.51	0.65
2000	4,381	1,131	0.21	275	180	0.60	0.74
2001	9,262	2,096	0.18	210	136	0.61	0.77
2002	11,691	4,032	0.26	409	10	0.98	0.79
2003	9,760	2,040	0.17	337	7	0.98	0.85
2004	9,085	1,394	0.13	424	2	1.00	0.88
2005	6,862	1,841	0.21	397	3	0.99	0.83
2006	16,060	1,732	0.10	433	4	0.99	0.91

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
2007	3,173	1,417	0.31	263	3	0.99	0.76
2008	4,794	1,702	0.26	378	69	0.85	0.77
2009	7,113	1,214	0.15	452	8	0.98	0.87
2010	5,879	1,589	0.21	388	5	0.99	0.83
Average	***8,110***	***1,232***	***0.15***	***305***	***41***	***0.90***	***0.86***

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). For brood years 1989-2004, NRR for summer Chinook in the Wenatchee averaged 0.95 (range, 0.16-2.90) if harvested fish were not include in the estimate and 2.64 (range, 0.36-9.79) if harvested fish were included in the estimate (Table 6.27). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.30 (the calculated target value in Murdoch and Peven 2005). HRRs exceeded NRRs in 12 of the 16 years of data, regardless if harvest was or was not included in the estimate (Table 6.27). Hatchery replacement rates for Wenatchee summer Chinook have exceeded the estimated target value of 5.30 in three or six of the 16 years of data depending on if harvest was or was not included in the estimate.

Table 6.27. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for summer Chinook in the Wenatchee Basin, brood years 1989-2004.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	346	14,331	2,149	9,141	6.21	0.64	5,111	21,713	14.77	1.52
1990	87	10,861	88	9,463	1.01	0.87	118	12,805	1.36	1.18
1991	128	10,168	23	5,556	0.18	0.55	71	17,148	0.55	1.69
1992	341	11,652	442	5,875	1.30	0.50	630	8,441	1.85	0.72
1993	524	9,450	92	5,025	0.18	0.53	157	8,575	0.30	0.91
1994	418	10,154	1,239	3,877	2.96	0.38	1,945	6,106	4.65	0.60
1995	398	7,755	1,000	5,220	2.51	0.67	1,574	8,273	3.95	1.07
1996	334	6,168	371	4,354	1.11	0.71	575	6,803	1.72	1.10
1997	240	5,913	4,214	9,585	17.56	1.62	7,389	16,845	30.79	2.85
1998	472	5,352	2,281	15,514	4.83	2.90	7,686	52,412	16.28	9.79
1999	488	5,476	636	11,854	1.30	2.16	2,478	46,486	5.08	8.49
2000	492	5,512	3,308	3,981	6.72	0.72	14,169	17,086	28.80	3.10
2001	493	11,360	635	19,058	1.29	1.68	2,401	72,464	4.87	6.38

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
2002	482	15,723	1,783	4,911	3.70	0.31	4,448	12,308	9.23	0.78
2003	496	11,800	1,431	1,940	2.89	0.16	3,080	4,199	6.21	0.36
2004	496	10,479	586	7,441	1.18	0.71	1,447	18,510	2.92	1.77
Average	***390***	***9,510***	***1,267***	***7,675***	***3.43***	***0.95***	***3,330***	***20,636***	***8.33***	***2.64***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. SARs were based on CWT returns. For the available brood years, SARs have ranged from 0.00037 to 0.01530 for hatchery summer Chinook in the Wenatchee basin (Table 6.28).

Table 6.28. Smolt-to-adult ratios (SARs) for Wenatchee hatchery summer Chinook, brood years 1989-2005.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	144,905	1,027	0.00709
1990	119,214	115	0.00096
1991	190,371	71	0.00037
1992	605,055	615	0.00102
1993	210,626	157	0.00075
1994	452,340	1,920	0.00424
1995	668,409	1,540	0.00230
1996	585,590	567	0.00097
1997	480,418	7,351	0.01530
1998	641,109	7,611	0.01187
1999	988,328	2,456	0.00249
2000	903,368	13,816	0.01528
2001	596,618	2,386	0.00400
2002	805,919	4,318	0.00536
2003	639,381	3,032	0.00474
2004	603,942	1,432	0.00237
2005	631,492	3,517	0.00557
Average	***545,123***	***3,055***	***0.00498***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

6.8 ESA/HCP Compliance

Broodstock Collection

Per the 2009 broodstock collection protocol, 492 natural-origin (adipose fin present) summer Chinook adults were targeted for collection at Dryden and Tumwater dams. The actual 2009 collection totaled 491 summer Chinook (482 natural-origin and 9 hatchery-origin; the hatchery origin fish were not direct collections but rather adipose present non-wired fish with a hatchery scale pattern) in combination from Dryden Dam and Tumwater Dam. Trapping began 1 July and ended 27 August 2009.

Summer Chinook and steelhead broodstock collections occurred concurrently at Dryden Dam; therefore, steelhead and spring Chinook encounters at Dryden Dam during Wenatchee summer Chinook broodstock collection were attributable to steelhead broodstock collections authorized under ESA Permit 1395 take authorizations. No steelhead or spring Chinook takes were associated with the Wenatchee summer Chinook collection.

Consistent with impact minimization measures in ESA Permit 1347, all ESA-listed species handled during summer Chinook broodstock collection were subject to water-to-water transfers or anesthetized if removed from water during handling.

Hatchery Rearing and Release

The 2009 Wenatchee summer Chinook program released an estimated 843,866 smolts, representing 97.7% of the 864,000 programmed production and was within the 10% overage allowance identified in ESA permit 1347.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January 2010 through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Smolt and Emigrant Trapping

ESA-listed spring Chinook and steelhead were encountered during operation of the Lower Wenatchee Trap. ESA takes are reported in the steelhead (Section 3.8) and spring Chinook (Section 5.8) sections and are not repeated here.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Wenatchee Basin during 2011 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 7: METHOW SUMMER CHINOOK

7.1 Broodstock Sampling

This section focuses on results from sampling 2009-2010 Methow summer Chinook broodstock, which were collected in the East and West Ladder of Wells Dam in 2009, and the West Ladder in 2010. Summer Chinook adults collected at Wells Dam are also used in the Okanogan/Similkameen supplementation program. Complete information is not currently available for the 2011 return (this information will be provided in the 2012 annual report).

Origin of Broodstock

Both 2009 and 2010 broodstock consisted almost entirely of natural-origin (adipose fin present) summer Chinook (Table 7.1). These fish were used for both the Methow and Okanogan supplementation programs. In 2010, to meet production goals, hatchery-origin adults were collected in concert with natural-origin fish. About 2% of the 2010 broodstock were comprised of hatchery-origin fish (hatchery-origin was determined by examination of scales and CWTs).

Table 7.1. Numbers of wild and hatchery summer Chinook collected for broodstock, numbers that died before spawning, and numbers of Chinook spawned for the Methow/Okanogan programs, 1989-2010. Unknown origin fish (i.e., undetermined by scale analysis, no CWT or fin clips, and no additional hatchery marks) were considered naturally produced. Mortality includes fish that died of natural causes typically near the end of spawning and were not needed for the program and surplus fish killed at spawning.

Brood year	Wild summer Chinook					Hatchery summer Chinook					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
1989[a]	1,419	72	-	1,297	-	341	17	-	312	-	1,609
1990[a]	864	34	-	828	-	214	8	-	206	-	1,034
1991[a]	1,003	59	-	924	-	341	20	-	314	-	1,238
1992[a]	312	6	-	297	-	428	9	-	406	-	703
1993[a]	813	48	-	681	-	464	28	-	388	-	1,069
1994	385	33	11	341	12	266	15	7	244	1	585
1995	254	13	10	173	58	351	28	9	240	74	413
1996	316	15	11	290	0	234	2	9	223	0	513
1997	214	11	5	198	0	308	24	20	264	0	462
1998	239	28	58	153	0	348	18	119	211	0	364
1999	248	5	19	224	0	307	2	16	289	0	513
2000	184	15	5	164	0	373	17	17	339	0	503
2001	135	8	36	91	0	423	29	128	266	0	357
2002	270	2	21	247	0	285	11	33	241	0	488
2003	449	14	53	381	0	112	2	9	101	0	482
2004	541	23	12	506	0	17	0	1	16	0	522
2005	551	29	76	391	55	12	2	0	9	1	400
2006	579	50	10	500	19	12	2	0	10	0	510
2007	504	22	26	456	0	19	0	2	17	0	473
2008	418	5	9	404	0	41	0	0	41	0	445

Brood year	Wild summer Chinook					Hatchery summer Chinook					Total number spawned
	Number collected	Prespawn loss	Mortality	Number spawned	Number released	Number collected	Prespawn loss	Mortality	Number spawned	Number released	
2009	553	31	15	507	0	5	5	0	0	0	507
2010	503	13	6	484	0	8	0	0	8	0	492
Average[b]	***489***	***24***	***23***	***434***	***8***	***223***	***11***	***22***	***188***	***4***	***622***

[a] Number of fish spawned and collected during these years included fish retained from the right- and left-bank ladder traps at Wells Dam and fish collected from the volunteer channel. There was no distinction made between fish collected at trap locations and program (i.e., aggregated population used for Wells, Methow, and Okanogan summer Chinook programs).
[b] Because of bias from aggregating the spawning population from 1989-1993, averages are based on adult numbers collected from 1994-2006.

Age/Length Data

Ages of summer Chinook broodstock were determined from analysis of scales and/or CWTs. Broodstock collected from the 2009 return consisted primarily of age-4 and 5 natural-origin Chinook (89%) and age-5 hatchery-origin Chinook (100%). Age-2 and 3 natural-origin fish collectively made up 15% of the broodstock (Table 7.2). Age-3 and 6 hatchery-origin Chinook collectively made up 11% of the broodstock (Table 7.2).

Broodstock collected from the 2010 return consisted primarily of age-4 and 5 natural-origin Chinook (83%) and age-4 and 5 hatchery-origin Chinook (75%). Age-2 and 3 natural-origin fish collectively made up 17% of the broodstock (Table 7.2). Age-3 and 6 hatchery-origin Chinook collectively made up 25% of the broodstock (Table 7.2).

Table 7.2. Percent of hatchery and wild summer Chinook of different ages (total age) collected from broodstock for the Methow/Okanogan programs, 1991-2010.

Return Year	Origin	Total age				
		2	3	4	5	6
1991	Wild	0.5	6.8	35.1	55.4	2.2
	Hatchery	0.5	5.1	36.2	49.0	9.2
1992	Wild	0.0	13.1	36.2	50.7	0.0
	Hatchery	0.0	0.0	0.0	0.0	0.0
1993	Wild	0.0	3.9	75.3	20.8	0.0
	Hatchery	0.0	1.0	85.9	13.1	0.0
1994	Wild	3.1	9.7	26.3	60.3	0.6
	Hatchery	0.0	14.7	11.3	74.0	0.0
1995	Wild	0.0	4.6	15.2	75.6	4.6
	Hatchery	0.0	0.4	13.0	25.6	61.0
1996	Wild	0.0	8.4	56.6	30.4	4.6
	Hatchery	0.0	3.0	31.0	47.0	19.0
1997	Wild	1.0	9.3	52.9	34.8	2.0
	Hatchery	0.0	20.7	10.8	62.0	6.5
1998	Wild	2.0	14.1	54.8	29.1	0.0
	Hatchery	2.3	18.5	56.6	15.9	6.7
1999	Wild	4.7	5.1	53.7	36.0	0.5
	Hatchery	0.3	3.6	28.0	66.1	2.0

Return Year	Origin	Total age				
		2	3	4	5	6
2000	Wild	0.6	14.0	28.7	56.1	0.6
	Hatchery	0.0	27.0	14.3	54.3	4.3
2001	Wild	7.1	26.0	52.0	11.8	3.1
	Hatchery	0.3	19.8	68.1	9.5	2.3
2002	Wild	0.4	17.4	66.0	16.2	0.0
	Hatchery	0.0	2.4	39.4	58.2	0.0
2003	Wild	0.7	3.9	65.9	29.5	0.0
	Hatchery	0.9	5.6	18.5	69.4	5.6
2004	Wild	0.8	15.3	11.6	72.1	0.2
	Hatchery	0.0	6.7	53.3	33.3	6.7
2005	Wild	0.0	17.2	69.9	11.0	1.9
	Hatchery	0.0	1.0	40.0	50.0	0.0
2006	Wild	1.6	3.0	41.0	52.9	1.5
	Hatchery	0.0	16.7	25.0	50.0	8.3
2007	Wild	1.8	15.3	8.2	70.2	4.5
	Hatchery	0.0	0.0	21.1	57.9	21.0
2008	Wild	0.3	17.1	67.8	13.6	1.2
	Hatchery	0.0	2.6	52.7	42.1	2.6
2009	Wild	1.3	10.0	68.3	20.4	0.0
	Hatchery	0.0	0.0	0.0	100.0	0.0
2010	Wild	0.21	16.4	50.8	32.6	0.0
	Hatchery	0.0	12.5	50.0	25.0	12.5
Average	***Wild***	***1.3***	***11.5***	***46.8***	***39.0***	***1.4***
	Hatchery	***0.2***	***8.1***	***32.8***	***45.1***	***8.4***

Mean lengths of natural-origin summer Chinook of a given age differed little between 2009 and 2010 (Table 7.3). Average fork lengths for age-5 natural-origin adults were 20 cm longer than that of age-5 hatchery fish (Table 7.3). Differences in hatchery-origin and natural-origin fish were hard to discern given the small sample size of hatchery-origin fish (i.e., few hatchery fish were included in the broodstock).

Table 7.3. Mean fork length (cm) at age (total age) of hatchery and wild Methow/Okanogan summer Chinook collected from broodstock for the Methow/Okanogan programs, 1991-2010; N = sample size and SD = 1 standard deviation.

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
1991	Wild	47	1	-	68	15	6	82	78	10	94	123	8	97	5	5
	Hatchery	47	1	-	49	10	6	78	71	5	91	96	8	96	18	6
1992	Wild	-	0	-	55	9	5	69	25	6	78	35	6	-	0	-

Return year	Origin	Summer Chinook fork length (cm)														
		Age-2			Age-3			Age-4			Age-5			Age-6		
		Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD	Mean	N	SD
	Hatchery	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
1993	Wild	-	0	-	72	3	4	86	58	7	98	16	5	-	0	-
	Hatchery	-	0	-	42	1	-	76	85	8	88	13	6	-	0	-
1994	Wild	42	10	6	51	31	7	80	84	9	93	193	8	104	2	13
	Hatchery	-	0	-	49	38	5	76	29	7	88	191	7	-	0	-
1995	Wild	-	0	-	67	6	8	79	20	9	96	99	5	94	6	5
	Hatchery	-	0	-	52	1	-	73	32	9	89	63	9	95	150	8
1996	Wild	-	0	-	68	22	9	83	149	8	95	80	7	101	12	5
	Hatchery	-	0	-	52	7	10	77	72	7	90	109	8	100	44	7
1997	Wild	36	2	6	60	19	7	85	108	8	96	71	7	98	4	11
	Hatchery	-	0	-	45	63	5	71	33	9	92	189	7	97	20	7
1998	Wild	43	4	6	59	23	6	83	107	7	96	58	7	-	0	-
	Hatchery	42	8	7	50	64	6	74	190	8	92	54	8	98	23	5
1999	Wild	38	10	3	64	11	8	82	115	8	96	77	6	104	1	-
	Hatchery	37	1	-	53	11	9	75	92	7	91	204	6	98	6	5
2000	Wild	39	1	-	66	23	7	83	47	6	96	92	5	95	1	-
	Hatchery	-	0	-	54	100	7	78	53	8	93	201	6	99	16	6
2001	Wild	40	9	3	65	33	8	87	66	8	93	15	5	97	4	16
	Hatchery	44	1	-	51	79	7	78	271	8	93	38	7	102	9	5
2002	Wild	56	1	-	65	44	7	88	167	6	100	41	7	-	0	-
	Hatchery	-	0	-	45	6	5	76	100	7	95	148	5	-	0	-
2003	Wild	43	3	6	61	16	6	87	268	7	99	120	6	-	0	-
	Hatchery	49	1	-	55	6	9	73	20	8	91	75	7	102	6	9
2004	Wild	51	4	4	67	78	6	81	59	6	97	368	7	99	1	-
	Hatchery	-	0	-	52	1	-	70	8	5	97	5	8	109	1	-
2005	Wild	-	0	-	68	89	6	83	363	8	94	57	6	101	10	7
	Hatchery	-	0	-	55	1	-	70	4	4	89	5	4	-	0	-
2006	Wild	48	9	3	69	16	4	88	222	7	97	286	6	97	8	6
	Hatchery	-	0	-	52	2	0	80	3	3	88	6	7	94	1	-
2007	Wild	50	8	6	69	69	9	85	37	8	98	317	6	96	20	8
	Hatchery	-	0	-	-	0	-	70	4	2	94	11	7	91	4	18
2008	Wild	52	1	-	70	67	6	87	265	6	95	53	7	103	5	7
	Hatchery	-	0	-	55	1	-	79	20	5	89	16	7	104	1	-
2009	Wild	49	7	6	69	54	7	91	368	6	99	110	6	-	0	-
	Hatchery	-	0	-	-	0	-	-	0	-	79	1	-	-	0	-
2010	Wild	56	1	-	70	79	6	90	245	6	98	157	6	-	0	-
	Hatchery	-	0	-	74	1	-	86	4	6	99	2	1	117	1	-

Sex Ratios

Male summer Chinook in the 2009 broodstock made up about 47% of the adults collected, resulting in an overall male to female ratio of 0.89:1.00 (Table 7.4.). In 2010, males made up about 49.5% of the adults collected, resulting in an overall male to female ratio of 0.98:1.00 (Table 7.4). The ratio for both 2009 and 2010 broodstock was below the assumed 1:1 ratio goal in the broodstock protocol.

Table 7.4. Numbers of male and female wild and hatchery summer Chinook collected for broodstock at Wells Dam for the Methow/Okanogan programs, 1991-2010. Ratios of males to females are also provided.

Return year	Number of wild summer Chinook			Number of hatchery summer Chinook			Total M/F ratio
	Males (M)	Females (F)	M/F	Males (M)	Females (F)	M/F	
1989[a]	752	667	1.13:1.00	181	160	1.13:1.00	1.13:1.00
1990[a]	381	482	0.79:1.00	95	120	0.79:1.00	0.79:1.00
1991[a]	443	559	0.79:1.00	151	191	0.79:1.00	0.79:1.00
1992[a]	349	318	1.10:1.00	38	35	1.09:1.00	1.10:1.00
1993[a]	513	300	1.71:1.00	293	171	1.71:1.00	1.71:1.00
1994	205	180	1.14:1.00	165	101	1.63:1.00	1.32:1.00
1995	103	149	0.69:1.00	158	197	0.80:1.00	0.75:1.00
1996	178	138	1.29:1.00	132	102	1.29:1.00	1.29:1.00
1997	102	112	0.91:1.00	174	134	1.30:1.00	1.12:1.00
1998	130	109	1.19:1.00	263	85	3.09:1.00	2.03:1.00
1999	138	110	1.25:1.00	161	146	1.10:1.00	1.17:1.00
2000	82	102	0.80:1.00	243	130	1.87:1.00	1.40:1.00
2001	89	46	1.93:1.00	311	112	2.78:1.00	2.53:1.00
2002	166	104	1.60:1.00	149	136	1.10:1.00	1.31:1.00
2003	255	194	1.31:1.00	61	51	1.20:1.00	1.29:1.00
2004	263	278	0.95:1.00	12	5	2.40:1.00	0.97:1.00
2005	365	186	1.96:1.00	6	6	1.00:1.00	1.93:1.00
2006	287	292	0.98:1.00	9	3	3.00:1.00	1.00:1.00
2007	228	276	0.83:1.00	11	8	1.38:1.00	0.84:1.00
2008	210	208	1.01:1.00	13	28	0.46:1.00	0.94:1.00
2009	261	292	0.89:1.00	2	3	0.67:1.00	0.89:1.00
2010	248	255	0.97:1.00	5	3	1.67:1.00	0.98:1.00
Total[b]	***5,748***	***5,357***	***1.07:1.00***	***2,633***	***1,927***	***1.37:1.00***	***1.15:1.00***

[a] Numbers and male to female ratios were derived from the aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.
[b] Total values were derived from 1994-present data to exclude aggregate population bias from 1989-1993 returns.

Fecundity

Fecundities for the 2009 and 2010 summer Chinook broodstock averaged 5,115 and 5,116 eggs per female, respectively (Table 7.5). These values are close to the overall average of 4,991 eggs per female. Mean observed fecundities for the 2009 and 2010 returns were slightly above the expected fecundity of 5,000 eggs per female assumed in the broodstock protocol.

Table 7.5. Mean fecundity of wild, hatchery, and all female summer Chinook collected for broodstock at Wells Dam for the Methow/Okanogan programs, 1989-2010; NA = not available.

Return year	Mean fecundity		
	Wild	Hatchery	Total
1989*	NA	NA	4,750
1990*	NA	NA	4,838
1991*	NA	NA	4,819
1992*	NA	NA	4,804
1993*	NA	NA	4,849
1994*	NA	NA	5,907
1995*	NA	NA	4,930
1996*	NA	NA	4,870
1997	5,166	5,296	5,237
1998	5,043	4,595	4,833
1999	4,897	4,923	4,912
2000	5,122	5,206	5,170
2001	5,040	4,608	4,735
2002	5,306	5,258	5,279
2003	5,090	4,941	5,059
2004	5,130	5,118	5,130
2005	4,545	4,889	4,553
2006	4,854	4,824	4,854
2007	5,265	5,093	5,260
2008	4,814	4,588	4,787
2009	5,115	-	5,115
2010	5,124	4,717	5,116
Average	***5,037***	***4,927***	***4,991***

* Individual fecundities were not assigned to females until 1997 brood.

7.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 493,827 eggs are needed to meet the program release goal of 400,000 smolts. From 1989 through 2010, the egg take goal was reached in seven of those years (Table 7.6).

Table 7.6. Numbers of eggs taken from summer Chinook broodstock collected at Wells Dam for the Methow/Okanogan programs, 1989-2010.

Return year	Number of eggs taken
1989	482,800
1990	464,097
1991	586,594
1992	486,260
1993	531,490
1994	595,390
1995	491,000
1996	448,000
1997	401,162
1998	389,346
1999	483,726
2000	403,268
2001	279,272
2002	466,530
2003	473,681
2004	537,210
2005	305,826
2006	509,334
2007	549,802
2008	441,778
2009	560,602
2010	505,188
Average	***472,380***

Number of acclimation days

Rearing of the 2009 brood Methow summer Chinook was similar to previous years with fish being held on well water before being transferred to Carlton Pond for final acclimation on Methow River water in March 2011 (Table 7.7). Groups of the 1994 and 1995 broods were reared for longer durations at Methow FH on Methow River water.

Table 7.7. Number of days Methow summer Chinook were acclimated at Carlton Pond, brood years 1989-2009.

Brood year	Release year	Transfer date	Release date	Number of days
1989	1991	15-Mar	6-May	52
1990	1992	26-Feb	28-Apr	61
1991	1993	10-Mar	23-Apr	44
1992	1994	4-Mar	21-Apr	48

Brood year	Release year	Transfer date	Release date	Number of days
1993	1995	18-Mar	2-May	45
1994	1996	25-Sep	28-Apr	215
		19-Mar	28-Apr	40
1995	1997	22-Oct	8-Apr	168
		19-Mar	22-Apr	34
1996	1998	9-Mar	14-Apr	36
1997	1999	10-Mar	20-Apr	41
1998	2000	19-Mar	2-May	44
1999	2001	18-Mar	18-Apr	31
2000	2002	28-Mar	1-May	34
2001	2003	27-Mar	24-Apr	28
2002	2004	16-Mar	24-Apr	39
2003	2005	18-Mar	21-Apr	34
2004	2006	12-Mar	22-Apr	41
2005	2007	12-Mar	15-Apr – 8-May	34-57
2006	2008	4-7-Mar	16-Apr – 2 May	40-59
2007	2009	18-24-Mar	21-Apr	28-34
2008	2010	4-5, 8-9-Mar	4-21-Apr	33-50
2009	2011	25, 29, 31-Mar & 4-Apr	11-25-Apr	8-31

Release Information

Numbers released

The 2009 brood Methow summer Chinook program achieved 101% of the 400,000 target goal with about 404,956 fish being released volitionally on 11-25 April 2011 (Table 7.8).

Table 7.8. Numbers of Methow summer Chinook smolts released from the hatchery, brood years 1989-2009. The release target for Methow summer Chinook is 400,000 smolts.

Brood year	Release year	CWT mark rate	Number of smolts released
1989	1991	0.8529	420,000
1990	1992	0.9485	391,650
1991	1993	0.6972	540,900
1992	1994	0.9752	402,641
1993	1995	0.4623	433,375
1994	1996	0.9851	406,560
1995	1997	0.9768	353,182
1996	1998	0.9221	298,844

Brood year	Release year	CWT mark rate	Number of smolts released
1997	1999	0.9884	384,909
1998	2000	0.9429	205,269
1999	2001	0.9955	424,363
2000	2002	0.9928	336,762
2001	2003	0.9902	248,595
2002	2004	0.9913	399,975
2003	2005	0.9872	354,699
2004	2006	0.9848	400,579
2005	2007	0.9897	263,723
2006	2008	0.9783	419,734
2007	2009	0.9837	433,256
2008	2010	0.9394	397,554
2009	2011	0.9862	404,956
Average		***0.9319***	***377,216***

Numbers tagged

The 2009 brood Methow summer Chinook were 98.6% CWT and adipose fin-clipped (Table 7.8).

No juvenile hatchery summer Chinook were PIT tagged in 2011. Table 7.9 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Methow River.

Table 7.9. Summary of PIT-tagging activities for Methow hatchery summer Chinook, brood years 2008-2010; NA = data not available.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	10,100	4	0	10,096
2009	2011	5,050	17	9	5,024
2010	2012	0	0	0	0

Fish size and condition at release

Fish were released volitionally as yearling smolts during the period 11-25 April 2011. Size at release from the acclimated population was 96.6% and 125% of the respective target fork length and weight goals (Table 7.10). This brood year exceeded the target CV for length by 76%.

Table 7.10. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Methow summer Chinook smolts released from the hatchery, brood years 1991-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1991	1993	152	13.6	40.3	11
1992	1994	145	16.0	37.2	12
1993	1995	154	8.6	37.1	12
1994	1996	163	8.2	48.2	9
1995	1997	141	9.6	37.0	12
1996	1998	199	13.1	105.1	4
1997	1999	153	7.6	39.5	12
1998	2000	164	8.7	51.7	9
1999	2001	153	9.3	41.5	11
2000	2002	170	10.2	54.2	8
2001	2003	167	7.4	52.7	9
2002	2004	148	13.1	35.7	13
2003	2005	148	10.1	35.5	13
2004	2006	142	9.8	31.1	15
2005	2007	158	15.0	42.2	11
2006	2008	156	18.0	42.8	11
2007	2009	138	21.0	32.1	14
2008	2010	155	14.2	42.0	11
2009	2011	170	15.8	56.9	8
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of the Methow summer Chinook from green (unfertilized) egg-to-release was above the standard set for the program (Table 7.11). High survival can be attributed to exceeding the survival standards set for the program and just missing the unfertilized egg-eyed egg and the eyed egg-ponding survival rates. Currently, it is unknown if gamete viability is gender biased or is uniform between sexes and more influenced by between-year environmental variations.

It is important to note that the Methow summer Chinook program typically receives progeny from the highest ELISA females, while the lowest titer progeny are reserved for the Okanogan program. The inability to effectively manage bacterial kidney disease at Similkameen Pond during the winter months precludes an even mix of progeny for a given brood year between the two programs. As a result, in some years poor survival performance at any level may be more directly related to this procedure than a function of the overall program.

Table 7.11. Hatchery life-stage survival rates (%) for Methow summer Chinook, brood years 1989-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
1989[a]	89.8	99.5	89.9	96.7	99.7	99.4	73.3	98.5	87.0
1990[a]	93.9	99.0	84.9	97.1	81.2	80.6	97.7	99.5	84.4
1991[a]	93.1	95.5	88.2	98.0	99.4	99.1	97.5	99.6	92.2
1992[a]	96.9	99.0	87.8	98.0	99.9	99.9	90.9	98.3	82.8
1993[a]	82.2	99.4	85.4	97.6	99.8	99.5	92.0	99.4	81.5
1994	96.1	90.0	86.6	100.0	98.1	97.4	73.1	99.1	68.3
1995	91.9	96.2	98.2	84.1	96.5	96.2	92.7	89.6	71.9
1996	95.4	98.1	83.2	100.0	97.7	96.9	86.5	89.0	66.7
1997	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.7	95.9
1998	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.9	52.7
1999	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.9	87.7
2000	90.5	96.9	89.2	98.1	98.5	98.3	94.6	94.4	83.5
2001	96.2	92.3	89.1	97.6	97.2	97.1	97.5	99.8	89.0
2002	97.1	98.1	88.3	99.9	97.7	97.5	96.7	99.9	85.7
2003	96.7	97.5	82.8	98.2	99.7	99.2	93.7	99.9	74.9
2004	93.6	98.2	84.0	97.8	99.6	99.2	98.3	98.5	74.6
2005	97.0	89.6	88.0	95.5	99.6	98.9	96.6	99.9	86.2
2006	92.9	89.5	86.3	98.3	99.6	98.7	97.2	99.5	82.4
2007	92.6	99.6	84.1	98.5	99.7	99.5	98.9	99.8	81.9
2008	99.6	97.9	91.9	99.5	99.3	98.9	98.5	99.9	90.0
2009[b]	93.6	93.5	91.0	97.7	99.7	99.2	98.8	100.0	87.9
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival rates were calculated from aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.

[b] Survival rates were calculated from aggregate collections at Wells east fish ladder for the Methow and Okanogan/Similkameen programs. About 41% of the total fish collected were used to estimate survival rates.

7.3 Disease Monitoring

Results of adult broodstock bacterial kidney disease (BKD) monitoring indicated that most females (98.6%) had ELISA values less than 0.199. Less than 2% of females had ELISA values less than 0.120, which means that only a small percentage of the progeny (1.4%) needs to be reared at densities not to exceed 0.06 fish per pound (Table 7.12).

Table 7.12. Proportion of bacterial kidney disease (BKD) titer groups for the Methow/Okanogan summer Chinook broodstock, brood years 1997-2011. Also included are the proportions to be reared at either 0.125 fish per pound or 0.060 fish per pound.

Brood year[a]	Optical density values by titer group				Proportion at rearing densities (fish per pound, fpp)	
	Very Low (≤ 0.099)	Low (0.1-0.199)	Moderate (0.2-0.449)	High (≥ 0.450)	≤ 0.125 fpp (<0.119)	≤ 0.060 fpp (>0.120)
1997	0.6267	0.1333	0.0622	0.1778	0.6844	0.3156
1998	0.9632	0.0184	0.0123	0.0061	0.9816	0.0184
1999	0.9444	0.0198	0.0238	0.0119	0.9643	0.0357
2000	0.7476	0.0952	0.0238	0.1333	0.8000	0.2000
2001	0.9801	0.0199	0.0000	0.0000	1.0000	0.0000
2002	0.9567	0.0130	0.0130	0.0173	0.9740	0.0260
2003	0.9620	0.0127	0.0169	0.0084	0.9747	0.0253
2004	0.9585	0.0151	0.0075	0.0189	0.9736	0.0264
2005	0.9884	0.0000	0.0000	0.0116	0.9884	0.0116
2006	0.9962	0.0038	0.0000	0.0000	0.9962	0.0038
2007	0.9202	0.0266	0.0152	0.0380	0.9354	0.0646
2008	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000
2009	0.9891	0.0073	0.0037	0.0000	0.9927	0.0073
2010	0.9960	0.0040	0.0000	0.0000	1.0000	0.0000
2011	0.9766	0.0140	0.0000	0.0093	0.9860	0.0140
Average	*0.9337*	*0.0255*	*0.0119*	*0.0288*	*0.9501*	*0.0499*

[a] Individual ELISA samples were not collected before the 1997 brood.

7.4 Spawning Surveys

Surveys for Methow summer Chinook redds were conducted from late September to mid-November, 2011, in the Methow River. Total redd counts (not peak counts) were conducted in the river (see Appendix L for more details).

Redd Counts

A total of 941 summer Chinook redds were counted in the Methow River in 2011 (Table 7.13). This was higher than the overall average of 629 redds.

Table 7.13. Total number of redds counted in the Methow River, 1989-2011.

Survey year	Total redd count
1989	149*
1990	418*
1991	153
1992	107

Survey year	Total redd count
1993	154
1994	310
1995	357
1996	181
1997	205
1998	225
1999	448
2000	500
2001	675
2002	2,013
2003	1,624
2004	973
2005	874
2006	1,353
2007	620
2008	599
2009	692
2010	887
2011	941
Average	***629***

* Total counts based on expanded aerial counts.

Redd Distribution

Summer Chinook redds were not evenly distributed among the seven reaches in the Methow River. Most redds (79%) were located in reaches downstream from the town of Twisp and in Reach 5 between Methow Valley Irrigation Diversion (MVID) and the Winthrop Bridge (Table 7.14; Figure 7.1). Few summer Chinook spawned upstream from the Winthrop Bridge in Reaches 6 and 7.

Table 7.14. Total number of summer Chinook redds counted in different reaches on the Methow River during September through early November, 2011. Reach codes are described in Table 2.11.

Survey reach	Total redd count	Percent
Methow 1 (M1)	113	12
Methow 2 (M2)	235	25
Methow 3 (M3)	258	27
Methow 4 (M4)	139	15
Methow 5 (M5)	184	20
Methow 6 (M6)	5	1
Methow 7 (M7)	7	1
Totals	***941***	***100.0***

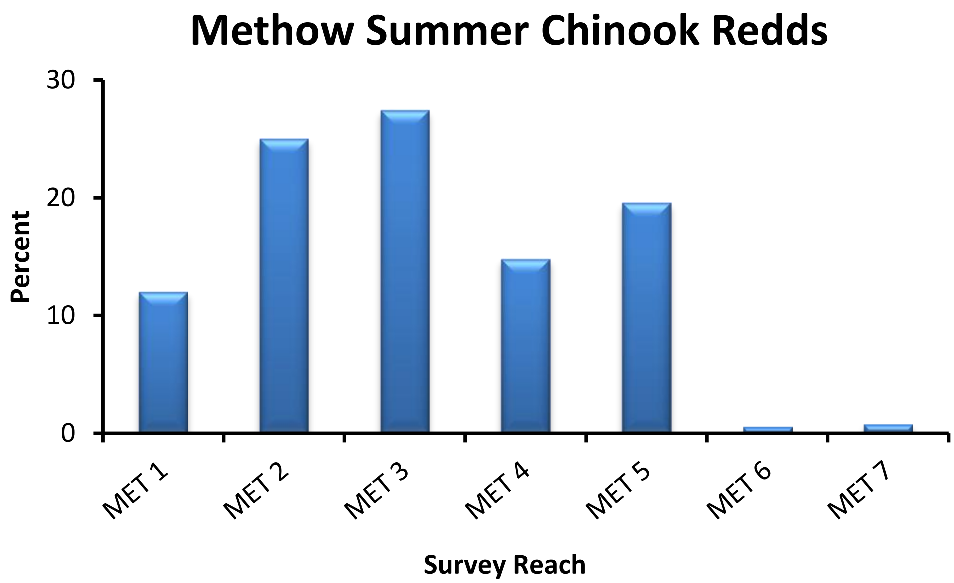

Figure 7.1. Percent of the total number of summer Chinook redds counted in different reaches on the Methow River during September through mid-November, 2011. Reach codes are described in Table 2.11.

Spawn Timing

Spawning in 2011 began the last week of September, peaked the second week of October, and ended after the second week of November (Figure 7.2). Stream temperatures in the Methow River, when spawning began, varied from 7.0-10.0°C. Peak spawning occurred in the upper reaches of the Methow River during the second week of October and in the lower reaches the following week.

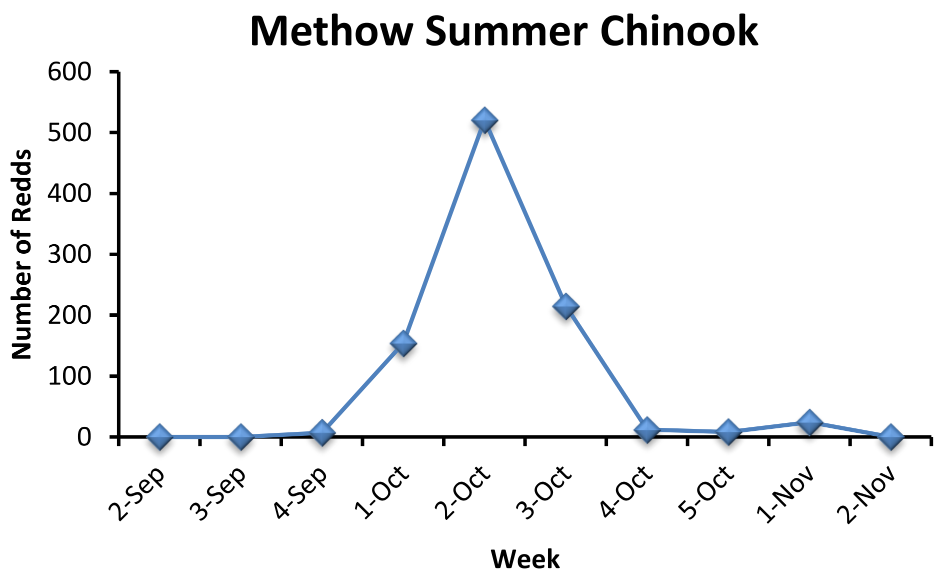

Figure 7.2. Number of new summer Chinook redds counted during different weeks in the Methow River, September through mid-November 2011.

Spawning Escapement

Spawning escapement for Methow summer Chinook was calculated as the total number of redds times the fish per redd ratio estimated from fish sampled at Wells Dam. The estimated fish per redd ratio for Methow summer Chinook in 2011 was 3.10. Multiplying this ratio by the number of redds counted in the Methow River resulted in a total spawning escapement of 2,917 summer Chinook (Table 7.15).

Table 7.15. Spawning escapements for summer Chinook in the Methow River for return years 1989-2011.

Return year	Fish/Redd	Redds	Total spawning escapement
1989*	3.30	149	492
1990*	3.40	418	1,421
1991*	3.70	153	566
1992*	4.30	107	460
1993*	3.30	154	508
1994*	3.50	310	1,085
1995*	3.40	357	1,214
1996*	3.40	181	615
1997*	3.40	205	697
1998	3.00	225	675
1999	2.20	448	986
2000	2.40	500	1,200
2001	4.10	675	2,768
2002	2.30	2,013	4,630

Return year	Fish/Redd	Redds	Total spawning escapement
2003	2.42	1,624	3,930
2004	2.25	973	2,189
2005	2.93	874	2,561
2006	2.02	1,353	2,733
2007	2.20	620	1,364
2008	3.25	599	1,947
2009	2.54	692	1,758
2010	2.81	887	2,492
2011	3.10	941	2,917
Average	***3.01***	***629***	***1,705***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

7.5 Carcass Surveys

Surveys for Methow summer Chinook carcasses were conducted during late September to mid-November, 2011, in the Methow River (see Appendix L for more details).

Number sampled

A total of 559 summer Chinook carcasses were sampled during September through mid-November in the Methow River (Table 7.15).

Table 7.15. Numbers of summer Chinook carcasses sampled within each survey reach on the Methow River, 1991-2011. Reach codes are described in Table 2.11.

Survey year	Number of summer Chinook carcasses							
	M-1	M-2	M-3	M-4	M-5	M-6	M-7	Total
1991	0	12	8	4	2	0	0	**26**
1992	8	8	19	0	17	1	0	**53**
1993	19	25	14	2	5	0	0	**65**
1994[a]	43	33	20	5	13	0	0	**114**
1995	14	33	58	7	7	0	0	**119**
1996	6	30	46	5	2	0	0	**89**
1997	6	12	38	2	19	1	0	**78**
1998	90	84	99	17	30	0	0	**320**
1999	47	144	232	32	37	12	2	**506**
2000	62	118	105	9	99	5	0	**398**
2001	392	275	88	14	76	11	1	**857**
2002	551	318	518	164	219	34	10	**1,814**
2003	115	383	317	115	128	5	0	**1,063**
2004	40	173	187	82	92	2	1	**577**
2005	154	173	182	42	112	3	0	**666**
2006	121	149	111	56	146	3	1	**587**
2007	135	131	108	27	55	0	0	**456**

Survey year	Number of summer Chinook carcasses							
	M-1	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**	**Total**
2008	64	128	197	33	57	3	0	**482**
2009	144	158	159	36	94	0	0	**591**
2010	105	180	185	38	63	5	1	**577**
2011	56	134	202	78	83	5	1	**559**
Average	***103***	***129***	***138***	***37***	***65***	***4***	***1***	***476***

[a] An additional 113 carcasses were sampled, but reach was not identified.

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Methow River in 2011 (Table 7.15; Figure 7.3). Most of the carcasses in the Methow River were found downstream from Twisp.

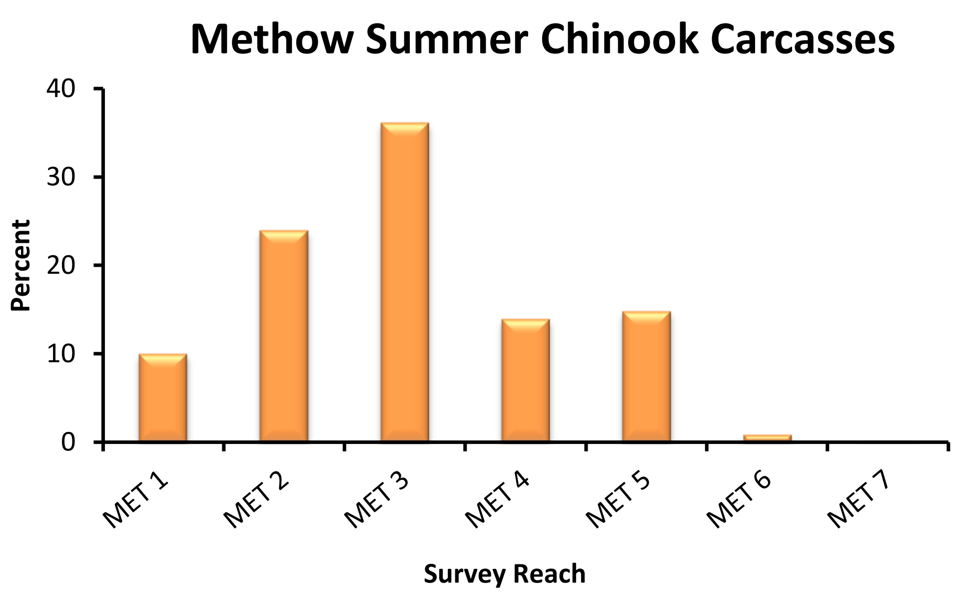

Figure 7.3. Percent of summer Chinook carcasses sampled within different reaches on the Methow River during September through mid-November, 2011. Reach codes are described in Table 2.11.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2011 will be available after analysis of CWTs and scales. Based on the available data (1991-2010), hatchery and wild summer Chinook carcasses were not distributed equally among the reaches in the Methow River (Table 7.16). A larger percentage of hatchery carcasses occurred in the lower reaches, while a larger percentage of wild summer Chinook carcasses occurred in upstream reaches (Figure 7.4).

Table 7.16. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches on the Methow River, 1991-2011.

Survey year	Origin	Survey reach							Total
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	
1991	Wild	0	12	8	4	2	0	0	**26**
	Hatchery	0	0	0	0	0	0	0	**0**
1992	Wild	8	8	19	0	17	1	0	**53**
	Hatchery	0	0	0	0	0	0	0	**0**
1993	Wild	11	15	9	0	3	0	0	**38**
	Hatchery	8	7	5	2	2	0	0	**24**
1994	Wild	21	17	8	4	9	0	0	**59**
	Hatchery	20	15	11	0	3	0	0	**49**
1995	Wild	6	9	27	7	5	0	0	**54**
	Hatchery	7	24	25	0	1	0	0	**57**
1996	Wild	1	20	29	4	2	0	0	**56**
	Hatchery	5	7	11	1	0	0	0	**24**
1997	Wild	5	5	28	1	17	0	0	**56**
	Hatchery	1	4	7	1	2	1	0	**16**
1998	Wild	41	46	70	9	23	0	0	**189**
	Hatchery	48	36	28	6	5	0	0	**123**
1999	Wild	27	79	110	14	17	4	2	**253**
	Hatchery	15	57	102	17	13	7	0	**211**
2000	Wild	23	78	74	7	72	3	0	**257**
	Hatchery	37	33	20	1	16	2	0	**109**
2001	Wild	49	102	54	9	66	11	1	**292**
	Hatchery	330	157	32	4	6	0	0	**529**
2002	Wild	124	163	362	129	183	34	9	**1,004**
	Hatchery	412	141	138	24	22	0	1	**738**
2003	Wild	33	123	176	63	85	3	0	**483**
	Hatchery	80	122	127	38	36	2	0	**405**
2004	Wild	14	108	144	61	73	1	0	**401**
	Hatchery	24	52	28	17	12	1	1	**135**
2005	Wild	62	99	133	33	107	3	0	**437**
	Hatchery	92	74	49	9	5	0	0	**229**
2006	Wild	68	103	83	49	131	3	1	**438**
	Hatchery	53	46	28	7	15	0	0	**149**
2007	Wild	52	71	62	19	45	0	0	**249**
	Hatchery	93	60	47	9	10	0	0	**219**
2008	Wild	15	69	158	29	54	2	0	**327**
	Hatchery	49	59	39	4	3	1	0	**155**
2009	Wild	54	91	104	28	86	0	0	**363**
	Hatchery	90	67	55	8	8	0	0	**228**
2010	Wild	33	79	102	24	53	5	1	**297**

Survey year	Origin	Survey reach							Total
		M-1	M-2	M-3	M-4	M-5	M-6	M-7	
	Hatchery	72	101	83	14	10	0	0	**280**
Average	***Wild***	***34***	***65***	***88***	***25***	***53***	***4***	***1***	***270***
	Hatchery	***72***	***53***	***42***	***8***	***8***	***1***	***0***	***184***

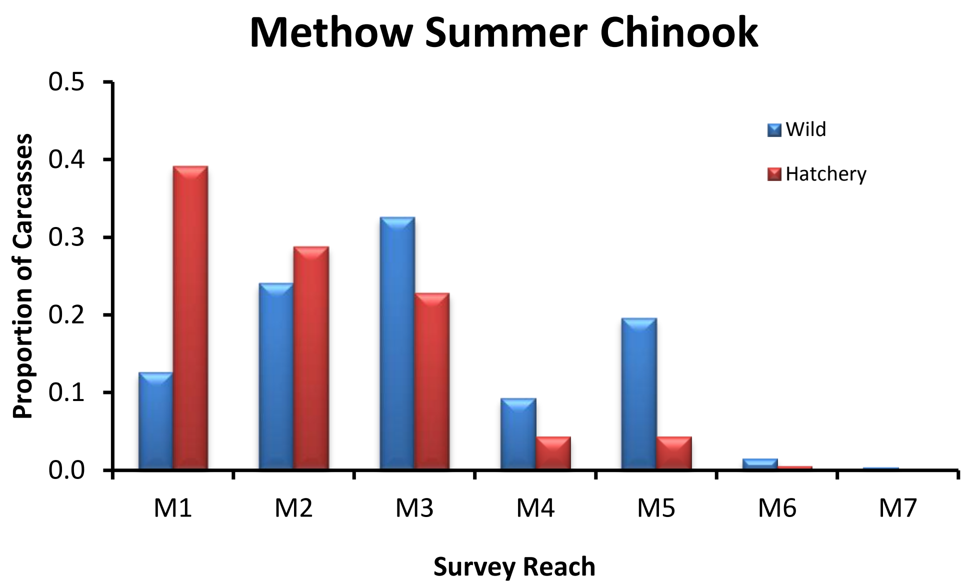

Figure 7.4. Distribution of wild and hatchery produced carcasses in different reaches on the Methow River, 1993-2010. Reach codes are described in Table 2.11.

Sampling Rate

Overall, 19% of the total spawning escapement of summer Chinook in the Methow Basin was sampled in 2011 (Table 7.17). Sampling rates among survey reaches varied from 5 to 32%.

Table 7.17. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Methow Basin, 2011. Reach codes are described in Table 2.11.

Survey reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Methow 1 (M1)	113	56	350	0.16
Methow 2 (M2)	235	134	729	0.18
Methow 3 (M3)	258	202	800	0.25
Methow 4 (M4)	139	78	431	0.18
Methow 5 (M5)	184	83	570	0.15
Methow 6 (M6)	5	5	16	0.32
Methow 7 (M7)	7	1	22	0.05
Total	***941***	***559***	***2,917***	***0.19***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Methow River in 2011 are provided in Table 7.18. The average size of males and females sampled in the Methow River were 62 cm and 70 cm, respectively.

Table 7.18. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different reaches on the Methow River, 2011. Reach codes are described in Table 2.11.

Stream/watershed	Mean length (cm)	
	Male	Female
Methow 1 (M1)	60.1 (13.7)	70.8 (6.8)
Methow 2 (M2)	59.5 (15.6)	69.1 (5.5)
Methow 3 (M3)	59.5 (12.9)	69.4 (5.8)
Methow 4 (M4)	65.2 (12.4)	70.8 (4.4)
Methow 5 (M5)	66.0 (11.5)	71.5 (6.3)
Methow 6 (M6)	71.1 (7.6)	-
Methow 7 (M7)	-	76.0 (0)
Total	***61.8 (13.8)***	***70.0 (5.8)***

7.6 Life History Monitoring

Life history characteristics of Methow summer Chinook were assessed by examining carcasses on spawning grounds and fish collected or examined at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

Migration timing of hatchery and wild Methow/Okanogan summer Chinook was determined from broodstock data collected at Wells Dam. Counting of summer/fall Chinook at Wells Dam occurs from 29 June to 15 November. Broodstock collection at the Dam occurs from early July (week 27) to mid-September (week 37) (Table 2.1). Based on broodstock sampling in 2011, both wild and hatchery summer Chinook arrived at Wells Dam about the same time (Table 7.19). This was true throughout most of the migration period. This pattern was also observed when data were pooled for the 2007-2011 survey period.

Table 7.19. The week that 10%, 50% (median), and 90% of the wild and hatchery summer Chinook salmon passed Wells Dam, 2007-2011. The average week is also provided. Migration timing is based on collection of summer Chinook broodstock at Wells Dam.

Survey year	Origin	Methow/Okanogan Summer Chinook Migration Time (week)				Sample size
		10 Percentile	50 Percentile	90 Percentile	Mean	
2007	Wild	27	30	34	30	485
	Hatchery	27	30	33	30	433
2008	Wild	28	30	34	30	542
	Hatchery	28	30	36	31	884
2009	Wild	27	29	34	30	585
	Hatchery	27	29	33	29	708
2010	Wild	27	29	33	29	377
	Hatchery	27	29	32	29	801
2011	Wild	30	32	36	32	516
	Hatchery	30	32	35	33	1,223
Average	Wild	***27***	***30***	***34***	***31***	***505***
	Hatchery	***28***	***31***	***35***	***31***	***810***

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2010 in the Methow River were salt age-3 fish (Table 7.20; Figure 7.5). A higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1, 2, and 3 hatchery fish returned than did salt age-1, 2, and 3 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 7.20. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Methow River, 1993-2010.

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1993	Wild	0.05	0.08	0.76	0.11	0.00	38
	Hatchery	0.00	1.00	0.00	0.00	0.00	20
1994	Wild	0.03	0.26	0.51	0.20	0.00	101
	Hatchery	0.00	0.07	0.93	0.00	0.00	110
1995	Wild	0.00	0.09	0.70	0.20	0.00	54
	Hatchery	0.02	0.04	0.44	0.51	0.00	55
1996	Wild	0.04	0.30	0.54	0.13	0.00	56
	Hatchery	0.00	0.05	0.50	0.41	0.05	22

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1997	Wild	0.00	0.22	0.51	0.27	0.00	55
	Hatchery	0.13	0.06	0.56	0.25	0.00	16
1998	Wild	0.09	0.38	0.45	0.09	0.00	188
	Hatchery	0.02	0.52	0.41	0.04	0.00	123
1999	Wild	0.01	0.51	0.43	0.05	0.00	252
	Hatchery	0.00	0.07	0.90	0.03	0.00	210
2000	Wild	0.01	0.09	0.75	0.16	0.00	257
	Hatchery	0.10	0.16	0.62	0.11	0.00	97
2001	Wild	0.02	0.20	0.72	0.07	0.00	292
	Hatchery	0.10	0.60	0.26	0.04	0.00	526
2002	Wild	0.01	0.17	0.61	0.21	0.00	1,003
	Hatchery	0.01	0.41	0.57	0.01	0.00	734
2003	Wild	0.01	0.11	0.50	0.37	0.00	478
	Hatchery	0.02	0.03	0.90	0.04	0.00	399
2004	Wild	0.00	0.09	0.35	0.56	0.00	394
	Hatchery	0.07	0.28	0.30	0.35	0.00	141
2005	Wild	0.00	0.11	0.74	0.14	0.01	410
	Hatchery	0.06	0.26	0.65	0.02	0.00	220
2006	Wild	0.00	0.02	0.33	0.64	0.00	356
	Hatchery	0.01	0.19	0.49	0.30	0.00	164
2007	Wild	0.03	0.09	0.24	0.59	0.05	208
	Hatchery	0.07	0.09	0.74	0.09	0.01	214
2008	Wild	0.01	0.14	0.70	0.13	0.01	301
	Hatchery	0.09	0.41	0.27	0.14	0.00	151
2009	Wild	0.00	0.11	0.41	0.48	0.00	317
	Hatchery	0.17	0.26	0.52	0.04	0.00	242
2010	Wild	0.01	0.16	0.58	0.24	0.00	271
	Hatchery	0.01	0.69	0.29	0.02	0.00	247
Average	***Wild***	***0.01***	***0.16***	***0.54***	***0.28***	***0.00***	***280***
	Hatchery	***0.05***	***0.32***	***0.55***	***0.07***	***0.00***	***205***

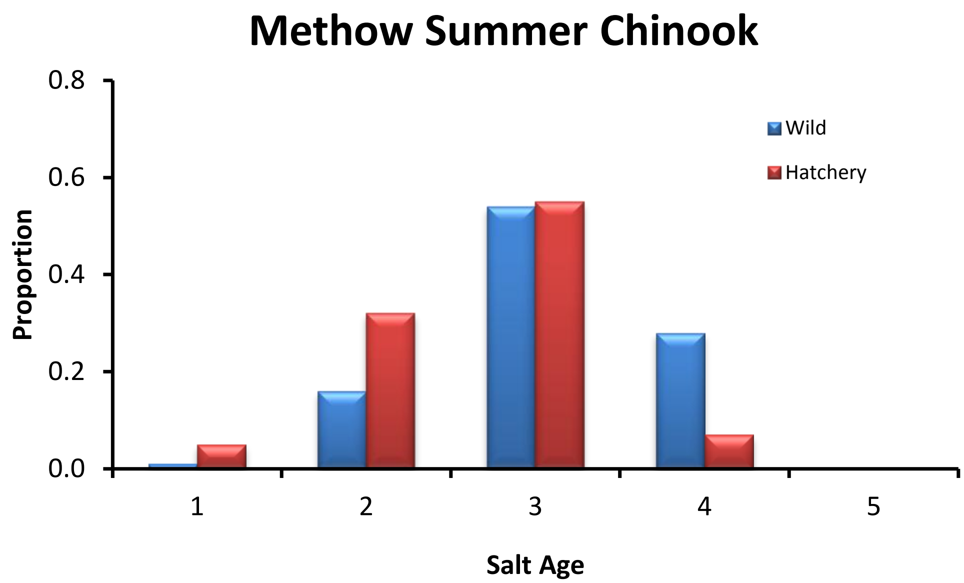

Figure 7.5. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Methow River for the combined years 1993-2010.

Size at Maturity

On average, hatchery summer Chinook were about 5 cm smaller than wild summer Chinook sampled in the Methow Basin (Table 7.21). This is interesting given that a slightly higher percentage of hatchery fish returned as age-6 fish than did wild fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 7.21. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Methow Basin, 1993-2010; SD = 1 standard deviation.

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	41	74	9	51	89
	Hatchery	24	62	8	36	80
1994	Wild	112	69	8	35	87
	Hatchery	114	67	5	43	77
1995	Wild	62	74	6	52	88
	Hatchery	57	73	7	46	85
1996	Wild	64	70	11	34	91
	Hatchery	23	72	7	58	85
1997	Wild	62	76	9	35	90
	Hatchery	16	68	15	33	87
1998	Wild	196	67	10	38	97
	Hatchery	123	63	10	37	87
1999	Wild	293	66	8	43	99

Survey year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
	Hatchery	211	66	7	26	89
2000	Wild	288	74	8	37	89
	Hatchery	109	68	12	24	87
2001	Wild	328	67	10	29	86
	Hatchery	529	63	10	31	87
2002	Wild	1,076	70	8	37	94
	Hatchery	738	67	9	33	87
2003	Wild	543	71	8	35	88
	Hatchery	405	69	8	35	89
2004	Wild	442	73	7	38	89
	Hatchery	135	65	12	34	85
2005	Wild	437	69	8	45	86
	Hatchery	229	64	9	36	79
2006	Wild	438	73	7	35	92
	Hatchery	149	69	8	38	91
2007	Wild	249	72	11	33	89
	Hatchery	219	69	9	22	84
2008	Wild	384	69	8	30	90
	Hatchery	210	63	15	23	86
2009	Wild	363	71	9	32	88
	Hatchery	228	63	12	30	83
2010	Wild	296	69	8	33	90
	Hatchery	280	62	9	39	81
Pooled	***Wild***	***5,674***	***71***	***9***	***29***	***99***
	Hatchery	***3,799***	***66***	***10***	***22***	***91***

Contribution to Fisheries

Most of the harvest on hatchery-origin Methow summer Chinook occurred in the Ocean (Table 7.22). Ocean harvest has made up 13% to 99% of all hatchery-origin Methow summer Chinook harvested. Brood years 1989 and 1998 provided the largest harvests, while brood years 1996 and 1999 provided the lowest.

Table 7.22. Estimated number and percent (in parentheses) of hatchery-origin Methow summer Chinook captured in different fisheries, brood years 1989-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	1,047 (52)	884 (44)	0 (0)	66 (3)	1,997
1990	58 (59)	41 (41)	0 (0)	0 (0)	99
1991	12 (20)	49 (80)	0 (0)	0 (0)	61
1992	17 (55)	14 (45)	0 (0)	0 (0)	31
1993	14 (58)	8 (33)	2 (8)	0 (0)	24
1994	153 (81)	34 (18)	1 (1)	1 (1)	189
1995	77 (99)	0 (0)	1 (1)	0 (0)	78
1996	13 (93)	1 (7)	0 (0)	0 (0)	14
1997	221 (89)	7 (3)	0 (0)	21 (8)	249
1998	1,761 (83)	101 (5)	14 (1)	234 (11)	2,110
1999	2 (13)	13 (87)	0 (0)	0 (0)	15
2000	364 (71)	88 (17)	27 (5)	33 (6)	512
2001	320 (52)	97 (16)	43 (7)	160 (26)	620
2002	272 (48)	96 (17)	61 (11)	137 (24)	566
2003	58 (58)	17 (17)	7 (7)	18 (18)	100
2004	133 (49)	55 (20)	16 (6)	68 (25)	272
2005	296 (54)	136 (25)	50 (9)	68 (12)	550

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Methow Basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Few hatchery-origin Methow summer Chinook have strayed into basins outside the Methow (Table 7.23). Although hatchery-origin Methow summer Chinook have strayed into the Okanogan Basin, Entiat Basin, Chelan tailrace, and Hanford Reach, they have made up less than 1% of the spawning escapement within those basins.

Table 7.23. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Methow summer Chinook, return years 1994-2008. For example, for return year 2002, 0.4% of the summer Chinook escapement in the Okanogan Basin consisted of hatchery-origin Methow summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	72	1.8	-	-	-	-	-	-
1995	0	0.0	9	0.3	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-

Return year	Wenatchee		Okanogan		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	6	0.2	0	0.0	0	0.0	7	0.0
2000	0	0.0	3	0.1	0	0.0	0	0.0	0	0.0
2001	0	0.0	0	0.0	0	0.0	0	0.0	7	0.0
2002	0	0.0	54	0.4	0	0.0	0	0.0	0	0.0
2003	0	0.0	1	0.0	6	1.4	0	0.0	0	0.0
2004	0	0.0	7	0.1	3	0.7	0	0.0	0	0.0
2005	0	0.0	24	0.3	0	0.0	0	0.0	0	0.0
2006	0	0.0	12	0.1	0	0.0	0	0.0	0	0.0
2007	0	0.0	17	0.4	2	1.1	1	0.4	0	0.0
2008	0	0.0	12	0.2	0	0.0	0	0.0	0	0.0
Total	***0***	***0.0***	***217***	***0.3***	***11***	***0.2***	***1***	***0.0***	***14***	***0.0***

Based on brood year analyses, on average, about 4.0% of the returns have strayed into non-target spawning areas, falling below the target of 5% (Table 7.24). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-11.9%. Few (<2% on average) have strayed into non-target hatchery programs.

Table 7.24. Number and percent of hatchery-origin Methow summer Chinook that homed to target spawning areas and the target hatchery program, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2005. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	773	55.7	459	33.0	81	5.8	76	5.5
1990	199	70.6	81	28.7	0	0.0	2	0.7
1991	82	65.6	43	34.4	0	0.0	0	0.0
1992	68	63.0	40	37.0	0	0.0	0	0.0
1993	25	65.8	10	26.3	3	7.9	0	0.0
1994	419	79.7	94	17.9	13	2.5	0	0.0
1995	126	81.8	28	18.2	0	0.0	0	0.0
1996	57	93.4	4	6.6	0	0.0	0	0.0
1997	379	93.8	7	1.7	18	4.5	0	0.0
1998	1,653	94.7	32	1.8	60	3.4	0	0.0
1999	18	100.0	0	0.0	0	0.0	0	0.0
2000	239	93.0	4	1.6	14	5.4	0	0.0
2001	272	88.3	6	1.9	29	9.4	1	0.3

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2002	315	95.2	4	1.2	12	3.6	0	0.0
2003	131	99.2	1	0.8	0	0.0	0	0.0
2004	194	85.5	6	2.6	27	11.9	0	0.0
2005	352	90.0	13	3.3	23	5.9	3	0.8
Total	***5,302***	***81.6***	***832***	***12.8***	***280***	***4.3***	***82***	***1.3***

Genetics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix K). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS).

The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1993-2003, the PNI was less than 0.67, indicating that the hatchery environment had a greater influence on adaptation of Methow summer Chinook than did the natural environment (Table 7.25). However, since brood year 2003, the PNI has been greater than 0.67, indicating that the natural environment has a greater influence on adaptation of Methow summer Chinook than does the hatchery environment.

Table 7.25. Proportionate natural influence (PNI) of the Methow summer Chinook supplementation program for brood years 1989-2010. PNI was calculated as the proportion of naturally produced Chinook in the hatchery broodstock (pNOB) divided by the proportion of hatchery Chinook on the spawning grounds (pHOS) plus pNOB. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	492	0	0.00	1,297	312	0.81	1.00
1990	1,421	0	0.00	828	206	0.80	1.00
1991	566	0	0.00	924	314	0.75	1.00
1992	460	0	0.00	297	406	0.42	1.00
1993	309	199	0.39	681	388	0.64	0.62
1994	573	512	0.47	341	244	0.58	0.55
1995	563	651	0.54	173	240	0.42	0.44
1996	424	191	0.31	290	223	0.57	0.65
1997	512	185	0.27	198	264	0.43	0.61
1998	432	243	0.36	153	211	0.42	0.54
1999	537	449	0.46	224	289	0.44	0.49
2000	838	362	0.30	164	339	0.33	0.52
2001	1,052	1,716	0.62	91	266	0.25	0.29
2002	2,505	2,125	0.46	247	241	0.51	0.53
2003	2,224	1,706	0.43	381	101	0.79	0.65
2004	1,609	580	0.26	506	16	0.97	0.79
2005	1,672	889	0.35	391	9	0.98	0.74
2006	2,039	694	0.25	500	10	0.98	0.80
2007	764	600	0.44	456	17	0.96	0.69
2008	1,293	654	0.34	404	41	0.91	0.73
2009	1,093	665	0.38	507	0	1.00	0.72
2010	1,326	1,166	0.47	484	8	0.98	0.68
Average	***1,032***	***618***	***0.32***	***434***	***188***	***0.68***	***0.68***

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). For brood years 1989-2004, NRR for summer Chinook in the Methow averaged 1.20 (range, 0.10-4.75) if harvested fish were not include in the estimate and 2.34 (range, 0.18-10.52) if harvested fish were included in the estimate (Table 7.26). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.30 (the calculated target value in Murdoch and Peven 2005). HRRs exceeded NRRs in nine out of the 16 years of data, regardless if harvest was or was not included in the estimate (Table 7.26). Hatchery replacement rates for Methow summer Chinook have exceeded the estimated target value of 5.30 in two of the 16 years of data, regardless if harvest is or is not included in the estimate.

Table 7.26. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for wild summer Chinook in the Methow Basin, brood years 1989-2004.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	202	492	1,389	621	6.88	1.26	3,386	1,507	16.76	3.06
1990	202	1,421	282	933	1.40	0.66	381	1,268	1.89	0.89
1991	266	566	125	276	0.47	0.49	186	413	0.70	0.73
1992	214	460	108	599	0.50	1.30	139	773	0.65	1.68
1993	234	508	38	420	0.16	0.83	62	685	0.26	1.35
1994	260	1,085	526	521	2.02	0.48	715	710	2.75	0.65
1995	242	1,214	154	1,150	0.64	0.95	232	1,732	0.96	1.43
1996	220	615	61	420	0.28	0.68	75	518	0.34	0.84
1997	209	697	404	1,448	1.93	2.08	653	2,351	3.12	3.37
1998	235	675	1,745	3,203	7.43	4.75	3,855	7,102	16.40	10.52
1999	222	986	18	2,828	0.08	2.87	33	5,189	0.15	5.26
2000	222	1,200	257	813	1.16	0.68	769	2,441	3.46	2.03
2001	223	2,768	308	2,857	1.38	1.03	928	8,658	4.16	3.13
2002	222	4,630	331	1,073	1.49	0.23	897	2,924	4.04	0.63
2003	224	3,930	132	397	0.59	0.10	232	698	1.04	0.18
2004	223	2,189	227	1,654	1.02	0.76	499	3,643	2.24	1.66
Average	***226***	***1,465***	***382***	***1,201***	***1.71***	***1.20***	***615***	***2,538***	***3.68***	***2.34***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. SARs were based on CWT returns.

For the available brood years, SARs have ranged from 0.00008 to 0.01886 for hatchery summer Chinook in the Methow Basin (Table 7.27).

Table 7.27. Smolt-to-adult ratios (SARs) for Methow summer Chinook, brood years 1989-2005.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	358,237	2,874	0.00802
1990	371,483	364	0.00098
1991	377,097	130	0.00034
1992	392,636	138	0.00035
1993	200,345	62	0.00031
1994	400,488	710	0.00177
1995	344,974	229	0.00066
1996	289,880	74	0.00026
1997	380,430	649	0.00171
1998	202,559	3,821	0.01886
1999	422,473	33	0.00008
2000	334,337	768	0.00230
2001	246,159	923	0.00375
2002	310,846	894	0.00288
2003	353,495	232	0.00066
2004	394,490	296	0.00126
2005	262,496	937	0.00357
Average	***336,246***	***775***	***0.00281***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

7.7 ESA/HCP Compliance

Broodstock Collection

Summer Chinook adults collected at Wells Dam are used for both the Methow and Okanogan supplementation programs. Per the 2009 broodstock collection protocol, 556 natural-origin (adipose fin present) adults were targeted for collection between 1 July and 13 September at the East Ladder of Wells Dam. Actual collections occurred between 2 July and 9 September and totaled 558 summer Chinook. ESA Permit 1347 provides authorization to collect Methow and Okanogan summer Chinook at Wells Dam three days per week and up to 16 hours per day from July through November. During 2009, broodstock collection activities were accomplished within the allowable trapping days authorized under ESA Permit 1347.

Collection of Methow and Okanogan summer Chinook broodstock at Wells Dam occurred concurrently with collection of summer steelhead for the Wells steelhead program authorized under ESA Section 10 Permit 1395. Encounters with steelhead and spring Chinook during Methow and Okanogan summer Chinook broodstock collections did not result in takes that were outside those authorized in Permit 1347 and in Permit 1395 for the Wells Steelhead program. Steelhead encountered during summer Chinook collections that were not required for steelhead broodstock were passed at the trap site and were not physically handled. Any spring Chinook encountered during summer Chinook broodstock activities were also passed without handling.

Hatchery Rearing and Release

The 2009 brood Methow/Okanogan summer Chinook reared throughout their juvenile life-stages at Eastbank Fish Hatchery and the Carlton Acclimation pond without incident (see Section 7.2). The 2009 brood smolt release totaled 404,956 summer Chinook, representing 101.1% of the production objective and was compliant with the 10% overage allowable in ESA Section 10 Permit 1347.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January 2011 through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Methow Basin during 2011 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 8: OKANOGAN/SIMILKAMEEN SUMMER CHINOOK

8.1 Broodstock Sampling

Summer Chinook broodstock for the Okanogan/Similkameen and Methow programs is collected at the mouth of the Okanogan River via purse seine and at the East and West Ladder of Wells Dam. Refer to Section 7.1 for information on the origin, age and length, sex ratios, and fecundity of summer Chinook broodstock collected at Wells Dam.

8.2 Hatchery Rearing

Rearing History

Number of eggs taken

Based on the unfertilized egg-to-release survival standard of 81%, a total of 711,111 eggs are required to meet the program release goal of 576,000 smolts. From 1989 through 2010, the egg take goal was reached in 13 of those years (Table 8.1).

Table 8.1. Numbers of eggs taken from summer Chinook broodstock collected at Wells Dam for the Okanogan program, 1989-2010.

Return year	Number of eggs taken
1989	724,200
1990	696,144
1991	879,892
1992	729,389
1993	797,234
1994	893,086
1995	736,500
1996	672,000
1997	601,744
1998	584,018
1999	725,589
2000	645,403
2001	418,907
2002	718,599
2003	710,521
2004	805,814
2005	452,928
2006	757,350
2007	824,703
2008	662,668
2009	840,902

Return year	Number of eggs taken
2010	726,979
Average	***709,299***

Number of acclimation days

Summer Chinook were released volitionally from Similkameen Pond as yearling smolts beginning in April and ending in May 2011. Fish acclimated at Similkameen were held for 169 to 193 days (Table 8.2). Summer Chinook at Bonaparte Pond were released volitionally between 19 April and 5 May. Fish acclimated at Bonaparte Pond were held for 167-185 days before release.

Table 8.2. Number of days Okanogan summer Chinook broods were acclimated at Similkameen and Bonaparte ponds, brood years 1989-2009.

Brood year	Release year	Rearing facility	Transfer date	Release date	Number of days
1989	1991	Similkameen	29-Oct	7-May	190
1990	1992	Similkameen	5-Nov	25-Apr	171
1991	1993	Similkameen	1-Nov	9-Apr	159
1992	1994	Similkameen	2-Nov	1-Apr	150
			26-Feb	1-Apr	34
1993	1995	Similkameen	24-Oct	1-Apr	159
			24-Feb	1-Apr	36
1994	1996	Similkameen	30-Oct	6-Apr	158
			14-Mar	6-Apr	23
1995	1997	Similkameen	1-Oct	1-Apr	182
1996	1998	Similkameen	10-Oct	15-Mar	156
1997	1999	Similkameen	7-Oct	19-Apr	194
1998	2000	Similkameen	5-Oct	19-Apr	196
1999	2001	Similkameen	5-Oct	18-Apr	195
2000	2002	Similkameen	10-Oct	8-Apr	180
2001	2003	Similkameen	1-Oct	29-Apr	210
2002	2004	Similkameen	9-Nov	23-Apr	165
2003	2005	Similkameen	19-Oct	28-Apr	191
2004	2006	Similkameen	26-Oct	23-Apr	179
2005	2007	Bonaparte	6-Nov	11-Apr	156
		Similkameen	25-Oct	18-Apr – 9-May	179-200
2006	2008	Similkameen	15-17-Oct	16-Apr – 7-May	182-205
2007	2009	Bonaparte	3-4-Nov	10-22-Apr	157-170

Brood year	Release year	Rearing facility	Transfer date	Release date	Number of days
		Similkameen	20-24-Oct	14-Apr – 9-May	172-201
2008	2010	Bonaparte	2-4-Nov	19-Apr – 5-May	167-185
		Similkameen	26-28-Oct	19-Apr – 14-May	176-201
2009	2011	Bonaparte	8-9-Nov	12-Apr	155-156
		Similkameen	25-27-Oct	13-Apr – 5-May	169-193

Release Information

Numbers released

The 2009 Okanogan summer Chinook program achieved 91.1% of the 576,000 target goal with about 675,903 fish being released volitionally into the Similkameen and Okanogan rivers. About 151,382 summer Chinook were released from Bonaparte Pond on 12 April, while 524,521 fish were released volitionally from the Similkameen facility between 13 April and 5 May (Table 8.3).

Table 8.3. Numbers of Okanogan summer Chinook smolts released from the Similkameen and Bonaparte ponds, brood years 1989-2009; NA = not available. The release target for Okanogan summer Chinook is 576,000 smolts.

Brood year	Release year	Rearing facility	CWT mark rate	Number of smolts released
1989	1991	Similkameen	0.5732	352,600
1990	1992	Similkameen	0.6800	540,000
1991	1993	Similkameen	0.5335	675,500
1992	1994	Similkameen	0.9819	548,182
1993	1995	Similkameen	0.6470	586,000
1994	1996	Similkameen	0.4176	536,299
1995	1997	Similkameen	0.9785	587,000
1996	1998	Similkameen	0.9769	507,913
1997	1999	Similkameen	0.9711	589,591
1998	2000	Similkameen	0.9825	293,191
1999	2001	Similkameen	0.9689	630,463
2000	2002	Similkameen	0.9928	532,453
2001	2003	Similkameen	0.9877	26,642
2002	2004	Similkameen	0.9204	388,589
2003	2005	Similkameen	0.9929	579,019
2004	2006	Similkameen	0.9425	703,359
2005	2007	Bonaparte	0	0 (assumed)
		Similkameen	0.9862	275,919
2006	2008	Bonaparte	NA	NA
		Similkameen	0.9878	604,035

Brood year	Release year	Rearing facility	CWT mark rate	Number of smolts released
2007	2009	Bonaparte	0.9920	102,099
		Similkameen	0.9914	513,039
2008	2010	Bonaparte	0.9947	175,729
		Similkameen	0.9947	343,628
2009	2011	Bonaparte	0.9981	151,382
		Similkameen	0.9953	524,521
Average		Bonaparte	***0.7462***	***143,070***
		Similkameen	***0.8467***	***492,283***

Numbers tagged

The 2009 brood Okanogan summer Chinook from the Similkameen and Bonaparte facilities were respectively 99.8% CWT and adipose fin-clipped (Table 8.3).

No juvenile hatchery summer Chinook were PIT tagged in 2011. Table 8.4 summarizes the number of hatchery summer Chinook that have been PIT-tagged and released into the Okanogan Basin.

Table 8.4. Summary of PIT-tagging activities for Okanogan hatchery summer Chinook, brood years 2008-2010.

Brood year	Release year	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2008	2010	5,700 (high density)	1,169	0	4,531
		5,700 (low density)	1,407	0	4,293
2009	2011	5,100	11	0	5,089
2010	2012	0	0	0	0

Fish size and condition at release

Size at release of the Similkameen population was 75% and 54.4% of the target fork length and weight, respectively. The target CV for fork length was exceeded by 29% (Table 8.5). No information was available for the Bonaparte acclimation group.

Table 8.5. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Okanogan summer Chinook smolts released from the hatchery, brood years 1989-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1989	1991	-	-	41.3	11
1990	1992	143	9.5	37.8	12
1991	1993	125	15.5	22.4	20
1992	1994	120	15.4	20.7	22

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1993	1995	132	-	23.2	20
1994	1996	136	16.0	29.6	15
1995	1997	137	8.2	32.8	14
1996	1998	127	12.8	26.2	17
1997	1999	144	9.9	36.0	13
1998	2000	148	5.9	41.0	11
1999	2001	141	15.7	35.4	13
2000	2002	121	13.4	20.4	22
2001	2003	132	8.2	25.7	18
2002	2004	119	13.4	20.8	22
2003	2005	133	10.6	28.9	16
2004	2006	132	9.9	29.8	15
2005	2007	132	9.6	25.9	18
2006	2008	120	12.3	20.9	22
2007	2009	124	12.6	21.9	21
2008	2010	140	12.3	35.1	13
2009	2011	132	11.6	24.7	18
Targets		***176***	***9.0***	***45.4***	***10***

Survival Estimates

Overall survival of Okanogan summer Chinook from green (unfertilized) egg to release was below the standard set for the program (Table 8.6). Lower than expected ponding-to-release and transport-to-release survival had the greatest effect on the overall survival performance. Currently, it is unknown if gamete viability is gender biased or is uniform between sexes and more influenced by between-year environmental variations.

Table 8.6. Hatchery life-stage survival rates (%) for Okanogan summer Chinook, brood years 1989-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Rearing facility	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
		Female	Male							
1989[a]	Similkameen	89.8	99.5	89.9	96.7	99.7	99.4	73.3	57.4	48.7
1990[a]	Similkameen	93.9	99.0	84.9	97.1	81.2	80.6	97.7	98.6	77.6
1991[a]	Similkameen	93.1	95.5	88.2	97.1	99.4	99.1	98.4	97.1	76.8
1992[a]	Similkameen	96.9	99.0	87.0	98.0	99.9	99.9	91.7	92.6	75.2
1993[a]	Similkameen	82.2	99.4	85.4	97.6	99.8	99.5	92.0	90.2	73.5
1994	Similkameen	96.1	90.0	86.6	100.0	98.1	97.4	73.1	89.8	60.1
1995	Similkameen	91.9	96.2	98.2	84.1	96.5	96.2	92.7	98.2	79.7
1996	Similkameen	95.4	98.1	83.2	100.0	97.7	96.9	86.5	92.5	75.6
1997	Similkameen	91.9	94.6	86.1	98.4	98.7	98.3	98.8	99.4	98.0

Brood year	Rearing facility	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
		Female	Male							
1998	Similkameen	84.0	96.2	54.1	98.0	99.4	98.9	96.6	99.6	50.2
1999	Similkameen	98.8	98.7	92.9	96.9	98.0	97.6	96.9	99.0	86.9
2000	Similkameen	90.5	96.9	89.2	98.5	98.2	98.0	93.6	97.2	82.5
2001	Similkameen	96.2	92.3	89.1	97.6	99.7	99.5	7.4	11.9	6.4
2002	Similkameen	97.1	98.1	89.8	98.0	99.7	99.5	51.6	52.2	54.1
2003	Similkameen	96.7	97.5	86.8	97.6	99.3	98.5	98.0	98.8	81.5
2004	Similkameen	93.6	98.2	84.0	97.6	99.6	99.3	97.8	98.8	80.2
	Bonaparte	93.6	98.2	84.0	97.6	99.6	99.3	97.9	98.9	80.3
2005	Similkameen	97.0	89.6	88.0	99.5	99.5	99.0	93.5	94.6	81.8
	Bonaparte	97.0	89.6	88.0	99.5	99.5	99.0	0.0	0.0	0.0
2006	Similkameen	92.9	89.5	86.3	98.3	99.6	99.3	94.1	95.5	79.8
2007	Similkameen	92.6	99.6	80.8	99.1	99.5	99.1	97.0	98.1	77.7
	Bonaparte	92.6	99.6	80.8	99.1	99.5	99.1	95.6	96.7	76.6
2008	Similkameen	97.9	99.6	91.2	96.8	99.7	99.3	89.8	90.5	79.3
	Bonaparte	97.9	99.6	91.2	96.8	99.7	99.3	86.9	87.8	76.7
2009[b]	Similkameen	93.6	93.5	91.0	98.2	99.7	99.5	97.8	98.6	87.4
	Bonaparte	3.6	93.5	91.0	98.2	99.7	99.5	74.8	75.3	66.8
Standard		***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] Survival rates were calculated from the aggregate population collected at Wells Fish Hatchery volunteer channel and left- and right-ladder traps at Wells Dam.

[b] Survival rates were calculated from aggregate collections at Wells east fish ladder for the Methow and Okanogan/Similkameen programs. About 59% of the total fish collected were used to estimate survival rates.

8.3 Disease Monitoring

Rearing of the 2009 brood Okanogan summer Chinook was similar to previous years with fish being held on well water before being transferred for final acclimation on Similkameen or Okanogan river water. The Similkameen and Bonaparte groups were transferred in late October and early November, respectively. The Bonaparte group began developing bacterial gill disease infections in December 2010. No further problems developed after treatment. Fish acclimating at the Similkameen facility were diagnosed with having an external fungus in November. In March 2011 bacterial gill disease developed and was treated. No additional disease-related problems were noted before the fish were released.

Results of adult broodstock bacterial kidney disease (BKD) monitoring for Methow/Okanogan summer Chinook are shown in Table 7.11 in Section 7.3.

8.4 Spawning Surveys

Surveys for Okanogan/Similkameen summer Chinook redds were conducted from late September to mid-November, 2011, in the Okanogan and Similkameen rivers. Total redd counts (not peak counts) were conducted in the rivers (see Appendix L for more details).

Redd Counts

A total of 3,123 summer Chinook redds were counted in the Okanogan Basin in 2011 (Table 8.7). This was greater than the overall average of 1,783 redds.

Table 8.7. Total number of redds counted in the Okanogan Basin, 1989-2011.

Survey year	Number of summer Chinook redds		
	Okanogan River	**Similkameen River**	**Total count**
1989	151	370	521
1990	99	147	246
1991	64	91	155
1992	53	57	110
1993	162	288	450
1994	375*	777	1,152
1995	267*	616	883
1996	116	419	535
1997	158	486	644
1998	88	276	364
1999	369	1,275	1,644
2000	549	993	1,542
2001	1,108	1,540	2,648
2002	2,667	3,358	6,025
2003	1,035	378	1,413
2004	1,327	1,660	2,987
2005	1,611	1,423	3,034
2006	2,592	1,666	4,258
2007	1,301	707	2,008
2008	1,146	1,000	2,146
2009	1,672	1,298	2,970
2010	1,011	1,107	2,118
2011	1,714	1,409	3,123
Average	***854***	***928***	***1,783***

* Reach-expanded aerial counts.

Redd Distribution

Summer Chinook redds were not evenly distributed among the survey reaches in the Okanogan Basin. Most redds (88%) were located in the upper Okanogan and lower Similkameen reaches (reaches upstream of the Riverside Bridge) (Table 8.8; Figure 8.1). Relatively few summer Chinook spawned downstream of the Riverside Bridge on the Okanogan River (Reaches 1-4).

Table 8.8. Total number of summer Chinook redds counted in different reaches in the Okanogan Basin during September through mid-November, 2011. Reach codes are described in Table 2.11.

Survey reach	Total redd count	Percent
Okanogan 1 (O1)	3	0
Okanogan 2 (O2)	20	1
Okanogan 3 (O3)	101	3
Okanogan 4 (O4)	55	2
Okanogan 5 (O5)	593	19
Okanogan 6 (O6)	942	30
Similkameen 1 (S1)	1,217	39
Similkameen 2 (S2)	192	6
Totals	***3,123***	***100***

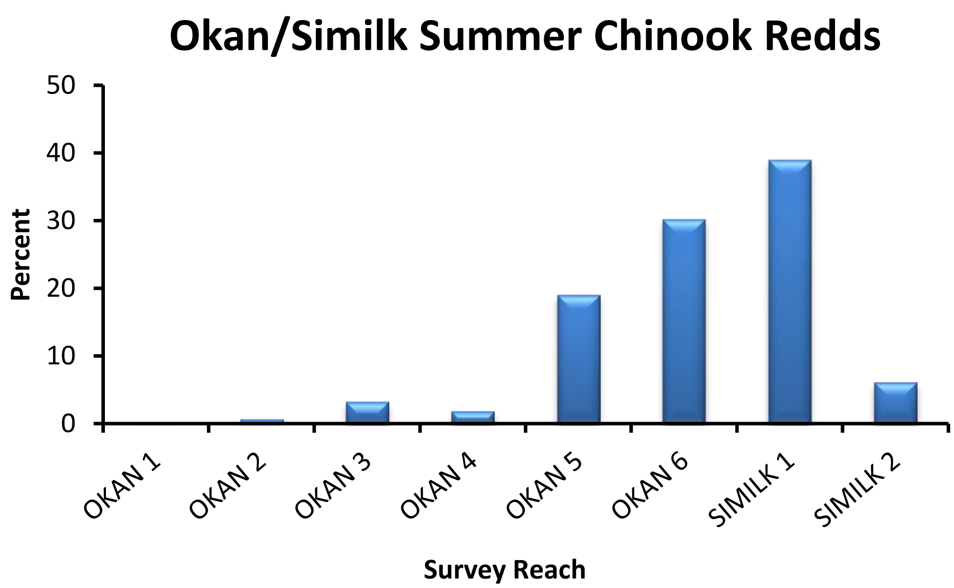

Figure 8.1. Percent of the total number of summer Chinook redds counted in different reaches in the Okanogan Basin during September through mid-November, 2011. Reach codes are described in Table 2.11.

Spawn Timing

Spawning in 2011 began the first week of October in the Okanogan Basin, and peaked during the second week of October in both rivers (Figure 8.2). Spawning began when stream temperature varied from 12.0-14.0°C.

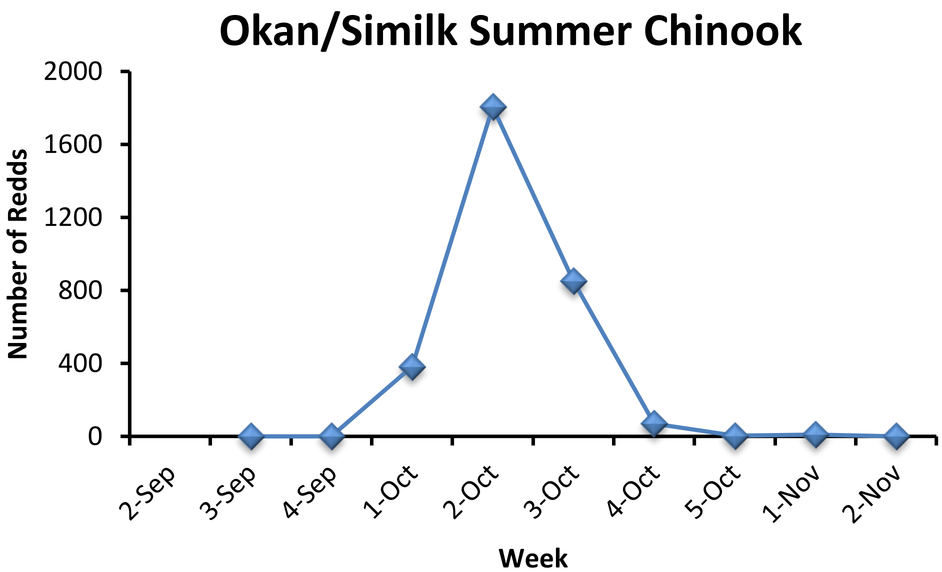

Figure 8.2. Number of new summer Chinook redds counted during different weeks in the Okanogan Basin, September through mid-November, 2011.

Spawning Escapement

Spawning escapement for Okanogan/Similkameen summer Chinook was calculated as the total number of redds times the fish per redd ratio estimated from fish sampled at Wells Dam. The estimated fish per redd ratio for Okanogan/Similkameen summer Chinook in 2011 was 3.10. Multiplying this ratio by the number of redds counted in the Okanogan and Similkameen rivers resulted in a total spawning escapement of 9,681 summer Chinook (Table 8.9).

Table 8.9. Spawning escapements for summer Chinook in the Okanogan and Similkameen rivers for return years 1989-2011.

Return year	Fish/Redd	Spawning escapement		
		Okanogan	Similkameen	Total
1989*	3.30	498	1,221	1,719
1990*	3.40	337	500	837
1991*	3.70	237	337	574
1992*	4.30	228	245	473
1993*	3.30	535	950	1,485
1994*	3.50	1,313	2,720	4,033
1995*	3.40	908	2,094	3,002
1996*	3.40	394	1,425	1,819
1997*	3.40	537	1,652	2,189
1998	3.00	264	828	1,092
1999	2.20	812	2,805	3,617
2000	2.40	1,318	2,383	3,701

Return year	Fish/Redd	Spawning escapement		
		Okanogan	Similkameen	Total
2001	4.10	4,543	6,314	10,857
2002	2.30	6,134	7,723	13,857
2003	2.42	2,505	915	3,420
2004	2.25	2,986	3,735	6,721
2005	2.93	4,720	4,169	8,889
2006	2.02	5,236	3,365	8,601
2007	2.20	2,862	1,555	4,417
2008	3.25	3,725	3,250	6,975
2009	2.54	4,247	3,297	7,544
2010	2.81	2,841	3,111	5,952
2011	3.10	5,313	4,368	9,681
Average	***3.01***	***2,282***	***2,564***	***4,849***

* Spawning escapement was calculated using the "Modified Meekin Method" (i.e., 3.1 x jack multiplier).

8.5 Carcass Surveys

Surveys for summer Chinook carcasses were conducted during late September to mid-November, 2011, in the Okanogan and Similkameen rivers (see Appendix L for more details).

Number sampled

A total of 1,775 summer Chinook carcasses were sampled during September through mid-November in the Okanogan Basin (Table 8.10). A total of 909 were sampled in the Okanogan River and 866 in the Similkameen River.

Table 8.10. Numbers of summer Chinook carcasses sampled within each survey reach in the Okanogan Basin, 1993-2011. Reach codes are described in Table 2.11.

Survey year	Number of summer Chinook carcasses								
	Okanogan						Similkameen		Total
	O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
1993[a]	0	2	3	0	23	13	73	1	**115**
1994[b]	0	4	4	0	27	5	318	60	**418**
1995	0	0	2	0	30	0	239	15	**286**
1996	0	0	0	2	5	2	226	0	**235**
1997	0	0	2	0	9	3	225	1	**240**
1998	0	1	8	1	7	7	340	4	**368**
1999	0	0	3	2	23	53	766	48	**895**
2000	0	2	20	15	47	16	727	41	**868**
2001	0	26	75	10	127	112	1,141	105	**1,596**
2002	10	32	83	35	204	573	1,265	259	**2,461**
2003[c]	0	0	26	0	15	208	180	8	**437**

Survey year	Number of summer Chinook carcasses								
	Okanogan						Similkameen		Total
	O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
2004	0	4	31	24	146	283	1,392	298	**2,178**
2005	0	8	93	37	371	431	731	276	**1,947**
2006	4	3	31	16	120	291	513	100	**1,078**
2007	2	1	48	1	459	519	657	29	**1,716**
2008	4	10	40	36	248	665	859	157	**2,019**
2009	2	7	31	32	348	500	702	150	**1,772**
2010	3	10	30	42	241	352	627	148	**1,453**
2011	0	0	55	14	361	479	752	114	**1,775**
Average	***1***	***6***	***31***	***14***	***148***	***237***	***618***	***95***	***1,150***

[a] 25 additional carcasses were sampled on the Similkameen and 46 on the Okanogan without any reach designation.
[b] One additional carcasses was sampled on the Similkameen without any reach designation.
[c] 793 carcasses were sampled on the Similkameen before initiation of spawning (pre-spawn mortality) and an additional 40 carcasses were sampled on the Okanogan. The cause of the high mortality (*Ichthyophthirius multifilis* and *Flavobacterium columnarae*) was exacerbated by high river temperatures.

Carcass Distribution and Origin

Summer Chinook carcasses were not evenly distributed among reaches within the Okanogan Basin in 2011 (Table 8.9; Figure 8.3). Most of the carcasses in the basin were found in the upper Okanogan River and lower Similkameen River. The highest percentage of carcasses (42%) was sampled in Reach 1 on the Similkameen River between the Driscoll Channel and Oroville Bridge.

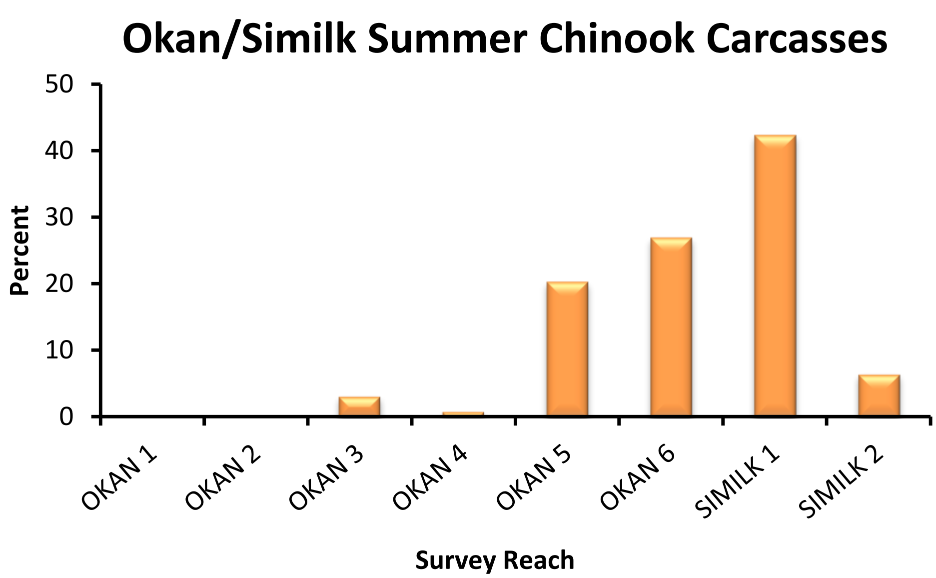

Figure 8.3. Percent of summer Chinook carcasses sampled within different reaches in the Okanogan Basin during September through mid-November, 2011. Reach codes are described in Table 2.11.

Numbers of wild and hatchery-origin summer Chinook carcasses sampled in 2011 will be available after analysis of CWTs and scales. Based on the available data (1991-2010), most fish, regardless of origin, were found in Reach 1 on the Similkameen River (Driscoll Channel to Oroville Bridge) (Table 8.11). However, a slightly larger percentage of hatchery fish were found in reaches on the Similkameen River than were wild fish (Figure 8.4). In contrast, a larger percentage of wild fish were found in reaches on the Okanogan River.

Table 8.11. Numbers of wild and hatchery summer Chinook carcasses sampled within different reaches in the Okanogan Basin, 1993-2010.

Survey year	Origin	Survey reach								Total
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
1993	Wild	0	0	3	0	13	4	48	1	**69**
	Hatchery	0	2	0	0	10	9	25	0	**46**
1994	Wild	0	0	1	0	8	1	113	22	**145**
	Hatchery	0	4	3	0	19	4	205	38	**273**
1995	Wild	0	0	1	0	10	0	66	4	**81**
	Hatchery	0	0	1	0	20	0	173	11	**205**
1996	Wild	0	0	0	1	3	1	53	0	**58**
	Hatchery	0	0	0	1	2	1	173	0	**177**
1997	Wild	0	0	1	0	0	2	83	0	**86**
	Hatchery	0	0	1	0	9	0	142	1	**153**
1998	Wild	0	1	3	1	6	5	162	4	**182**
	Hatchery	0	0	5	0	1	2	178	0	**186**
1999	Wild	0	0	0	0	9	24	298	10	**341**
	Hatchery	0	0	3	2	14	29	468	38	**554**
2000	Wild	0	0	8	8	24	11	189	4	**244**
	Hatchery	0	2	12	7	23	5	538	37	**624**
2001	Wild	0	10	23	5	67	42	390	54	**591**
	Hatchery	0	16	52	5	60	70	751	51	**1,005**
2002	Wild	6	14	20	10	81	212	340	72	**755**
	Hatchery	4	18	63	25	123	360	925	187	**1,705**
2003	Wild	0	0	13	0	12	149	221	116	**511**
	Hatchery	0	0	15	0	5	91	364	257	**732**
2004	Wild	0	2	19	19	108	225	1,126	260	**1,759**
	Hatchery	0	2	12	5	38	58	266	38	**419**
2005	Wild	0	5	51	21	256	364	532	176	**1,405**
	Hatchery	0	3	42	16	115	67	199	100	**542**
2006	Wild	2	2	23	11	110	271	70	78	**567**
	Hatchery	2	1	8	5	10	20	443	22	**511**
2007	Wild	1	0	33	1	303	347	441	21	**1,147**
	Hatchery	1	0	22	0	150	172	217	8	**570**
2008	Wild	2	1	16	11	121	341	361	44	**897**
	Hatchery	2	9	24	25	127	324	498	113	**1,122**
2009	Wild	2	3	14	15	192	352	341	76	**995**

Survey year	Origin	Survey reach								Total
		O-1	O-2	O-3	O-4	O-5	O-6	S-1	S-2	
	Hatchery	0	4	17	17	156	148	362	74	**778**
2010	Wild	1	5	19	18	154	180	332	69	**778**
	Hatchery	2	5	11	24	87	172	295	79	**675**
Average	***Wild***	***1***	***2***	***14***	***7***	***82***	***141***	***287***	***56***	***590***
	Hatchery	***1***	***4***	***16***	***7***	***54***	***85***	***346***	***59***	***572***

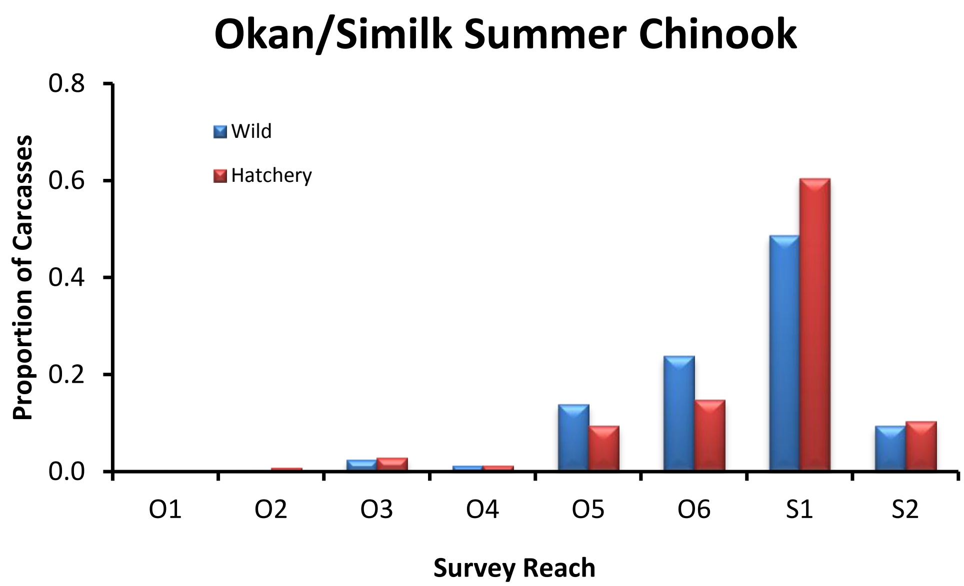

Figure 8.4. Distribution of wild and hatchery produced carcasses in different reaches in the Okanogan Basin, 1993-2010. Reach codes are described in Table 2.11.

Sampling Rate

Overall, 18% of the total spawning escapement of summer Chinook in the Okanogan Basin was sampled in 2011 (Table 8.12). Sampling rates among survey reaches varied from 0 to 20%.

Table 8.12. Number of redds and carcasses, total spawning escapement, and sampling rates for summer Chinook in the Okanogan Basin, 2011.

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Okanogan 1 (O1)	3	0	9	0.00
Okanogan 2 (O2)	20	0	62	0.00
Okanogan 3 (O3)	101	55	313	0.18
Okanogan 4 (O4)	55	14	171	0.08
Okanogan 5 (O5)	593	361	1,838	0.20
Okanogan 6 (O6)	942	479	2,920	0.16

Sampling reach	Total number of redds	Total number of carcasses	Total spawning escapement	Sampling rate
Similkameen 1 (S1)	1,217	752	3,773	0.20
Similkameen 2 (S2)	192	114	595	0.19
Total	***3,123***	***1,775***	***9,681***	***0.18***

Length Data

Mean lengths (POH, cm) of male and female summer Chinook carcasses sampled during surveys on the Okanogan and Similkameen rives in 2011 are provided in Table 8.13. The average size of males and females sampled in the Okanogan Basin were 61 cm and 71 cm, respectively.

Table 8.13. Mean lengths (postorbital-to-hypural length; cm) and standard deviations (in parentheses) of male and female summer Chinook carcasses sampled in different reaches in the Okanogan Basin, 2011.

Stream/watershed	Mean length (cm)	
	Male	Female
Okanogan 1 (O1)	-	-
Okanogan 2 (O2)	-	-
Okanogan 3 (O3)	51.1 (12.9)	69.0 (5.1)
Okanogan 4 (O4)	53.3 (15.2)	69.5 (0.7)
Okanogan 5 (O5)	60.0 (13.6)	70.0 (4.9)
Okanogan 6 (O6)	60.3 (10.7)	69.7 (3.9)
Similkameen 1 (S1)	63.3 (12.5)	71.3 (4.6)
Similkameen 2 (S2)	67.0 (9.5)	71.5 (3.6)
Total	***60.7 (12.6)***	***70.7 (4.5)***

8.6 Life History Monitoring

Life history characteristics of Okanogan/Similkameen summer Chinook were assessed by examining carcasses on spawning grounds and fish collected or examined at broodstock collection sites, and by reviewing tagging data and fisheries statistics.

Migration Timing

Migration timing for Okanogan/Similkameen summer Chinook is described in Section 7.6.

Age at Maturity

Because hatchery summer Chinook are released after one year of rearing and natural-origin summer Chinook migrate primarily as age-0 fish, total ages will differ between hatchery and natural-origin Chinook (see Hillman et al. 2011). Therefore, in this section, we evaluated age at maturity by comparing differences in salt (ocean) ages between the two groups.

Most of the wild and hatchery summer Chinook sampled during the period 1993-2010 in the Okanogan Basin were salt age-3 fish (Table 8.14; Figure 8.5). A higher percentage of salt age-4 wild Chinook returned to the basin than did salt age-4 hatchery Chinook. In contrast, a higher proportion of salt age-1, 2, and 3 hatchery fish returned than did salt age-1, 2, and 3 wild fish. Thus, a higher percentage of wild fish returned at an older age than did hatchery fish.

Table 8.14. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled on spawning grounds in the Okanogan Basin, 1993-2010.

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
1993	Wild	0.00	0.21	0.70	0.10	0.00	63
	Hatchery	0.00	0.98	0.02	0.00	0.00	44
1994	Wild	0.02	0.13	0.54	0.31	0.00	134
	Hatchery	0.02	0.09	0.89	0.00	0.00	290
1995	Wild	0.00	0.19	0.59	0.22	0.00	68
	Hatchery	0.01	0.15	0.36	0.49	0.00	200
1996	Wild	0.03	0.28	0.61	0.08	0.00	36
	Hatchery	0.02	0.22	0.56	0.20	0.01	174
1997	Wild	0.04	0.27	0.53	0.15	0.00	73
	Hatchery	0.00	0.02	0.87	0.11	0.00	148
1998	Wild	0.02	0.35	0.52	0.11	0.00	151
	Hatchery	0.05	0.50	0.23	0.22	0.00	185
1999	Wild	0.00	0.20	0.64	0.16	0.00	268
	Hatchery	0.00	0.12	0.85	0.02	0.00	552
2000	Wild	0.03	0.15	0.62	0.20	0.00	216
	Hatchery	0.12	0.02	0.76	0.10	0.00	545
2001	Wild	0.02	0.18	0.76	0.04	0.00	531
	Hatchery	0.05	0.88	0.02	0.05	0.00	1,005
2002	Wild	0.02	0.15	0.62	0.21	0.00	692
	Hatchery	0.01	0.19	0.80	0.01	0.00	1,681
2003	Wild	0.03	0.18	0.63	0.17	0.00	478
	Hatchery	0.03	0.06	0.79	0.12	0.00	653
2004	Wild	0.01	0.17	0.26	0.55	0.00	1,528
	Hatchery	0.01	0.32	0.45	0.23	0.00	382
2005	Wild	0.00	0.12	0.79	0.08	0.01	1,281
	Hatchery	0.02	0.06	0.77	0.15	0.00	530
2006	Wild	0.00	0.02	0.53	0.45	0.00	830
	Hatchery	0.05	0.18	0.24	0.53	0.00	139
2007	Wild	0.02	0.07	0.12	0.78	0.02	1,061
	Hatchery	0.22	0.30	0.42	0.05	0.01	559
2008	Wild	0.01	0.32	0.63	0.04	0.01	847
	Hatchery	0.02	0.60	0.36	0.02	0.00	1,108
2009	Wild	0.01	0.03	0.81	0.15	0.00	926
	Hatchery	0.05	0.05	0.86	0.03	0.00	783

Sample year	Origin	Salt age					Sample size
		1	2	3	4	5	
2010	Wild	0.00	0.16	0.45	0.39	0.00	711
	Hatchery	0.02	0.64	0.27	0.06	0.00	622
Average	***Wild***	***0.01***	***0.14***	***0.54***	***0.30***	***0.00***	***550***
	Hatchery	***0.04***	***0.31***	***0.57***	***0.08***	***0.00***	***533***

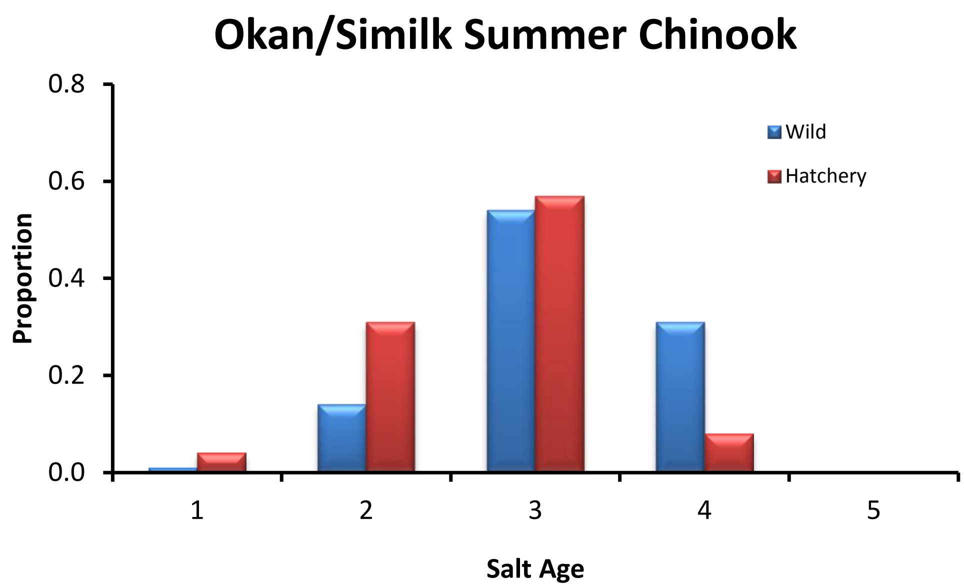

Figure 8.5. Proportions of wild and hatchery summer Chinook of different salt (ocean) ages sampled at broodstock collection sites and on spawning grounds in the Okanogan Basin for the combined years 1993-2010.

Size at Maturity

On average, hatchery summer Chinook were about 2 cm smaller than wild summer Chinook sampled in the Okanogan Basin (Table 8.15). This is interesting given that a slightly higher percentage of hatchery fish returned as age-5 and 6 fish than did wild fish. Future analyses will compare sizes of hatchery and wild fish of the same age groups and gender.

Table 8.15. Mean lengths (POH; cm) and variability statistics for wild and hatchery summer Chinook sampled in the Okanogan Basin, 1993-2010; SD = 1 standard deviation.

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1993	Wild	69	73	7	52	90
	Hatchery	59	62	6	47	75
1994	Wild	164	71	7	40	86
	Hatchery	300	69	8	30	84
1995	Wild	81	75	6	54	87
	Hatchery	201	73	8	39	87

Sample year	Origin	Sample size	Summer Chinook length (POH; cm)			
			Mean	SD	Minimum	Maximum
1996	Wild	22	68	14	22	85
	Hatchery	26	75	8	60	88
1997	Wild	87	71	7	44	85
	Hatchery	148	74	6	48	88
1998	Wild	182	70	8	45	94
	Hatchery	186	65	12	30	87
1999	Wild	340	73	7	56	91
	Hatchery	554	71	7	23	84
2000	Wild	241	70	10	32	86
	Hatchery	624	69	12	24	92
2001	Wild	579	67	9	26	90
	Hatchery	997	61	8	32	90
2002	Wild	755	69	9	28	91
	Hatchery	1,705	70	8	33	87
2003	Wild	533	68	9	30	93
	Hatchery	732	69	10	26	90
2004	Wild	1,757	71	10	33	94
	Hatchery	416	66	9	41	92
2005	Wild	1,407	66	7	41	99
	Hatchery	542	68	8	31	85
2006	Wild	940	72	6	31	91
	Hatchery	138	70	10	33	86
2007	Wild	1,147	75	9	27	99
	Hatchery	570	63	13	30	85
2008	Wild	897	65	9	29	86
	Hatchery	1,122	65	8	32	89
2009	Wild	995	70	7	28	89
	Hatchery	777	70	9	35	86
2010	Wild	778	71	9	43	90
	Hatchery	675	64	10	22	87
Pooled	***Wild***	***10,974***	***70***	***8***	***22***	***99***
	Hatchery	***9,772***	***68***	***9***	***22***	***92***

Contribution to Fisheries

Most of the harvest on hatchery-origin Okanogan/Similkameen summer Chinook occurred in the Ocean (Table 8.16). Ocean harvest has made up 37-100% of all hatchery-origin Okanogan/Similkameen summer Chinook harvested. Brood years 1997, 1998, 2000, and 2004 provided the largest harvests, while brood year 1996 provided the lowest.

Table 8.16. Estimated number and percent (in parentheses) of hatchery-origin Okanogan/Similkameen summer Chinook captured in different fisheries, brood years 1989-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1989	2,366 (80)	553 (19)	0 (0)	42 (1)	2,961
1990	351 (88)	34 (9)	0 (0)	12 (3)	397
1991	224 (86)	37 (14)	0 (0)	0 (0)	261
1992	425 (91)	28 (6)	2 (0)	10 (2)	465
1993	24 (80)	6 (20)	0 (0)	0 (0)	30
1994	385 (92)	23 (6)	2 (0)	7 (2)	417
1995	655 (93)	9 (1)	12 (2)	25 (4)	701
1996	5 (100)	0 (0)	0 (0)	0 (0)	5
1997	6,608 (92)	136 (2)	36 (1)	416 (6)	7,196
1998	4,353 (89)	251 (5)	45 (1)	219 (4)	4,868
1999	1,355 (68)	224 (11)	31 (2)	383 (19)	1,993
2000	3,130 (69)	533 (12)	222 (5)	664 (15)	4,549
2001	183 (57)	81 (25)	31 (10)	24 (8)	319
2002	701 (56)	200 (16)	90 (7)	258 (21)	1,249
2003	696 (37)	568 (31)	130 (7)	466 (25)	1,860
2004	2,788 (38)	1,853 (25)	642 (9)	2,021 (28)	7,304
2005	468 (46)	192 (19)	79 (8)	281 (28)	1,020

Straying

Stray rates were determined by examining CWTs recovered on spawning grounds within and outside the Okanogan Basin. Targets for strays based on return year (recovery year) and brood year should be less than 5%.

Few hatchery-origin Okanogan summer Chinook have strayed into basins outside the Okanogan (Table 8.17). Although hatchery-origin Okanogan summer Chinook have strayed into other spawning areas, they made up less than 5% of the spawning escapement within those areas. The Chelan tailrace has received the largest number of Okanogan strays.

Table 8.17. Number and percent of spawning escapements within other non-target basins that consisted of hatchery-origin Okanogan summer Chinook, return years 1994-2008. For example, for return year 2002, 1% of the summer Chinook spawning escapement in the Entiat Basin consisted of hatchery-origin Okanogan summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1994	0	0.0	0	0.0	-	-	-	-	-	-
1995	0	0.0	0	0.0	-	-	-	-	-	-
1996	0	0.0	0	0.0	-	-	-	-	-	-
1997	0	0.0	0	0.0	-	-	-	-	-	-

Return year	Wenatchee		Methow		Chelan		Entiat		Hanford Reach	
	Number	%	Number	%	Number	%	Number	%	Number	%
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	0	0.0	6	0.5	30	4.5	0	0.0	3	0.0
2001	12	0.1	0	0.0	10	1.0	0	0.0	0	0.0
2002	0	0.0	3	0.1	4	0.7	5	1.0	0	0.0
2003	0	0.0	8	0.2	22	5.3	14	2.0	0	0.0
2004	0	0.0	0	0.0	5	1.2	0	0.0	0	0.0
2005	5	0.1	27	1.1	36	8.1	7	1.9	8	0.0
2006	0	0.0	5	0.2	4	1.0	2	0.3	0	0.0
2007	0	0.0	3	0.2	4	2.1	0	0.0	0	0.0
2008	0	0.0	9	0.5	41	8.2	4	1.3	0	0.0
Total	***17***	***0.0***	***61***	***0.2***	***156***	***3.2***	***32***	***0.8***	***11***	***0.0***

On average, less than 1% of the returns have strayed into non-target spawning areas, falling below the target of 5% (Table 8.18). Depending on brood year, percent strays into non-target spawning areas have ranged from 0-4.2%. Few (<1% on average) have strayed into non-target hatchery programs.

Table 8.18. Number and percent of hatchery-origin Okanogan summer Chinook that homed to target spawning areas and the target hatchery, and number and percent that strayed to non-target spawning areas and non-target hatchery programs, by brood years 1989-2005. Percent stays should be less than 5%.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1989	3,132	69.7	1,328	29.6	2	0.0	31	0.7
1990	729	71.4	291	28.5	0	0.0	1	0.1
1991	1,125	71.3	453	28.7	0	0.0	0	0.0
1992	1,264	68.5	572	31.0	8	0.4	1	0.1
1993	54	62.1	32	36.8	0	0.0	1	1.1
1994	924	80.8	203	17.7	16	1.4	1	0.1
1995	1,883	85.4	271	12.3	50	2.3	0	0.0
1996	27	100.0	0	0.0	0	0.0	0	0.0
1997	11,659	97.1	309	2.6	35	0.3	2	0.0
1998	2,784	95.4	102	3.5	31	1.1	2	0.1
1999	828	96.7	18	2.1	10	1.2	0	0.0
2000	2,091	93.8	29	1.3	94	4.2	15	0.7
2001	105	98.1	2	1.9	0	0.0	0	0.0
2002	702	96.2	17	2.3	11	1.5	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2003	1,580	96.2	47	2.9	16	1.0	0	0.0
2004	4,500	94.8	185	3.9	60	1.3	2	0.0
2005	579	92.9	22	3.5	22	3.5	0	0.0
Total	***33,387***	***88.7***	***3,859***	***10.3***	***333***	***0.9***	***56***	***0.1***

Genetics

Genetic studies were conducted to investigate relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin (Kassler et al. 2100; the entire report is appended as Appendix K). Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – Methow/Okanogan (MEOK) stock, and Wells Hatchery were also included in the analysis. Samples of natural and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has affected the genetic structure of these populations. The study also calculated the effective number of breeders for collection locations of natural and hatchery-origin summer Chinook from 1993 and 2008.

In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Proportion of Natural Influence

Another method for assessing the genetic risk of a supplementation program is to determine the influence of the hatchery and natural environments on the adaptation of the composite population. This is estimated by the proportion of natural-origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery-origin fish in the natural spawning escapement (pHOS). The ratio pNOB/(pHOS+pNOB) is the Proportion of Natural Influence (PNI). The larger the ratio (PNI), the greater the strength of selection in the natural environment relative to that of the hatchery environment. In order for the natural environment to dominate selection, PNI should be greater than 0.67 (HSRG/WDFW/NWIFC 2004).

For brood years 1993-2003, the PNI was less than 0.67, indicating that the hatchery environment had a greater influence on adaptation of Okanogan summer Chinook than did the natural environment (Table 8.19). However, since brood year 2003, the PNI has generally been greater than 0.67, indicating that the natural environment has a greater influence on adaptation of Okanogan summer Chinook than does the hatchery environment.

Table 8.19. Proportionate natural influence (PNI) of the Okanogan/Similkameen summer Chinook supplementation program for brood years 1989-2010. PNI was calculated as the proportion of naturally produced Chinook in the hatchery broodstock (pNOB) divided by the proportion of hatchery Chinook on the spawning grounds (pHOS) plus pNOB. NOS = number of natural-origin Chinook on the spawning grounds; HOS = number of hatchery-origin Chinook on the spawning grounds; NOB = number of natural-origin Chinook collected for broodstock; and HOB = number of hatchery-origin Chinook included in hatchery broodstock.

Brood year	Spawners			Broodstock			PNI
	NOS	HOS	pHOS	NOB	HOB	pNOB	
1989	1,719	0	0.00	1,297	312	0.81	1.00
1990	837	0	0.00	828	206	0.80	1.00
1991	574	0	0.00	924	314	0.75	1.00
1992	473	0	0.00	297	406	0.42	1.00
1993	915	570	0.38	681	388	0.64	0.63
1994	1,322	2,709	0.67	341	244	0.58	0.46
1995	979	2,023	0.67	173	240	0.42	0.39
1996	568	1,251	0.69	290	223	0.57	0.45
1997	862	1,327	0.61	198	264	0.43	0.41
1998	600	492	0.45	153	211	0.42	0.48
1999	1,274	2,343	0.65	224	289	0.44	0.40
2000	1,174	2,527	0.68	164	339	0.33	0.33
2001	4,306	6,551	0.60	91	266	0.25	0.29
2002	4,346	9,511	0.69	247	241	0.51	0.43
2003	1,933	1,487	0.43	381	101	0.79	0.64
2004	5,309	1,412	0.21	506	16	0.97	0.82
2005	6,441	2,448	0.28	391	9	0.98	0.78
2006	5,507	3,094	0.36	500	10	0.98	0.73
2007	2,983	1,434	0.32	456	17	0.96	0.75
2008	2,998	3,977	0.57	404	41	0.91	0.61
2009	4,204	3,340	0.44	507	0	1.00	0.69
2010	3,189	2,763	0.46	484	8	0.98	0.68
Average	***2,387***	***2,239***	***0.42***	***434***	***188***	***0.68***	***0.64***

Natural and Hatchery Replacement Rates

Natural replacement rates (NRR) were calculated as the ratio of natural-origin recruits (NOR) to the parent spawning population (spawning escapement). For brood years 1989-2004, NRR for summer Chinook in the Okanogan averaged 1.15 (range, 0.16-3.80) if harvested fish were not include in the estimate and 2.39 (range, 0.35-10.15) if harvested fish were included in the estimate (Table 8.20). NRRs for more recent brood years will be calculated as soon as all tag recoveries and sampling rates have been loaded into the database.

Hatchery replacement rates (HRR) are the hatchery adult-to-adult returns and were calculated as the ratio of hatchery-origin recruits (HOR) to the parent broodstock collected. These rates should be greater than the NRRs and greater than or equal to 5.30 (the calculated target value in Murdoch and Peven 2005). HRRs exceeded NRRs in 13 of the 16 years of data, regardless if harvest was or was not included in the estimate (Table 8.20). Hatchery replacement rates for Okanogan summer Chinook have exceeded the estimated target value of 5.30 in seven or ten of the 16 years of data depending on if harvest was or was not included in the estimate.

Table 8.20. Broodstock collected, spawning escapements, natural and hatchery-origin recruits (NOR and HOR), and natural and hatchery replacement rates (NRR and HRR; with and without harvest) for wild summer Chinook in the Okanogan Basin, brood years 1989-2004.

Brood year	Broodstock Collected	Spawning Escapement	Harvest not included				Harvest included			
			HOR	NOR	HRR	NRR	HOR	NOR	HRR	NRR
1989	304	1,719	4,493	2,139	14.78	1.24	7,454	3,559	24.52	2.07
1990	288	837	1,021	1,477	3.55	1.76	1,418	2,057	4.92	2.46
1991	364	574	1,578	884	4.34	1.54	1,839	1,026	5.05	1.79
1992	304	473	1,845	1,069	6.07	2.26	2,310	1,343	7.60	2.84
1993	328	1,485	87	474	0.27	0.32	117	637	0.36	0.43
1994	302	4,033	1,144	1,397	3.79	0.35	1,561	1,911	5.17	0.47
1995	385	3,002	2,204	1,357	5.72	0.45	2,905	1,795	7.55	0.60
1996	330	1,819	27	728	0.08	0.40	32	868	0.10	0.48
1997	313	2,189	12,005	4,418	38.35	2.02	19,201	7,080	61.35	3.23
1998	352	1,092	2,919	4,145	8.29	3.80	7,787	11,083	22.12	10.15
1999	333	3,617	856	6,680	2.57	1.85	2,849	22,341	8.56	6.18
2000	334	3,701	2,229	1,729	6.67	0.47	6,778	5,271	20.29	1.42
2001	335	10,857	107	8,993	0.32	0.83	426	35,972	1.27	3.31
2002	333	13,857	730	6,043	2.19	0.44	1,979	16,421	5.94	1.19
2003	337	3,420	1,643	558	4.88	0.16	3,503	1,192	10.39	0.35
2004	335	6,721	4,747	3,128	14.17	0.47	12,051	7,980	35.97	1.19
Average	***330***	***3,712***	***2,352***	***2,826***	***7.25***	***1.15***	***4,013***	***7,534***	***13.82***	***2.39***

Smolt-to-Adult Survivals

Smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery smolts released. SARs were based on CWT returns.

For the available brood years, SARs have ranged from 0.00006 to 0.03263 for hatchery summer Chinook in the Okanogan Basin (Table 8.21).

Table 8.21. Smolt-to-adult ratios (SARs) for Okanogan/Similkameen summer Chinook, brood years 1989-2005.

Brood year	Number of tagged smolts released[a]	Estimated adult captures[b]	SAR
1989	202,125	4,290	0.02122
1990	367,207	970	0.00264
1991	360,380	977	0.00271
1992	537,190	2,285	0.00425
1993	379,139	117	0.00031
1994	217,818	1,538	0.00706
1995	574,197	2,854	0.00497
1996	487,776	31	0.00006
1997	572,531	18,682	0.03263
1998	287,948	7,678	0.02666
1999	610,868	2,778	0.00455
2000	528,639	6,751	0.01277
2001	26,315	424	0.01611
2002	245,997	1,974	0.00802
2003	574,908	3,488	0.00607
2004	579,570	11,616	0.02004
2005	273,463	1,633	0.00597
Average	***401,534***	***4,005***	***0.01036***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

8.7 ESA/HCP Compliance

Broodstock Collection

Because summer Chinook adults collected at Wells Dam are used for both the Methow and Okanogan supplementation programs, please refer to Section 7.7 for information on ESA compliance during broodstock collection.

Hatchery Rearing and Release

The 2009 brood Okanogan/Similkameen summer Chinook reared throughout their juvenile life-stages at Eastbank Fish Hatchery and Similkameen and Bonaparte Acclimation ponds. Elevated mortality associated with bacterial cold-water disease and bacterial gill disease (see Section 8.3) at Bonaparte Pond resulted in significant fish losses, which caused the program to fall below the release target of 576,000 smolts. Subsequent treatment of fish reduced the mortality to residual levels. The 2009 brood smolt release from the Similkameen and Bonaparte ponds totaled 675,903 summer Chinook, representing 117.3% of the production objective for the Okanogan/Similkameen program and was out of compliance with the 10% overage in production allowable in ESA Section 10 Permit 1347 by about 42,303 fish.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January 2010 through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

Spawning Surveys

Summer Chinook spawning ground surveys conducted in the Okanogan Basin during 2011 were consistent with ESA Section 10 Permit No. 1347. Because of the difficulty of quantifying the level of take associated with spawning ground surveys, the Permit does not specify a take level associated with these activities, even though it does authorize implementation of spawning ground surveys. Therefore, no take levels are reported. However, to minimize potential impacts to established redds, wading was restricted to the extent practical, and extreme caution was used to avoid established redds when wading was required.

SECTION 9: TURTLE ROCK SUMMER CHINOOK

9.1 Broodstock Sampling

Broodstock for the Turtle Rock programs are collected as part of the Wells summer Chinook volunteer program. Refer to Snow et al. (2007) for information related to adults collected for these programs.

9.2 Hatchery Rearing

Rearing History

Number of eggs taken

Broodstock for the Turtle Rock summer Chinook are collected at Wells Dam and consist of volunteers to the hatchery. In recent years some naturally produced fish have been incorporated into the brood. Eyed eggs are transferred from Wells FH to Eastbank FH for rearing. As such, the number of green (unfertilized) eggs collected for this program is reported as egg inventory and distribution reports provided by Wells FH personnel.

Disease

Within the normal and accelerated subyearling program, the primary cause of mortality in the early life stages (swim-up to early ponding) continues to be coagulated yolk as a result of lack of chilled water during incubation. No additional significant health concerns were encountered with the two subyearling groups during rearing and no treatments were recommended. External fungus was diagnosed in the yearling program in December. No further issue developed after treatment. No additional disease-related problems were noted before the fish were released.

Number of acclimation days

Rearing of the 2009-brood normal and accelerated subyearling Turtle Rock summer Chinook was similar to previous years with fish being held on well water before being transferred to Turtle Rock for final acclimation on 13 May 2010. Both rearing groups were released on 7 June 2010 after 21 days of acclimation on Columbia River water. One group of yearling Turtle Rock summer Chinook was released on 2 May 2011, after 180 days of acclimation on Columbia River water. The Chelan River net pen group was released on 19 April, after 167 days of acclimation on Chelan River water.

Release Information

Numbers released

The subyearling Turtle Rock summer Chinook program was discontinued in 2010; however, releases of subyearling Chinook in past years are shown in Tables 9.1 and 9.2. Production from the subyearling programs was converted to the yearling program.

The 2009 yearling summer Chinook program achieved 73.5% of the 600,000 target goal with about 441,116 fish being released (250,667 from Turtle Rock and 190,449 from the Chelan River net pens) (Table 9.3). Releases of 2010 yearling Chinook will be reported in the 2012 report.

Table 9.1. Numbers of Turtle Rock summer Chinook subyearlings released from the hatchery, 1995-2010. The release target for Turtle Rock summer Chinook subyearlings was 810,000 fish.

Brood year	Release year	CWT mark rate	Number of subyearlings released
1995	1996	0.1873	1,074,600
1996	1997	0.9653	385,215
1997	1998	0.9780	508,060
1998	1999	0.6453	301,777
1999	2000	0.9748	369,026
2000	2001	0.3678	604,892
2001	2002	0.9871	214,059
2002	2003	0.3070	656,399
2003	2004	0.4138	491,480
2004	2005	0.4591	411,707
2005	2006	0.4337	490,074
2006	2007	0.3388	538,392
2007	2008	0.4385	439,806
2008	2009	0.6355	309,003
2009	2010	NA	713,130
Average		***0.6111***	***500,508***

Table 9.2. Numbers of Turtle Rock summer Chinook accelerated subyearlings released from the hatchery, 1995-2009. The release target for Turtle Rock summer Chinook accelerated subyearlings was 810,000 fish.

Brood year	Release year	CWT mark rate	Number of subyearlings released
1995	1996	0.9834	169,000
1996	1997	0.4163	477,300
1997	1998	0.3767	521,480
1998	1999	0.6033	307,571
1999	2000	0.9556	347,946
2000	2001	0.4331	449,329
2001	2002	0.4086	480,584
2002	2003	0.5492	364,461
2003	2004	0.6414	289,696
2004	2005	0.5471	364,453
2005	2006	0.9783	457,340
2006	2007	0.5510	342,273
2007	2008	0.4745	392,024
2008	2009	0.5295	372,320
Average		***0.6034***	***381,127***

Table 9.3. Numbers of Turtle Rock summer Chinook yearling smolts released from the hatchery, 1995-2009. The release target for Turtle Rock summer Chinook is 200,000 smolts.

Brood year	Release year	Acclimation facility	CWT mark rate	Number of smolts released
1995	1997	Turtle Rock	0.9688	150,000
1996	1998	Turtle Rock	0.9582	202,727
1997	1999	Turtle Rock	0.9800	202,989
1998	2000	Turtle Rock	0.9337	217,797
1999	2001	Turtle Rock	0.9824	285,707
2000	2002	Turtle Rock	0.9948	165,935
2001	2003	Turtle Rock	0.9824	203,279
2002	2004	Turtle Rock	0.9799	195,851
2003	2005	Turtle Rock	0.9258	215,366
2004	2006	Turtle Rock	0.9578	206,734
2005	2007	Turtle Rock	0.9810	204,644
2006	2008	Chelan	0.9752	99,271
		Turtle Rock	0.9752	43,943
2007	2009	Chelan	0.9426	112,604
		Turtle Rock	0.9426	61,003
2008	2010	Chelan	0.9818	200,999
		Turtle Rock	0.9818	252,762
2009	2011	Chelan[a]	-	190,449
		Turtle Rock	0.9721	250,667
Average		***Chelan***	***0.9665***	***137,625***
		Turtle Rock	***0.9678***	***190,627***

[a] No CWT mark rate was provided because of the early release of this group.

Numbers tagged

The 2009 yearling Chinook were 97.2% CWT and adipose fin-clipped.

In 2012, a total of 4,200 summer Chinook from the 2010 brood were PIT tagged at the Chelan River Hatchery during 21-23 and 27 March. Fish were tagged in four groups of 1,050 per group. Fish were not fed during tagging or for 1-2 days before and after tagging. Chinook averaged 143 mm in length and 34.0 g at time of tagging. As of the end of March 2012, no fish have died or shed their tags.

Table 9.4 summarizes the number of yearling summer Chinook that have been PIT-tagged and released from the Turtle Rock Program.

Table 9.4. Summary of PIT-tagging activities for Turtle Rock yearling summer Chinook, brood years 2007-2010.

Brood year	Release year	Raceway/Program	Number of fish tagged	Number of tagged fish that died	Number of tags shed	Number of tagged fish released
2007	2009	Circular Reuse	10,104	128	1	9,975
		Standard	10,102	162	3	9,937
2008	2010	Circular Reuse	11,102	15	0	11,087
		Standard	11,100	18	2	11,080
2009	2011	Turtle Rock	5,051	106	0	4,945
		Chelan Net Pens	5,050	2	0	5,048
2010	2012	Turtle Rock	0	0	0	0
		Chelan Net Pens	4,200			

Fish size and condition at release

Although the subyearling summer Chinook program was discontinued, sizes of subyearlings released from Turtle Rock Hatchery before 2010 are shown in Tables 9.5 and 9.6.

Table 9.5. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook subyearlings released from the hatchery, 1995-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1995	1996	102	6.3	12.6	36
1996	1997	87	8.0	7.4	62
1997	1998	98	6.2	10.2	45
1998	1999	96	6.3	10.7	43
1999	2000	90	9.0	9.8	46
2000	2001	100	7.1	11.3	40
2001	2002	104	7.2	13.4	34
2002	2003	97	7.3	11.8	39
2003	2004	101	8.0	12.0	43
2004	2005	100	7.8	11.4	40
2005	2006	100	6.5	12.5	36
2006	2007	95	7.2	9.5	48
2007	2008	79	7.4	5.6	81
2008	2009	86	7.9	7.9	57
2009[a]	2010	89	7.1	7.0	65
Targets		***112***	***9.0***	***11.4***	***40***

[a] Pre-release growth sample was conducted using pond mortalities.

Table 9.6. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook accelerated subyearlings released from the hatchery, 1995-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Fork length (mm)		Mean weight	
		Mean	CV	Grams (g)	Fish/pound
1995	1996	129	7.1	27.3	17
1996	1997	107	6.5	15.6	29
1997	1998	117	6.0	18.9	24
1998	1999	119	8.0	18.9	24
1999	2000	114	6.7	19.0	24
2000	2001	111	7.0	16.8	27
2001	2002	117	8.4	19.5	23
2002	2003	116	11.3	21.2	21
2003	2004	113	14.9	17.0	30
2004	2005	117	11.3	20.1	23
2005	2006	119	9.1	22.2	21
2006	2007	118	8.3	19.1	24
2007	2008	95	7.7	10.0	45
2008[a]	2009	97	8.6	10.6	43
Targets		***112***	***9.0***	***11.4***	***40***

[a] The 2008 brood year was the last year of the accelerated subyearling program.

Size at release of the 2009 yearling summer Chinook was 89.8% and 103% of the target fork length and weight, respectively, for the Chelan Falls group. This group also exceeded the target CV for length by 67.8%. The Turtle Rock group was 98.9% and 131.0% of the target fork length and weight, respectively, and exceeded the target CV for length by 94.4% (Table 9.7).

Table 9.7. Mean lengths (FL, mm), weight (g and fish/pound), and coefficient of variation (CV) of Turtle Rock summer Chinook yearlings released from the hatchery, 1995-2009. Size targets are provided in the last row of the table.

Brood year	Release year	Acclimation facility	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
1995	1997	Turtle Rock	-	-	-	-
1996	1998	Turtle Rock	166	14.2	60.9	7
1997	1999	Turtle Rock	198	4.6	91.3	5
1998	2000	Turtle Rock	161	11.9	53.9	8
1999	2001	Turtle Rock	164	18.6	59.0	8
2000	2002	Turtle Rock	170	15.3	59.0	8
2001	2003	Turtle Rock	154	22.3	48.6	9
2002	2004	Turtle Rock	157	16.7	44.0	12
2003	2005	Turtle Rock	173	13.8	54.7	8
2004	2006	Turtle Rock	176	20.6	45.3	7

Brood year	Release year	Acclimation facility	Fork length (mm)		Mean weight	
			Mean	CV	Grams (g)	Fish/pound
2005	2007	Turtle Rock	158	11.0	43.5	10
2006	2008	Chelan	172	14.5	58.4	8
		Turtle Rock	157	25.8	54.1	8
2007	2009	Chelan	153	18.8	45.7	10
		Turtle Rock	167	14.6	49.3	9
2008	2010	Chelan	146	22.9	40.6	11
		Turtle Rock	172	15.9	58.5	8
2009	2011	Chelan	158	15.1	46.6	10
		Turtle Rock	174	17.5	59.3	8
Targets			***176***	***9.0***	***45.4***	***10***

Survival Estimates

Normal subyearling releases

Overall survival of the normal subyearling Turtle Rock summer Chinook program from green egg to release was below the standard set for the program (Table 9.8). Lower than expected survival at ponding and post-ponding reduced the overall program performance. This program was discontinued in 2010.

Table 9.8. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (zero program) summer Chinook, brood years 2004-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2004	NA	NA	93.5	74.4	93.9	91.4	90.8	99.7	63.1
2005	NA	NA	94.4	87.9	85	84.8	84.2	99.4	69.8
2006	NA	NA	97.8	87.9	85.0	84.8	84.2	99.4	72.4
2007	NA	NA	92.7	84.9	88.5	86.7	84.8	99.6	66.7
2008	NA	NA	78.8	95.0	80.7	79.3	79.9	99.8	59.8
2009	NA	NA	95.0	89.4	89.5	89.2	79.7	89.5	67.7
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

Accelerated subyearling releases

Overall survival of the accelerated subyearling Turtle Rock summer Chinook program from green egg to release was below the standard set for the program (Table 9.9). Lower than expected survival in post-ponding reduced the overall program performance. This program was discontinued in 2010.

Table 9.9. Hatchery life-stage survival rates (%) for Turtle Rock subyearling (accelerated program) summer Chinook, brood years 2004-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Unfertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Unfertilized egg-release
	Female	Male							
2004	NA	NA	92.5	98.3	93.4	92.4	90.0	97.8	81.8
2005	NA	NA	93.8	94.6	83.7	83.4	81.7	98.8	72.5
2006	NA	NA	86.1	94.6	83.7	83.4	81.7	98.8	66.5
2007	NA	NA	93.4	95.4	78.4	77.5	76.3	98.9	67.9
2008[a]	NA	NA	93.4	95.0	79.8	78.8	78.2	99.3	67.1
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

[a] The 2008 brood year was the last year of the accelerated subyearling program.

Yearling releases

Overall survival of the yearling Turtle Rock summer Chinook program from green egg to release was above the standard set for the program (Table 9.10). Higher than expected survivals in all life stages contributed to the increased program performance.

Table 9.10. Hatchery life-stage survival rates (%) for Turtle Rock yearling summer Chinook, brood years 2004-2009. Survival standards or targets are provided in the last row of the table.

Brood year	Collection to spawning		Un-fertilized egg-eyed	Eyed egg-ponding	30 d after ponding	100 d after ponding	Ponding to release	Transport to release	Un-fertilized egg-release
	Female	Male							
2004	NA	NA	92.9	97.7	96.8	96.4	95.5	99.6	86.7
2005	NA	NA	89.1	97.5	98.1	97.8	96.6	99.1	83.9
2006	NA	NA	86.2	78.8	97.6	97.1	95.2	98.7	64.8
2007 (Turtle Rock)	NA	NA	80.3	97.6	98.8	98.2	95.4	99.1	74.8
2007 (Chelan Falls)	NA	NA	80.3	97.6	98.8	98.2	94.9	97.1	74.4
2008 (Turtle Rock)	NA	NA	93.5	98.0	99.4	97.2	95.9	98.8	87.8
2008 (Chelan Falls)	NA	NA	93.5	98.0	97.6	98.7	96.4	99.3	88.2
2009 (Turtle Rock)	NA	NA	90.8	96.8	99.7	99.0	97.2	98.1	85.5
2009 (Chelan Falls)	NA	NA	90.9	96.9	99.8	99.0	96.7	97.7	85.2
Standard	***90.0***	***85.0***	***92.0***	***98.0***	***97.0***	***93.0***	***90.0***	***95.0***	***81.0***

9.3 Life History Monitoring

Life history characteristics of Turtle Rock summer Chinook were assessed by examining carcasses on spawning grounds and by reviewing tagging data and fisheries statistics.

Contribution to Fisheries

Normal subyearling releases

Most of the harvest on Turtle Rock summer Chinook (normal subyearling releases) occurred in the Ocean (10-100% of the fish harvested; Table 9.11). Brood year 1995, 1999, 2001, and 2005 provided the largest total harvests, while brood year 1997 and 1998 provided the lowest. This program was discontinued in 2010.

Table 9.11. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (normal subyearling releases) captured in different fisheries, brood years 1995-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	693 (84)	106 (13)	11 (1)	16 (2)	826
1996	71 (80)	0 (0)	5 (5)	13 (15)	89
1997	10 (100)	0 (0)	0 (0)	0 (0)	10
1998	21 (100)	0 (0)	0 (0)	0 (0)	21
1999	184 (64)	26 (9)	4 (1)	75 (26)	289
2000	36 (55)	8 (12)	8 (12)	14 (21)	66
2001	164 (64)	30 (12)	20 (8)	44 (17)	258
2002	23 (20)	33 (29)	3 (3)	56 (49)	115
2003	9 (10)	55 (61)	2 (2)	24 (27)	90
2004	42 (37)	29 (25)	2 (2)	42 (37)	115
2005	100 (38)	95 (36)	24 (9)	44 (17)	263

Accelerated subyearling releases

Most of the harvest on Turtle Rock summer Chinook (accelerated subyearling releases) occurred in ocean fisheries (Table 9.12). Ocean harvest has made up 27% to 100% of all Turtle Rock summer Chinook harvested (no fish from the 2003 brood year were harvested). Brood year 1999 provided the largest total harvest, while brood years 1995, 1997, 2002, and 2003 provided the lowest. This program was discontinued in 2010.

Table 9.12. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (accelerated subyearling releases) captured in different fisheries, brood years 1995-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	3 (100)	0 (0)	0 (0)	0 (0)	3
1996	77 (89)	5 (6)	5 (6)	0 (0)	87
1997	3 (100)	0 (0)	0 (0)	0 (0)	3
1998	97 (95)	2 (2)	3 (3)	0 (0)	102
1999	1,027 (76)	142 (10)	12 (1)	178 (13)	1,359
2000	117 (100)	0 (0)	0 (0)	0 (0)	117
2001	205 (59)	49 (14)	13 (4)	80 (23)	347

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
2002	9 (100)	0 (0)	0 (0)	0 (0)	9
2003	0 (0)	0 (0)	0 (0)	0 (0)	0
2004	45 (27)	79 (48)	6 (4)	34 (21)	165
2005	65 (59)	12 (11)	26 (24)	7 (6)	110

Yearling releases

Most of the harvest on Turtle Rock summer Chinook (yearling releases) occurred in ocean fisheries (Table 9.13). Ocean harvest has made up 39% to 95% of all Turtle Rock summer Chinook harvested. Brood year 1998 provided the largest harvest, while brood year 1995 provided the lowest.

Table 9.13. Estimated number and percent (in parentheses) of Turtle Rock summer Chinook (yearling releases) captured in different fisheries, brood years 1995-2005.

Brood year	Ocean fisheries	Columbia River Fisheries			Total
		Tribal	Commercial (Zones 1-5)	Recreational (sport)	
1995	456 (75)	51 (8)	32 (5)	70 (11)	609
1996	766 (95)	14 (2)	2 (0)	21 (3)	803
1997	2,827 (91)	61 (2)	27 (1)	176 (6)	3,091
1998	4,291 (90)	224 (5)	16 (0)	230 (5)	4,761
1999	1,658 (73)	233 (10)	7 (0)	382 (17)	2,280
2000	1,125 (73)	129 (8)	48 (3)	244 (16)	1,546
2001	1,917 (59)	453 (14)	178 (5)	728 (22)	3,276
2002	1,007 (50)	384 (19)	102 (5)	536 (26)	2,030
2003	749 (45)	450 (27)	70 (4)	378 (23)	1,647
2004	837 (39)	557 (26)	127 (6)	607 (29)	2,128
2005	497 (45)	290 (26)	123 (11)	200 (18)	1,110

Straying

Normal subyearling releases

Rates of Turtle Rock summer Chinook (normal subyearling releases) straying into spawning areas in the upper basin have been low. Although Turtle Rock summer Chinook have strayed into other spawning areas, they made up less than 5% of the spawning escapement within those areas (Table 9.14). The Chelan tailrace has received the largest number of Turtle Rock strays. This program was discontinued in 2010.

Table 9.14. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock summer Chinook (normal subyearling releases), return years 1998-2008. For example, for return year 2003, 0.6% of the summer Chinook spawning escapement in the Okanogan Basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	8	0.1	3	0.3	13	0.4	63	9.5	0	0.0	0	0.0
2001	0	0.0	5	0.2	13	0.1	0	0.0	0	0.0	0	0.0
2002	0	0.0	0	0.0	13	0.1	0	0.0	0	0.0	0	0.0
2003	7	0.1	7	0.2	19	0.6	6	1.4	0	0.0	0	0.0
2004	5	0.0	4	0.2	13	0.2	6	1.4	0	0.0	0	0.0
2005	5	0.1	0	0.0	5	0.1	0	0.0	2	0.5	0	0.0
2006	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2007	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2008	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	***25***	***0.02***	***19***	***0.08***	***76***	***0.11***	***75***	***1.55***	***2***	***0.05***	***0***	***0.0***

On average, about 29% of the brood year returns have strayed into spawning areas in the upper basin (Table 9.15). Depending on brood year, percent strays into spawning areas have ranged from 0-100%. Few (0.9% on average) have strayed into non-target hatchery programs.

Table 9.15. Number and percent of Turtle Rock summer Chinook (normal subyearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2005.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	197	74.1	64	24.1	5	1.9
1996	-	-	54	54.5	44	44.4	1	1.0
1997	-	-	2	28.6	5	71.4	0	0.0
1998	-	-	0	0.0	24	100.0	0	0.0
1999	-	-	40	43.5	52	56.5	0	0.0
2000	-	-	5	50.0	5	50.0	0	0.0
2001	-	-	56	77.8	16	22.2	0	0.0
2002	-	-	10	100.0	0	0.0	0	0.0
2003	-	-	27	100.0	0	0.0	0	0.0
2004	-	-	71	97.3	2	2.7	0	0.0
2005	-	-	80	92.0	7	8.0	0	0.0
Total	***-***	***-***	***542***	***70.7***	***219***	***28.6***	***6***	***0.8***

Accelerated subyearling releases

Rates of Turtle Rock summer Chinook (accelerated subyearling releases) straying into spawning areas in the upper basin have been low. Although Turtle Rock summer Chinook have strayed into other spawning areas, they made up less than 5% of the spawning escapement within those areas (Table 9.16). The Chelan tailrace, Entiat Basin, and Methow Basin have received the largest number of Turtle Rock strays. This program was discontinued in 2010.

Table 9.16. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock summer Chinook (accelerated subyearling releases), return years 1998-2008. For example, for return year 2001, 0.2% of the summer Chinook spawning escapement in the Methow Basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	3	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
1999	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2000	7	0.1	0	0.0	0	0.0	24	3.6	0	0.0	0	0.0
2001	0	0.0	12	0.4	31	0.3	0	0.0	0	0.0	0	0.0
2002	0	0.0	5	0.1	0	0.0	0	0.0	0	0.0	0	0.0
2003	0	0.0	45	1.1	0	0.0	22	5.3	13	1.9	16	0.0
2004	0	0.0	7	0.3	0	0.0	14	3.3	0	0.0	18	0.0
2005	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2006	0	0.0	0	0.0	0	0.0	0	0.0	2	0.3	0	0.0
2007	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
2008	0	0.0	7	0.4	0	0.0	27	5.4	0	0.0	0	0.0
Total	***10***	***0.01***	***76***	***0.30***	***31***	***0.04***	***87***	***1.79***	***15***	***0.39***	***34***	***0.01***

On average, about 40% of the brood year returns have strayed into spawning areas in the upper basin (Table 9.17). Depending on brood year, percent strays into spawning areas have ranged from 0-83%. Few (<1% on average) have strayed into non-target hatchery programs.

Table 9.17. Number and percent of Turtle Rock summer Chinook (accelerated subyearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2005.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	7	70.0	3	30.0	0	0.0
1996	-	-	33	32.4	69	67.6	0	0.0
1997	-	-	6	100.0	0	0.0	0	0.0
1998	-	-	2	16.7	10	83.3	0	0.0
1999	-	-	138	54.1	117	45.9	0	0.0

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
2000	-	-	12	40.0	18	60.0	0	0.0
2001	-	-	57	96.6	2	3.4	0	0.0
2002	-	-	0	0.0	0	0.0	0	0.0
2003	-	-	3	100.0	0	0.0	0	0.0
2004	-	-	90	75.6	29	24.4	0	0.0
2005	-	-	64	75.3	21	24.7	0	0.0
Total	***-***	***-***	***412***	***60.5***	***269***	***39.5***	***0***	***0.0***

Yearling releases

Rates of Turtle Rock summer Chinook (yearling releases) straying into spawning areas in the upper basin have varied widely depending on spawning area. Most of these fish strayed to spawning areas within the Chelan tailrace, Entiat Basin, and Methow Basin. Turtle Rock summer Chinook have made up 6-23% of the spawning escapement within those basins (Table 9.18). Relatively few, on average, have strayed to spawning areas in the Okanogan Basin, Wenatchee Basin, and the Hanford Reach (i.e., they made up less than 5% of the spawning escapement in these areas).

Table 9.18. Number (No.) and percent of spawning escapements within other non-target basins that consisted of Turtle Rock summer Chinook (yearling releases), return years 1998-2008. For example, for return year 2003, 4.3% of the summer Chinook spawning escapement in the Methow Basin consisted of Turtle Rock summer Chinook. Percent strays should be less than 5%.

Return year	Wenatchee		Methow		Okanogan		Chelan		Entiat		Hanford Reach	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1998	0	0.0	2	0.3	0	0.0	0	0.0	0	0.0	0	0.0
1999	3	0.1	2	0.2	0	0.0	0	0.0	0	0.0	0	0.0
2000	18	0.3	57	4.8	167	4.5	73	11.0	0	0.0	10	0.0
2001	109	1.0	523	18.9	334	3.1	316	32.1	0	0.0	7	0.0
2002	92	0.6	437	9.4	194	1.4	191	32.8	136	27.1	0	0.0
2003	64	0.5	170	4.3	14	0.4	165	39.4	180	26.0	9	0.0
2004	10	0.1	51	2.3	116	1.7	75	17.9	0	0.0	0	0.0
2005	5	0.1	73	2.9	73	0.8	88	19.8	42	11.4	0	0.0
2006	0	0.0	100	3.7	25	0.3	64	15.2	9	1.6	0	0.0
2007	0	0.0	65	4.8	31	0.7	40	21.2	20	8.2	19	0.1
2008	18	0.3	72	3.7	60	0.9	115	23.1	46	14.4	0	0.0
Total	***319***	***0.31***	***1,552***	***6.21***	***1,014***	***1.41***	***1,127***	***23.2***	***433***	***11.3***	***45***	***0.01***

On average, about 65% of the brood year returns have strayed into spawning areas in the upper basin (Table 9.19). Depending on brood year, percent strays into spawning areas have ranged from 37-86%. Few (<1% on average) have strayed into non-target hatchery programs.

Table 9.19. Number and percent of Turtle Rock summer Chinook (yearling releases) that homed to the target hatchery and strayed to non-target spawning areas and non-target hatchery programs, by brood years 1995-2005.

Brood year	Homing				Straying			
	Target stream		Target hatchery		Non-target streams		Non-target hatcheries	
	Number	%	Number	%	Number	%	Number	%
1995	-	-	180	39.3	278	60.7	0	0.0
1996	-	-	218	27.2	583	72.8	0	0.0
1997	-	-	254	14.2	1,531	85.6	3	0.2
1998	-	-	166	16.1	864	83.8	1	0.1
1999	-	-	181	42.7	243	57.3	0	0.0
2000	-	-	89	27.4	236	72.6	0	0.0
2001	-	-	389	59.8	261	40.2	0	0.0
2002	-	-	303	57.8	220	42.0	1	0.2
2003	-	-	373	62.9	220	37.1	0	0.0
2004	-	-	287	56.5	221	43.5	0	0.0
2005	-	-	188	40.6	275	59.4	0	0.0
Total	-	-	***2,628***	***34.7***	***4,932***	***65.2***	***5***	***0.1***

Smolt-to-Adult Survivals

Subyearling-to-adult and smolt-to-adult survival ratios (SARs) were calculated as the number of hatchery adult recaptures divided by the number of tagged hatchery subyearling or yearling Chinook released. SARs were based on CWT returns.

Normal subyearling releases

For the available brood years, SARs for normal subyearling-released Chinook have ranged from 0.000034 to 0.001562 (Table 9.20). This program was discontinued in 2010.

Table 9.20. Subyearling-to-adult ratios (SARs) for Turtle Rock normal subyearling-released summer Chinook, brood years 1995-2005.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	201,230	205	0.001019
1996	371,848	187	0.000503
1997	496,904	17	0.000034
1998	194,723	28	0.000144
1999	197,793	203	0.001026
2000	222,460	28	0.000126

Brood year	Number released[a]	Estimated adult captures[b]	SAR
2001	211,306	330	0.001562
2002	200,163	38	0.000190
2003	203,410	49	0.000241
2004	198,019	91	0.000460
2005	197,135	143	0.000725
Average	***244,999***	***120***	***0.000548***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

Accelerated subyearling releases

For the available brood years, SARs for accelerated subyearling-released Chinook have ranged from 0.000011 to 0.004614 (Table 9.21). This program was discontinued in 2010.

Table 9.21. Subyearling-to-adult ratios (SARs) for Turtle Rock accelerated subyearling-released summer Chinook, brood years 1995-2005.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	166,203	13	0.000078
1996	198,720	79	0.000398
1997	196,459	3	0.000015
1998	185,551	69	0.000372
1999	192,665	889	0.004614
2000	194,603	63	0.000324
2001	196,355	167	0.000851
2002	200,165	5	0.000025
2003	185,834	2	0.000011
2004	203,255	156	0.000768
2005	192,045	82	0.000427
Average	***191,987***	***139***	***0.000717***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

Yearling releases

For the available brood years, SARs for yearling-released Chinook have ranged from 0.007212 to 0.026761 (Table 9.22).

Table 9.22. Smolt-to-adult ratios (SARs) for Turtle Rock yearling-released summer Chinook, brood years 1995-2005.

Brood year	Number released[a]	Estimated adult captures[b]	SAR
1995	145,318	1,048	0.007212
1996	194,251	1,553	0.007995
1997	198,924	4,805	0.024155
1998	215,646	5,771	0.026761
1999	280,683	2,671	0.009516
2000	165,072	1,870	0.011328
2001	199,694	3,883	0.019445
2002	192,234	2,525	0.013135
2003	199,386	2,089	0.010477
2004	202,682	2,604	0.012848
2005	202,329	1,565	0.007735
Average	***199,656***	***2,762***	***0.013692***

[a] Includes all tag codes and CWT released fish (CWT + Ad Clip fish and CWT-only fish).

[b] Includes estimated recoveries (spawning ground, hatcheries, harvest, etc.) and observed recoveries if estimated recoveries were unavailable.

9.4 ESA/HCP Compliance

Broodstock Collection

The 2009 brood Turtle Rock summer Chinook program is supported through adult collections at the volunteer trap at Wells Fish Hatchery and in conjunction with the Wells summer Chinook collections. During 2009, broodstock collections at the volunteer trap were consistent with the 2009 Upper Columbia River Salmon and Steelhead Broodstock Objectives and site-based broodstock collection protocols as required in ESA permit 1347. The 2009 collection totaled 1,355 summer Chinook (combined Wells Fish Hatchery and Turtle Rock Fish Hatchery programs), representing 100% of the targeted broodstock collection objective.

Hatchery Rearing and Release

Brood year 2009 releases totaled 1,154,246 fish, including yearling and regular sub-yearling releases (441,116 and 713,130 juveniles, respectively). These releases represented 63.4% of the Rocky Reach HCP and ESA Section 10 Permit 1347 production for the combined Turtle Rock yearling and subyearling production.

Hatchery Effluent Monitoring

Per ESA Permits 1196, 1347, and 1395, permit holders shall monitor and report hatchery effluents in compliance with applicable National Pollution Discharge Elimination Systems (NPDES) (EPA 1999) permit limitations. There was one NPDES violation reported at Chelan PUD Hatchery facilities during the period 1 January through 31 December 2011. NPDES monitoring and reporting for Chelan PUD Hatchery Programs during 2011 are provided in Appendix F.

SECTION 10: REFERENCES

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SECTION 11: APPENDICES

Appendix A: **Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2011.**

Appendix B: **Fish Trapping at the Chiwawa, Upper Wenatchee, and Lower Wenatchee Smolt Traps during 2011.**

Appendix C: **Summary of ISEMP PIT Tagging Activities in the Wenatchee Basin, 2011.**

Appendix D: **Wenatchee Steelhead Spawning Ground Surveys, 2011.**

Appendix E: **Examining the Genetic Structure of Wenatchee Basin Steelhead and Evaluating the Effects of the Supplementation Program.**

Appendix F: **NPDES Hatchery Effluent Monitoring, 2011.**

Appendix G: **Steelhead Stock Assessment at Priest Rapids Dam, 2011.**

Appendix H: **Wenatchee Sockeye and Summer Chinook Spawning Ground Surveys, 2011.**

Appendix I: **Genetic Diversity of Wenatchee Sockeye Salmon.**

Appendix J: **Genetic Diversity of Natural Chiwawa River Spring Chinook Salmon.**

Appendix K: **Genetic Diversity of Upper Columbia Summer Chinook Salmon.**

Appendix L: **Summer Chinook Spawning Ground Surveys in the Methow and Okanogan Basin, 2011.**

Appendix A

Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2011

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February 25, 2012

TO: HCP Hatchery Committee

FROM: Tracy Hillman

Subject: Abundance and Total Numbers of Chinook Salmon and Trout in the Chiwawa River Basin, Washington, 2011

The Chelan County Public Utility District (PUD) hatchery program is operated through a habitat conservation program (HCP) that was incorporated into the PUD's license in 2004. The HCP directed the signatories to develop a monitoring and evaluation plan within one year of the effective date. This resulted in the development of the Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Hatchery Programs (Murdoch and Peven 2005). This study will help the HCP Hatchery Committee determine if it is meeting Objective 7 in the monitoring and evaluation plan (Murdoch and Peven 2005).

Objective 7: *Determine if the proportion of hatchery fish on the spawning grounds affects the freshwater productivity (i.e., number of juveniles per redd) of supplemented streams when compared to non-supplemented streams.*

We estimated densities and total numbers of age-0 spring Chinook salmon *Oncorhynchus tshawytscha*, trout *Oncorhynchus* sp., and char *Salvelinus* sp. in the Chiwawa River Basin, Washington, in August 2011. This was the 19th year of an ongoing study to assess the freshwater productivity (juveniles/redd) of Chinook salmon in the Chiwawa Basin. We used landscape classification to stratify streams in the basin that supported juvenile Chinook salmon (Hillman and Miller 2004). Classification "explained" most of the variability in fish numbers caused by geology, land type, valley bottom type, stream state condition, and habitat type. We identified ten reaches on the lower 31 miles (50 km) of the Chiwawa River and one reach in each of Phelps, Rock, Chikamin, Big Meadow, Alder, Brush, Clear, Y, and Unnamed[1] creeks (Figure 1). Each reach consisted of several combinations of state-type and habitat-type strata. We used classification to find reference areas for reaches in the Chiwawa River. We matched Reach 3 and Reach 8 of the Chiwawa River with a moderately-confined section of Nason Creek (RM 0.62-1.70) and an unconfined area of the Little Wenatchee River (RM 4.39-8.55), respectively

[1]Unnamed tributary that drains the eastside of Chiwawa Ridge. Its confluence with the Chiwawa River is about 1 mile (1.6 km) downstream from the mouth of Phelps Creek.

(Hillman and Miller 2004). Following methods described in Hillman and Miller (2004), we used underwater observations to estimate numbers of fish in 187 randomly selected sites.

During sampling in August 2011, discharge in the Chiwawa River averaged 594 cubic feet per second (cfs) and ranged from 349 to 971 cfs (Figure 2). Stream temperatures for the study period ranged from 8.0 to 14.5^{o}C. Fish species observed in the Chiwawa Basin and reference areas during the 1992-2011 survey period[2] included: spring Chinook salmon, coho salmon *O. kisutch*, sockeye salmon *O. nerka* (in the Little Wenatchee River reference area), steelhead/rainbow trout *O. mykiss* (hatchery rainbow were present only in 1992 and 1993), cutthroat trout *O. clarki lewisi*, bull trout *S. confluentus*, brook trout *S. fontinalis*, mountain whitefish *Prosopium williamsoni*, dace *Rhinichthys* sp., suckers *Catostomus* sp., and sculpin *Cottus* sp. The age-0 spring Chinook that we observed in the Chiwawa Basin during the 2011 survey were produced from 502 redds counted in the fall of 2010 (Hillman et al. 2011). Assuming a mean fecundity of 4,314 eggs per female Chinook (from females collected for broodstock), and that no female produced more than one redd (Murdoch et al. 2009), we estimated that the Chiwawa River Basin was seeded with 2,165,628 eggs in 2010 (Appendix A).

In 2011, riffles made up the largest fraction of habitat types in reaches of the Chiwawa Basin (57% of the total stream surface area) (Table 1). Pools (18%), glides (8%), and multiple channels (17%) constituted the remaining 43% of the stream surface area. We consistently found woody debris associated with multiple-channel habitat.

Chinook Salmon Abundance

Chinook salmon were the most abundant salmonid in the Chiwawa Basin. We estimated, based on surface area, that age-0 Chinook salmon numbered 141,510 (±13% of the estimated total) in the Chiwawa River Basin in August 2011 (Table 2). Extrapolating based on volume of habitat types, age-0 Chinook numbered 143,020 (±14%) in the Chiwawa Basin. About 4% of the juvenile Chinook were in tributaries to the Chiwawa River. During the 1992-2011 surveys, numbers of age-0 Chinook ranged from 5,815 to 141,510 in the Chiwawa Basin (Figure 3; Appendix B). Most of the difference in juvenile numbers among years resulted from different seeding levels (Figure 4). Numbers of Chinook redds in the Chiwawa Basin during 1992-2011 ranged from 13 to 1,046, resulting in seeding levels of 66,248 to 4,836,704 eggs (Appendix A).

As in most years, age-0 Chinook in 2011 were distributed contagiously among reaches in the Chiwawa River (Table 2). In the Chiwawa River, densities of age-0 Chinook were highest in the upper reaches (Reaches 7-10). The highest densities in the Chiwawa Basin were in tributaries to the Chiwawa River (Table 2). Age-0 Chinook were most abundant in multiple channels and least abundant in glides and riffles. We found the majority of the Chinook associated with woody debris in multiple channels (multiple channel use index = 2.78)[3]. These sites (multiple channels)

[2] The study period 1992-2011 includes only 19 years of sampling because there was no sampling in 2000.

[3] The habitat use index was calculated as follows: Multiple channel use = ($parr_{mc}/parr_t$) / ($area_{mc}/area_t$), where $parr_{mc}$ = the number of parr counted in multiple channel habitat, $parr_t$ = the total number of parr counted within all habitat types, $area_{mc}$ = the area of multiple channel habitat within the sampling frame, and $area_t$ = the total area of the sampling frame. A multiple channel use index value of 1 would indicate that parr were uniformly distributed among habitat types and exhibited no preference for multiple habitat types. Values of the use index greater than 1 indicate

made up 17% of the total area of the Chiwawa Basin, but they provided habitat for 43% of all the age-0 Chinook in the basin in 2011 (Appendix C). In contrast, riffles made up 57% of the total area, but provided habitat for only 19% of all age-0 Chinook in the Chiwawa Basin (riffle use index = 0.26). Pools made up 18% of the total area and provided habitat for 34% of all age-0 Chinook in the basin (pool use index = 1.54). Few Chinook used glides that lacked woody debris (glide use index = 0.29).

As noted earlier, we assumed that the Chiwawa River was seeded with 2,165,628 Chinook eggs (502 redds times 4,314 eggs/female) in fall, 2010, and that at least 141,510 of those survived to August 2011. This means that the egg-to-parr survival was at least 6.5% (95% confidence bound 5.7-7.4%). During 1992-2011, egg-to-parr survival averaged 8.8% (range 2.7-19.1%) in the Chiwawa Basin (Appendix A). This survival rate comports with those from other streams. For example, Mullan et al. (1992) estimated an egg-to-parr survival rate of 9.8% for spring Chinook salmon in Icicle Creek, a tributary of the Wenatchee River. Using a Beverton and Holt model, Hubble (1993) estimated that egg-to-parr survival of Chinook in the Chewuck River, a tributary to the Methow River, ranged between 13% and 32%, depending on percent seeding level in the basin. Kiefer and Forster (1991) estimated a mean egg-to-parr survival rate of 5.5% (range 5.1-6.7%) for naturally-spawning spring Chinook salmon in the entire upper Salmon River. They also noted that egg-to-parr survival of natural spawners and adult outplants in the headwater streams of the upper Salmon River averaged 24.4% (range 16.1-32.0%). Petrosky (1990) reported an egg-to-parr survival range of 1.2-29.0% for Chinook in the upper Salmon River, Idaho. Konopacky et al. (1986) estimated egg-to-parr survival of Chinook in Bear Valley Creek, Idaho, as 8.1-9.4%. Work by Richards and Cernera (1987) in Bear Valley Creek indicated an egg-to-parr survival of 2.1%.

Mean densities of age-0 Chinook salmon in two reaches of the Chiwawa River were generally less than those in corresponding reference areas (Figure 5). Within both the Chiwawa River and its reference areas, pools and multiple channels consistently had the highest densities of age-0 Chinook.

We estimated a total of 967 (±28% of the estimated total) age-1+ Chinook salmon in the Chiwawa Basin in August 2011 (Table 3). This was the highest estimate since the initiation of the study. In August 1992-2011, numbers of age-1+ Chinook ranged from 5 to 967 in the Chiwawa River Basin (Figure 3; Appendix B). These fish occurred throughout the Chiwawa River. We found relatively few age-1+ Chinook in tributaries. Age-1+ Chinook were most abundant in multiple channels and pools.

Juvenile Chinook Salmon Productivity (Fish/Redd)

Freshwater productivity of juvenile Chinook salmon was estimated as the number of parr (age-0 Chinook) per redd in the Chiwawa Basin. Theoretically, the relationship between number of parr and redds can be explained mathematically provided the relationship between the two parameters goes through the origin, increases monotonically at low spawning levels, and shows some level of density dependence at high spawning levels. We identified four alternative hypotheses that

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use of multiple channels to a greater extent than the average, while scores between 0 and 1 indicate below-average use of multiple channel habitat.

may explain the relationship between spawning level (redds) and numbers of age-0 Chinook:

1. The first hypothesis assumed that the number of juveniles increases constantly toward an asymptote as the number of redds increases. After the asymptote is reached, the number of juveniles neither increases nor decreases. The asymptote represents the maximum number of juveniles the system can support (i.e., carrying capacity for the system). This hypothesis was modeled with a Beverton-Holt curve that took the form:

$$\boldsymbol{J} = \frac{(\boldsymbol{\alpha R})}{(\boldsymbol{\beta} + \boldsymbol{R})}$$

   where ***J*** is the number of juvenile (age-0) Chinook, ***R*** is the number or redds, ***α*** is the maximum number of juveniles produced, and ***β*** is the number of redds needed to produce (on average) juveniles equal to one-half the maximum number of juveniles.

2. The second hypothesis, like the first, assumed that the number of juveniles increases toward an asymptote (carrying capacity) as the number of redds increases. After the carrying capacity is reached, the number of juveniles neither increases nor decreases. The carrying capacity represents the maximum number of juveniles the system can support. This hypothesis was modeled with a smooth hockey stick function that took the form:

$$\boldsymbol{J} = \boldsymbol{J_\infty}\left(\boldsymbol{1} - \boldsymbol{e}^{-\left(\frac{\boldsymbol{\alpha}}{\boldsymbol{J}\infty}\right)\boldsymbol{R}}\right)$$

   where ***J*** and ***R*** are as above, ***α*** is the slope at the origin of the spawner-recruitment curve, and $\boldsymbol{J_\infty}$ is the carrying capacity of juveniles.

3. The third hypothesis assumed that the number of juveniles increases to a maximum and then declines as the number or redds increases. In this case, mortality rate of juveniles (or eggs) is proportional to the initial number of redds. Higher mortality rate is associated with density-dependent growth coupled with size-dependent predation. This hypothesis was modeled with a Ricker curve that took the form:

$$\boldsymbol{J} = \boldsymbol{\alpha R e^{-\beta R}}$$

   where ***J*** and ***R*** are as above, ***α*** is the number of juveniles per redd at low spawning levels, and ***β*** describes how quickly the juveniles per redd drop as the number of redds increases.

4. The fourth hypothesis, like the first, assumed that the number of juveniles increases constantly, but unlike the first, the number of juveniles does not reach an asymptote. Rather, the number of juveniles increases indefinitely, but at a slowing rate of increase. This hypothesis was modeled with both a Cushing curve and a Gamma function. The Cushing curve took the form:

$$\boldsymbol{J} = \boldsymbol{\alpha R^{\gamma}}$$

   where ***J*** and ***R*** are as above, ***α*** is the number of juveniles per redd at low spawning levels, and ***γ*** describes the level of density dependence at high spawning levels. The Gamma function is a three-parameter model that has the form:

$$\boldsymbol{J} = \boldsymbol{\alpha R^{\gamma} e^{-\beta R}}.$$

This is an un-normalized gamma function that is similar to the Cushing curve when β = 0.

We used Akaike's Information Criterion for small sample size (AIC_c) to determine which model(s) best explained the productivity of juvenile Chinook in the Chiwawa Basin. AIC_c was estimated as:

$$\boldsymbol{AIC_c = -2log(\pounds(\theta|data)) + 2K + \left(\frac{2K(K+1)}{n-K-1}\right)}$$

where ***log(£(θ|data))*** is the maximum likelihood estimate, ***K*** is the number of estimable parameters (structural parameters plus the residual variance parameter), and ***n*** is the sample size (Burnham and Anderson 2002). We used least-squares methods to estimate ***log(£(θ|data))***, which was calculated as $\boldsymbol{log(\sigma^2)}$, where $\boldsymbol{\sigma^2}$ = residual sum of squares divided by the sample size ($\boldsymbol{\sigma^2 = RSS/n}$). AIC_c assesses model fit in relation to model complexity (number of parameters). The model with the smallest AIC_c value represents the "best approximating" model within the model set. Remaining models were ranked relative to the best model using AIC_c difference scores ($\boldsymbol{\Delta AIC_c}$), Akaike weights ($\boldsymbol{w_i}$), and evidence ratios. Models with $\boldsymbol{\Delta AIC_c}$ values less than 2 indicate that there is substantial support for these models as being the best-fitting models within the set (Burnham and Anderson 2002). Models with values greater than 2 have less support. Akaike weights are probabilities estimating the strength of the evidence supporting a particular model as being the best model within the model set. Models with small $\boldsymbol{w_i}$ values are less plausible as competing models (Burnham and Anderson 2002). If no single model could be specified as the best model, a "best subset" of competing models was identified using (1) AIC_c differences to indicate the level of empirical support each model had as being the best model, (2) evidence ratios based on Akaike weights to indicate the relative probability that any model is the best model, and (3) coefficients of determination (R^2) assessing the explanatory power of each model.

The use of AIC_c indicated that the Beverton-Holt model best approximated the information in the juveniles/redd data (Table 4; Figure 6). The estimated structural parameters for this model were:

$$Juveniles = \frac{(141{,}283 \times Redds)}{(171 + Redds)}$$

where the estimated standard errors for the two parameters were 21,735 and 59, respectively. The adjusted R^2 = 0.81. The second-best model was the smooth hockey stick model, which was 0.84 AIC_c units from the best model (Table 4; Figure 6). The estimated parameters for this model were:

$$LN(Juveniles) = 11.6 + LN\left(1 - e^{-\left(\frac{752.9}{105{,}617}\right)Redds}\right)$$

where the estimated standard errors of the two parameters were 1.2 and 159, respectively, and the R^2 = 0.82. The AIC_c difference scores, Akaike weights, and evidence ratios indicated that there was substantial support for both the Beverton-Holt and smooth hockey stick models (Table

4). There was less support for the remaining models (Ricker, Gamma[4], and Cushing), which were > 4 AIC_c units from the best models. This was further supported by the fact that, relative to the best models, the remaining models had evidence ratios greater than 6.

Although the Beverton-Holt, smooth hockey stick, and Ricker models have different biological assumptions, they all indicated a density-dependent relationship between spawning levels (redds) and juvenile Chinook production. This was not only evident in the best approximating models, but there was also a significant negative relationship between juveniles per redd and numbers of redds in the Chiwawa Basin (Figure 7). Although data at high seeding levels are lacking, the Beverton-Holt model would limit the production of juvenile Chinook to less than about 180,000 parr in the basin (bootstrap upper 95% CI of $\boldsymbol{\alpha}$ in the Beverton-Holt model). In contrast, the smooth hockey stick model, which fit the data as well as the Beverton-Holt model, would limit the carrying capacity for juvenile Chinook to about 140,000 parr (bootstrap upper 95% CI of $\boldsymbol{J_\infty}$ in the smooth hockey stick model). Additional information at high spawning escapements is needed to determine more precisely the maximum juvenile productivity in the Chiwawa Basin.

Steelhead/Rainbow Abundance

Based on stream surface area, we estimated a total of 39,446 (±5% of the estimated total) age-0 steelhead/rainbow (<4 in) in reaches of the Chiwawa Basin in August 2011 (Table 5). During the 1992-2011 survey period, numbers of age-0 steelhead/rainbow ranged from 1,410 to 45,727 in the Chiwawa River Basin (Figure 8; Appendix B). In 1992-2011, numbers of age-0 steelhead/rainbow varied among reaches, but were typically highest in the lower reaches of the Chiwawa River. In all years they most often used riffle and multiple channel habitats in the Chiwawa River, although we also found them associated with woody debris in pool and glide habitat. In tributaries they were generally most abundant in small pools. Those that we observed in riffles selected stations in quiet water behind small and large boulders or occupied stations in quiet water along the stream margin. In pool and multiple-channel habitats, we found age-0 steelhead/rainbow using the same kinds of habitat as age-0 Chinook salmon.

We estimated that 14,903 (±10% of the estimated total) age-1+ steelhead/rainbow (4-8 in) lived in reaches of the Chiwawa Basin in August 2011 (Table 6). During the survey period 1992-2011, numbers of age-1+ steelhead/rainbow ranged from 2,533 to 22,130 (Figure 8; Appendix B). In most years we found these fish in nearly all reaches, but they were typically most numerous in lower reaches of the Chiwawa River. We observed age-1+ steelhead/rainbow mostly in pool, riffle, and multiple-channel habitats. Those that we observed in pools were usually in deeper water than age-0 steelhead/rainbow and Chinook. Like age-0 steelhead/rainbow, age-1+ steelhead/rainbow selected stations in quiet water behind boulders in riffles, but we generally did not find the two age groups together. Age-1+ steelhead/rainbow appeared to use deeper and faster water than did age-0 steelhead/rainbow.

We estimated that steelhead/rainbow larger than 8 inches numbered 65 (±25% of the estimated total) in the Chiwawa Basin in August 2011 (Table 7). During the period 1992-2011,

[4] The γ parameter in the Gamma model was greater than 0, which means that this model is nearly identical to the Ricker model. The reason it did not rank higher is because it contains an extra parameter, which means that it has less bias and greater variance than the Ricker model.

steelhead/rainbow numbers ranged from 8 to 1,869 (Appendix B). Steelhead/rainbow larger than 8 inches were most abundant in the lower Chiwawa River; however, in 1992 and 1993, they were most abundant near campgrounds in Reaches 8, 9, and 10 (these were mostly hatchery fish planted near the campgrounds). We found very few in tributary survey reaches. Most of the steelhead/rainbow larger than 8 inches used deep pools (>5 feet), and occupied stations near the bottom at the upstream end of pools.

Bull Trout Abundance

We estimated, based on surface area that at least 86 (±34% of the estimated total) juvenile (2-8 in) bull trout lived in reaches of the Chiwawa River Basin in August 2011 (Table 8). We found most of these fish in the upper-most reaches and in tributaries of the Chiwawa River. During 1992-2011, numbers of juvenile bull trout ranged from 79 to 505 (Figure 9; Appendix B). These estimates and those for adult bull trout are incomplete because we did not sample the entire range of bull trout in all tributaries. We did not extend our surveys into the headwaters of the Chiwawa River because there were no juvenile Chinook there. Areas beyond the distribution of juvenile Chinook salmon are known to support bull trout, steelhead/rainbow, and cutthroat trout (USFS 1993). In addition, our estimates of bull trout abundance were based on daytime snorkel surveys, which may underestimate the actual abundance of bull trout.[5] Several studies (e.g., Goetz 1994; Thurow and Schill 1996; Hillman and Chapman 1996; Bonar et al. 1997) have found bull trout population estimates based on nighttime snorkeling to be in some cases more accurate than daytime snorkeling, especially for juvenile bull trout. Our estimates of adult bull trout numbers may be more accurate than those for juveniles.

In all years we found most juvenile bull trout in the upstream reaches of the Chiwawa River. Of the reaches we surveyed, they were most numerous in Reaches 8-10 on the Chiwawa River. We found the majority of these fish in multiple channels, pools, and riffles, and few in glides. They consistently occupied stations close to the stream bottom over rubble and small boulder substrate or near woody debris. This is similar to the observation of Pratt (1984) in the upper Flathead River Basin in Montana. She found that juvenile bull trout lay close to instream cover and that they tended to conceal themselves. As a result, she found it difficult to accurately estimate their numbers. Although this implies that we underestimated numbers of juvenile bull trout in the Chiwawa River, the relative distribution of juvenile bull trout is valid if we assume that we saw the same fraction of juveniles in all reaches (i.e., detection probability was the same across survey sites).

We estimated a total of 621 (±15% of the estimated total) adult (>8 in) bull trout in reaches of the Chiwawa Basin in August 2011 (Table 9). In previous years, numbers ranged from 76 to 900 (Figure 9; Appendix B). As with juvenile bull trout, we found most of the adult bull trout upstream from Reach 6; although they were found in all reaches on the Chiwawa River. We found few adult bull trout in tributaries of the Chiwawa River. Adult bull trout primarily used pools and multiple channel habitat, although most of the smaller adults (<10 in) used riffles. In

[5] Because there are no estimates for probability of detecting bull trout with daytime underwater observation methods in the Chiwawa Basin, we could not adjust bull trout numbers based on detectability. Therefore, the numbers reported in this report likely underestimate the "true" number of bull trout in the survey area.

all years we found few adult bull trout near campgrounds. There also appeared to be an inverse association between numbers of adult bull trout and numbers of age-0 Chinook salmon in pools in Reaches 7-10. That is, where we found large bull trout we generally observed few juvenile Chinook salmon.

Abundance of Other Salmonids

In August 2011, we estimated that at least 47 brook trout, an exotic species closely related to the bull trout, occurred in the Chiwawa River, Chikamin Creek, Big Meadow Creek, Minnow Creek, and in the Little Wenatchee River survey areas. Brook trout occurred in the lower seven reaches on the Chiwawa River. In both the Chiwawa and Little Wenatchee rivers, brook trout usually used multiple channels. Few appeared to be bull trout/brook trout hybrids. In Chikamin, Minnow, and Big Meadow creeks, brook trout were most abundant in pools. Brook trout lengths ranged from 2-8 inches.

At least 241 westslope cutthroat trout occurred in the Chiwawa River, Rock Creek, Phelps Creek, and Little Wenatchee River survey areas in August 2011. These fish most often occurred in pools and multiple channel habitats. They ranged in size from 2-18 inches. Juvenile coho salmon were observed in Nason Creek, Minnow Creek, and Chikamin Creek.

We observed both juvenile and adult mountain whitefish in the Chiwawa River, Rock Creek, Phelps Creek, Nason Creek, and the Little Wenatchee River survey areas. In sum, at least 4,806 adult and 533 juvenile whitefish lived in these streams in August 2011. We found few whitefish in most tributaries to the Chiwawa River.

Conclusion

This was the 19th year of a study to monitor trends in juvenile spring Chinook production in the Chiwawa River Basin. As shown in Figure 3, numbers of juvenile Chinook salmon in the Chiwawa Basin have fluctuated widely over the 19-year period. Numbers of juveniles in 2001 and 2002 were some of the highest recorded, while numbers in the mid-1990s were some of the lowest. Interestingly, the highest spawning escapements (highest redd numbers) resulted in the lowest egg-parr survival rates (Appendix A). This is supported by the fact that the best approximating models clearly demonstrated a density-dependent relationship between seeding levels and juvenile production. Indeed, there was a significant negative relationship between parr per redd and numbers of redds in the Chiwawa Basin. This is an important observation because Objectives 1, 3, 4, and 7 and their associated hypotheses in the monitoring and evaluation plan (Murdoch and Peven 2005) are only valid when the supplemented population is below its carrying capacity.

The presence of density dependence in the early life stages of spring Chinook is not surprising. Rarely does density dependence appear in numbers of adult spring Chinook or on their spawning grounds. The Chiwawa Basin appears to have plenty of spawning habitat, as indicated by the large numbers of spawners and redds widely distributed throughout the basin during 2001 and 2002. However, those large spawning escapements did not translate into large numbers of juveniles or smolts. Thus, density-dependent regulation appears to occur sometime during the early life stages of the fish, likely at the fry stage. It is possible that physical habitat (space) during higher flows when fry are emerging may limit juvenile Chinook production in the basin.

Low nutrient levels and its effects on food (macroinvertebrates) production may also be a limiting factor in the basin. If spawning escapements remain relatively high, marine-derived nutrients should increase in the basin, resulting in more food for juvenile Chinook salmon.

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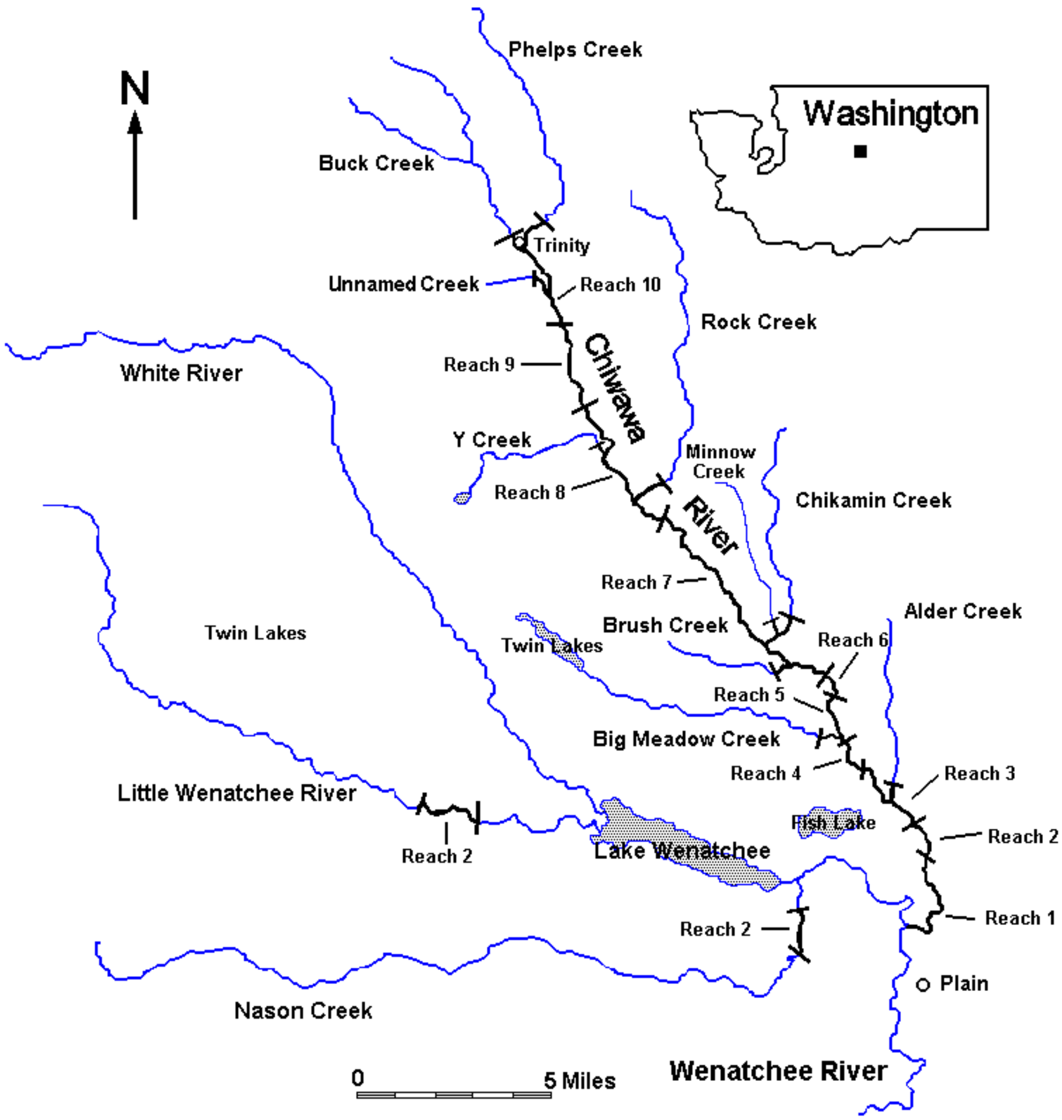

Figure 1. Location of study reaches on the Chiwawa River, and Chikamin, Rock, Big Meadow, Unnamed, Alder, Brush and Phelps creeks, Chelan County, Washington. Reach 2 on Nason Creek and Reach 2 on the Little Wenatchee River were matched with Reaches 3 and 8 on the Chiwawa River, respectively.

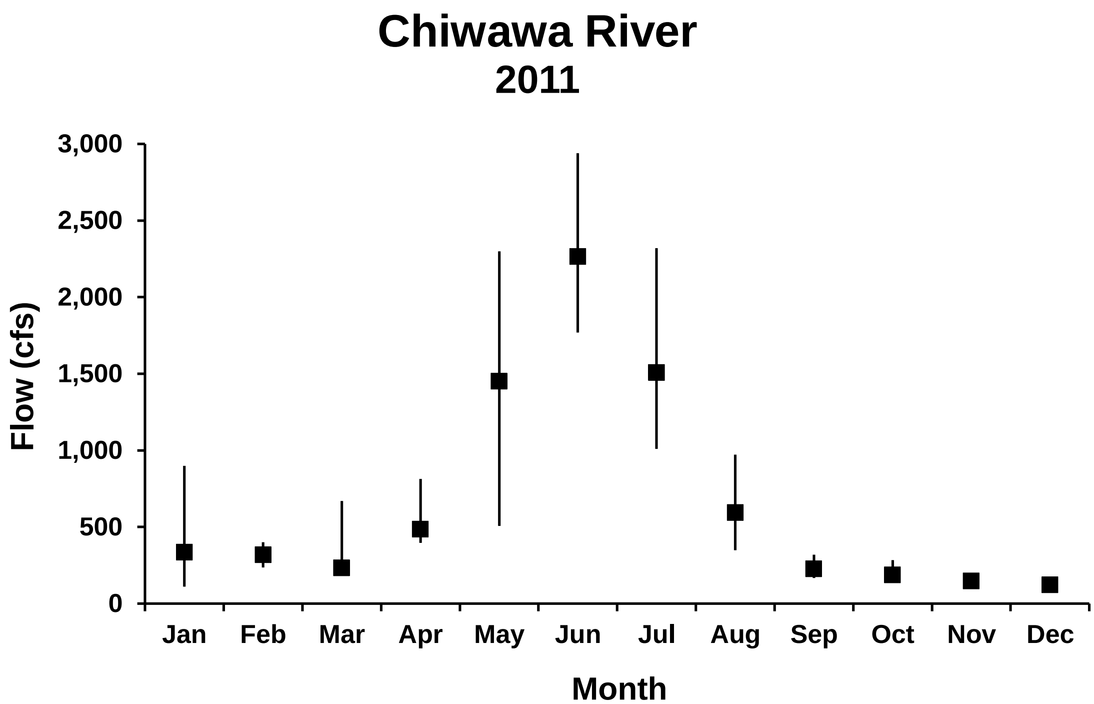

Figure 2. Mean, minimum, and maximum monthly flows in the Chiwawa River for 2011.

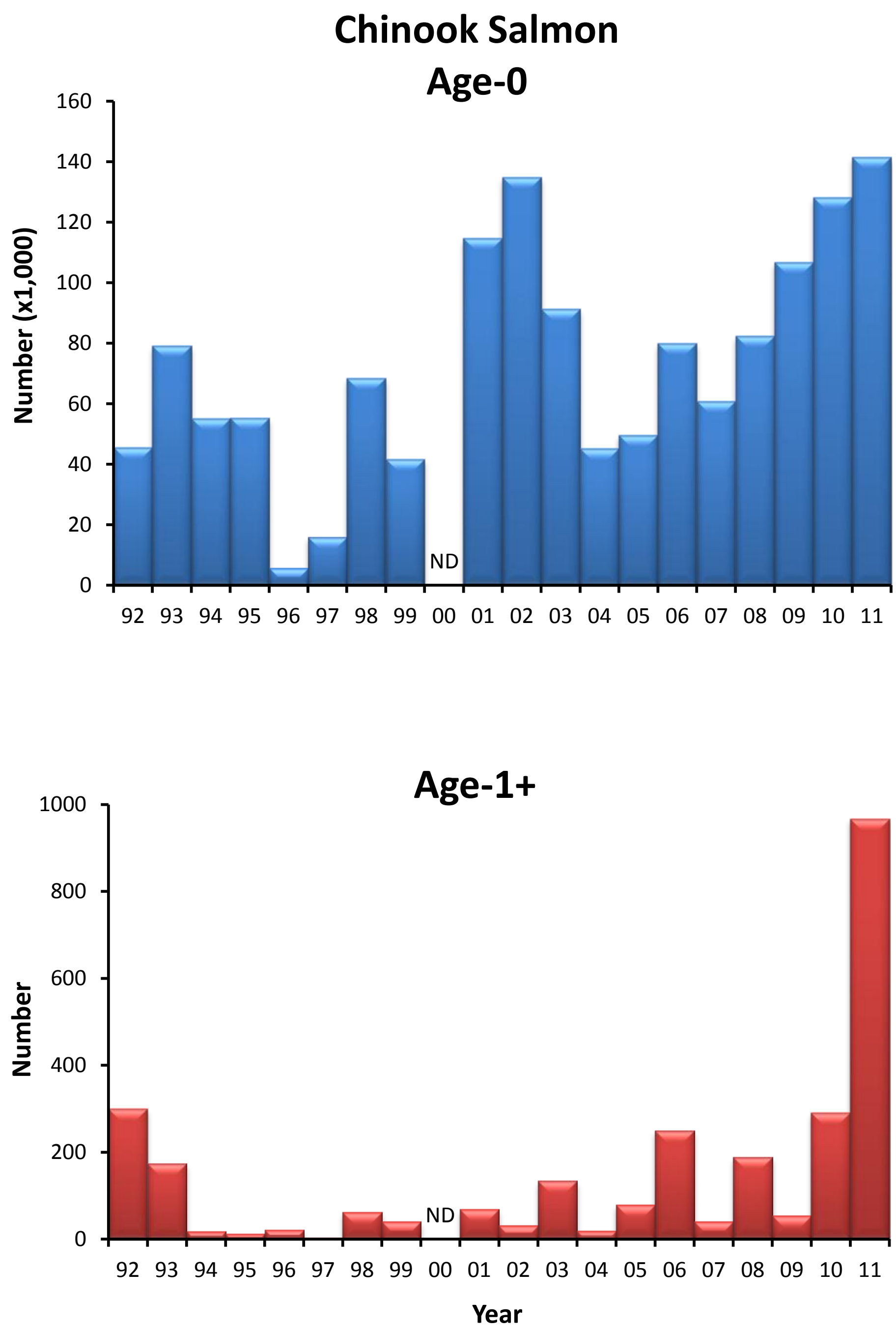

Figure 3. Numbers of age-0 and age-1+ Chinook salmon within the Chiwawa River Basin in August 1992-2011; ND = no data.

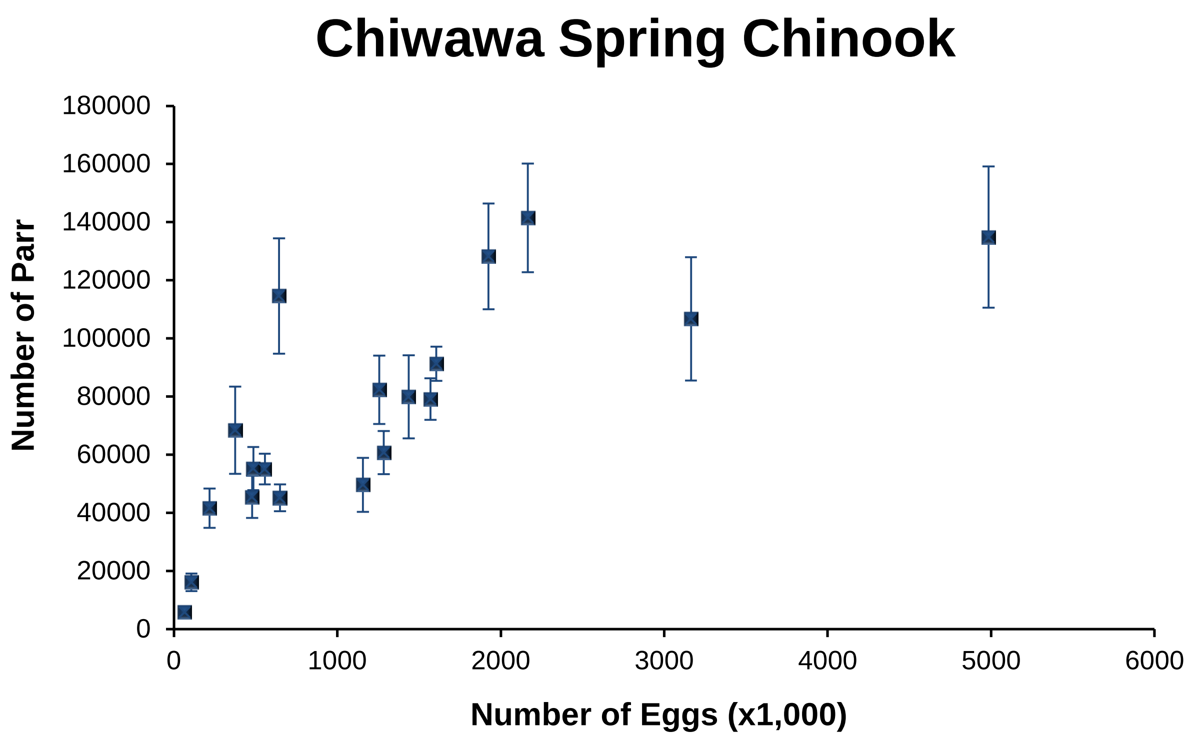

Figure 4. Relationship between total numbers of age-0 Chinook salmon (based on fish/ha) and numbers of eggs in the Chiwawa River Basin. Vertical bars indicate 95% confidence bounds.

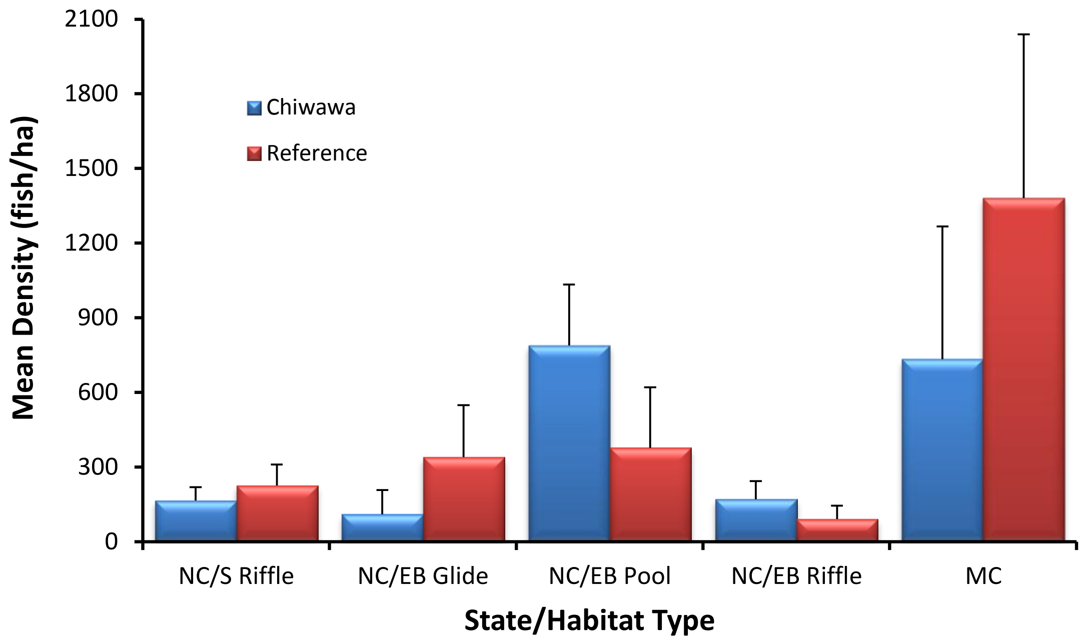

Figure 5. Comparison of the 18-year means (95% CI) of age-0 Chinook salmon densities (fish/ha) within state/habitat types in Reaches 3 and 8 of the Chiwawa River and their matched reference areas on Nason Creek and the Little Wenatchee River. There was no sampling in 2000 and no sampling in reference areas in 1992.

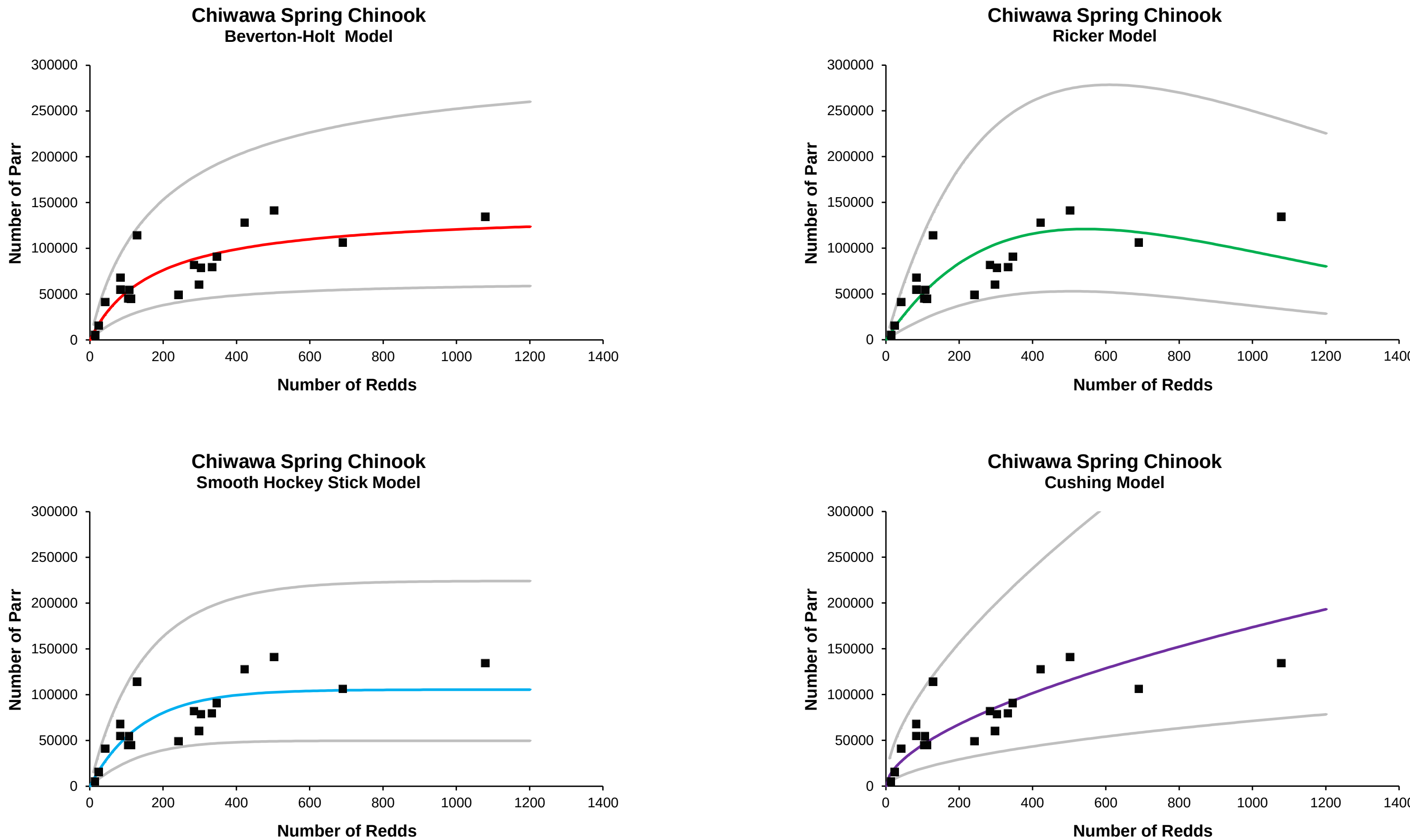

Figure 6. Relationship between numbers of juvenile (age-0) Chinook and redds in the Chiwawa Basin, 1992-2011 (no sampling occurred in 2000). Figures show the fit of the Beverton-Holt model, smooth hockey stick, Ricker model, and the Cushing model to the data. Gray lines indicate the upper and lower 95% C.B.

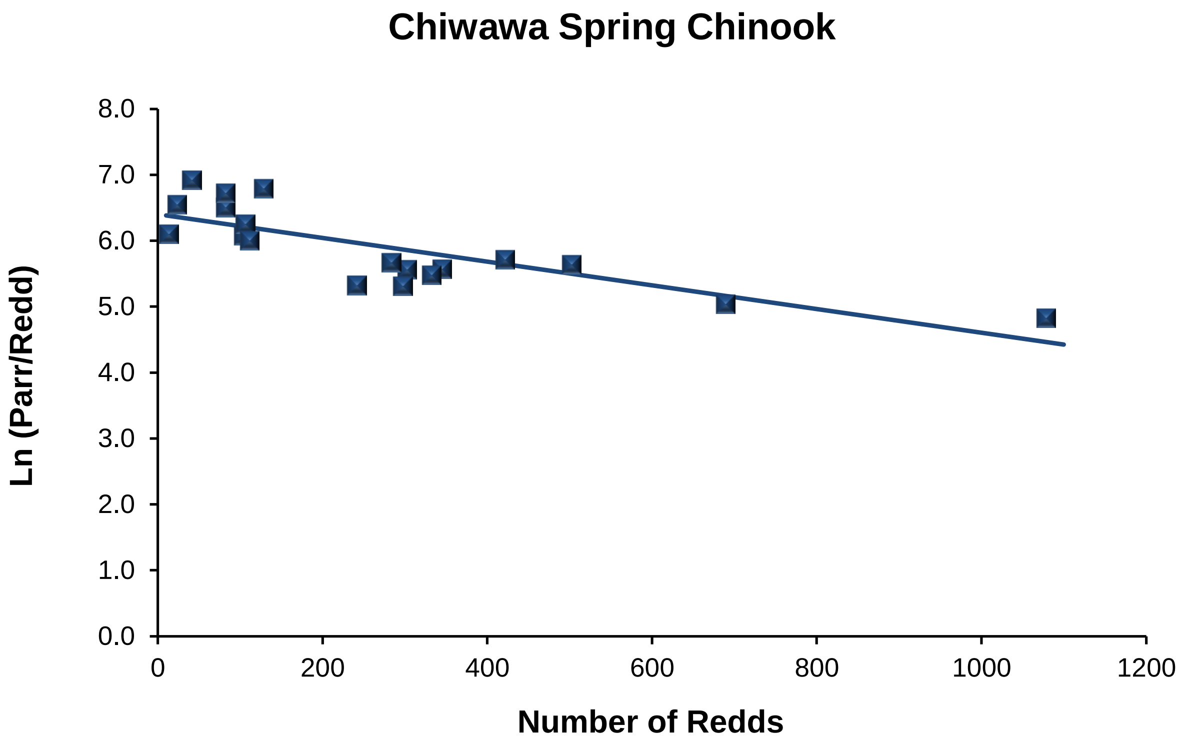

Figure 7. Relationship between natural log parr/redd and numbers of redds in the Chiwawa River Basin, 1992-2011. No sampling was conducted in 2000. Estimates for 1992-2011 included the Chiwawa River and its tributaries; the 1992 estimate included only the Chiwawa River. The linear relationship LN(P/R) = 6.40 – 0.002(Redds) was significant with P = 0.0000; R^2 = 0.644.

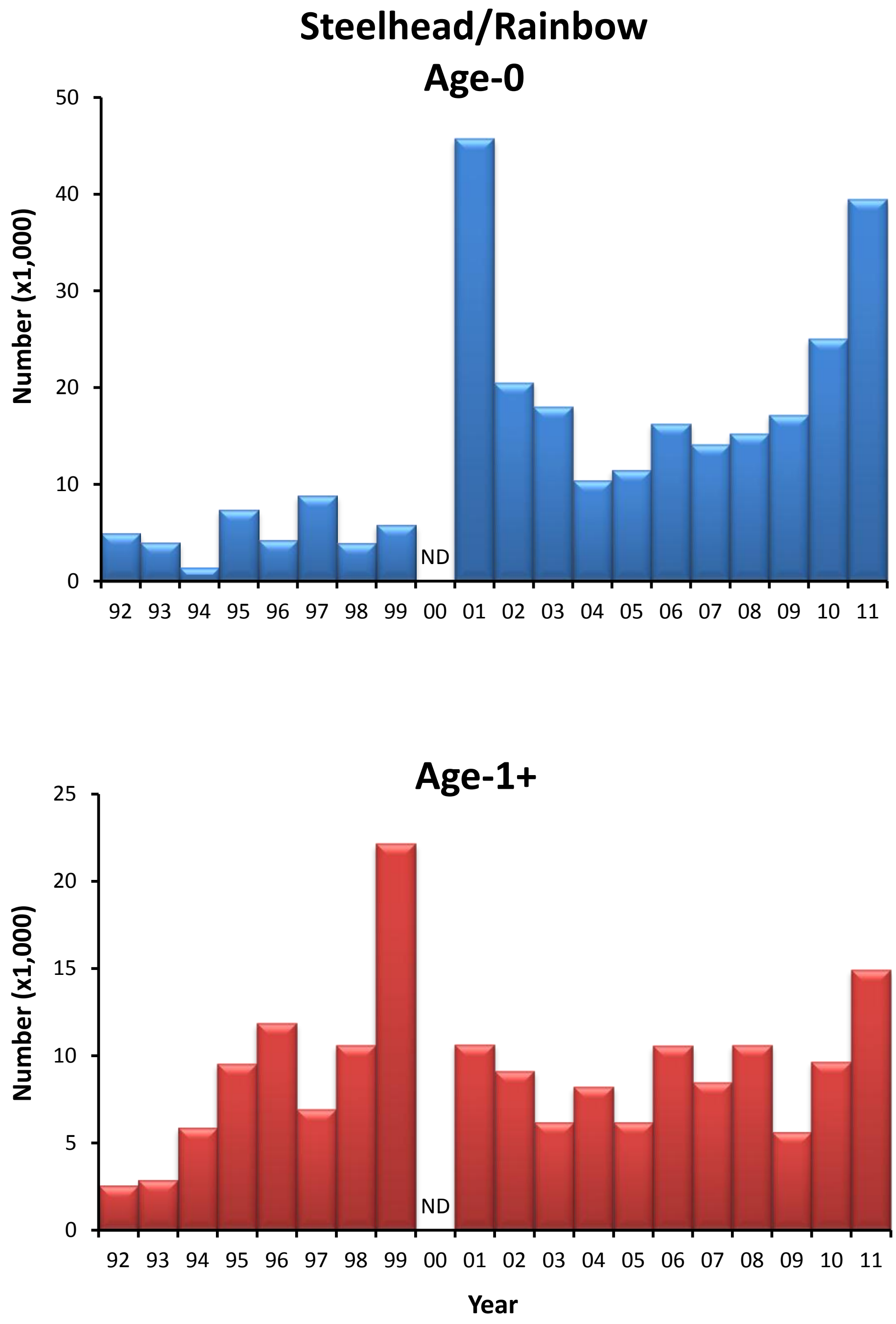

Figure 8. Numbers of age-0 (<4 in) and age-1+ (4-8 in) steelhead/rainbow within the Chiwawa River Basin in August 1992-2011; ND = no data.

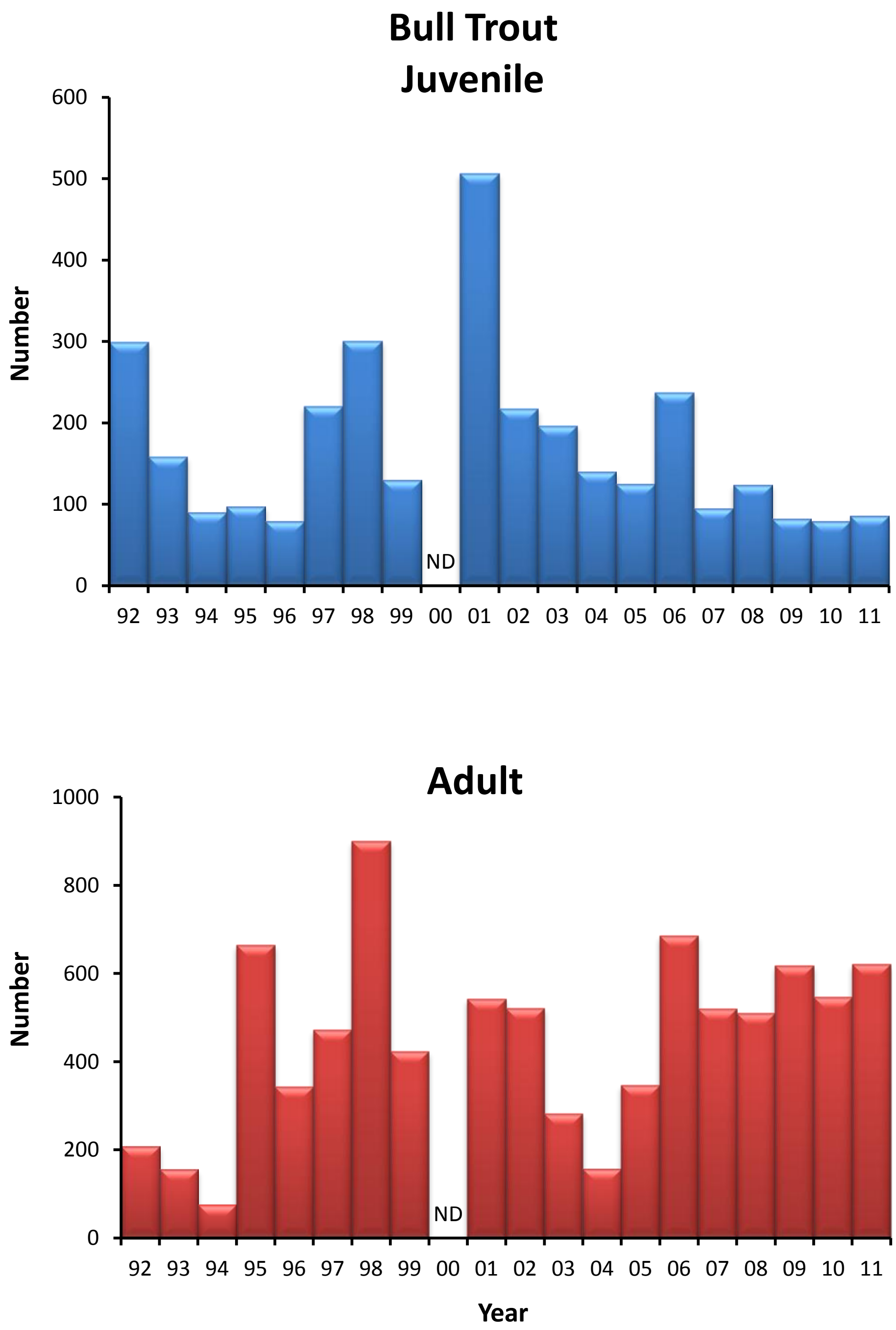

Figure 9. Numbers of juvenile (2-8 inches) and adult (>8 inches) bull trout within the Chiwawa River Basin in August 1992-2011; ND = no data.

Table 1. Description, location (river mile), and area (hectares) of land-class strata (reaches) used by age-0 Chinook salmon in the Chiwawa River Basin, 2011. Reaches were classified according to geologic district, landtype association, valley-bottom type, stream state-type, and habitat type within the Cascade Ecoregion; MCV = moderately confined valley, CC = confined canyon, UCV = unconfined valley, NC = natural channel, EB = eroded banks, S = straight, G = glide, P = pool, R = riffle, and MC = multiple channel. See Hillman and Miller (2004) for definitions of stream state codes.

Reach	RM	Gradient	Geologic district	Landtype association	Valley bottom type	Stream state type	Habitat type	Area (ha)	
								Total	Sample
Chiwawa River									
1	0.00-3.77	0.007	Glacial Drift over Chumstick Formation	Glacial Valley	MCV Alluvial	NC/EB	G	0.63	0.63
						NC/EB	P	1.61	1.16
						NC/EB	R	18.62	1.85
2	3.77-5.51	0.010	Glacial Drift over Chumstick Formation	Glacial Canyon	CC Fluvial	NC/EB	G	0.26	0.26
						NC/EB	P	0.82	0.28
						NC/EB	R	8.00	0.62
3	5.51-7.88	0.009	Glacial Drift over Chumstick Formation	Glacial Valley	MCV Alluvial	NC/S	R	5.89	0.89
						NC/EB	G	0.15	0.15
						NC/EB	R	4.38	0.59
						MC	MC	0.51	0.51
4	7.88-8.90	0.007	Glacial Drift over Chumstick Formation	Glacial Canyon	CC Fluvial	NC/EB	P	0.36	0.27
						NC/EB	R	3.12	0.83
						MC	MC	0.45	0.45
5	8.90-10.83	0.011	Glacial Drift over Chumstick Formation	Glacial Valley	MCV Alluvial	NC/EB	P	0.13	0.13
						NC/EB	R	10.58	1.06
6	10.83-11.80	0.008	Glacial Drift over Chumstick Formation	Glacial Canyon	CC Fluvial	NC/EB	P	0.47	0.47
						NC/EB	R	3.83	0.94
						MC	MC	0.35	0.35
7	11.80-20.03	0.001	Glacial Drift over Chumstick Formation	Glacial Valley	UCV Alluvial	NC	G	2.79	0.29
						NC	P	7.43	2.19
						NC	R	1.26	0.28
						NC/EB	G	4.13	1.47
						NC/EB	P	7.77	1.89
						NC/EB	R	4.90	0.71
						MC	MC	5.35	0.91
8	20.03-25.42	0.003	Glacial Drift over Swakane Gneiss	Glacial Valley	UCV Alluvial	NC/EB	G	3.29	1.21
						NC/EB	P	7.83	1.85
						NC/EB	R	6.60	1.12
						EB	P	0.25	0.25
						EB	R	0.42	0.42
						MC	MC	9.20	3.76
9	25.42-28.81	0.007	Glacial Drift over Swakane Gneiss	Glacial Valley	MCV Alluvial	NC	G	0.29	0.29
						NC	P	5.25	0.69
						NC	R	2.69	0.75
						MC	MC	3.06	0.68
10	28.81-31.11	0.011	Pre-upper Jurassic Gneiss	Glacial Valley	MCV Alluvial	NC	P	1.16	0.64
						NC	R	3.67	0.98
						MC	MC	4.45	0.35

Table 1. Concluded.

Reach	RM	Gradient	Geologic district	Landtype association	Valley bottom type	Stream state type	Habitat type	Area (ha)	
								Total	Sampled
Phelps Creek									
1	0.00-0.35	0.043	Pre-upper Jurassic Gneiss	Glacial Valley	MCV	NC	MC	0.32	0.32
Chikamin Creek[1]									
1	0.00-0.94	0.013	Glacial Drift over Chumstick Formation	Glacial Valley	UCV Alluvial	NC	G	0.03	0.03
						NC	P	0.25	0.10
						NC	R	0.46	0.15
						MC	MC	0.11	0.11
Rock Creek									
1	0.00-0.73	0.020	Glacial Drift over Swakane Gneiss	Glacial Valley	UCV Alluvial	NC	P	0.18	0.05
						NC	R	0.38	0.08
						MC	MC	0.13	0.13
Unnamed Creek									
1	0.00-0.05		Pre-upper Jurassic Gneiss	Glacial Valley	MCV Alluvial	NC	P	0.03	0.03
						NC	R	0.01	0.01
Big Meadow Creek									
1	0.00-0.35	0.025	Glacial Drift over Chumstick Formation	Glacial Valley	MCV Alluvial	NC	P	0.17	0.04
						NC	R	0.06	0.01
						NC	MC	0.03	0.03
Alder Creek									
1	0.00-0.01		Glacial Drift over Chumstick Formation	Glacial Valley	MCV Alluvial	NC	P	0.002	0.002
						NC	R	0.006	0.006
Brush Creek									
1	0.00-0.01		Glacial Drift over Chumstick Formation	Glacial Valley	UCV Alluvial	NC	P	0.003	0.003
						NC	R	0.004	0.004
Clear Creek									
1	0.00-0.05		Glacial Drift over Chumstick Formation	Glacial Valley	UCV Alluvial	NC	P	0.002	0.002
						NC	R	0.004	0.004
Y Creek									
1	0.00-0.05		Glacial Drift over Swakane Gneiss	Glacial Valley	UCV Alluvial	NC	P	0.000	0.000
						NC	R	0.000	0.000

[1] Includes the lower 0.2 miles of Minnow Creek.

Table 2. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of age-0 Chinook salmon in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	607.3	0.132	12,668	±5,289	0.42	12,960	±5,245	0.40
2	206.3	0.031	1,873	±52	0.03	1,678	±122	0.07
3	441.7	0.085	4,828	±422	0.09	4,960	±407	0.08
4	1,042.7	0.189	4,098	±282	0.07	4,185	±335	0.08
5	472.2	0.076	5,057	±267	0.05	4,003	±333	0.08
6	622.4	0.114	2,894	±310	0.11	2,845	±192	0.07
7	1,308.0	0.168	43,987	±7,074	0.16	46,001	±8,908	0.19
8	1,157.4	0.167	31,933	±15,962	0.50	33,618	±16,093	0.48
9	1,331.3	0.183	15,030	±925	0.06	13,248	±1,721	0.13
10	1,514.7	0.299	14,056	±3,760	0.26	14,485	±3,556	0.25
Phelps Creek								
1	200.0	0.072	64	±0	0.00	64	±0	0.00
Chikamin Creek[1]								
1	3,249.4	1.471	2,762	±1,135	0.41	2,764	±1,297	0.47
Rock Creek								
1	1,927.5	0.671	1,330	±253	0.19	1,385	±502	0.36
Unnamed Creek								
1	5,300.0	0.812	53	±0	0.00	53	±0	0.00
Big Meadow Creek								
1	2,234.6	0.680	581	±102	0.18	475	±133	0.28
Alder Creek								
1	5,250.0	5.060	42	±0	0.00	42	±0	0.00
Brush Creek								
1	35,666.7	33.968	214	±0	0.00	214	±0	0.00
Clear Creek								
1	6,666.7	4.651	40	±0	0.00	40	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**982.0**	**0.157**	**141,510**	**±18,697**	**0.13**	**143,020**	**±19,592**	**0.14**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 3. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of age-1+ Chinook salmon in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	1.9	0.000	40	±12	0.30	39	±56	1.44
2	0.0	0.000	0	±0	0.00	0	±0	0.00
3	5.4	0.001	59	±10	0.17	64	±11	0.17
4	3.6	0.001	14	±0	0.00	13	±0	0.00
5	0.0	0.000	0	±0	0.00	0	±0	0.00
6	1.3	0.000	6	±0	0.00	5	±0	0.00
7	11.0	0.001	369	±191	0.52	383	±287	0.75
8	5.7	0.001	157	±118	0.75	161	±174	1.08
9	0.0	0.000	0	±0	0.00	0	±0	0.00
10	0.0	0.000	0	±0	0.00	0	±0	0.00
Phelps Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Chikamin Creek[1]								
1	83.5	0.038	71	±26	0.37	72	±29	0.40
Rock Creek								
1	281.2	0.075	194	±155	0.80	155	±135	0.87
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	219.2	0.060	57	±7	0.12	42	±6	0.14
Alder Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Brush Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Clear Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**6.7**	**0.001**	**967**	**±275**	**0.28**	**934**	**±367**	**0.39**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 4. Summary of the six productivity models of juvenile (age-0) Chinook salmon in the Chiwawa Basin. Models are shown, including the number of parameters (*K*), AIC_c values, AIC_c difference scores (Δ_i), the likelihood of the model given the data ($£(g_i|x)$), Akaike weights (w_i), and adjusted R^2 values. The sample size (*n*) for all models was 19. Models describe the relationship between juvenile Chinook numbers (dependent variable) and redd numbers (independent variable).

Model	K^a	AIC_c	Δ_i	$£(g_i\|x)$	w_i	Adj R^2
Beverton-Holt	3	-93.55	0.00	1.00	0.56	0.81
Smooth Hockey Stick	3	-92.70	0.84	0.66	0.37	0.82
Ricker	3	-87.97	5.57	0.06	0.04	0.75
Gamma[b]	4	-87.03	6.52	0.04	0.02	0.77
Cushing	3	-86.50	7.05	0.03	0.02	0.73

[a] ***K*** is the number of structural parameters in the model plus 1 for σ^2.
[b] The γ parameter in the Gamma model was greater than 0, which means that this model is nearly identical to the Ricker model. The reason it did not rank higher than the Ricker model is because the Gamma model contains an extra parameter, which means that it has less bias and greater variance than the Ricker model (less parsimonious).

Table 5. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of age-0 (<4 in) steelhead/rainbow in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	407.1	0.086	8,493	±490	0.06	8,456	±475	0.06
2	349.7	0.056	3,175	±409	0.13	3,046	±492	0.16
3	533.8	0.102	5,834	±368	0.06	5,980	±330	0.06
4	493.6	0.093	1,940	±250	0.13	2,065	±303	0.15
5	919.8	0.147	9,851	±389	0.04	7,762	±404	0.05
6	255.9	0.047	1,190	±121	0.10	1,165	±104	0.09
7	154.2	0.020	5,185	±1,602	0.31	5,476	±1,501	0.27
8	5.7	0.001	157	±208	1.32	161	±219	1.36
9	0.0	0.000	0	±0	0.00	0	±0	0.00
10	0.0	0.000	0	±0	0.00	0	±0	0.00
Phelps Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Chikamin Creek[1]								
1	1,768.2	0.802	1,503	±454	0.30	1,507	±514	0.34
Rock Creek								
1	1,165.2	0.360	804	±342	0.43	744	±364	0.49
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	4,100.0	1.230	1,066	±177	0.17	860	±259	0.30
Alder Creek								
1	7,000.0	6.747	56	±0	0.00	56	±0	0.00
Brush Creek								
1	25,333.3	24.127	152	±0	0.00	152	±0	0.00
Clear Creek								
1	6,666.7	4.651	40	±0	0.00	40	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**273.7**	**0.041**	**39,446**	**±1,932**	**0.05**	**37,470**	**±1,899**	**0.05**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 6. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of age-1+ (4-8 in) steelhead/rainbow in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	167.7	0.036	3,499	±220	0.06	3,509	±247	0.07
2	131.6	0.020	1,195	±239	0.20	1,106	±291	0.26
3	205.7	0.039	2,248	±132	0.06	2,275	±124	0.06
4	122.6	0.023	482	±207	0.43	511	±187	0.37
5	212.4	0.034	2,275	±52	0.02	1,803	±65	0.04
6	120.4	0.022	560	±114	0.20	550	±92	0.17
7	68.1	0.008	2,291	±852	0.37	2,273	±850	0.37
8	28.2	0.004	779	±1,066	1.37	827	±1,065	1.29
9	0.0	0.000	0	±0	0.00	0	±0	0.00
10	0.0	0.000	0	±0	0.00	0	±0	0.00
Phelps Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Chikamin Creek[1]								
1	488.2	0.221	415	±84	0.20	415	±93	0.22
Rock Creek								
1	681.2	0.220	470	±228	0.49	455	±267	0.59
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	2,650.0	0.738	689	±67	0.10	516	±128	0.25
Alder Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Brush Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Clear Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**103.4**	**0.016**	**14,903**	**±1,452**	**0.10**	**14,240**	**±1,470**	**0.10**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 7. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of steelhead/rainbow larger than 8 inches in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	1.4	0.000	29	±11	0.38	30	±32	1.07
2	0.3	0.000	3	±2	0.67	1	±4	4.00
3	0.2	0.000	2	±0	0.00	1	±0	0.00
4	0.3	0.000	1	±2	2.00	1	±2	2.00
5	0.3	0.000	3	±0	0.00	5	±0	0.00
6	0.0	0.000	0	±0	0.00	0	±0	0.00
7	0.7	0.000	24	±11	0.46	27	±20	0.74
8	0.1	0.000	2	±3	1.50	1	±4	4.00
9	0.0	0.000	0	±0	0.00	0	±0	0.00
10	0.0	0.000	0	±0	0.00	0	±0	0.00
Phelps Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Chikamin Creek[1]								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Rock Creek								
1	1.4	0.001	1	±0	0.00	1	±0	0.00
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Alder Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Brush Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Clear Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**0.5**	**0.000**	**65**	**±16**	**0.25**	**67**	**±38**	**0.57**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 8. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of juvenile bull trout (2-8 in) in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
2	0.0	0.000	0	±0	0.00	0	±0	0.00
3	0.0	0.000	0	±0	0.00	0	±0	0.00
4	0.0	0.000	0	±0	0.00	0	±0	0.00
5	0.0	0.000	0	±0	0.00	0	±0	0.00
6	0.0	0.000	0	±0	0.00	0	±0	0.00
7	0.0	0.000	0	±0	0.00	0	±0	0.00
8	0.9	0.000	25	±22	0.88	20	±24	1.20
9	0.4	0.000	4	±5	1.25	7	±5	0.71
10	1.4	0.000	13	±7	0.54	15	±10	0.67
Phelps Creek								
1	31.3	0.011	10	±0	0.00	10	±0	0.00
Chikamin Creek[1]								
1	10.6	0.004	9	±3	0.00	8	±3	0.00
Rock Creek								
1	36.2	0.013	25	±16	0.64	27	±24	0.89
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Alder Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Brush Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Clear Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**0.6**	**0.000**	**86**	**±29**	**0.34**	**87**	**±35**	**0.40**

[1] Includes lower 0.2 miles of Minnow Creek.

Table 9. Estimated mean densities (fish/hectare and fish/m^3), total numbers, 95% confidence bounds on total numbers, and error of the estimated total number of adult bull trout (>8 in) in reaches in the Chiwawa River Basin, Washington, August 2011.

Reach	Mean density		Surface area (ha)			Volume (m^3)		
	Fish/ha	Fish/m^3	Total No.	95% C.B.	± Error	Total No.	95% C.B.	± Error
Chiwawa River								
1	1.4	0.000	29	±6	0.21	30	±25	0.83
2	2.3	0.000	21	±1	0.05	16	±20	1.25
3	0.5	0.000	6	±0	0.00	6	±0	0.00
4	3.3	0.001	13	±5	0.38	13	±13	1.00
5	1.2	0.000	13	±1	0.08	11	±1	0.09
6	1.5	0.000	7	±0	0.00	7	±0	0.00
7	5.7	0.001	191	±31	0.16	192	±83	0.43
8	5.7	0.001	156	±75	0.48	161	±105	0.65
9	8.9	0.001	100	±32	0.32	94	±59	0.63
10	9.2	0.002	85	±26	0.31	87	±51	0.59
Phelps Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Chikamin Creek[1]								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Rock Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Unnamed Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Big Meadow Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Alder Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Brush Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Clear Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Y Creek								
1	0.0	0.000	0	±0	0.00	0	±0	0.00
Grand Total	**4.3**	**0.001**	**621**	**±91**	**0.15**	**617**	**±159**	**0.26**

[1] Includes lower 0.2 miles of Minnow Creek.

APPENDIX A. Numbers of redds, eggs, age-0 Chinook salmon, parr per redd, and percent egg-to-parr survival in the Chiwawa River Basin, brood years 1991-2010; NS = not sampled. Numbers of eggs were calculated as the number of redds times the mean fecundity of females collected for broodstock.

Brood Year	Chinook Salmon			Parr/Redd	Egg-to-parr survival (%)
	Redds	Eggs	Age-0 (parr)		
1991	104	478,400	45,483	437	9.5
1992	302	1,570,098	79,113	262	5.0
1993	106	556,394	55,056	519	9.9
1994	82	485,686	55,240	674	11.4
1995	13	66,248	5,815	447	8.8
1996	23	106,835	16,066	699	15.0
1997	82	374,740	68,415	834	18.3
1998	41	218,325	41,629	1,015	19.1
1999	34	166,090	NS	NS	NS
2000	128	642,944	114,617	895	17.8
2001	1,078	4,984,672	134,874	125	2.7
2002	345	1,605,630	91,278	265	5.7
2003	111	648,684	45,177	407	7.0
2004	241	1,156,559	49,631	206	4.3
2005	332	1,436,564	79,902	241	5.6
2006	297	1,284,228	60,752	205	4.7
2007	283	1,256,803	82,351	291	6.6
2008	689	3,163,888	106,705	155	3.4
2009	421	1,925,233	128,220	305	6.7
2010	502	2,165,628	141,510	282	6.5
Average	**261**	**1,214,682**	**73,781**	**271**	**8.8**

APPENDIX B. Estimated numbers of salmonids (based on fish/ha) in the Chiwawa River Basin, Washington, 1992-2011; NS = not sampled.

Survey year	Chinook salmon		Steelhead/Rainbow			Bull trout	
	Age-0	Age-1+	Age-0	Age-1+	>8 in[1]	2-8 in	>8 in
1992[2]	45,483	563	4,927	2,533	1,869	299	208
1993	79,113	174	4,004	2,860	768	158	156
1994	55,056	18	1,410	5,856	67	90	76
1995	55,241	13	7,357	9,517	140	97	664
1996	5,815	22	4,245	11,849	78	79	343
1997	16,066	5	8,823	6,905	48	220	472
1998	68,415	63	3,921	10,585	78	300	900
1999	41,629	41	5,838	22,130	33	130	423
2000	NS	NS	NS	NS	NS	NS	NS
2001	114,617	69	45,727	10,623	420	505	542
2002	134,874	32	20,521	9,090	181	217	521
2003	91,278	134	18,020	6,179	49	196	282
2004	45,177	21	10,380	8,190	8	140	157
2005	49,631	79	11,463	6,188	48	125	346
2006	79,902	388	16,245	10,533	50	238	686
2007	60,752	41	14,073	8,448	77	95	520
2008	82,351	189	15,230	10,576	144	124	510
2009	106,705	54	17,179	5,629	85	82	618
2010	128,220	291	25,018	9,616	63	79	547
2011	141,510	967	39,446	14,903	65	86	621

[1]During 1992-1993, numbers included both hatchery and wild rainbow trout. Thereafter, only wild trout were observed.
[2]Only the Chiwawa River was sampled in 1992. No tributaries were sampled in that year.

APPENDIX C. Proportion of total habitat available, fraction of all age-0 Chinook within each habitat type, and densities (fish/ha) and numbers of age-0 Chinook within each habitat type in the Chiwawa River Basin, survey years 1992-2011; NS = not sampled.

Habitat	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Proportion of total habitat available											
Glide	0.10	0.09	0.10	0.10	0.10	0.09	0.09	0.09	NS	0.07	0.08
Pool	0.19	0.19	0.21	0.18	0.18	0.17	0.16	0.17	NS	0.15	0.16
Riffle	0.61	0.61	0.57	0.59	0.57	0.57	0.58	0.55	NS	0.49	0.48
M. Chan	0.10	0.11	0.12	0.14	0.14	0.17	0.17	0.19	NS	0.29	0.28
Fraction of all age-0 Chinook within habitat types											
Glide	0.07	0.03	0.02	0.01	0.02	0.01	0.01	0.01	NS	0.03	0.01
Pool	0.30	0.28	0.22	0.21	0.30	0.16	0.17	0.14	NS	0.23	0.24
Riffle	0.19	0.16	0.12	0.11	0.43	0.23	0.08	0.11	NS	0.18	0.15
M. Chan	0.45	0.53	0.64	0.67	0.24	0.60	0.74	0.74	NS	0.57	0.60
Densities of age-0 Chinook within habitat types (fish/ha)											
Glide	254	251	93	55	11	12	78	13	NS	351	187
Pool	584	1,049	619	541	82	122	607	257	NS	1,392	1,468
Riffle	116	188	124	91	38	52	79	62	NS	336	300
M. Chan	1,710	3,408	2,985	2,328	84	449	2,620	1,201	NS	1,820	2,069
Number of age-0 Chinook within habitat types											
Glide	2,967	2,458	857	623	137	130	837	157	NS	3,231	1,931
Pool	13,468	21,814	12,131	11,294	1,755	2,553	11,454	5,933	NS	25,890	32,612
Riffle	8,531	12,616	6,698	6,197	2,525	3,699	5,392	4,626	NS	20,629	19,754
M. Chan	20,517	42,225	35,370	36,965	1,396	9,682	50,728	30,912	NS	64,866	80,576

APPENDIX C. Concluded.

Habitat	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean
Proportion of total habitat available											
Glide	0.07	0.07	0.08	0.08	0.07	0.09	0.08	0.08	0.08		**0.08**
Pool	0.17	0.16	0.16	0.16	0.17	0.23	0.22	0.23	0.18		**0.18**
Riffle	0.49	0.50	0.47	0.47	0.47	0.51	0.54	0.53	0.57		**0.53**
M. Chan	0.26	0.27	0.29	0.30	0.29	0.17	0.15	0.16	0.17		**0.21**
Fraction of all age-0 Chinook within habitat types											
Glide	0.02	0.01	0.01	0.03	0.02	0.03	0.02	0.02	0.04		**0.02**
Pool	0.23	0.07	0.19	0.31	0.46	0.40	0.36	0.34	0.34		**0.28**
Riffle	0.15	0.14	0.07	0.12	0.12	0.11	0.11	0.11	0.19		**0.14**
M. Chan	0.60	0.77	0.73	0.54	0.40	0.45	0.51	0.53	0.43		**0.56**
Densities of age-0 Chinook within habitat types (fish/ha)											
Glide	200	58	49	237	113	238	230	286	526		**170**
Pool	951	155	492	1,240	1,211	1,210	1,453	1,436	1,805		**919**
Riffle	216	101	60	166	118	156	175	200	330		**155**
M. Chan	1,626	1,008	1,057	1,147	603	1,872	2,993	3,293	2,515		**1,659**
Number of age-0 Chinook within habitat types											
Glide	1,884	540	442	2,498	1,120	2,668	2,371	3,164	6,122		**1,797**
Pool	21,091	3,183	9,626	26,754	28,851	34,314	39,382	44,765	48,846		**20,827**
Riffle	13,783	6,501	3,367	10,753	7,809	9,773	11,558	14,446	27,883		**10,344**
M. Chan	54,519	34,952	36,196	46,580	25,409	38,275	55,607	69,609	61,944		**41,912**

Appendix B

Fish Trapping at the Chiwawa and Upper Wenatchee Smolt Traps during 2011

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM -SCIENCE DIVISION
SUPPLEMENTATION RESEARCH TEAM
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January 24, 2012

To: HCP Hatchery Committee

From: John Walter, Ben Truscott, Andrew Murdoch and Todd Miller

Cc: Distribution List

Subject: 2011 Chiwawa and Wenatchee River Smolt Estimates

Smolt monitoring programs in the Wenatchee Basin were intended to estimate the number of naturally produced migrating smolts at either the subbasin (e.g., Chiwawa River) or watershed scale (e.g., Wenatchee River Basin) depending on the target stock (Table 1). In addition, population estimates of hatchery sockeye emigrating from Lake Wenatchee were used to calculate post release survival (i.e., subyearling parr to yearling smolt). The size of smolt traps operated was determined by water depth and river discharge at each of the locations. The number of smolt traps operated was determined by the expected trap efficiency. Smolt traps were located downstream from all (i.e., Chiwawa spring Chinook, Wenatchee spring Chinook, and Wenatchee sockeye), or the majority (i.e., Wenatchee summer Chinook and Wenatchee steelhead) of the spawning areas (Figure 1).

Table 1. Target stocks and corresponding smolt trapping locations used in 2011.

Stock	Smolt trap location	Smolt trap	
		Number	Diameter (m)
Chiwawa spring Chinook	Chiwawa	1	2.6
Wenatchee sockeye	Lake Wenatchee	2	1.5
Wenatchee spring Chinook [a]	Monitor (Lower Wenatchee)	2	2.6
Wenatchee summer Chinook [a]	Monitor (Lower Wenatchee)	2	2.6
Wenatchee steelhead [a]	Monitor (Lower Wenatchee)	2	2.6

[a] Trap did not operate in 2011

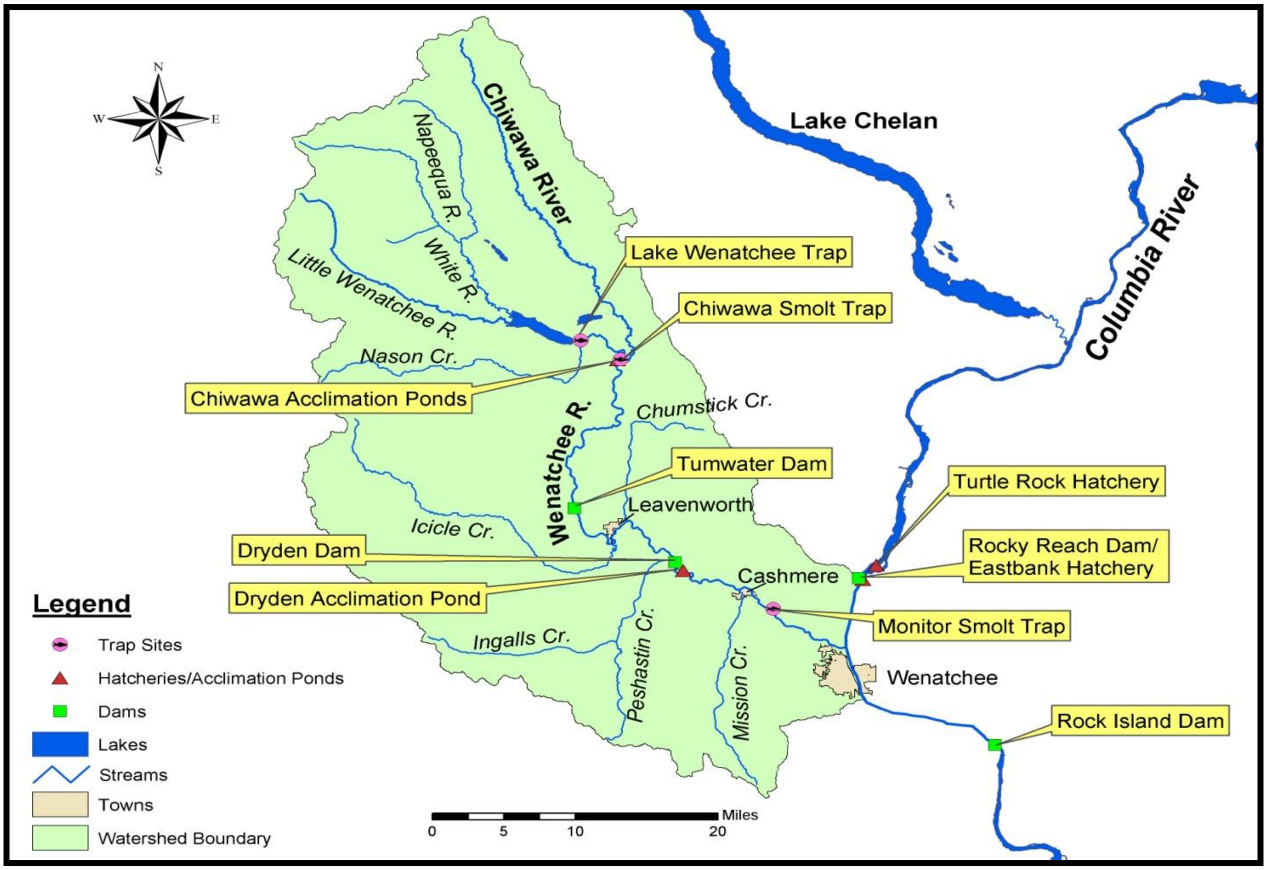

Figure 1. Locations of the Upper Wenatchee (Lake Wenatchee Trap), Chiwawa, and Lower Wenatchee River (Monitor Smolt Trap) smolt traps.

Methods

Fish were removed from the trap at a minimum every morning and placed in an anesthetic solution of MS-222. Fish were identified to species and counted. Non-target species were allowed to fully recover in fresh water prior to being released in an area of calm water downstream from the smolt trap. Target species were held in separate live boxes when needed for mark/recapture efficiency trials conducted in the evening.

Fork length was measured to the nearest millimeter and weight to the nearest 0.1 g. A Fulton type condition factor ($WH10^5/FL^3$) was calculated for all target species. The degree of smoltification (parr, transitional, or smolt) was assessed by visual examination. Juvenile spring Chinook and steelhead were classified as parr if parr marks were distinct, transitional if parr marks were not distinct, and smolts if parr marks were not visible and the fish exhibited a silvery appearance.

Mark/recapture efficiency trials were conducted throughout the trapping season. The frequency of mark/recapture trials was dependent on the number of fish captured (i.e., no less than 100) and the river discharge. These trials were conducted over the widest range of discharge possible (interval depends on trap location). Fish utilized for mark/recapture trials were marked by clipping the tip of either the upper or lower lobe of the caudal fin or were PIT tagged by Chelan County PUD (CCPUD) personnel. Chinook fry (i.e., FL < 50 mm) used in mark/recapture trials were dyed using a Bismark brown solution. Marked fish were distributed evenly on both sides of the river in pools or in calm pockets of water around boulders. In the case of the Upper Wenatchee River smolt trap, marked fish were transported and released into Lake Wenatchee. Marked fish were released between 1800 h and 2000 h. All recaptures of marked fish typically occurred within 48 h after each trial. Emigration estimates were calculated using estimated daily trap efficiency derived from the regression formula using trap efficiency (dependent variable) and discharge (independent variable).

Trap efficiency was calculated using the following formula:

$$\text{Trap efficiency} = E_i = R \ / \ Mi,$$

Where E_i is the trap efficiency during time period i; M_i is the number of marked fish released during time period i; and R_i is the number of marked fish recaptured during time period i. The number of fish captured was expanded by the estimated daily trap efficiency (e) to estimate the daily number of fish migrating past the trap (N_i) using the following formula:

$$\text{Estimated daily migration} = \hat{N}_i = C_i / \hat{e}_i$$

where N_i is the estimated number of fish passing the trap during time period i; C_i is the number of unmarked fish captured during time period i; and e_i is the estimated trap efficiency for time period i based on the regression equation.

The variance for the total daily number of fish migrating past the trap was calculated using the following formulas:

$$\text{Variance of daily migration estimate} = \text{var}\left[\hat{N}_i\right] = \hat{N}_i^2 \frac{\text{MSE}\left(1 + \frac{1}{n} + \frac{\left(X_i - \overline{X}\right)^2}{(n-1)s_X^2}\right)}{\hat{e}_i^2}$$

where X_i is the discharge for time period i, and n is the sample size. If a relationship between discharge and trap efficiency was not present (i.e., $P < 0.05$; r^2 ~0.5), a pooled trap efficiency was used to estimate daily emigration:

$$\text{Pooled trap efficiency} = e_p = \sum R / \sum M$$

The daily emigration estimate was calculated using the formula:

$$\text{Daily emigration estimate} = \hat{N}_i = C_i / e_p$$

The variance for daily emigration estimates using the pooled trap efficiency was calculated using the formula:

Variance for daily emigration estimate = $\text{var}\left[\hat{N}_i\right] = \hat{N}_i^2 \dfrac{e_p(1-e_p)\big/\sum M}{e_p^2}$

The total emigration estimate and confidence interval was calculated using the following formulas:

Total emigration estimate = $\sum \hat{N}_i$

95% confidence interval = $1.96 \times \sqrt{\sum \text{var}\left[\hat{N}_i\right]}$

Results

Chiwawa River Smolt Trap

2009 Brood Year

The Chiwawa River smolt trap was located approximately 1 km upstream from the confluence with the Wenatchee River. The smolt trap operated between 8 March and 30 November. During that time period the trap was inoperable for 20 days as a result of high river flows, debris, snow/ice, or mechanical failure. During breaks in operation, the estimated number of Chinook captured was calculated from the mean number of fish captured two days prior and two days after the break in operation. The trap was operated in two positions dependent on river discharge (i.e., lower > 12 m^3/s and upper < 12 m^3/s). Daily trap efficiencies were estimated from two regression models (independent variable = discharge) depending on trap position and age class (i.e., subyearling and yearling Chinook).

Wild yearling spring Chinook (2009 brood) were primarily captured between 8 March and 24 June (Figure 2). A total of 4,848 yearling Chinook were captured (Appendix A) and an estimated 5,332 yearling Chinook would have been captured if the trap had operated without interruption. Mortality for the season totaled 10 yearling spring Chinook (0.2 %). Seven mark/recapture efficiency trials were conducted in the lower position with a mean (SD) trap efficiency of 17.45 (0.10) %. In 2011, mark/recapture trials were conducted at all desired discharge levels and a statistically significant flow-efficiency regression model was obtained. The 2011 regression model for the lower position (R^2 = 0.75, P < 0.05) was used to estimate yearling Chinook emigration. The estimated number (95% C.I.) of yearling Chinook that emigrated from the Chiwawa River in 2011 was 30,959 (±7,386).

2010 Brood Year

Wild subyearling spring Chinook were captured between March 8 and November 30, with major peaks occurring in August, September, and November (Figure 2). A total of 20,561 subyearling Chinook were captured and an estimated 21,636 subyearling Chinook would have been captured if the trap had operated without interruption (Figure 2). Mortality for the season totaled 100 subyearling spring Chinook (0.5%). Twenty-two mark/recapture efficiency trials were conducted with a mean (SD) trap efficiency of 18.3 (0.08) %, which resulted in a significant regression model (i.e., upper trap position; $R^2 = 0.69$, $P < 0.01$). However, subyearling Chinook were also captured while the trap was operated in the lower position. Hence, a separate regression model from 2002 was used for that time period ($R^2 = 0.62$, $P < 0.01$). In 2011, the estimated number of subyearling spring Chinook (excluding fry < 50 mm FL) that moved downstream of the Chiwawa River smolt trap during the sampling period was 59,305 (± 5,983).

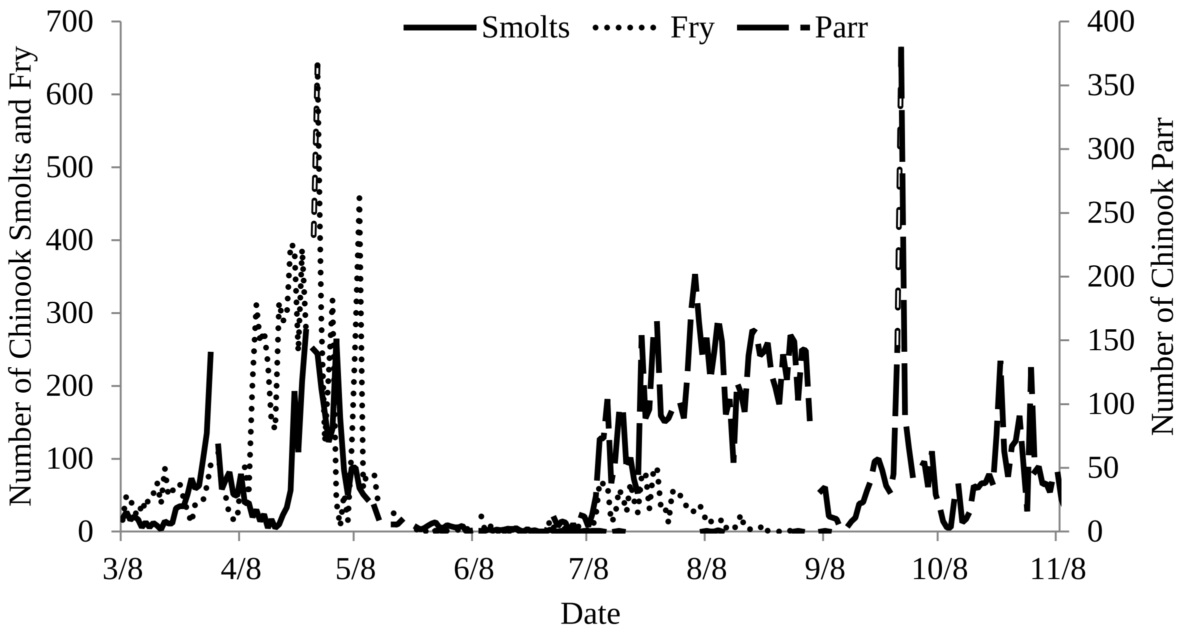

Figure 2. Daily number of spring Chinook smolts, parr, and fry captured at the Chiwawa River smolt trap in 2011.

Subyearling Fry

The proportion of subyearling Chinook that were captured and classified as fry was slightly less in 2011 (52%) than 2010 (58%). However, it was still higher than observed in previous years (Table 2). Because fry migrations are not a typical life history strategy of stream type Chinook, it is unclear if fry captured at the Chiwawa trap are emigrating from the Chiwawa River and rearing in the Wenatchee River, a temporary downstream movement due to environmental factors or a density dependent response. The influence of water temperature and discharge on the estimated daily number of fry that moved downstream of trap, using multiple factorial regression models, was examined. Both water temperature and discharge were not significant, but the interaction term was significant ($P = 0.03$). A surface plot (Distance weighted least squares) of estimated daily fry abundance, water temperature and change in discharge suggests that at low water temperatures a positive change in discharge results in the largest daily fry abundance, while changes in discharge at higher water temperatures had little influence in daily fry abundance (Figure 3). A positive relationship was observed between the estimated number of fry that moved downstream of the trap and the number of redds within 9 km of the trap (i.e., upper limit of the nearest spawning habitat; Figure 4).

Table 2. Spring Chinook subyearling capture by brood year and corresponding redd counts in the Chiwawa River.

Brood Year	Total number of redds	Number of redds < 9 km upstream of trap	Number of fry captured	Total fry abundance
[a]2010	502	13	10,627	113,143
[a]2009	421	11	7,696	70,013
[a]2008	689	25	13,538	147,918
[a]2007	283	4	1,985	30,782
[a]2006	297	3	4,852	64,842
[a]2005	333	22	1,444	25,022
[a]2004	241	3	2,675	23,101
[b]2003	111	9	1,485	13,913
[b]2002	345	37	8,644	108,091
[b]2001	1078	120	16,081	306,914
[b]2000	128	25	68	245
[b]1999	34	3	11	74
[b]1998	41	5	7	42
[b]1997	82	12	17	181
[b]1996	23	1	0	0
[b]1995	13	2	--	1,306
[b]1994	82	1	--	125
[b]1993	106	11	--	311
[b]1992	302	8	--	1,817

[a] Spawning distribution data from WDFW
[b] Spawning distribution data from CCPUD

Results from this analysis suggests that environmental conditions (i.e., increases in discharge at low water temperatures) and the abundance of redds in close proximity to the trap are likely factors responsible for the increase in fry observed at the Chiwawa smolt trap, suggesting that the movement patterns observed are not true migrations, but rather displacement due to environmental conditions present during emergence or a density dependent response in years of high redd abundance. Hillman and Miller (2002) reported large numbers of subyearling Chinook in tributaries of the Chiwawa River where no spawning had been reported. These data suggest considerable movement during the summer rearing period. Due to the high likelihood that fry do migrate upstream and rear in the Chiwawa River, fry have not been included in our emigrant production estimates.

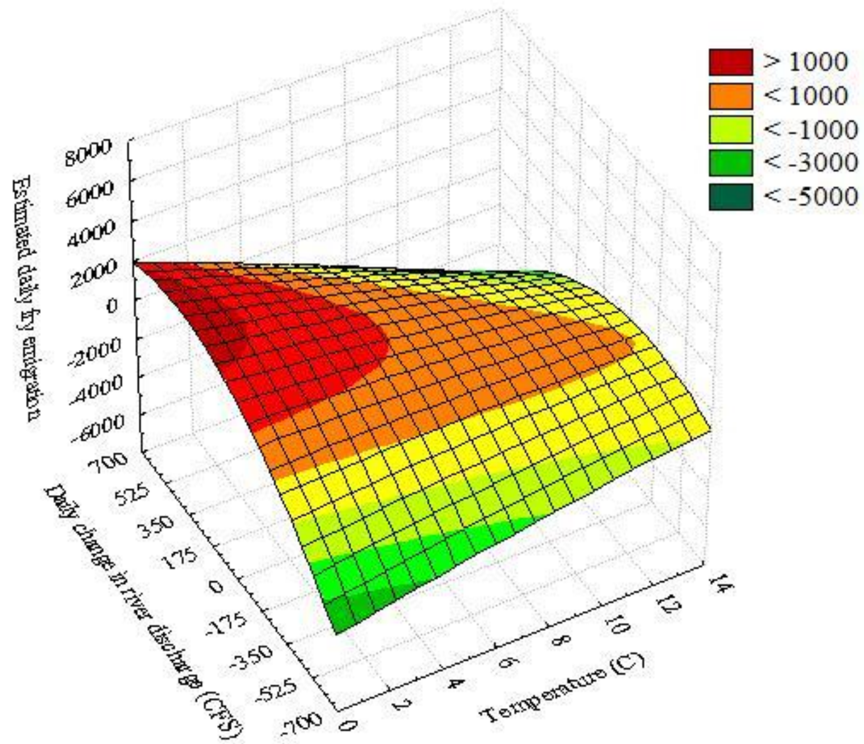

Figure 3. Relationship between daily fry abundance, water temperature and changes in discharge at the Chiwawa smolt trap in 2011.

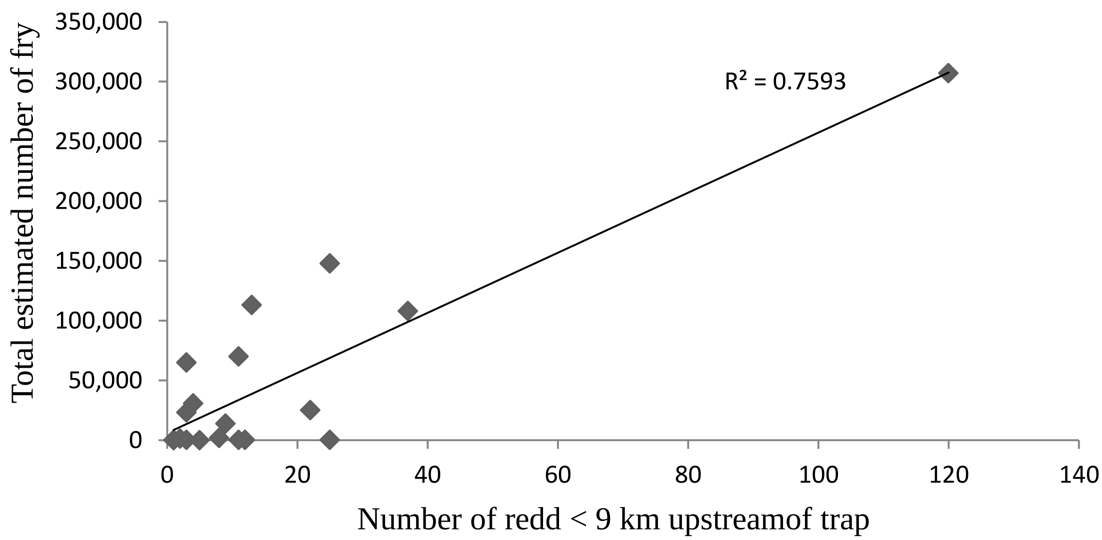

Figure 4. The relationship between total fry abundance and the number of redds in close proximity to the smolt trap.

Emigrant Survival

The estimated total egg deposition was calculated by multiplying the mean fecundity of the 2009 brood spawners (Hillman et al. 2011) by the total number of redds found during surveys in the Chiwawa River basin in 2009 (Ford et al. 2010). Egg-to-emigrant survival was calculated by dividing the estimated egg deposition by the total number of subyearling (excluding fry) that emigrated in 2010 and yearling spring Chinook that emigrated in 2011. The estimated egg-to-emigrant survival for the 2009 brood Chiwawa spring Chinook was 3.2% (Table 3).

Table 3. Estimated egg deposition (# of redds x mean broodstock fecundity) and egg-to-emigrant survival rates for Chiwawa River spring Chinook salmon.

Brood year	Number of redds	Estimated egg deposition	Estimated number			Egg-to-emigrant survival (%)
			Subyearling	Yearling	Total emigrants	
1992	302	1,570,098	25,818	39,723	65,541	4.2
1993	106	556,394	14,036	8,662	22,698	4.1
1994	82	485,686	8,595	16,472	25,067	5.2
1995	13	66,248	2,121	3,830	5,951	9.0
1996	23	106,835	3,708	15,475	19,183	18.0
1997	82	374,740	16,228	28,334	44,562	11.9
1998	41	207,675	2,855	23,068	25,923	11.9
1999	34	166,090	4,988	10,661	15,649	9.4
2000	128	642,944	14,854	40,831	55,685	8.7
2001	1,078	4,836,704	459,784	86,482	546,266	11.0
2002	345	1,605,630	93,331	90,948	184,279	11.5
2003	111	648,684	16,881	16,755	33,637	5.2
2004	241	1,156,559	44,079	72,080	116,158	10.0
2005	333	1,436,564	108,595	69,064	177,659	12.3
2006	297	1,284,228	62,922	45,050	107,972	8.4
2007	283	1,241,521	60,196	25,809	86,006	6.9
2008	689	3,163,199	85,161	35,023	120,184	3.8
2009	421	1,925,233	30,996	30,959	61,955	3.2
2010	502	2,165,628	59,305	--	--	--

Length and Weight

Individual length and weight measurements were recorded from a sample of the daily catch. The mean fork length (SD) of captured yearling and subyearling Chinook (fry excluded) was 94 (8) mm and 73 (11) mm, respectively (Table 4).

Table 4. Mean fork lengths (mm), weights (g), and body condition factor of spring Chinook salmon captured in the Chiwawa River smolt trap during 2011.

	Yearling smolts			Subyearling parr		
	Mean	SD	*N*	Mean	SD	*N*
Fork length	94	8	4,761	73	11	7,035
Weight	8.7	2.2	4,734	4.8	2.2	6,870
K factor	1.04	0.10	4,734	1.15	0.16	6,870

Nontarget Salmonids

During the trapping period, 195 steelhead smolts and 981 steelhead/rainbow parr were captured. Mortality for the season totaled 8 steelhead juveniles (0.7%). The mean fork length (SD) of steelhead parr and smolts captured was 94 (42) mm and 163 (20) mm, respectively (Table 5). Bull trout also comprised a large proportion of incidental species captured. During the trapping period, 7 adult (>300 mm) and 351 juvenile bull trout were captured (Table 6). Low numbers of fish captured prevented us from estimating the total number of steelhead and bull trout that emigrated from the Chiwawa River during the sampling period. Mortality for the season totaled 1 juvenile bull trout (0.3%). The monthly totals of all fish captured are listed in Appendix A.

Table 5. Mean fork lengths (mm), weights (g), and body condition factor of juvenile steelhead captured in the Chiwawa River smolt trap during 2011.

	Parr			Smolts		
	Mean	SD	*N*	Mean	SD	*N*
Fork length	94	42	935	163	20	192
Weight	15.3	24.9	897	43.7	16.9	192
K factor	1.05	0.18	897	0.97	0.08	192

Table 6. Mean fork lengths (mm), weights (g), and body condition factor of bull trout captured in the Chiwawa River smolt trap during 2011. Weights were not measured on adults.

	Juvenile			Adult		
	Mean	SD	*N*	Mean	SD	*N*
Fork length	189	34	345	463	50	6
Weight	71.0	37.6	313	--	--	--
K factor	0.97	0.15	313	--	--	--

Upper Wenatchee River Smolt Trap

The Upper Wenatchee River smolt traps were located approximately 0.5 km below the outlet of Lake Wenatchee. The trap operated nightly between 4 March and 1 July 2011. Of those fish captured during the sampling period, 48,128 and 3,017 were wild and hatchery sockeye, respectively (Figure 4). Mortality during the season totaled 120 wild sockeye (0.3%) and 73 hatchery sockeye (2.4%). The traps also captured 786 wild spring Chinook smolts and 135 juvenile steelhead. Mortality totaled 18 wild yearling Chinook (2.3%). There was no mortality of wild steelhead or bull trout captured during the sampling period. The monthly totals of all fish captured are listed in Appendix B.

Five mark/recapture efficiency trials with wild and hatchery sockeye were conducted during the sampling period. A total of 4,483 wild and 298 hatchery sockeye were marked (i.e., caudal fin clip) and released into Lake Wenatchee. A total of 146 wild and 7 hatchery sockeye were recaptured. A delay in migration and subsequent recapture of the marked fish from Lake Wenatchee confounded the relationship between discharge and trap efficiency (i.e., unequal probability of recapture). Both the wild and hatchery sockeye smolt production estimates were calculated using wild and hatchery pooled daily trap efficiencies (3.3% and 2.4% respectively).

The estimated smolt production (95% C.I.) for wild sockeye was 1,500,730 (±58,436). Age classes of wild sockeye were determined from scales collected randomly from the run (Table 7). Egg deposition was calculated based on the female to male ratio and spawning escapement determined at Tumwater Dam multiplied by fecundity of the broodstock (D. DeChand, WDFW, personal communication). Historical egg-to-smolt survival rates for wild Wenatchee sockeye have ranged between 1.2% and 21.2% (Table 8).

The estimated number (95% CI) of hatchery sockeye that emigrated from Lake Wenatchee was 159,089 (±28,150). This was the fifth brood year in which all hatchery sockeye parr were released at a similar size and time since 1999. The number of hatchery sockeye (2009 brood) released in the fall of 2010 was 227,743 resulting in a parr-to-smolt survival rate of 69.9 % (Table 9).

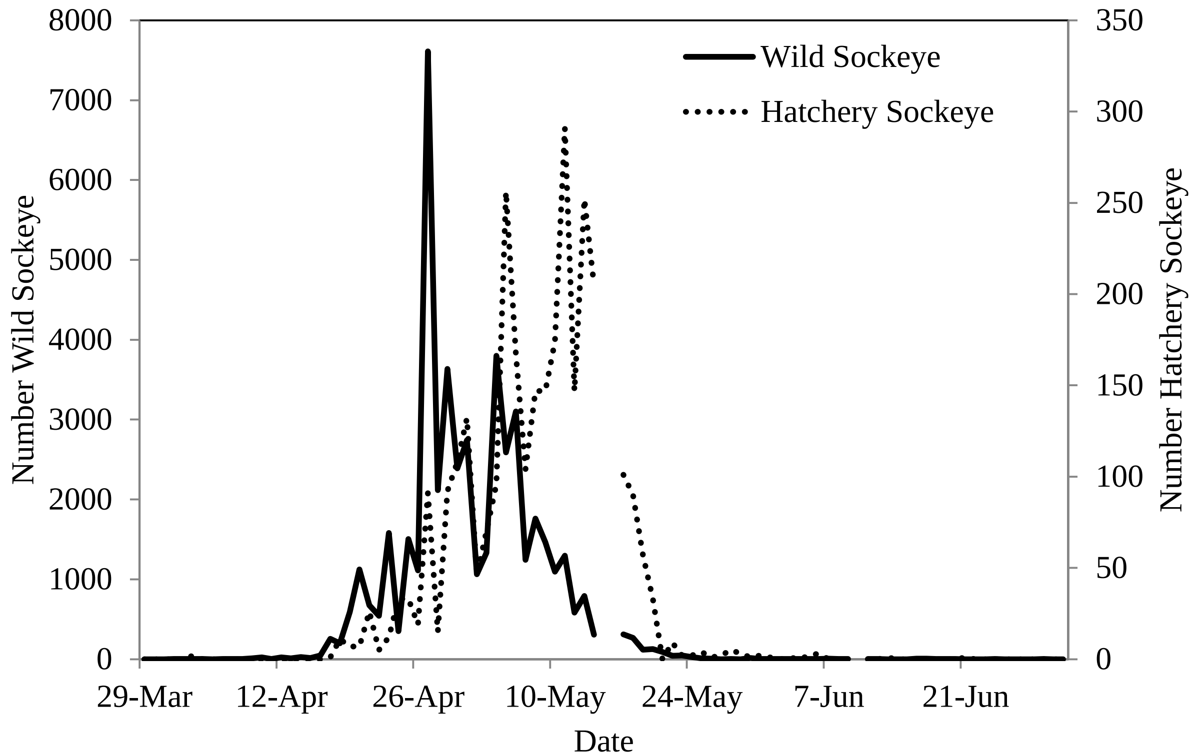

Figure 5. Number of wild and hatchery sockeye captured at the Upper Wenatchee River smolt trap, 2011.

Table 7. Age composition derived from scale samples and estimated number of wild sockeye smolts emigrating from Lake Wenatchee.

Run year	Proportion of wild smolts			Total emigrants
	Age 1+	Age 2+	Age 3+	
1997	0.075	0.906	0.019	55,359
1998	0.955	0.037	0.008	1,447,259
1999	0.619	0.381	0.000	1,944,966
2000	0.599	0.400	0.001	985,490
2001	0.943	0.051	0.006	39,353
2002	0.961	0.039	0.000	729,716
2003	0.740	0.026	0.000	5,439,032
2004	0.929	0.071	0.000	5,771,187
2005	0.230	0.748	0.022	723,413
2006	0.994	0.006	0.000	1,266,971
2007	0.996	0.004	0.000	2,797,313
2008	0.804	0.195	0.001	549,682
2009[b]	0.927	0.073	0.000	355,549
2010[b]	0.963	0.036	0.001	3,958,888
2011[a]	0.786	0.213	0.001	1,500,730

[a] Ages not confirmed by scales.
[b] estimates refined based on PIT tag survival to McNary Dam

Table 8. Estimated egg deposition (mean fecundity x estimated # of females) and egg-to-emigrant survival rates for Lake Wenatchee sockeye salmon.

Brood year	Estimated egg deposition	Estimated number of wild smolts				Egg-to-smolt survival (%)
		Age 1+	Age 2+	Age 3+	Total	
1995	4,902,120	4,174	53,549	0	57,723	1.2
1996	10,035,288	1,382,133	741,032	985	2,124,150	21.2
1997	13,223,588	1,203,934	394,196	236	1,598,366	12.1
1998	5,692,106	590,309	2,007	0	592,316	10.4
1999	1,188,488	37,110	28,459	0	65,569	5.5
2000	30,506,949	701,257	1,378,795	0	2,080,052	6.8
2001	64,187,600	4,024,884	409,754	15,915	4,450,553	6.9
2002	49,197,456	5,361,433	541,113	0	5,902,546	12.0
2003	7,576,738	166,385	7,602	0	173,987	2.3
2004	38,749,845	1,259,369	11,189	275	1,270,833	3.3
2005	15,946,506	2,786,123	107,243	0	2,893,366	18.1
2006[b]	7,296,032	442,164	25,919	1,507	469,590	6.4
2007[b]	6,232,804	329,629	142,916	594	473,139	7.6
2008[a,b]	30,084,691	3,814,226	320,567	--	--	--
2009[a]	9,684,965	1,179,569	--	--	--	--

[a] Incomplete brood year.
[b] estimates refined based on PIT tag survival to McNary Dam

Table 9. Release-to-smolt survival rates for Lake Wenatchee hatchery sockeye.

Brood year	Releas e year	Run year	Number of fish released	Fork length (mm) at release (SD)	Date of release	Number of fish captured	Estimated number of smolts	Release to smolt survival
1995	1996	1997	150,808	106 (6)	25 Oct	130	28,828	19.1%
1996	1997	1998	284,630	107 (7)	22 Oct	279	55,985	19.8%
1997	1998	1999	197,195	122 (7)	09 Nov	586	112,524	57.1%
1998	1999	2000	121,344	112 (8)	29 Oct	66	24,684	20.3%
1999	2000	2001	84,466	94 (9)	28 Aug	319	30,326	35.9%
1999	2000	2001	83,489	134 (15)	01 Nov	548	63,720	76.3%
2000	2001	2002	92,055	123 (8)	27 Aug	142	30,918	33.6%
2000	2001	2002	98,119	146 (12)	27 Sept	416	90,593	92.3%
2001	2002	2003	96,486	118 (9)	28 Aug	162	36,484	37.8%
2001	2002	2003	104,452	135 (9)	23 Sept	465	103,838	99.4%
2002	2003	2004	98,509	73 (5)	16 Jun	31	5,192	4.4%
2002	2003	2004	104,855	118 (9)	25 Aug	376	98,412	85.9%
2002	2003	2004	112,419	145 (14)	22 Oct	292	112,419	100.0%
2003	2004	2005	32,755	79 (4)	15 Jun	0	0	0.0%
2003	2004	2005	104,879	118 (7)	25 Aug	229	19,574	18.7%
2003	2004	2005	102,825	158 (13)	03 Nov	1,185	102,825	100.0%
2004	2005	2006	81,428	116 (7)	29 Aug	1,500	159,500	92.2%
2004	2005	2006	91,495	151 (7)	02 Nov			
2005	2006	2007	140,542	149 (14)	30 Oct	516	140,542	100.0%
2006[a]	2007	2008	225,670	138 (15)	31 Oct	1,367	121,843	54.0%
2007[a]	2008	2009	252,133	137 (7)	29 Oct	263	119,908	47.6%
2008[a]	2009	2010	154,772	138 (13)	28 Oct	1,909	126,326	81.3%
2009	2010	2011	227,743	145 (13)	27 Oct	3,017	159,089	69.9%

[a] Estimates were refined based on the relative PIT tag survival rates to McNary Dam

Lower Wenatchee River Smolt Trap

The Lower Wenatchee River smolt traps were located at the West Monitor Bridge (rkm 9.6). Due to reconstruction of the bridge and changes in permitting policy at the Chelan County Planning Department the traps were not installed in 2011. CCPUD and WDFW are currently in planning and permitting phases for a new Lower Wenatchee River smolt trap site at approximately (rkm 13). The current projection for operation at this site is the spring of 2012.

Discussion

Chiwawa River Smolt Trap

When trapping ended for the season, daily number of subyearling Chinook captured ranged from 29 to 105 fish per day. Therefore, because trapping ended during the migration period, the 2010 brood estimate should be considered a conservative estimate. The number of fry captured at the Chiwawa trap has steadily increased over the years as the number of redds has increased. Due to limitations in tagging technology, abundance estimates for fry are currently unknown. Furthermore, it is unclear as to the fate of spring Chinook fry. Spring Chinook fry may be responding to density dependent factors in the Chiwawa Basin and are forced to emigrate as fry. Alternatively fry captured at the trap could be an artifact of the typical downstream dispersal patterns observed in newly emerged fry and the abundance of fry captured is simply a function of the redd distribution and the interaction with the environment, as suggested by the latest analysis. As tagging technology improves it may be possible to tag small subyearling fry and investigate their migration patterns and survival. Currently, the minimum tagging length for 12 mm PIT tags is 60 mm. A survival study concerning small Moapa White River springfish *Crenichthys baileyi moapae* showed no difference in survival between tagged and untagged spring fish using 9 mm PIT tags (Dixon and Mesa 2011). Lengths of tagged fish in that study ranged from 42 mm to 60 mm. A Bismark brown solution will continue to be used to mass mark fish less than 60 mm until further investigations using 9 mm PIT tags in salmonids less than 60 mm have been conducted. Furthermore, fry abundance estimates were calculated using the parr flow-trap efficiency model. Additional mark recapture trials with subyearling fry during the spring migration period may be necessary in order to develop fry specific flow-efficiency models to more accurately estimate fry abundance.

Since the spring of 2008, an instream PIT tag antenna array has been in operation directly upstream from the Chiwawa River smolt trap site providing an opportunity to monitor subyearling Chinook movement patterns during the non-trapping period. All PIT tagged subyearling Chinook released in 2010 were queried at the Lower Chiwawa River antenna array (CHL). Of the 3,447 tags queried, only 8 observations (0.2%) were detected after trapping had ceased. Six of the tags were from mark recapture trials released in August and October upstream of the antenna array. These fish did not migrate during the recapture period and therefore violated one of the mark/recapture assumptions. The remaining two fish were released below the Chiwawa River smolt trap on 18 and 22 November and were detected upstream of the release location at the CHL on 29 November. These results suggest that the vast majority of subyearling Chinook parr (> 60 mm FL) do truly emigrate from the Chiwawa River during the trapping period. During the summer of 2010, 535 subyearling Chinook parr were captured and tagged remotely by WDFW and CCPUD crews in the upper reaches of the Chiwawa River. Of these 535 fish 5 were detected at the CHL array during periods of no trapping, 10 were recaptured at the trap during 2010 and 11 were recaptured at the trap as yearlings in 2011. The addition of an independent sample group such as this one on a yearly basis would have great usefulness with respect to abundance estimates. Not only could different life strategies be analyzed but estimates of migration during periods of no trap operation could be more greatly refined.

Upper Wenatchee River Smolt Trap

Wild and hatchery sockeye were used in five mark/recapture efficiency trials. While significant numbers of sockeye were caught to perform trials at variable discharge levels, a flow stratified linear model was not obtained ($P > 0.05$, $R^2 < 0.50$). A delay in migration and subsequent recapture of the marked fish from Lake Wenatchee negatively affected the relationship between discharge and trap efficiency (i.e., unequal probability of recapture). Therefore, the pooled trap efficiencies of 3.3% for wild sockeye and 2.4% for hatchery sockeye were used to calculate sockeye smolt production estimates of 1,500,730 (± 58,436) and 159,089 (± 28,150), respectively. The pooled trap efficiencies for 2011 were significantly higher than previous years that ranged from 0.5-1.5%. The higher efficiency resulted in lower variance in the estimates compared to previous years. The 2011 smolt trap estimate was also consistent with results from a hydroacoustic and trawl survey conducted in Lake Wenatchee on 21 September 2010 before hatchery fish were released. CRITFC funded Canada DFO to perform a hydroacoustic survey and estimated a total of 1,637,000 juvenile sockeye (Rankin et al. 2011) suggesting that overwinter survival of wild sockeye in Lake Wenatchee was 92% compared to 70% for hatchery fish.

If the appropriate permits are obtained from the USFS, the trap site is scheduled to move approximately 8 km downstream in 2012. The goal of relocating the trap is to eliminate potential bias in trap efficiency estimates associated with releasing marked fish back into the lake. Flow-efficiency models developed at the new site will provide more accurate abundance estimates of sockeye emigrating from Lake Wenatchee.

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Appendix A. Monthly total juvenile capture information for the Chiwawa River smolt trap.

				2011						
Species/Origin	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
Chinook										
Wild yearling	1,007	2,461	1,296	72	7	3	2	0	0	4,848
Wild subyearling	1,114	6,121	1,799	118	3,023	4,464	1,673	1,292	957	20,561
Hatchery yearling	0	557	25,037	7	0	13	5	0	1	25,620
Steelhead										
Wild	25	171	347	225	103	47	207	44	7	1,176
Smolt	3	72	110	10	0	0	0	0	0	195
Parr	22	99	237	215	103	47	207	44	7	981
Hatchery	0	2	8,198	29	0	1	14	6	0	8,250
Coho										
Wild yearling	1	2	0	0	0	0	0	0	0	3
Wild subyearling	2	0	0	1	1	0	0	0	0	4
Hatchery yearling	0	0	0	0	0	0	0	0	0	0
Bull trout										
Juvenile	8	12	17	33	26	15	78	117	45	351
Adult	0	0	0	0	0	2	5	0	0	7
Cutthroat	0	0	0	4	6	9	16	3	0	38
Eastern brook	0	0	0	2	0	0	1	0	0	3
Whitefish	9	25	4	0	23	588	297	35	9	990
Northern pikeminnow	0	0	0	0	0	14	4	1	1	20
Longnose dace	8	7	319	304	162	19	487	204	16	1,526
Sucker spp.	0	0	0	0	0	0	0	0	0	0
Redside shiner	0	0	0	0	0	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0	0	0
Sculpin spp.	10	4	7	4	13	22	46	20	3	129

Appendix B. Monthly total juvenile capture information for the Upper Wenatchee River smolt trap.

2011											
Species/Origin	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Chinook											
Wild yearling	110	166	447	63	0	--	--	--	--	--	786
Wild subyearling	10	41	52	5	1	--	--	--	--	--	109
Hatchery yearling	28	92	107	65	0	--	--	--	--	--	292
Steelhead											
Wild	25	59	37	14	0	--	--	--	--	--	135
Smolt	0	1	6	1	0	--	--	--	--	--	8
Parr	25	58	31	13	0	--	--	--	--	--	127
Hatchery	0	29	336	11	0	--	--	--	--	--	376
Sockeye											
Wild	0	23,858	24,230	40	0	--	--	--	--	--	48,128
Hatchery	0	462	2,546	9	0	--	--	--	--	--	3,017
Coho											
Wild yearling	2	1	6	0	0	--	--	--	--	--	9
Wild subyearling	0	0	0	0	0	--	--	--	--	--	0
Hatchery yearling	2	195	415	76	0	--	--	--	--	--	688
Bull trout											
Juvenile	4	4	5	1	0	--	--	--	--	--	14
Adult	1	0	0	0	0	--	--	--	--	--	1
Cutthroat	0	0	1	1	0	--	--	--	--	--	2
Whitefish	6	51	11	5	1	--	--	--	--	--	74
Northern pikeminnow	0	47	187	44	1	--	--	--	--	--	279
Longnose dace	2	0	4	2	0	--	--	--	--	--	8
Sucker spp.	1	0	4	3	0	--	--	--	--	--	9
Redside shiner	0	7	35	7	0	--	--	--	--	--	49
Yellow perch	0	0	0	0	0	--	--	--	--	--	0

Appendix C. Yearly total juvenile capture information for the Chiwawa River smolt trap.

Species origin	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Chinook													
Wild yearling	6,482	3,765	8,711	4,433	4,974	2,874	4,326	8,012	1,423	2,763	1,791	3,917	3,460
Wild subyearling	13,344	30,641	12,741	16,286	14,584	10,933	5,257	25,150	53,818	5,188	1,480	564	3,844
Hatchery yearling	22,481	14,097	22,367	17,634	9,796	3,965	7,557	5,893	2,926	0	6	60	97
Steelhead													
Wild	1,226	1,957	1,700	1,211	1,789	1,672	2,441	1,662	778	1,091	326	253	622
Smolt	210	248	448	152	53	45	280	32	86	63	181	133	160
Parr	1,016	1,709	1,250	1,056	1,736	1,627	2,161	1,630	692	1,028	145	120	462
Hatchery	9,921	2,708	2,684	1,964	1,384	2,104	9,678	5,886	2,720	134	45	78	3
Coho													
Wild yearling	4	0	0	0	3	4	0	0	0	0	0	0	0
Wild subyearling	5	1	13	12	2	0	0	0	0	0	0	0	0
Hatchery yearling	3	3	1	0	126	8	0	0	0	2	0	0	0
Bull Trout *Juvenile*	499	496	513	250	125	175	238	438	339	264	421	234	605
Bull Trout *Adult*	45	24	33	29	39	41	12	6	8	25	19	16	57
Cutthroat	54	66	52	40	56	44	45	28	37	183	22	13	34
Eastern brook	0	8	4	3	4	4	2	6	7	25	10	9	17
Whitefish	778	3,340	2,672	2,186	2,267	3,672	3,669	1,212	871	1,825	837	317	1,565
Northern pikeminnow	5	47	7	15	0	0	13	1	3	14	12	2	54

Appendix C. cont.

Species origin	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Longnose dace	1,393	2,081	2,934	2,349	1,951	3,133	3,162	1,557	604	1,217	1,456	130	1,481
Sucker spp.	0	7	9	1	8	10	5	4	0	6	40	3	11
Redside shiner	0	0	0	0	1	2	1	1	0	0	0	0	0
Yellow perch	0	0	0	0	0	0	0	0	1	14	0	1	4
Sculpin spp.	51	78	143	73	104	23	34	13	58	77	56	24	119

Appendix D. Yearly total juvenile capture information for the Upper Wenatchee River smolt trap.

Species/Origin	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Chinook													
Wild yearling	569	323	194	1,597	138	61	355	257	34	62	49	228	90
Wild subyearling	254	312	71	213	2,012	2,541	139	40	5	118	10	84	0
Hatchery yearling	245	1,074	398	750	10	6	1	0	0	0	0	5	0
Steelhead													
Wild	95	66	28	80	42	36	55	14	2	37	1	9	4
Smolt	43	37	14	15	10	1	1	0	2	4	1	1	3
Parr	52	29	14	65	32	35	54	14	0	33	0	8	1
Hatchery	357	637	61	178	160	354	27	43	41	0	0	0	0
Sockeye													
Wild	60,792	7,314	9,133	38,628	20,309	6,580	37,953	25,165	3,299	848	2,635	9,887	6,926
Hatchery	1,909	2,444	1,367	2,387	1,500	1,416	1,866	668	558	1,581	66	572	268
Coho													
Wild yearling	4	9	6	3	10	2	1	0	0	0	0	0	0
Wild subyearling	15	1	16	0	0	5	0	0	0	0	0	0	0
Hatchery yearling	632	585	120	311	125	340	81	98	27	119	11	10	0
Bull Trout *Juvenile*	4	9	3	5	1	5	0	0	1	3	6	4	1
Bull Trout *Adult*	0	0	0	2	0	3	1	0	0	2	0	0	0
Cutthroat	2	2	2	1	0	1	2	0	0	12	0	0	1
Whitefish	81	78	35	49	3	26	19	6	4	16	4	16	10
Northern pikeminnow	201	234	106	113	46	17	46	23	5	28	26	43	33
Longnose dace	9	42	8	24	2	53	58	0	0	20	3	6	2
Sucker spp.	14	30	3	18	2	28	47	12	0	23	5	25	6
Redside shiner	66	90	21	37	21	47	62	14	0	21	15	23	12
Yellow perch	0	0	0	1	0	0	0	0	0	0	0	0	0
Sculpin spp.	244	188	251	201	35	85	68	34	12	96	46	67	59

Appendix E. Yearly total juvenile capture information for the Lower Wenatchee River smolt trap.

Species/Origin	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Chinook											
Wild yearling	1,079	5,346	612	1,906	652	333	1,061	1,619	336	206	284
Wild subyearling	50,685	37,568	30,547	86,142	63,580	224,858	225,549	110,528	39,714	70,952	72,244
Hatchery yearling	43,613	6,709	19,440	45,467	35,261	23,709	11,846	20,939	3,421	8,758	2,753
Steelhead											
Wild	484	264	319	495	151	246	360	413	252	341	468
Smolt	407	216	220	433	105	210	299	343	187	273	426
Parr	77	48	99	62	45	36	61	70	76	68	42
Hatchery	2,735	1,949	2,106	2,697	3,769	2,013	3,465	2,175	2,260	1,711	2,219
Sockeye											
Wild	3,153	1,259	216	6,340	5,204	202	3,224	7,544	5,042	58	1,114
Hatchery		263	207	248	68	79	335	271	281	131	12
Coho											
Wild yearling	188	114	111	292	103	189	58	199	72	0	0
Wild subyearling	2,112	515	1,013	431	1,460	1,846	927	29	1,443	191	0
Hatchery yearling	8,013	9,709	4,296	29,305	13,627	11,943	15,455	8,034	12,363	11,265	12,305
Bull Trout *Juvenile*	2	0	1	2	1	3	2	0	1	1	4
Bull Trout *Adult*	0	0	0	0	0	0	0	0	0	0	0
Cutthroat	0	1	1	0	0	0	0	0	0	2	0
Whitefish	48	52	67	23	118	9	34	115	31	78	73
Northern pikeminnow	198	13	57	135	475	90	75	21	93	10	9
Longnose dace	643	383	568	1,820	801	659	2,374	488	593	445	319
Speckled dace	0	0	1	0	0	0	5	4	3	7	17
Umatilla dace	0	0	2	0	0	0	2	1	12	36	17
Sucker spp.	390	63	612	339	3,420	203	208	172	169	201	121
Peamouth	62	1	2	1	0	0	0	0	0	0	11

Appendix E. cont.

Species/Origin	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Chiselmouth	1	0	0	1	32	0	7	2	7	1	6
Redside shiner	570	18	69	84	952	166	100	14	47	47	8
Yellow bullhead	1	0	0	0	0	0	0	0	0	0	1
Pacific lamprey	680	1,245	1,431	2,876	1,933	685	650	922	978	1,267	1,393
River lamprey	0	0	0	0	0	0	0	1	0	18	20
Sculpin spp.	70	123	49	64	118	171	86	71	97	55	76
Stickleback (3 spined)	4	7	4	39	78	51	85	18	48	246	0

Appendix C

Summary of PIT Tagging Activities in the Wenatchee Basin, 2011

Appendix C. Numbers of fish captured, PIT tagged, lost, and released in the Wenatchee Basin during February through November, 2011.

Sampling Location	Species and Life Stage	Number held	Number of recaptures	Number tagged	Number died	Shed Tags	Total released	Percent mortality
Chiwawa Trap	Wild Subyearling Chinook	6,640	466	6,043	12	1	6,030	0.18
	Wild Yearling Chinook	4,582	193	4,326	7	1	4,318	0.15
	Wild Steelhead/Rainbow	1,048	3	1,016	4	0	1,012	0.38
	Hatchery Steelhead/Rainbow	1	0	1	0	0	1	0.00
	Wild Coho	0	0	0	0	0	0	0.00
	Total	**12,271**	**662**	**11,386**	**23**	**2**	**11,361**	**0.19**
Upper Wenatchee Trap	Wild Subyearling Chinook	1	0	1	0	0	1	0.00
	Wild Yearling Chinook	755	11	717	3	0	714	0.40
	Wild Steelhead/Rainbow	93	5	82	0	0	82	0.00
	Hatchery Steelhead/Rainbow	14	14	0	0	0	0	0.00
	Wild Coho	5	2	1	0	0	1	0.00
	Wild Sockeye	6	0	0	0	0	0	0.00
	Total	**874**	**32**	**801**	**3**	**0**	**798**	**0.34**
Total:	**Wild Subyearling Chinook**	**6,641**	**466**	**6,044**	**12**	**1**	**6,031**	**0.18**
	Wild Yearling Chinook	**5,337**	**204**	**5,043**	**10**	**1**	**5,032**	**0.19**
	Wild Steelhead/Rainbow	**1,141**	**8**	**1,098**	**4**	**0**	**1,094**	**0.35**
	Hatchery Steelhead/Rainbow	**15**	**14**	**1**	**0**	**0**	**1**	**0.00**
	Wild Coho	**5**	**2**	**1**	**0**	**0**	**1**	**0.00**
	Wild Sockeye	**6**	**0**	**0**	**0**	**0**	**0**	**0.0**
Grand Total:		**13,145**	**694**	**12,187**	**26**	**2**	**12,159**	

Appendix D

Wenatchee Steelhead Spawning Ground Surveys, 2011

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13 December 2011

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From: Andrew Murdoch and Chad Herring

Subject: 2011 Wenatchee River Basin Steelhead Spawning Ground Surveys

Summer steelhead migrate to their spawning grounds as early as nine months prior to spawning. Run escapement estimates of summer steelhead counted at Columbia River dams or at Tumwater Dam in the Wenatchee River may not accurately reflect the size of the spawning population because of fallback and prespawn mortality that may occur prior to spawning. English et al. (2003) reported fallback rates for Rock Island (4.9%) and Rocky Reach (6.5%) dams were similar, but no information regarding Tumwater Dam was reported. In the same study, survival to spawning was not explicitly calculated, but kelting rates for the Wenatchee River ranged between 68% and 77% and may serve as a minimum survival rate. Keefer et al. (2008) conducted a more comprehensive study throughout the Columbia Basin and reported mortality rates of summer steelhead that overwintered in the Columbia River or tributaries was 14.5% and 18.9%, respectively.

Redd counts may be used to calculate a more accurate estimate of the spawning population, but requires knowledge concerning the number of redds constructed per female and the number of fish per redd. Female steelhead have been reported to construct multiple redds, ranging between 1.02 and 6.91 redds (Reingold 1965; Gallagher and Gallagher 2005; Kuligowski et al. 2005). Large variation in the reported number of redds per female within and across populations may be natural or more simply a lack of precision in the methodology used (e.g., errors in redd counts or the number of female spawners). While the sex ratio may be an appropriate surrogate for the number of fish per redd under the assumption females construct a single redd. However, if female steelhead construct multiple redds, it is also likely male steelhead spawn at multiple redd locations with either the same or different females resulting in an overestimate of the spawning population. An estimate of the spawning population coupled with other population specific information (i.e., ratio of hatchery and wild spawners and age composition) are critical data needed to assess the productivity of the population (i.e., recruits per spawner).

Our objectives in conducting steelhead spawning ground surveys were to 1) determine spawn timing of naturally spawning steelhead (both hatchery and wild origin) and 2) estimate the abundance of redds constructed within selected tributaries and 3) calculate error rates in redd detection and determine what factors (e.g., environmental or habitat variables) affect observer efficiency. We also examined the relationship between run escapement upstream of Tumwater Dam (i.e., female and total) and redd counts as a method of assessing the precision of our estimates.

Methods

Run Escapement

Steelhead migrating upstream of Tumwater Dam were captured, sampled (sex, length, weight, scales), and PIT tagged as part of a separate study. Gender was determined using ultrasonography and secondary sexual characteristics (i.e., kype, coloration, body shape). Origin was determined using hatchery marks (i.e., fin clip, VIE, CWT, or eroded fins) or scale pattern analysis if no marks were identified.

Spawning Ground Surveys

Spawning grounds surveys were primarily concentrated in the upper Wenatchee Basin because all hatchery fish were released upstream of Tumwater Dam. Peshastin Creek was included in our surveys because it was identified as a potential reference stream (i.e., no hatchery releases since 1998) for the Wenatchee Basin. Survey methodology involved surveying non-random index areas, defined as major spawning area(s) for each stream. Index areas in the major spawning streams (i.e. Wenatchee, Nason, Peshastin, Icicle and Chiwawa) were surveyed every third day, with the remaining index areas surveyed as frequently as once a week. Redds were either individually flagged or in the case of large aggregates of localized spawning, mapped and numbered sequentially. All redds were also geo-referenced using handheld global positioning devices. Between 2000 and 2003, the number of index areas has increased as more information became available. Beginning in 2004, survey methodology has remained similar. Hence, direct comparisons of redd counts to years before 2004 may not be appropriate.

Index area spawning ground surveys were conducted by foot or raft on the Wenatchee River and most major tributaries (Appendix A). For each index area, the same surveyor(s) conducted all surveys. However, when the end of spawning within an index area was thought to be nearly complete, a different observer (i.e., naïve) surveyed the index area to determine the number of redds still visible at the end of spawning. At approximately the same time, non-index areas within a reach or stream were also surveyed. The total number of redds in non-index areas was estimated by dividing the number of redds found in non-index areas by the proportion of redds still visible inside the index area. The reach total redd count was calculated by combining the number of redds in the index area and the estimated number of redds in the non-index areas. Murdoch and Peven (2005) provide a more detailed description of the methodology (Appendix F, Task 7-3).

The sex ratio of the entire population upstream of Tumwater Dam was used as the redd expansion factor (i.e., number fish per redd). The sex ratio was calculated using the number of female and male steelhead allowed to pass upstream of Tumwater Dam during trapping and video count operations. Spawning escapement was estimated by multiplying the estimated total number of redds by the number of fish per redd. Linear regression analysis was used to examine the relationship between run escapement estimates, index area redd counts, and total redd counts upstream of Tumwater Dam. Fallback rates at Tumwater Dam were calculated based on the number of PIT tagged steelhead recaptured or tagged at Tumwater Dam that were detected downstream of Tumwater Dam prior to spawning divided by the total number of PIT tagged steelhead.

Observer Efficiency Study

In 2010, a three year study was initiated to estimate redd observer variability generally following the methods described in Thurow and McGrath (2010). A total of five index areas within the Wenatchee River Basin were selected for the observer efficiency study based on several biological, environmental, and habitat related variables that were thought to potentially influence redd detection (Table 1). For each study reach, hereafter referred as the census reach, the same surveyor(s) was used to conduct surveys every three days.

Table 1. Proposed study reaches and relevant data for Wenatchee Basin steelhead

Parameter	Pesh. 1	Icicle 1	Nason 3	Wen. 9	Wen. 10
Elevation (m)	893	1008	1962	1526	1698
Stream Order	5	5	4	6	6
Gradient (%)	2.50	0.14	0.34	0.32	0.10
Stream width (m)	16	33	19	47	48
Survey method	Raft	Raft	Raft	Raft	Raft
Survey effort	1	2	1	2	2
Habitat type	Plane bed	Pool riffle	Pool riffle	Plane bed	Pool riffle
Spawner abundance	Moderate	Moderate	High	High	High
Spawner density (redds/m^2)	Moderate (0.0007)	Moderate (0.0007)	High (0.0014)	Low (0.0001)	Low (0.0004)
Spawner distribution	Uniform	Clumped	Uniform	Uniform	Clumped
Water clarity	Good	Excellent	Good	Good	Excellent
Water source	Glacial/snow	Snow	Snow	Lake/Glacial	Lake
Contrast	Average	Excellent	Good	Good	Average
Channel complexity	Simple	Simple	Complex	Simple	Simple

All census reaches had ten equidistant habitat transects to quantify habitat variables that may affect observer efficiency. Habitat transect data was collected during the first survey of each census reach. At each habitat transect a waypoint was taken using a hand held GPS unit. Measurements at each transect include wetted channel width, stream depth at ¼, ½ and ¾ of the wetted channel width, and proportion of substrate type. In between each habitat transect a count was made of large woody debris, gravel bars, islands and the percentage of substrate with overhead cover. During a census survey all features were georeferenced using a hand-held GPS unit and denoted on aerial photographs. Features were then classified as either redds, old redds constructed by a different species, test or incomplete redds, or hydrologic features that may subsequently be misidentified as a redd. During or after peak spawning for each census reach, multiple independent (naïve) observers conducted surveys and counted all redds observed. Independent observers georeferenced and denoted on aerial photographs all features that were believed to be steelhead redds. ArcGIS and aerial photographs were used to compare features believed to be redds identified by independent surveys to census survey features that were visible during the time the independent survey was conducted. Redds identified by the independent surveyors were then classified as a true redd, a visible redd that was omitted, or a false identification.

Steelhead Redd Life

Because surveys were not conducted past the end of the spawning period, redd life for many redds could not be fully determined (i.e., redds were still visible on the last survey day). Hence, estimates of mean redd life for a specific reach would be biased if only redds with a complete redd life were included. High escapement in 2011 also influenced redd life via redd superimposition. We attempted to address both of these factors by calculating redd life using two different approaches. Standard redd life was defined as the number of days a redd was visible that were not affected by redd superimposition or a freshet. Standard redd life includes those redds that were still visible before the first major freshet of the season. Operational redd life is the number of days a redd is visible throughout the spawning period regardless of cause (i.e.., natural periphyton growth, redd superimposition or freshet).

Steelhead Spawning Location and Timing

The spawning distribution and timing of hatchery and naturally produced steelhead was assessed using colored anchor tags (origin specific) inserted at trapping locations (Priest Rapids, Dryden and Tumwater Dams). During spawning ground surveys, observations of tagged females were correlated with redd location and date. Comparisons of spawning location were made by stream (t-test) and by reach (ANOVA) using georeferenced redd locations converted to the distance (km) upstream from the mouth of the tributary. Because spawn timing is influenced by water temperature, an analysis of covariance was used to determine the influence of elevation on spawn timing. In cases where elevation did not significantly influence spawn timing, comparison of spawn date were compared using t-tests.

Results

Run Escapement

The estimated total run escapement to Tumwater Dam was 2,160 steelhead. This includes 101 wild and 103 hatchery steelhead collected as broodstock and 826 hatchery steelhead removed for adult management. The estimated steelhead run escapement upstream of Tumwater Dam was 1,130 fish that includes 11 fish detected on videotape and 1,119 trapped and released upstream. Due to adult management at Tumwater Dam, run escapement in 2011 was 50% lower than in 2010, and was 20% lower than the previous 5-year average of 1,419 fish (Table 1). Without the removal of a large proportion of hatchery origin steelhead, run escapement for 2011 would be 5% lower than the 2010 run escapement but 48% greater than the 5-year average. A greater proportion of female than male steelhead were observed at Tumwater Dam resulting in a fish per redd value of 1.79, assuming each female constructed a single redd. Of those steelhead released upstream of Tumwater Dam 71% (*N* = 807) were determined to be naturally produced.

Spawning Ground Surveys

An average snow pack coupled with cool air temperatures led to below average stream flows for most of the survey season. During the third week of April an increase in air temperature resulted in a temporary increase in stream flow resulting in poor survey conditions for approximately 4 days. After the second week of May, air temperatures increased such that snowmelt resulted in elevated water conditions for the remainder of the spawning period. Overall, survey conditions in 2011 were less than optimal compared to previous years. Poor environmental conditions (i.e., snow, rain, wind and clouds) were more common in 2011 and likely had a negative impact on redd detection rates.

Steelhead began spawning during the third week of March in Icicle Creek and the Wenatchee River and the first week of April in Peshastin Creek. In Nason Creek a small number of redds were documented in the first and second weeks of March with the majority of spawning commencing the first week of April. Spawning activity appeared to begin once the mean daily stream temperature reached ~4.4^{o}C and was observed in water temperatures ranging from 2.6 - 9.0 ^{o}C. Steelhead spawning peaked in Icicle Creek the second week of April. Peak spawning occurred the third week in April and the fourth week in April for the Nason Creek and Peshastin Creek, respectively. While, spawning activity in the mainstem Wenatchee River peaked the first week of May (Appendix B).

The estimated number of redds in the Wenatchee Basin decreased 4% between 2010 (*N* = 969) and 2011 (*N* = 932) and was 89% greater the 5-year average of 494 redds (Appendix C). In 2011, the proportion of redds in Nason Creek (25.2%) was less than the 5-year mean (29.0%; Table 3). Redd distribution in Nason Creek continues to primarily be occurring in the middle two reaches (76%; Appendix D1). Steelhead redds observed in the Chiwawa River were also found in locations consistent with previous years (Appendix D2). The proportion of redds found in all streams upstream of Tumwater Dam decreased from a high of 96% in 2006 to 51% in 2011 (Appendix D3). The number of redds in Peshastin Creek decreased 3% between 2010 and 2011 (Appendix D4). The number of steelhead redds in Icicle Creek, another major spawning tributary downstream of Tumwater Dam, increased in 2011 and was 33% greater than the number of redds observed in 2010. The overall number of redds in the Wenatchee River decreased from 380 in 2010 to 323 in 2011, the proportion of all redds in the Wenatchee River also decreased from 39.2% in 2010 to 34.7% in 2011. However, the proportion of redds found within index and non-index areas upstream of Tumwater Dam in 2011 (93%) was higher than the 9 year average (78%), but within the observed range (Table 4).

Table 2. Total number, gender, and sex ratio of steelhead migrating upstream of Tumwater Dam between 2001 and 2011. Sex ratio in 2001 was determined by the number of fish passed and collected during broodstock collection at Tumwater and Dryden dams. For 2002-2008, gender was determined visually at Tumwater Dam. For 2009 - 2011, gender was determined visually and/or by ultrasound.

Year	Number of steelhead to Tumwater Dam			Male to female ratio	Number of fish per redd
	Total	Female	Male		
2001	820	394	426	1.08	2.08
2002	1,720	641	1,079	1.68	2.68
2003	1,813	1,137	676	0.59	1.59
2004	1,918	869	1,049	1.21	2.21
2005	2,598	1,620	978	0.60	1.60
2006	1,057	505	552	1.09	2.09
2007	657	339	318	0.94	1.94
2008	1,328	473	855	1.81	2.81
2009	1,781	973	808	0.83	1.83
2010	2,270	973	1,297	1.33	2.33
2011	1,130	631	499	0.79	1.79

Table 3. Comparison of the number and distribution of steelhead redds in 2011 and the five year geometric mean (2006-2010).

Stream	2011		Geo. mean (2006-2010)	
	Number of redds	Distribution (%)	Number of redds	Distribution (%)
Nason Creek	235	25.2	112	29.0
Chiwawa River	77	8.3	26	6.7
White River	0	0.0	0	0.0
L. Wenatchee River	2	0.2	0	0.0
Peshastin Creek	115	12.3	46	11.9
Icicle Creek	180	19.3	41	10.6
Wenatchee River	323	34.7	161	41.7
Above Tumwater	150	46.4	114	76.0
Below Tumwater	173	53.6	36	24.0
Total	932	100.0	386	100.0

Table 4. Comparison of the number of redds found within index areas and the estimated number of redds in non-index areas upstream of Tumwater Dam between 2001 and 2011.

Year	Index area	Non-index area	Estimated total	Within index area (%)
2001	118	19	137	86
2002	296	179	475	62
2003	353	88	441	80
2004	277	92	369	75
2005	828	136	964	86
2006	192	34	226	85
2007	105	29	134	78
2008	124	35	159	78
2009	284	107	391	73
2010	546	95	641	85
2011	427	33	460	93

Female and total escapement explained a similar proportion of the variation in the estimated total number of redds (Figure 1). Given the variation in sex ratios and that only female steelhead construct redds, we would expect female escapement to explain a greater proportion of the variation in number of redds. This would suggest that the mean number of redds constructed by a female is relatively constant.

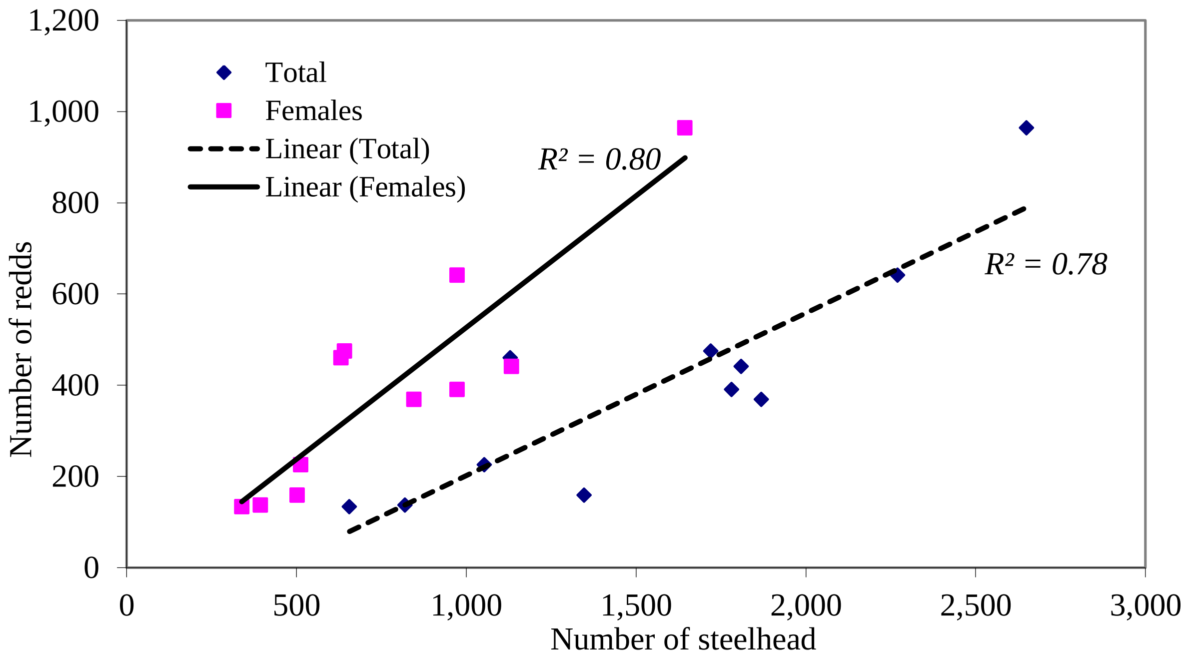

Figure 1. Relationship between steelhead run escapement (total and female) upstream of Tumwater Dam and total redd counts.

However, total run escapement explained a greater proportion of the variation in index redd counts than total redd counts (Figure 2). As run escapement increases, habitat within the index areas may be near capacity and subsequently a greater proportion of redds are found outside index areas.

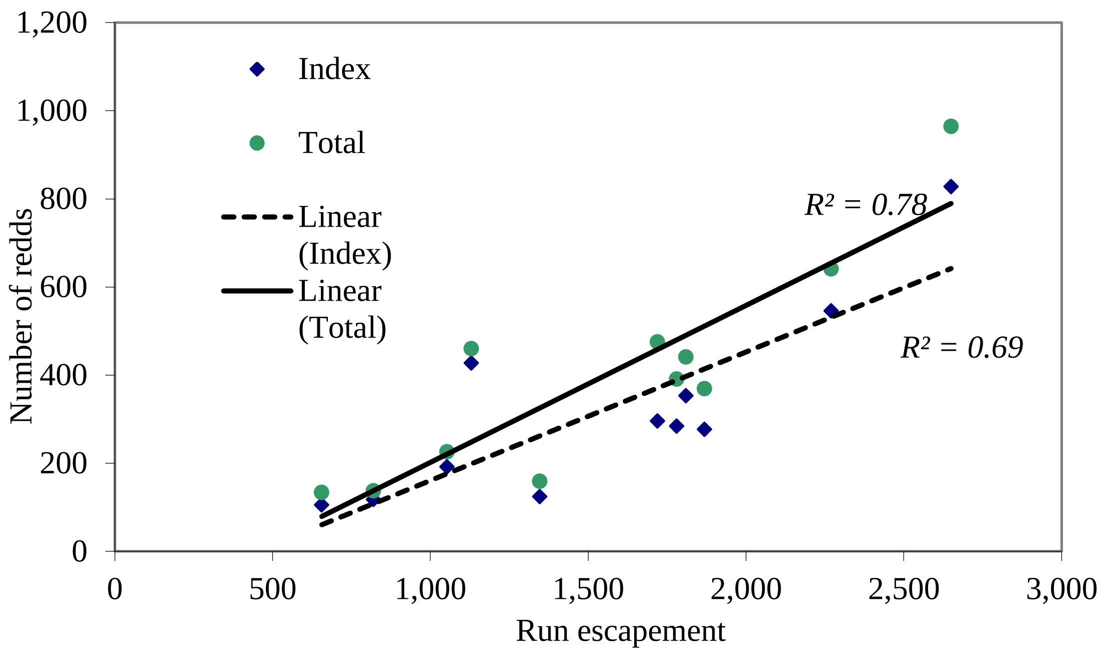

Figure 2. Relationship between steelhead run escapement upstream of Tumwater Dam and total and index area redd counts.

Spawning Escapement

In 2011, 73% of the steelhead migrating above Tumwater Dam were accounted for on spawning grounds compared to the 5-year average (2006-2010) of 45% (Table 5). While environmental conditions do affect the accuracy of our estimates, other factors also contribute to the differences observed between run and spawning escapement estimates that can be estimated or quantified (i.e., prespawn mortality and fallback). Because no estimate of survival to spawning is available for steelhead in the Wenatchee Basin, we assumed that survival to spawning was at a minimum similar to that of steelhead overwintering in lower Columbia River tributaries (i.e., Deschutes and John Day) reported by Keefer et al (2008). Actual survival in the Wenatchee River may be considerably lower than that reported by Keefer et al. (2008) as a result of colder water temperatures and depleted energy reserves attributed to a greater migration distance.

While direct enumeration of steelhead upstream of Tumwater Dam is possible, it may not be appropriate to assume that all steelhead that migrate upstream of Tumwater Dam spawn upstream of Tumwater Dam (i.e., fallback). Using PIT tag recapture data, we were able to calculate a minimum fallback rate of steelhead at Tumwater Dam in 2011. Nearly all the steelhead (99.1%) that migrated past Tumwater Dam was implanted with a PIT tag in the pelvic girdle. PIT tag detection at all Columbia and Snake River hydroelectric projects and some major spawning tributaries downstream of Tumwater Dam (e.g., lower Wenatchee, Icicle, Mission, Chumstick and Peshastin Creek) provided recapture data. Because some steelhead may have spawned in areas downstream of Tumwater Dam with no PIT tag antenna array or simply lost their tag, fallback rates were considered minimum values. Of the PIT tagged steelhead that were passed upstream of Tumwater Dam (N = 1,119), 1.0% (N = 11) were detected prior to spawning downstream of Tumwater Dam. While most fallback steelhead (63%, N = 7) were detected in the lower Wenatchee Basin, a small number of fish were also detected at hydroelectric dams in the Columbia River (N = 4). We used estimates of prespawn mortality and observed fallback rates to adjust run escapement estimates upstream of Tumwater Dam that may better represent the actual size of the spawning population. After adjustment, the proportion of the run escapement accounted for on the spawning grounds increased from 73% to 91% (Table 6).

Table 5. Comparison of run and estimated spawning escapement for steelhead upstream of Tumwater Dam between 2001 and 2011.

Year	Run escapement (A)	Number of redds (B)	Number of fish per redd (C)	Estimated spawning escapement (D = B x C)	Proportion of run escapement (E = D/A)
2001	820	137	2.08	285	0.35
2002	1,720	475	2.68	1,273	0.74
2003	1,813	441	1.59	701	0.39
2004	1,918	369	2.21	815	0.42
2005	2,598	964	1.60	1,542	0.59
2006	1,057	226	2.09	472	0.45
2007	657	134	1.94	260	0.40
2008	1,328	159	2.81	447	0.34
2009	1,781	391	1.83	716	0.40
2010	2,270	641	2.33	1,494	0.66
2011	1,130	460	1.79	823	0.73

Table 6. Comparison of steelhead run escapement estimates at Tumwater Dam to the estimate spawning escapement derived from redd counts after adjusting for fallback and prespawn mortality.

Year	Tumwater Dam count	Adjusted Tumwater Dam counts		Number of redds	Number of fish per redd	Estimated spawning escapement	Proportion of run escapement
		Fallback	Prespawn mortality				
	(A)	(B = A - 3.0%)	(C = B - 18.9%)	(D)	(E)	(F = D x E)	(G = F/C)
2001	820	795	645	137	2.08	285	0.44
2002	1,720	1,668	1,353	475	2.68	1,273	0.94
2003	1,810	1,756	1,424	441	1.60	706	0.50
2004	1,869	1,813	1,470	369	2.21	815	0.55
2005	2,650	2,571	2,085	964	1.61	1,552	0.74
2006	1,053	1,021	828	226	2.05	463	0.56
2007	657	637	517	134	1.94	260	0.50
2008	1,358	1,317	1,068	159	2.81	447	0.42
2009	1,781	1,639[a]	1,329	391	1.83	716	0.54
2010	2,270	2,240[b]	1,817	641	2.33	1,494	0.82
2011	1,130	1,119[c]	908	460	1.79	823	0.91

[a] Adjusted for a fallback rate of 8.0% as determined by PIT tag detections for the 2009 brood.
[b] Adjusted for a fallback rate of 1.3% as determined by PIT tag detections for the 2010 brood.
[c] Adjusted for a fallback rate of 0.9% as determined by PIT tag detections for the 2011 brood.

Steelhead Redd Life

Standard redd life averaged 18 d in the 2011, but exhibited similar high variation within each reach (CV 23 – 37; Table 7). In most reaches, with the exception being W9, operational redd life (mean = 14 d) was shorter than standard redd life ranging between 78 - 103% of the standard redd life. Reach elevation was not significantly correlated with standard redd life (r = 0.07, P = 0.49) or with operational redd life (r = 0.05, P = 0.46). Potential factors that influenced redd life (e.g., environmental and habitat) will be evaluated at a later date.

Table 7. Summary results of steelhead redd life variability in the Wenatchee Basin in 2011.

Reach	Mean	*N*	SD	CV	Range	
					Min	Max
			Standard redd life			
P1	14.0	24	5.2	37.2	7	26
I1	21.6	49	4.9	22.9	14	33
W9	14.5	11	4.5	30.8	7	25
W10	--	--	--	--	--	--
N3	21.6	15	6.8	31.3	7	31
			Operational redd life			
P1	13.7	31	5.2	37.8	3	26
I1	16.8	113	7.2	42.7	4	33
W9	15.0	26	5.8	39.1	3	28
W10	6.9	10	1.4	21.0	6	9
N3	19.6	38	7.2	36.6	5	31

Observer Efficiency Study

Of the five reaches identified before spawning, one reach was not included in the analysis (Wenatchee 10) because of low redd abundance. The overall redd abundance in Wenatchee 10 reach was 66 redds, but only 42 of those redds visible during naïve surveys and was below our minimum sample size goal of 50 redds. There was little variation in the number of redds independent observers found within a census reach (CV range 20 - 38%; Table 8). A good relationship was found between the mean proportion of visible redds correctly identified within a reach with density ($r = 0.84$; $P = 0.15$) or with stream width ($r = 0.68$; $P = 0.32$), but were not statistically significant.

Table 8. Summary results of single pass steelhead redd observer variability surveys in the Wenatchee Basin in 2011.

Census reach	*N*	Redd statistics			Redds		Omission		False ID	
		Mean	CV	Range	%	SD	%	SD	%	SD
P1	10	15	20	11 – 20	40.7	6.6	59.3	6.6	16.0	11.3
N3	10	49	33	30 – 73	74.6	12.4	25.4	12.4	19.8	12.1
I1	10	46	32	22 – 65	51.5	18.8	48.5	18.8	11.3	7.7
W9	8	14	38	7 – 20	25.9	10.2	74.1	10.2	23.2	12.6

Individual surveyor observer efficiencies showed wide variation in correctly identifying steelhead redds with a range of 22.8% to 66.3% and a mean of 48.7% (Table 9). The proportion of features that were incorrectly classified as steelhead redds (i.e., False ID) was also highly variable with a range of 5.4% to 40.9% and a mean of 17.3%. The proportion of redds correctly identified by an independent observer among reaches was similar but less variable (mean = 0.48; CV = 43%) than the variation within a reach (mean = 0.49; CV = 46%).

Table 9. Summary of individual redd observer variability conducted during steelhead spawning ground surveys in the Wenatchee Basin.

Surveyor Aliases	*N*	Redds		Omission		False ID	
		%	SD	%	SD	%	SD
A	3	46.6	19.2	53.4	19.2	11.0	7.0
B	4	52.9	30.8	47.1	30.8	12.1	11.3
C	4	52.9	18.8	47.1	18.8	14.0	2.9
D	1	58.3	-	41.7	-	6.7	-
G	4	38.7	23.0	61.3	23.0	26.2	9.3
H	1	22.8	-	77.2	-	40.9	-
I	4	50.6	30.6	49.4	30.6	29.4	12.4
K	2	66.3	19.4	33.7	19.4	15.3	15.0
M	3	50.6	26.1	49.4	26.1	14.4	8.2
N	2	50.5	43.2	49.5	43.2	18.1	19.4
R	3	55.7	26.5	44.3	26.5	16.1	14.7
S	2	47.6	0.8	52.4	0.8	22.6	5.4
T	2	35.5	7.5	64.5	7.5	14.2	8.2
U	2	52.2	25.5	47.8	25.5	13.2	9.3
V	1	49.3	-	50.7	-	5.4	-
Mean		48.7	22.6	51.3	22.6	17.3	10.3

No relationship was found between the proportion of redds correctly identified and experience conducting salmonid spawning ground surveys (r_s = -0.06), or experience conducting steelhead spawning ground surveys (r_s = 0.06) or experience conducting steelhead spawning ground surveys on a specific reach (r_s = 0.11). The relationships between experience and the proportion of redds falsely identified were slightly better than that of redds correctly identified but none were statistically significant.

Because redd life is shorter than the spawning period, estimates of observer efficiency included only visible redds. Mean total error for redd observer efficiencies for visible redds was 62.3% (CV = 29.4) of all features identified (Figure 3). While net error was only 44.6% (CV = 48.5), but more variable than total error (Figure 4). Total and net error rates based on the total number redds were 35.5% (CV = 42.1) and 25.6% (CV = 58.0), respectively (Figure 6 and 7). While error rates based on the total number of redds were lower than those based only on visible redds, in nearly all cases (89%) redd abundance was underestimated (Figure 8 and 9). Interestingly, no relationship between total error rates (Figure 10) or net error rates (Figure 11) and the number of visible redds was detected.

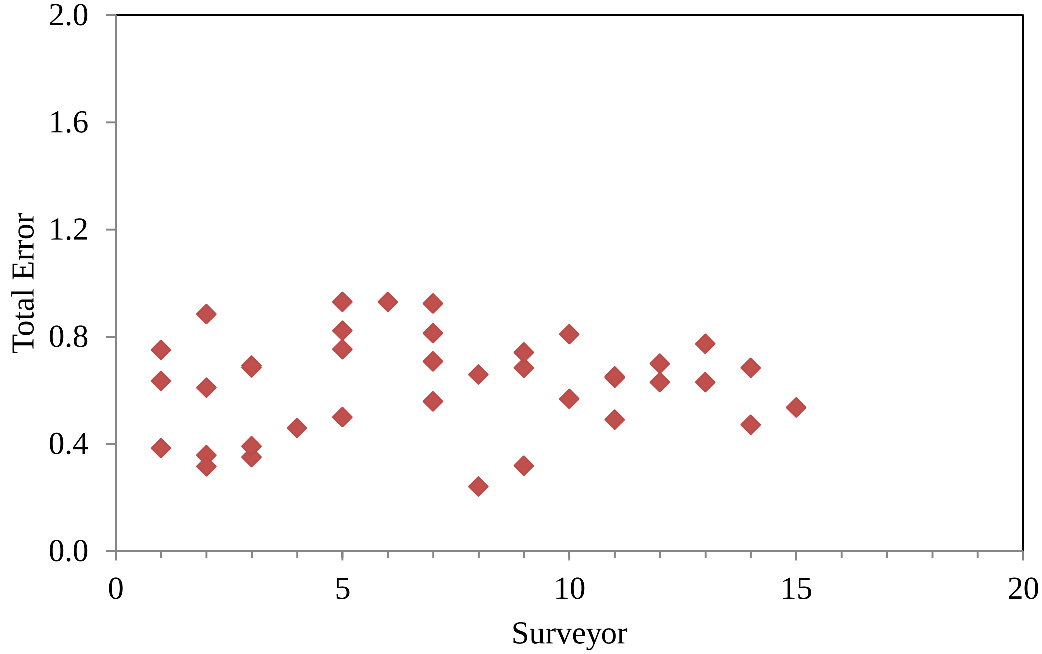

Figure 3. Total error (# of false redds + # of redds omitted/# of visible redds) by surveyor for Wenatchee steelhead spawning ground surveys in 2011.

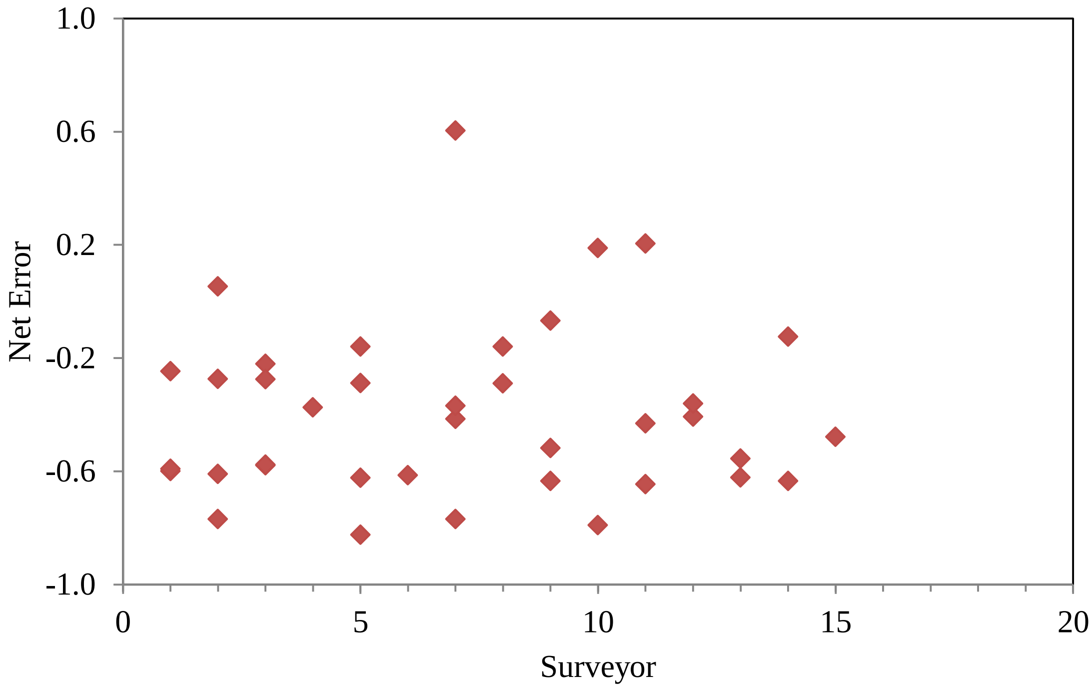

Figure 5. Net error (# of false redds - # of redd omitted/# of visible redds) by surveyor for Wenatchee steelhead spawning ground surveys in 2011.

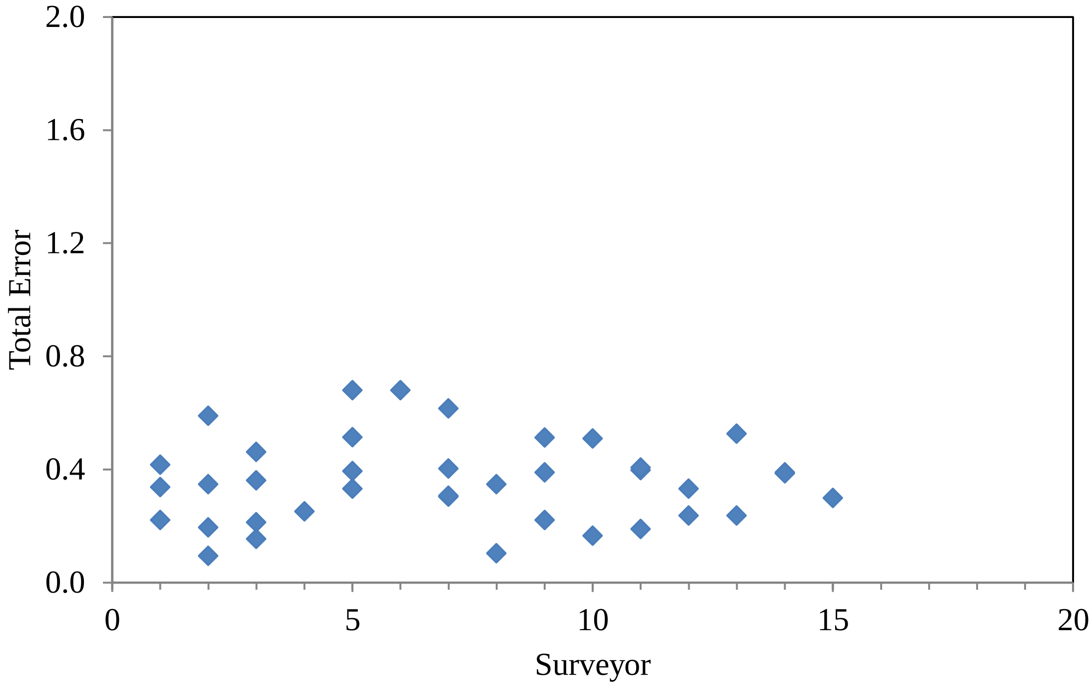

Figure 6. Total error (# of false redds + # of redds omitted/# of total redds) by surveyor for Wenatchee steelhead spawning ground surveys in 2011.

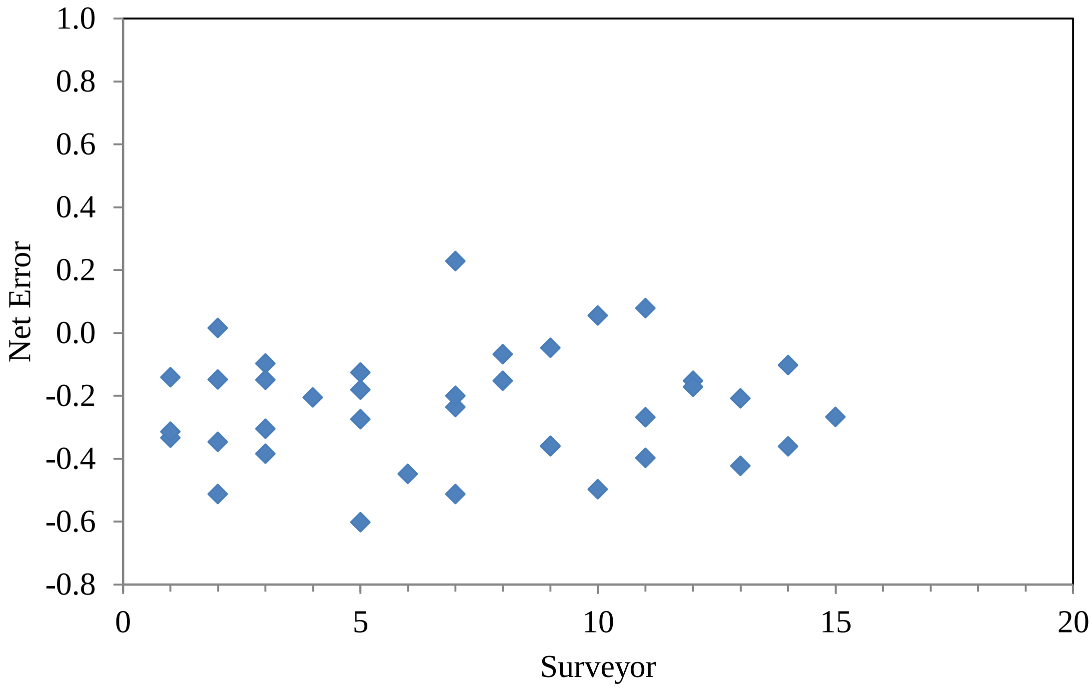

Figure 7. Net error (# of false redds - # of redd omitted/# of total redds) by surveyor for Wenatchee steelhead spawning ground surveys in 2011.

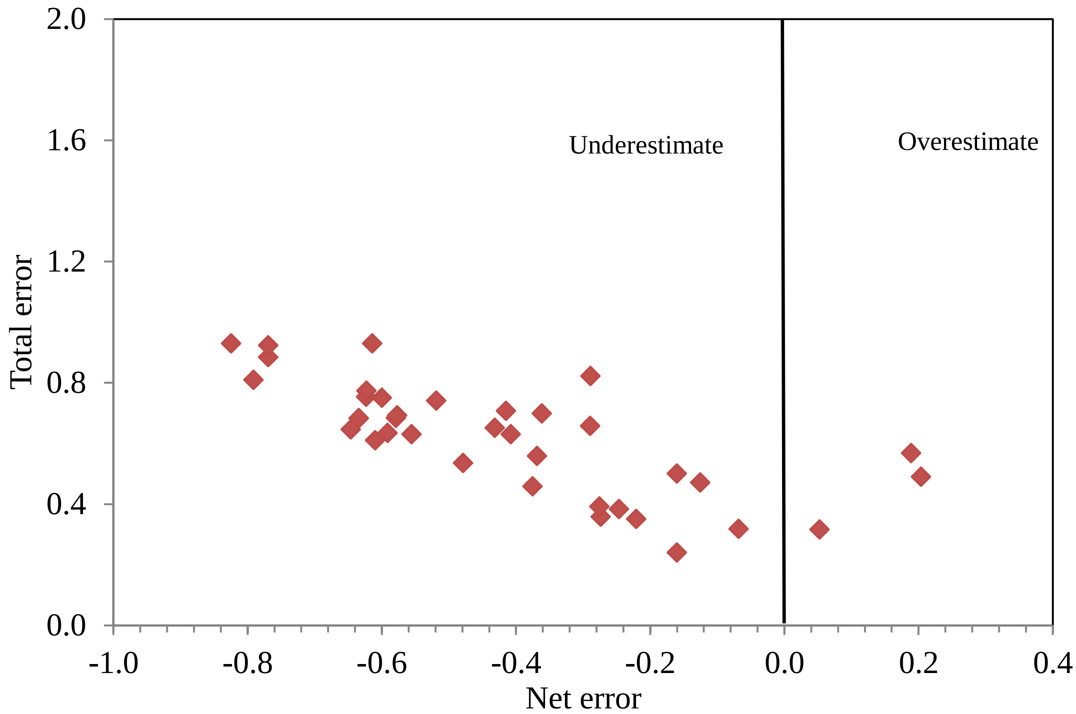

Figure 8. Total error rates compared to net error rates of visible redds for ground based redd counts in census reaches for Wenatchee steelhead in 2011.

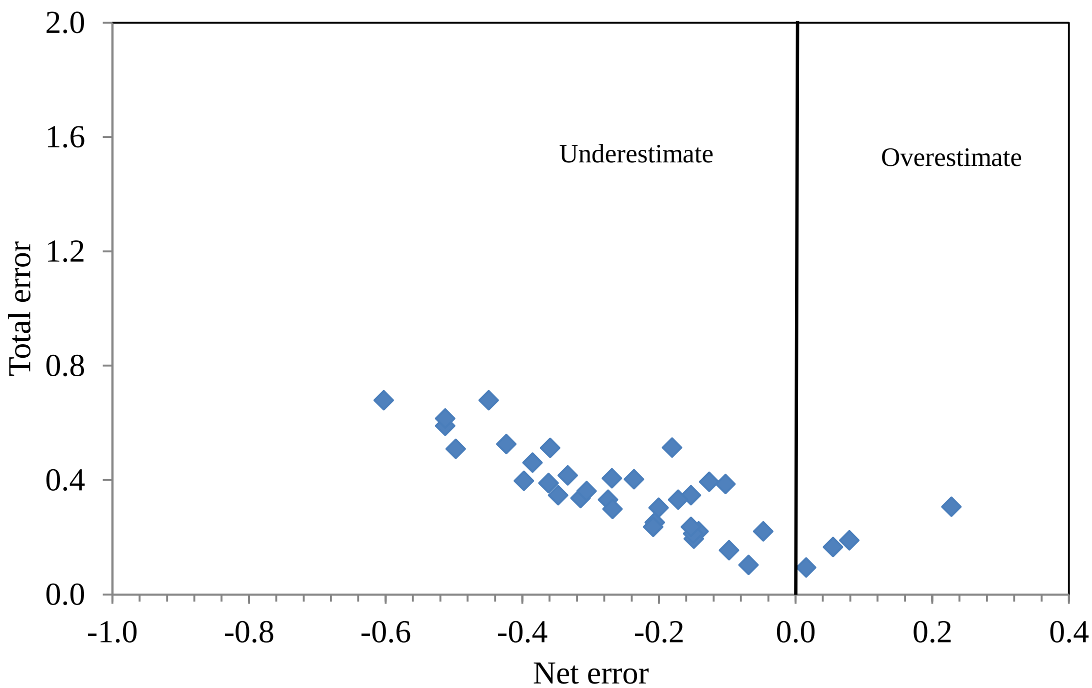

Figure 9. Total error rates compared to net error rates of the total number of redds for ground based redd counts in census reaches for Wenatchee steelhead in 2011.

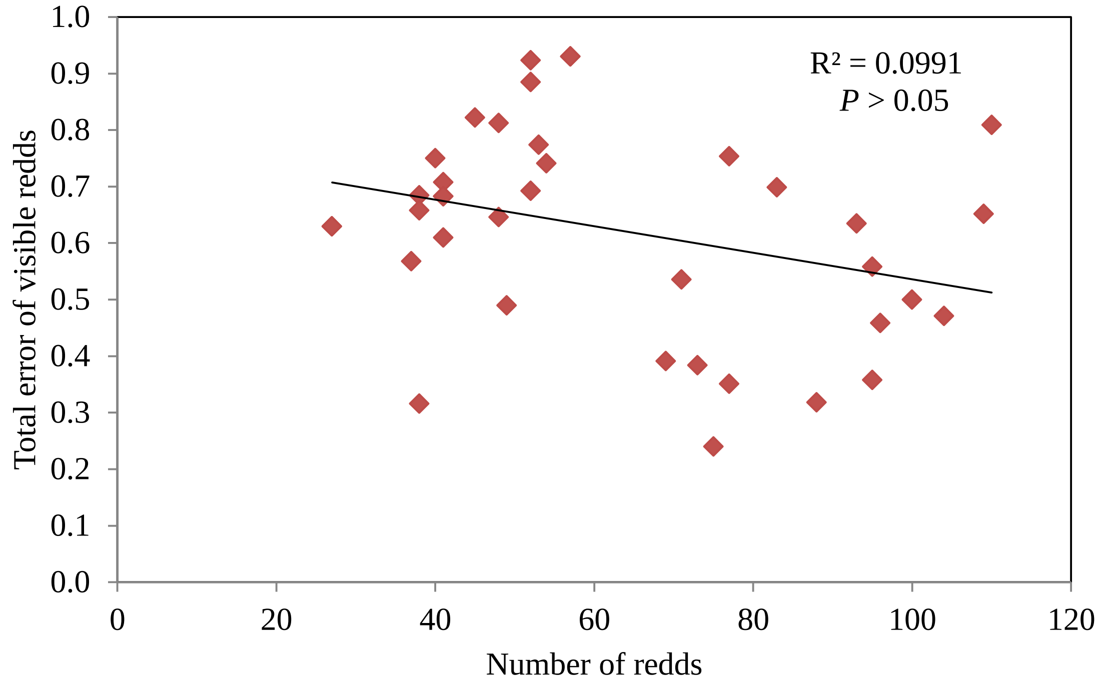

Figure 10. Total error rates compared to the number of visible redds based on ground based redd counts in census reaches for Wenatchee steelhead in 2011.

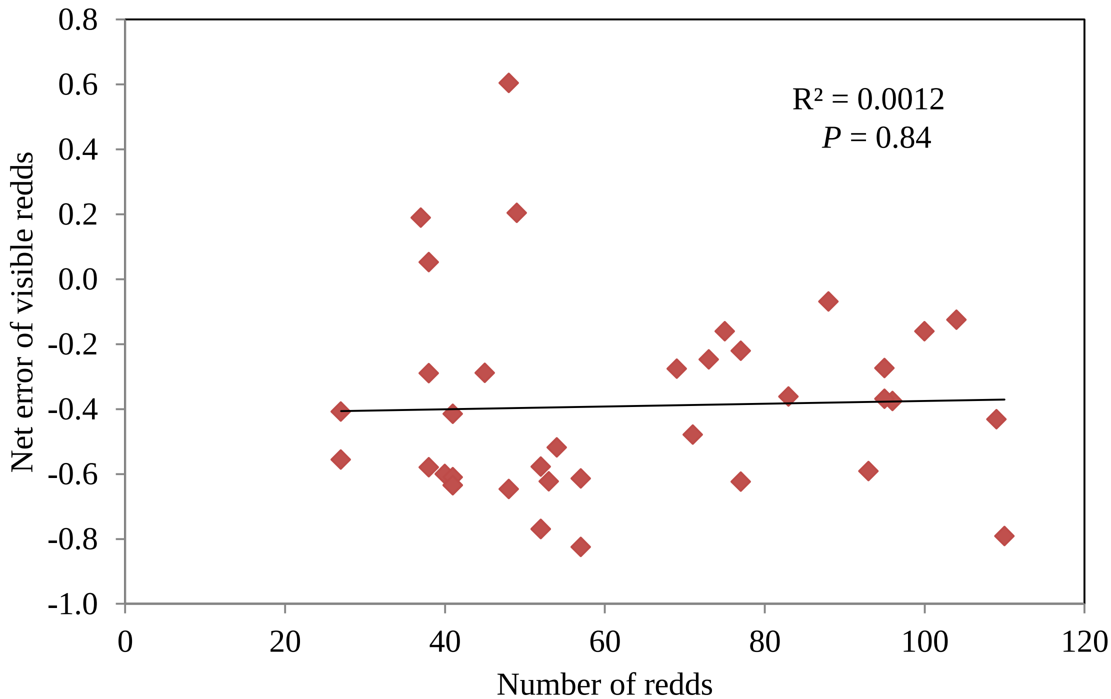

Figure 11. Net error rates compared to the number of visible redds based on ground based redd counts in census reaches for Wenatchee steelhead in 2011.

At the reach scale, mean error rates were highly variable within a reach (Table 9). However, mean error rates for tributaries were more similar than the rate for the Wenatchee River reach. Mean error rates for tributaries were also lower, but more variable than for the Wenatchee River. Discharge was positively correlated with error rates (Figure 12). While redd density was negatively correlated (Figure 13). Error rates for visible redds was also related to the error rates for all redds (Figure 14).

Table 10. Mean redd observer error rates for steelhead census reaches in Wenatchee Basin in 2011.

Reach	Error rates for all redds				Error rates for visible redds			
	Total	CV	Net	CV	Total	CV	Net	CV
I1	0.29	41.32	0.23	54.64	0.55	34.70	0.42	46.64
N3	0.25	38.59	0.12	65.73	0.48	30.54	0.24	72.66
P1	0.36	22.67	0.26	33.13	0.69	9.24	0.50	27.46
W9	0.56	18.18	0.45	17.86	0.81	14.20	0.67	15.97

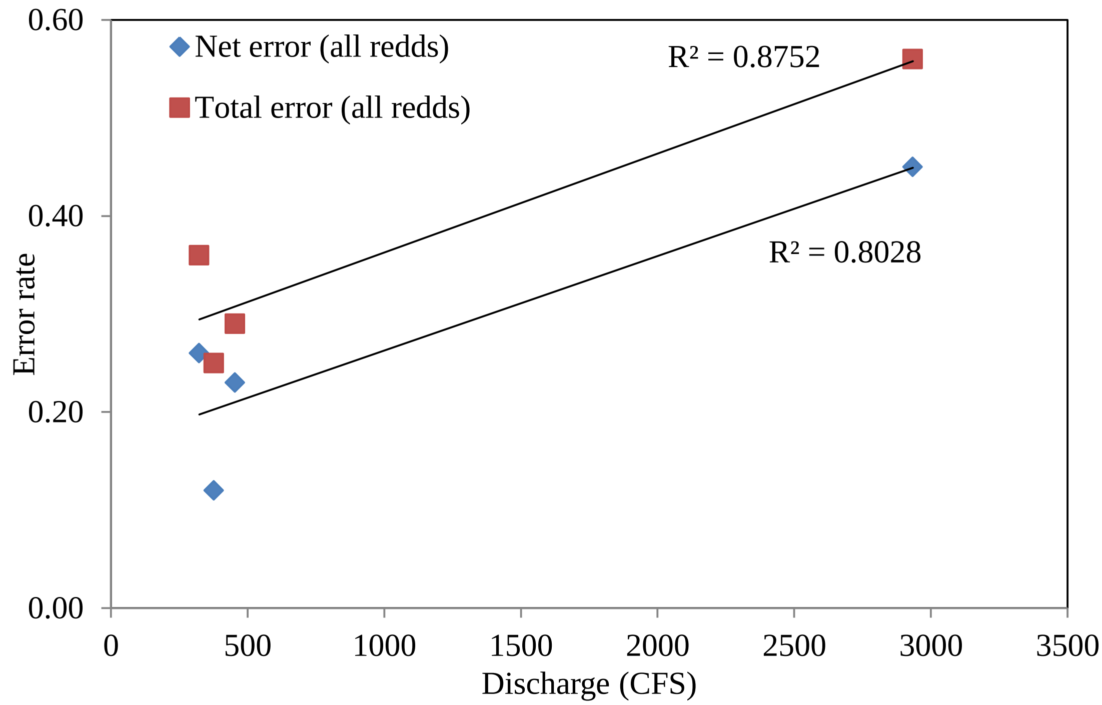

Figure 12. Relationship of mean error rates and discharge for steelhead census reaches in the Wenatchee River Basin in 2011.

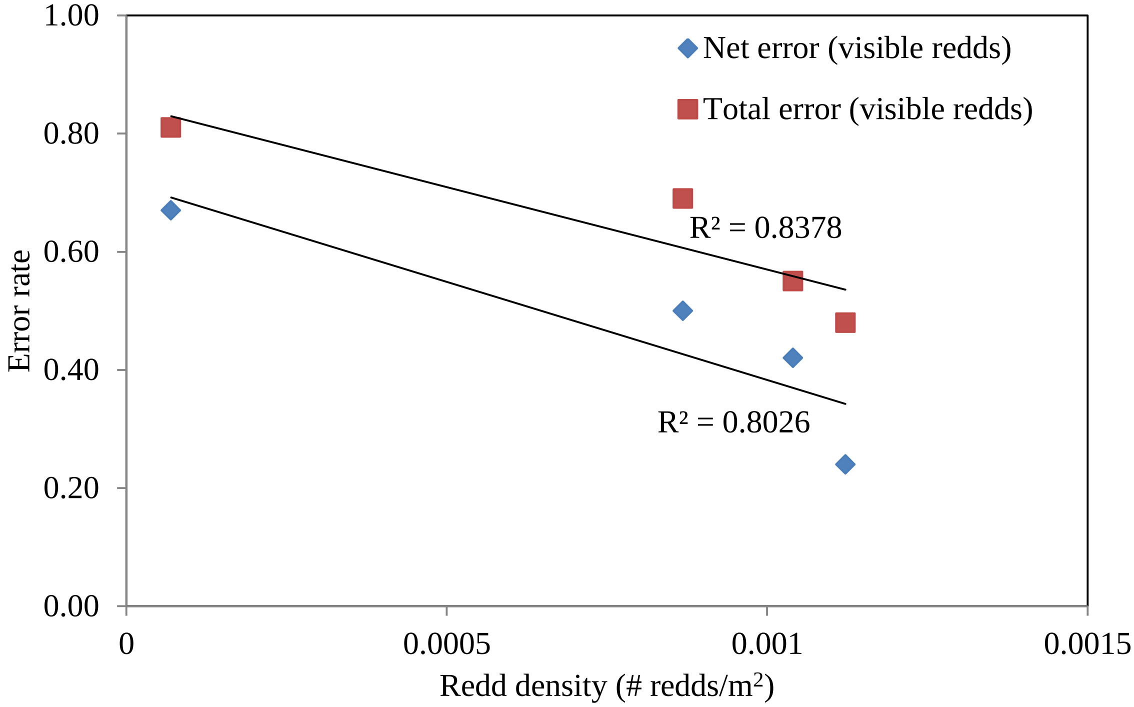

Figure 13. Relationship of mean error rates and redd density for steelhead census reaches in the Wenatchee River Basin in 2011.

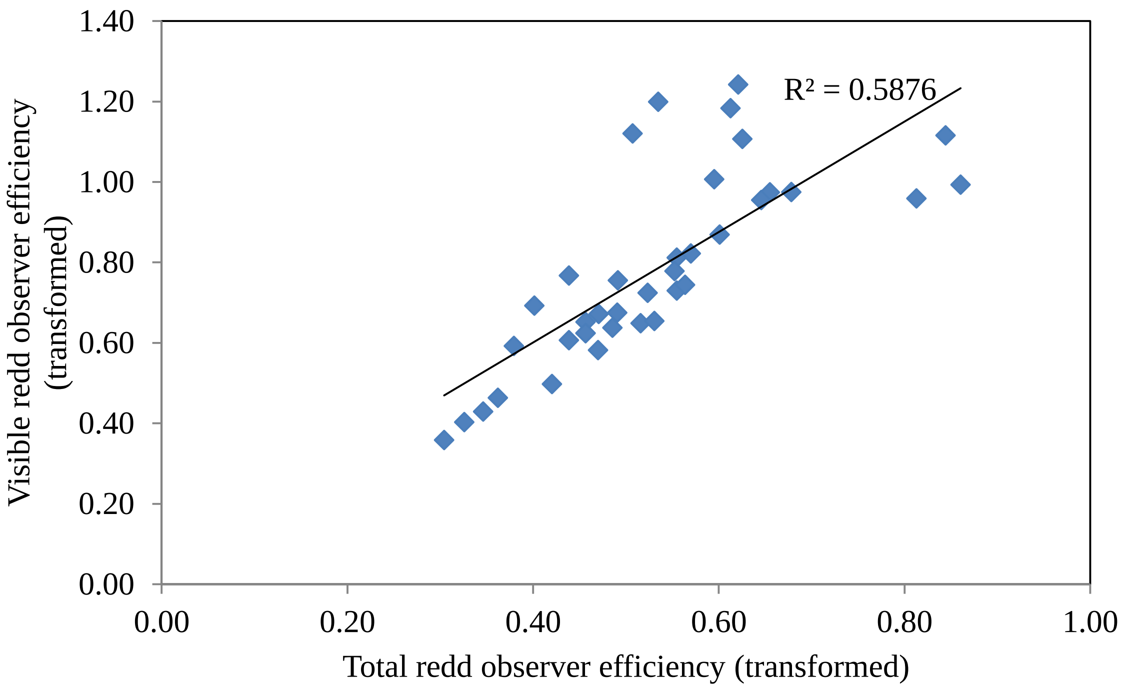

Figure 14. Relationship between visible and total error rates for steelhead census surveys in the Wenatchee River Basin in 2011.

Steelhead Spawning Distribution and Timing

Of the 844 redds identified in 2011, females were observed on 249 (30%). Of those, anchor tags were identified on 98 (39%) females, comprised of 79 wild and 19 hatchery steelhead. The majority of the anchor tag observations were on the upper Wenatchee River (46%) and Nason Creek (51%). Hence, the analysis of hatchery and wild spawning distribution and timing was limited to the specific reaches were the majority of the observations were made.

In the Wenatchee River, steelhead redds were observed throughout the entire river, but exhibited a clumped distribution skewed to the upper reaches (Figure 15). Tagged female steelhead were observed in the upper most reaches (W9 and W10) of the Wenatchee River (rkm 59-87), a section that contained 57% of all redds found in the Wenatchee River (Figure 16). No difference in spawn timing (Mann – Whitney U-test: P = 0.67) and spawning distribution (Mann – Whitney U-test: P = 0.49) between hatchery and naturally produced fish was detected.

The spawning distribution in Nason Creek was more uniform than in the Wenatchee River, but was still heavily skewed to the upper reaches (N2 and N3) of the survey area (Figure 17). No difference in spawn timing (Mann – Whitney U-test: P = 0.38) and spawning distribution (Mann – Whitney U-test: P = 0.09) between hatchery and naturally produced fish was detected.

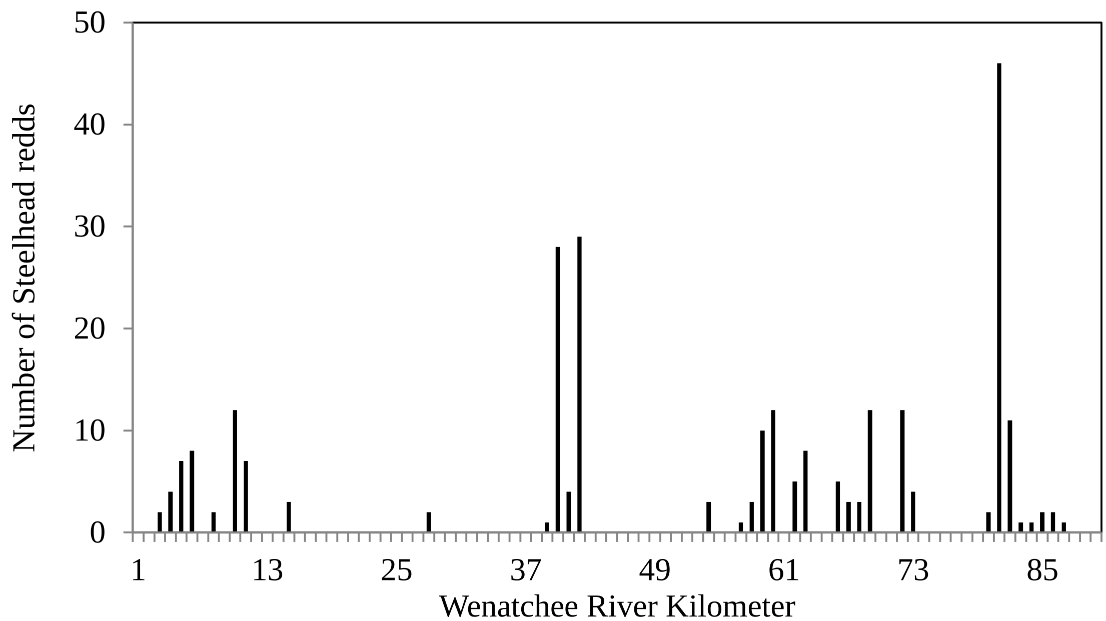

Figure 15. Distribution of steelhead redds in the Wenatchee River in 2011.

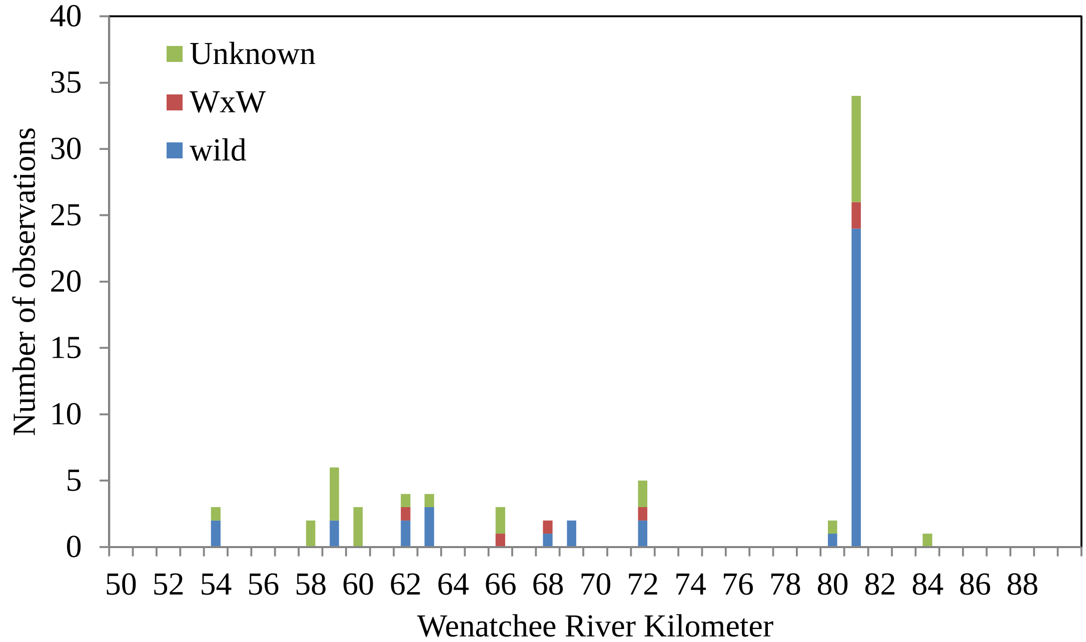

Figure 16. Distribution of anchor tagged female steelhead in the upper Wenatchee River.

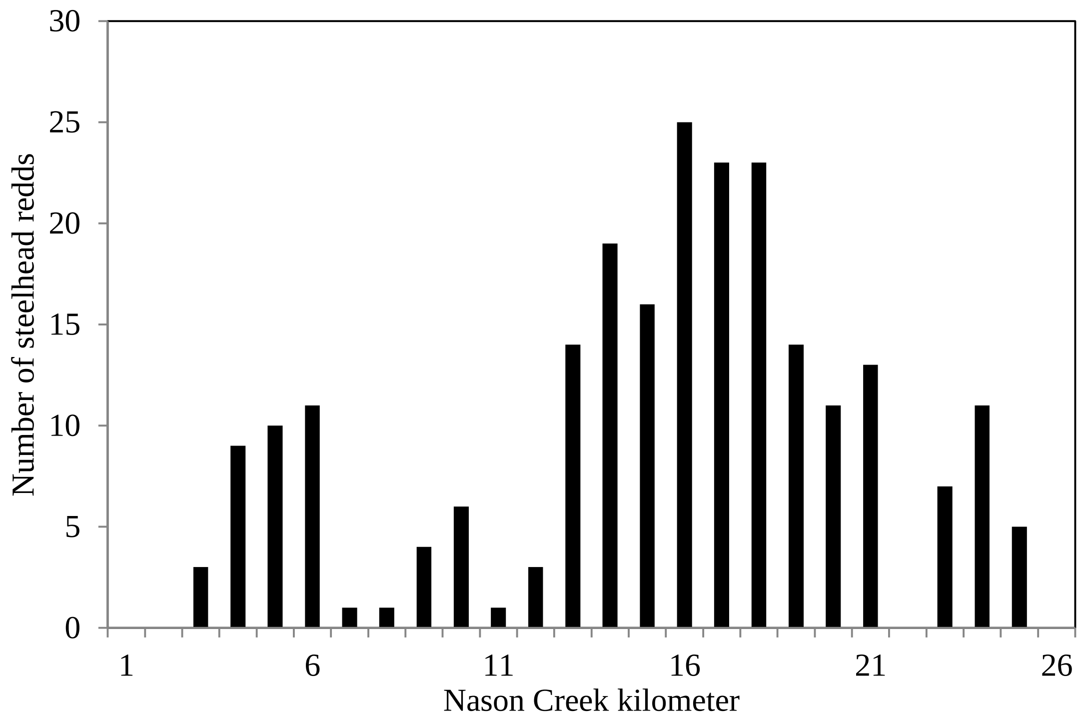

Figure 17. Distribution of steelhead redds in Nason Creek in 2011.

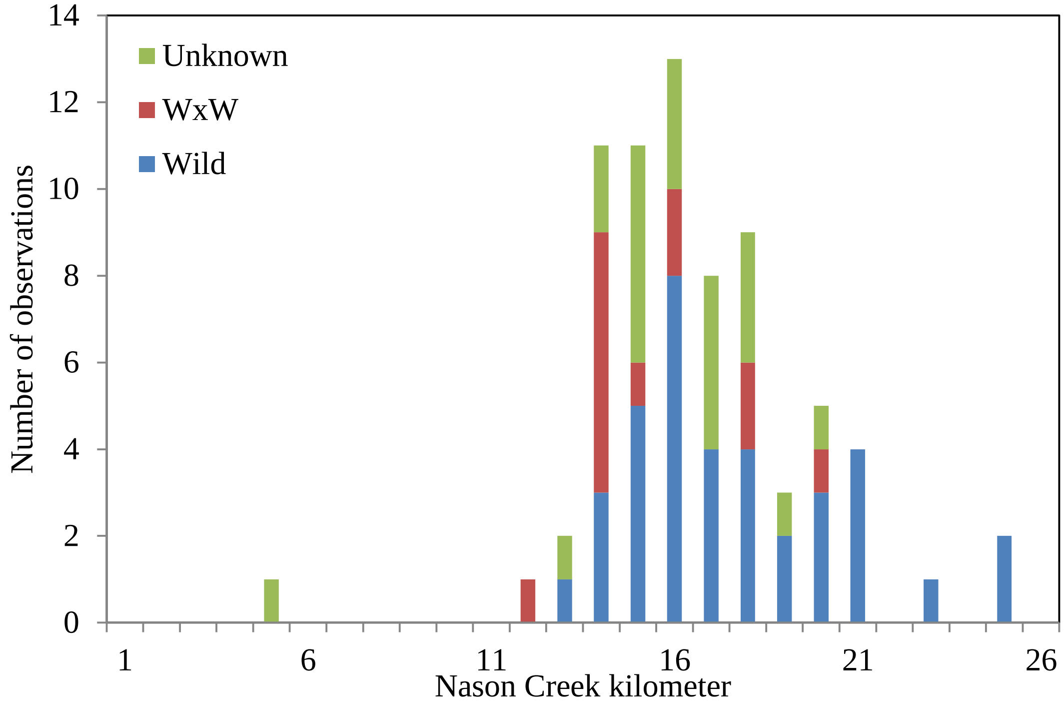

Figure 18. Distribution of anchor tagged female steelhead in Nason Creek in 2011.

Discussion

Beginning with the 2011 run year, an adult management program was initiated for steelhead at Tumwater Dam with an escapement goal of 1,094 steelhead. The first priority will be to maximize the number of natural origin recruits with any shortfalls to be made up with hatchery origin fish with natural origin parents (i.e., WxW matings). As a result of adult management at Tumwater Dam, the proportion of natural origin fish on the spawning grounds increased from a previous three year mean of 31% to 71% in 2011.

Suboptimal survey conditions as a result of above normal river discharge during and following the peak of spawning likely decreased observer efficiency compared to previous years and may have resulted in an underestimate of redd abundance. Despite these factors, the proportion of the run escapement accounted for on the spawning grounds was much greater than expected. We attributed this increase to the increase in survey frequency. In previous years, index areas were surveyed approximately once a week. Female steelhead appear to have a relatively short redd residence time (1-3 d) compared to Chinook salmon (4-16 d). Hence, the probability of detecting a steelhead redd is likely greater when the redd is newly constructed and the female steelhead is still present on the redd. However, redd density was correlated to observer efficiency and may have contributed to a greater proportion of run escapement.

High correlation between the expanded total redd counts and run escapement ($r = 0.89$; $P < 0.01$) suggests that the methodology used to estimate spawner abundance can be very robust. It also suggests that factors responsible for the observed difference in run and estimated spawning escapement are relatively constant with respect to escapement levels across years. Given the large differences between run and spawn escapement upstream of Tumwater Dam, it is evident that multiple factors are contributing to the difference in the escapement estimates.

Tumwater Dam offers a unique opportunity to examine all the possible factors that may influence the size of the spawning population. Furthermore, it is not unreasonable to apply results of studies designed to answer these critical uncertainties to all populations in the upper Columbia River Basin. In the following section, we discuss these factors in more detail.

Estimates of the Number of Redds

The current methodology does not involve conducting weekly surveys of the entire available spawning habitat (e.g., spring Chinook, summer Chinook, and sockeye). Steelhead are thought to have a greater range of spawning habitats than other anadromous species making a total redd census logistically impractical and costly. In the Wenatchee Basin, the Integrated Status and Effectiveness Monitoring Program (ISEMP) has been conducting probabilistic sampling (e.g., GRTS) of those areas not covered under the current methodology. When available, annual estimates of redd abundance outside of the current survey area should provide some indication regarding the extent of steelhead spawning habitat. Beginning in 2011, temporary PIT tag arrays were placed at the upper extent of spawning ground survey reaches in an effort to enumerate spawning activity outside the current survey area. Based on these data spawning escapement estimates will be recalculated at the tributary level at a later date. Within the current survey area, while a majority of the steelhead redds are consistently found within index areas, this may simply be a result of an artifact in the methodology and river reaches surveyed. Furthermore, observer efficiency is potentially a large source of error in conducting redd counts (Dunham et al. 2001; Muhlfeld et al. 2006). Studies were conducted in 2011 to estimate observer efficiency and not only identify, but also quantify sources of error (redd omission or false identification). Other studies are planned (i.e., 2012 and beyond) that are designed to evaluate the accuracy of the current spawning ground protocol.

Spawning Escapement Estimates

Monitoring and evaluation plans require estimates of the spawning population in order to evaluate hatchery program effectiveness (e.g, wild and hatchery abundance and productivity) and determine appropriate escapement levels (i.e., carrying capacity). Steelhead exhibit a diverse life history and complex migration patterns thereby reducing the reliability that run escapement estimates (i.e., dam counts) accurately reflect the size of the spawning population. Steelhead spawning ground surveys are currently conducted in every major steelhead population in the Upper Columbia Basin. However, uncertainty in using these data to estimate the size of the spawning population lies in some factors previously discussed (i.e., observer efficiency and sampling design), but also in the manner in which redd counts are expanded to estimate the population.

The conversion of redd counts to an estimate of the spawning population requires knowledge of the average number of redds constructed per female and the number of fish per redd (Gallagher et al. 2007). In some populations, female steelhead were reported to construct multiple redds. If steelhead in the Wenatchee Basin do construct multiple redds, differences in run and escapement estimates would increase as a result of a lower spawning escapement estimate. For example, if female steelhead construct an average of 1.5 redds, the difference in run and spawning escapement estimates would increase 9%. Redd abundance estimates are used to estimate the female escapement, which are then expanded by the sex ratio to estimate the male population on the spawning grounds. The number of fish per redd is based on the sex ratio of the population. This approach assumes 1) equal survival to spawning and 2) every male spawns on average at one redd location. A tagging study is needed and planned in the next few years to test these assumptions.

Observer Efficiency

The correct identification of steelhead redds in the Wenatchee Basin was higher in the tributaries of the Wenatchee River than the main stem itself. This could be directly related with the attributes of the tributaries versus the main stem Wenatchee River (i.e. redd density, stream depth, width and channel complexity). In addition, other factors that may contribute to observer efficiency include surveyor experience and environmental conditions (i.e. discharge, cloud cover, precipitation and turbidity). Given the wide range of individual observer efficiencies an attempt to quantify surveyor experience and channel complexity should be made. Observer efficiencies rates calculated using this method represent instantaneous observer efficiency rather than the efficiency of weekly or semi-weekly surveys to estimate redd abundance. Methods are being developed to estimate the variance of redd counts and should be finalized in 2012.

Spawning Distribution and Timing

Differences in spawn timing have been observed in Wenatchee summer steelhead broodstock, but fish are held in a controlled environment on well water. Based on the differences observed in the hatchery, it is possible that a considerable portion of hatchery origin steelhead spawn prior to initiation of spawning ground surveys. Spawning ground surveys start in early March with redds typically being found during April suggesting that hatchery steelhead are spawning within the current survey period.

Results from 2011 suggest that hatchery and naturally produced fish do have similar spawning distributions, both spatially and temporally. Although the analysis was restricted to the upper Wenatchee River and Nason Creek, these areas comprise the majority of redds found upstream of Tumwater Dam. Similar studies planned for 2012 will provide an additional year of data.

Recommendations

Of all the factors that are contributing to the difference between run and spawning escapement estimates, redds constructed in streams not included in the survey area have the potential to account for a significant portion of the observed difference. The reported number of redds upstream of Tumwater Dam underestimate the total number of redds because all available spawning habitat (i.e., low order streams) is not surveyed. Studies have been ongoing in the Wenatchee Basin designed to estimate the number of redds in areas not covered under the current survey design. Data from these studies (i.e., ISEMP) must be analyzed and incorporated into spawning escapement estimates.

The accuracy and precision of the current methodology used in estimating the redd abundance and observer efficiency are currently ongoing Studies focused on testing assumptions used in estimating the size of the spawning population (number of redds per female and number of fish per redd) should incorporate an assessment of 1) fallback 2) survival to spawning 3) the spawning distribution of the hatchery and wild steelhead. Information from these studies is required to ensure spawning escapement estimates have sufficient accuracy and precision, such that inferences regarding the efficacy of naturally spawning hatchery steelhead can be made in a timely manner.

Spawning distributions of hatchery and wild steelhead in the Wenatchee Basin can be assessed at the tributary level using PIT tags. All major and minor spawning areas will eventually have instream PIT tag antenna arrays. However, this methodology requires that an adequate and representative sample of adults is tagged every year. Spawning distribution within tributaries at a reach level can also be assessed using instream arrays if desired. However, assessment of spawn timing in the natural environment is problematic and will require a periodic assessment of individuals on the spawning grounds.

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Appendix A. Wenatchee River Basin survey reaches and index/reference areas – surveys conducted weekly from March through June.

Reach	Index/reference area
	Wenatchee River
Sleepy Hollow Br. to Lower Cashmere Br. (W2)	Monitor boat ramp to Cashmere boat ramp
Leavenworth Bridge to Icicle Road Bridge (W6)	Leavenworth boat ramp to Icicle River
Tumwater Dam to Tumwater Bridge (W8)	Swiftwater boat ramp to Tumwater Bridge
Tumwater Bridge to Plain (W9)	Tumwater Bridge to Plain
Plain to Lake Wenatchee (W10)	Chiwawa pump station to Lake Wenatchee
	Peshastin Creek
Mouth to Camas Creek (P1)	Kings Bridge to Camas Creek
Camas Creek to mouth of Scotty Creek (P2A)	Ingalls Creek to Ruby Creek
Camas Creek to mouth of Scotty Creek (P2C)	HWY 97 MP 175 to FR7320
	Ingalls Creek
Mouth to Trailhead rm 1.0 (D1)	Mouth to Trailhead rm 1.0
Trailhead to Wilderness Boundary rm 1.5 (D2)	Trailhead to Wilderness Boundary rm 1.5
	Chiwawa River
Mouth to Grouse Creek (C1)	Mouth to Road 62 Bridge rm 6.4
Grouse Creek to Rock Creek (C2)	Chikamin Creek to Log jam
	Clear Creek
Mouth to HWY 22 (V1)	Mouth to HWY 22
HWY 22 to Lower culvert rm 2.0 (V2)	HWY 22 to Lower culvert
	Nason Creek
Mouth to Kahler Creek Bridge (N1)	Mouth to Swamp Creek
Kahler Cr. Bridge to HWY 2 Bridge (N2)	Round Mtn. RD Bridge to HWY 2 Bridge
HWY 2 Bridge to Lower R.R. Bridge (N3)	HWY 2 Bridge to Lower R.R. Bridge
Lower R.R. Bridge to Whitepine Creek (N4)	Lower R.R. Bridge to Whitepine Creek
	Icicle River
Mouth to Hatchery (I1)	Mouth to Hatchery
	Little Wenatchee River
Mouth to Lost Creek (L2)	Fish Weir to Lost Creek
Lost Creek to Rainy Creek Bridge (L3)	Lost Creek to Rainy Creek Bridge
	White River
Sears Cr. Bridge to Napeequa River (H2)	Riprap bank to Napeequa River
Napeequa River to mouth of Panther Creek (H3)	Napeequa River to Grasshopper Meadows.
	Napeequa River
Mouth to rm 1.0 (Q1)	Mouth to rm 1.0

Appendix B. Summary of steelhead spawning ground index surveys in the Wenatchee River basin in 2011.

Reach	Survey Week of index Area														Index Total	Reach Total	Expanded # of redds
	27 Feb	6 Mar	13 Mar	20 Mar	27 Mar	3 Apr	10 Apr	17 Apr	24 Apr	1 May	8 May	15 May	22 May	29 May			
Wenatchee River																	
W1																6	8
W2			0	2	0	0	2	9	6	2	1				22	39	53
W3																2	3
W4																0	0
W5																0	0
W6		0	0	0	0	2	8	9	7	5	0				31	61	109
W7																0	0
W8		0	0	0		0	0	0	1	2					3	3	3
W9		0	0	0	0	1	11	19	10	21	16				78	78	78
W10		0	0	0	0	4	7	5	20	25	5				66	66	66
Total		0	0	2	0	7	28	42	44	55	22				200	255	320
Peshastin Creek																	
P1		0	0	0	0	1	9	17	21	12	10				70	90	103
P2		0	0	0	0	0	1	0	2	3	2				8	9	10
Total		0	0	0	0	1	10	17	23	15	12				78	99	113
Chiwawa River																	
C1		0	0	0	0	0	5	17	7	12	7				48	48	48
C2							3	4	3	4	1				15	15	15
Total		0	0	0	0	0	8	21	10	16	8				63	63	63

Appendix B. Continued.

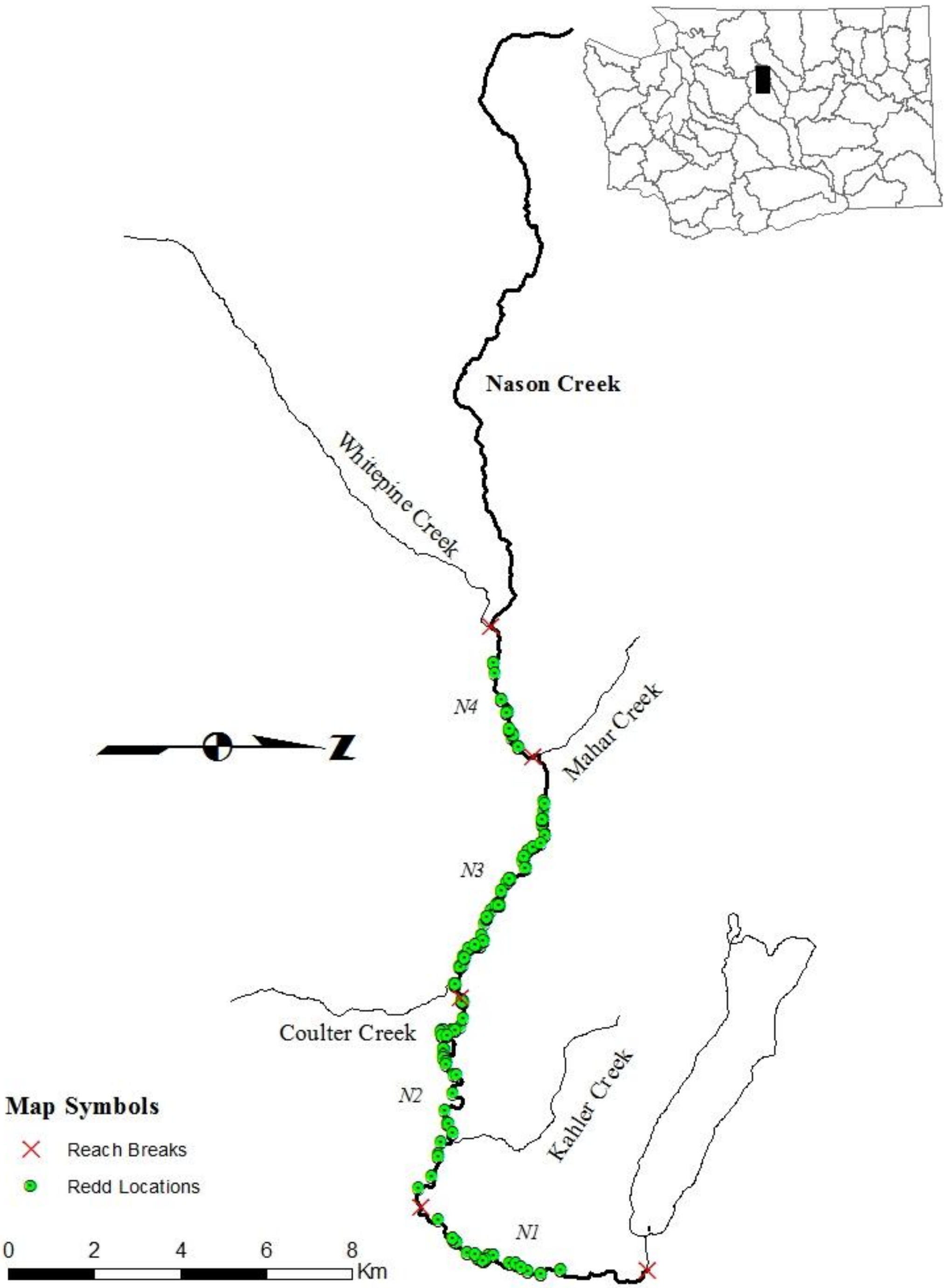
Reach	Survey Week of index Area														Index Total	Reach Total	Expanded # of redds
	27 Feb	6 Mar	13 Mar	20 Mar	27 Mar	3 Apr	10 Apr	17 Apr	24 Apr	1 May	8 May	15 May	22 May	29 May			
								Clear Creek									
V1			0	0	0	0	0	0	0	1	7	3	0		11	11	11
V2																0	0
Total			0	0	0	0	0	0	0	1	7	3	0		11	11	11
								Nason Creek									
N1		0	1	1		0	1	17	7	6					33	33	33
N2		0	1	0	0	0	2	10	4	10	9	0			36	67	71
N3		4	1	0	0	2	13	12	23	30	23	0			108	108	108
N4		0	1	0	0	0	1	10	8	1	2	0			23	23	23
Total		4	4	1	0	2	17	49	42	47	34	0			200	231	235
								Icicle River									
Total		0	0	3	6	20	68	33	11	20	14				175	180	180
								White River									
H2											0	0				0	0
H3																0	0
Total											0	0				0	0
								Little Wenatchee River									
L2											0					0	0
L3											2				2	2	2
Total											2				2	2	2
								Wenatchee River Basin									
Total		4	4	6	6	30	131	162	130	154	99	3	0		729	841	924

Appendix C. Steelhead spawning surveys in the Wenatchee River basin, 2001 – 2011. Redd counts are expanded values derived from sample rates within index areas.

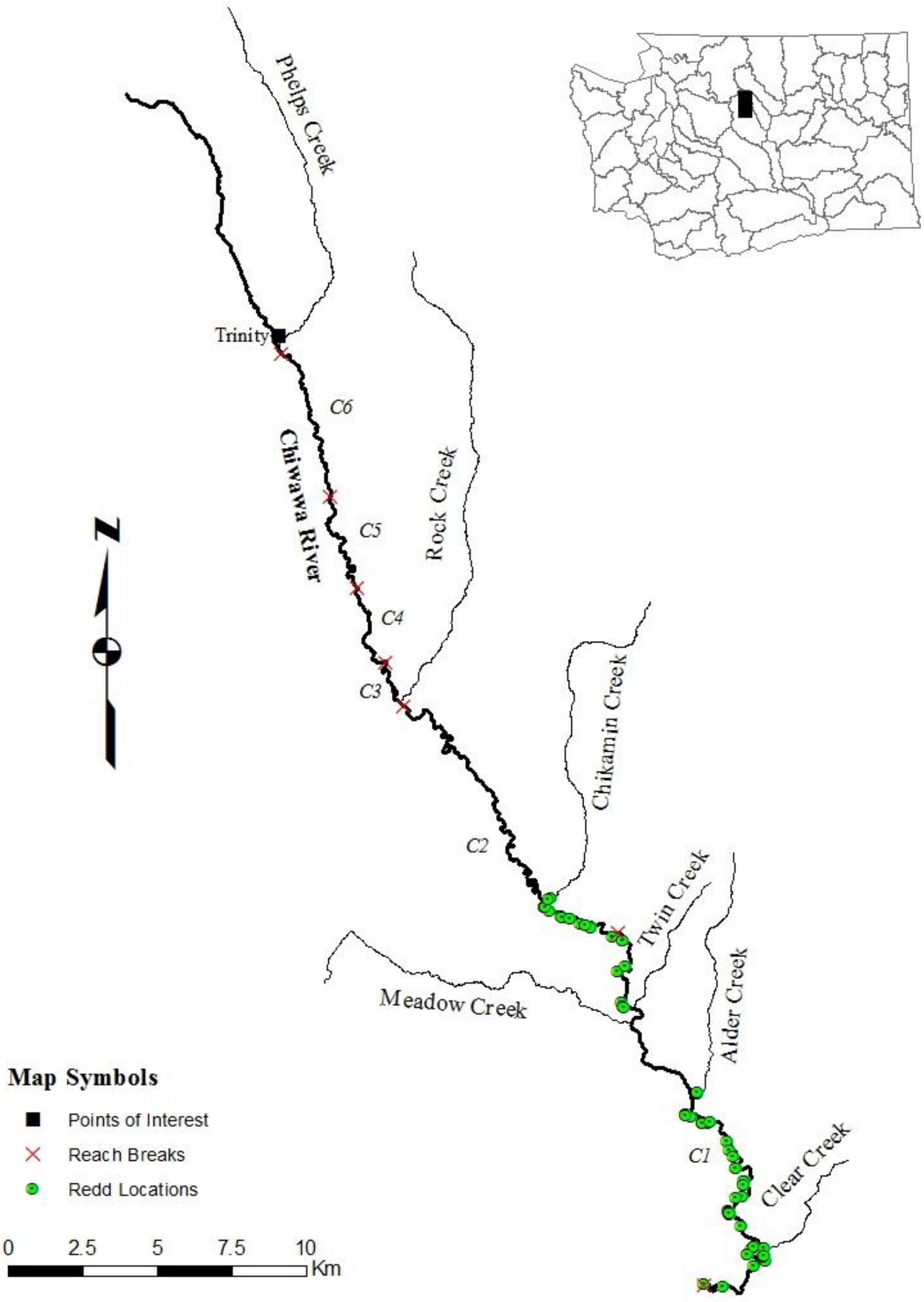
Basin/subbasin	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Chiwawa River Basin											
Chiwawa River	25	27	26	17	118	8	3	9	68	40	63
Rock Creek	--	1	0	0	0	0	--	--	0	0	0
Chikamin creek	--	0	0	1	2	1	0	--	2	11	2
Meadow Creek	--	5	1	5	16	3	0	0	3	3	0
Twin Creek	--	4	0	--	0	--	--	--	--	0	--
Goose Creek	--	0	--	--	--	--	--	--	--	--	--
Alder Creek	--	0	5	2	14	0	0	0	0	8	1
Deep Creek	--	0	--	--	--	--	--	--	--	--	--
Clear Creek	--	43	32	37	12	7	8	2	2	12	11
Subtotal	25	80	64	62	162	19	11	11	75	74	77
Nason Creek Basin											
Nason Creek	27	80	121	124	410	74	78	87	126	269	235
White Pine Creek	--	--	--	0	0	0	0	--	0	1	0
Un-named Creek	--	--	--	3	0	3	0	1	0	0	0
Roaring Creek	--	--	--	--	2	0	0	0	0	0	0
Subtotal	27	80	121	127	412	77	78	88	126	270	235
White River Basin											
White River	--	0	1	0	2	0	1	0	0	3	0
Panther Creek	--	--	0	0	0	0	0	0	0	--	--
Napeequa River	--	0	2	0	0	0	0	1	0	0	--
Subtotal		0	3	0	2	0	1	1	0	3	0
Little Wenatchee River											
Mainstem	--	1	5	0	0	--	0	--	0	4	2
Icicle Creek											
Mainstem	19	27	16	23	8	41	6	37	102	120	180
Peshastin Creek Basin											
Peshastin Creek	--	--	15	32	91	67	17	48	32	115	113
Mill Creek	--	--	--	--	1	0	0	1	0	0	0
Ingalls Creek	--	--	0	0	0	0	--	--	--	--	--
Ruby Creek	--	--	0	0	0	--	--	--	0	0	0
Tronsen Creek	--	--	0	2	5	0	0	0	0	3	2
Scotty Creek	--	--	0	0	0	0	0	0	0	0	0
Shaser Creek	--	--	0	0	0	0	0	0	0	0	0
Schafer Creek	--	--	--	0	0	0	0	0	0	0	0

Subtotal	--	--	15	34	97	67	17	49	32	118	115
				Wenatchee River							
Mainstem	116	315	248	136	456	191	46	100	327	377	320
Beaver Creek	--	0	0	* 15	3	0	0	0	0	2	2
Chiwaukum Creek	--	--	0	--	0	0	--	0	0	1	1
Subtotal	116	315	248	151	459	191	46	100	327	380	323
Wenatchee Basin Total	**187**	**503**	**472**	**397**	**1,140**	**395**	**159**	**286**	**662**	**969**	**932**

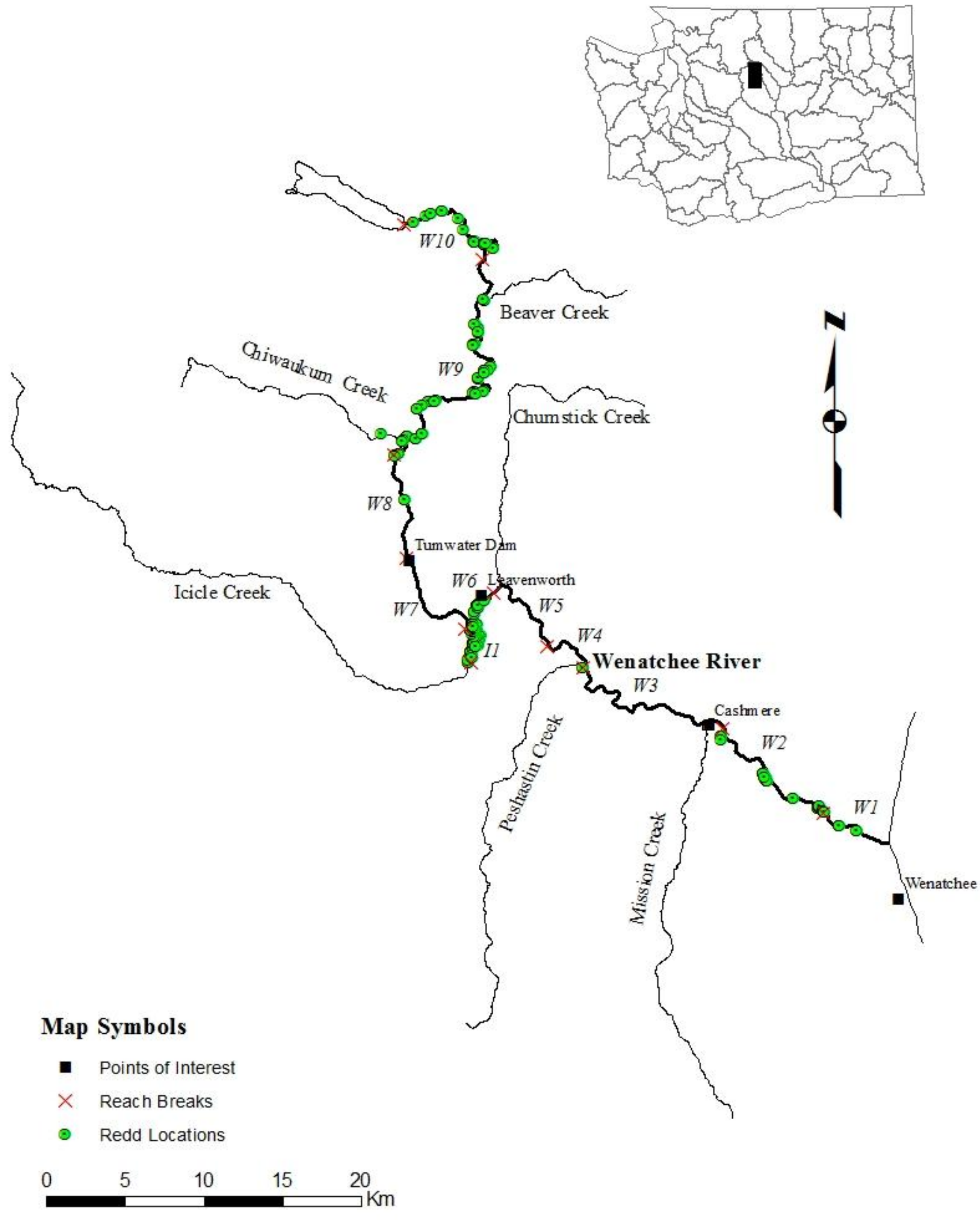
***Redds were enumerated by USFS**



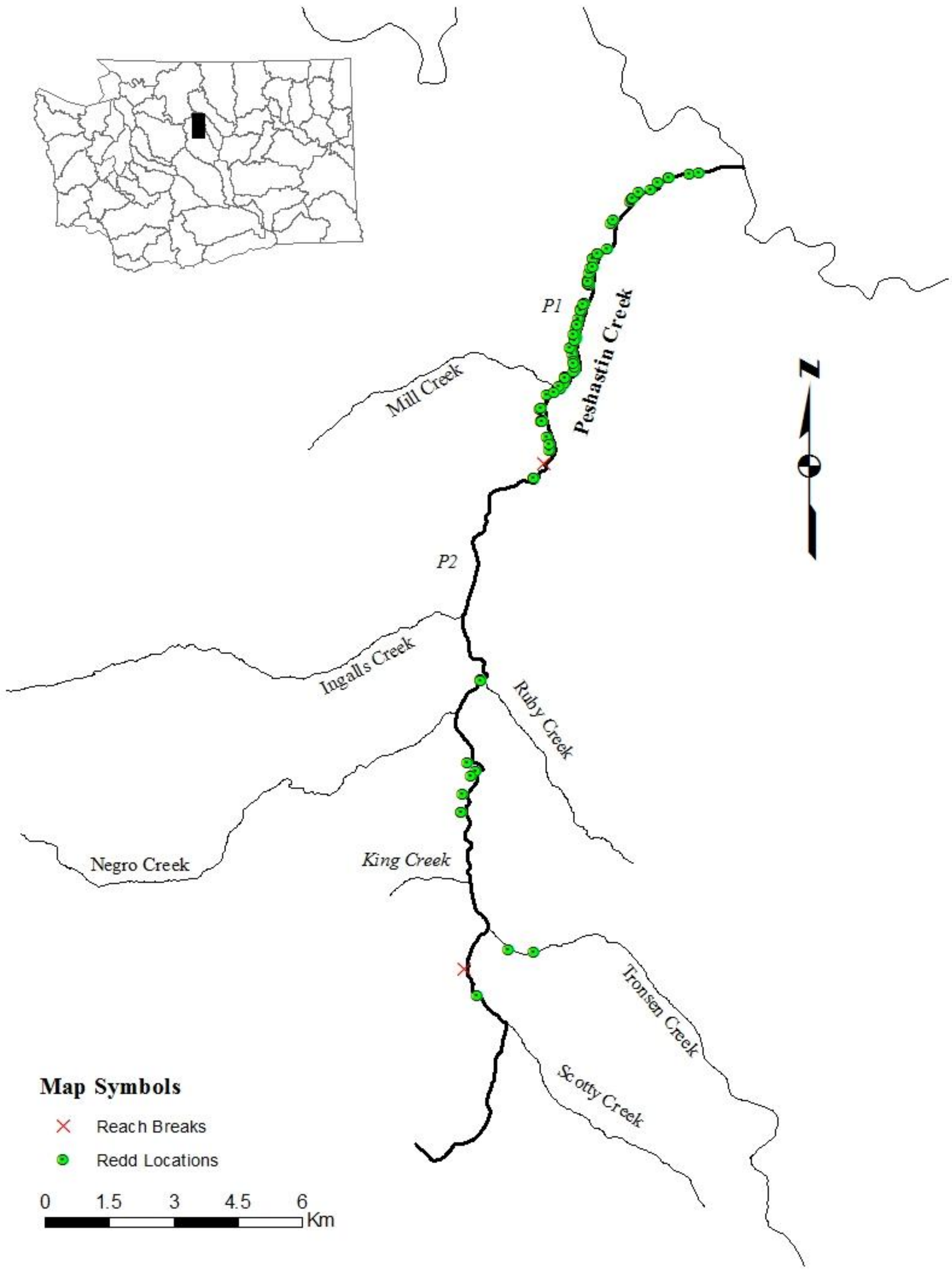
Appendix D1. Steelhead spawning distribution in the Nason Creek Basin in 2011.



Appendix D2. Steelhead spawning distribution in the Chiwawa River Basin in 2011.



Appendix D3. Steelhead spawning distribution in the Wenatchee River and Icicle Creek in 2011.



Appendix D4. Steelhead spawning distribution in the Peshastin Creek Basin in 2011.

Appendix E

Genetic Diversity of Wenatchee Summer Steelhead

Examining the Genetic Structure of Wenatchee Basin Steelhead and Evaluating the Effects of the Supplementation Program

Developed for

Chelan County PUD

and the

Rock Island Habitat Conservation Plan Hatchery Committee

Developed by
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17 January 2012

Table of Contents

Executive Summary

In 1997, Wenatchee River summer steelhead, as part of the upper Columbia River evolutionarily significant unit (ESU), were listed as threatened under the Endangered Species Act (ESA). To address concerns about effects of hatchery supplementation, the hatchery program for hatchery produced (HOR) summer steelhead to be planted in the Wenatchee River changed from using mixed ancestry broodstock collected in the Columbia River to using Wenatchee River broodstock collected in the Wenatchee River. Three monitoring and evaluation (M&E) indicators were developed to measure the genetic effects of hatchery production on wild fish populations. To address these indicators, temporal collections of tissue samples from Wenatchee River hatchery-produced (HOR) and natural origin (NOR) adults captured and sampled at Dryden and Tumwater dams and from NOR juveniles from three Wenatchee River tributaries and the Entiat River were surveyed for genetic variation with 132 genetic (SNPs) markers. Peshastin Creek (a Wenatchee River tributary) and the Entiat River served as no-hatchery-outplant controls, meaning they have stopped receiving HOR juvenile outplants. As per the M&E plan, we interrogated these data for the presence or absence of spatial and temporal trends in allele frequencies, genetic distances, and effective population size.

Allele frequencies – Changes to the summer steelhead hatchery supplementation program had no detectable effect on genetic diversity of wild populations. On average, HOR adults had higher minor allele frequencies (MAF) than NOR adults, which may simply reflect the mixed ancestry of HOR adults. Both HOR and NOR adults had MAF similar to juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants. This suggests that the hatchery program has had little effect on allele frequencies since broodstock sources changed in 1998.

Genetic distances – As intended, interbreeding of Wenatchee River HOR and NOR adults reduced the genetic differences between Wells Hatchery HOR adults and Wenatchee River NOR adults observed in the first few years after changing the broodstock collection protocol. Though there were detectable genetic differences between HOR and HOR adults, the magnitude of that

difference declined over time. HOR adults were genetically quite different from NOR adults and juveniles based on pair-wise F_{ST} and principal components analysis (PCA), most likely because of the much smaller effective population size (N_b) in the hatchery population (see below). Pair-wise F_{ST} estimates and genetic distances between HOR and NOR adults collected the same year declined over time suggesting that the interbreeding of HOR and NOR adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year (the year fish were hatched, determined using scale-based age estimates) were inconclusive because of limitations of the data.

Effective population size (N_b) – Although the effective population size of the Wenatchee River hatchery summer steelhead program was consistently small, it does not appear to have caused a reduction in the effective population size of wild populations. On average, estimates of N_b were much lower and varied less for HOR adults than for NOR adults and juveniles. Estimates of N_b for HOR adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1997. There was no indication that this had any effect on N_b in NOR adults and juveniles; N_b estimates for NOR adults and juveniles were, on average, higher and varied considerably over the time period covered by our dataset (1998 – 2010) and showed no temporal trend.

Introduction

The National Marine Fisheries Service (NMFS) recognizes 15 Evolutionary Significant Units (ESU) for west coast steelhead (*Oncorhynchus mykiss*). The Upper Columbia ESU, which contains steelhead in the Wenatchee Basin, was listed as endangered under the Endangered Species Act (ESA) in 1997. Included in this listing were the Wells hatchery steelhead (program initiated in the late 1960s) that originated from a mixed group of native steelhead and are considered to be genetically similar to natural spawning populations above Wells Dam. Juvenile steelhead from Wells Fish Hatchery was the primary stock released into the Wenatchee River (Murdoch et al. 2003). The 1998 steelhead status review identified several areas of concern for this ESU including the risk of genetic homogenization due to hatchery practices and the high proportion (65% for the Wenatchee River) of hatchery fish present on the spawning grounds (Good et al. 2005). The Biological Review Team (BRT) further identified the relationship between the resident and anadromous forms of *O. mykiss* and possible changes in the population structure ('genetic heritage of the naturally spawning fish') in the basin as two areas requiring additional study. Furthermore, the West Coast Steelhead BRT (2003) recommended that stocks in the Wenatchee, Entiat, and Methow rivers, within the Upper Columbia ESU, be managed as separate populations.

A review of the presence of resident *O. mykiss* in the Upper Columbia ESU (Good et al. 2005) shows that rainbow trout are relatively abundant in upper Columbia River tributaries currently accessible to steelhead as well as in upriver tributaries unavailable to anadromous access by Chief Joseph and Grand Coulee dams (Kostow 2003). U.S. Fish and Wildlife Service (USFWS) biologists surveyed the abundance of trout and steelhead juveniles in the Wenatchee, Entiat, and Methow river drainages in the mid-1980s and found adult trout (defined as those with fork length > 20 cm) in all basins (Mullan et al. 1992). The results also supported the hypothesis that resident *O. mykiss* are more abundant in tributary or mainstem areas upstream of the areas used by steelhead for rearing. No samples of rainbow trout from the Wenatchee were available for this study.

In addition to the mixed ancestry Wells Hatchery steelhead, Skamania Hatchery (Washougal River steelhead ancestry) steelhead were also released into the Wenatchee River basin for several years in the late 1980s (L. Brown, Washington Dept. of Fish and Wildlife [WDFW], personal communication). In 1996, broodstock for the Wenatchee River steelhead program were collected from Priest Rapids Dam and Dryden (rkm 24.9) and Tumwater (rkm 52.6) dams on the Wenatchee River. Because of the ESA listing, broodstock collection after 1996 was restricted to the Wenatchee River in an effort to develop a localized broodstock (Murdoch et al. 2003). Thus, starting in 1998, all juvenile steelhead released into the Wenatchee River and Wenatchee River tributaries were offspring of only Wenatchee River captured broodstock.

In response to the need for evaluation of the supplementation program, both a monitoring and evaluation plan (Murdoch and Peven 2005) and the associated analytical framework (Hays et al. 2006) were developed for the Habitat Conservation Plans Hatchery Committee through the joint effort of the fishery co-managers (Confederated Tribes of the Colville Reservation [CCT], NMFS, USFWS, WDFW, and Yakama Nation [YN]) and Chelan County, Douglas County, and Grant County Public Utility Districts (PUD). These reports outline 10 objectives to be applied to various species assessing the impacts of hatchery operations mitigating the operation of Rock Island and Rocky Reach Dams. This report pertains to Wenatchee River basin steelhead (*O. mykiss*) and the steelhead supplementation program as addressed by objective 3, specifically the first three evaluation indicators.

> **Objective 3:** Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.
>
> **3.1 Allele Frequency**
>
> **3.2 Genetic Distances Between Populations**
>
> **3.3 Effective Spawning Population**

To address these evaluation indicators the WDFW Molecular Genetics Lab (MGL) obtained pertinent tissue collections and samples, surveyed genetic variation with SNP markers using our standard laboratory protocols, and calculated the relevant genetic metrics and statistics. We used collections from both the Entiat River and Wenatchee River basins. Both have received hatchery plants from non-local stocks [i.e. Entiat was stocked with both Wenatchee and Wells program juveniles averaging 12K and 18K respectively during 1995-2001, and Wenatchee received on average 177K juveniles from the Wells program during 1995-2001; (Good et al. 2005)], and both have all or some part of the basin designated as natural production "reference" drainage – no hatchery outplanting (i.e., the entire Entiat Basin, and Peshastin Creek in the Wenatchee River basin) (Good et al. 2005).

Materials and methods

Sample collections

To address objectives 3.1 through 3.3, we obtained samples from hatchery (HOR, adipose fin clipped) and natural origin (NOR, adipose fin intact) adult summer steelhead captured at Dryden or Tumwater diversion dams in the summer and fall of 1997 through 2009 (excepting 2004 and 2005; Table 1). All or some fraction of these fish was later used as hatchery broodstock the calendar year following the sampling year. In order to keep things simple we have reported years as the spawning year, i.e., the calendar year the fish were spawned, not the calendar year they were captured.

To address objective 3.2, it was necessary to have samples from natural origin fish from each of the spawning populations in the basin. It is difficult to obtain adult samples from known spawning populations due to the life history and behavior of steelhead, without tributary weirs or some other blocking method of collection. The NOR adult samples used as broodstock collected from Dryden and Tumwater Dams were a mixed collection representing all of the spawning populations located upstream. Therefore to determine population substructure within the basin we obtained collections of juvenile fish from smolt traps located within tributaries representing three major populations in the basin and from the Entiat River (Chiwawa River, Nason Creek, and Peshastin Creek; Table 2). We also obtained two collections of juvenile fish caught in a smolt trap in the lower Wenatchee River. These, like the NOR adult collections, were a mixed collection presumably representing all populations located upstream. Fin tissue was taken from each fish and preserved in 95% ethanol.

Sample processing

Fin tissue samples were processed for 1468 HOR and NOR adult steelhead broodstock (Table 1) and for 1542 juvenile *O. mykiss* from the Wenatchee and Entiat Rivers (Table 2). Samples were genotyped at 152 single nucleotide polymorphism loci (SNPs, Tables 3, 4). We originally proposed to use microsatellites, but WDFW MGL and other regional genetic laboratories (Columbia River Inter-Tribal Fish Commission [CRITFC], Idaho Fish and Game [IDFG], USFWS) are moving toward using SNPs and they provide the same kinds of information with faster processing. Twenty SNP loci were developed to discriminate among trout species; 14 distinguish *O. mykiss* from coastal cutthroat trout (*O. clarkii clarkii*) and westslope cutthroat (*O. clarkii lewisi*), and 6 distinguish steelhead and coastal cutthroat from westslope cutthroat (Table 4). The remaining 132 SNP loci were developed to be used for population structure, parentage assignment, or other population genetic studies of *O. mykiss* (Table 3). These markers comprised the current standard set of SNP markers used for genetic studies of *O. mykiss* at WDFW MGL.

We used Qiagen DNEasy ® kits (Qiagen Inc., Valencia, CA), following the recommended protocol for animal tissues, to extract and isolate DNA from fin tissue. SNP genotypes were obtained through PCR and visualization on Fluidigm EP1 integrated fluidic circuits (chips). Protocols followed Fluidigm's recommendations for TaqMan SNP assays as follows: Samples were pre-amplified by Specific Target Amplification (STA) following Fluidigm's recommended protocol with one modification. The 152 assays were pooled to a concentration of 0.2X and mixed with 2X Qiagen Multiplexing Kit (Qiagen, Inc., Valencia CA), instead of TaqMan PreAmp Master Mix (Applied Biosystems), to a volume of 3.75µl, to which 1.25µl of unquantified sample DNA was added for a total reaction volume of 5µl. Pre-amp PCR was conducted on a MJ Research or Applied Biosystems thermal cycler using the following profile: 95°C for 15 min followed by 14 cycles of 95°C for 15 sec and 60°C for 4 minutes. Post-PCR reactions were diluted with 20µl dH_2O to a final volume of 25µl.

Specific SNP locus PCRs were conducted on the Fluidigm chips. Assay loading mixture contained 1X Assay Loading Reagent (Fluidigm), 2.5X ROX Reference Dye (Invetrogen) and 10X custom TaqMan Assay (Applied Biosystems); sample loading mixture contains 1X TaqMan Universal PCR Master Mix (Applied Biosystems), 0.05X AmpliTaq Gold DNA polymerase (Applied Biosystems), 1X GT sampling loading reagent (Fluidigm) and 2.1 µL template DNA. Four µL assay loading mix and 5 µL sample loading mix were pipetted onto the chip and loaded by the IFC loader (Fluidigm). PCR was conducted on a Fluidigm thermal cycler using a two step profile. Initial mix thermal profile was 70°C for 30min, 25°C for 5 min, 52.3° for 10 sec, 50.1°C for 1 min 50sec, 98°C for 5 sec, 96°C for 9 min 55 sec, 96°C for 15 sec, 58.6°C for 8 sec, and 60.1°C for 43 sec. Amplification thermal profile was 40 cycles of 58.6°C for 10 sec, 96°C for 5 sec, 58.6°C for 8 sec and 60.1°C for 43 sec with a final hold at 20°C.

The SNP assays were visualized on the Fluidigm EP1 machine using the BioMark data collection software and analyzed using Fluidigm SNP genotyping analysis software. To ensure all SNP markers were being scored accurately and consistently, all data were scored by two researchers and scores of each researcher were compared. Disputed scores were called missing data (i.e., no genotype).

Evaluation of loci

A two-tailed exact test of Hardy–Weinberg equilibrium (HWE) was performed for each locus in each collection or population using the Markov Chain method implemented in GENEPOP v4.1 (dememorization number 1000, 100 batches, 1000 iterations per batch; Raymond and Rousset 1995; Rousset 2008). Significance of probability values was adjusted for multiple tests using false discovery rate (Verhoeven et al. 2005). F_{IS}, a measure of the fractional reduction in heterozygosity due to inbreeding in individuals within a subpopulation and an additional indicator of scoring issues, was calculated according to Weir and Cockerham (1984) using GENEPOP v4.1. Allele frequencies were calculated using CONVERT v1.0 (Glaubitz 2004). Expected and observed heterozygosities were calculated using GDA v1.1 (Lewis and Zaykin 2001).

Allele frequencies, genetic distances and population differentiation

To evaluate Q1 of Objective 3.1 and 3.2, we evaluated trends and patterns in allele frequencies, genetic distances and population differentiation. To test for temporal patterns in allele frequencies, we compared sample or spawn year to two diversity metrics, allele frequency and observed heterozygosity, from each adult and juvenile collection. Each SNP locus had only one or two alleles, so we used the minor allele frequency (MAF) of each SNP locus for each adult collection and averaged across loci. We also calculated the average observed heterozygosity (Ho) for each SNP locus within each adult and juvenile collection. We examined the presence or absence of a temporal trend in average allele frequency and observed heterozygosity with logistic regression analysis in R (R Development Core Team 2009).

To partition genetic variance into temporal, spatial (juvenile) and origin (adult) fractions, we performed hierarchical analysis of molecular variance (AMOVA) using ARLEQUIN v3.0 (Excoffier et al. 2005) with 1,000 permutations. We performed this analysis separately for juvenile and adult collections. Juveniles were grouped by sampling location (tributary) and adults were grouped by origin (HOR or NOR). To estimate the magnitude of genetic differences among temporal and spatial collections we calculated pairwise F_{ST} estimates among collections using FSTAT (Goudet 1995) with 1000 permutations. Statistical significance was adjusted using false discovery rate (Verhoeven et al. 2005).

To evaluate the temporal changes in genetic relationships, we compared spawn year to within spawn year pairwise F_{ST} estimates between NOR and NOR adults using beta regression (Simas and Rocha 2010). We used beta regression because the dependent variable was bound by zero and one but not binomial. Analysis was performed in R (package "betareg", Cribari-Neto and Zeileis 2010), with a loglog link.

We used principal component analyses (PCA) to explore the relationship between the covariation among the SNP loci within each collection and genetic differentiation between HOR and NOR collections, and to determine if the degree of differentiation has changed with time. Since each SNP is represented by only two alleles, only one allele per SNP is necessary to fully describe the covariation among all SNPs. We used MATLAB® scripts (2007a, The Mathworks, Natlick, MA) to calculate the principal components from SNP allele frequencies using only the major allele (1-MAF) for each SNP. We defined the major allele as the allele with the higher mean frequency across all collections, regardless of its status within any individual collection. We conducted three PCA analyses using: (1) all adult samples, aggregated based on origin (HOR versus NOR) and spawn year (i.e., the year the adult fish were used as broodstock) (N = 1437, 22 collections), (2) same as #1, but with the addition of all juvenile samples (N = 2938, 37 collections), and (3) only those adults samples with available age information (Mike Hughes, WDFW, personal communication) aggregated based on origin, and spawn year or brood year (i.e., the year the fish were hatched) (N = 1313, 20 spawn-year or 25 brood-year collections).

Molecular differentiation between HOR and NOR adults within a year was calculated based on principal component scores using Euclidian distances. We calculated pair-wise Euclidian distances between HOR and NOR fish within a spawn year or brood year using the first three principal components, and standardized each distance by subtracting from it the mean Euclidian distance calculated across all pair-wise distances. We used Mahalanobis distances to calculate the variation among HOR and NOR collections (calculated separately), again using the first three principal components. Here, we calculated Mahalanobis distances as the Euclidian distances between each collection and the centroid of all collections (HOR and NOR combined), but the Euclidian distances are scaled based on the dispersion of collections around the centroid (i.e., the variance). Euclidian and Mahalanobis distances were calculated using MATLAB scripts.

Effective spawning population

To evaluate Q1 of Objective 3.3, we estimated N_e using the single-sample linkage disequilibrium methods implemented in the program LDNE (Waples and Do 2008). This method requires that you input the P_{crit} value, the minimum frequency at which alleles were included in the analysis, since results can be biased depending on this setting (Waples and Do 2010). SNP markers typically have only one or two alleles; if one of two alleles is excluded based on its frequency in the collection it essentially excludes the locus, reducing the overall dataset. Therefore, we used P_{crit} values ranging from 0.1 to 0.001 to evaluate whether trends in N_e changed given which loci were used. Confidence intervals were calculated using a jackknife procedure.

We calculated an estimate of N_e for all adult and juvenile collections individually. However, the intention of an integrated hatchery program such as the Wenatchee River steelhead hatchery program is that HOR and NOR fish are integrated and progress as a single population through intentional interbreeding in the hatchery and presumed natural interbreeding in the wild. Thus, we also combined annual HOR and NOR collections to calculate an overall N_e estimate as has been done in other genetic monitoring and evaluation analyses (e.g., Small et al. 2007, [Chinook salmon, *O. tshawytscha*]).

Estimates of N_e from linkage refer to the generations that produced the sample. To calculate the ratio of effective population size to census size (N_e/N), we obtained the number of fish spawned in the hatchery (1993 through 2006, i.e., those that produced the adipose fin clipped adults that returned to spawn in the Wenatchee River 1998 through 2010) and the estimated escapement of fish spawning naturally (HOR and NOR separately) for the same time period. Estimates of census population size in spawning tributaries was obtained by multiplying the fraction of redds counted within tributaries (Chad Herring ,WDFW, unpublished data) by the total Wenatchee River census population estimate (Andrew Murdoch, WDFW, unpublished data). To calculate N_e/N, we performed two analyses. First, for adults, we assumed a five year generation time for natural origin adults and a four year generation time for hatchery origin adults and divided the N_e estimate by the census population estimate from four or five years earlier. For juveniles, we assumed an age at outmigration of two years and divided the N_e estimates by the estimate of census population size for the appropriate tributary. Second, we used available adult age data to parse individuals into cohorts originating in brood years (rather than spawn years) and then used LDNE to estimate N_e from cohort collections. We performed both analyses to make full use of all available data; age data were not available for many adults, and because of variable survival and sampling not all cohorts had sufficient numbers of HOR and NOR adults. According to Luikart et al. (2010), estimates produced using linkage disequilibrium should be interpreted as something between effective population size (N_e) and the effective number of breeders (N_b). Using cohorts, the estimate produced by LDNE is clearly an estimate of N_b rather than N_e. In order to keep things simple, we have referred to all estimates as N_b.

Results and Discussion

Collections and samples received

From 1468 samples from HOR and NOR adult steelhead broodstock, 1437 produced sufficient genetic data for further analysis (Table 1). From 1542 samples from NOR juvenile steelhead from Wenatchee River tributaries and the Entiat River, 1501 produced sufficient genetic data for further analysis and were genetically identified as *O. mykiss* (Table 2). Samples genetically identified as *O. clarki* (2 samples from the Chiwawa River, 1 from the Entiat River) or *O. clarki*/*O. mykiss* hybrids (4 – lower Wenatchee River, 4 – Nason Creek, 4 – Chiwawa River, and 1 – Entiat River) were omitted from further analysis.

Evaluation of loci

Three loci showed deviations from HWE in 10 or more of 37 Wenatchee steelhead collections before correcting for multiple tests (AOmy016, AOmy051, AOmy252, Table A1) indicating possible scoring issues. These loci were omitted from further analysis. Nine of the remaining loci were monomorphic or nearly monomorphic in all collections (average MAF < 0.1, AOmy023, AOmy028, AOmy123, AOmy129, AOmy132, AOmy209, AOmy229, AOmy270, AOmy271, Table A1) contributing little or nothing to analytical power. These loci were also omitted from further analysis. No genetic data was available for collection 10FD due to poor PCR amplification at locus AOmy213 for the entire collection. AOmy213 had a relatively low MAF in most collections so rather than re-processing this collection at this locus or running different sets of loci for different tests, we omitted this locus from further analysis. Only six tests of deviation from HWE were significant after correcting for 4348 tests using false discovery rate. Two of these tests were in loci already omitted. The remaining four tests were spread among the remaining loci, indicating no more loci needed to be omitted from further analysis.

Objective 3.1, 3.2 – Allele frequencies and Genetic distances

Allele frequencies

Average MAF of SNP loci ranged from 0.00 to 0.60 in HOR adult collections and from 0.00 to 0.61 in NOR adult collections (Table A1). Observed heterozygosity ranged from 0.00 to 0.75 in HOR adult collections and from 0.01 to 0.67 in NOR adult collections. Juvenile collections produced similar ranges of MAF and Ho (Table A1). Average MAF and Ho of HOR adult collections appeared to be greater than those of natural origin collections. However, logistic regression analysis indicated there was no significant temporal trend in either diversity statistic (Figure 1). Similarly, there was no consistent temporal trend in MAF or Ho of juvenile collections (Figure 2). Both the Chiwawa River and Nason Creek, the two tributaries that currently still receive hatchery juvenile outplants, both appeared to have declining allele frequencies, but neither was statistically significant ($P > 0.90$). However, the power to detect significant trends was limited by the small sample sizes (n = 3 sample years).

Analysis of Molecular Variance

Analysis of molecular variance (AMOVA) of adult collections (i.e., temporal and origin structure) indicated most of the genetic variance was among individuals or among individuals within populations (99.04%). Most of the remaining variance was temporal variation within hatchery and natural origin groups (0.61%) with the remaining variation from origin (0.35%). AMOVA of juvenile collections (i.e., spatial structure) indicated most of the genetic variance was among individuals (98.44%) or among individuals within populations (0.94%). Most of the remaining variance existed among temporal collections within tributary collections (0.37%) with the smallest fraction as among tributary variance (0.24%). Thus, overall, there was more variability among years than among tributaries or origins, but no trend in the temporal variability.

Pair-wise F_{ST} *estimates*

HOR adults were genetically different that NOR adults as estimated by F_{ST} (full pair-wise table in Table A2, all pair-wise F_{ST} estimates with P-values ≤ 0.05 before correcting for multiple tests were significantly different from zero after correcting for multiple tests using false discovery rate). On average, HOR adult collections were as different from one another (mean F_{ST} = 0.011) as they were from NOR adult collections among years (mean F_{ST} = 0.009) or from NOR adult collections within years (mean F_{ST} = 0.010). Among year comparisons of NOR adult collections were, on average, nearly an order of magnitude lower (mean = 0.002). These patterns held whether spawn year or brood year (data not shown) was used to group individuals. Over time, within spawn year pair-wise F_{ST} estimates between HOR and NOR adults declined over time (β = -0.014, P = 0.0185; Figure 3), suggesting that the integration of hatchery and wild fish is slowly genetically homogenizing the groups. That relationship disappeared when adults were grouped by brood year (i.e., comparing fish produced the same year) and all brood years were used (β = -0.009, P = 0.615, data not shown). However, when the dataset was restricted to just those brood years when all typical (age at maturation frequency among all years > 0.10) age classes were present in the dataset (HOR = age 3, 4; NOR = age 4, 5, 6; brood years 1996-1998, 2004-2005) a non-significant (P = 0.278) negative relationship (β = -0.12) of F_{ST} and brood year was apparent. When the data were further restricted to just the years after the hatchery program changed to only collecting broodstock in the Wenatchee River (brood years 1998, 2004-2005), the slope was also negative (β = -0.09), but the relationship was not statistically significant (P = 0.962).

Within tributary among sample year pair-wise comparisons of juvenile collections were, on average, only very slightly smaller than comparisons among tributaries (0.005 vs. 0.006, respectively, Table 5, all pair-wise F_{ST} estimates with P-values ≤ 0.05 before correcting for multiple tests were significantly different from zero after correcting for multiple tests using false discovery rate). Nason Creek and Peshastin Creek on average showed higher among sample year F_{ST} estimates (0.010 and 0.007, respectively) than the Chiwawa or Entiat Rivers (0.004 and 0.002, respectively). The pair-wise comparison of the two collections of lower Wenatchee River smolts, presumably a mix of Chiwawa, Nason, Peshastin smolts and smolts from other spawning tributaries, was an order of magnitude smaller (F_{ST} = 0.0002), and not significantly different than zero (Table 5). There was no temporal trend in pair-wise comparisons of juvenile collections. However with, at most, four annual collections, detecting any temporal trend was unlikely. We also had no collections from years prior to 1998 (the first year of new hatchery program broodstock collecting protocols) with which to compare contemporary data, nor could we find any reports or papers containing pre-hatchery-program-change genetic comparisons among Wenatchee River tributary populations, making it impossible to determine whether or not changing the hatchery program has had any effect at all on population structure. However, these data will be useful for future studies.

Principal Components

Each principal component analysis (Figures 4, 5) indicated that the genetic structure among HOR collections differed from that among NOR collections, and that this difference has decreased with time. When adult fish were aggregated based on origin and spawn-year, there was a clear differentiation between HOR and NOR adult collections along PC 1, and a separation among HOR collections, differentiating the early spawn-years (1998 – 2003) from the later spawn-years (2004 – 2010) along PC 2 and PC 3, respectively (Figure 4). The pair-wise genetic distances between HOR and NOR collections from the same spawn year (i.e., the HOR and NOR fish used as broodstock within the same year) decreased from the largest distance in 1998 to small distances in 2009 and 2010, although the smallest distance occurred in 2004 (Figure 4, top right). That is, within hatchery broodstock, the genetic difference between HOR and NOR fish decreased, on average, from 1998 to 2010, and the decrease appeared to be a mutual convergence of NOR fish shifting right along PC 1 and HOR fish shifting downward along PC 2 and PC 3. This increasing similarity in adult fish mirrored that seen in within year pair-wise F_{ST} estimates between HOR and NOR adults which also declined over time (Figure 3).

Overall, there was considerably more genetic variation among the HOR collections than there was among the NOR collections with average Mahalanobis distances (distance between each collection and the overall centroid [0,0,0]) among the HOR and NOR collections being 4.2 and 1.5, respectively. Since each NOR collection was generally composed of 3-4 brood-years, while HOR collections rarely were composed of more than two brood-years, we attributed the lower year-to-year genetic variability of the NOR broodstock to the greater homogenizing effect of including four or more brood-years compared with only two brood years for the HOR broodstock.

Including the 15 juvenile collections, along with the 22 adult collections, did not materially alter the principal component structure (Figure 6), although the total genetic variation accounted for by the three principal components decreased from 44% using only the adults to 33% when juveniles were included. For the most-part, the juvenile fish appeared intermediate between HOR and NOR fish, but there was greater overlap in principal component scores (and therefore greater genetic similarity) of the juvenile and NOR collections, than of the juvenile and HOR collections. The average Euclidian distance between the juvenile and HOR collections was 0.49, compared to 0.23 between the juvenile and NOR collections, which was no different than 0.23 and 0.22 for the within juvenile and NOR collections, respectively.

By using the available adult age data, we were able to compare the genetic differentiation among the same set of fish when they are aggregated by origin (hatchery versus natural) and brood-year (year fish were hatched) with aggregates based on origin and spawn-year (year adult fish were spawned). A brood-year analysis compares within a year the genetic diversity generated from hatchery broodstock with that naturally produced in the spawning grounds. A spawn-year analysis compares the HOR and NOR genetic diversity that was mixed among cohorts of the parental generations. The same basic pattern of genetic structure that we have seen in spawn-year analyses (Figure 4, Figure 6, and the right side of Figure 5) also occurred in the brood-year analysis (left side of Figure 5). That is, from Figure 5 we saw (1) that HOR and NOR fish were differentiated from each other; (2) there was considerably more genetic variation (temporal variation) among the hatchery-origin collections than there was among the natural-origin collections (for brood-year, Mahalanobis distances = 5.18 and 0.75, respectively; for spawn-year, Mahalanobis distances = 4.25 and 1.25, respectively), and (3) that the genetic distances between HOR and NOR collections were lower in the more recent brood- and spawn-years, than in the earlier brood- and spawn-years (Figure 7; R^2 = 0.41 or 41%, $P < 0.05$). This indicated that the HOR and NOR fish used as broodstock in 2010 were more similar to each other than they were at the inception of the new hatchery program.

The relationship between genetic distance and brood-year was not the same as the relationship between genetic distance and spawn-year. For brood-year, although the slope was negative (i.e., trending downward or decreased differentiation with time) and the two most-recent brood years (2005-2006) showed relatively small HOR and NOR adult differentiation, the negative slope was not significantly different from zero and the regression accounted for only 7% of the variation. This was likely the result of insufficient sampling of certain age classes from many brood years (especially from NOR adults) due to two un-processed sample years (2005 and 2006).

Objective 3.3 – Effective spawning population

There was no difference in the temporal trends in estimates of N_b with P_{crit} set from 0.1 to 0.001 (Figure 8, data not shown for all collections), so we have reported only results with $P_{crit} = 0.001$, i.e., the full genetic dataset. Using either spawn-year or brood year, estimates of NOR adult N_b were higher and varied more than those of HOR adults (Figures 9, 10), concordant with the PCA analysis. Estimates for HOR adults ranged from 17 to 174 (by spawn year, mean = 65) or from 6 to 130 (by brood year, mean = 39). Estimates for NOR adults ranged from 36 to 982 (by spawn year, mean = 405) or from 59 to 2966 (by brood year, mean = 645). Many N_b estimates for NOR adults had confidence intervals extending to infinity on the upper bound. This reflected the difficulty in obtaining precise estimates of N_b for large populations (Waples and Do 2010).

Estimates of N_b for HOR steelhead dropped by approximately half from 1994, when broodstock were still collected at Wells Hatchery, to 1998, when the program used Wenatchee River trapped adults only, suggesting an effect of changing broodstock collection practices, which began in 1997 (Figures 8, 9). Since 1997, the hatchery population N_b remained at a relatively stable lower level (Figures 8, 9, and 10). There was no obvious change in N_b for NOR steelhead since 1993; the N_b estimate for 1993 was the largest, however the confidence interval overlapped estimates from many other years. The temporal trend in N_b estimates from combined collections mirrored those of the HOR collections alone, though estimates using combined collections were slightly larger (Figure 11).

As with N_b estimates, estimates of the ratio of N_b/N for NOR adults varied more than those of HOR adults (Figures 12, 13). However, using spawn year, i.e., mixtures of cohorts, the average N_b/N ratio for HOR adults was equal to that of NOR adults (mean $N_b/N = 0.26$), whereas when using brood year, the average N_b/N ratio for NOR adults was double that of HOR adults (NOR average =0.40, HOR average = 0.20). This is likely a consequence of the homogenizing effect of mixed cohorts. Estimates of N_b for HOR adults using spawn year were close to those estimated using brood year because of the lower diversity in age at maturation, whereas for NOR, grouping by brood year produces different estimates than when grouping by spawn year because of higher diversity in age at maturation. Regardless of which estimate was used, there was no temporal trend in N_b/N for either NOR or HOR adults.

Summary

On average, HOR adults had higher minor allele frequencies (MAF) than NOR adults, and both had similar MAF as juveniles collected in spawning tributaries and in the Entiat River. There was no temporal trend in allele frequencies or observed heterozygosity in adult or juvenile collections and allele frequencies in control populations were no different than those still receiving hatchery outplants suggesting that the hatchery program has had little effect on allele frequencies since 1998.

HOR adults were genetically quite different from NOR adults and juveniles based on pair-wise F_{ST} and principal components analysis (PCA), most likely because of the much smaller effective population size (N_b) in the hatchery population. Pair-wise F_{ST} estimates and genetic distances between HOR and NOR adults collected the same year declined over time suggesting that the interbreeding of HOR and NOR adults in the hatchery (and presumably in the wild) is slowly homogenizing Wenatchee River summer steelhead. Analyses using brood year (the year fish were hatched, determined using scale-based age estimates) were inconclusive because of limitations of the data.

On average, estimates of N_b were much lower and varied less for HOR adults than for NOR adults and juveniles. Estimates of N_b for HOR adults declined from the earliest brood years to a stable new low value after broodstock practices were changed in 1997. There was no indication that this had any effect on N_b in NOR adults and juveniles; N_b estimates for NOR adults and juveniles were, on average, higher and varied considerably over the time period covered by our dataset (1998 – 2010) and showed no temporal trend. Small N_b sizes increase the risk of loss of genetic diversity due to inbreeding and random effects (genetic drift). The N_b of the hatchery component of the population may be increased by spawning more families, using specific mating designs, and minimizing variance in reproductive success. However, given the apparent lack of effects overall, changes to the hatchery protocol may not be necessary.

Overall, hatchery practices appear to have had little effect on natural origin Wenatchee summer steelhead neutral genetic diversity or N_b. We cannot accurately assess their effects on population structure at this time. However, it is interesting to note that when juvenile collections are analyzed separately from adult collections, Peshastin Creek, which has received fewer hatchery outplants in the past and is currently a refuge from hatchery outplants, is genetically different than other tributaries and the Entiat River (data not shown). On the other hand, the Entiat River, which is also a refuge from hatchery outplants and is not a tributary of the Wenatchee River, is genetically very similar to Nason Creek and the Chiwawa River, both Wenatchee River tributaries. This suggests, though it does not conclude, that within basin population structure may have existed before summer steelhead hatchery production began in the upper Columbia River and that the population structure was eliminated by hatchery influence long before 1998.

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Figures

Figure 1. Observed average minor allele frequencies (MAF) and observed heterozygosities (Ho) of 119 SNP loci from 11 annual collections of hatchery-produced (HOR) and natural origin (NOR) adult steelhead from the Wenatchee River. Trend lines are from a logistic regression. Note the X axis does not cross the Y axis at the origin. Neither the slopes nor the intercepts were statistically significant.

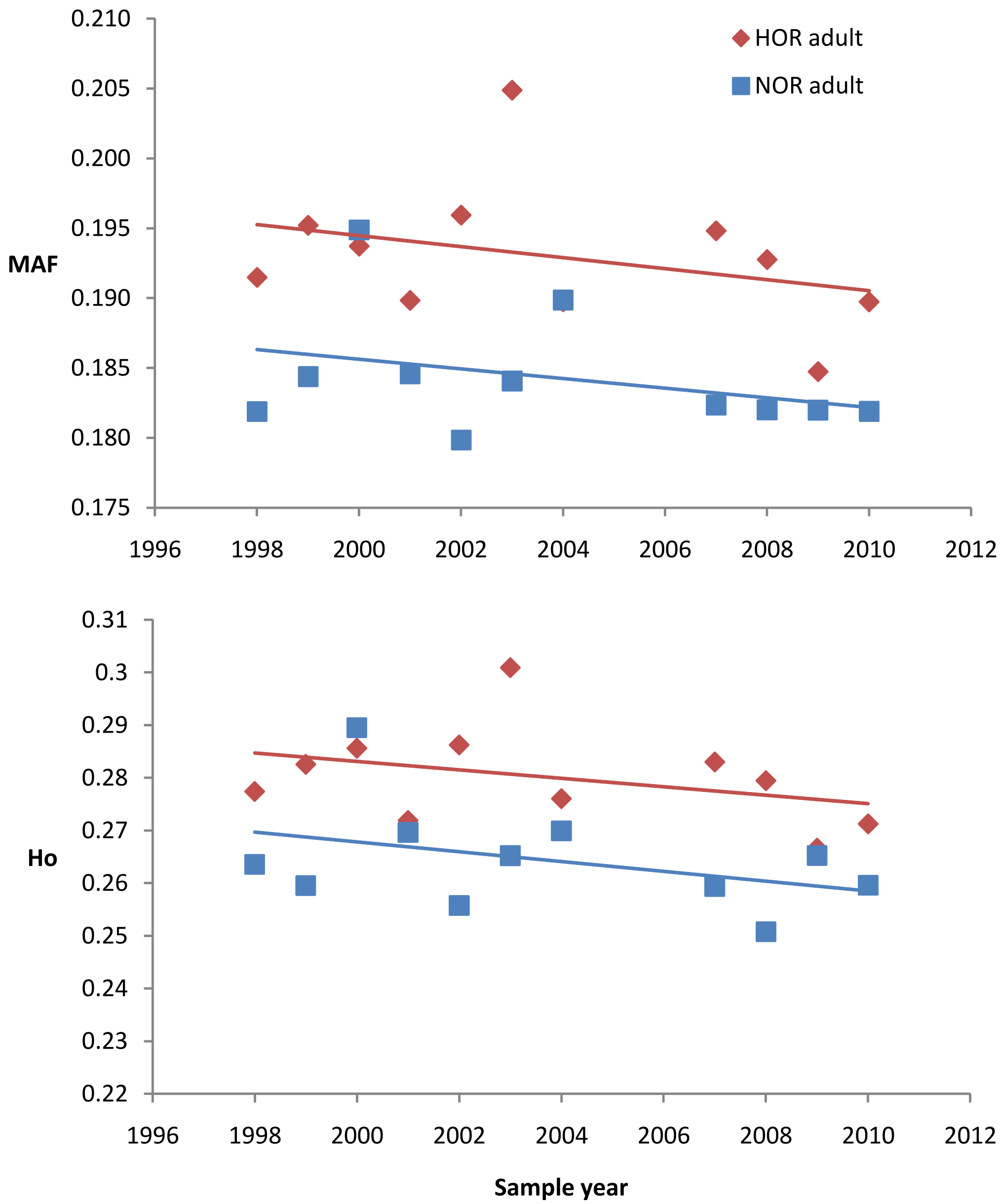


Figure 2. Observed average minor allele frequencies (MAF) and observed heterozygosities (Ho) of 119 SNP loci from 15 collections of natural origin juvenile steelhead from Wenatchee River tributaries, the lower Wenatchee River and the Entiat River. There were no consistent temporal trends in MAF or Ho in these collections.

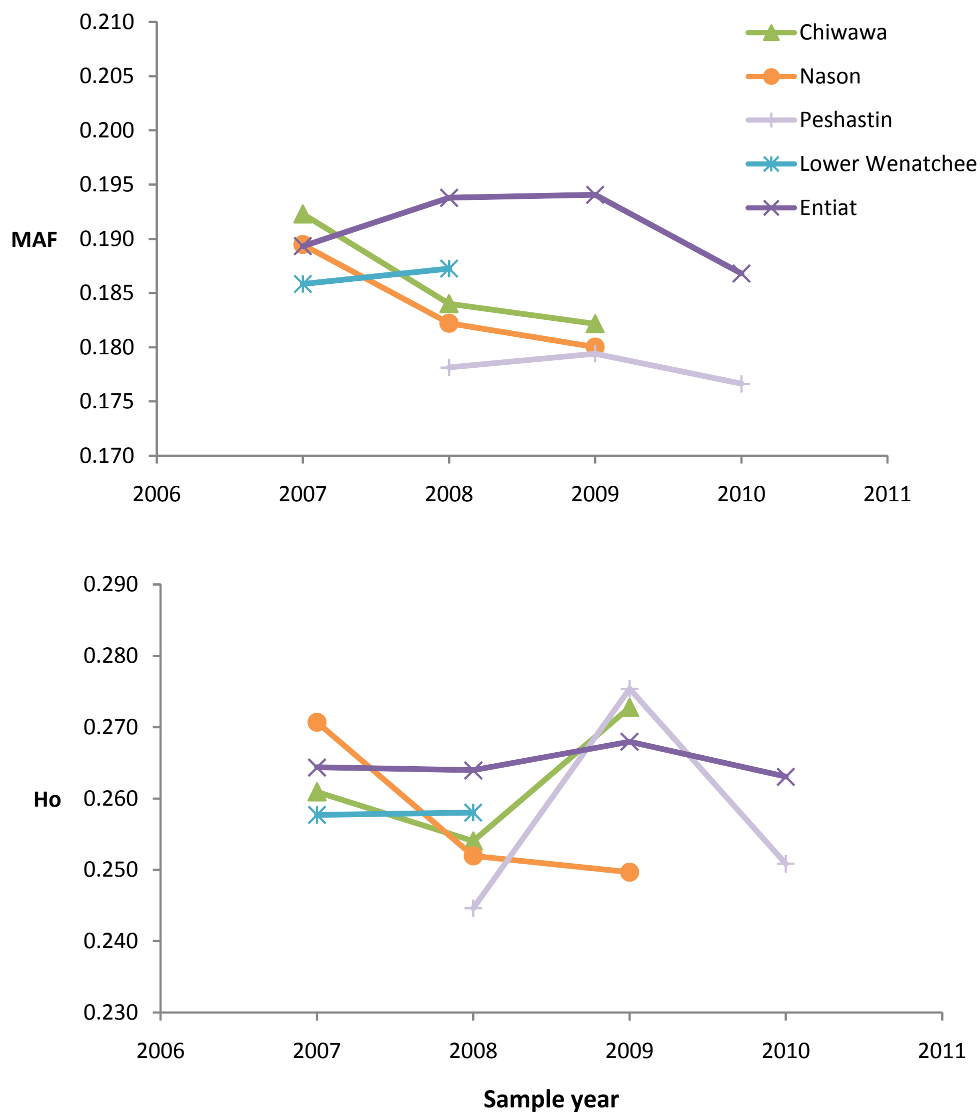


Figure 3. The relationship of time with pairwise F_{ST} estimates between hatchery-produced (adipose fin clipped) and natural origin (unclipped) adults of the same sample year. The line is the prediction based on beta regression.

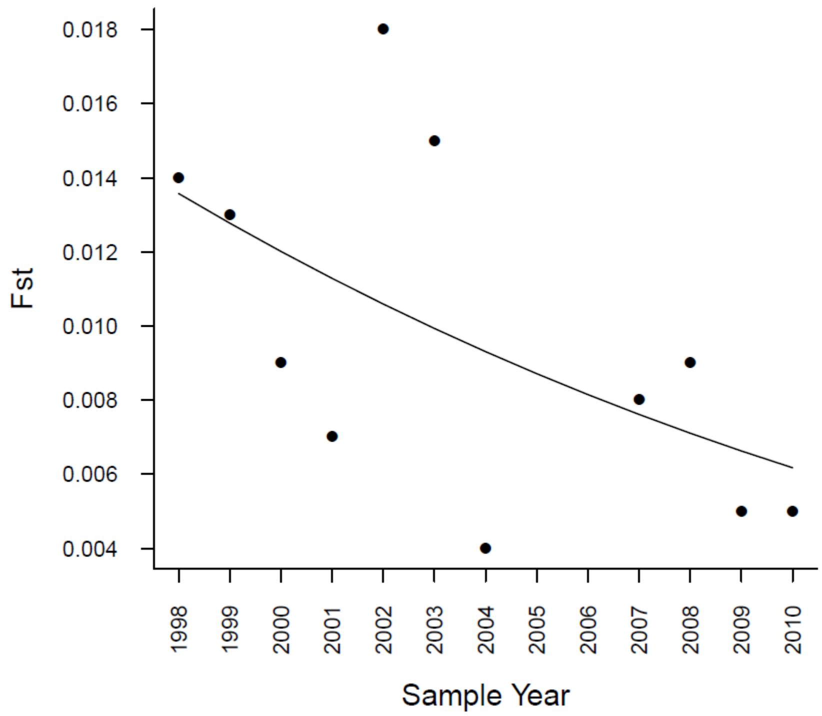


Figure 4. Principal component (PC) 1 versus 2 (top left), PC 1 versus 3 (bottom left), and PC 2 versus 3 (bottom right) based on an analysis using all adults aggregated into origin and spawn-year collections. Natural-origin spawn-years are shown in italicized typeface. The percentage within the label of each axis convey the percent of total genetic variance that is accounted for by that axis. Taken together, the three principal components account for 44% of the total SNP variation. Top right shows pairwise Euclidian distances versus spawn-year, with zero distance equal to average distance across all pairwise distances. Blue line is least-squares fit with $R^2 = 0.45$.

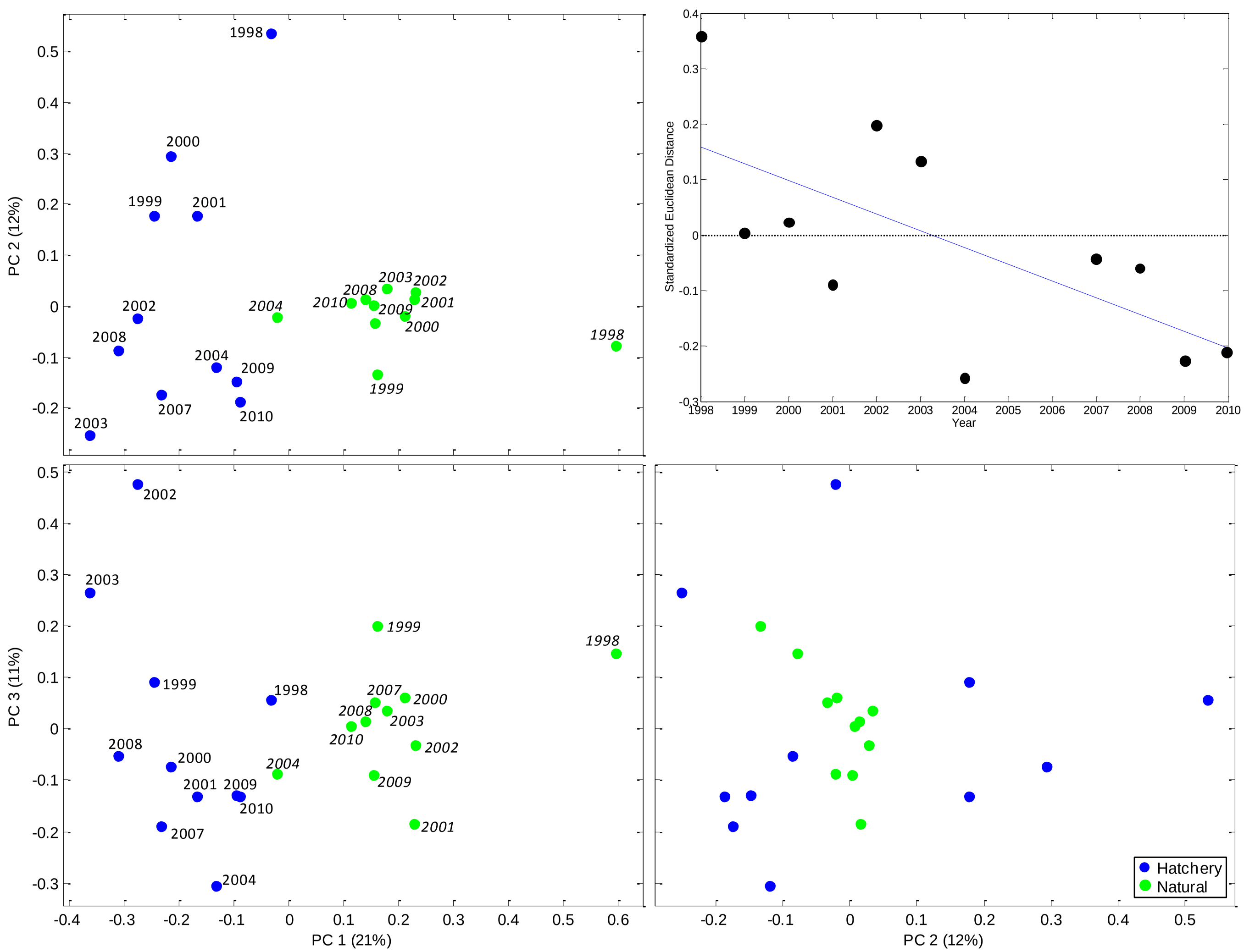


Figure 5. Principal components (PC) 1 versus 2 (top) and 3 (bottom) for adults aggregated into brood-year (BY; left) and spawn-year (SY; right). Spawn-year analysis is the same as in Figure x1, except fewer individuals per collection were included (see methods). Note that for the SY analysis here PC 2 and 3 are similar to PC 3 and 2, respectively, in Figure x1. Only BY1995 (earliest year with paired hatchery-natural data), BY2000 (extreme PC 1 score), and BY2006 (latest year with paired hatchery-natural data) are labeled. Hatchery- and natural-origin individuals from BY1995, BY2000, and BY2006, returned to spawn (spawn-year) in 1999 (hatchery)/1999-2001 (natural), 2003-2004 (hatchery)/2004 and 2007 (natural), and 2009-2010 (hatchery)/2010 (natural), respectively. These years are labeled in the upper right figure. Only 4 year-old BY 2006 natural-origin fish are represented in the SY 2010 collection.

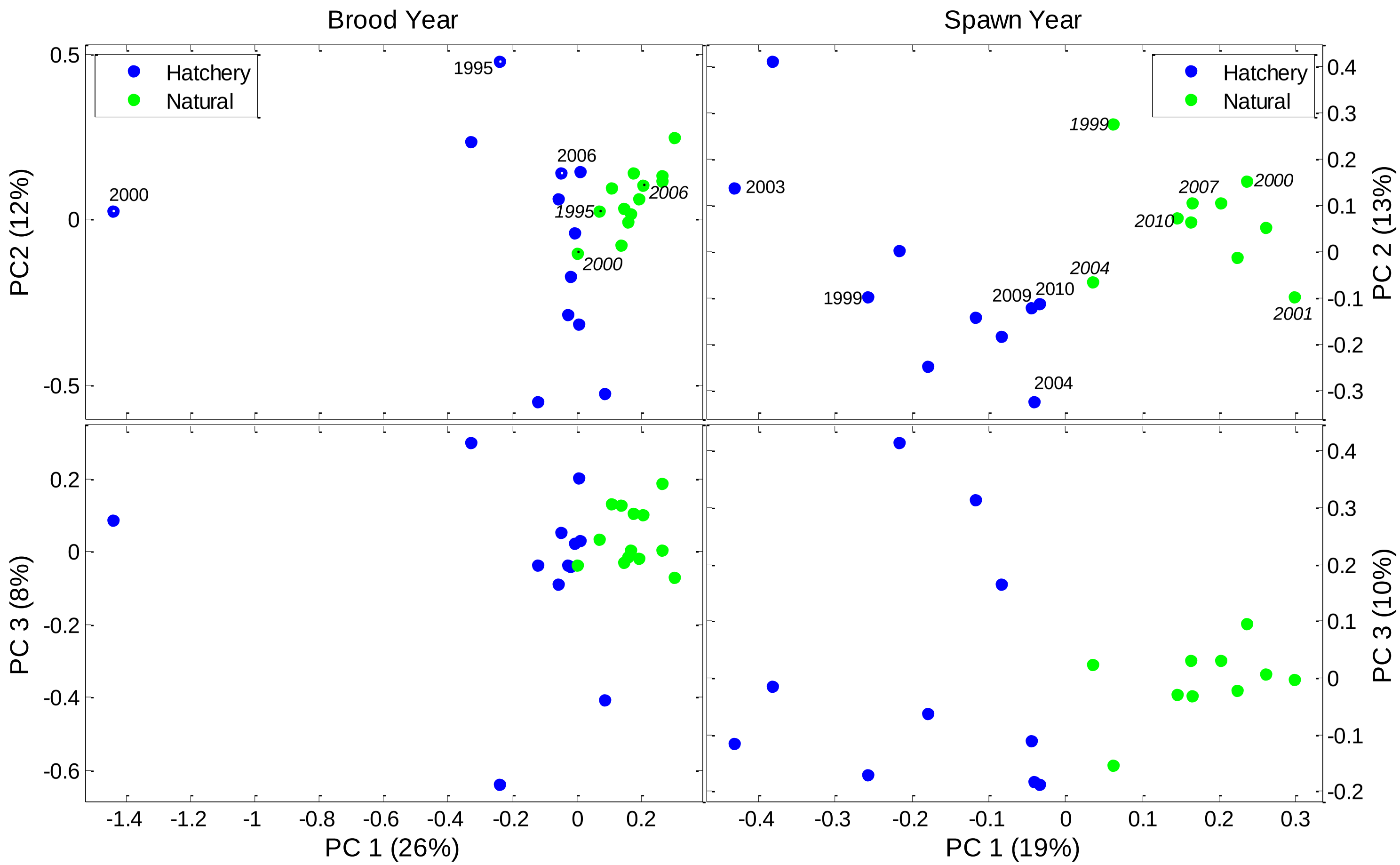


Figure 6. Principal component (PC) 1 versus 2 (top) and PC 1 versus 3 (bottom) based on an analysis using all adult and juvenile fish aggregated into age (juvenile versus adult), origin (hatchery versus adult) and spawn-year collections.

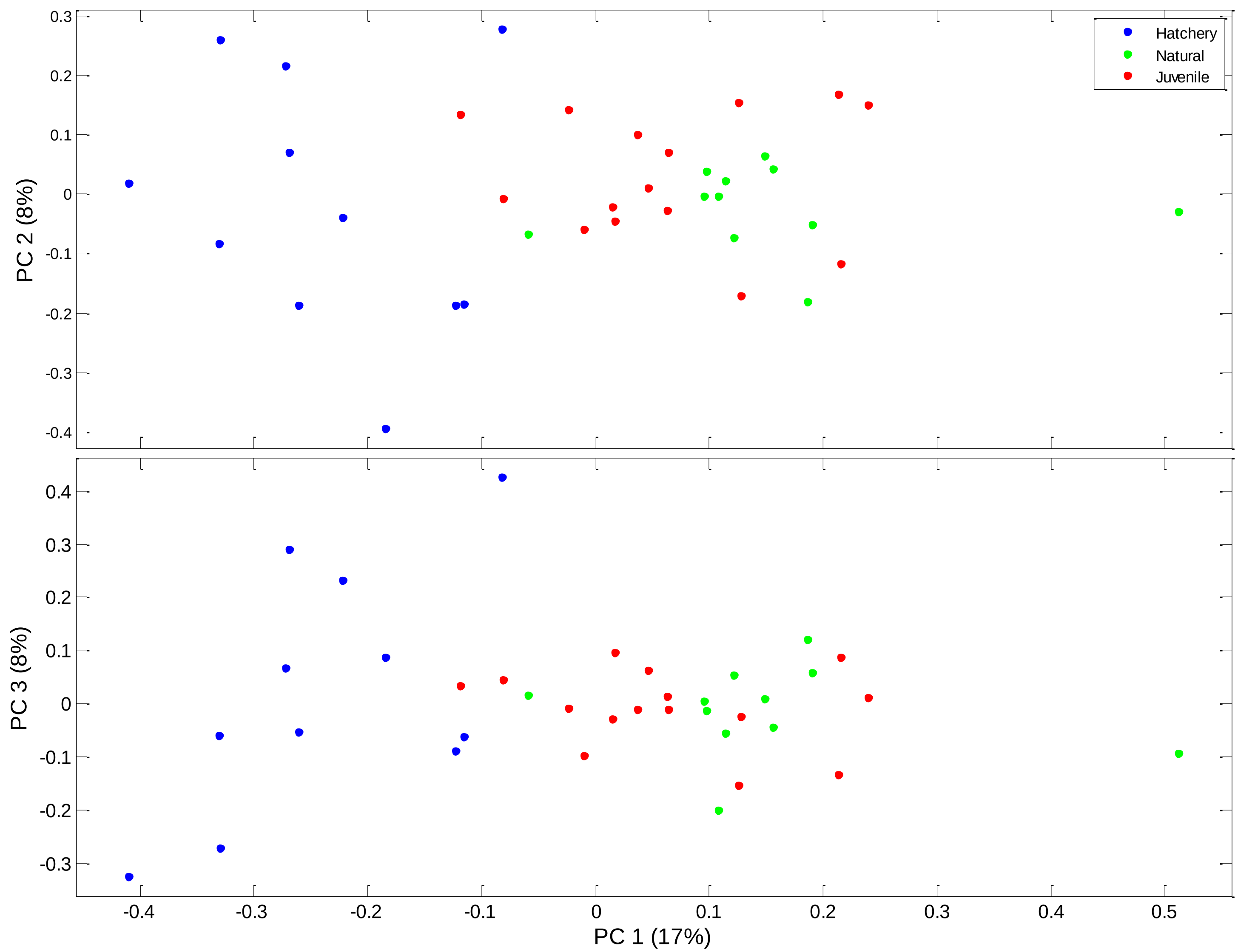


Figure 7. Pairwise Euclidian distances versus brood-year (top) and spawn-year (bottom), with zero distance equal to average distance across all pairwise distances. Blue lines are least-squares fits, which is not significant (slope = 0) for brood-year, but significant (slope > 0) for spawn-year.

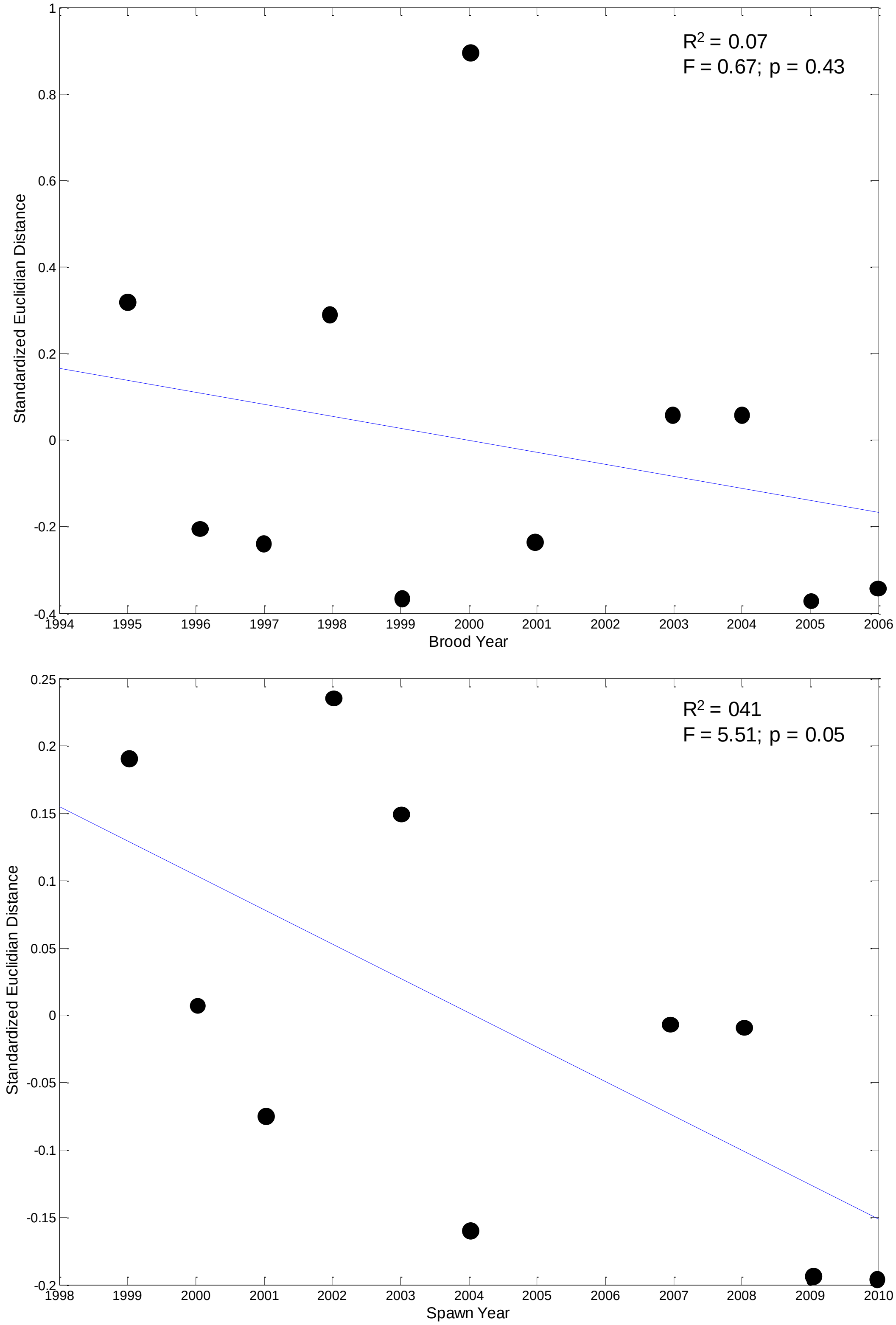


Figure 8. Effective population size estimates (N_b) from Wenatchee River adult hatchery-produced steelhead annual collections calculated using single sample methods implemented in the program LDNE (Waples and Do 2008). Each line connects annual estimates of N_b estimated with a different value of P_{crit}, the smallest allelic proportion allowed during analysis. With SNP data, omitting an allele omits the locus. Estimates of N_b changed very little when P_{crit} varied from 0.1 to 0.001. Setting P_{crit} = 0.001 forced the use of all available loci.

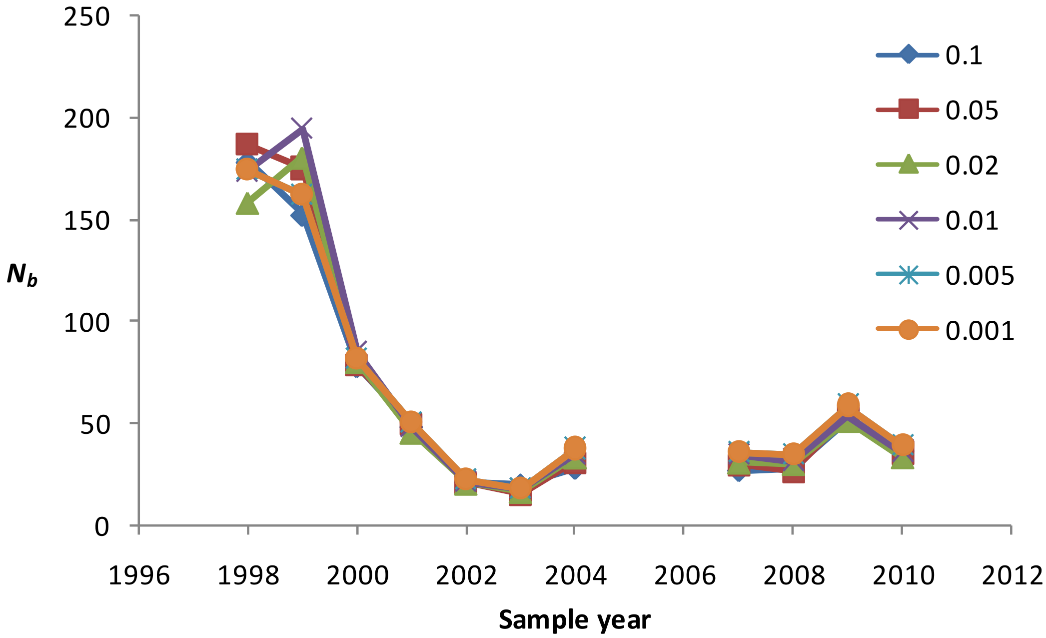


Figure 9. Estimates of Wenatchee River steelhead effective number of breeders (N_b) estimated using the single sample methods incorporated in the program LDNE (Waples and Do 2008). Estimates of N_b refer to parental (and even grantparental) generations. N_b data were plotted against their estimated parental brood year. We assumed a 5 year generation time for natural origin adults (NOR), a 4 year generation time for hatchery-produced adults (HOR) and an age of smolt outmigration of age 2 for smolt collections from Wenatchee River tributaries (Chiwawa River, Nason Creek, Peshastin Creek), the lower Wenatchee River, and the Entiat River. Bars represent the 95% confidence interval estimated by jackknife procedure. Bars that exceed the upper limit of the Y axis are labeled with the upper bound (Inf. = infinity).

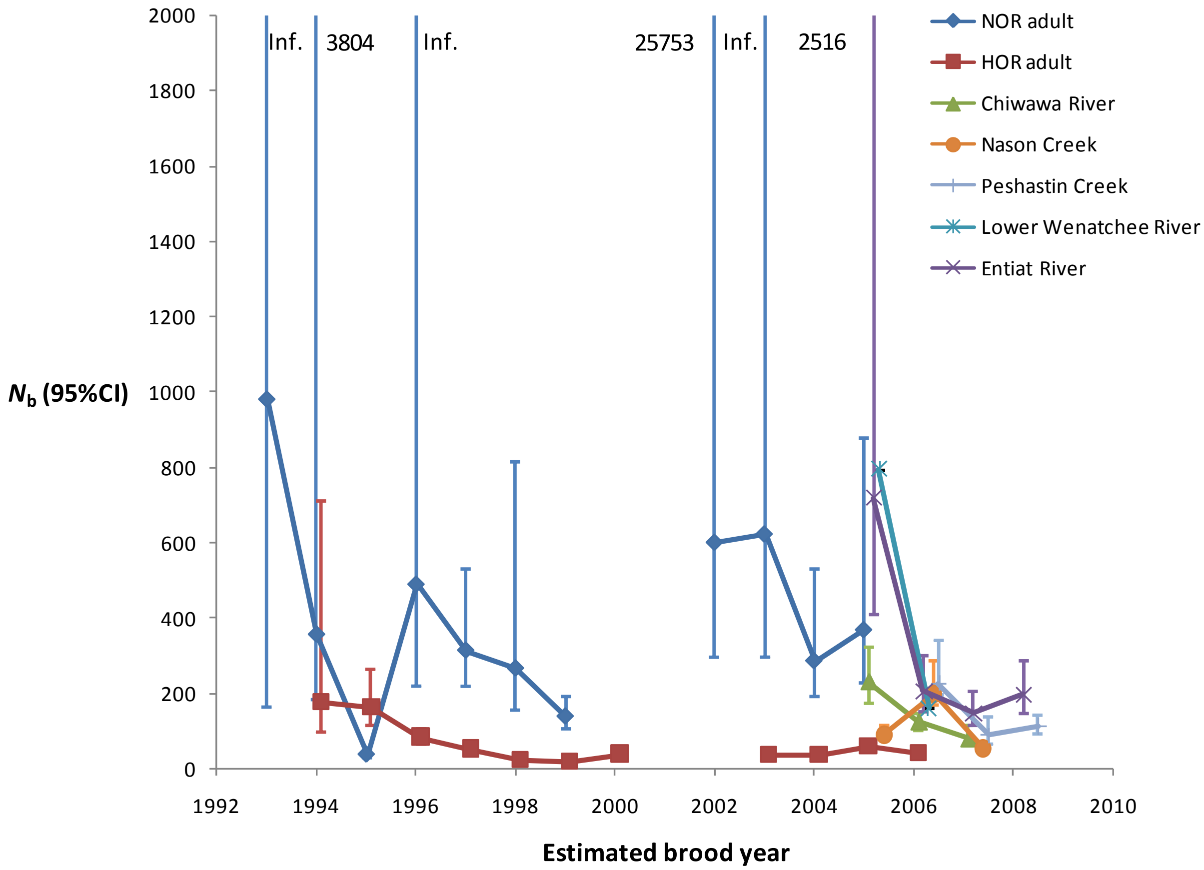


Figure 10. Estimates of N_b for collections of hatchery-produced (HOR) and natural origin (NOR) Wenatchee River summer steelhead grouped by brood year rather than spawn year. Brood year was estimated using scale-based age data. Error bars that extend past the top of the chart are all bounded by infinity.

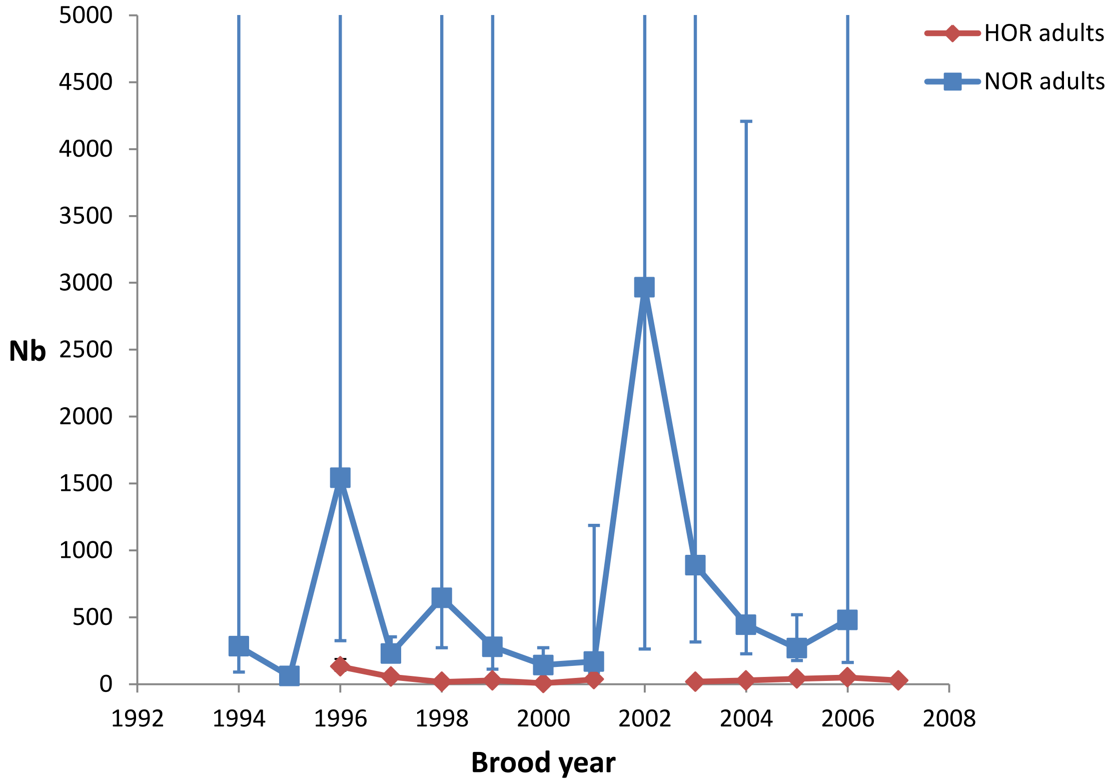


Figure 11. Estimates of N_b for combined annual adult hatchery-produced (HOR) and natural origin (NOR) steelhead and for HOR adults alone. The temporal patterns are similar, though estimates from combined collections are larger than those from HOR collections alone.

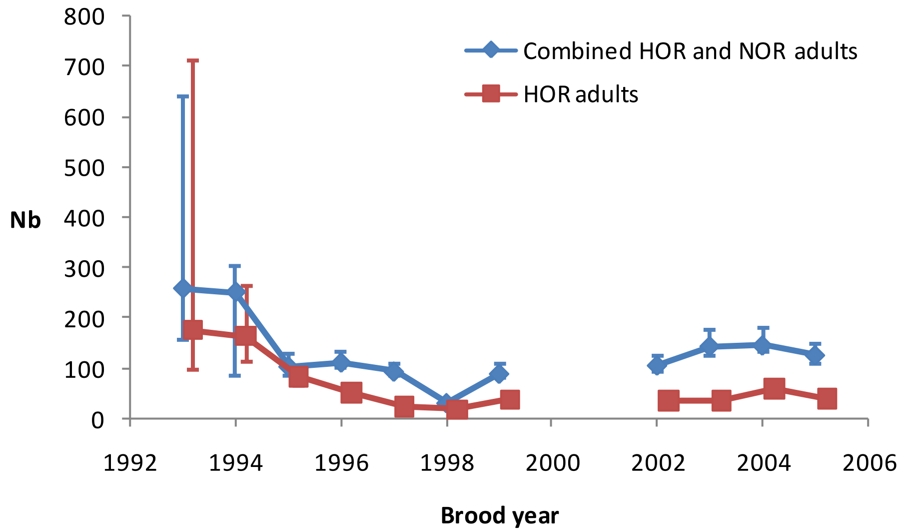


Figure 12. N_b/N ratios for hatchery-produced (HOR) and natural origin (NOR) adult Wenatchee River summer steelhead grouped by spawn year. The average N_b/N ratios are not different, though in later years NOR adults appear to have lower N_b/N ratios.

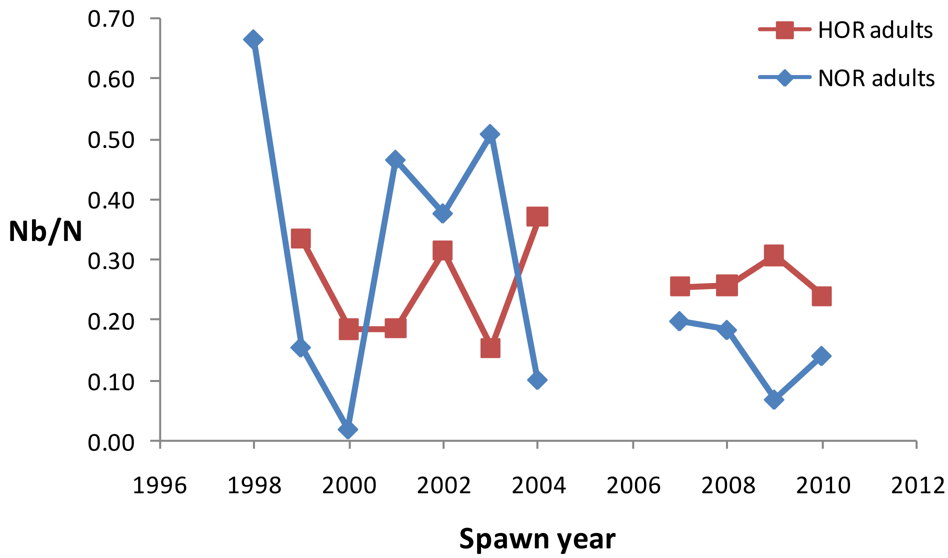
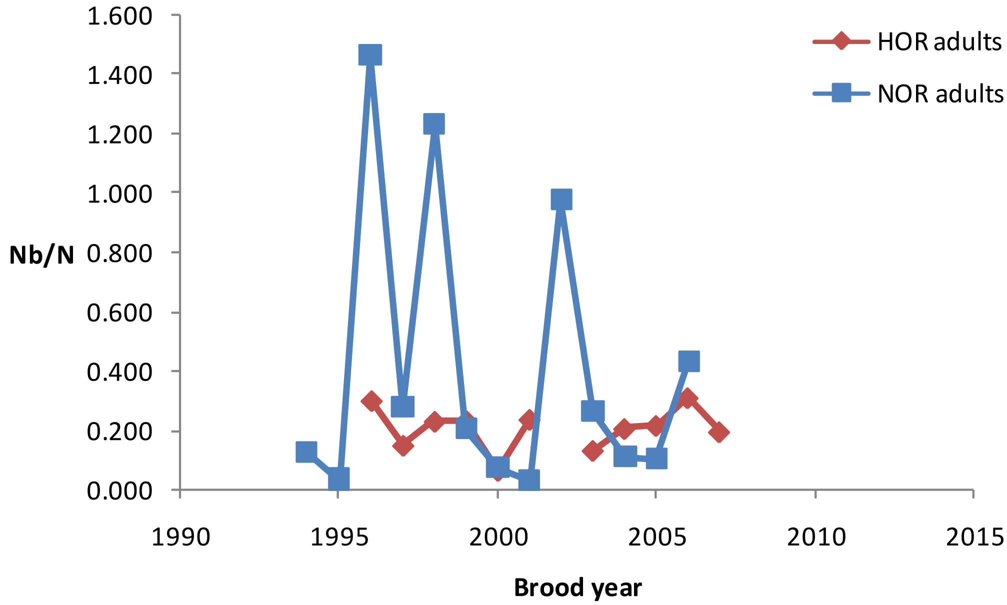


Figure 13. N_b/N ratios for hatchery-produced (HOR) and natural origin (NOR) adult Wenatchee River summer steelhead collections with individuals grouped in brood years rather than spawn years. Individual brood year was estimated using scale-based age data.



Tables

Table 1. Samples of adult steelhead collected for Wenatchee Program broodstock and used for genetic monitoring and evaluation.

Origin	Sampling Location	Year spawned	WDFW Collection code	Samples (N)	Unused Samples[a]
Hatchery	Dryden/Tumwater Dams	1998	98AE	32	4
		1999	98LJ	62	2
		2000	99NE	60	5
		2001	00DQ	99	1
		2002	01MS	64	
		2003	02NP	89	
		2004	03KW	61	
		2007	06CW	64	1
		2008	08AG	56	
		2009	09AV	74	
		2010	10FE	76	1
			Total	737	14
Natural	Dryden/Tumwater Dams	1998	98AF	30	5
		1999	99AA	51	1
		2000	99ND	33	3
		2001	00DP	50	
		2002	01MR	95	
		2003	02NO	50	
		2004	03KV	71	3
		2007	06CX	74	
		2008	08AF	74	1
		2009	09AU	82	2
		2010	10FD	90	2
			Total	700	17

[a]Samples were not used if they had incomplete (≤ 80% or 95 of 119 loci) or duplicate genotypes.

Table 2. Samples of natural origin juvenile steelhead and rainbow trout collected from four Wenatchee basin rivers or creeks and the Entiat River.

Sampling Location	Collection Year	WDFW Collection Code	Samples (N)	Unused samples[a]
Chiwawa River	2007	07AO	127	5
	2008	08CG	143	1
	2009	09NF	35	2
Entiat River	2007	07AL	134	4
	2008	08CI	82	4
	2009	09NC	74	1
	2010	10OX	82	1
Lower Wenatchee River	2007	07AM	139	5
	2008	08CE	98	2
Nason Creek	2007	07AN	81	4
	2008	08CF	133	6
	2009	09NG	103	2
Peshastin Creek	2008	08CH	142	2
	2009	09NE	34	1
	2010	10OY	94	1
		Total	1501	41

[a]Samples were not used if they were genetically identified as cutthroat trout or cutthroat/rainbow trout hybrids, or if they had incomplete (≤ 80% or 95 of 119 loci) or duplicate genotypes.

Table 3. List of 132 general use, diploid single nucleotide polymorphic (SNP) loci genotyped in Wenatchee River basin and Entiat River steelhead.

WDFW Name	Locus Name	Allele 1	Allele 2	Reference
AOmy005	Omy_aspAT-123	T	C	(Campbell et al. 2009)
AOmy014	Omy_e1-147	G	T	(Sprowles et al. 2006)
AOmy015	Omy_gdh-271	C	T	(Campbell et al. 2009)
AOmy016	Omy_GH1P1_2	C	T	(Aguilar and Garza 2008)
AOmy021	Omy_LDHB-2_e5	T	C	(Aguilar and Garza 2008)
AOmy023	Omy_MYC_2	T	C	(Aguilar and Garza 2008)
AOmy027	Omy_nkef-241	C	A	(Campbell et al. 2009)
AOmy028	Omy_nramp-146	G	A	(Campbell et al. 2009)
AOmy047	Omy_u07-79-166	G	T	WDFW - S. Young unpubl.
AOmy051	Omy_121713-115	T	A	(Abadía-Cardoso et al. 2011)
AOmy056	Omy_128693-455	T	C	(Abadía-Cardoso et al. 2011)
AOmy059	Omy_187760-385	A	T	(Abadía-Cardoso et al. 2011)
AOmy061	Omy_96222-125	T	C	(Abadía-Cardoso et al. 2011)
AOmy062	Omy_97077-73	T	A	(Abadía-Cardoso et al. 2011)
AOmy063	Omy_97660-230	C	G	(Abadía-Cardoso et al. 2011)
AOmy065	Omy_97954-618	C	T	(Abadía-Cardoso et al. 2011)
AOmy067	Omy_aromat-280	A	T	WSU - J. DeKoning unpubl.
AOmy068	Omy_arp-630	G	A	(Campbell et al. 2009)
AOmy071	Omy_cd59-206	C	T	WSU - J. DeKoning unpubl.
AOmy073	Omy_colla1-525	C	T	WSU - J. DeKoning unpubl.
AOmy079	Omy_g12-82	T	C	WSU - J. DeKoning unpubl.
AOmy081	Omy_gh-475	C	T	(Campbell et al. 2009)
AOmy082	Omy_gsdf-291	T	C	WSU - J. DeKoning unpubl.
AOmy089	Omy_hsp90BA-193	C	T	(Campbell and Narum 2009)
AOmy094	Omy_inos-97	C	A	WSU - J. DeKoning unpubl.
AOmy095	Omy_mapK3-103	A	T	CRITFC - N. Campbell unpubl.
AOmy096	Omy_mcsf-268	T	C	WSU - J. DeKoning unpubl.
AOmy100	Omy_nach-200	A	T	WSU - J. DeKoning unpubl.

AOmy107	Omy_Ots249-227	C	T	(Campbell et al. 2009)
AOmy108	Omy_oxct-85	A	T	WSU - J. DeKoning unpubl.
AOmy110	Omy_star-206	A	G	WSU - J. DeKoning unpubl.
AOmy111	Omy_stat3-273	G	Deletion	WSU - J. DeKoning unpubl.
AOmy113	Omy_tlr3-377	C	T	WSU - J. DeKoning unpubl.
AOmy117	Omy_u09-52-284	T	G	WDFW - S. Young unpubl.
AOmy118	Omy_u09-53-469	T	C	WDFW - S. Young unpubl.
AOmy120	Omy_u09-54.311	C	T	WDFW - S. Young unpubl.
AOmy123	Omy_u09-55-233	A	G	WDFW - S. Young unpubl.
AOmy125	Omy_u09-56-119	T	C	WDFW - S. Young unpubl.
AOmy129	Omy_BAMBI4.238	T	C	WDFW - S. Young unpubl.
AOmy132	Omy_G3PD_2.246	C	T	WDFW - S. Young unpubl.
AOmy134	Omy_Il-1b-028	T	C	WDFW - S. Young unpubl.
AOmy137	Omy_u09-61.043	A	T	WDFW - S. Young unpubl.
AOmy151	Omy_p53-262	T	A	CRITFC - N. Campbell unpubl.
AOmy173	BH2VHSVip10	C	T	Pascal & Hansen unpubl.
AOmy174	OMS00003	T	G	(Sánchez et al. 2009)
AOmy176	OMS00013	A	G	(Sánchez et al. 2009)
AOmy177	OMS00018	T	G	(Sánchez et al. 2009)
AOmy179	OMS00041	G	C	(Sánchez et al. 2009)
AOmy181	OMS00052	T	G	(Sánchez et al. 2009)
AOmy182	OMS00053	T	C	(Sánchez et al. 2009)
AOmy183	OMS00056	T	C	(Sánchez et al. 2009)
AOmy184	OMS00057	T	G	(Sánchez et al. 2009)
AOmy185	OMS00061	T	C	(Sánchez et al. 2009)
AOmy186	OMS00062	T	C	(Sánchez et al. 2009)
AOmy187	OMS00064	T	G	(Sánchez et al. 2009)
AOmy189	OMS00071	A	G	(Sánchez et al. 2009)
AOmy190	OMS00072	A	G	(Sánchez et al. 2009)
AOmy191	OMS00078	T	C	(Sánchez et al. 2009)
AOmy192	OMS00087	A	G	(Sánchez et al. 2009)

AOmy193	OMS00089	A	G	(Sánchez et al. 2009)
AOmy194	OMS00090	T	C	(Sánchez et al. 2009)
AOmy195	OMS00092	A	C	(Sánchez et al. 2009)
AOmy196	OMS00094	T	G	(Sánchez et al. 2009)
AOmy197	OMS00103	A	T	(Sánchez et al. 2009)
AOmy198	OMS00105	T	G	(Sánchez et al. 2009)
AOmy199	OMS00112	A	T	(Sánchez et al. 2009)
AOmy200	OMS00116	T	A	(Sánchez et al. 2009)
AOmy201	OMS00118	T	G	(Sánchez et al. 2009)
AOmy202	OMS00119	A	T	(Sánchez et al. 2009)
AOmy203	OMS00120	A	G	(Sánchez et al. 2009)
AOmy204	OMS00121	T	C	(Sánchez et al. 2009)
AOmy205	OMS00127	T	G	(Sánchez et al. 2009)
AOmy206	OMS00128	T	G	(Sánchez et al. 2009)
AOmy207	OMS00132	A	T	(Sánchez et al. 2009)
AOmy208	OMS00133	A	G	(Sánchez et al. 2009)
AOmy209	OMS00134	A	G	(Sánchez et al. 2009)
AOmy210	OMS00153	T	G	(Sánchez et al. 2009)
AOmy211	OMS00154	A	T	(Sánchez et al. 2009)
AOmy212	OMS00156	A	T	(Sánchez et al. 2009)
AOmy213	OMS00164	T	G	(Sánchez et al. 2009)
AOmy215	OMS00175	T	C	(Sánchez et al. 2009)
AOmy216	OMS00176	T	G	(Sánchez et al. 2009)
AOmy218	OMS00180	T	G	(Sánchez et al. 2009)
AOmy220	Omy_1004	A	T	(Hansen et al. 2011)
AOmy221	Omy_101554-306	T	C	(Abadía-Cardoso et al. 2011)
AOmy222	Omy_101832-195	A	C	(Abadía-Cardoso et al. 2011)
AOmy223	Omy_101993-189	A	T	(Abadía-Cardoso et al. 2011)
AOmy225	Omy_102505-102	A	G	(Abadía-Cardoso et al. 2011)
AOmy226	Omy_102867-443	T	G	(Abadía-Cardoso et al. 2011)
AOmy227	Omy_103705-558	T	C	(Abadía-Cardoso et al. 2011)

AOmy228	Omy_104519-624	T	C	(Abadía-Cardoso et al. 2011)
AOmy229	Omy_104569-114	A	C	(Abadía-Cardoso et al. 2011)
AOmy230	Omy_105075-162	T	G	(Abadía-Cardoso et al. 2011)
AOmy231	Omy_105385-406	T	C	(Abadía-Cardoso et al. 2011)
AOmy232	Omy_105714-265	C	T	(Abadía-Cardoso et al. 2011)
AOmy233	Omy_107031-704	C	T	(Abadía-Cardoso et al. 2011)
AOmy234	Omy_107285-69	C	G	(Abadía-Cardoso et al. 2011)
AOmy235	Omy_107336-170	C	G	(Abadía-Cardoso et al. 2011)
AOmy238	Omy_108007-193	A	G	(Abadía-Cardoso et al. 2011)
AOmy239	Omy_109243-222	A	C	(Abadía-Cardoso et al. 2011)
AOmy240	Omy_109525-403	A	G	(Abadía-Cardoso et al. 2011)
AOmy241	Omy_110064-419	T	G	(Abadía-Cardoso et al. 2011)
AOmy242	Omy_110078-294	A	G	(Abadía-Cardoso et al. 2011)
AOmy243	Omy_110362-585	G	A	(Abadía-Cardoso et al. 2011)
AOmy244	Omy_110689-148	A	C	(Abadía-Cardoso et al. 2011)
AOmy245	Omy_111005-159	C	T	(Abadía-Cardoso et al. 2011)
AOmy246	Omy_111084-526	A	C	(Abadía-Cardoso et al. 2011)
AOmy247	Omy_111383-51	C	T	(Abadía-Cardoso et al. 2011)
AOmy248	Omy_111666-301	T	A	(Abadía-Cardoso et al. 2011)
AOmy249	Omy_112301-202	T	G	(Abadía-Cardoso et al. 2011)
AOmy250	Omy_112820-82	G	A	(Abadía-Cardoso et al. 2011)
AOmy252	Omy_114976-223	T	G	(Abadía-Cardoso et al. 2011)
AOmy253	Omy_116733-349	C	T	(Abadía-Cardoso et al. 2011)
AOmy254	Omy_116938-264	A	G	(Abadía-Cardoso et al. 2011)
AOmy255	Omy_117259-96	T	C	(Abadía-Cardoso et al. 2011)
AOmy256	Omy_117286-374	A	T	(Abadía-Cardoso et al. 2011)
AOmy257	Omy_117370-400	A	G	(Abadía-Cardoso et al. 2011)
AOmy258	Omy_117540-259	T	G	(Abadía-Cardoso et al. 2011)
AOmy260	Omy_117815-81	C	T	(Abadía-Cardoso et al. 2011)
AOmy261	Omy_118175-396	T	A	(Abadía-Cardoso et al. 2011)
AOmy262	Omy_118205-116	A	G	(Abadía-Cardoso et al. 2011)

AOmy263	Omy_118654-91	A	G	(Abadía-Cardoso et al. 2011)
AOmy265	Omy_120255-332	A	T	(Abadía-Cardoso et al. 2011)
AOmy266	Omy_128996-481	T	G	(Abadía-Cardoso et al. 2011)
AOmy267	Omy_129870-756	C	T	(Abadía-Cardoso et al. 2011)
AOmy268	Omy_131460-646	C	T	(Abadía-Cardoso et al. 2011)
AOmy269	Omy_98683-165	A	C	(Abadía-Cardoso et al. 2011)
AOmy270	Omy_cyp17-153	C	T	WSU - J. DeKoning unpubl.
AOmy271	Omy_ftzf1-217	A	T	WSU - J. DeKoning unpubl.
AOmy272	Omy_GHSR-121	T	C	CRITFC - N. Campbell unpubl.
AOmy273	Omy_metA-161	T	G	CRITFC - N. Campbell unpubl.
AOmy274	Omy_UBA3b	A	T	(Hansen et al. 2011)

Primer and probe sequences for unpublished loci available by request.

Table 4. List of 20 species identification single nucleotide polymorphic (SNP) loci genotyped in Wenatchee River basin and Entiat River steelhead.

		Expected genotype			
WDFW Name	Locus Name	*O. mykiss*	*O. clarkii clarkii*	*O. clarkii lewisi*	Reference
ASpI001	Ocl_Okerca	T	C	C	(McGlauflin et al. 2010)
ASpI002	Ocl_Oku202	A	C	C	(McGlauflin et al. 2010)
ASpI003	Ocl_Oku211	G	T	T	(McGlauflin et al. 2010)
ASpI004	Ocl_Oku216	C	C	A	(McGlauflin et al. 2010)
ASpI005	Ocl_Oku217	C	C	A	(McGlauflin et al. 2010)
ASpI006	Ocl_SsaHM5	A	A	G	(McGlauflin et al. 2010)
ASpI007	Ocl_u800	T	C	C	(McGlauflin et al. 2010)
ASpI008	Ocl_u801	A	T	T	(McGlauflin et al. 2010)
ASpI009	Ocl_u802	C	C	T	(McGlauflin et al. 2010)
ASpI010	Ocl_u803	C	T	T	(McGlauflin et al. 2010)
ASpI011	Ocl_u804	G	G	C	(McGlauflin et al. 2010)
ASpI012	Omy_B9_228	A	A	C	(Finger et al. 2009)
ASpI013	Omy_CTDL1_243	C	A	A	(Finger et al. 2009)
ASpI014	Omy_F5_136	C	G	G	(Finger et al. 2009)
ASpI016	Omy_myclarp404-111	T	G	G	CRITFC - S. Narum - unpubl.
ASpI017	Omy_myclgh1043-156	C	T	T	CRITFC - S. Narum - unpubl.
ASpI018	Omy_Omyclmk436-96	A	C	C	CRITFC - S. Narum - unpubl.
ASpI019	Omy_RAG11_280	T	A	A	(Sprowles et al. 2006)
ASpI020	Omy_URO_302	T	C	C	(Finger et al. 2009)
ASpI021	Omy_BAC-F5.238	C	G	G	WDFW - S. Young unpubl.

Primer and probe sequences for unpublished loci available by request.

Table 5. Pairwise F_{ST} estimates for collections from Wenatchee River tributaries and the Entiat River (below diagonal) and associated bootstrap estimated *P*-values (above diagonal).

		Chiwawa River			Nason Creek			Peshastin Creek			Lower Wenatchee River		Entiat River			
Population	Year	2007	2008	2009	2007	2008	2009	2008	2009	2010	2007	2008	2007	2008	2009	2010
Chiwawa	2007		**0.000**	**0.003**	**0.000**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.001**	**0.001**	**0.000**	**0.001**	**0.000**	**0.000**
River	2008	0.004		**0.004**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
	2009	0.004	0.003		**0.000**	**0.001**	0.061	**0.000**	**0.001**	**0.000**	0.086	**0.050**	**0.022**	0.108	**0.005**	**0.045**
Nason	2007	0.011	0.010	0.007		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Creek	2008	0.007	0.007	0.005	0.009		**0.003**	**0.000**	**0.002**	**0.000**	0.079	**0.000**	**0.001**	**0.000**	**0.000**	**0.000**
	2009	0.007	0.007	0.003	0.014	0.006		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Peshastin	2008	0.010	0.011	0.008	0.013	0.010	0.013		**0.001**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Creek	2009	0.005	0.005	0.006	0.010	0.007	0.008	0.003		**0.002**	**0.002**	**0.047**	**0.028**	**0.004**	**0.005**	**0.001**
	2010	0.010	0.011	0.008	0.015	0.008	0.011	0.003	0.003		**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Lower Wenatchee	2007	0.003	0.003	0.000	0.005	0.008	0.007	0.009	0.010	0.008		0.112	**0.020**	**0.012**	**0.002**	**0.017**
River	2008	0.002	0.005	0.002	0.003	0.004	0.005	0.007	0.009	0.006	0.000		**0.049**	0.459	**0.047**	**0.002**
Entiat	2007	0.005	0.006	0.002	0.005	0.006	0.005	0.005	0.007	0.006	0.001	0.002		0.451	0.173	**0.000**
River	2008	0.004	0.004	0.000	0.007	0.005	0.007	0.008	0.009	0.011	0.002	0.001	0.000		0.644	**0.002**
	2009	0.005	0.006	0.002	0.003	-0.001	0.003	0.002	0.003	0.004	0.003	0.002	0.002	0.000		**0.028**
	2010	0.005	0.006	0.003	0.006	0.004	0.006	0.006	0.008	0.009	0.002	0.003	0.003	0.003	0.002	

P-values in bold were significant at $\alpha = 0.05$ after correcting for multiple tests using false discovery rate.

Appendix F

NPDES Hatchery Effluent Monitoring, 2011

NPDES MONITORING FOR WDFW FACILITIES

All WDFW hatcheries monitor their discharge in accordance with the National Pollutant Discharge Elimination System (NPDES) permit. This permit is administered in Washington by the Washington Department of Ecology under agreement with the United States Environmental Protection Agency. The permit was renewed effective June 1, 2005 and will expire June 1, 2010.

Facilities are exempted from sampling during any month that pounds of fish on hand fall below 20,000 lbs and pounds of feed used fall below 5,000 lbs, with the exception of offline settling basin discharges which are to be monitored once per month when ponds are in use and discharging to receiving waters.

Sampling at permitted facilities includes the following parameters:

<FLOW	Measured in millions of gallons per day (MGD) discharge.
<SS EFF	Average net settleable solids in the hatchery effluent, measured in ml/L.
<TSS COMP	Average net total suspended solids, composite sample (6 x/day) of the hatchery effluent, measured in mg/L.
<TSS MAX	Maximum daily net total suspended solids, composite sample (6 x/day) of the hatchery effluent, measured in mg/L.
<SS PA	Maximum settleable solids discharge from the pollution abatement pond, measured in ml/L.
<SS %	Removal of settleable solids within the pollution abatement pond from inlet to outlet, measured as a percent. No longer required under permit effective June 1, 2000.
<TSS PA	Maximum total suspended solids effluent grab from the pollution abatement pond discharge, measured in mg/L.
<TSS %	Removal of suspended solids within the pollution abatement pond from inlet to outlet, measured as a percent. No longer required under permit effective June 1, 2000.
<SS DD	Settleable solids discharged during drawdown for fish release. One sample per pond drawdown, measured in ml/L.
<TRC	Total residual chlorine discharge after rearing vessel disinfection and after neutralization with sodium thiosulfate. One sample per disinfection, measured in ug/L.

In addition, at Similkameen Hatchery only, the following sampling was conducted at the request of WA Dept of Ecology, but is not required under NPDES permit:

<SS IW	Settleable solids influent grab taken as wastes are pumped into the pollution abatement pond, measured in mg/L. No longer monitored as of January 2008.
<TSS IW	Total suspended solids influent grab as wastes are pumped into the pollution abatement pond, measured in mg/L. No longer monitored as of January 2008.

National Pollutant Discharge Elimination System (NPDES) Effluent Summary
for the period of January 1, 2011 through December 31, 2011
as reported on the Discharge Monitoring Reports (DMRs)
submitted to the Washington State Department of Ecology

Eastbank Hatchery
NPDES Permit Number WAG13-5011

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS PA	SS %	TSS PA	TSS %	Lbs of Fish	Lbs of Feed
2011	JAN	28.44	0	0.4	0.4	12000	0.01		8.6		84243	22682
	FEB	29.08	0	0.2	0.2	10500	0.01		34.6		109171	22401
	MAR	19.44	0	0.4	0.4	7500	0.01		23.4		82868	12230
	APR	14.52	0	0.3	0.6	15000	0		13.4		50278	2123
	MAY	11.41	0	0	0	7000	0		7.2		11665	5685
	JUN	20.7	0	1.6	1.6	15000	0.1		67.3		19827	6607
	JUL	27.14	0	0.4	0.4	7000	0.01		19.8		27796	7601
	AUG	27.79	0	0.6	0.6	15000	0.01		62		37282	12676
	SEP	28.44	0	0.2	0.2	15000	0.01		21.2		49736	11489
	OCT	28.89	0	0.65	1.3	15000	0.01		12		50498	11012
	NOV	27.79	0	0	0	12000	0.01		23.8		37282	12676
	DEC	28.44	0	1.4	1.4	7000	0.01		19.2		49736	11489

Turtle Rock
NPDES Permit Number WAG13-5004

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	18	0	-0.2	-0.2	53574	5027		
	FEB	18	0	-0.2	-0.2	60210	3514		
	MAR	18	0	0.6	0.6	64089	3916		
	APR	13.96	0	0	0	64072	5784		
	MAY	7.03	0	3	3	4271	0	0.1	6
	JUN	No Monitoring				0	0		
	JUL	No Monitoring				0	0		
	AUG	No Monitoring				0	0		
	SEP	No Monitoring				0	0		
	OCT	No Monitoring				0	0		
	NOV	No Monitoring				0	0		
	DEC	No Monitoring				0	0		

Wells Hatchery
NPDES Permit Number WAG13-5009

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS PA	SS %	TSS PA	TSS %	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	15.5	0	0.4	0.4	*	*		*		100949	17683		
	FEB	16.5	0	0.2	0.2	*	*		*		117150	17088		
	MAR	19.5	0	0.6	0.6	*	*		*		153208	17272		
	APR	21.9	0	0.8	0.8	*	*		*		137225	8357		
	MAY	37.3	0	0	0	*	*		*		4304	4819	0	0.15
	JUN	4.2	0	0	0	495	0		6.2		6390	2707		
	JUL	8.1	0	0.4	0.4	495	0		1.2		9354	4003		
	AUG	9.2	0	0	0	495	0		0.8		18406	6780		
	SEP	9	0	0.8	0.8	495	0		4		29955	8231		
	OCT	9.6	0	0.2	0.2	495	0		1.6		42196	11926		
	NOV	12.9	0	0	0	495	0		0.4		54573	12851		
	DEC	18.1	0	0	0	*	*		*		69745	12715		

* PA pond - No discharge this month

Chiwawa Ponds - Chiwawa River
NPDES Permit Number WAG13-5015

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	8.15	0	-0.6	-0.6	45584	660		
	FEB	8.6	0	-1.2	-1.2	40601	1034		
	MAR	8.45	0	0	0	40384	1430		
	APR	8.93	0	-2.2	-2.2	44910	6336		
	MAY	9.3	0	-0.4	-0.4	26798	0		
	JUN	No Monitoring				0	0		
	JUL	No Monitoring				0	0		
	AUG	No Monitoring				0	0		
	SEP	No Monitoring				0	0		
	OCT	4.75	0	-0.8	-0.8	17000	1980		
	NOV	4.65	0	-0.4	-0.4	15810	949		
	DEC	4.53	0	1.2	1.2	19044	1108		

Chiwawa Ponds - Wenatchee River
NPDES Permit Number WAG13-5015

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	No Monitoring							
	FEB	No Monitoring							
	MAR	No Monitoring							
	APR	No Monitoring							
	MAY	No Monitoring							
	JUN	No Monitoring							
	JUL	No Monitoring							
	AUG	No Monitoring							
	SEP	No Monitoring							
	OCT					2580	86		
	NOV					3368	894		
	DEC	7.77	0	1.2	1.2	8846	1185		

Carlton Acclimation Pond
NPDES Permit Number WAG13-5013

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	No Monitoring				0	0		
	FEB	10.08	-0.05	-2.4	-2.4	45555	2900		
	MAR	10.08	0	1.3	1.6	46000	3200	0.1	0.2
	APR	No Monitoring				0	0		
	MAY	No Monitoring				0	0		
	JUN	No Monitoring				0	0		
	JUL	No Monitoring				0	0		
	AUG	No Monitoring				0	0		
	SEP	No Monitoring				0	0		
	OCT	No Monitoring				0	0		
	NOV	No Monitoring				0	0		
	DEC	No Monitoring				0	0		

Methow Hatchery
NPDES Permit Number WAG13-5000

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS PA	SS %	TSS PA	TSS %	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	11.52	0	-1	-1	14400	0.1		3.4		20531	2800		
	FEB	10.83	0	0.6	0.6	14400	0.1		2.4		25354	3600		
	MAR	8.85	0	0.4	0.4	14400	0.1		9.6		31700	5100		
	APR	11.52	0	-0.8	-0.8	14400	0.1		0		21100	2800	0.5	0
	MAY	4.6	0	0.3	0.6	14400	0.1		2.4		4100	900		
	JUN	6.48	0	0	0	14400	0.1		2.2		6400	1500		
	JUL	6.48	0	-3.2	-3.2	14400	0		5.4		8000	1500		
	AUG	6.48	0	0.2	0.2	14400	0.1		20.2		10500	2900		
	SEP	6.48	0	1.2	1.2	14400	0.1		1.6		11300	2500		
	OCT	10.02	0	0.2	0.02	14400	0.1		5.8		13800	2800		
	NOV	6.48	0	0.2	0.2	14400	0.1		4.4		15000	2300		
	DEC	15.1	0	-0.3	-0.2	14400	0.1		6.2		11300	2500		

Similkameen Hatchery
NPDES Permit Number WAG13-5007

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS IW	TSS IW	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	5.9	0	-1.2	-1.2				20865	0		
	FEB	5.9	0	-1.6	-1.6				22138	0		
	MAR	11.5	0	-9.8	-9.8				26621	5566		
	APR	11.7	0	-1.6	-1.6				32303	7392		
	MAY	11.7	0	-0.8	0.2				34107	66	0.01	13.8
	JUN	No Monitoring							0	0		
	JUL	No Monitoring							0	0		
	AUG	No Monitoring							0	0		
	SEP	No Monitoring							0	0		
	OCT	5.7	0	1	1				25127	748		
	NOV	5.7	0	0.2	0.2				20855	616		
	DEC	5.7	0	0.5	1.2				18210	0		

Chelan Hatchery
NPDES Permit Number WAG13-5006

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS PA	SS %	TSS PA	TSS %	Lbs of Fish	Lbs of Feed
2011	JAN	7.76	0.05	4.9	4.9	6984000	0.05		1.8		25202	7745
	FEB	6.4	0.05	1.6	1.6	6984000	0.05		3.8		36393	10166
	MAR	8.39	0.05	3.8	3.8	6984000	0.05		10.2		47061	17525
	APR	12.85	0.05	2	2	10180800	0.05		5.7		29722	16348
	MAY	6.8	0.05	*5.4	5.4	5510230	0.05		2.8		6760	7091
	JUN	8.4	0.05	2.4	2.4	8426880	0.05		2.6		11830	4009
	JUL	8.5	0.05	3.4	3.4	8461440	0.05		4.4		16632	5242
	AUG	10.4	0.05	2.6	2.6	10447200	0.05		2.6		19687	14488
	SEP	7.5	0.05	3.8	3.8	7555680	0.05		3.8		25137	16740
	OCT	5.1	0.05	0.8	0.8	68000	0.01		3.2		18320	9139
	NOV	5.1	0.05	0.2	0.2	68000	0.01		2.8		16187	4108
	DEC	1.4	0.05	1.4	1.4	68000	0.01		4		12870	6008

*One violation reported.

Chelan Falls Hatchery
NPDES Permit Number WAG13-7019

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	FLOW PA	SS PA	SS %	TSS PA	TSS %	Lbs of Fish	Lbs of Feed
2011	JAN	No Monitoring									0	0
	FEB	No Monitoring									0	0
	MAR	No Monitoring									0	0
	APR	No Monitoring									0	0
	MAY	No Monitoring									0	0
	JUN	No Monitoring									0	0
	JUL	No Monitoring									0	0
	AUG	No Monitoring									0	0
	SEP	No Monitoring									0	0
	OCT	No Monitoring									0	0
	NOV	7.92	0	1.8	1.8						18667	22400
	DEC	7.92	0	-0.4	-0.4						7445	22400

Dryden Acclimation Pond
NPDES Permit Number WAG13-5014

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	No Monitoring				0	0		
	FEB	No Monitoring				0	0		
	MAR	14.83	-0.01	0.6	0.6	61606	3036		
	APR	20.88	-0.01	0.9	1.2	78211	11564	0.02	3.6
	MAY	No Monitoring				0	0		
	JUN	No Monitoring				0	0		
	JUL	No Monitoring				0	0		
	AUG	No Monitoring				0	0		
	SEP	No Monitoring				0	0		
	OCT	No Monitoring				0	0		
	NOV	No Monitoring				0	0		
	DEC	No Monitoring				0	0		

Priest Rapids
NPDES Permit Number WAG13-7013

YEAR	MONTH	FLOW	SS EFF	TSS COMP	TSS MAX	Lbs of Fish	Lbs of Feed	SS DD	TSS DD
2011	JAN	45.2	0			0	0		
	FEB	45.3	0	-0.4	-0.4	2746	881		
	MAR	25.3	0	0.6	0.6	12541	7659		
	APR	26.65	0	2.2	2.6	36170	14640		
	MAY	39.4	0	-0.4	-0.4	97062	18126		
	JUN	58.2	0	-0.6	-0.6	128058	19262	0	3.84
	JUL	No Monitoring				0	0		
	AUG	No Monitoring				0	0		
	SEP	64.63	0	1.4	1.4	15255	0		
	OCT	64.63		-2.6	0.4	0	0		
	NOV	64.63		1.2	1.2	0	0		
	DEC	13.8	0			15255	0		

Appendix G

Steelhead Stock Assessment at Priest Rapids Dam, 2009-2010

Priest Rapids Dam 2009-2010 Adult Upper Columbia River Steelhead Run-Cycle Stock Assessment Report

Introduction

Upper Columbia River (UCR) steelhead stock assessment sampling at Priest Rapids Dam (PRD) is authorized through the Endangered Species Act (ESA) Section 10 Permit 1395 (NMFS 2003). Permit authorizations include interception and biological sampling of up to 10 percent of the UCR steelhead passing PRD to determine upriver population size, estimate hatchery to wild ratios, determine age class contribution and evaluate the need for managing hatchery steelhead consistent with ESA recovery objectives which include fully seeding spawning habitat with naturally produced UCR steelhead supplemented with artificially propagated enhancement steelhead (NMFS 2003).

Stock Assessment

The 2009 steelhead sampling at Priest Rapids Dam began 16 July and concluded 15 October. Sampling consisted of operating the Priest Rapids Off Ladder Trap (OLAFT), located on the left bank Priest Rapids Dam, 8 hours per day, on Tuesdays and Thursdays, for a total of 27 sampling days. Steelhead were trapped, handled and released in accordance with Section 2.1 and 2.2.1 of the National Marine Fisheries Service (NMFS) Biological Opinion for ESA Permit 1395 (NMFS 2003). The cumulative sample rate attained during 2009 totaled 8.1% with one steelhead mortality observed (the fish was found dead the following morning in the release chamber).

The Washington Department of Fish and Wildlife (WDFW) sampled 3,243 steelhead from the 2009/2010 run-cycle passing PRD, totaling 39,996 steelhead, for an overall sampling rate of 8.1%. Of the 3,243 steelhead sampled, 2,639 (81.4%) were hatchery origin and 604 (18.6%) were wild origin. The estimated 2009-2010 run- cycle total wild steelhead return was 7,439 representing 327.7% of the 1986-2008 average and about 267.3% of the recent 5-year average (Table 1).

Based on external marks and external and internal tags, 2,639 hatchery origin steelhead sampled at Priest Rapids Dam during the 2009 return cycle included, 18.3% Wenatchee hatchery-origin steelhead and 68.3% "above Wells Dam" hatchery origin steelhead [1/] (Table 2)., while 9.3% of the hatchery origin steelhead sampled could not be assigned to a specific hatchery program. Ringold FH origin steelhead represented about 4.1% of the sample (Table 2).

1/- Defined as "above Wells Dam" because hatchery origin, adipose-clipped steelhead release into the Methow River from the Wells FH and Winthrop NFH have the same marks and are indistinguishable for one another.

Table 1. Priest Rapids Dam adult steelhead returns and stock composition, 1974-2009

Run-cycle[1/]	Hatchery	Wild	Wild percent	Total run
1974				2,950
1975				2,560
1976				9,490
1977				9,630
1978				4,510
1979				8,710
1980				8,290
1981				9,110
1982				10,770
1983				32,000
1984				26,200
1985				34,010
1986	20,022	2,342	10.5	22,364
1987	9,955	4,058	29.0	14,013
1988	7,530	2,670	26.2	10,200
1989	8,033	2,685	25.1	10,718
1990	6,252	1,585	20.2	7,837
1991	11,169	2,799	20.0	13,968
1992	12,102	1,618	11.8	13,720
1993	4,538	890	16.4	5,428
1994	5,880	855	12.7	6,735
1995	3,377	993	22.7	4,370
1996	7,757	843	9.8	8,600
1997	8,157	785	8.8	8,942
1998	4,919	928	15.9	5,847
1999	6,903	1,374	16.6	8,277
2000	9,023	2,341	20.6	11,364
2001	24,362	5,715	19.0	30,077
2002	12,884	2,983	18.8	15,867
2003	14,890	2,837	16.0	17,729
2004	15,670	2,985	16.0	18,655
2005	10,352	3,127	23.2	13,479
2006	8,738	1,677	16.1	10,415
2007	12,160	3,097	20.3	15,257
2008	13,528	3,030	18.3	16,558
2009	32,557	7,439	18.6	39,996
1986-2008 average	**10,357**	**2,270**	**17.8**	**12,627**
2004-2008 average	**12,090**	**2,783**	**18.7**	**14,873**

[1/] A return cycle is the combined total of steelhead passing PRD from 1 June – 30 November during year (x), plus steelhead passing PRD between 15 April and 31 May on year (x+1).

Table 2. Origin classification of steelhead sampled at Priest Rapids Dam, 16 July – 15 October 2009.

Steelhead origin																					
Wild			Hatchery																		
Wild			Wenatchee						Above Wells				Ringold FH			Unk. Hat.					
Criteria			VIE						Criteria				Criteria			Criteria			Total	Total	Total
NS	NM	Total	LTGR	RTGR	RTOR	RTPK	RTRD	Total	AD	LTYL	RTYL	Total	AD	RV	Total	SD	NM	Total	Wild	Hatchery	Total
x	x	604	x					230	x			1,782	x	x	108	x	x	245	604	2,639	3,243
				x				163		x		6									
					x			0			x	14									
						x		91													
							x	0													
Total		**604**						**484**				**1,802**			**108**			**245**	**604**	**2,639**	**3,243**
% Hatchery								**18.3**				**68.3**			**4.1**			**9.3**		**100.0**	
% Total		**18.6%**						**14.9**				**55.6**			**3.3**			**7.6**	**18.6**	**81.4**	**100.0**

Reconciliation of salt water age of wild and hatchery steelhead sampled at Priest Rapids Dam during 2009 was accomplished through scale sample analysis. Salt-age analysis of the 2009 UCR steelhead run-cycle provides an estimated hatchery-origin dominated by 1-salt fish (75.9%) followed by 2-salt age returns 26.3% (Table 3). Natural origin steelhead salt ages were 68.6% and 31.4% for salt ages 1 and 2, respectively. Three-salt age fish represented only 0.2% of the combined hatchery/wild sample (Table 3).

Table 3. Salt-water age composition of 2009 - 2010 return cycle Upper Columbia River steelhead sampled at Priest Rapids Dam, corrected by scale age/origin determination.

	Origin					
	Hatchery		Wild		Combined	
Salt-age	*N*	%	*N*	%	*N*	%
1-salt	922	75.9	411	68.6	1,333	73.5
2-salt	289	23.8	188	31.4	477	26.3
3-salt	4	0.3	-	-	4	0.2
4-salt	-	-	-	-	-	-
Total	**1,215**	**100**	**599**	**100**	**1,814**	**100**

Freshwater residency of naturally produced Upper Columbia River steelhead present in the 2009-2010 run cycle were dominated by age-2 freshwater fish (66.5%), and was moderately lower than the 1986-2008 average of 75.9% (Table 4).

Table 4. 2009 return year freshwater age of wild Upper Columbia River steelhead sampled at Priest Rapids Dam during steelhead stock assessment activities, compared to July – October 1986-2008 average.

Freshwater age	2009-2010 run cycle		1986-2008 proportion	
	N	%	*N*	%
1.x	81	14.3	237	7.1
2.x	376	66.5	2,545	75.9
3.x	102	18.1	547	16.3
4.x	6	1.1	20	0.6
5.x	-	-	2	<0.1
Total	**565**	**100**	**3,351**	**100**

Wild and hatchery origin steelhead exhibited similar saltwater growth in the 2009 run-cycle. Wild 1and 2-salt adults were slightly larger than their hatchery cohorts (Table 5). Age 1-salt hatchery and age 1 and 2-salt wild steelhead observed in the 2010-2011 adult run-cycle return past PRD were comparable in size to the 1986-2008 run-cycle average with 1-salt hatchery fish being most notably larger (Table 5).

Table 5. Average fork length of 1-salt and 2-salt, Upper Columbia River steelhead sampled at Priest Rapids Dam during July – October 2009 and the period between 1986-2008.

	Average fork length (cm)			
	2009-2010 run cycle		1986-2008 run cycle	
Salt age	Wild	Hatchery	Wild	Hatchery
x.1	60.6	60.0	60.3	58.6
x.2	72.2	71.4	72.5	71.3

Appendix H

Wenatchee Sockeye and Summer Chinook Spawning Ground Surveys, 2011

PUBLIC UTILITY DISTRICT NUMBER 1 OF CHELAN COUNTY
Natural Resource Division
Fish and Wildlife Department
327 N. Wenatchee Ave., Wenatchee WA 98801 (509) 663-8121

January 29, 2012

To: HCP Hatchery Committee

From: Lance Keller and Josh Murauskas

Subject: 2011 Wenatchee River Basin Summer Chinook and Sockeye Salmon Spawning Ground Surveys

Introduction

The Chelan County Public Utility District (District) has conducted or funded others to conduct intensive spawning ground surveys of spring and summer/fall (late run)[1] Chinook salmon (*Oncorhyncus tshawytscha*) and sockeye salmon (*O. nerka*) in river basins of the Columbia River upstream of Rock Island Dam. Summer/fall Chinook spawn in the entire mainstem of the Wenatchee River, from the mouth to the lake (Figure 1; Table 1). Sockeye spawn in the White and Little Wenatchee River basins (Figure 2).

The spawning surveys are performed yearly to assist in evaluating the effectiveness of the District's hatchery program. The purpose of this document is to report the results of the 2011 Chinook and sockeye salmon spawning ground surveys in the Wenatchee River basin. Information included in this document describes abundance, distribution, and timing of spawning activity.

[1] The majority of Chinook that ascend the mid-Columbia River as adults after July spawn between October and November in the mainstem of the Columbia, Wenatchee, Methow, Similkameen and Okanogan rivers. These fish have been called "summer" and "fall" Chinook based on their migration timing past the dams. Their life histories are identical (Mullan 1987), and should be termed "late-run" to separate them from earlier running "spring" Chinook that have a different life history. For consistency with previous year's reports, only the earlier segment of the late-run (those that ascend Rock Island Dam between June 24 and September 1; "summers") will be focused on in this report.

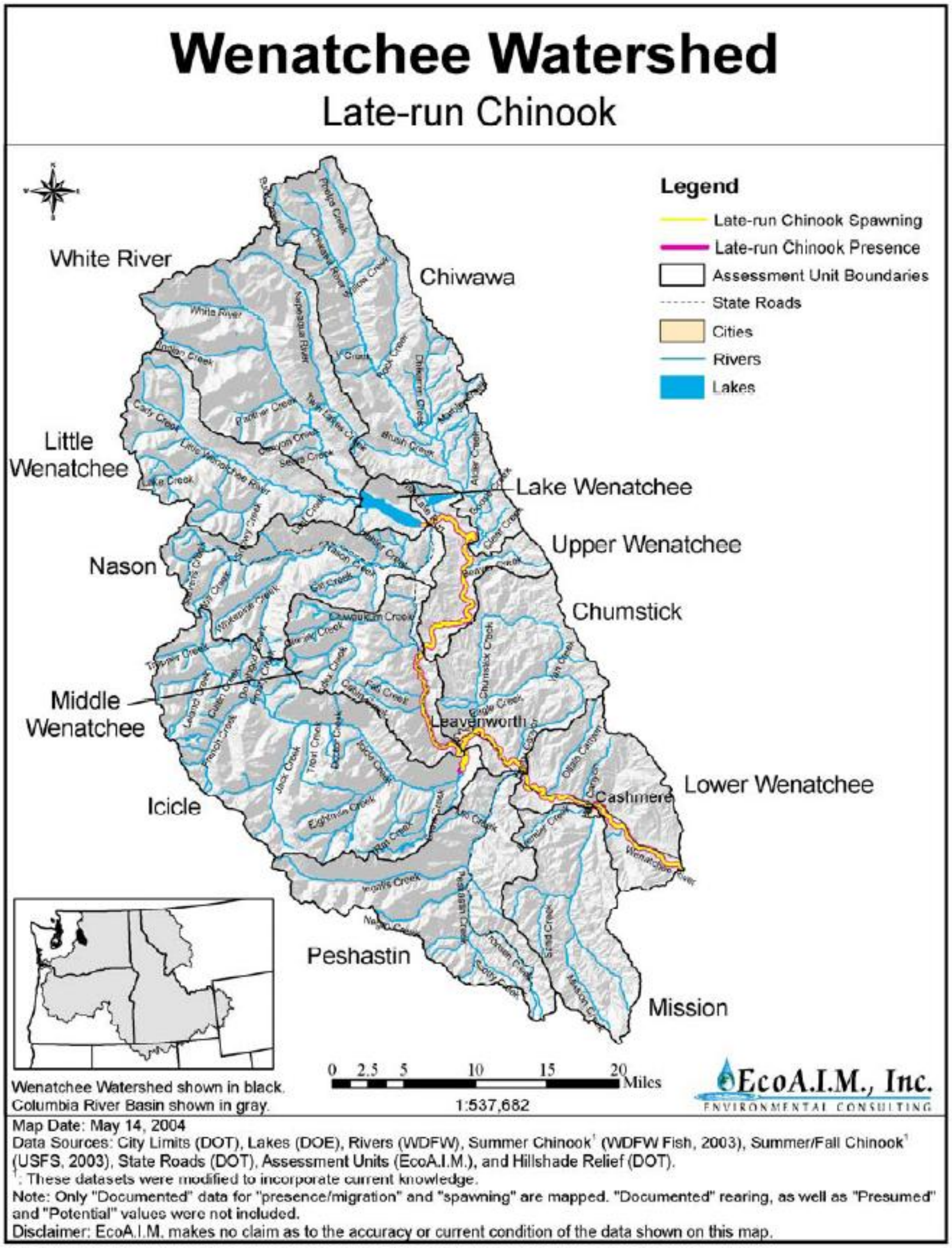


Figure 1. Map of the Wenatchee River Basin with spawning and migrational areas of late-run (summer/fall Chinook) areas highlighted (copied from the Wenatchee Sub basin Plan, NWPCC 2004).

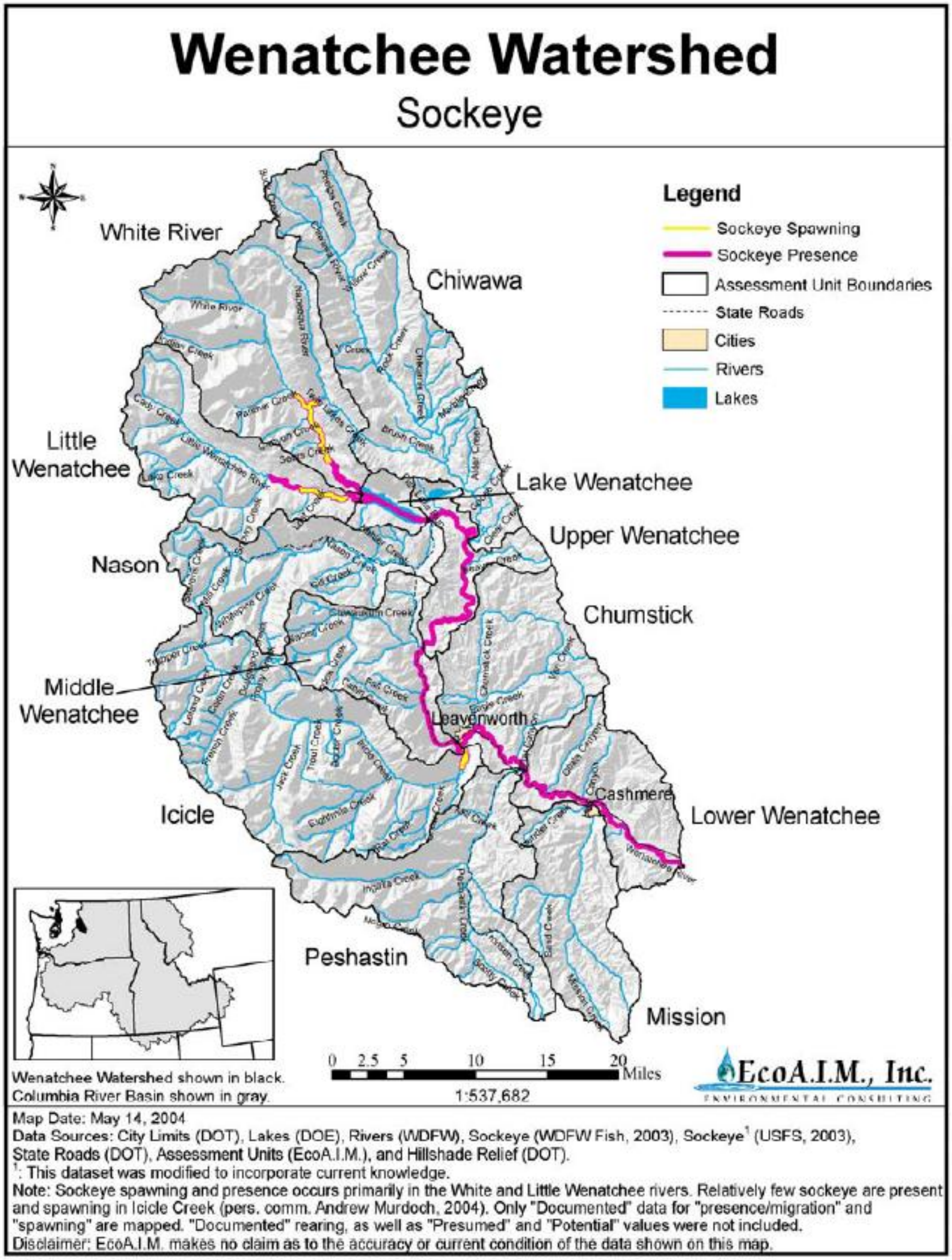


Figure 2. Map of the Wenatchee River Basin with spawning and migrational areas for sockeye highlighted (copied from the Wenatchee Sub basin Plan, NWPCC 2004).

Methods

In 2011, the study methodology was the same as used in 2010. In 2008, the summer Chinook spawning surveys were modified to incorporate additional mapping index areas in all ten river reach strata. Additionally, summer Chinook naïve counts were also performed in all river reach strata by the District. Previously, mapping index counts focused on six of the ten reaches and naïve counts were conducted solely by WDFW.

Chinook Spawning Ground Surveys

Chinook spawning ground surveys were conducted by foot, raft, or canoe. The most appropriate survey method was chosen for a given stream reach based on stream size, flow, and density of spawners. Because of the broad stream width and high spawner densities, individual summer Chinook redds were not flagged. Each reach was surveyed approximately once per week.

In 2011, summer Chinook spawning ground surveys occurred from September 19 to November 4.

Table 1. Designated survey reaches for spawning ground areas on the Wenatchee, Little Wenatchee, White, and Nepeequa rivers for all species.

Survey Section	River Mile
Wenatchee River-Summer Chinook	
Mouth to Sleepy Hollow Bridge	0 – 3.5
Sleepy Hollow Bridge to Lower Cashmere Bridge	3.5 – 9.5
Lower Cashmere Bridge to Dryden Dam	9.5 - 17.5
Dryden Dam to Peshastin Bridge	17.5 – 20.0
Peshastin Bridge to Leavenworth Bridge	20.0 – 23.9
Leavenworth Bridge to Icicle Road Bridge	23.9 – 26.4
Icicle Road Bridge to Tumwater Dam	26.4 – 30.9
Tumwater Dam to Tumwater Bridge	30.9 – 35.6
Tumwater Bridge to Chiwawa River	35.6 – 48.4
Chiwawa River to Lake Wenatchee	48.4 – 54.2
Little Wenatchee River-Sockeye	
Mouth to Old Fish Weir	0 – 2.7
Old Fish Weir to Lost Creek	2.7 – 5.2
Lost Creek to Rainey Creek	5.2 – 9.2
Rainey Creek to End	9.2 – End
White River-Sockeye	
Mouth to Sears Creek Bridge	0 – 6.4
Sears Creek Bridge to Napeequa River	6.4 – 11.0
Napeequa River to Grasshopper Meadows	11.0 – 12.9
Grasshopper Meadows to Falls	12.9 – 14.3
Napeequa River-Sockeye	
Mouth to End	0 - End

Peak and total redd count methodologies were used during the summer Chinook surveys in 2011 (see Appendix F of Murdoch and Peven (2005) for more detail). A peak count was conducted by counting all visible redds (new and old) observed within a reach on each survey. The objective of the peak redd count methodology was to capture the apex of spawning activity over an entire spawning season. This apex occurs at different times between reaches during the season, i.e. spawning begins sooner in the upstream reaches compared to the downstream reaches. The sum of all of the apex counts for the entire river was the peak redd count for the year. Peak counts provided an index of spawning and have been used historically (Attachment 1).

Two different approaches were used to estimate the total number of redds within the Wenatchee River. The first method used map counts to expand peak counts. Under this approach, a total redd count was conducted by counting or mapping only new or recently constructed redds within an area. Each new redd was mapped on aerial photos and enumerated. The objective of the total redd count methodology was to capture 1) "early" redds that may fade over time due to siltation or algae growth, and 2) redds that become disfigured by superimposition (when new redds are constructed on top of previously existing redds).

Since it was not feasible to map all new redds within the entire river, an expansion was used to estimate the total count for the entire Wenatchee River. To account for the different spawning substrate types in the main stem Wenatchee River, the river was delineated into ten distinct reaches in consultation with WDFW (Table 2). Within each of these reaches, index areas were identified as being representative areas of spawning activity. Peak counts were performed within each total reach (referred to as non-index areas), while mapping new redds only occurred within the index areas. An expansion was developed based on the ratio of mapped to peak counts for each reach (i.e., each reach had its own expansion factor), and the sum of the expanded counts was the estimate of the total redd counts. Additional details of how total redd counts were calculated are provided below.

a. Calculate an index peak expansion factor (*IP*) by dividing the peak number of redds in the index by the total number of redds (map count) in the index area.

$$IP = n_{peak} / n_{total}$$

b. Expand the non-index area peak redd counts by the *IP* to estimate the total number of redds in the entire reach (reach total; *RT*).

$$RT_{peak} = n_{peak} / IP$$

c. Estimate the total number of redds (total redds; *TR*) by summing the reach totals.

$$TR_{peak} = \sum RT$$

The second approach relied on a "naïve" count to expand redd numbers in reaches that did not have map counts. As noted above, the reaches with map counts were referred to as index reaches and those that were not mapped were called non-index reaches. Near the end of the spawning period (early November), one team of observers counted all visible redds within all non-index reaches. A separate, independent team counted all visible redds within the index reaches (these were the naïve counts). Surveys within the index and non-index areas occurred within one day of each other near the end of the spawning period. The naïve counts were divided by the total map count to estimate an index expansion factor. This factor was then applied to the total visible count in the non-index areas to estimate the total number of redds within each reach. The sum of the expanded counts was the estimate of the total redd count for the river. Additional details of how total numbers of redds are estimated using this approach are provided below.

a. Calculate an index expansion factor (*IF*) by dividing the number of visible redds in the index by the total number of redds (map counts) in the index area.

$$IF = n_{visible} / n_{total}$$

b. Expand the non-index area redd counts by the proportion of visible redds in the index to estimate the total number of redds in the entire reach (reach total; *RT*).

$$RT_{visible} = n_{non-index} / IF$$

c. Estimate the total number of redds (total redds; *TR*) by summing the reach totals.

$$TR_{visible} = \sum RT$$

The total redd count methods are believed to provide a more accurate indication of total spawning than the peak redd count methodology, because the peak count methodology only accounts for visible redds each week during the survey season. For example, summer Chinook redds that were visible during the first week of spawning may not be visible during the third week; those redds would be missed in the third and subsequent weeks' redd counts. Using the total count methodology, the redds in the first week would be mapped and accounted for in subsequent weeks, even though they may fade at some point during the future surveys.

Table 2. Index (Mapping) Areas on the Wenatchee River for 2011.

Reach	Reach description	Distance (miles)	Mapping index area within reach
1	Sleepy Hollow Br to River Mouth	3.5	Sleepy Hollow Br to River Bend
2	Cashmere Br to Sleepy Hollow Br	6	Cashmere Br 2 to Old Monitor Br.
3	Dryden Dam to Cashmere Br	8	Dryden Dam to Williams Canyon
4	Peshastin Br to Dryden Dam	2.5	Peshastin Br to Dryden Dam
5	Leavenworth Br to Peshastin Br	3.9	Leavenworth Br to Irrigation Flume
6	Icicle Rd Br to Leavenworth Br	2.5	Icicle Mouth to Boat Takeout
7	Tumwater Dam to Icicle Rd Br	4.5	Penstock Br to Icicle Rd Br
8	Tumwater Br to Tumwater Dam	4.7	Tumwater Br to Swiftwater Campground
9	Old Plain Br to Tumwater Br	12.8	RR Tunnel to Swing Pool
10	Lake Wenatchee to Old Plain Br	5.8	Bridge to Swamp

Sockeye Spawning Abundance

In 2011, sockeye abundance was enumerated using two methods: (1) on-the-ground surveys using an "area-under-the-curve" (AUC) approach and (2) a PIT-tag-based mark recapture study.

AUC Method:

Sockeye spawning ground surveys began August 23 and ended October 6. Spawning areas in the Little Wenatchee (Table 1) were surveyed at least once per week. Both the Little Wenatchee and White rivers have falls that are migration barriers to sockeye, and spawning is known to occur only within the first few miles of the Napeequa River, a tributary to the White River.

The AUC method was based on the number of live spawners counted. Using AUC, the number of fish observed in a survey was plotted against the day of the year and the number of fish-days was estimated using an algorithm. The number of fish spawning was then estimated by dividing the cumulative fish-days by the estimated mean number of days that the average spawner was alive in the survey area (survey- or stream-life). This was then multiplied by a correction factor for fish visibility (observer efficiency; Hillborn et al. 1999).

Hillborn et al. (1999) outlined what they termed as the most commonly used form of AUC, *trapezoidal approximation*:

$$AUC = \sum_{i=2}^{n} (t_i - t_{i-1}) \frac{(x_i + x_{i-1})}{2}$$

where t_i is the day of the year and x_i is the number of salmon observed for the *i*th survey. Attempts were made to initiate surveys before the presence of fish; however, when the first or last survey was not zero, then the above algorithm was not valid and Hillborn et al. (1999) recommend using the rules that the Alaska Department of Fish and Game use:

$$AUC_{first} = (x_i s)/2$$

where s is the survey life. Survey attempts should also be made until all salmon die, but when this was not possible, then the final survey should be calculated as:

$$AUC_{last} = (x_{last} s)/2$$

Then total escapement (E) is estimated as:

$$\hat{E} = \frac{AUC}{s} v$$

where v is a correction for observer efficiency. Since survey life has not been empirically estimated for the Wenatchee system, we used 11 days based on Perrin and Irvine (1990) and Hyatt et al. (2006).

Mark Recapture Method:
Adult sockeye salmon were removed from the adult fishway at Tumwater Dam on the Wenatchee River, northwest of Leavenworth, Washington during the 2009 and 2010 migration. Fish were anesthetized, tagged with a PIT, and released into the forebay consistent with techniques used by the Washington Department of Fish and Wildlife. Resulting tag files were queried in PITAGIS (2010), providing detection histories for each study fish. Adult sockeye salmon were tagged at Bonneville Dam by another organization in 2009 and 2010; fish from this tag group that were detected at Tumwater Dam were also used in the analyses. Total passage of adult sockeye salmon through Tumwater Dam was obtained from Columbia River Data Access in Real Time (DART 2010).

Detection efficiency of in-stream arrays was calculated for the Little Wenatchee River in both 2009 and 2010; efficiency was calculated for the White River arrays after the 2010 migration since only a single array was available during 2009. The in-stream arrays include a series of upstream and downstream coils (**Error! Reference source not found.**). Combined, these coils represented the upstream and downstream detection arrays, respectively. Overall detection efficiency P_{all} of the arrays was calculated based on observed detection probabilities of individual arrays:

$$P_{all} = 1 - (1 - P_{array\ 1})(1 - P_{array\ 2})$$

where the probability of missing a fish on both the upstream P_{array1} and downstream P_{array2} arrays were combined for an overall efficiency P_{all} (Connolly et al. 2008).

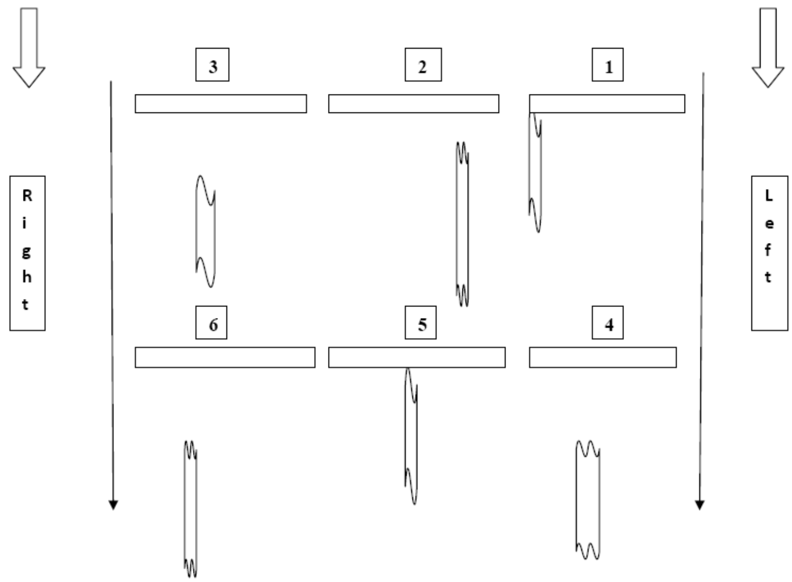


Figure 3. PIT array configuration on the Little Wenatchee River, 2009.

Resulting data from passage at Tumwater Dam, mark and recapture using PITs, and detection efficiency estimates can provide estimation of escapement to spawning tributaries. Basic assumptions include: (1) the study population is "closed," i.e., no individuals die or emigrate between the initial mark and subsequent recaptures; (2) tags are not lost and detections are correctly identified; (3) all individuals have the same probability of being detected, and (4) the number of recapture events are proportional to the total population. Lastly, it was assumed that PIT-tagging efforts at Tumwater have negligible influence on fish behavior and tagged individuals behave similarly to untagged individuals. The resulting escapement rate, adjusted for detection efficiency, was then applied to the total population as such:

$$Escapement = \left(\frac{\left(\frac{Obs_{LWN}}{Eff_{LWN}} + \frac{Obs_{WTL}}{Eff_{WTL}} \right)}{PITs_{TUM}} \right) \times Counts_{TUM}$$

where the PIT detections (*Obs*) at the Little Wenatchee (*LWN*) and lower White River (*WTL*) were adjusted for detection efficiency (*Eff*) at both sites, compared to the number released (*PITs*) at Tumwater Dam (*TUM*), and the resulting proportion was applied to the population observed (*Counts*) passing Tumwater Dam.

Results

Summer Chinook

Peak Counts

The cumulative peak summer Chinook redd count was 2,583 in 2011, based on District ground surveys along the Wenatchee River (Table 3). Spawning activity began the third week of September and peaked during middle of October.

Table 3. Summary of summer Chinook redd peak counts, total redd estimates (TR) and spawner densities by reach in the Wenatchee River, 2011. Expansion factors were rounded to two decimal places (0.00) prior to calculating reach totals.

Reach	Peak Count	CCPUD Estimates		CCPUD Naïve Estimates	
		RT_{Peak}	$Density_{Peak}$ (redds/mile)	$RT_{Visible}$	$Density_{Visible}$ (redds/mile)
1	1	1	5	0	0
2	111	127	21	133	22
3	232	254	32	277	35
4	67	75	30	75	30
5	41	25	6	34	9
6	910	1,002	400	1,744	698
7	214	246	55	236	52
8	182	206	44	199	42
9	475	698	55	704	55
10	350	435	75	459	79
Total	***2,583***	***3,069***	***57***	***3,861***	***71***

Total Counts

The total number of redds in the Wenatchee River was 3,069 (RT_{peak}), using data from District surveys and the peak expansion factor. The District also estimated 3,861 redds (RT_{visble}) based on their naïve surveys (Table 3). All survey methods (peak and visible) indicated that redd densities were highest in Reach 6 and lowest in Reach 1 (Table 3; Figure 4), consistent with the previous four years. The historical summer Chinook peak counts (1996-2011) for the Wenatchee River basin are summarized in Attachment 1.

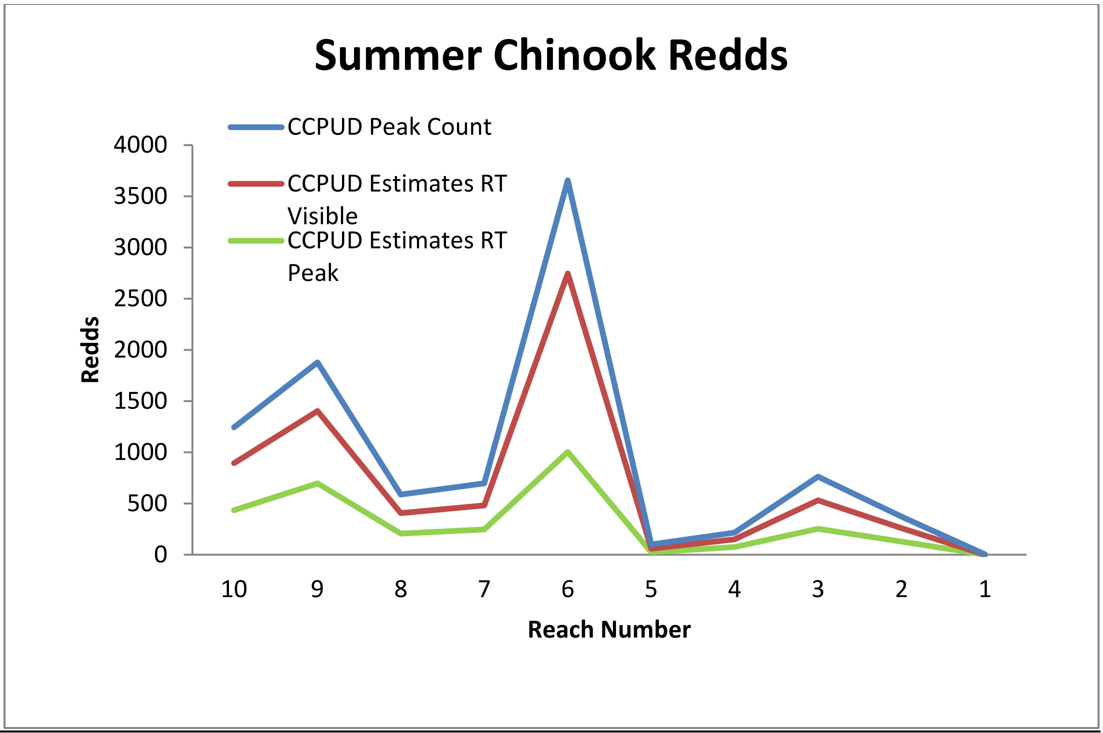


Figure 4. Alternative estimates of reach totals (RT) for summer Chinook redds in the Wenatchee River in 2011 [RT_{peak}=District peak counts expanded by peak expansion method and RT_{visble} =District naïve counts expanded by naïve expansion factor].

Sockeye Salmon

Sockeye AUC Method

Live fish counts

Fish counts were conducted for sockeye from August 23 through October 6. Peak spawning occurred in the Little Wenatchee (1,753) during the middle of September (Figure 5; Table 4).

Escapement

The total estimated spawning escapement of sockeye to the Wenatchee tributaries was 17,013 in 2011 (Table 4). The escapement estimate is based solely on tributary observations.

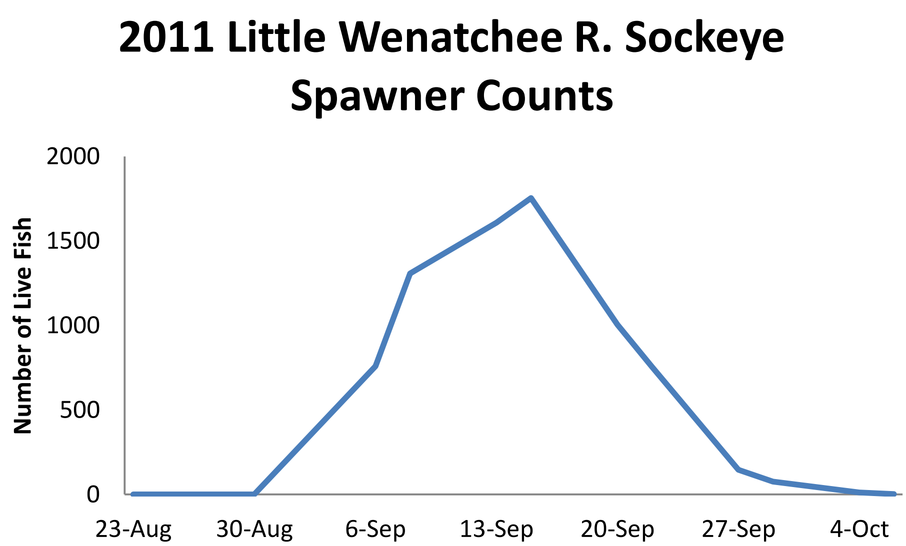


Figure 5. Approximate live counts and survey dates for sockeye salmon in the Little Wenatchee R., 2011.

Table 4. Number of live fish and total spawning escapement estimates for sockeye salmon in the Wenatchee Basin, August through October, 2011.

River	Peak number of live fish	Escapement
Little Wenatchee	**1,753**	**2,431**
Napeequa	**N/A**[1]	**172**[2]
White	**N/A**[1]	**14,410**[2]
Total	***N/A***	***17,013***[2]

[1] No AUC counts were conducted on these streams in 2011.

[2] Escapement was calculated using a historical linear regression to the Little Wenatchee River.

Sockeye Mark Recapture Method

Fishway enumeration at Tumwater Dam indicated that 18,634 adult sockeye salmon passed the facility during the 2011 migration. Adult return counts at Tumwater Dam were not sufficient to open a recreational fishery in Lake Wenatchee for 2011. PIT tags were implanted in 484 (Table 5) of these fish prior to subsequent detections in nearby tributaries. Based on the recapture of PIT-tagged adult sockeye and assigned detection efficiency, total estimated escapement from Tumwater Dam into the Little Wenatchee was 1,570. Due to complications with the White River PIT tag array, total escapement to the White river was calculated using a linear regression derived from historical AUC spawning escapements in the Little Wenatchee and White Rivers from 2006 through 2010 (Figure 6). Escapement to the Little Wenatchee significantly explains 87% of the variation in escapement to the White River (p = 0.0198). Estimated escapement in 2011 totaled 17,013, including 14,582 fish in the White River and 2,431 fish in the Little Wenatchee River, for a combined escapement rate of 0.913 percent of the population in 2011 (Table 6).

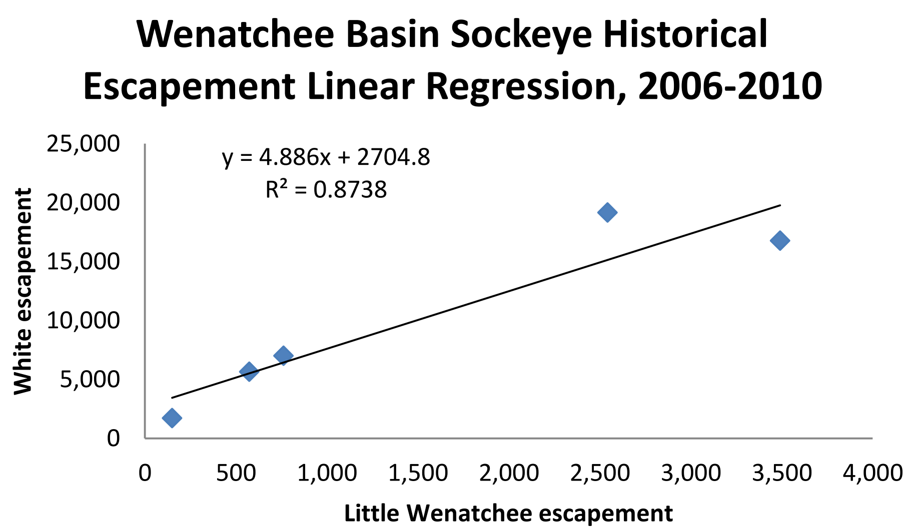


Figure 6. Historical linear regression relationship between escapement of sockeye salmon into the Little Wenatchee and White Rivers, 2006-2010.

Table 5. Number of adult sockeye salmon PIT-tagged, released, and detected upstream of Tumwater Dam in 2009, 2010, and 2011, including escapement estimates of PIT-tagged fish based on array detection probabilities.

Release Location	Number Released	White River [3]		L. Wenatchee River [4]		Chiwawa R.	Nason Creek
		Observed	*Estimated*	Observed	*Estimated*	Observed	Observed
Tumwater (2009) [1]	998	347	*855*	34	*35*	35	7
Bonneville (2009) [2]	87	34	*84*	4	*4*	2	0
Tumwater (2010) [1]	1,054	530	*589*	61	*61*	3	1
Bonneville (2010) [2]	110	41	*46*	6	*6*	0	0
Tumwater (2011) [1]	381	64	*N/A*[5]	26	*27*	0	0
Bonneville (2011) [2]	103	19	*N/A*[5]	14	*14*	0	0
Combined (2009)	1,085	381	*939*	38	*39*	37	7
Combined (2010)	1,164	571	*635*	67	*67*	3	1
Combined (2011)	484	40	*41*	84	*0*	0	0

[1] Also includes fish detected downstream of release point (fallbacks).
[2] Number of fish released at Bonneville and subsequently detected at Tumwater Dam.
[3] Based on a detection efficiency p_{all} = 0.406 in 2009 (assigned from 2010 data), p_{all} = 0.900 in 2010, and p_{all} = 0.981 in 2011.
[4] Based on a detection efficiency p_{all} = 0.971 in 2009 and p_{all} = 1.000 in 2010.
[5] Technical difficulties with the White R. PIT array prevented the calculation of detection efficiency.

Table 6. Estimated escapement of adult sockeye salmon to Little Wenatchee and White rivers based on mark-recapture events, in-stream detection efficiency, and adult enumeration at Tumwater Dam, 2009-2011.

Year	Tumwater count	Recreational harvest	Little Wenatchee	White River	Combined	Escapement
2009	16,034	2,229	576	13,876	14,452	0.901
2010	35,821	4,129	2,062	19,542	21,604	0.603
2011[1]	*18,634*	*0*	*2,431*	*14,582*	*17,013*	*0.913*
Average	*23,499*	*2,119*	*1,690*	*16,000*	*17,690*	*0.753*

[1] Escapement was calculated using AUC counts for the Little Wenatchee R. and a linear regression relationship to the Little Wenatchee R. for the White R.

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Attachment 1

Historic peak redd counts in the Wenatchee River for summer/fall Chinook salmon. Prior to 1995, all counts based on highest count of multiple agencies surveys, which were usually aerial counts from fixed-wing aircraft. Since 1995, counts are ground counts based on Chelan PUD surveys.

Year	Highest Count	Year	Highest Count	Year	Highest Count
1960	502	1970	1333	1980	2024
1961	872	1971	1419	1981	1469
1962	1035	1972	1364	1982	1140
1963	1223	1973	1119	1983	723
1964	1300	1974	1155	1984	1332
1965	706	1975	925	1985	1058
1966	1260	1976	1106	1986	1322
1967	1593	1977	1365	1987	2955
1968	1776	1978	1956	1988	2102
1969	1354	1979	1698	1989	3331
1990	2479	2000	2022	2010	2553
1991	2180	2001	2857	2011	2583
1992	2328	2002	5419		
1993	2334	2003	4281		
1994	2426	2004	3764		
1995	1872	2005	3327		
1996	1435	2006	7165		
1997	1388	2007	1857		
1998	1660	2008	2338		
1999	2188	2009	2667		

Appendix I

Genetic Diversity of Wenatchee Sockeye Salmon

Assessing the Genetic Diversity of Lake Wenatchee Sockeye Salmon And Evaluating The Effectiveness Of Its Supportive Hatchery Supplementation Program

Developed for

Chelan County PUD

and the

Habitat Conservation Plan's Hatchery Committee

Developed by
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March 2008

Executive Summary

Nine spawning populations of sockeye (*Oncorhynchus nerka*) salmon have been identified in Washington, including stocks in the Lake Wenatchee basin (SaSI 5800) (Washington Department of Fisheries et al. 1993). Lake Wenatchee sockeye are classified as an Evolutionary Significant Unit (ESU), and consists of sockeye salmon that spawn primarily in tributaries above Lake Wenatchee (the White River, Napeequa River, and Little Wenatchee Rivers). Since 1990, the Wenatchee Sockeye Program has released juveniles into Lake Wenatchee to supplement natural production of sockeye salmon in the basin. The program's broodstock are predominantly natural-origin sockeye adults returning to the Wenatchee River captured at Tumwater Dam (Rkm 52.0), where a net-pen system is used to house both maturing adults and juveniles prior to release into Lake Wenatchee to over-winter.

Previous genetic studies have generally found a lack of concordance between population genetic relationships and their geographic distributions. These studies indicate that the nearest geographic neighbors of sockeye salmon populations are not necessarily the most genetically similar. Specifically for the Columbia River Basin, sockeye from Lake Wenatchee, Okanogan River, and Redfish Lake may be more closely related to a population from outside the Columbia River (depending on marker used) then to each other.

In this study we investigated the temporal and spatial genetic structure of Lake Wenatchee sockeye collections, without regard to sockeye populations outside of the Lake Wenatchee area. Our primary objective here was to determine if the Wenatchee Sockeye Program affected the natural Lake Wenatchee sockeye population. More specifically, we were tasked to determine if the genetic composition of Lake Wenatchee sockeye population had been altered by a supplementation program that was based on the artificial propagation of a small subset of that population. Using microsatellite DNA allele frequencies, we investigated population differentiation between temporally replicated collections of natural-origin Lake Wenatchee sockeye and program broodstock. We analyzed thirteen collections of Lake Wenatchee sockeye (Table 1), eight temporally replicated collections of natural-origin Lake Wenatchee sockeye (N=786) and five temporally replicated collections of Wenatchee Sockeye Program broodstock (N=248). Paired natural – broodstock collections were available from years 2000, 2001, 2004, 2006, and 2007.

Conclusions

We observed that allele frequency distributions were consistent over time, irrespective of collection origin, resulting in small and statistically insignificant measures of genetic differentiation among collections. We interpreted these results to indicate no year-to-year differences in allele frequencies among natural-origin or broodstock collections. Furthermore, there were no observed difference between pre- and post-supplementation collections. Therefore, we accepted our null hypothesis that the allele frequencies of the broodstock collections equaled the allele frequencies of the natural collections, which equaled the allele frequency of the donor population. Given the small differences in genetic composition among collections, the genetic model for estimating N_e produced estimates with extremely large variances, preventing the observation of any trend in N_e.

Introduction

A report titled "Conceptual Approach to Monitoring and Evaluating the Chelan County Public Utility District Hatchery Programs" was prepared July 2005 by Andrew Murdoch and Chuck Peven for the Chelan PUD Habitat Conservation Plan's Hatchery Committee. This report outlined 10 objectives to be applied to various species assessing the impact (positive or negative) of hatchery operations mitigating the operation of Rock Island Dam. This current study pertains only to Lake Wenatchee sockeye and objective 3:

> *Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.*

In order to evaluate cause and effect of hatchery supplementation, WDFW Molecular Genetics Lab surveyed genetic variation of Lake Wenatchee sockeye. The conceptual approach for this project follows that of a parallel study regarding the Wenatchee River spring Chinook supplementation program (Blankenship et al. 2007). We determined the genetic diversity present in the Lake Wenatchee sockeye population by analyzing temporally replicated collections spanning 1989 – 2007, which included collections from before and following the inception of the Wenatchee Sockeye Program. Documenting the genetic composition of the Lake Wenatchee sockeye population is necessary to assess the effect of the hatchery program on the Lake Wenatchee population. In addition, this work provides a genetic baseline for future projects requiring genetic data. See study objectives below for specific details about how this project addresses Murdoch and Peven (2005) objective 3.

Lake Wenatchee Sockeye Salmon

Nine spawning populations of sockeye (*Oncorhynchus nerka*) salmon have been identified in Washington (Washington Department of Fisheries et al. 1993): 1) Baker

River, 2) Ozette Lake, 3) Lake Pleasant, 4) Quinault Lake, and 5) Okanogan River (classified as native stock); 6) Cedar River (classified as non-native stock); 7) Lake Wenatchee, classified as mixed stock); 8) Lake Washington/Lake Sammamish tributaries; and 9) Lake Washington beach spawners (classified as unknown origin). Chapman et al. (1995) listed four additional spawning aggregations of sockeye salmon that appear consistently in Columbia River tributaries: the Methow, Entiat, and Similkameen Rivers; and Icicle Creek in the Wenatchee River drainage.

Located in north central Washington, the Wenatchee River basin drains a portion of the eastern slope of the Cascade Mountains, including high mountainous regions of the Cascade crest. The headwater area of the Wenatchee River is Lake Wenatchee, a typical low productivity oligotrophic or ultra-oligotrophic sockeye salmon nursery lake (Allen and Meekin 1980, Mullan 1986, Chapman et al. 1995). Sockeye salmon bound for Lake Wenatchee enter the Columbia River in April and May and arrive at Lake Wenatchee in late July to early August (Chapman et al. 1995; Washington Department of Fisheries et al. 1993). The run timing of Lake Wenatchee sockeye salmon, classified as an Evolutionary Significant Unit (ESU), appears to have become earlier by 6 - 30 days during the past 70 years (Chapman et al. 1995; Quinn and Adams 1996). Additionally, scale pattern analysis suggests Wenatchee sockeye migrate past Bonneville Dam earlier than the sockeye bound for the Okanogan River (Fryer and Schwartzberg 1994). The Wenatchee population spawns from mid-September through October in the Little Wenatchee, White, and Napeequa Rivers above Lake Wenatchee (Washington Department of Fisheries et al. 1993), peaking in late September (Chapman et al. 1995). Limited beach spawning is believed to occur in Lake Wenatchee (L. Lavoy pers. com.; Mullan 1986), although Gangmark and Fulton (1952) reported two lakeshore seepage areas in Lake Wenatchee that were used by spawning sockeye salmon. Sockeye salmon fry enter Lake Wenatchee between March and May (Dawson et al. 1973), and typically rear in the lake for one year before leaving as smolts (Gustafson et al. 1997; Peven 1987).

Both the physical properties of the habitat and ecological/biological factors of the sockeye populations differ between the Lake Wenatchee ESU and the geographically proximate Okanogan ESU. For example: 1) Different limnology is encountered by sockeye salmon in Lakes Wenatchee and Osoyoos; 2) Lake Wenatchee sockeye predominantly return at ages four and five (a near absence of 3-year-olds), where a large percentage of 3-year-olds return to the Okanogan population; and 3) the apparent one month separation in juvenile outmigration-timing between Okanogan- and Wenatchee-origin fish (Gustafson et al. 1997 and references therein).

Sockeye Artificial Propagation In Lake Wenatchee

The construction of Grand Coulee Dam completely blocked fish passage to the upper Columbia River, and 85% of sockeye salmon passing Rock Island Dam between 1935 and 1936 were estimated to be from natural stocks bound for areas up-river to Grand Coulee Dam (Mullan 1986; Washington Department of Fisheries et al. 1938). To compensate for loss of habitat resulting from Grand Coulee Dam, the federal government initiated the Grand Coulee Fish-Maintenance Project (GCFMP) in 1939 to maintain fish runs in the Columbia River above Rock Island Dam. Between 1939 and 1943, all sockeye salmon entering the mid-Columbia River were trapped at Rock Island Dam, and over 32,000 mixed Lake Wenatchee, Okanogan River, and Arrow Lake adult sockeye salmon were released into Lake Wenatchee (Gustafson et al. 1997 Appendix Table D-2). In addition to adult relocation, between 1941 and 1969 over 52.8 million fry descended from original spawners collected at Rock Island and Bonneville Dams, were released into Lake Wenatchee (Gustafson et al. 1997 Appendix Table D-2).

No releases of artificially-reared sockeye salmon occurred in the Wenatchee watershed during the years 1970 to 1989 (Gustafson et al. 1997 Appendix Table D-2). Since 1990, the Wenatchee Sockeye Program has released juveniles into Lake Wenatchee to supplement natural production of sockeye salmon in the basin. Sockeye adults returning to the Wenatchee River are captured at Tumwater Dam (Rkm 52.0) and transferred to Lake Wenatchee net pens until mature. The Wenatchee Sockeye Program goals are 260 adults with an equal sex ratio, <10% hatchery-origin returns (identified by coded wire tags), and the adults removed for broodstock account for <10% of the run size. Fish are spawned at Lake Wenatchee and their gametes are taken to Rock Island Fish Hatchery

Complex (i.e., Eastbank) for fertilization and incubation. Fry are returned to the Lake Wenatchee net -pens after they are large enough to be coded wire tagged, and are housed in the pens until fall (one year after spawning), when they are liberated into the lake to over-winter. For brood years 1991 – 2004 an average of 218,683 (std. dev. = 71,090) pen-reared Lake Wenatchee-origin juvenile sockeye salmon have been released yearly into Lake Wenatchee.

Previous Genetic Studies

Protein (allozyme) variation – Surveying genetic variation at 12 allozyme loci, Utter et al. (1984) reported moderate population structure among 16 sockeye collections from southeast Alaska through the Columbia River Basin, including Okanogan and Wenatchee stocks, with an apparent genetic association between upper Fraser River and Columbia River sockeye salmon. Winans et al. (1996) surveyed variation at 55 allozyme loci for 25 sockeye salmon and two kokanee collections from 21 sites in Washington, Idaho, and British Columbia, and reported the lowest level of allozyme variability of any species of Pacific salmon and a highest level of inter-population differentiation. Furthermore, these authors reported that there was no clear relationship between geographic and genetic differentiation among the populations within there study. Other studies corroborate the results of Winans et al. (1996), finding a lack of discernible geographic patterning for sockeye salmon populations in British Columbia, Alaska, and Kamchatka (Varnavskaya et al. 1994, Wood et al. 1994, Wood 1995). These studies indicate that the nearest geographic neighbors of sockeye salmon populations are not necessarily the most genetically similar, which contrasts with the other Pacific salmon species that exhibit concordance between geographic and genetic differentiation (Utter et al. 1989, Winans et al. 1994, Shaklee et al. 1991). As part of the comprehensive status review of west coast sockeye salmon (Gustafson et al. 1997), NMFS biologists collected new allozyme genetic information for 17 sockeye salmon populations and one kokanee population in Washington and combined these data for analysis with the existing Pacific Northwest sockeye salmon and kokanee data from Winans et al. (1996). Results of the updated study were consistent with Winans et al. (1996), with no clear concordance between geographic and genetic distances. Sockeye salmon from Lake Wenatchee, Redfish Lake, Ozette Lake, and Lake Pleasant are very distinct from other collections in the study, and Columbia River populations were not necessarily most closely related to each other. Gustafson et al. (1997) also examined between-year variability within a collection location and found low levels of statistical significance among the five Lake Wenatchee collections included in the study (For 10 pair-wise comparisons using sum-G test, five were statistically significant). Lake Wenatchee brood year 1987 accounted for three of the significant comparisons, which were driven by unusually high frequencies of two allozyme alleles (ALAT*95 and ALAT*108) (Winans et al. 1996). Nevertheless, Gustafson et al. (1997) conclude that, in general, temporal variation at a locale was considerably less than between-locale variation.

Nucleic acid variation - Beacham et al. (1995) reported levels of variation in nuclear DNA of *O. nerka* using minisatellite probes. They analyzed 10 collections, including a sample from Lake Wenatchee. Cluster analysis showed the Lake Wenatchee sample was different from all the other collections, including those from the Columbia River. Using a similar molecular technique, Thorgaard et al. (1995) examined the use of multi-locus DNA fingerprinting (i.e., banding patterns) to discriminate among 14 sockeye salmon and kokanee populations. Dendrograms based on analysis of banding patterns produced different genetic affinity groups depending on the probes used. While none of the five DNA probes showed a close relationship between Lake Wenatchee and Okanogan River sockeye salmon, if information from all probes were combined, *O. nerka* from Redfish Lake, Wenatchee, and Okanogan were separate from kokanee of Oregon and Idaho and a sockeye salmon sample from the mid-Fraser River.

Study Objective

We documented temporal variation in genetic diversity (i.e., heterozygosity and allelic diversity), and investigated population differentiation between temporally replicated collections of natural-origin Lake Wenatchee sockeye and program broodstock, using microsatellite DNA allele frequencies. Temporally replicated collections from the same location can also be used to estimate effective population size (N_e). If populations are "ideal", the census size of a population is equal to the "genetic size" of the population.

Yet, numerous factors lower the “genetic size” below census, such as, non-equal sex ratios, changes in population size, and variance in the numbers of offspring produced from parent pairs. N_e is thought to be between 0.10 and 0.33 of the estimated census size (Bartley et al. 1992; RS Waples pers. comm.), although numerous observations differ from this general rule. N_e can be calculated directly from demographic data, or inferred from observed differences in genetic variance over time. Essentially, when calculated from genetic data, N_e is the estimated size of an “ideal” population that accounts for the genetic diversity changes observed, irrespective of abundance.

We will address the hypotheses associated with Objective 3 in Murdock and Peven (2005) using the following four specific tasks:

Task 1 - Document the observed genetic diversity.

Task 2 - Test for population differentiation among Lake Wenatchee collections and the associated supplementation program.

Task 2 was designed to address two hypotheses listed as part of Objective 3 in Murdoch and Peven (2005):

- Ho: Allele frequency $_{\text{Hatchery}}$ = Allele frequency $_{\text{Naturally produced}}$ = Allele frequency $_{\text{Donor pop}}$.
- Ho: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations $_{\text{Year y}}$

Murdoch and Peven (2005) proposed these two hypotheses to help evaluate supplementation programs through a “Conceptual Process” (Figure 5 in Murdoch and Peven 2005). There are two components to the first hypothesis, which must be considered separately for Lake Wenatchee sockeye. The first component involves comparisons between natural-origin populations from Lake Wenatchee to determine if there have been changes in allele frequencies through time starting with the donor population. Documenting a change does not necessarily indicate that the supplementation program has directly affected the natural-origin fish, as additional tests would be necessary to support that hypothesis. The intent of the second component is to determine if the hatchery produced populations have the same genetic composition as the naturally produced populations.

Task 3 - Calculate N_e using the temporal method for multiple samples from the same location to document trend.

Task 4 - Compare N_e estimates with trend in census size for Lake Wenatchee sockeye.

Methods and Materials

Sampling

Thirteen collections of Lake Wenatchee sockeye were analyzed, eight temporally replicated collections of natural Lake Wenatchee sockeye (N=786) and five temporally replicated collections of Wenatchee Sockeye Program broodstock (N=248) (Table 1). Paired natural – broodstock collections were available from years 2000, 2001, 2004, 2006, and 2007 (Table 1). All collections were made at Tumwater Dam on the Wenatchee River. Note that collections classified as broodstock were predominantly natural-origin sockeye. A majority of the genetic samples were from dried scales. The tissue collections from 2006 and 2007 were fin clips stored immediately in ethanol after collection. DNA was extracted from stored tissue using Nucleospin 96 Tissue following the manufacturer's standard protocol (Macherey-Nagel, Easton, PA, U.S.A.).

Laboratory Analysis

Polymerase chain reaction (PCR) amplification was performed using 17 fluorescently end-labeled microsatellite marker loci, *One* 2 (Scribner et al 1996) *One* 100, 101, 102, 105, 108, 110, 114, and 115 (Olsen et al. 2000), *Omm* 1130, 1135, 1139, 1142, 1070, and 1085 (Rexroad et al. 2001), *Ots* 3M (Banks et al. 1999) and *Ots* 103 (Small et al. 1998). PCR reaction volumes were 10 μL, with the reaction variables being 2 μL 5x PCR buffer (Promega), 0.6 μL $MgCl_2$ (1.5 mM) (Promega), 0.2 μL 10 mM dNTP mix (Promega), and 0.1 μL *Go Taq* DNA polymerase (Promega). Loci were amplified as part of multiplexed sets, so primer molarities and annealing temperatures varied. Multiplex one had an annealing temperature of 55°C, and used 0.09 Molar (M) *One* 108, 0.06 M *One* 110, and 0.11 M *One* 100. Multiplex two had an annealing temperature of 53°C, and used 0.08 M *One* 102, 0.1 M *One* 114, and 0.05 M *One* 115. Multiplex three had an annealing temperature of 55°C, and used 0.08 M *One* 105 and 0.07 M *Ots* 103. Multiplex four had an annealing temperature of 53°C, and used 0.09 M *Omm* 1135 and 0.08 M *Omm* 1139. Multiplex five had an annealing temperature of 60°C, and used 0.2 M *Omm* 1085, 0.09 M *Omm* 1070, and 0.05 M *Ots* 3M. Multiplex six had an annealing temperature of 48°C, and used 0.06 M *One* 2, 0.08 M *Omm* 1142, and 0.08 M *Omm* 1130. *One* 101 was run in isolation with a primer molarity of 0.06. Thermal cycling was conducted on either PTC200 (MJ Research) or GeneAmp 9700 thermal cyclers as follows: 94°C (2 min); 30 cycles of 94°C for 15 sec., 30 sec. annealing, and 72°C for 1 min.; a final 72°C extension and then a 10°C hold. PCR products were visualized by denaturing polyacrylamide gel electrophoresis on an ABI 3730 automated capillary analyzer (Applied Biosystems). Fragment analysis was completed using GeneMapper 3.7 (Applied Biosystems).

Genetic data analysis

Assessing within collection genetic diversity - Heterozygosity measurements were reported using Nei's (1987) unbiased gene diversity formula (i.e., expected heterozygosity) and Hedrick's (1983) formula for observed heterozygosity. Both tests were implemented using the microsatellite toolkit (Park 2001). For each locus and collection FSTAT version 2.9.3.2 (Goudet 1995) was used to assess Hardy-Weinberg equilibrium, where deviations from the neutral expectation of random associations among alleles were calculated using a randomization procedure. Alleles were randomized among individuals within collections (4160 randomizations for this dataset) and the F_{IS} (Weir and Cockerham 1984) calculated for the randomized datasets were compared to the observed F_{IS} to obtain an unbiased estimation of the probability that the null hypothesis was true. The 5% nominal level of statistical significance was adjusted for multiple tests (Rice 1989). Genotypic linkage disequilibrium was calculated following Weir (1979) using GENETIX version 4.05 (Belkhir et al. 1996). Statistical significance of linkage disequilibrium results was assessed using a permutation procedure implemented in GENETIX for each locus by locus combination within each collection.

Assessing among collection genetic differentiation - The temporal stability of allele frequencies was assessed by the randomization chi-square test implemented in FSTAT version 2.9.3.2 (Goudet 1995). Multi-locus genotypes were randomized between collections. The G-statistic for observed data was compared to G-statistic distributions from randomized datasets (i.e., null distribution of no differentiation between collections). Population differentiation was also investigated using pairwise estimates of F_{ST}. Multi-locus estimates of pairwise F_{ST}, estimated by a "weighted" analysis of variance (Weir and Cockerham, 1984), were calculated using GENETIX version 4.05 (Belkhir et al.1996). F_{ST} was used to quantify population structure, the deviation from statistical expectations (i.e., excess homozygosity) due to non-random mating between populations. To determine if the observed F_{ST} estimate was consistent with statistically expectations of no population structure, a permutation test was implemented in GENETIX (1000 permutations).

Effective population size (N_e) – Estimates of the effective population size were obtained using a multi-collection temporal method (Waples 1990a). The temporal method assumes that cohorts are used, but we did not decompose the collection year samples into their respective cohorts using age data. Therefore, N_e estimates that pertain to individual year classes of breeders are not valid; however the harmonic mean over all samples will estimate an N_e that pertains to the time period from which the collections are derived. Comparing samples from years *i* and *j*, Waples' (1990a) temporal method estimates the effective number of breeders ($\hat{N}_{b(i,j)}$) according to:

$$\hat{N}_{b(i,j)} = \frac{b}{2(\hat{F} - 1/\tilde{S}_{i,j})}$$

The standardized variance in allele frequency ($\hat{F}$) is calculated according to Pollack (1983). The parameter b is calculated analytically from age structure information and the number of years between samples (Tajima 1992). The age-at-maturity information required to calculate b was obtained from ecological data (Hillman et al. 2007). The harmonic mean of sample sizes from years *i* and *j* is $\tilde{S}_{i,j}$. The harmonic mean over all pairwise estimates of $\hat{N}_{b(i,j)}$ is $\tilde{N}_b$. SALMONNb (Waples et al. 2007) was used to calculate $\tilde{N}_b$.

Results and Discussion

In this section we combine our presentation and interpretations of the genetic analyses. Additionally, this section is organized based on the task list presented in the study plan.

Task 1 - Document the observed genetic diversity.

Substantial genetic diversity was observed over all Lake Wenatchee sockeye collections analyzed (Table 1), with heterozygosity estimates over all loci having a mean of 0.79. Genetic diversity was consistent with expected Hardy-Weinberg random mating genotypic proportions for all collections. The F_{IS} observed for each collection was not statistically significant given the distribution of F_{IS} generated using a randomization procedure. Additionally, there were no statistically significant associations observed between alleles across loci (i.e., linkage equilibrium) (data not shown). We concluded from these results that the genetic data from each collection was consistent with statistical expectations for random association of alleles within and between loci. In other words, each collection represents samples from a single gene pool (i.e., populations), and the genetic diversity observed has no detectable technical artifacts or evidence of natural selection.

Task 2 - Test for differentiation among Lake Wenatchee collections and the associated supplementation program.

We explicitly tested the hypothesis of no significant differentiation within natural-origin or broodstock collections from Lake Wenatchee using a randomization chi-square test. The null hypothesis for these tests was that the allele frequencies from two different populations were drawn from the same underlying distribution. We show the results for the pairwise comparisons among eight temporally replicated natural-origin collections from Lake Wenatchee (28 pairwise tests), and report all tests were non-significant (Table 2A). Similarly, for five temporally replicated broodstock collections, 10 of 10 pairwise tests were non-significant (Table 2B). We also tested if natural-origin and broodstock collections were differentiated from each other over time, and report that 40 of 40 tests were non-significant (Table 2C). The nominal level of statistical significance ($\alpha = 0.05$) was adjusted for multiple comparisons using strict Bonferroni correction (Rice 1989). Yet, there are perhaps slight differences between paired natural-broodstock collections. Note that the p-values for comparisons regarding 2006 and 2007 paired collections are lower than for comparisons regarding 2000, 2001, and 2004. The small sample sizes for broodstock collections in 2006 and 2007 may not have been random samples from the Lake Wenatchee sockeye population.

Given the consistencies observed for allele frequency distributions over time, metrics of population structure were expected to be small. This was the case, as the estimated F_{ST} over all thirteen collections was 0.0003. This observed value fell within the distribution of F_{ST} values expected if there were no population structure present (permutation test p-value 0.12). Analysis of the paired natural-broodstock collections corroborated this result. Pairwise estimates of F_{ST} were 0.000 for years 2000, 2001, 2004, and 2007, and 0.002 for 2006. All five estimates were non-significant. Essentially, all 13 sockeye collections could be considered samples from the same population. Given these results, it is valid to combine all collections for statistical analysis. Therefore, we did not calculate genetic distances among any collections, as it is inappropriate to estimate distances that are effectively zero.

Conclusions

We interpret these data to indicate that there appears to be no significant year-to-year differences in allele frequencies among natural-origin or broodstock collections, nor are there observed differences between collections pre- and post-supplementation. As a result, we accept the null hypothesis that the allele frequencies of the broodstock collections equal the allele frequencies of the natural collections, which equals the allele frequency of the donor population. Furthermore, the observed genetic variance that can be attributed to among collection differences was negligible.

Task 3 - Calculate N_e using the temporal method for multiple samples from the same location to document trend.

The fundamental parameter for inferring N_e using genetic data is the standardized variance in allele frequency ($\hat{F}$) (Pollack 1983). Methods estimate N_e from observed changes in $\hat{F}$ over temporally replicated collections from the same location. Yet, as previously shown, there were no statistically significant differences detected in allele frequencies. The underlying model for estimating N_e produced estimates with extremely large variances, given small temporal differences in $\hat{F}$, which rendered any trend in N_e unobservable. Table 3 shows N_e estimates calculated using temporally replicated natural collections.

Task 4 - Compare N_e estimates with trend in census size for Lake Wenatchee sockeye.

See Task 3

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Table 1 Lake Wenatchee sockeye collections analyzed. MNA is the mean number of alleles per locus, Hz is unbiased heterozygosity, Obs Hz is observed heterozygosity, and HW is the p-value of the null hypothesis of random association of alleles (i.e., Hardy – Weinberg equilibrium). For reference, the nominal level of statistical significance at $\alpha = 0.05$ is 0.0002 after correction for multiple tests.

Year	Collection Code	Tissue Type	Source	N	MNA	Hz	Obs Hz	HW
1989	89[1]	Scales	Natural	96	14.35	0.792	0.791	0.424
1990	90[1]	Scales	Natural	96	13.19	0.793	0.779	0.131
2000	00AAE	Scales	Broodstock	96	12.31	0.787	0.776	0.213
2000	00[1]	Scales	Natural	96	11.76	0.801	0.826	0.868
2001	01AAS	Scales	Broodstock	53	9.47	0.788	0.793	0.392
2001	01[1]	Scales	Natural	96	14.35	0.786	0.794	0.456
2002	02[1]	Scales	Natural	96	14.53	0.794	0.777	0.780
2004	04[1]	Scales	Natural	96	14.65	0.798	0.803	0.704
2004	04AAV	Scales	Broodstock	43	14.35	0.796	0.795	0.051
2006	06CN	Tissue	Broodstock	38	14.59	0.793	0.785	0.688
2006	06CO	Tissue	Natural	96	14.53	0.806	0.803	0.408
2007	07EE	Tissue	Broodstock	18	14.00	0.790	0.790	0.221
2007	07EF	Tissue	Natural	96	14.35	0.789	0.800	0.347

[1] Samples taken from scale cards provided by Jeff Fryer (CRITFC)

Table 2 Allelic differentiation for Lake Wenatchee sockeye collections. A single analysis tested (pairwise) the allelic differentiation between all thirteen collections; however p-values for G-statistics are partitioned in the table by A) natural-origin, B) broodstock, and C) natural versus broodstock. Underlined values are for paired natural-broodstock collections from the same year. For reference, the nominal level of statistical significance at $\alpha = 0.05$ is 0.0006 after correction for multiple tests. No significant values were observed.

A) Natural-Origin Collections

	89	90	00	01	02	04	06CO	07EF
89		0.257	0.359	0.531	0.331	0.127	0.031	0.263
90			0.953	0.148	0.753	0.903	0.077	0.283
00				0.328	0.527	0.607	0.604	0.400
01					0.209	0.081	0.127	0.093
02						0.085	0.707	0.235
04							0.312	0.577
06CO								0.435
07EF								

B) Broodstock Collections

	00AAE	01AAS	04AAV	06CN	07EE
00AAE		0.189	0.090	0.008	0.058
01AAS			0.122	0.020	0.116
04AAV				0.008	0.031
06CN					0.326
07EE					

C) Natural vs. Broodstock

	89	90	00	01	02	04	06CO	07EF
00AAE	0.027	0.309	<u>0.572</u>	0.018	0.041	0.012	0.093	0.040
01AAS	0.115	0.471	0.160	<u>0.219</u>	0.519	0.049	0.654	0.133
04AAV	0.136	0.219	0.210	0.423	0.208	<u>0.328</u>	0.037	0.153
06CN	0.029	0.004	0.053	0.007	0.022	0.004	<u>0.019</u>	0.001
07EE	0.099	0.229	0.053	0.015	0.093	0.178	0.090	<u>0.037</u>

Table 3 Estimation of N_e for temporally replicated natural-original sockeye collections. Above the diagonal are pairwise estimates of N_e, where negative values mean sampling variance can account for genetic variance observed (i.e., genetic drift unnecessary). Below the diagonal are variances for pairwise estimates of N_e. Absent variance values (denoted by **-**) were too large for SalmonNb to display.

Collection	89	90	00	01	02	04	06CO	07EF
89		-3936.6	-1414	-2636.3	671.4	1871.1	1066.1	1951.2
90	2.59E+09		-1490.3	3649.1	-31144	-6808.4	817.6	93190.2
00	1.40E+09	4.45E+09		-592.2	-6842.2	-667.1	-1736.9	-1350.1
01	1.21E+09	1.47E+09	2.33E+09		977.1	6160.4	387.8	2531.5
02	1.91E+09	1.33E+09	1.16E+09	2.29E+09		1495.6	-848.5	3213.6
04	2.21E+09	3.62E+09	4.08E+09	1.27E+09	1.14E+09		896.6	2155.3
06CO	1.34E+09	1.39E+09	1.73E+09	**-**	4.51E+09	1.2E+09		3278.6
07EF	2.15E+09	1.51E+09	1.18E+09	1.68E+09	**-**	1.36E+09	2.65E+09	

Appendix J

Genetic Diversity of Chiwawa River Spring Chinook Salmon

Assessing the Genetic Diversity of Natural Chiwawa River Spring Chinook Salmon and Evaluating the Effectiveness of its Supportive Hatchery Supplementation Program

Developed for

Chelan County PUD

and the

Habitat Conservation Plan's Hatchery Committee

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Table of Contents

Executive Summary

The main objective of this study was to determine the potential impacts of the Chiwawa River Supplementation Program on natural spring Chinook in the upper Wenatchee system. We did this by investigating population differentiation between temporally replicated Chiwawa River natural and hatchery samples from the Wenatchee River watershed using microsatellite DNA allele frequencies and the statistical assignment of individual fish to specific populations. Additionally, to assess the genetic effect of the hatchery program, we investigated the relationship between census and effective population sizes using collections obtained before and after the supplementation program. In this summary, we briefly describe the salient results contained within this report; however, each "Task" within the Results/Discussion section below contains extended coverage for each topic along with an expanded interpretation of each result.

Overall, we observed substantial genetic diversity within collections, with heterozygosities equal to roughly 80%, over thirteen microsatellite markers. Microsatellite allele frequencies among temporally replicated collections from the same population (i.e., location) were variable, resulting in significant genetic differentiation among these collections. However, these difference are likely the result of salmon life history in this area, as four-year-old Chinook comprise a majority of returns each year. That is, the genetic tests are detecting the differences of contributing parents from each cohort, rather than a hatchery effect.

Analysis of Chiwawa River Collections

To assess the multiple competing hypotheses regarding population differentiation within and among Chiwawa River collections, we found it necessary to organized the Chiwawa genetic data into three data sets: (1) fish origin (hatchery versus natural), (2) spawning location (hatchery broodstock versus in-river (natural) spawners), and (3) four "treatment" groups (1. hatchery-origin hatchery broodstock, 2. hatchery-origin natural spawner, 3. natural-origin natural spawner, and 4. natural-origin hatchery broodstock). We conducted separate analyses using each of the three data sets, with each analysis

touching on some aspect of the components necessary to move through the Conceptual Process outlined by Murdoch and Peven (2005).

Origin Dataset – We report that allele frequencies within and between natural- and hatchery-origin collections are significantly different, but there does not appear to be a robust signal indicating that the recent natural-origin collections have diverged greatly from the pre- or early post-supplementation collections. Genetic drift will occur in all populations, but does not appear to be a major factor affecting allele frequencies within the Chiwawa collections.

Spawning Location Dataset – There are significant allele frequency differences within and between hatchery broodstock and natural spawner collections. However, in recent years the allele frequency differences between the hatchery broodstock and natural spawner collections have declined. Furthermore, based on linkage disequilibrium, there is a genetic signal that is consistent with increasing homogenization of allele frequencies within hatchery broodstock collections, but a similar homogenization within the natural spawner collection is not apparent. These data suggest that there exists consistent year-to-year variation in allele frequencies among hatchery and natural spawning collections, but there is a trend toward homogenization of the allele frequencies of the natural- and hatchery-origin fish that compose the hatchery broodstock.

Four Treatment dataset – Although there are signals of allelic differentiation among Chiwawa River collections, there are no robust signs that these collections are substantially different from each other. We used two different analyses to measure the degree of genetic variation that exists among individuals and collections within the Chiwawa River. First, we conducted a principal component analysis using all Chiwawa samples with complete genotypes (i.e., no missing alleles from any locus). Although the first two principal component axes account for only 10.5% of the total molecular variance, a substantially greater portion of that variance is among individual fish, regardless of their identity, rather than among hatchery and natural collections. The variances in principal component scores among individuals are 11 and 13 times greater than the variance in scores among collections.

Secondly, using an Analysis of Molecular Variance (AMOVA), we were able to determine how best to group populations, with "best" being defined as that grouping that accounts for the greatest proportion of among group (i.e., population) variance. Furthermore, by partitioning molecular variance into different hierarchical components, we are able to determine what level accounts for the majority of the molecular variance. The AMOVA results clearly show that nearly all molecular variation, no matter how the data are organized, resides within a collection. The percentage of total molecular variance occurring within collections ranged from 99.68% to 99.74%. These results indicate that the significant differences among collections of Chiwawa fish account for less than one percent of the total molecular variance, and these differences cannot be attributed to fish origin or spawning location.

Effective Population Size (N_e)

The contemporary estimate of N_e calculated using genetic data combined for Chiwawa natural-origin spawners (NOS) and hatchery-origin spawners (HOS) Chinook is N_e=386.8, which is slightly larger than the pre-hatchery N_e we estimated using demographic data from 1989 – 1992. Additionally, the N_e /N ratio calculated using 386.8 for N_e and the arithmetic mean yearly census of NOS and HOS Chinook from 1989 – 2005 for N is 0.40. These results suggest the N_e has not declined during the period of Chiwawa Hatchery Supplementation Program operation.

Analysis Of Upper Wenatchee Tributary Collections

We compared genetic data for spring Chinook collected from the major spawning aggregates of the Wenatchee River. We observed significant differences in allele frequencies among temporally replicated collections within populations, and among populations within the upper Wenatchee. However, these differences account for a very small portion of the overall molecular variance, and these populations overall are very similar to each other. Of all the populations within the Wenatchee River, the White River appears to be the most distinct. Yet, this distinction is more a matter of detail than of large significance, as the median F_{ST} between White River collections and all other collections (except the Little Wenatchee collection; see Results/Discussion) is less than 1.5% among population variance. We consider the implications of these results in the Conclusion section that follows the Results/Discussion section. Additionally, there is no evidence that the Chiwawa River Supplementation Program has changed the allele frequencies in the Nason Creek and White River populations, despite the presence of hatchery-origin fish in both these systems.

Introduction

Murdoch and Peven (2005) outlined 10 objectives to assess the impact (positive or negative) of hatchery operations mitigating the operation of Rock Island Dam. Two objectives relate to monitoring the genetic integrity of populations:

Objective 3: Determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery program. Additionally, determine if hatchery programs have caused changes in phenotypic characteristics of natural populations.

Objective 5: Determine if the stray rate of hatchery fish is below the acceptable levels to maintain genetic variation between stocks.

This study addresses Objective 3 (above), and documents analyses and results WDFW completed for populations of spring Chinook (*Oncorhynchus tshawytscha*) in the Wenatchee River watershed. This study was not intended to specifically address Objective 5 (above); however, genetic data provide results relevant to Objective 5. The critical component of Objective 3 is to determine if hatchery supplementation has effected change. Furthermore, change in this context means altering census size and/or genetic marker allele frequencies; we did not attempt to measure changes in fitness. Perhaps a more meaningful rewording of Objective 3 is, “Did the hatchery supplementation program succeed at increasing the census size of a target population while leaving genetic integrity intact?” In order to evaluate cause and effect of hatchery supplementation, we surveyed and compared genetic variation in samples collected before and after potential effects from the Chiwawa Hatchery Supplementation Program. Samples were acquired from the primary spawning aggregates in the upper Wenatchee River watershed: Nason Creek, Little Wenatchee River, White River, and Chiwawa River. Hatchery samples were acquired from programs that could potentially affect genetic composition of Wenatchee stocks, the integrated Chiwawa River stock (local stock), Leavenworth National Fish Hatchery spring Chinook (Carson Stock – non local), and Entiat NFH (Carson Stock – non local). Additionally, the genetic markers used were the Genetic Analysis of Pacific Salmonids (GAPS) (Seeb et al. in review) standardized microsatellites, so all data from the Wenatchee study will be available for inclusion in the GAPS Chinook coastwide microsatellite baseline.

History of Artificial Propagation

Artificial propagation in the upper Columbia River began in 1899 when hatcheries were constructed on the Wenatchee and Methow rivers (Mullan 1987). These initial operations were small, with the Tumwater Hatchery on the Wenatchee River releasing several hundred thousand fry, and the Methow River hatchery producing few Chinook salmon before it was closed in 1913 (Craig and Suomela 1941, Nelson and Bodle 1990). The Leavenworth State Hatchery operated in the Wenatchee River Basin between 1913 and 1931 using eggs from non-native stocks (Willamette River spring-run and lower Columbia Chinook hatchery fall-run). These early attempts at hatchery production were largely unsuccessful for spring-run Chinook (WDF 1934). Between 1931 and 1939, no Chinook salmon hatcheries were in operation above Rock Island Dam (Rkm 730).

In 1938, the last salmon was allowed to pass upstream through the uncompleted Grand Coulee Dam (Rkm 959). To mitigate the loss of habitat, adult Chinook salmon were trapped, under the auspices of the Grand Coulee Fish Maintenance Project (GCFMP), at Rock Island Dam beginning in May 1939, and relocated into three of the remaining accessible tributaries to the upper Columbia River: the Wenatchee, Entiat, and Methow Rivers. GCFMP transfers continued through the autumn of 1943. Spring- and summer/fall-run fish were differentiated at Rock Island Dam based on a 9 July cutoff date for Chinook arrivals at Rock Island Dam (Fish and Hanavan 1948). Spring-run adults collected at Rock Island Dam (pre 9 July fish) were either transported to Nason Creek on the Wenatchee River to spawn naturally (1939-43), or to the newly constructed Leavenworth NFH (1940) for holding and subsequent spawning (1940-43). Eggs were incubated on site or transferred to the Entiat NFH (1941) and Winthrop NFH (1941). In 1944 spring-run adults were allowed to freely pass Rock Island Dam. The GCFMP did not differentiate among late-run stocks (post 9 July fish) passing Rock Island Dam. Late-run offspring reared at the Leavenworth NFH, Entiat NFH, and Winthrop NFHs were an amalgamation of summer and fall upper Columbia River populations (Fish and Hanavan 1948). Late-run fish were transplanted into the upper and lower Wenatchee, Methow, and Entiat Rivers.

After 1943, the Winthrop NFH continued to use local spring-run Chinook for hatchery production, while the other NFHs largely focused on summer-run Chinook salmon. Renewed emphasis on spring run production in the mid-1970s saw the inclusion of local and non-local eggs (Carson NFH stock, Klickitat River stock, and Cowlitz River stock) to the NFHs. In the early 1980s, imports of non-native eggs were reduced significantly, and thereafter the Leavenworth, Entiat, and Winthrop NFHs have relied on adults returning to their facilities for their egg needs (Chapman et al. 1995). Regarding late-run Chinook, due to the variety of methods employed to collect broodstock at dams, hatcheries, or the result of juvenile introductions into various areas, Chinook populations and runs (i.e., summer and fall) have been mixed considerably in the upper Columbia system over the past five decades (reviewed in Chapman et al. 1994).

Washington Department of Fish and Wildlife (WDFW) operates two facilities producing spring-run Chinook, the Methow Fish Hatchery (MFH) owned by Douglas County PUD that began operation in 1992 and Eastbank Fish Hatchery (EFH) owned by Chelan County PUD that began operation in 1989. Both programs were designed to implement supplementation (supportive breeding) programs for naturally spawning populations on the Methow and Wenatchee Rivers, respectively (Chapman et al. 1995). As part of the Rock Island Mitigation Agreement between Chelan County Public Utility District and the fishery management parties (RISPA 1989), a supplementation (supportive breeding) program was initiated in 1989 on the Chiwawa River to mitigate smolt mortality resulting from the operation of Rock Island Hydroelectric Project. EFH uses broodstock collected at a weir on the Chiwawa River, although in recent years hatchery fish have been collected at Tumwater Dam. Similarly, the MFHC uses returning adults collected at weirs on the Methow River and its tributaries, the Twisp and Chewuch Rivers (Chapman et al. 1995; Bugert 1998). Although low run size and trap efficiency has resulted in most broodstock being collected from the hatchery outfall or in some years Wells Dam, progeny produced from these programs are reared at and released from satellite sites on the tributaries where the adults were collected. Numerous other facilities have reared spring-run Chinook salmon on an intermittent basis.

Previous Genetic Studies – Population differentiation

Waples et al. (1991a) examined 21 polymorphic allozyme loci in samples from 44 populations of Chinook salmon in the Columbia River Basin. These authors reported three major clusters of Columbia River Basin Chinook salmon: 1) Snake River spring- and summer-run Chinook salmon, and mid and upper Columbia River spring-run Chinook salmon, 2) Willamette River spring-run Chinook salmon, 3) mid and upper Columbia River fall- and summer-run Chinook salmon, Snake River fall-run Chinook salmon, and lower Columbia River fall- and spring-run Chinook salmon. Utter et al. (1995) examined allele frequency variability at 36 allozyme loci in samples of 16 upper Columbia River Chinook populations. Utter et al. (1995) indicated that spring-run populations were distinct from summer- and fall-run populations, where the average genetic distance between spring-run and late-run Chinook were about eight times the average of genetic distances between samples within each group. Additionally, allele frequency differences among spring-run populations were considerably greater than that among summer- and fall-run populations in the upper Columbia River. Utter et al. (1995) also reported hatchery populations of spring-run Chinook salmon were genetically distinct from natural spring-run populations, but hatchery populations of fall-run Chinook salmon were not genetically distinct from natural fall-run populations.

As part of an evaluation of the relative reproductive success for the Chiwawa River supplementation program, Murdoch et al. (2006), used eleven microsatellite loci to assess population differentiation among spring Chinook salmon population samples in the upper Wenatchee River. Murdoch et al. (2006) reported a >99% accuracy of correctly identifying spring-run and fall-run Chinook from the Wenatchee River. They also reported slight, but significantly different genetic variation among wild spring populations and between wild and hatchery stocks. Yet, since the spring-run populations are genetically similar, identifying individuals genetically from the upper tributaries of the Wenatchee River was difficult. This result is exemplified in their individual assignment results, where < 8% of spring-run individuals, hatchery or wild, were correctly assigned using their criterion of an LOD (log of odds) score greater than 2. Murdoch et al. (2006) also reported contemporary natural spring Chinook show heterozygote deficit and low linkage disequilibrium (LD), while contemporary hatchery spring Chinook show heterozygote excess and high LD.

Williamson et al. (submitted) have continued the work of Murdoch et al. (2006) by analyzing Chiwawa River demographic data from 1989 – 2005 to estimate the proportions of recruits that were produced by Chinook with hatchery or wild origin. In an “ideal” population, the genetic size (i.e., effective size or N_e) and the census size are equal; however various demographic factors such as unequal sex ratios and variance in reproductive success among individuals reduces the genetic size below the census size. It is generally thought that the genetic size is approximately 10-33% the census size (Bartley et al. 1992; RS Waples pers. comm.), although values have been reported outside this range (Araki et al. 2007; Arden and Kapuscinski 2003; Heath et al. 2002). Despite being difficult to estimate, the effective population size in many respects is a more important parameter to know than census size, because N_e determines how genetic diversity is distributed within populations and how the forces of evolution (i.e., forces that change genetic diversity over time) will affect the genetic variation present.

Williamson et al. (submitted) used demographic data to 1) investigate the effect of unequal sex ratio on genetic diversity, 2) investigate the effect of variation in reproductive success on genetic diversity, 3) investigate the effect of fluctuations in population size on genetic diversity, and 4) estimate the effective population size, using the inbreeding method (Ryman and Laikre 1991). Most importantly, they use demographic data from 1989 – 2000 to assess the impact of the Chiwawa Hatchery Supplementation Program on the effective population size of natural-origin Chiwawa River spring Chinook. They estimate that the N_e of naturally spawning Chiwawa Chinook (i.e., both hatchery- and wild-origin fish on the spawning grounds) from 1989 –

1992 was N_e = 2683 and in 1997 – 2000 was N_e = 989. They compare spawning ground N_e to estimates calculated from combined broodstock and naturally spawning Chinook demographic data. The combined inbreeding N_e estimate from 1989 – 1992 was N_e = 147 and in 1997 – 2000 was N_e = 490. Williamson et al. (submitted) argue that since the combined N_e estimate is lower than the naturally spawning estimate, the supplementation program has had a negative impact on the Chiwawa River N_e.

Williamson et al. (submitted) also present genetic data for Chinook recovered on spawning grounds in upper Wenatchee River tributaries in 2004 and 2005. These genetic data are derived from the Murdoch et al. (2006) study. They compare samples collected from Chiwawa River (i.e., hatchery and wild), White River, Nason Creek, and Leavenworth Hatchery. Additionally, they include a 1994 Chiwawa River wild smolt sample for comparison with the 2004 brood year. Williamson et al. (submitted) report statistically significant genetic differentiation among Chiwawa River, White River and Nason Creek. Additionally, they report that the 1994 and 2004 Chiwawa River wild samples are not statistically different, but the 2004 Chiwawa wild and hatchery collections are statistically different.

Study Objectives

This study investigated within and among population genetic diversity to assess the effect of the Chiwawa Hatchery's supplemental program on the natural Chiwawa River spring Chinook population. Differences among temporal population samples, the census size, heterozygosity, and allelic diversity were documented. We investigated population differentiation between the Chiwawa River natural and hatchery samples, and among all temporally replicated samples from the Wenatchee River watershed using microsatellite DNA allele frequencies and the statistical assignment of individual fish to specific populations. To assess the genetic effect of the hatchery program, correlation between census and effective population sizes were investigated using temporally replicated samples obtained before and after the supplementation program operation. To address the hypotheses associated with Objective 3 in Murdock and Peven (2005) we developed eleven specific “Tasks” (Blankenship and Murdoch 2006), to which we analyzed specific genetic data. We present the results from these analyses specific to each individual Task.

Methods and Materials

Tissue collection and DNA extraction

We analyzed thirty-two population collections of adult spring Chinook salmon (*Oncorhynchus tshawytscha*) obtained from the Wenatchee River between 1989 and 2006 (Table 1). Nine collections of natural Chinook adults from the Chiwawa River (n=501), and nine collections of Chiwawa Hatchery Chinook (n=595) were collected at a weir located in the lower Chiwawa River. The 1993 and 1994 Chiwawa Hatchery samples are smolt samples from the 1991 and 1992 hatchery brood years, respectively. Additional samples were collected from upper Wenatchee River tributaries, White River, Little Wenatchee River, and Nason Creek. Six collections of natural White River Chinook (n=179), one collection from the Little Wenatchee (n=19), and six collections from Nason Creek (n=268) were obtained. Single collections were obtained for Chinook spawning in the mainstem Wenatchee River and Leavenworth National Fish Hatchery. An additional out-of-basin collection from Entiat River was also included in the analysis. Samples collected in 1992 or earlier are scale samples. All other samples were either fin clips or operculum punches, stored immediately in ethanol after collection. DNA was extracted from stored tissue using Nucleospin 96 Tissue following the manufacturer’s standard protocol (Macherey-Nagel, Easton, PA, U.S.A.).

Laboratory analysis

We performed polymerase chain reaction (PCR) amplification on each fish sample using the 13 fluorescently end-labeled microsatellite marker loci standardized as part of the GAPS project (Seeb et al. in review). GAPS genetic loci are: *Ogo*2, *Ogo*4 (Olsen et al. 1998); *Oki*100 (unpublished); *Omm*1080 (Rexroad et al. 2001); *Ots*201b (unpublished); *Ots*208b, *Ots*211, *Ots*212, and *Ots*213 (Grieg et al. 2003); *Ots*3M, *Ots*9 (Banks et al.

1999); *Ots*G474 (Williamson et al. 2002); *Ssa*408 (Cairney et al. 2000). PCR reaction volumes were 10 µL, and contained 1 µL 10x PCR buffer (Promega), 1.0 µL MgCl2 (1.5 mM final) (Promega), 0.2 µL 10 mM dNTP mix (Promega), and 0.1 units/mL Taq DNA polymerase (Promega). Loci were amplified as part of multiplexed sets, so primer molarities and annealing temperatures varied. Multiplex one had an annealing temperature of 50°C, and used 0.37 Molar (M) *Oki*100, 0.35 M *Ots*201b, and 0.20 M *Ots*208b, and 0.20 M *Ssa*408. Multiplex two had an annealing temperature of 63°C, and used 0.10 M *Ogo*2, and 0.25 M of a non-GAPS locus (*Ssa* 197). Multiplex three had an annealing temperature of 56°C, and used 0.18 M *Ogo*4, 0.18 M *Ots*213, and 0.16 M *Ots*G474. Multiplex four had an annealing temperature of 53°C, and used 0.26 M *Omm*1080, and 0.12 M *Ots*3M. Multiplex five had an annealing temperature of 60°C, and used 0.30 M *Ots*212, 0.20 M *Ots*211, and 0.10 M *Ots*9. Thermal cycling was conducted on either a PTC200 thermal cycler (MJ Research) or GeneAmp 9700 (Applied Biosystems) as follows: 95°C (2 min); 30 cycles of 95°C for 30 sec., 30 sec. annealing, and 72°C for 30 sec.; a final 72°C extension and then a 10°C hold. PCR products were visualized by electrophoresis on an ABI 3730 automated capillary analyzer (Applied Biosystems). Fragment analysis was completed using GeneMapper 3.7 (Applied Biosystems). Standardization of genetic data to GAPS allele standards was conducted following Seeb et al. (in review).

Genetic data analysis

Assessing within population genetic diversity - Heterozygosity measurements are reported using Nei's (1987) unbiased gene diversity formula (i.e., expected heterozygosity) and Hedrick's (1983) formula for observed heterozygosity. Both tests are implemented using the microsatellite toolkit (Park 2001). We used GENEPOP version 3.4 (Raymond and Rousset 1995) to assess Hardy-Weinberg equilibrium (HWE), where deviations from the neutral expectation of random associations among alleles are calculated using a Markov chain method (5000 iterations in this study) to obtain unbiased estimates of Fisher's exact test. Global estimates of F_{IS} according to Weir and Cockerham (1984) were calculated using GENEPOP version 3.4. Genotypic linkage disequilibrium was calculated following Weir (1979) using GENEPOP version 3.4.

Linkage results for population collections are reported as the proportion of pairwise (locus by locus) tests that are significant (alpha = 0.01). Linkage disequilibrium is considered statistically significant if more than 5% of the pairwise tests based on permutation are significant for a collection.

Within- and among-population genetic differentiation – The temporal stability of allele frequencies within populations, and pairwise differences in allele frequencies among populations were assessed using several different procedures. First, we tested for differences in allele frequencies among populations defined in Table 1 using a randomization chi-square test implemented in GENEPOP version 3.4 (Raymond and Rousset 1995). This procedure tests for differences between pairs of populations where alleles are randomized between the populations (i.e., genic test). The null hypothesis for this test is that the allele frequency distributions between two populations are the same. A low p-value should be interpreted as the allele frequency distributions being compared are unlikely to be samples drawn from the same underlying distribution.

Second, to graphically describe allele frequency differences among populations we conducted a nonmetric multidimensional scaling analysis using allele-sharing distance matrices from two different data sets. Pairwise allele-sharing distances are calculated as 1 – (mean over all loci of the sums of the minima of the relative frequencies of each allele common to a pair of populations). To calculate the allele-sharing distances for each pair of populations we used PowerMarker v3.25 (Liu and Muse 2005). Nonmetric multidimensional scaling is a technique designed to construct an n-dimensional "map" of populations, given a set of pairwise distances between populations (Manly 1986). The output from this analysis is a set of coordinates along n-axes, with the coordinates specific to the number of n-dimensions selected. To simplify our analysis we selected a 2-dimensional analysis to represent the relative positions of each population in a typical bivariate plot. The goodness of fit between the original allele-sharing distances and the pairwise distances between all populations along the 2-dimensional plot is measured by a "stress" statistic. Kruskal (in Rohlf 2002) developed a five-tier guide for evaluating stress levels, ranging from a perfect fit (stress=0) to a poor fit (stress=0.40). We conducted the nonmetric multidimensional scaling analysis for one data set containing Chiwawa natural- and hatchery-origin collections, and another data set containing Chiwawa broodstock and in-river spawner collections. We used the mdscale module in MATLAB R2006b (The Mathworks 2006) to generate the nonmetric multidimensional scaling coordinates.

We examined the geographic and temporal structure of populations in the upper Wenatchee (Chiwawa River, Nason Creek, and White River, only) using a series of analyses of molecular variance (AMOVAs). Here, we defined an AMOVA as an analysis of variance of allele frequencies, as originally designed by Cockerham (1969), but implemented in Arlequin v2.1 (Schneider et al. 2000). These analyses permit populations to be aggregated into groups, and molecular variance is then partitioned into within collections, among collections, but within groups, and among group components. With this approach, we were able to determine how best to group populations, with "best" being defined as that grouping that accounts for the greatest proportion of among group variance. Furthermore, by partitioning molecular variance into three different hierarchical components, we are able to determine what level accounts for the majority of the molecular variance.

Finally, we explored the partitioning of molecular variance between among-individuals and among-populations using a principal component analysis and multi-locus estimates of pairwise F_{ST}, estimated by a "weighted" analysis of variance (Weir and Cockerham, 1984). Principal component analysis is a data-reduction technique whereby the correlation structure among variables can be used to combine variables into a series of multivariate components, with each original variable receiving a weighted value for each component based on its correlation with that component. Here, we used a program written by Warheit in MATLAB R2006b (The Mathworks 2006) that treats each allele for each locus as a single variable (13 loci = 26 alleles or variables), and these 26 "variables" were arranged into 26 components, with each component accounting for a decreasing amount of molecular variance. Estimates of F_{ST} were calculated using GENETIX version 4.05 (Belkhir et al.1996). To determine if the F_{ST} estimates were statistically different from random (i.e., no structure), 1000 permutations were implemented in GENETIX version 4.05 (Belkhir et al.1996).

Effective population size (N_e) – Estimates of the effective population size were obtained using two methods, a multi-collection temporal method (Waples 1990), and a single-collection method (Waples 2006) using linkage disequilibrium data. The temporal method assumes that cohorts are used, but we did not decompose the collection year samples into their respective cohorts using age data. Therefore, N_e estimates that pertain to individual year classes of breeders are not valid; however the harmonic mean over all samples will estimate the contemporary N_e. Comparing samples from years *i* and *j*, Waples' (1990) temporal method estimates the effective number of breeders ($\hat{N}_{b(i,j)}$) according to:

$$\hat{N}_{b(i,j)} = \frac{b}{2(\hat{F} - 1/\hat{S}_{i,j})}$$

The standardized variance in allele frequency ($\hat{F}$) is calculated according to Pollack (1983). The parameter b is calculated analytically from age structure information and the number of years between samples (Tajima 1992). The age-at-maturity information required to calculate b was obtained from Murdoch et al. (2006) for this analysis. They observed for Chiwawa Hatchery Chinook that 8.6% matured at age 2, 4% at age 3, 87% at age 4, and 0.4% at age 5. For Chiwawa natural Chinook, Murdoch et al. (2006) observed that 1.8% matured at age 3, 81.6% at age 4, and 16.7% at age 5. The harmonic mean of sample sizes from years *i* and *j* is $\tilde{S}_{i,j}$. Over all pairwise comparisons the harmonic mean of all $\hat{N}_{b(i,j)}$ is $\tilde{N}_b$, the contemporary estimate of the effective population size (N_e). SALMONNb (Waples et al. 2007) was used to calculate $\tilde{N}_b$. As suggested by authors, alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

The method of Waples (2006) uses linkage disequilibrium (i.e., mean squared correlation of allele frequencies at different gene loci) as a means of estimating effective population size (N_e) from a single sample. While this method is biased in some cases where N_e /N ratio is less the 0.1 and the sample size is less than the true N_e, it has been shown to produce comparable results to the temporal method. Burrows' delta method is used to estimate LD, and a bias corrected estimate of N_e is calculated after eliminating alleles with frequency less than 0.05. This test was implemented using LDN_e (Do and Waples unpublished). In age-structured species, N_e estimates based on LD are best interpreted as the effective number of breeders (N_b) that produced the sample (Waples 2006). N_b should be multiplied by the mean generation length (i.e., 4 in this case) to obtain an overall estimate of N_e based on an N_b estimate. We analyzed collections categorized by spawning location (i.e., hatchery broodstock or in-river) and did not analyze collections categorized by origin (i.e., hatchery or natural). Waples' (2006) method estimates N_e from observed LD, therefore the corresponding N_e estimates for the hatchery collections would be low and the estimates for the natural collections would be high. Yet, since the supplementation program is integrated, and hatchery fish can spawn naturally, we feel it inappropriate to analyze the hatchery and natural samples as if they were separate, which would essentially partition all the LD into the hatchery samples.

Each collection has an N_b estimate and an associated confidence interval. If the confidence interval includes infinity, it means that sampling error accounts for all the LD observed (i.e., empirical LD is less than expected LD). The usual interpretation is that there is no evidence for any disequilibrium caused by genetic drift in a finite number of parents. Since the LD method estimates the number of breeders that contributed to the sample being analyzed, in order to calculate an N_e /N ratio, the appropriate census size must be used. The census size used to derive a ratio was the estimate four years prior to the collection analyzed using LD, which assumed a strict four-year-old lifecycle, although the observed proportion of four-year-olds was approximately 85% each year. The census numbers (Table 2) used to calculate the ratios for Chiwawa broodstock and in-river spawners were combined NOS (natural-origin spawners) and HOS (hatchery-origin spawners) census estimates.

Individual assignment – A population baseline file was constructed containing all 1704 individual Chinook from 34 population collections (Table 1; Chiwawa origin data set plus all samples from other populations). All individuals in the baseline had geneotypes that included nine or more loci. Individual Chinook were assigned to their most likely population of origin based on the partial Bayesian criteria of Rannala and Mountain (1997), using a "jack-knife" procedure, where each individual to be assigned was removed from the baseline prior to the calculation of population likelihoods. This procedure was implemented in a program written by Warheit in MATLAB R2006b (The Mathworks 2006). Two assignment criteria were used, 1) the population with the largest posterior probability for an individual was the "most-likely" population of origin (i.e., all individuals assigned to a collection), and 2) an assignment was consider valid only if the posterior probability was greater than or equal to 0.9. Please note that while the analysis used 34 population collections to assign Rannala and Mountain likelihoods for each individual, these likelihoods were aggregated based on "population" (i.e., Chiwawa, Nason, White, and so on) and posterior probabilities were calculated for population location, rather than individual collections.

Results and Discussion

In this section we combine our presentation and interpretations of the genetic analyses. Additionally, this section will be organized based on the task list presented in the study plan. Overall conclusions are provided following this section.

Task 1: Determine trend in census size for Chiwawa River spring Chinook.

Census data from 1989 – 2005 are provided in Table 2 for the Chiwawa Hatchery broodstock and spring Chinook present in the Chiwawa River. The demographic data for naturally spawning Chinook are based on redd sampling and carcass surveys, while broodstock data are based on Chiwawa hatchery records. As the supplementation program is integrated by design, we also present the proportion of natural-origin broodstock (pNOB) incorporated into the hatchery, in addition to the number of natural-origin (NOS) and hatchery-origin (HOS) spawners present in Chiwawa River. The census size fluctuated yearly, and a general reduction in census size was observed in the mid to late 1990's. This trend was apparent in both the broodstock and in the river. The arithmetic mean census size from 1989 – 2005 for the Chiwawa Hatchery (i.e., broodstock) was N=87.5 per year. The arithmetic mean census size from 1989 – 2005 for the Chiwawa River (i.e., NOS and HOS combined) was N=961.9 per year. For collection years when adult Chiwawa hatchery-origin fish would have been absent in the Chiwawa River (1989 – 1992), the arithmetic mean of natural Chiwawa Chinook census size is N=962.7. We will use this number as the baseline census size to assess if census size has changed. We used two different values for the contemporary census size in the Chiwawa River, NOS only and NOS + HOS. Additionally, we used collection years 2002 – 2005 for the contemporary NOS and HOS estimates, as these are the most recent data and the number of years included for estimation is the same as the pre-hatchery estimate above (i.e., four years). For NOS only, the arithmetic mean census size from 2002 – 2005 was N=536.0. For total census size (i.e., NOS and HOS combined), the arithmetic mean census size from 2002 – 2005 was N=1324.0. For the demographic data presented here, the contemporary census size is larger than the census estimate derived from the years prior to hatchery operation.

<u>Task 2:</u> Document the observed genetic diversity.

Genetic Diversity Categorized By Origin

For Chiwawa River collections categorized by origin (Table 1A), substantial genetic diversity was observed, with heterozygosity estimates over all loci, having a mean of 0.80. Genetic diversity was consistent with expected Hardy-Weinberg random mating genotypic proportions for ten of the eighteen collections. Eight of the nine Chiwawa natural collections were consistent with HWE, and two of nine Chiwawa Hatchery collections were consistent with HWE. F_{IS} is observed to be slight for all Chiwawa population collections, suggesting individuals within collections do not show excessive homozygosity.

The deviations from HWE observed were generally associated with hatchery collections. The two smolt collections (i.e., 1993 and 1994) showed significant deviations from HWE, which may be a function of non-random hatchery practices involving the contributing natural-origin parental broodstocks (i.e., 1991 and 1992 cohort). Deviations from HWE in the remaining hatchery collections may be the result of few individuals being represented in the broodstock (see below).

Additionally, linkage disequilibrium (LD) was also common for Chiwawa hatchery-origin collections and minimal for Chiwawa natural-origin collections. The random association of alleles between loci (i.e., linkage equilibrium) is expected under ideal conditions. LD is observed when particular genotypes are encountered more than expected by chance. Laboratory artifacts (e.g. null alleles) or physical linkage of loci on the same chromosome can cause LD, but the LD we observed was not associated with certain locus combinations, which you would expect if either artifacts or physical linkage were the cause of LD. LD was observed for seven of the nine hatchery-origin collections. As with the deviations from HWE, the high LD in the 1993 and 1994 hatchery-origin collections may be a result of non-random hatchery practices. The substantial LD observed in the hatchery-origin adult collections (collection years 2000, 2001, 2004, and 2006) might be the result of small parental broodstock sizes contributing to those returning adults. During the mid 1990's, the Chiwawa broodstock size was low, with zero individuals collected in 1995 and 1999; so fewer individuals would be contributing to the hatchery adult returns than the natural. This idea is corroborated by the lower LD observed for the 2005 hatchery-origin collection, which had a contributing parental broodstock size in 2001 (i.e., the major contributing parental generation) approximately eight times as large as the previous few collection years (Table 2). LD reappears in the 2006 Chiwawa hatchery-origin collection, which had a contributing parental broodstock size (i.e., for the most-part, the 2002 hatchery brood year) five times lower (Table 2) than that of the 2005 collection.

While seven of nine hatchery-origin collections showed significant LD, only one natural origin collection showed LD, and for this collection, only 10% of the loci-pairs were in disequilibrium (Table 1). The fact that LD predominated in the hatchery samples, suggests that variance in reproductive success (i.e., overrepresentation of particular parents) is higher in the hatchery-origin than in natural-origin collections.

Genetic Diversity Categorized By Spawning Location

For upper Wenatchee River collections categorized by spawning location (Table 1B), substantial genetic diversity was observed, with heterozygosity estimates over all loci, having a mean of 0.79 and ranging from a low of 0.69 (1993 White River) to 0.85 (1993 Little Wenatchee). Genetic diversity was consistent with HWE for nineteen of twenty-nine population collections. For the collections that departed from HWE, seven were from the Chiwawa River, one was from Leavenworth Hatchery, one was the Wenatchee mainstem collection of hatchery-origin – naturally spawning fish, and one was from the White River. F_{IS} is observed to be slight for all population collections except the 1993 White River collection (10% heterozygote deficit) (Table 1B). Collections deviating with HWE generally correlated with collections having high LD. Twelve population collections showed a proportion of pairwise linkage disequilibrium tests (across all loci) greater than 5% (Table 1B), eight of which were Chiwawa collections.

Starting in 1996, spawning location collections are composed of both natural- and hatchery-origin samples. The LD seen in the later spawning location collections may be caused by an admixing effect (i.e., mixing two populations), where random mating has not had the chance to freely associate alleles into genotypes. Interestingly, there appears to be a trend of reducing LD through time within the broodstock collections (Table 1B), which suggests that a "homogenizing" effect is taking place within the Chiwawa River. This observation is discussed more fully in Task 3 below.

<u>Task 3:</u> Test for population differentiation among collections within the Chiwawa River and associated supplementation program.

Introduction

Task 3 was designed to address two hypotheses listed as part of Objective 3 in Murdoch and Peven (2005):

- Ho: Allele frequency $_{\text{Hatchery}}$ = Allele frequency $_{\text{Naturally produced}}$ = Allele frequency $_{\text{Donor pop}}$.
- Ho: Genetic distance between subpopulations $_{\text{Year x}}$ = Genetic distance between subpopulations $_{\text{Year y}}$

Murdoch and Peven (2005) proposed these two hypotheses to help evaluate the Chiwawa supplementation program through the "Conceptual Process" (Figure 5 in Murdoch and Peven 2005; repeated here as Figure 1). There are two components to the first hypothesis, which must be considered separately. The first component involves comparisons between natural-origin populations in the Chiwawa to determine if there have been changes in allele frequencies or genetic distances, through time starting with the donor population. Documenting a change does not necessarily indicate that the supplementation program has directly affected the natural origin fish, as additional tests would be necessary to support that hypothesis. The intent of the second component is to determine if the hatchery produced populations have the same genetic composition as the naturally produced populations.

Although on the surface these two components and their associated comparisons may appear simple, from a hypothesis-testing perspective the analyses are complicated by the fact that natural-origin fish may have had hatchery-origin parents, and hatchery-origin fish may have had natural-origin parents. As such, we organized the Chiwawa genetic data into three data sets: (1) fish origin (hatchery versus natural), (2) spawning location (hatchery broodstock versus in-river (natural) spawners), and (3) four "treatment" groups (1. hatchery-origin hatchery broodstock, 2. hatchery-origin natural spawner, 3. natural-origin natural spawner, and 4. natural-origin hatchery broodstock). We conducted separate analyses using each of the three data sets, with each analysis touching on some aspect of the components necessary to move through the Conceptual Process (Figure 1).

Hatchery- Versus Natural-Origin

We address the following questions with the origin data set:

1. Are there changes in allele frequencies and allele sharing distances in the natural-origin collections from pre-supplementation to today?
2. Are there changes in allele frequencies and allele sharing distances in the hatchery-origin collections from early supplementation to today?
3. Are there significant differences in allele frequencies and large allele sharing distances between hatchery- and natural-origin adults from a collection year, and has this pattern changed through time?

Genic Differentiation Tests – We explicitly tested the hypothesis of no significant differentiation within natural- or hatchery-origin collections from the Chiwawa River using a randomization chi-square test. We show the results for the pairwise comparisons among natural-origin collections from the Chiwawa River populations in the first block of the second page of Table 3. Ten of the 36 (28%) pairwise comparisons have highly significant allele frequency differences, while only 12 of the 36 comparisons (33%) showed no significant differences. Eight of these 12 comparisons involved the 1996 collection, which included only eight samples and therefore provided little power to differentiate allele frequencies. If we exclude the 1996 collection, only 14% of the pairwise comparisons showed no significant differences, and here all but one of these comparisons involved the 1989 collection. The 1989 collection appeared to be the least differentiated collection in the natural-origin data set in that all pairwise comparisons were either not significant, or only mildly significant at the nominal critical value. No comparisons involving the 1989 collection were significant using a Bonferroni-corrected critical value, and 1989 is the only natural-origin collection in our data set that can be classified as "pre-supplementation."

We can interpret these results to indicate that although there appears to be significant year-to-year differences in allele frequencies among post-supplementation collections, the allele frequencies between each post-supplementation collection and the 1989 pre-supplementation collection are not greatly different. However, the level of differentiation does increase from the early post-supplementation years to the more recent years (2001, 2004-2006), although the statistical level of this significance never exceeds the Bonferroni-corrected critical value. Finally, sample sizes were also small for the 1989 collection (n = 36) and we cannot eliminate a reduction in power as a contributing factor for the lack of significance for these tests.

As with the hatchery-origin collections, most pairwise comparisons of allele frequencies between hatchery-origin samples were significant (Table 3, first page, upper block). Out of the 36 pairwise comparisons, all but three are significant at some level, and most comparisons are highly significant. Similar to the natural-origin analysis, the non-significant results were limited to comparisons involving the 1996, which included only eight samples.

As a result of this analysis *we reject the hypothesis that there was no significant differentiation among natural- or hatchery-origin collections from the Chiwawa River*. Furthermore, the allele frequencies of the hatchery-origin collections are significantly different from those of natural-origin collections (Table 3, first page, second block). For those fish collected in the same year, allele frequencies are significantly different between hatchery- and natural-origin collections, although in 2005 the level of significance was below the Bonferroni critical value (Table 3). The next step is to examine the pattern of allelic differentiation to discover first if there is a trend among the data, and second, if this trend suggests that the allele frequency differences among Chiwawa River natural-origin fish collections has been affected by the hatchery-origin fish.

Allele-sharing and Nonmetric Multidimensional Scaling – We constructed a pairwise allele-sharing distance matrix for all hatchery- and natural-origin collections from the Chiwawa River and subjected this matrix to a nonmetric multidimensional scaling analysis, restricting the analysis to two dimensions (Figure 2). The stress statistic for this analysis is 0.09, a value Kruskal (in Rohlf 2002) listed as a good to excellent fit between the actual allele-sharing distances and the Euclidean (straight-line) distances in the plot.

In other words, Figure 2 is a good visual representation of the allele sharing distance matrix; collections with a high percentage of alleles shared will be closer to each other than collections with a lower percentage of alleles shared.

With the exception of the two outlier years (1996 and 1998) the Chiwawa natural-origin collections form a tight cluster indicating an overall common set of shared alleles among these collections. Even if we ignore the 1996 and 1998 hatchery-origin collections, there appears to be a greater variance in shared alleles among the Chiwawa hatchery-origin collections than the natural-origin collections (Figure 2). In fact, the median percentage of alleles shared among the Chiwawa natural-origin collections is 76% compared with 69% alleles shared among the Chiwawa hatchery-origin collections.

Also, there appears to be a convergence in allele sharing distances (i.e., a decrease in allele frequency differences) between the hatchery- and natural-origin fish from the late 1980s/early 1990s to 2006. The series of red arrows in Figure 2 represent the progression of change in hatchery-origin allele sharing distances from 1996 (first adult hatchery origin fish in our analysis) to 2006 and this progression is decidedly in the direction of the natural-origin cluster. However, the most recent natural-origin collections (2001, 2004-2006) appear to have pulled closer to the hatchery-origin collections, compared with the 1989 natural-origin collection (note the close proximity of the 2000 and 1989 natural-origin collections). Nevertheless, the cluster of natural-origin collections adjacent to the hatchery-origin collections in Figure 2 also includes the 1993 natural-origin collection. Qualitatively, it appears that the initial hatchery-origin and natural-origin collections were more different from each other in terms of the percentage of shared alleles than are the most recent hatchery- and natural-origin collections. This may have been a result of a non-random sample of natural-origin fish that was used as broodstock in the initial years of the supplementation program (see discussion in Task 2 concerning deviations from HWE and linkage disequilibrium).

That being said, we do need to emphasize that Figure 2 is dominated by five outlier collections (two each from the 1996 and 1998 collections, and the 1994 smolt collection).

The 1996 and 1998 collections are characterized by small samples sizes, and the 1994 smolt collection has nearly all pairs of loci in linkage disequilibrium (Table 1). If we eliminate these five outlier groups, both the hatchery- and natural-origin collections form a relatively tight cluster. Excluding the five outliers, the median percentage of shared alleles among all pairwise combinations of Chiwawa hatchery versus Chiwawa natural collections is 76%. This compares with a median pairwise percentage of 79% among only Chiwawa natural-origin collections. That is, there are nearly as many alleles shared between the hatchery-origin and natural-origin collections as there are among the natural-origin collections themselves. There is also a narrowing of differences between natural- and hatchery-origin fish from the same collection years from 1993 (76% shared alleles) through 2006 (83% shared alleles).

If allelic differentiation among collections is a function of genetic drift, we would expect a positive correlation between the number of years between two collections and the allele sharing distance. That is, if genetic drift is the primary cause of allele frequency differences between two collections, the greater the number of years between the two collections the larger the allele-sharing distance. For both the natural- and hatchery-origin collections we examined the relationship between the number of years between a pair of collections and the collections' allele-sharing distance (Figure 3). Although the relationship between time interval and allele distance appears to be a positive function in the natural collections, the slope of the regression line is 0.0017, and is not significantly different from zero. Furthermore, the correlation coefficient (r^2) equals 0.1068, which means that the time interval between collections accounts for only 10% of the pairwise differences in allelic distance. The hatchery-origin collections do show a significantly positive slope (0.0037; $p = 0.0254$) and a regression coefficient nearly three times greater than that for the natural-origin collections. However, the correlation coefficient is still relatively small ($r^2 = 0.3290$), indicating that the time interval between collections accounts for one-third of the pairwise differences in allelic distance. The results suggest that if genetic drift is a factor in allelic differentiation between collections, it is only a minor factor, and appears to have affected the hatchery-origin collections more than the natural-origin collections.

If four-year-old fish dominate each collection year, we would expect a closer relationship among collections that are spaced at intervals of four years. The average percentage of alleles shared between two natural-origin collections that are separated by four years or a multiple of four years is 81%, compared with 78% for natural-origin collections separated by years that are not divisible by four. Likewise, for hatchery-origin collections the average percentage of alleles shared is 80% and 75% for collections separated by years divisible and not divisible by four, respectively. Although the percent differences described above are relatively small, they are consistent with the idea that allelic differences between collections are a function of year-to-year variability among different cohorts of four year-old fish.

Summary – The allele frequencies within and between natural- and hatchery-origin collections are significantly different, but there does not appear to be a robust signal indicating that the recent natural-origin collections have diverged greatly from the pre- or early post-supplementation collections. Genetic drift will occur in all populations, but does not appear to be a major factor with the Chiwawa collections. We propose that the differences among collections are a function of differences in allele frequencies among cohorts of the four year-old fish that dominate each collection.

Hatchery Broodstock Versus Natural (In-River) Spawners

We address the following questions with the spawner data set:

1. Are there changes in allele frequencies and allele sharing distances in the natural spawning collections from pre-supplementation to today?
2. Are there changes in allele frequencies and allele sharing distances in the hatchery broodstock collections from early supplementation to today?
3. Are there significant differences in allele frequencies and large allele sharing distances between hatchery and natural spawning adults from a collection year, and has this pattern changed through time?

Genic Differentiation Tests – For the most part there are significant differences in allele frequencies among collections for both the hatchery broodstock and natural spawners (Table 4), and these differences are consistent with the origin data set (Table 3). There are four collection years with paired samples (2001, 2004-2006) where we can compare allele frequency differences between the hatchery broodstock and natural spawners, within the same year. The 2001 hatchery broodstock and natural spawner collections have significantly different allele frequencies, but the level of significance decreased from 2001 to 2004, and become non-significant in 2005 and 2006 (Table 4). This indicates that by 2005, the hatchery broodstock and natural spawners collections were effectively sampling from the same population of fish. Additionally, the percentage of alleles shared between the hatchery broodstock and the natural spawners increased from 76% in 2001 to 86% in 2006 (allele sharing distance matrix, not shown). From this analysis, we conclude that although there are year-to-year differences in allele frequencies within the natural and hatchery spawner collections, *there appears to be a convergence of allele frequencies within collection-year, between the natural and hatchery spawner populations*.

Linkage Disequilibrium – Linkage disequilibrium is the correlation of alleles between two loci, and can occur for several reasons. If two loci are physically linked on the same chromosome, than alleles from each of these loci should be correlated. However, linkage between two loci can occur as a result of population bottlenecks, small population sizes, and natural selection. If any of these conditions had occurred or were occurring within the Chiwawa River system, we would expect to find substantial linkage disequilibrium in many or perhaps all Chiwawa collections. However, many Chiwawa collections, especially the natural-origin collections, do not show linkage disequilibrium (Table 1), and it would appear that the linkage disequilibrium within certain Chiwawa collections is not a function of the processes listed above. Linkage disequilibrium can also result if the collection is composed of an admixture. That is, if two or more reproductively isolated populations are combined into a single collection, the collection will show linkage disequilibrium. Each broodstock and natural spawning collection is composed of natural- and hatchery-origin fish. If these hatchery- and natural-origin fish are drawn from the same population, the spawning collections should not show substantial linkage disequilibrium. However, if the hatchery- and natural-origin fish are from different populations (i.e., full hatchery – natural integration has not been achieved), the spawning collections should show substantial linkage disequilibrium.

There are only three Chiwawa spawning collections that are not composed of both hatchery- and natural-origin samples: 1989 (natural-origin, natural spawner), 1993 (natural-origin, hatchery broodstock), and 2001 (natural-origin, natural spawner). Of the 10 spawning collections with both hatchery- and natural-origin fish, seven show significant linkage disequilibrium. Two of the three collections that did not show linkage disequilibrium are the 1996 and 1998 hatchery broodstock collections, which are composed of only seven natural- and six hatchery-origin fish, and two natural- and 19 hatchery-origin fish, respectively. Within the hatchery broodstock collections with linkage disequilibrium, the percent of loci pairs showing linkage decreased from 32% in 2000 to 13% in 2001 and 2004, to only 1% and 5% in 2005 and 2006, respectively (Table 1). If the homogenization of allele frequencies of natural- and hatchery-origin fish was increasing from 2000 to 2006, we would expect a decrease in linkage disequilibrium among the broodstock collections. This is what occurred within the hatchery broodstock collections, but did not occur within the natural spawner collections, where the percent of loci pairs showing linkage was 18% in 2004, 6% in 2005, and 10% in 2006 (Table 1). Furthermore, the 2001 natural spawner collection, with no hatchery-origin component showed linkage disequilibrium with 9% of loci pairs.

There is no correlation between percent of loci pairs showing linkage disequilibrium and percent of broodstock composed of hatchery-origin fish ($r^2 = 0.0045$). Furthermore, the natural spawner and hatchery broodstock collections were each composed of roughly the same average percentage of hatchery-origin fish (57% and 53%, respectively). If the decrease in linkage disequilibrium among the hatchery broodstock collections from 2000 to 2006 was a result of a homogenization of allele frequencies of natural- and hatchery-origin fish in the broodstock, the same degree of homogenization did not occur within the natural spawner collections. This would occur if natural- and hatchery-origin fish spawning within the river remain segregated, either by habitat or by fish behavior.

Summary – As with the origin data set, there are significant allele frequency differences within and between hatchery broodstock and natural spawner collections. However, in recent years the allele frequency differences between the hatchery broodstock and natural spawner collections has declined. Furthermore, based on linkage disequilibrium, there is a genetic signal that is consistent with increasing homogenization of allele frequencies within hatchery broodstock collections, but a similar homogenization within the natural spawner collection is not apparent. These data suggest that there exists consistent year-to-year variation in allele frequencies among hatchery and natural spawning collections, but there is a trend toward homogenization of the allele frequencies of the natural- and hatchery-origin fish that compose the hatchery broodstock.

Four Treatment Groups

Analyses of genetic differences between hatchery (broodstock) and natural spawner collections is confounded by the fact that each these two groups are composed of fish of natural- and hatchery-origin. To understand the effects of hatchery supplementation on *natural-origin fish that spawn naturally*, we needed to divide the Chiwawa data set into four mutually exclusive groups: (1) hatchery-origin hatchery broodstock, (2) hatchery-origin natural spawner, (3) natural-origin hatchery broodstock, and (4) natural-origin natural spawner, with each group consisting of multiple collection years, for a total of 25 different groups.

Allele-sharing and Nonmetric Multidimensional Scaling –As with previous analyses discussed above, we constructed a pairwise allele-sharing distance matrix for all collections from each of these treatment groups and subjected this matrix to a nonmetric multidimensional scaling analysis, restricting the analysis to two dimensions. Figure 4 shows that five outlier groups dominate the allele-sharing distances within this data set. These outlier groups are also present in Figure 2, as discussed above, and Figure 2 and 4 resemble each other because the same fish are included in each analysis. The difference between Figures 2 and 4 is that in Figure 4 the fish are grouped into collection year and the four treatment groups, rather than collection year and two treatment groups (hatchery- versus natural-origin).

Figure 4 does not provide useful resolution of the groups within the polygon, because the outlier groups dominate the allele sharing distances. We removed the five outlier groups from Figure 4, recalculated the allele sharing distances and subjected this new matrix to a multidimensional scaling analysis (Figure 5). Figure 5 shows separation among the 2001, 2004-2006 collections, but this separation does not necessarily indicate that within-year collections are more similar to each other than any collection is to a collection from another year. For example, the 2006 natural-origin natural spawner and the 2005 natural-origin hatchery broodstock collections share 81% alleles, while the 2006 natural-origin natural spawner and 2006 hatchery-origin hatchery broodstock collections share 75% alleles. There does not appear to be any discernable pattern of change in allele-sharing distance among the collections relevant to pre- or post-supplementation. Although the 1989 pre-supplementation natural-origin collection appears distinct (Figure 5), the 1993 natural-origin hatchery broodstock collection appears quite similar to the 2005 and 2006 natural-origin collections (Figure 5). The 1993 natural-origin hatchery broodstock collection, although not technically pre-supplementation, is composed of fish whose ancestry cannot be traced to any Chiwawa hatchery fish. Therefore, there is no clear pattern of allele sharing change from pre-supplementation to recent collections.

There does appear to be some change in the average percentage of alleles shared within the 2001 to 2006 collections, with an increase from 74% in 2001 and 2004 to 78% and 79% in 2005 and 2006, respectively. The results provided by this analysis are consistent with the results presented in the origin and spawner data sets. That is, there are allele frequency and allele sharing differences among the collections, but analyses do not strongly suggest that these differences are a function of the supplementation program. Furthermore, there is also a weak signal that the hatchery and natural collections within the most recent years are more similar to each other than in the previous years.

Overall Genetic Variance – Although there are signals of allelic differentiation among Chiwawa River collections, there are no robust signs that these collections are substantially different from each other. We used two different analyses to measure the degree of genetic variation that exists among individuals and collections within the Chiwawa River. First, we conducted a principal component analysis using all Chiwawa samples with complete genotypes (i.e., no missing alleles from any locus). Although the first two principal component axes account for only 10.5% of the total molecular variance, a substantially greater portion of that variance is among individual fish, regardless of their identity, rather than among hatchery and natural collections (Figure 6). The variances in principal component scores among individuals are 11 and 13 times greater than the variance in scores among collections, along the first and second axes, respectively.

Second, we conducted a series of analyses of molecular variance (AMOVA) to ascertain the percentage of molecular variance that could be attributed to differences among collections. We organized these analyses to test also for differences in the hierarchical structure of the data. That is, we tested for differences among collections using the following framework:

- No organizational structure – all 25 origin-spawner collections considered separately
- Origin-spawner collections organized into 10 collection year groups
- Origin-spawner collections organized into 2 breeding location groups (hatchery versus natural)
- Origin-spawner collections organized into 2 origin groups (hatchery versus natural)
- Origin-spawner collections organized into the 4 origin-spawner groups

It is clear from this analysis that nearly all molecular variation, no matter how the data are organized, resides within a collection (Table 5). The percentage of total molecular variance occurring within collections ranged from 99.68% to 99.74%. The among group variance component was limited to less than 0.26% and in all organizational structures, except “no structure,” the among group percentage was not significantly greater than zero. Furthermore, none of the organizational structures provided better resolution than “no structure” in terms of accounting for molecular variance within the data set. *These results indicate that if there are significant differences among collections of Chiwawa fish, these differences account for less than one percent of the total molecular variance, and these differences cannot be attributed to fish origin or spawning location.*

Summary and Conclusions

We reject the null hypothesis that the allele frequencies of the hatchery collections equal the allele frequencies of the natural collections, which equals the allele frequency of the donor population. Furthermore, because the allele-sharing distances are not consistent within and among collections years, we also reject the second stated hypothesis discussed above. However, there is an extremely small amount of genetic variance that can be attributed to among collection differences. The allelic differentiation that does exist among collections does not appear to be a function of fish origin, spawning location, genetic drift, or collection year. Figure 5 and related statistics does suggest that hatchery and natural collections in 2005 and 2006 are more similar to each other than previous years’ collections, and this would be expected in a successful integrated hatchery supplementation program.

Since each of these collection years are generally composed of four-year-old fish, the differentiation among these collections for the most part is differentiation among specific cohorts. The slightly greater percentage of alleles shared among collections that are separated in time by multiples of four years, compared with collections that are not separated in time as such, suggests that cohort differences may be the most important factor accounting for differences in allele frequencies among collections.

<u>Task 4:</u> Develop a model of genetic drift.

See Task 3

Task 5: Analyze spring Chinook population samples from the Chiwawa River and Chiwawa Hatchery from multiple generations.

See Task 3

Task 6: Analyze among population differences for upper Wenatchee spring Chinook.

Supplementation of the Chiwawa River spring Chinook population may affect populations within the Wenatchee River watershed other than the Chiwawa River stock. If the stray rate for Chiwawa hatchery-origin fish is greater than that for natural-origin fish, an increase in gene flow from the Chiwawa population into other populations may result. If this gene flow is high enough, Chiwawa River fish may alter the genetic structure of these other populations. Records from field observations indicate that hatchery-origin fish are present in all major spawning aggregates (A.R Murdoch, unpublished data), and these fish are successfully reproducing (Blankenship et al 2006). The intent of this task is to investigate if there have been changes to the genetic structure of the spring Chinook stocks within upper Wenatchee tributaries during the past 15-20 years, and if changes have occurred, are they a function of the Chiwawa River Supplementation Program? Therefore, we ask the following two questions:

1. Are allele frequencies within populations in the upper Wenatchee stable through time? That is, is there significant allelic differentiation among collections within upper Wenatchee populations?
2. Are the recent collections from the upper Wenatchee populations more similar to the Chiwawa population than earlier collections from the same populations?

For this task we analyzed natural spawning collections from the White River (natural-origin), Little Wenatchee River (natural-origin), Nason Creek (natural-origin), and

Wenatchee mainstem (hatchery-origin), and hatchery collections from Leavenworth NFH and Entiat River NFH (Table 1). We also included in the analysis the natural- and hatchery-origin collections from the Chiwawa River. There are no repeated collections from Leavenworth, Entiat, Little Wenatchee, and Wenatchee mainstem (Table 1), so for many of the analyses we have limited our discussion to the Chiwawa River, White River, and Nason Creek collections. Furthermore, genetic structure of the Little Wenatchee collection, which consisted of only 19 samples, was unexpectedly quite different from the other collections. For example, the F_{ST} statistic measures the percent of total molecular variation that can be attributed to differences between populations. The median F_{ST} for all pairwise combinations of collections from all populations, except Little Wenatchee (33 populations, 528 individual F_{ST} statistics) equals 0.010 (1%), with a range of 0.000 to 0.037 (Table 6). The median F_{ST} for the Little Wenatchee paired with all other collections (33 individual F_{ST} statistics) equals 0.106 (10.6%), with a range of 0.074 to 0.121. The ten-fold increase in the F_{ST} statistic indicates that either the Little Wenatchee spring Chinook is unique among the upper Wenatchee River stocks, or this 1993 collection is somehow aberrant. Therefore, we exclude the Little Wenatchee collection from many other analyses.

Population Differentiation – Table 3 provides the levels of significance for all pairwise genic differentiation tests. Most between-collection comparisons are highly significant, with no pattern of increasing or decreasing differentiation with time, and no differences when comparisons are made with Chiwawa hatchery- versus Chiwawa natural-origin fish. For example, excluding the outlier 1996 and 1998 Chiwawa hatchery- and natural-origin collections, Nason Creek showed highly significant allele frequency differences between the Chiwawa hatchery- and natural-origin collections at 100% and 86% of the comparisons, respectively. The same comparisons with the White River produced 100% and 93% highly significant allele frequency comparisons, respectively. Allele frequencies between Nason Creek and White River were likewise differentiated from each other.

The collection allele frequencies within the upper Wenatchee system are significantly different, and these differences do not appear to change as a function of time (Table 3). Nason Creek shows greater within-population year-to-year variation in allele frequencies than does the White River, with 47% of the pairwise comparisons showing highly significant differences, compared with only 13% for the White River. However, the 2005 and 2006 collections from the White River appear to be somewhat more differentiated from not only each other, but from the earlier collections from the White River.

Despite the high degree of temporal and spatial structure suggested by the genic differentiation tests, as described above for within-Chiwawa analysis (Task 3), most of the genetic variation within this data set occurs within populations, rather than between populations (Table 6). The F_{ST} values for most population comparisons are between 0.01 and 0.02, indicating 1% to 2% among-population variance, with the remaining 98% to 99% variance occurring within populations. The White River shows the highest median F_{ST} among the natural-origin collections, equal to 0.014, compared with 0.009 for both the Nason Creek and Chiwawa natural-origin collections. The median F_{ST} for the Chiwawa hatchery-origin collections (0.012) was higher than that for the Chiwawa natural-origin collections.

Table 7 summarizes the information from the F_{ST} analyses, under five different temporal and spatial scenarios. Under all scenarios, over 99% of the molecular variance is within populations. There is significantly greater spatial structure among populations ("Origin") in 2005 and 2006 than from 1989 to 1996. That is, there appears to be more spatial structure among the Chiwawa hatchery-origin, Chiwawa natural-origin, White River, and Nason Creek now, than in 1989 to 1996, despite the potential homogenizing and cumulative effect of hatchery strays. However, we stress that the amount of molecular variance associated with the among population differences, despite being significantly greater than 0.00%, is limited to only 0.43%.

Allele-sharing and Nonmetric Multidimensional Scaling – As in the Chiwawa River data discussed above, we constructed an allele-sharing distance matrix and then subjected that matrix to a multidimensional scaling analysis (Figure 7). Consistent with all previously discussed multidimensional scaling analyses, the 1996 and 1998 adult, and the 1994 smolt collections are outliers. There is clear separation between the White River collections and all other natural-origin and Chiwawa hatchery-origin collections, indicating that there are more alleles shared among the Nason Creek and Chiwawa collections, than with the White River collections. Furthermore, there is a slight separation between the Chiwawa natural-origin natural spawner collections and Nason Creek collections, suggesting different groups of shared alleles between these populations. There is more variation in the allele-sharing distances among collections involved with the Chiwawa hatchery (origin or broodstock) than any of the natural-origin collections, even if we exclude the 1994, 1996, and 1998 collections. This suggests that there is more year-to-year variation in the composition of hatchery-origin and hatchery broodstock than within natural-origin populations throughout the upper Wenatchee. All Wenatchee mainstem fish are hatchery-origin, and if these fish are from the Chiwawa Supplementation Program (rather than from Leavenworth), it is not unexpected that this collection would be plotted within the Chiwawa polygon (Figure 7).

Assignment of Individual to Populations – Finally, we conducted individual assignment tests whereby we assigned each individual fish to a population, based on a procedure developed by Rannala and Mountain (1997) (Table 8 and 9). Individual fish may be correctly assigned to the population from which they were collected, or incorrectly assigned to a different population. Incorrect assignments may occur if the fish is an actual migrant (i.e., source population different from population where collected), or because the genotype for that fish matches more closely with a population different from its source. If there are many individuals from a population incorrectly assigned to populations other than its source population, that original population is either unreal (i.e., an admixture), or there is considerable gene flow between that population and other populations. Furthermore, in assigning individuals to populations, we can either accept the assignment with the highest probability, regardless of how low that probability may be, or we can establish a more stringent criterion, such as to not accept an assignment unless the posterior probability is equal to or greater than 0.90. This value is roughly equal to having the likelihood of the most-likely population equal to 10 times that of the second most-likely population.

We provide a summary of the assignments in Tables 8 and 9. On average, nearly 50% of the fish are assigned incorrectly if we accept all assignments (Table 8), but the incorrect assignment rate drops to roughly 10% when we accept only those assignments with probabilities greater than 0.90. However, with this more stringent criterion, nearly 64% of the fish go unassigned. These results indicate that the allele frequency distributions for these populations are very similar, and it would be very difficult to assign an individual fish of unknown origin to the correct population. If all fish are assigned, there is a 50% chance, overall, of a correct assignment. If you accept only those assignment with the 0.90 criterion, nearly two-thirds of the fish would be unassigned, but there is a 90% chance of correctly assigning those fish that are indeed assigned.

Of all the populations in the data set, there are fewer errors associated with assigning fish to the White River. If all fish are assigned (Table 8), 72% of those fish assigned to the White River, are actually from the White River (115 fish out of a total of 159 fish assigned to the White River). This compares to a rate of only 52% and 53% for Nason Creek and Chiwawa natural-origin, respectively, and 60% for the Chiwawa hatchery-origin collections. With the 0.90 criterion (Table 9), 89% of the fish assigned to the White River, are actually from the White River, compared with 70% and 65% for Nason Creek and Chiwawa natural origin, respectively, and 81% for the Chiwawa hatchery origin.

When all fish are assigned, most of the incorrectly assigned fish from Nason Creek and White River are assigned to Chiwawa River, at roughly equal frequencies to the hatchery- and natural-origin populations. Incorrectly assigned fish to other populations occur at a slightly higher rate in Nason Creek than in the White River. However, when only those fish meeting the 0.90 criterion are assigned (Table 9), incorrectly assigned fish from Nason Creek are distributed among White and Chiwawa Rivers, as well as Leavenworth NFH, and the Entiat NFH. Mis-assignment to the Chiwawa hatchery-origin was the highest among the Nason Creek collections, equal to nearly 14%. This contrasts with the White River where mis-assignments do not exceed 7% anywhere, and there is a roughly even distribution of mis-assignments among Nason Creek and Chiwawa River collections.

Summary and Conclusions – There is little geographic or temporal structure among populations within the upper Wenatchee systems. Among population molecular variance is limited to 1% or less. The little variance that can be attributed to among populations indicates that the White River is more differentiated from the Chiwawa and Nason populations than these populations are from each other. Furthermore, although we cannot rule out a hatchery effect on the Nason Creek and White River populations, there is no indication there has been any temporal changes in allele frequencies within these populations that can be attributed directly to the Chiwawa River Supplementation Program. In fact, Table 7 weakly suggests that there is more differentiation among these populations now, than there was before or at the early stages of Chiwawa supplementation.

Therefore, returning to our two original questions, there are significant differences in allele frequencies among collections within populations, and among populations within the upper Wenatchee spring Chinook stocks. However, these differences account for a very small portion of the overall molecular variance, and these populations overall are very similar to each other. There is no evidence that the Chiwawa River Supplementation Program has changed the allele frequencies in the Nason Creek and White River populations, despite the presence of hatchery-origin fish in both these systems. Finally, of all the populations within the Wenatchee River, the White River appears to be the most distinct. Yet, this distinction is more a matter of detail than of large significance, as the median F_{ST} between White River collections and all other collections (except the Little Wenatchee) is less than 1.5% among population variance.

<u>Task 7:</u> **Calculate the inbreeding effective population size using demographic data for each sample year, and document the ratio of census to effective size.**

This analysis was completed by Williamson et al. (submitted).

<u>Task 8:</u> **Calculate LD N_b using genetic data for each sample year, and document the ratio of census to effective size.**

We report N_e estimated for the Chiwawa River collections based on the bias correction method of Waples (2006) implemented in LDNe (Do and Waples unpublished). N_e estimates based on LD are best interpreted as the effective number of breeders (N_b) that produced the sample (Waples 2006).

For collections categorized by spawning location (i.e., hatchery broodstock or natural), estimates of N_b are shown in Table 10. Considering the hatchery broodstock, N_b estimates range from 30.4 (1996) to 274.3 (2005). To obtain N_e /N ratios, the N_b estimate is multiplied by four (i.e., mean generation length) and divided by the total in river (i.e., NOS [natural-origin spawners] plus HOS [hatchery-origin spawners]) census data from four years prior (i.e., major cohort; see Table 2). The observed N_e /N ratios for the broodstock collections range from 11% to 54% of the census estimate, excluding the 2000 collection which is 106%. A ratio greater than one is possible under special circumstances, and certain artificial mating schemes within hatcheries can inflate N_e above N; yet, it is unknown if this is the case for this collection. While no direct comparisons are possible, the N_b estimates reported by Williamson et al. (submitted) for Chiwawa broodstock collections from 2000 – 2003 are similar in magnitude to our estimates. For Chiwawa natural spawner collections, the N_b estimates range from 5.2 (1989) to 231.5 (2005), with observed N_e /N ratios of 22% - 48% of the census estimate.

Task 9: Calculate N_b using the temporal method for multiple samples from the same location.

Estimates of effective number of breeders (N_b) derived from Waples' (1990) temporal method are shown in Tables 11-13. Eight collection years were used for the Chiwawa broodstock collections (Table 11). The harmonic mean of all pairwise estimates of N_b ($\tilde{N}_b$) was 269.4. This estimate is the contemporary N_e for Chiwawa broodstock collections. For the five collection years of Chiwawa in-river spawners (Table 12), the estimated $\tilde{N}_b$ = 224.2. This estimate is the contemporary N_e for Chiwawa River natural spawner collections. Since the Chiwawa Supplementation Program is integrated by design, we also performed another estimation of N_e using composite hatchery and natural samples. There are paired samples from 2004-2006. We combined genetic data for hatchery (HOS) and natural (NOS) origin fish from 2004 – 2006 to create a single Chiwawa River natural spawner sample for each year. The three composite samples from 2004 – 2006 were then analyzed using the temporal method (Table 13), resulting in a $\tilde{N}_b$ = 386.8. This estimate is the contemporary N_e for Chiwawa River.

Williamson et al. (submitted) estimated N_e using Waples' (1990) temporal method for Chinook captured in 2004 and 2005, and used age data to decompose brood years into consecutive cohorts from 2000 – 2003. They report for Chiwawa broodstock a $\tilde{N}_b$ = 50.4. This estimate is not similar to our Chiwawa broodstock estimate. However, if we analyze the hatchery-origin Chinook only, our estimate is $\tilde{N}_b$ = 80.1 for collection years 1989 – 2006 (data not shown). Williamson et al. (submitted) report for Chiwawa naturally spawning Chinook a $\tilde{N}_b$ = 242.7, which is slightly higher than our estimate for in-river spawners from 1989 – 2006, but lower than our estimate from combined NOS and HOS Chinook from 2004 – 2006 collection years.

<u>Task 10:</u> Use available data and the Ryman-Laikre and Wang-Ryman models to determine the expected change of N_e for natural spring Chinook salmon in the Wenatchee River due to hatchery operation.

N_e is generally thought to be between 0.10 and 0.33 of the estimated census size (Bartley et al. 1992; RS Waples pers. comm.). We used this range to generate an estimate of N_e for Chiwawa natural spawners prior to hatchery operation. For brood years 1989 – 1992, the arithmetic mean census size was N=962.7 (Table 2), resulting in an estimated N_e ranging from 96.3 – 317.7. The contemporary estimate of N_e calculated using genetic data for the Chiwawa in-river spawners is N_e=224.2 (Table 12), falling in the middle of the pre-hatchery range. The N_e /N ratio calculated using 224.2 and the arithmetic census of NOS Chinook from 1989 – 2005 is 0.42. A more appropriate contemporary N_e to compare with the pre-hatchery estimate (i.e., 96.3 – 317.7) is the combined NOS and HOS estimate from natural spawners, since the supplementation program is integrated. As discussed above, the contemporary estimate of N_e calculated using genetic data for Chiwawa NOS and HOS Chinook is N_e=386.8 (Table 13), which is slightly larger than the pre-hatchery range, suggesting the N_e has not declined during the period of hatchery operation. The N_e /N ratio calculated using 386.8 and the arithmetic census of NOS and HOS Chinook from 1989 – 2005 is 0.40. These results suggest the Chiwawa Hatchery Supplementation Program has not resulted in a smaller N_e for the natural spawners from the Chiwawa River.

Williamson et al. (submitted) argued that since their combined (i.e., broodstock and natural) N_e estimate was lower than the naturally spawning estimate, the supplementation program likely had a negative impact on the Chiwawa River N_e. We disagree with this interpretation of these data. Since the natural spawning component is mixed hatchery and natural ancestry, the N_e estimates from natural spawning data are the results that bear on possible hatchery impacts. The census data show the population declined in the mid 1990's and rebounded by 2000 (Table 2). This trend is reflected in the N_e results, as shown above, and Williamson et al. (submitted) clearly show in their Table 4 the N_e was lower in 2000 (N_e = 989) than it was in 1992 (N_e = 2683). Yet, the important comparison they make in our view was the natural spawning N_e versus the natural only component N_e (i.e., hypothetically excluding hatchery program). Williamson et al. (submitted) report the 1989 – 1992 N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) was essentially the same as the natural only component estimate, 2683 and 2776, respectively. This result is not surprising since no HOS fish were present between 1989 – 1992. They also report that the 1997 – 2000 N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) was N_e =989, while the natural-origin estimate of N_e in 1997 – 2000 was N_e = 629. Since the natural-origin estimate of 629 is lower than 989, the N_e estimate from all in-river spawners, we argue that their analysis of demographic data show the N_e estimated from naturally spawning Chinook (i.e., NOS and HOS integrated) is larger only if the hatchery Chinook in the river are ignored.

Task 11: Use individual assignment methods to determine the power of self-assignment for upper Wenatchee River tributaries.

See "Assignment of Individual to Populations" in Task 6

Conclusions

Has the Chiwawa Hatchery Supplementation Program succeeded at increasing the census size of the target population while leaving genetic integrity intact? This is an important question, as hatcheries can impact natural populations by reducing overall genetic diversity (Ryman and Laikre 1991), reducing the fitness of the natural populations through relaxation of selection or inadvertent positive selection of traits advantageous in the hatchery (Ford 2002; Lynch and O'Hely 2001), and by reducing the reproductive success of natural populations (McLean et al. 2003). The census data presented here show that the current natural spawning census size is similar to the pre-supplementation census size. Despite large numbers of hatchery-origin fish on the Chiwawa River spawning grounds, the genetic diversity of the natural-origin collections appear unaffected by the supplementation program; heterozygosities are high, and contemporary N_e is similar (perhaps slightly higher) than pre-supplementation N_e. We did find significant year-to-year differences in allele frequencies in both the origin and spawner datasets, but these differences do not appear to be related to fish origin, spawning area, or genetic drift. However, we do suggest that cohort differences may be the most important factor accounting for differences in allele frequencies among collections.

The main objective of this study was to determine the potential impacts of the hatchery program on natural spring Chinook in the upper Wenatchee system. We did this by analyzing temporally replicated collections from the Chiwawa River, and by comparing genetic diversity prior to the presumed effect of the Chiwawa Hatchery Supplementation Program, with contemporary collections. We report that the genetic diversity present in the Chiwawa River is unchanged (allowing for differences among cohorts) from 1989 – 2006, and the contemporary estimate of the effective population size (N_e) using genetic data is approximately the same as the N_e estimate extrapolated from 1989 – 1992 census data (i.e., pre-hatchery collection years). We observed substantial genetic diversity, with heterozygosities ~80% over thirteen microsatellite markers. Yet, temporal variation in allele frequencies was the norm among temporal collections from the same populations (i.e., location). The genetic differentiation of replicated collections from the same population is likely the result of salmon life history in this area, as four-year-old Chinook comprise a majority of returns each year. The genetic tests are detecting the differences of contributing parents for each cohort. An important point related to the temporal variation, is that the hatchery broodstock is composed in part of the natural origin Chinook from the Chiwawa River. When we compared the genetic data (within a collection year) for Chinook brought into the hatchery as broodstock with the Chinook that remained in the river (years 2001, 2004 – 2006), there was a trend of decreasing statistical differences in allele frequencies from 2001 to 2004, and no differences were detected for 2005 and 2006. While the replicated collections may have detectable differences in allele frequencies, those differences reflect actual differences in cohorts, not the result of hatchery operations, and the hatchery broodstock collection method captures the differences in returning Chiwawa River spring adults each year. We conclude from these results that the genetic diversity of natural spring Chiwawa Chinook has been maintained during the Chiwawa Hatchery Supplementation Program.

We observe slight, but statistically significant population differentiation between Chiwawa River, White River, and Nason Creek collections. Murdoch et al (2006) and Williamson et al. (submitted) also observed population differentiation between Chiwawa River, White River, and Nason Creek collections. Yet, 99.3% of the genetic variation observed was within samples, very little variance could be attributed to population differences (i.e., population structure). The AMOVA analysis and poor individual assignment results suggest the occurrence of gene flow among Wenatchee River locations or a very recent divergence of these groups. While Murdoch et al. 2006 did not perform an AMOVA analysis, their F_{ST} results provide comparable data to our among-population results. Murdoch et al. 2006 report F_{ST} ranging from 2%-3% for pairwise comparisons between of Chiwawa, White, and Nason River collections. Since F_{ST} is an estimate of among-sample variance, these results also imply a majority of the genetic variance (i.e., 97%-98%) resides within collections. To provide further context for the magnitude of these variance estimates, we present the among-group data from Murdoch et al. 2006 comparing summer-run and spring-run Chinook from the Wenatchee River. They report that approximately 91% of observed genetic variance is within-collection for comparisons between collections of summer- and spring-run Chinook. Ultimately, the information provided by this and other reports will be incorporated into the management process for Wenatchee River Chinook. However, we would like to emphasize that the application of these genetic data to management is more about the goals related to the distribution of genetic diversity in the future than specific data values reported. If Chinook are collected at Tumwater Dam instead of within the upper Wenatchee River tributaries, a vast majority of the genetic variation present in the basin would be captured, although any differences among tributaries would be mixed. Alternatively, management policies could be crafted to promote and maintain the among-group genetic diversity that genetic studies consistently observe to be non-zero within the Wenatchee River.

We agree with Murdoch et al. (2006) that it appears hatchery Chinook are not contributing to reproduction in proportion to their abundance. Additionally, if the total census size (i.e., NOS and HOS combined) within the Chiwawa River does not continue to increase, genetic diversity may decline within this system, given the smaller N_e within the hatchery-origin collections compared with the natural-origin collections.

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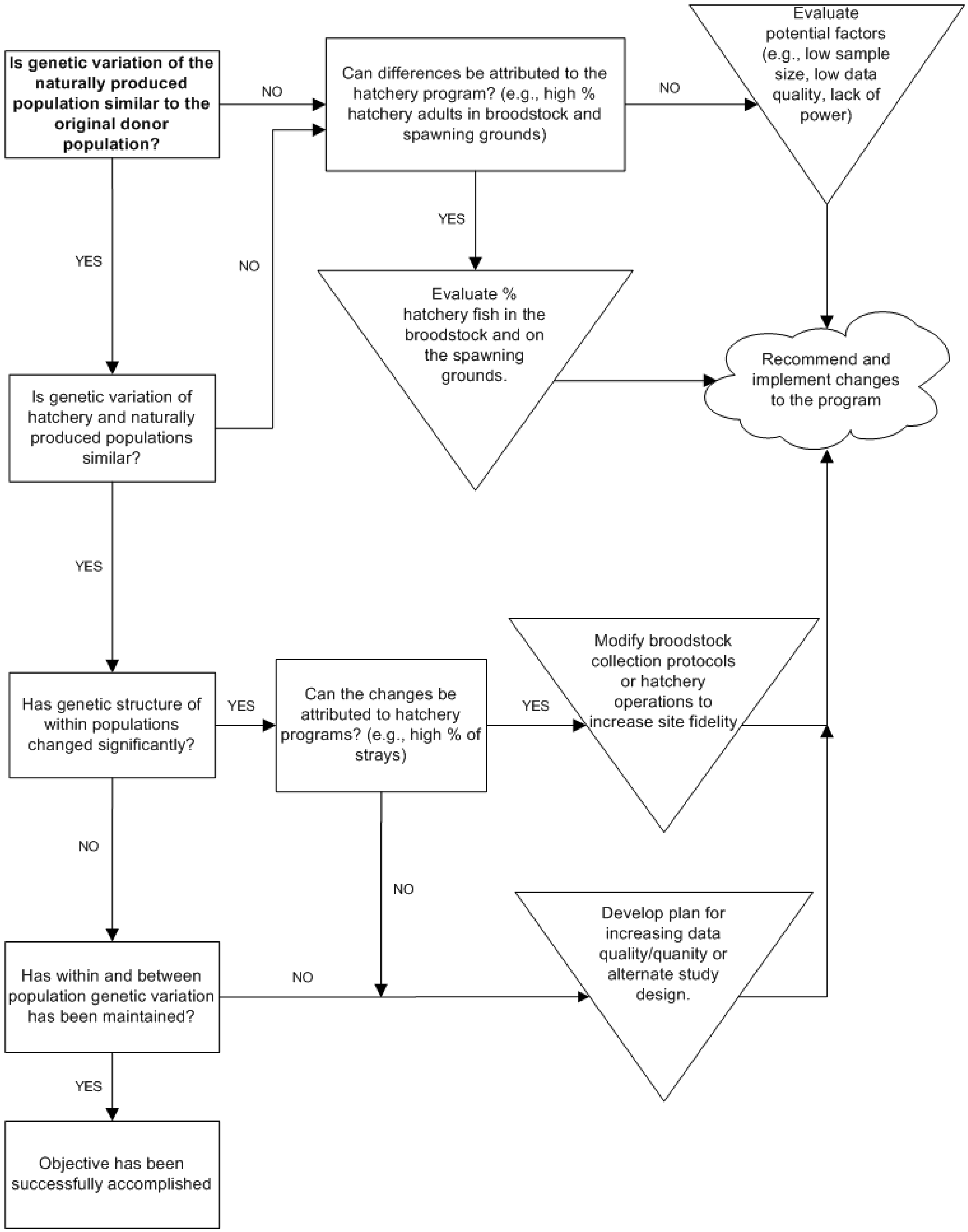

Figure 1. Conceptual process for evaluating potential changes in genetic variation in the Chiwawa naturally produced populations as a result of the supplementation hatchery programs (From Murdoch and Peven 2005).

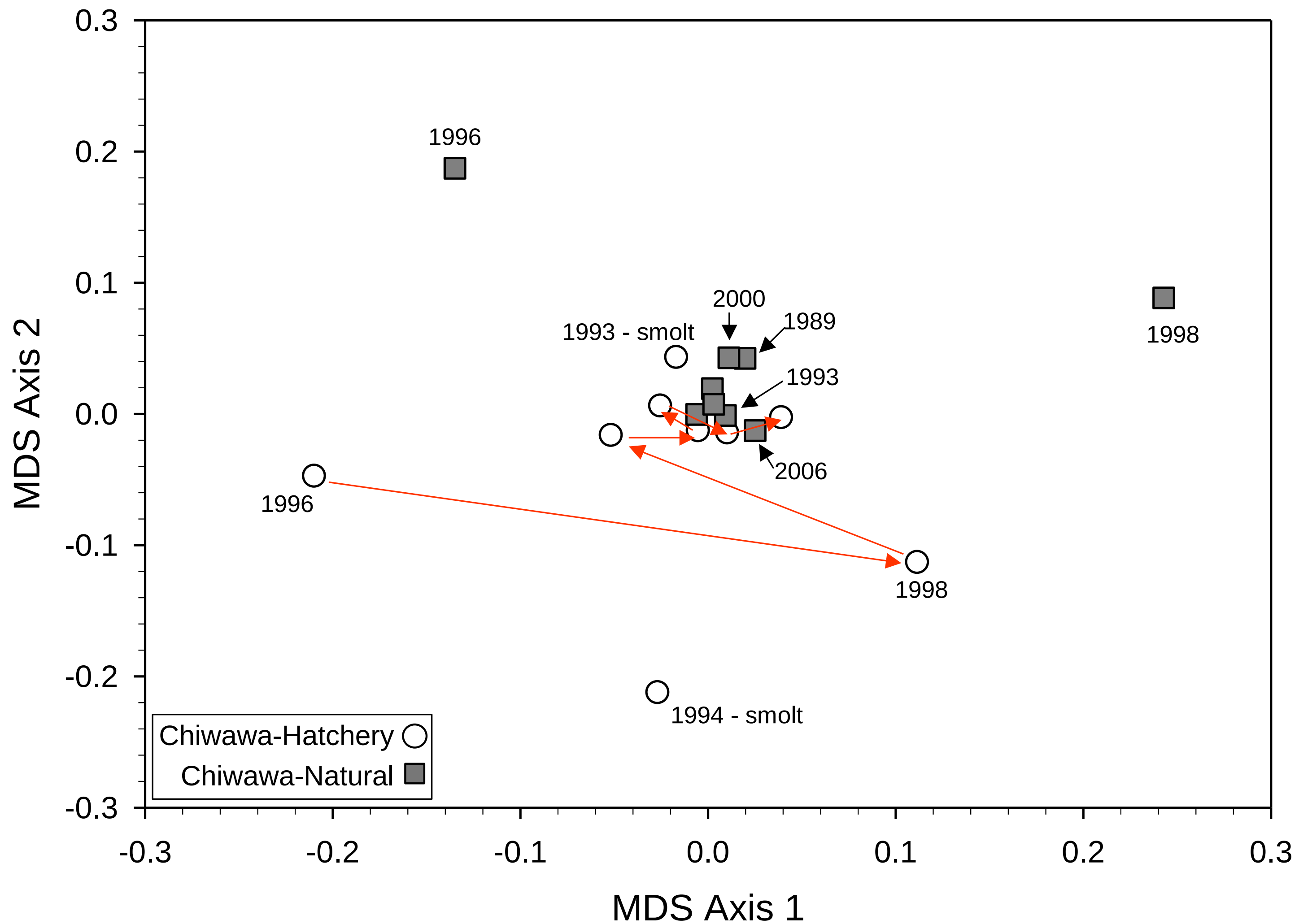

Figure 2. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa data set organized by fish origin (i.e., hatchery versus natural). The red arrows connect consecutive hatchery-origin collections starting with the first adult collection (1996) and ending with the 2006 collection (see Table 1 for collection years).

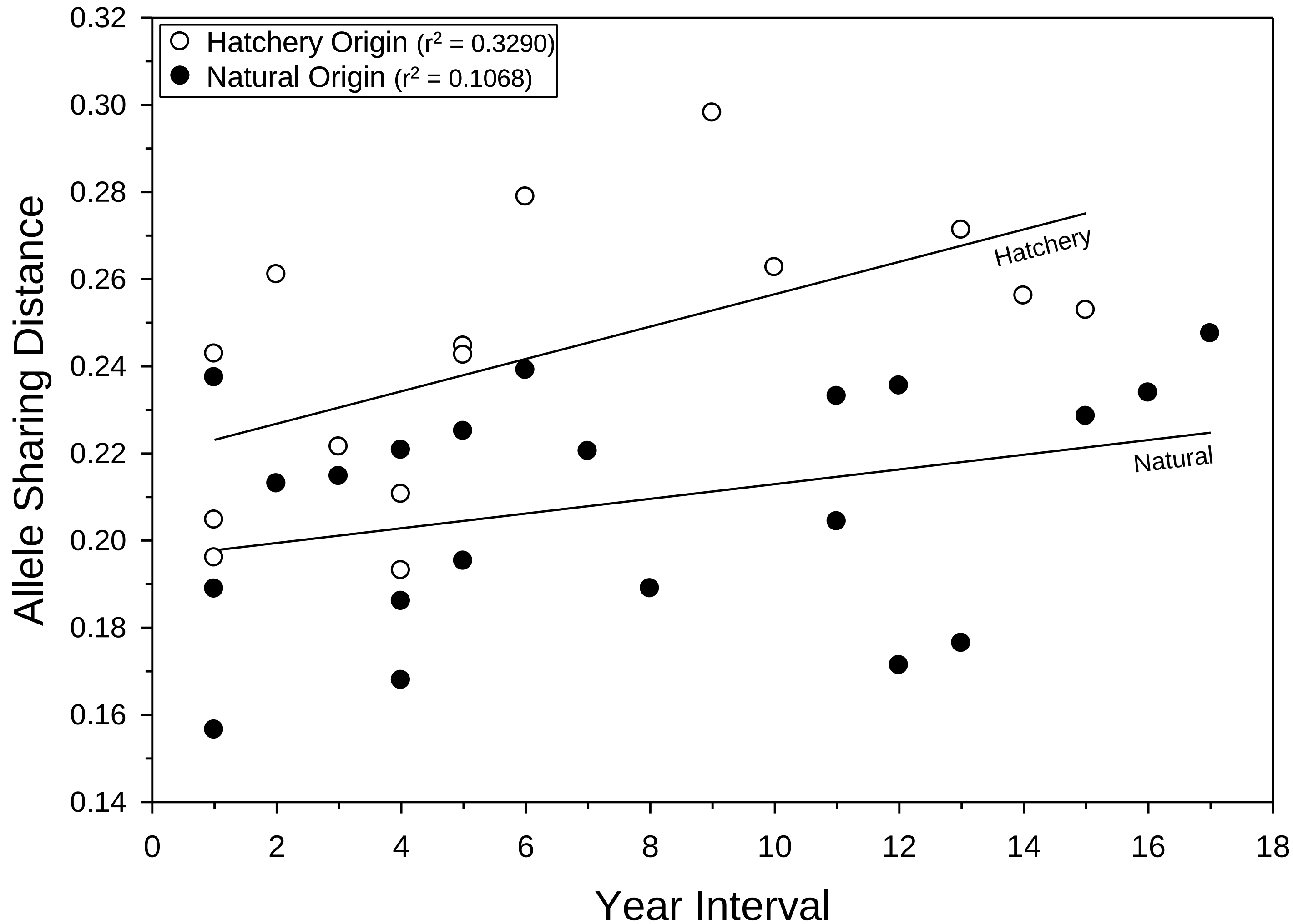

Figure 3. Relationships between the time interval in years and allele sharing distances, with each circle representing the pairwise relationship between two Chiwawa collections. Separate regression lines for the natural- and hatchery-origin collections. The slope for the natural-origin collection is not significantly different from zero (p=0.1483), while the slope for hatchery-origin collection is significantly greater than zero (p=0.0254) indicating a positive relationship between time interval and allele sharing distance.

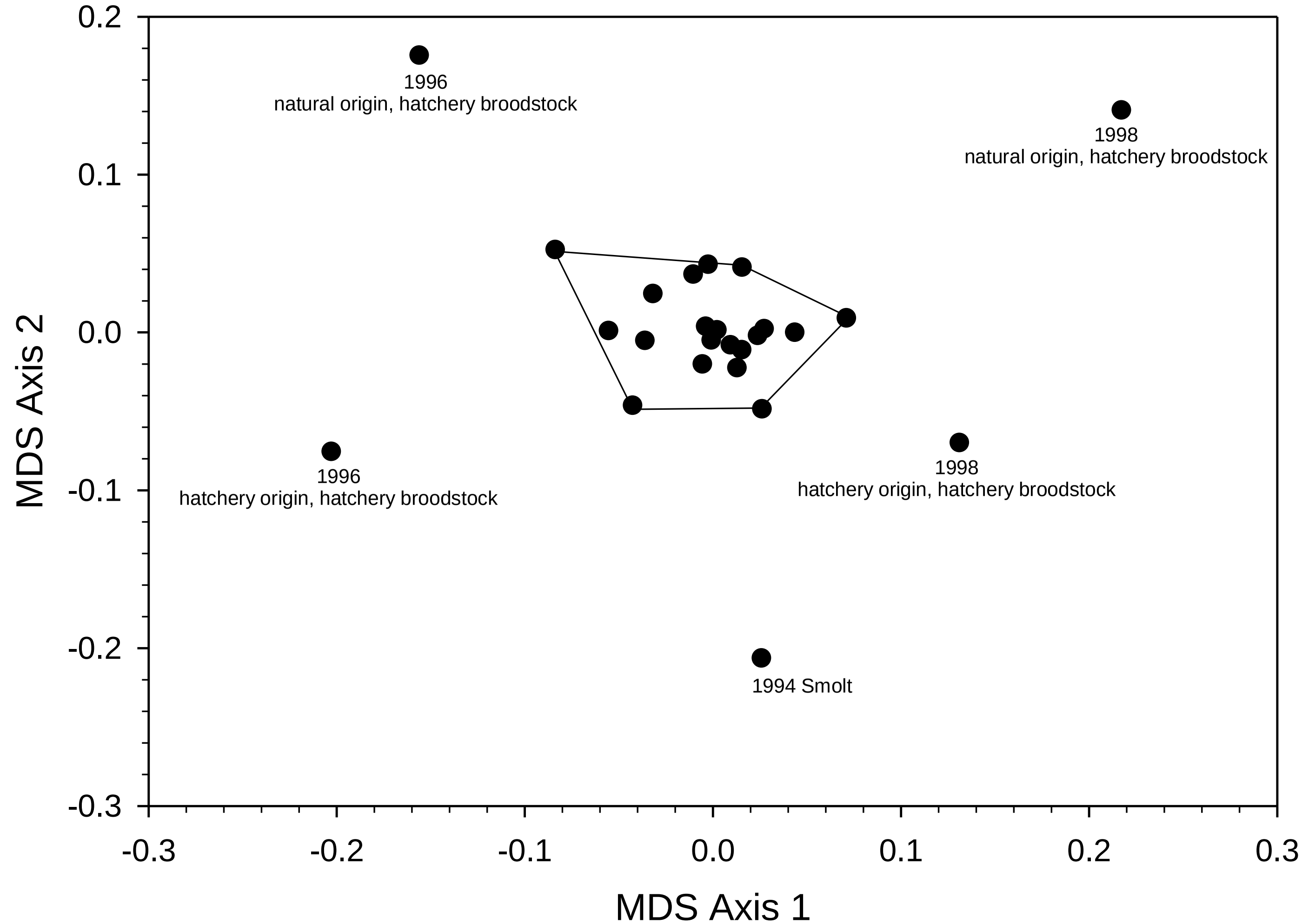

Figure 4. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa data set organized by four treatment groups, as discussed in the text. Each circle represents a single collection within each of the four treatment groups, and the polygon encloses all groups that are not outliers. Each outlier group is specifically labeled.

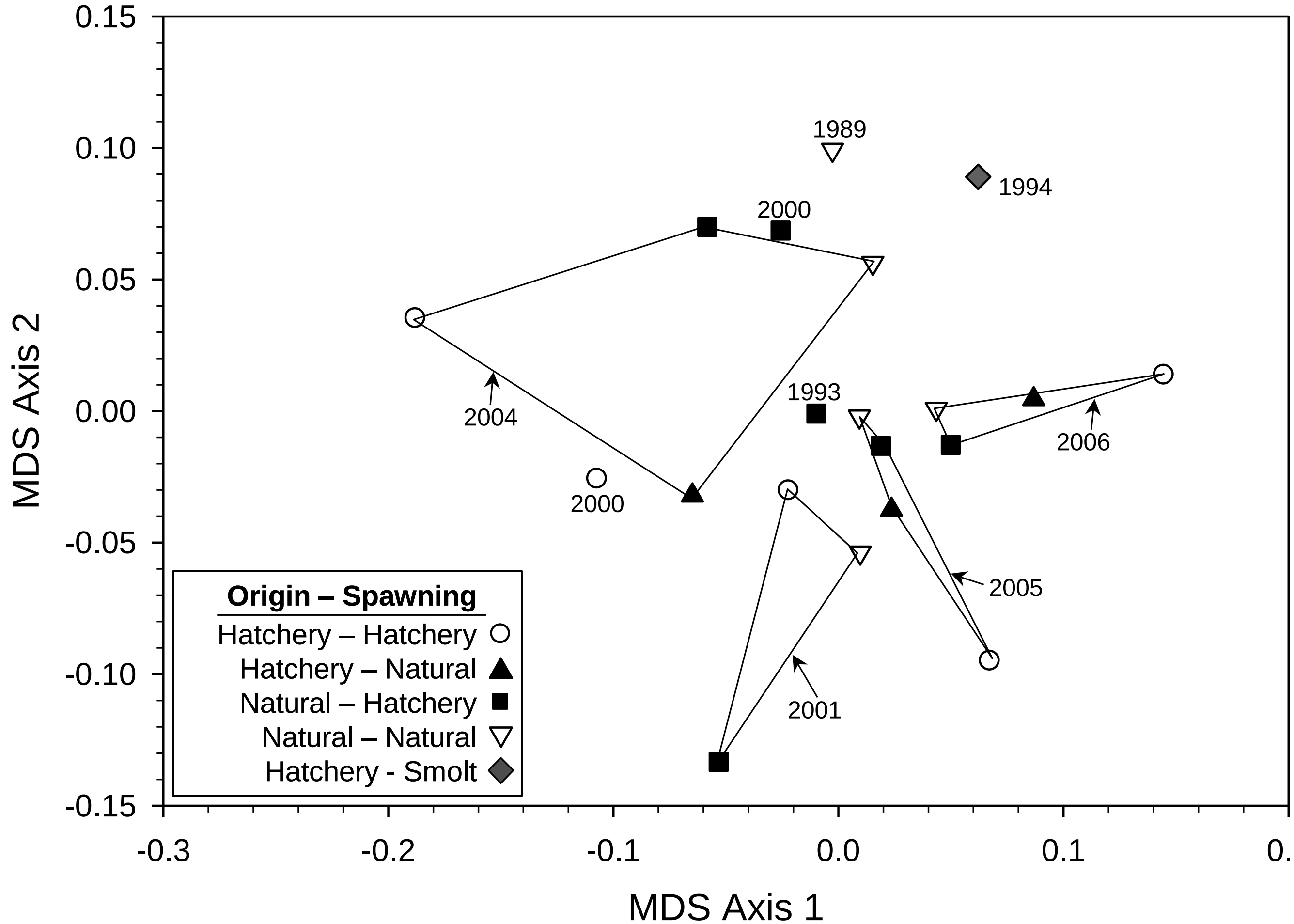

Figure 5. As in Figure 4, but allele-sharing distance matrix recalculated without the five outlier groups shown in Figure 4. Polygons group together treatment groups from the same collection year. Dates associated with symbols also refer to collection year. Collection years 2004-2006 included all four treatment groups, while collection year 2001 did not include a hatchery-origin natural spawner group. Legend is read as follows: Open circles refer to hatchery-origin hatchery spawner group, while filled box refers to natural-origin hatchery spawner group, and so on.

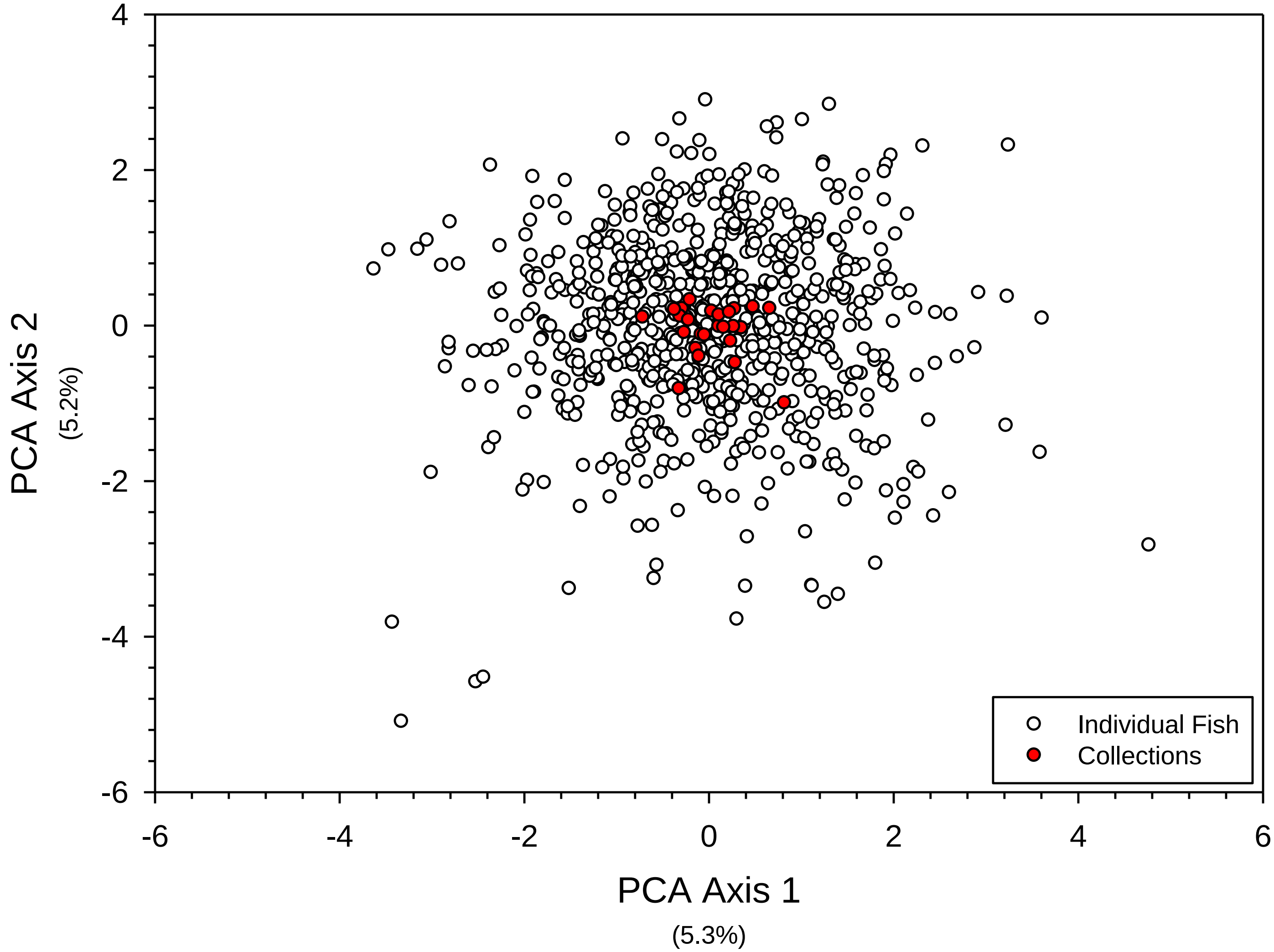

Figure 6. Principal component (PC) analysis of individual fish from the Chiwawa River. Only fish with complete microsatellite genotypes were included in the analysis (n = 757). Open circles are the PC scores for individual fish, and the filled circles are the centroids (bivariate means) for each of the 25 groups discussed in the text. PC axes 1 and 2 account for only 10.5% of the total molecular variance.

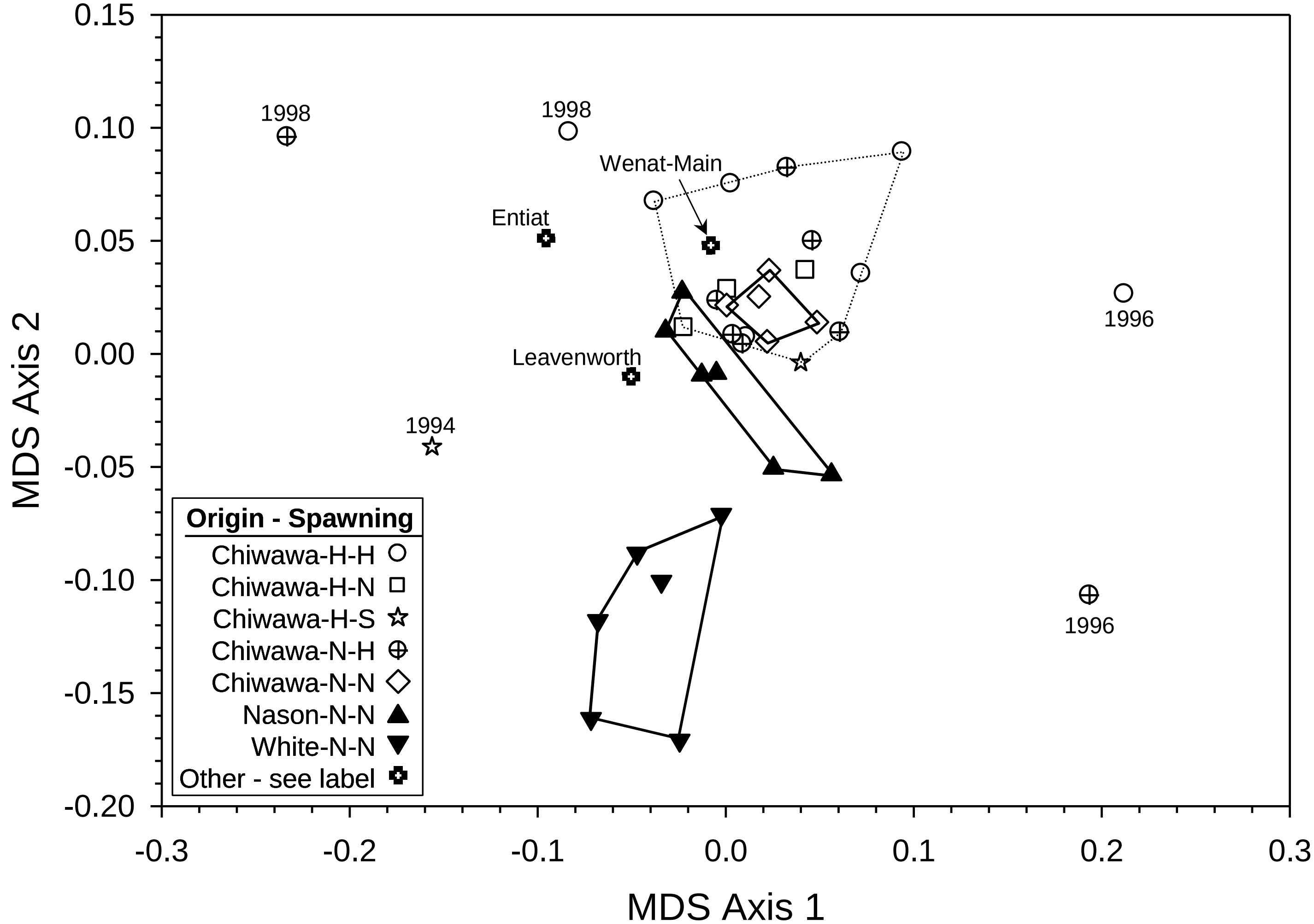

Figure 7. Multidimensional scaling plot from an allele-sharing distance matrix calculated from the Chiwawa origin data set and all other non-Chiwawa collections, except Little Wenatchee River. Legend is read with abbreviations beginning with origin and then spawning location. H=hatchery, N=natural, and S=smolts. Polygons with solid lines enclose the natural-origin natural spawner collections from each population (i.e., river). The polygon with the dotted lines enclose all Chiwawa collections, except for the five outlier collections, as discussed in text.

Table 1 Summary of within population genetic data. Chiwawa collection data are summarized in A) by origin of the sample (i.e., clipped vs. non-clipped). All collection data are summarized in B) by spawning location (i.e., hatchery broodstock or on spawning grounds). Hz is heterozygosity, HWE is the statistical significance of deviations from Hardy-Weinberg expectations (* = 0.05, ** = 0.01, and *** = 0.001), LD is the proportion of pairwise locus tests (across all populations) exhibiting linkage disequilibrium (bolded values are statistically significant), and the last column is mean number of alleles per locus.

Collection	Sample size	Gene Diversity	Observed Hz	HWE	F_{IS}	LD	Mean # Alleles
A) Origin							
1993 Chiwawa Hatchery	95	0.77	0.79	***	-0.02	**0.86**	14.00
1994 Chiwawa Hatchery	95	0.76	0.77	***	-0.01	**0.91**	11.38
1996 Chiwawa Hatchery	8	0.75	0.81	-	-0.01	0.00	8.23
1998 Chiwawa Hatchery	27	0.81	0.82	-	0.00	0.04	12.62
2000 Chiwawa Hatchery	43	0.75	0.78	***	-0.01	**0.19**	12.46
2001 Chiwawa Hatchery	69	0.77	0.80	***	-0.02	**0.14**	15.31
2004 Chiwawa Hatchery	72	0.77	0.77	***	0.01	**0.45**	15.92
2005 Chiwawa Hatchery	91	0.79	0.82	*	-0.03	**0.05**	16.15
2006 Chiwawa Hatchery	95	0.80	0.84	***	-0.05	**0.49**	15.85
1989 Chiwawa Natural	36	0.76	0.78	-	0.01	0.00	12.77
1993 Chiwawa Natural	62	0.78	0.81	-	-0.02	0.04	15.85
1996 Chiwawa Natural	8	0.72	0.78	-	-0.02	0.00	7.54
1998 Chiwawa Natural	10	0.78	0.84	-	0.00	0.00	8.23
2000 Chiwawa Natural	39	0.78	0.79	***	0.00	**0.10**	14.00
2001 Chiwawa Natural	75	0.78	0.80	-	-0.03	0.03	15.31
2004 Chiwawa Natural	85	0.78	0.77	-	0.02	0.01	15.77
2005 Chiwawa Natural	90	0.79	0.79	-	0.01	0.01	16.15
2006 Chiwawa Natural	96	0.80	0.81	-	-0.01	0.01	16.46

Table 1 Within population genetic data analysis summary continued.

Collection	Sample size	Gene Diversity	Observed Hz	HW	F_{IS}	LD	Mean # Alleles
B) Spawning Location							
1993 Chiwawa Broodstock	62	0.78	0.81	-	-0.02	0.00	15.85
1996 Chiwawa Broodstock	16	0.75	0.79	-	-0.02	0.00	10.92
1998 Chiwawa Broodstock	37	0.82	0.83	-	0.00	0.01	14.38
2000 Chiwawa Broodstock	82	0.78	0.78	***	0.00	**0.32**	15.62
2001 Chiwawa Broodstock	89	0.78	0.80	*	-0.02	**0.13**	15.77
2004 Chiwawa Broodstock	61	0.77	0.76	*	0.02	**0.13**	14.92
2005 Chiwawa Broodstock	75	0.79	0.78	*	0.02	0.01	15.85
2006 Chiwawa Broodstock	89	0.80	0.83	-	-0.03	**0.05**	16.46
1989 Chiwawa River	36	0.76	0.78	-	0.01	0.00	12.77
2001 Chiwawa River	55	0.78	0.80	-	-0.02	**0.09**	14.00
2004 Chiwawa River	96	0.78	0.78	*	0.01	**0.18**	17.23
2005 Chiwawa River	106	0.79	0.82	*	-0.02	**0.06**	16.69
2006 Chiwawa River	102	0.80	0.83	***	-0.03	**0.10**	16.77
1989 White River	48	0.75	0.75	-	0.01	0.01	12.85
1991 White River	19	0.76	0.76	-	0.03	0.00	10.92
1992 White River	22	0.75	0.79	-	-0.02	0.01	11.00
1993 White River	21	0.75	0.69	*	0.10	0.00	10.15
2005 White River	29	0.75	0.77	-	-0.01	0.03	12.23
2006 White River	40	0.76	0.76	-	0.01	0.04	13.38

Table 1 Within population genetic data analysis summary continued.

Collection	Sample size	Gene Diversity	Observed Hz	HW	F_{IS}	LD	Mean # Alleles
1993 Little Wenatchee R.	19	0.84	0.85	-	0.02	0.00	11.23
1993 Nason Creek	45	0.78	0.80	-	-0.01	0.01	13.77
2000 Nason Creek	51	0.76	0.78	-	-0.02	**0.13**	13.92
2001 Nason Creek	41	0.79	0.81	-	-0.01	**0.08**	14.23
2004 Nason Creek	38	0.76	0.76	-	0.02	0.03	13.23
2005 Nason Creek	45	0.78	0.82	-	-0.04	0.03	14.92
2006 Nason Creek	48	0.80	0.82	-	-0.01	0.00	15.77
2001 Wenatchee River	32	0.79	0.80	*	0.00	0.04	12.85
2000 Leavenworth NFH	73	0.80	0.82	*	-0.02	**0.15**	16.23
1997 Entiat NFH	37	0.81	0.83	-	-0.01	**0.06**	14.38

Table 2 Demographic data for Chiwawa Hatchery and Chiwawa natural spring Chinook salmon. BS is census size of hatchery broodstock, pNOB is the proportion of hatchery broodstock of natural origin, NOS is the census size of natural-origin spawners present in Chiwawa River, HOS is the census size of hatchery-origin spawners present in Chiwawa River, Total is NOS and HOS combined, and pNOS is the proportion of spawners present in Chiwawa River of natural origin.

	Hatchery		In River			
Brood Year	BS	pNOB	NOS	HOS	Total	pNOS
1989	28	1	1392	0	1392	1.00
1990	18	1	775	0	775	1.00
1991	32	1	585	0	585	1.00
1992	78	1	1099	0	1099	1.00
1993	94	1	677	491	1168	0.58
1994	11	0.64	190	90	280	0.68
1995	0	0	8	50	58	0.14
1996	18	0.44	131	51	182	0.72
1997	111	0.29	210	179	389	0.54
1998	47	0.28	134	45	178	0.75
1999	0	0	119	13	132	0.90
2000	30	0.3	378	310	688	0.55
2001	371	0.3	1280	2850	4130	0.31
2002	71	0.28	694	919	1613	0.43
2003	94	0.44	380	223	603	0.63
2004	215	0.39	820	788	1608	0.51
2005	270	0.33	250	1222	1472	0.17

Table 3 Levels of significance for pairwise tests of genic differentiation among all hatchery- and natural-origin collections used in this analysis. HS = highly significant (P < 0.000095; the Bonferroni corrected p-value for an alpha = 0.05); * = P < 0.05 (nominal critical value for most statistical test); - = P > 0.05 (not significant). A significant result between pairs of populations indicates that the allele frequencies between the pair are significantly different. Results are read by comparing the collections along the rows to collections along columns. The top block for each section is a symmetric matrix, as it compares collections within the same group.

		Chiwawa – Hatchery Origin								
		1993	**1994**	**1996**	**1998**	**2000**	**2001**	**2004**	**2005**	**2006**
Chiwawa – Hat. Origin	**1993**		HS	*	HS	HS	HS	HS	HS	HS
	1994	HS		HS	HS	HS	HS	HS	HS	HS
	1996	*	HS		*	-	*	-	-	*
	1998	HS	HS	*		HS	HS	HS	HS	HS
	2000	HS	HS	-	HS		HS	*	HS	HS
	2001	HS	HS	*	HS	HS		HS	*	HS
	2004	HS	HS	-	HS	*	HS		HS	HS
	2005	HS	HS	-	HS	HS	*	HS		HS
	2006	HS	HS	*	HS	HS	HS	HS	HS	
Chiwawa – Natural Origin	**1989**	HS	HS	-	HS	HS	*	HS	HS	HS
	1993	HS	HS	-	HS	HS	-	HS	*	HS
	1996	*	HS	-	*	-	-	-	-	-
	1998	HS	HS	-	-	HS	*	*	*	-
	2000	HS	HS	-	HS	HS	HS	*	HS	HS
	2001	HS	HS	-	HS	HS	HS	HS	*	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	*	HS	*	HS
	2006	HS	HS	-	*	HS	HS	HS	HS	HS
Nason	**1996**	HS	HS	-	HS	HS	HS	HS	HS	HS
	2000	HS	HS	*	HS	HS	HS	HS	HS	HS
	2001	HS	HS	-	HS	HS	HS	HS	HS	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	HS	HS	HS	HS
	2006	HS	HS	-	*	HS	HS	HS	HS	HS
White	**1989**	HS	HS	HS	HS	HS	HS	HS	HS	HS
	1991	HS	HS	-	HS	HS	HS	HS	HS	HS
	1992	HS	HS	*	HS	HS	HS	HS	HS	HS
	1993	HS	HS	*	HS	HS	HS	HS	HS	HS
	2005	HS	HS	-	HS	HS	HS	HS	HS	HS
	2006	HS	HS	HS	HS	HS	HS	HS	HS	HS
Other	**Wen-M**	HS	HS	*	HS	HS	*	*	-	HS
	Leaven	HS	HS	*	HS	HS	HS	HS	HS	HS
	Entiat	HS	HS	*	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		Chiwawa – Natural Origin								
		1989	**1993**	**1996**	**1998**	**2000**	**2001**	**2004**	**2005**	**2006**
Chiwawa – Natural Origin	**1989**		-	-	-	-	*	*	*	*
	1993	-		-	*	*	*	HS	*	HS
	1996	-	-		-	-	-	-	-	-
	1998	-	*	-		*	*	HS	*	*
	2000	-	*	-	*		HS	-	HS	HS
	2001	*	*	-	*	HS		HS	*	HS
	2004	*	HS	-	HS	-	HS		HS	HS
	2005	*	*	-	*	HS	*	HS		*
	2006	*	HS	-	*	HS	HS	HS	*	
Nason	**1996**	*	*	-	*	*	HS	HS	HS	HS
	2000	HS	HS	HS	HS	HS	HS	HS	HS	HS
	2001	HS	*	-	*	HS	HS	HS	HS	HS
	2004	HS	HS	-	HS	HS	HS	HS	HS	HS
	2005	*	*	-	*	HS	HS	HS	HS	HS
	2006	HS	HS	-	-	HS	HS	HS	HS	HS
White	**1989**	HS	HS	*	HS	HS	HS	HS	HS	HS
	1991	HS	HS	*	-	HS	HS	HS	HS	HS
	1992	HS	HS	-	*	HS	HS	HS	HS	HS
	1993	HS	*	-	*	HS	HS	HS	HS	HS
	2005	HS	*	*	*	HS	HS	HS	*	HS
	2006	HS	HS	*	HS	HS	HS	HS	HS	HS
Other	**Wen-M**	*	-	-	-	*	*	HS	*	*
	Leaven	HS	HS	*	*	HS	HS	HS	HS	HS
	Entiat	HS	HS	*	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		Nason					
		1996	2000	2001	2004	2005	2006
Nason	1996		HS	-	HS	-	*
	2000	HS		HS	HS	HS	HS
	2001	-	HS		*	-	*
	2004	HS	HS	*		*	HS
	2005	-	HS	-	*		-
	2006	*	HS	*	HS	-	
White	1989	HS	HS	HS	HS	HS	HS
	1991	*	HS	HS	HS	*	*
	1992	HS	HS	HS	HS	HS	HS
	1993	*	HS	HS	HS	HS	HS
	2005	*	HS	HS	HS	HS	HS
	2006	HS	HS	HS	HS	HS	HS
Other	Wen-M	HS	HS	HS	HS	*	HS
	Leaven	HS	HS	HS	HS	HS	HS
	Entiat	HS	HS	HS	HS	HS	HS

Table 3 (con't)

		White						Other		
		1989	1991	1992	1993	2005	2006	Wen-M 2001	Leaven 2000	Entiat 1997
White	1989		-	*	-	HS	HS	HS	HS	HS
	1991	-		-	-	*	*	*	HS	HS
	1992	*	-		-	*	*	HS	HS	HS
	1993	-	-	-		*	*	HS	HS	HS
	2005	HS	*	*	*		*	HS	HS	HS
	2006	HS	*	*	*	*		HS	HS	HS
Other	Wen-M	HS	*	HS	HS	HS	HS		HS	HS
	Leaven	HS	HS	HS	HS	HS	HS	HS		HS
	Entiat	HS	HS	HS	HS	HS	HS	HS	HS	

Table 4 Probabilities (above diagonal) and levels of significance (below diagonal) for pairwise tests of genic differentiation among all Chiwawa hatchery broodstock and Chiwawa natural spawner collections used in this analysis. HS = highly significant (P < 0.000476; the Bonferroni corrected p-value for an alpha = 0.05); * = P < 0.05 (nominal critical value for most statistical test); - = P > 0.05 (considered not significant). A significant result between pairs of populations indicates that the allele frequencies between the pair are significantly different. Pairwise comparisons between the hatchery broodstock and natural spawner collections from 2001, 2004, 2005, and 2006, respectively, are highlighted.

		Smolt		Hatchery Broodstock								Natural Spawners				
		1993	**1994**	**1993**	**1996**	**1998**	**2000**	**2001**	**2004**	**2005**	**2006**	**1989**	**2001**	**2004**	**2005**	**2006**
Smolt	**1993**		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	1994	HS		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hatchery Broodstock	**1993**	HS	HS		0.9155	0.0000	0.0073	0.3647	0.0003	0.0694	0.0000	0.2220	0.0039	0.0008	0.0095	0.0000
	1996	HS	HS	-		0.0151	0.8388	0.0452	0.4916	0.3189	0.0716	0.5591	0.0759	0.8101	0.2364	0.0786
	1998	HS	HS	HS	*		0.0000	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000	0.0000	0.0000	0.0005
	2000	HS	HS	*	-	HS		0.0000	0.4720	0.0000	0.0000	0.0036	0.0000	0.0712	0.0000	0.0000
	2001	HS	HS	-	*	HS	HS		0.0000	0.0059	0.0000	0.0003	0.0000	0.0000	0.0126	0.0000
	2004	HS	HS	*	-	HS	-	HS		0.0000	0.0000	0.0001	0.0000	0.0012	0.0000	0.0000
	2005	HS	HS	-	-	HS	HS	*	HS		0.0005	0.0024	0.0137	0.0025	0.7782	0.0018
	2006	HS	HS	HS	-	*	HS	HS	HS	*		0.0000	0.0000	0.0000	0.0000	0.5770
Natural Spawners	**1989**	HS	HS	-	-	HS	*	*	HS	*	HS		0.0023	0.0317	0.0000	0.0003
	2001	HS	HS	*	-	HS	HS	HS	HS	*	HS	*		0.0000	0.2641	0.0000
	2004	HS	HS	*	-	HS	-	HS	*	*	HS	*	HS		0.0000	0.0000
	2005	HS	HS	*	-	HS	HS	*	HS	-	HS	HS	-	HS		0.0000
	2006	HS	HS	HS	-	*	HS	HS	HS	*	-	*	HS	HS	HS	

Table 5 Analysis of molecular variance (AMOVA) for the Chiwawa collections, showing the partition of molecular variance into (1) within collections, (2) among collections but within group, and (3) among group components. Each column in the table represents a separate analysis testing for differences under a different spatial or temporal hypothesis. The different analyses are grouped together in a single table for comparisons. The values within the table are percentages and the parenthetical values are P-values, or probabilities, associated with that percentage. P-values greater than 0.05 indicate that the percentage is not significantly different from zero. For example, when collections are organized by hatchery- versus natural-origin ("Origin" – fourth column), 0.11% of the molecular variance is attributed to among group (i.e., hatchery- versus natural-origin), which is not significantly different from zero. No collections (first column) indicates no organization or grouping among all collections, and the among-group percentage is equal to the F_{ST} for the entire data set.

	No Structure	Collection Year	Spawning Location	Origin	Origin-Spawning Location
Among Groups	0.26 (0.00)	0.20 (0.43)	0.05 (0.48)	0.11 (0.15)	0.11 (0.06)
Among collections - Within groups	-	0.08 (0.003)	0.24 (0.00)	0.21 (0.00)	0.18 (0.06)
Within collections	99.74 (0.00)	99.72 (0.00)	99.71 (0.00)	99.68 (0.00)	99.71 (0.00)

Table 6 F_{ST} values for all pairwise combinations of populations. Each F_{ST} is the median value for all pairwise combinations of collections within each population (the number of collections within each population is shown parenthetically next to each population name on each row). For example, the F_{ST} for the Chiwawa hatchery versus the White River (0.019) is the median value of 54 pairwise comparisons. The bold values along the center diagonal are the median F_{ST} values within each collection. For those populations with only one collection, the diagonal value was set at 0.000.

	Chiwawa-Hatchery	Chiwawa-Natural	Entiat	Leaven-worth	Nason	Wenatchee-main	White	Little Wenatchee
Chiwawa-Hatchery (9)	**0.013**	0.008	0.016	0.012	0.011	0.005	0.019	0.111
Chiwawa-Natural (9)		**0.003**	0.012	0.011	0.007	0.003	0.014	0.105
Entiat (1)			**0.000**	0.005	0.010	0.008	0.019	0.078
Leavenworth (1)				**0.000**	0.007	0.008	0.014	0.092
Nason (6)					**0.006**	0.008	0.015	0.099
Wenatchee-main (1)						**0.000**	0.012	0.098
White (6)							**0.005**	0.113
Little Wenatchee (1)								**0.000**

Table 7 As in Table 5, except data includes Chiwawa hatchery- and natural-origin, Nason Creek, and White River collections

	All Years	All Years	1989-1996	2005-2006	2005-2006
	No Structure	Origin	Origin	Origin	Collection Year
Among Groups	0.28 (0.00)	0.33 (0.00)	-0.07 (0.67)	0.43 (0.01)	-0.06 (0.57)
Among Collections - Within groups	-	0.04 (0.00)	0.22 (0.00)	0.25 (0.00)	0.64 (0.00)
Within Collections	99.72	99.63	99.85	99.32	99.41

Table 8 Individual assignment results reported are the numbers of individuals assigned to each population using the partial Bayesian criteria of Rannala and Mountain (1997) and a "jack-knife" procedure (see Methods). The population with the highest posterior probability is considered the stock of origin (i.e., no unassigned individuals). Individuals from each population are assigned to specific populations (along rows). Bold values indicate correct assignment back to population of origin. Individuals assigned to a population are read down columns. For example, of the 595 individuals from Chiwawa hatchery origin, 134 individuals were assigned to Chiwawa natural origin (reading across). Of the 511 individuals assigned to Chiwawa natural origin (reading down), 60 were from Nason Creek.

Population	**Total**	**Unassigned**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1) Chiwawa Hatchery	595	0	**371**	134	2	16	0	45	15	12
2) Chiwawa Natural	501	0	156	**269**	4	5	0	42	9	16
3) Entiat	37	0	4	5	**13**	8	0	6	1	0
4) Leavenworth	73	0	9	8	3	**33**	0	17	0	3
5) Little Wenatchee	19	0	0	0	0	0	**19**	0	0	0
6) Nason	268	0	49	60	5	11	0	**131**	1	11
7) Wenatchee Mainstem	32	0	12	9	0	1	0	2	**6**	2
8) White	179	0	22	26	0	2	0	13	1	**115**
TOTAL	1704	0	623	511	27	76	19	256	33	159

Table 9 As in Table 8, except the posterior probability from the partial Bayesian criteria of Rannala and Mountain (1997) must be 0.90 or greater, to be assigned to a population. Those individuals with posterior probabilities less than 0.90 are unassigned.

Aggregate	**Total**	**Unassigned**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1) Chiwawa Hatchery	595	332	**214**	31	1	4	0	10	3	0
2) Chiwawa Natural	501	375	30	**82**	0	1	0	5	2	6
3) Entiat	37	24	1	1	**5**	4	0	2	0	0
4) Leavenworth	73	51	0	1	1	**19**	0	1	0	0
5) Little Wenatchee	19	2	0	0	0	0	**17**	0	0	0
6) Nason	268	188	11	6	2	5	0	**53**	0	3
7) Wenatchee Mainstem	32	23	4	3	0	0	0	0	**2**	0
8) White	179	92	4	3	0	1	0	5	1	**73**
TOTAL	1704	1087	264	127	9	34	17	76	8	82

Table 10 Estimates of N_e based on bias correction method of Waples (2006) implemented in LDNe (Do and Waples unpublished). Collections are categorized by spawning location. Sample size is the harmonic mean of the sample size, 95% CI is the confidence interval calculated using Waples' (2006) equation 12, and Major Cohort assumes that each collection is 100% four-year-olds.

	Sample size	Estimated N_b	95% CI	Major Cohort	Census	N_e/N
1993 Chiwawa Broodstock	58.4	103.1	77.0 - 149.7	1989	1392	0.30
1996 Chiwawa Broodstock	15.5	30.4	19.6 - 58.1	1992	1099	0.11
1998 Chiwawa Broodstock	33.4	37.7	29.8 - 49.7	1994	280	0.54
2000 Chiwawa Broodstock	77.8	48.4	41.4 - 57.2	1996	182	1.06
2001 Chiwawa Broodstock	80.4	49.6	42.2 - 59.2	1997	389	0.51
2004 Chiwawa Broodstock	56.6	48.1	39.0 - 60.9	2000	688	0.28
2005 Chiwawa Broodstock	73	274.3	148.9 - 1131.8	2001	4130	0.27
2006 Chiwawa Broodstock	88.4	198.3	136.1 - 340.5	2002	1613	0.49
1989 Chiwawa River	26.6	5.2	3.9 - 6.3	1985		
2001 Chiwawa River	46.7	38.6	31.0 - 49.3	1997	389	0.40
2004 Chiwawa River	88.5	82.6	67.3 - 104.4	2000	688	0.48
2005 Chiwawa River	104.2	231.5	161.8 - 382.7	2001	4130	0.22
2006 Chiwawa River	101.1	107.3	87.2 - 136	2002	1613	0.27

Table 11 Summary of output from program SALMONNb and data for eight Chiwawa broodstock collections from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	1993	1996	1998	2000	2001	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):								
1993	-	24.5	42.5	66.4	67.2	57.2	64.6	70.3
1996	82	-	21.2	25.8	26.0	24.4	25.6	26.4
1998	80	81	-	46.7	47.2	42.0	45.8	48.4
2000	80	82	84	-	78.6	65.2	75.1	82.7
2001	73	77	81	76	-	66.0	76.2	84.2
2004	77	81	75	76	78	-	63.5	69.0
2005	71	75	82	73	73	69	-	80.0
2006	81	80	84	75	74	75	72	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):								
1993	-	-742.7	406.9	1240.8	-5432.0	829.8	808.9	729.0
1996	22491.2	-	110.4	-1786.5	765.9	162.8	824.7	382.7
1998	10910.4	67299.1	-	101.8	237.1	69.6	307.0	140.0
2000	6910.0	742895.8	19122.7	-	490.6	1498.2	706.9	201.6
2001	49318.3	21402.8	9754.2	6126.6	-	307.8	82.0	362.5
2004	8338.4	257267.7	24283.0	145043.4	7095.7	-	269.7	140.1
2005	31511.8	22242.5	10015.8	6596.6	114931.1	8240.4	-	599.6
2006	6223.8	43935.2	73518.7	10152.5	5885.3	12827.0	6370.8	-

$\tilde{N}_b = 269.4$

Table 12 Summary of output from program SALMONNb and data for five Chiwawa in-river spawner collections from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	1989	2001	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):					
1989	-	33.3	40.2	41.7	42.2
2001	72	-	60.5	63.9	63.3
2004	72	77	-	95.3	94.0
2005	69	72	75	-	102.5
2006	76	76	77	78	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):					
1989	-	118.4	299.0	143.3	165.3
2001	40378.8	-	181.7	-1537.3	153.5
2004	10455.2	7265.5	-	387.1	329.4
2005	20923.6	68660.6	5040.7	-	356.8
2006	16227.2	8886.9	3802.0	4522.8	-

$\tilde{N}_b$ = 224.2

Table 13 Summary of output from program SALMONNb and data for three brood years that combined Chiwawa natural- and hatchery-origin samples from Wenatchee River. For each pairwise comparison of samples *i* and *j*, $\tilde{S}$ is the harmonic mean sample size, *n* is the number of independent alleles used in the comparison, $\hat{N}_{b(i,j)}$ are the pairwise estimates of N_b, and Var [$\hat{N}_{b(i,j)}$] is the variance of $\hat{N}_{b(i,j)}$. $\tilde{N}_b$ is the harmonic mean of the $\hat{N}_{b(i,j)}$. Alleles with a frequency below 0.05 were excluded from the analysis to reduce potential bias.

Year	2004	2005	2006
Pairwise $\tilde{S}$ (above diagonal) and *n* (below diagonal):			
2004	-	162	164.3
2005	77	-	188.2
2006	76	75	-
Pairwise $\hat{N}_{b(i,j)}$ (above diagonal) and Var [$\hat{N}_{b(i,j)}$] (below diagonal):			
2004	-	611.3	210.8
2005	9351.5	-	727.5
2006	14965.5	8673.9	-

$\tilde{N}_b$ = 386.8

Appendix K

Genetic Diversity of Upper Columbia River Summer Chinook Salmon

Genetic Structure of upper Columbia River Summer Chinook and Evaluation of the Effects of Supplementation Programs

by

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Abstract

We investigated genetic relationships among temporally replicated collections of summer Chinook from the Wenatchee River, Methow River, and Okanogan River in the upper Columbia River basin. Samples from the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – MEOK stock, and Wells Hatchery were also included in the analysis. Samples of natural- and hatchery-origin summer Chinook were analyzed and compared to determine if the supplementation program has had any impacts to the genetic structure of these populations. We also calculated the effective number of breeders for collection locations of natural- and hatchery-origin summer Chinook from 1993 and 2008. In general, population differentiation was not observed among the temporally replicated collection locations. A single collection from the Okanogan River (1993) was the only collection showing statistically significant differences. The effective number of breeders was not statistically different from the early collection in 1993 in comparison to the late collection in 2008. Overall, these analyses revealed a lack of differentiation among the temporal replicates from the same locations and among the collection from different locations, suggesting the populations have been homogenized or that there has been substantial gene flow among populations. Additional comparisons among summer-run and fall-run Chinook populations in the upper Columbia River were conducted to determine if there was any differentiation between Chinook with different run timing. These analyses revealed pairwise F_{ST} values that were less than 0.01 for the collections of summer Chinook to collections of fall Chinook from Hanford Reach, lower Yakima River, Priest Rapids, and Umatilla. Collections of fall Chinook from Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River had pairwise F_{ST} values that were higher in comparison to the collections of summer Chinook. The consensus clustering analysis did not provide good statistical support to the groupings, but did show relationships among collections based on geographic proximity. Overall the summer and fall run Chinook that have historically been

spawned together were not differentiated while fall Chinook from greater geographic distances were differentiated.

Introduction

The National Marine Fisheries Service (NMFS) recognizes 15 Evolutionary Significant Units (ESU) for Chinook salmon (*Oncorhynchus tshawytscha*) (Myers et al. 1998). The summer Chinook from the upper Columbia River are included in the Upper Columbia River Summer- and Fall-Run ESU, which encompasses all late-run (summer and fall), ocean-type Chinook salmon from the mainstem Columbia River and its tributaries (excluding the Snake River) between Chief Joseph and McNary Dams (Waknitz et al. 1995). Waknitz et al. (1995) concluded that due to high total abundance this ESU was not likely to become at risk from extinction. Yet, a majority of natural spawning activity was in the vicinity of Hanford Reach, and it was unclear whether natural production was self-sustaining given the vast summer Chinook artificial propagation efforts (Waknitz et al. 1995). Additionally, the Biological Review Team expressed concern about potential consequences to genetic and life-history traits from an increasing contribution of hatchery fish to total spawning escapement (Waknitz et al. 1995).

Artificial propagation of ocean-type Chinook from the middle/upper Columbia has been continuous since the implementation of the Grand Coulee Fish Maintenance Project (GCFMP) in 1939 (Myers et al. 1998). The US Fish and Wildlife Service established three hatchery programs for summer/fall Chinook during the GCFMP, Leavenworth NFH, Entiat NFH, and Winthrop NFH. The Washington Department of Fisheries (now Washington Department of Fish and Wildlife) followed with hatchery programs at Rocky Reach (1964), Wells Dam (1967), Priest Rapids (1974), and Eastbank (1990) facilities. Currently, only Leavenworth NFH and Winthrop NFH are not producing summer/fall Chinook. Entiat NFH has resumed production of summer/fall Chinook (Wells FH Stock) in 2009 and released their first yearling summer Chinook smolts in 2010. Since

1941, over 200 million ocean-type Chinook salmon have been released into the middle Columbia River Basin (Myers et al. 1998). Initially, the hatchery programs differentiated between early returning fish (i.e., stream-type) and later returning fish (i.e., ocean-type), but no distinction was made regarding the “summer” and “fall” components of the ocean-type stocks (Waknitz et al. 1995). Therefore, all Chinook salmon now migrating above Rock Island Dam descend from not only a mixture between different stocks from the basin, but also a mixture between the endemic summer and fall life histories. While hatchery protocols have been modified of late to maintain discreet summer and fall Chinook hatchery stocks (Utter et al. 1995; see also HGMP), physical evidence and genetic data suggests that summer and fall Chinook may have become homogenized. During the 1970’s and 80’s, given coded-wire tag recoveries, summer-run Chinook originating from above Rock Island Dam were believed to have spawned extensively with Hanford Reach and Priest Rapids Hatchery fish (Chapman 1994). Stuehrenberg et al. (1995) reported that 10% of their radio tagged summer Chinook were occupying typical fall-run spawning habitat on the mainstem Columbia river, and 25% of fall fish released from Priest Rapids were recovered as summers at (or above) Wells Hatchery. Genetic data reported by Marshall et al. (1995) and Waknitz et al. (1995) corroborate these observations, as genetic distances observed between summer and fall Chinook within the Upper Columbia River Summer- and Fall-Run ESU were essentially zero.

In response to the need for evaluation of the supplementation hatchery programs, both a monitoring and evaluation plan (DCPUD 2005; Murdoch and Peven 2005) and the associated analytical framework (Hays et al. 2006) were developed for the Habitat Conservation Plan’s Hatchery Committee through the joint effort of the fishery co-managers (CCT, NMFS, USFWS, WDFW, and YN) and Chelan County and Douglas County PUDs. These reports outline 10 objectives to be applied to various species assessing the impacts of hatchery operations mitigating the operation of Wells, Rocky Reach, and Rock Island hydroelectric projects. The present monitoring and evaluation study plan differs in scope from previous monitoring and evaluation projects proposed by WDFW Molecular Genetics Lab, in that it does not investigate a single watershed, but instead will encompass all summer Chinook stocks from the upper Columbia River including the three supplementation (Wenatchee, Methow, and Okanogan) and the harvest augmentation program (Wells summer Chinook). The objectives of this study were to determine if genetic diversity, population structure, and effective population size have changed in natural spawning populations as a result of the hatchery programs.

Materials and Methods

Collections

A total of 2,416 summer Chinook were collected from tributaries in the upper Columbia River basin and were analyzed (Table 1). Two collections of natural-origin summer Chinook from 1993 (prior to the supplementation program) were taken from the Wenatchee River Basin and were compared to collections of hatchery and natural-origin from 2006 and 2008 that were post-supplementation. Two pre-supplementation collections from the Methow River (1991 and 1993) were compared to post-supplementation collections from 2006 and 2008. Three pre-supplementation collections from the Okanogan River Basin (1991, 1992, and 1993) were compared with post-supplementation collections from 2006 and 2008. A collection of natural-origin summer Chinook from the Chelan River was also analyzed. Additionally, hatchery collections from Eastbank Hatchery (Wenatchee and MEOK stock) and Wells Hatchery were analyzed and compared to the in-river collections. Summer Chinook data (provided by the USFWS) from the Entiat River was also used for comparison. Lastly, data from eight collections of fall Chinook was compared to the collections of summer Chinook.

Laboratory Analyses

All laboratory analyses were conducted at the WDFW Genetics Laboratory in Olympia, Washington. Genomic DNA was extracted by digesting a small piece of fin tissue using the nucleospin tissue kits obtained from Macherey-Nagel following the recommended conditions in the user manual. Extracted DNA was eluted with a final volume of 100 µL.

Genotype information was generated using thirteen microsatellite markers following standard laboratory protocols and analysis methods. Descriptions of the loci assessed in this study and polymerase chain reaction (PCR) conditions are given in Table 2. PCR reactions were run with a thermal profile consisting of: denaturation at 95^{o}C for 3 min, denaturation at 95^{o}C for 15 sec, anneal for 30 sec at the appropriate temperature for each locus (Table 2), extension at 72^{o}C for 1 min, repeat cycle (steps 2-4), final extension at 72^{o}C for 30 minutes. PCR products were then processed with an ABI-3730 DNA Analyzer. Genotypes were visualized with a known size standard (GS500LIZ 3730) using GENEMAPPER 3.7 software. Alleles were binned in GENEMAPPER using the standardized allele sizes established for the Chinook GAPS dataset (Seeb et al. 2007).

Within-collection Statistical Analyses

Allele frequencies were calculated with CONVERT (version 1.3, Glaubitz 2003). Hardy-Weinberg proportions for all loci within each collection were calculated using GENEPOP (version 3.4, Raymond and Rousset 1995). Heterozygosity (observed and expected) was computed for each collection group using GDA (Lewis and Zaykin 2001).

Allelic richness and F_{IS} (Weir and Cockerham 1984) inbreeding coefficient were calculated using FSTAT (version 2.9.3.2, Goudet 2001). Linkage disequilibrium for each pair of loci in each collection was calculated using GENEPOP v 3.4 (10,000 dememorizations, 100 batches, and 5,000 iterations per batch). Pairwise estimates of genetic differentiation between collection groups were calculated using GENEPOP (version 3.4, Raymond and Rousset 1995). Statistical significance for the tests of Hardy-Weinberg proportions, linkage disequilibrium, and genotypic differentiation was evaluated using a Bonferroni correction of p-values to account for multiple, simultaneous tests (Rice 1989).

Between-collection Statistical Analyses

Pairwise F_{ST} estimates were computed to examine population structure among collections using GENETIX (version 4.03, Belkhir et al. 2001). This estimate uses allelic frequency data and departures from expected heterozygosity to assess differences between pairs of populations.

We used PHYLIP (version 3.5c, Felsenstein 1993) to calculate Cavalli-Sforza and Edwards (1967) pairwise chord distances between collections. Bootstrap calculations were performed using SEQBOOT followed by calculations of genetic distance using GENDIST. The NEIGHBOR-JOINING method of Saitou and Nei (1987) was used to generate the dendrograms and CONSENSE to generate a final consensus tree from the 1,000 replicates. The dendrogram generated in PHYLIP was plotted as an unrooted radial tree using TREEVIEW (version 1.6.6, Page 1996).

Effective Number of Breeders

The effective number of breeders (N_b) was estimated for pre- and post-supplementation program collections (where possible) to investigate whether hatchery programs had affected that genetic metric over the operational period. Wang (2009) derived an equation for effective size (N_e) as a function of the frequency of nested full-sib and half-sib families in a random collection of individuals.

$$\frac{1}{N_e} = \frac{1+3\alpha}{4}\left(Q_1 + Q_2 + 2Q_3\right) - \frac{\alpha}{2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right) \qquad \text{(equation 10)}$$

Where α is a measure of the deviation of genotype frequencies from Hardy-Weinberg expectation (equivalent to Wright's (1969) F_{IS}), Q_i are the probabilities that a pair of offspring are paternal half sibs, maternal half sibs, or full sibs, respectively, and N_1 and N_2 are the number of male and female parents that generation, respectively. Genetic parameters (i.e., sibship distributions) were estimated for summer Chinook collections using algorithms implemented in COLONY (Jones and Wang 2009). To be clear, Wang's (2009) method as implemented here will estimate N_b, given multi-locus genotypes from each collection were partitioned by brood year for this analysis. To obtain an estimate of N_e each N_b value must be multiplied by the mean generation time of that population.

Results

Collections

A total of 2,350 individuals from 32 collections of temporally replicated samples (six locations) were analyzed (Table 1). Temporally replicated collections of hatchery and natural-origin samples were from the Wenatchee, Methow, and Okanogan Rivers. Temporally replicated hatchery-origin summer Chinook were from Wells Hatchery, Eastbank Hatchery - Wenatchee stock, and Eastbank Hatchery - Methow/Okanogan (MEOK) stock. A total of 232 of those individuals were excluded from any analyses because they failed to amplify at nine or more loci. Data for remaining 2,118 individuals were analyzed to assess differences between temporally replicated natural- and hatchery-origin summer Chinook for each location and to compare the differences among the different collection locations. Summer Chinook data from the temporally replicated collection locations were then combined and compared to fall Chinook data from the GAPS v.3.0 dataset.

Statistical Analyses

The population statistics (Hardy-Weinberg equilibrium and F_{IS}) calculated for each of the 32 temporally replicated collection locations were consistent with neutral expectations (i.e., no associations among alleles). Three collections did have a single locus that did not meet expectations (Wenatchee hatchery-origin 2006, Wells hatchery 2006, and Okanogan hatchery-origin 2009). Based on these results we suggest the collections represented randomly breeding groups and were not comprised of mixtures of individuals from different genetic source populations.

Population differentiation was assessed for each of the temporally replicated collections from within each location (Table 3). This analysis revealed the only significant difference observed within a collection location pertained to the collection from 1993 Okanogan River natural-origin samples. Because of the significant difference of this collection to the other temporal replicates it was not included in further analyses.

Given the absence of genetic differentiation observed among the temporally replicated collections, the 32 collections from the Wenatchee, Methow, and Okanogan River were combined to form three location-specific collections for analysis. Population differentiation metrics were compared among the composite Wenatchee, Methow, and Okanogan collections and eight other location-specific collections (11 locations total). Comparing all collections, there were a total of 39 significant genic test comparisons out of a total 496 (Table 4). Thirty-eight of the 39 statistically significant pairwise differences pertained to the Okanogan River and 2006 Wells Hatchery collections (Table 4). F_{ST} results are described further below.

Within-collection genetic metrics were estimated for the 11 location-specific collections of summer Chinook from the upper Columbia River, in addition to eight collections of fall Chinook (Table 1). The population statistics (Hardy-Weinberg equilibrium and F_{IS}) calculated for these collections of summer and fall

Chinook were also consistent with neutral expectations. The collection from Lyons Ferry Hatchery had one locus that did not meet expectations and the collections from Crab Creek and Marion Drain both had three loci that did not meet expectations.

The hatchery collections in general had a higher percentage of significantly linked loci; however the observed genetic diversity were similar for the natural and hatchery-origin collections. Analysis of allelic richness was based on 11 individuals per collection, the minimum number of individuals across all collections with complete multilocus genotypes. The largest number of linked loci occurred in the Crab Creek, Entiat River, and Okanogan natural-origin collections. Allelic richness was on average lower in the collections of summer Chinook (10.7) collections in comparison to the collections of fall Chinook (11.0).

Pairwise F_{ST} (Table 4) estimates revealed low levels of differentiation, where all observed F_{ST} values between the collections of summer Chinook were lower than 0.0096. There were 15 out of 28 comparisons between collections of summer Chinook that were significantly different from zero and occurred primarily from comparisons of the Okanogan River (hatchery and natural-origin) and Wells Hatchery to all other collections. The collection of Eastbank Hatchery – MEOK stock was differentiated from the Wenatchee River natural-origin and Entiat River collections. The collection from the Chelan River had a small sample size of 23 individuals and only differentiated from the Eastbank Hatchery – MEOK stock. F_{ST} estimates regarding pairwise comparisons between each of four fall Chinook collection locations (Crab Creek, Lyons Ferry Hatchery, Marion Drain, and Snake River) to all other collections were significantly different from zero (Table 5). Pairwise comparisons for three other fall Chinook collections (Hanford Reach, lower Yakima River, and Umatilla River) to the collections of summer Chinook were significantly different from zero (Table 6). The only fall Chinook collection that was not significantly differentiated from all of the summer Chinook was Priest Rapids.

The relative genetic relationships among the test groups were assessed using the consensus clustering analysis (Figure 1). Statistical support for the dendrogram topology (i.e., tree shape) was low regarding the branching that separated the collections of summer Chinook from the upper Columbia River. The collections of fall Chinook; however were supported with bootstrap support over 76% with the exception of three collections (lower Yakima River, Crab Creek, and Umatilla River). In other words, 760 of the 1000 bootstrap replicates supported the placement of the node separating summer and fall collections. The collection from the Chelan River had bootstrap support of 68%; however the sample size for that collections was small (N = 23). Even though the bootstrap support was low among the collections of summer Chinook there was concordance between geography and genetic distance.

Where comparisons were possible between pre- and post-supplementation program collections, the effective number of breeders (N_b) estimated to have comprised those collections were slightly lower for contemporary (2008) collections; however in all cases the 95% confidence intervals overlapped between historical and contemporary collections, suggesting statistical equivalency. Regarding Wenatchee River collections, the point estimates of N_b ranged from 134 (08FU) to 190 (93DD), where all collections had overlapping confidence intervals (Table 7). The upper bound of the 1989 brood year for collection 93DD was very large, suggesting the sample size was insufficient for properly inferring the sibship distribution within the collection. Comparing the Okanogan natural collections 93ED and 08GA, the estimated N_b were 142 (CI 102 – 203) and 127 (CI 92 – 180), respectively. For the Eastbank Hatchery MEOK stock comparisons, the N_b estimated for the 93DF collection was 171 (CI 129 – 229), as compared to the 166 (CI 126 – 226) estimated for collection 08MO. In all cases, the estimated N_b can be converted to effective population size (N_e) by multiplying the estimate by the mean generation time.

Discussion

The collections of summer Chinook populations from the upper Columbia River are of interest because census sizes are reduced below historic levels and are the subject of mitigation and supplementation hatchery programs. Concern over the impacts of hatchery supplementation programs on the genetic integrity of natural-origin populations led to our primary objective, which was to evaluate genetic metrics for temporally replicated collections of summer Chinook in the upper Columbia River pre and post hatchery supplementation. A similar analysis by Kassler and Dean (2010) was conducted on spring Chinook in the Tucannon River to evaluate the effects of a supplementation and captive brood program on natural-origin stocks. Additionally, upper Columbia River spring Chinook supplementation programs (Blankenship et al. 2007; Small et al. 2007), spring and fall Chinook populations in the Yakima Basin (Kassler et al. 2008), and a potentially unique population of fall Chinook in Crab Creek (Small et al. 2010) have been evaluated. In the present analysis of summer Chinook populations, collections of pre- and post- supplementation summer Chinook were collected from the Wenatchee River, Methow River, and Okanogan River Basins and analyzed to determine if the genetic profile has changed as a result of the supplementation program. Analysis was then conducted on the collections of summer run to compare the fall run Chinook collections in the upper Columbia River basin.

Allozyme analyses of these three summer run Chinook stocks in the upper Columbia River have identified that each stock was distinct, with a closer relationship detected between the Wenatchee and Methow Rivers (WDF and WDW 1993, Marshall 2002). Wenatchee summer Chinook are thought to be a mixture of native summer Chinook and Chinook from the Grand Coulee Fish Maintenance Project (GCFMP). The goal of the GCFMP project between 1939 and 1943 was to trap migrating Chinook salmon at Rock Island dam (75 miles below Grand Coulee) and homogenize the populations, which reduced the genetic uniqueness of the distinct tributary populations present in the upper Columbia River.

We found allele frequencies for individual temporally replicated hatchery- and natural-origin collection locations of adult summer Chinook were not significantly different from that expected of a single underlying population, except for one collection (1993 Okanogan natural-origin; Table 3). This collection was differentiated to the Okanogan collections in 2006 and 2008; however it was not differentiated from the collection in 1992. The Okanogan collection from 1992 was also not differentiated to any other collection; therefore the difference in the collection from Okanogan 1993 was likely not an indication of genetic change from pre supplementation to post supplementation. The collection was however dropped from further analyses so as to not confuse interpretation of results. The lack of allelic differentiation observed among the temporally replicated collections was interpreted as the genetic metrics from each location in the early 1990's did not differ from the samples collected in 2008. Spanning a few generations, allele frequencies are not expected to change for large populations at genetic equilibrium. In contrast, changes in allele frequencies of small populations may occur due to the stochastic sampling of genes from one generation to the next (i.e., genetic drift).

A second round of analyses was conducted to evaluate the genetic relationships of the summer run collections (temporal collections were combined) with data from the Entiat River, Chelan River, and eight collections of fall Chinook. Assessment of the relationship between the summer run collections in comparison to each other provided very little evidence of genetic differentiation between these collections. While population differentiation did show some significant differences between the Okanogan River and Wells Hatchery collections, all of the pairwise F_{ST} values were below 0.003. Meaning that a very small proportion of the observed genetic variation could be attributed to restrictions in gene flow (i.e., population structure)

The comparison of the hatchery-origin collections revealed a lack of differentiation between the Eastbank Hatchery – Wenatchee stock, Eastbank Hatchery – MEOK stock, and the Wells Hatchery (with exception of the 2006 collection). The genetic similarity or low level of genetic differentiation among these stocks suggests that there has been an integration of natural- and hatchery-origin summer Chinook in the upper Columbia River or a lack of ancestral genetic difference. The difference of the 2006 Wells Hatchery collection to the other collections is most likely a result of sampling effect because of the lack of differentiation among the stocks in the basin. If the 2006 collection had been mixed from different sources of summer Chinook there would not be a detectable level of differentiation as was seen with the 2006 sample.

The analyses to compare summer and fall Chinook collections provided some understanding on the genetic relationships of Chinook with different run timings in the upper Columbia River basin. Historically, the hatchery programs in the upper Columbia River were separated into groups of the early returning fish (i.e., stream-type) and later returning fish (i.e., ocean-type), but the programs did not sort individuals identified as “summer” or “fall” stocks (Waknitz et al. 1995). Now all Chinook salmon that are migrating above Rock Island Dam descend from a mixture of different stocks from the upper Columbia River basin, but also a mixture between the endemic summer and fall life histories.

Small et al. (2010) conducted an analysis on summer run and fall run Chinook in the upper Columbia River and concluded that Crab Creek Chinook in the upper Columbia River were genetically distinct to all other fall and summer run Chinook stocks that were analyzed. They did note a departure from Hardy Weinberg expectation as a result of a null allele at the microsatellite locus *Ogo-4* and a higher linkage disequilibrium value due to the inclusion of family groups in one of their samples. Kassler et al. (2008) found differentiation among spring and fall Chinook populations in the Yakima River.

The tests of pairwise F_{ST} indicated a very low level of genetic differentiation (less than one percent difference) between collections of summer-run Chinook and fall-run Chinook. The range of pairwise F_{ST} values for comparisons between the summer run and fall run collections was 0.0016 – 0.0248. The larger values from the range were associated to the collections from Crab Creek, Lyons Ferry Hatchery, and Marion Drain. Studies by Kassler et al. (2008) and Small et al. (2010) have documented differences among the populations of these collections to others within the upper Columbia River basin. The low pairwise F_{ST} values between Priest Rapids and Hanford Reach collections and the summer run collections were not surprising because summer-run Chinook originating from above Rock Island Dam were believed to have spawned extensively with Hanford Reach and Priest Rapids Hatchery fish during the 1970's and 80's (Chapman 1994). The lack of differentiation among the summer and fall stocks in the Columbia River was also identified by Utter et al. (1995) and the HGMP where they state physical evidence and genetic data suggests that summer and fall Chinook may have become homogenized.

Despite low levels of statistical bootstrap support for dendrogram topology (i.e., tree shape), there was concordance observed between geographic location and the genetic relationships among the summer and fall Chinook populations. The collections from the Okanogan (hatchery and natural-origin) did separate out with collections from Wells Dam Hatchery, Entiat River, and Eastbank Hatchery – MEOK stock, and were next to a group of the Methow and Wenatchee collections. The fall Chinook populations are also separated to the summer collections and the position of all but three of these collections (lower Yakima River, Crab Creek, and Umatilla River) were statistically supported. The geographic proximity of the fall collections seemed to follow the observed pattern in this dendrogram. The relationship of the Snake River and Lyons Ferry Hatchery in proximity to the collection from Marion Drain was not surprising while the relationship between Priest Rapids and Hanford Reach was easily a result of the stocking practices of fall Chinook in the 1970 and 1980's.

A secondary objective of this study was to determine if the effective population size of upper Columbia River summer Chinook populations had changed over time due to supplementation efforts. We observed that the number of effective breeders in the collections from 1993 and 2008 has not changed thus providing reason to believe that the genetic diversity of summer Chinook in the upper Columbia River has not been altered through the supplementation program.

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Table 1. Samples of adult hatchery- and natural-origin summer and fall Chinook that were analyzed from the upper Columbia River. Total number of individuals that were analyzed / individuals with data for 9 or more loci that were included in the analysis. Collection statistics (allelic richness, linkage disequilibrium (before and after Bonferroni correction), F_{IS}, heterozygosity (H_O and H_E)) and p-values for deviations from Hardy-Weinberg equilibrium (HWE). P-values were defined as significant after implementation of Bonferroni correction for multiple tests (Rice 1989).

WDFW GSI code[a]	Collection location	N =	Allelic Richness[b]	Linkage Disequilibrium[c]	F_{IS} (p-value)[d]	H_O	H_E
93DD	Wenatchee River upstream of Tumwater Dam - natural origin	51 / 45					
93DE	Wenatchee River downstream of Tumwater Dam - natural origin	88 / 88					
06CQ	Wenatchee River upstream of Tumwater Dam - natural origin	95 / 86					
06CR	Wenatchee River downstream of Tumwater Dam - natural origin	95 / 82					
08FV	Wenatchee River upstream of Tumwater Dam - natural origin	95 / 82					
08FW	Wenatchee River downstream of Tumwater Dam - natural origin	95 / 87					
	Wenatchee River - Natural origin combined	**519 / 470**	**10.7**	**17 / 4**	**0.001 (0.403)**	**0.8504**	**0.8513**
06CP	Wenatchee River - hatchery origin	95 / 70					
08FU	Wenatchee River - hatchery origin	95 / 83					
	Wenatchee River - Hatchery origin combined	**190 / 153**	**10.6**	**18 / 6**	**0.018 (0.013)**	**0.8409**	**0.8561**
93EC	Methow River - natural origin	27 / 27					
06CT	Methow River - natural origin	95 / 90					
08FY	Methow River - natural origin	95 / 88					
09CO	Methow River - natural origin	91 / 80					
	Methow River - Natural origin combined	**308 / 285**	**10.7**	**4 / 1**	**0.006 (0.160)**	**0.8506**	**0.8554**
06CS	Methow River - hatchery origin	14 / 8					
08FX	Methow River - hatchery origin	21 / 18					
09CP	Methow River - hatchery origin	19 / 18					
	Methow River - Hatchery origin combined	**54 / 44**	**10.8**	**11 / 2**	**-0.003 (0.593)**	**0.8553**	**0.8523**

Table 1 continued.

92FM	Okanogan River - natural origin	49 / 46					
93ED*	Okanogan River - natural origin	103 / 87					
06CV	Okanogan River - natural origin	95 / 88					
08GA	Okanogan River - natural origin	95 / 92					
09CN	Okanogan River - natural origin	133 / 126					
	Okanogan River - Natural origin combined	**475 / 439**	**10.8**	**9 / 4**	**0.003 (0.304)**	**0.8563**	**0.8596**
* - not included in the combined dataset							
06CU	Okanogan River - hatchery origin	58 / 49					
08FZ	Okanogan River - hatchery origin	19 / 18					
09CM	Okanogan River - hatchery origin	117 / 107					
	Okanogan River - hatchery origin combined	**194 / 174**	**10.8**	**31 / 10**	**-0.011 (0.920)**	**0.8678**	**0.8586**
91FL	Wells Hatchery	68 / 42					
92FK	Wells Hatchery	25 / 23					
93DG	Wells Hatchery	11 / 9					
06DM	Wells Hatchery	95 / 91					
08HY	Wells Hatchery	95 / 91					
	Wells Hatchery combined	**294 / 256**	**10.7**	**8 / 3**	**-0.001 (0.529)**	**0.8670**	**0.8665**
08MN	**Eastbank Hatchery - Wenatchee River stock**	**95 / 90**	**10.7**	**6 / 1**	**0.020 (0.024)**	**0.8326**	**0.8498**
92FO	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	36 / 33					
93DF	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	90 / 86					
08MO	Eastbank Hatchery - Methow / Okanogan (MEOK) stock	95 / 88					
	Eastbank Hatchery - MEOK stock combined	**221 / 207**	**10.7**	**2 / 0**	**-0.005 (0.782)**	**0.8647**	**0.8604**
		2,350 / 2,118					

Table 1 continued.

06KN	**Chelan River**	**70 / 23**	**10.3**	**11 / 0**	**0.027 (0.118)**	**0.8334**	**0.8556**
Data provided by USFWS							
	Entiat River - summer Chinook	**190**	**10.9**	**33 / 10**	**0.008 (0.119)**	**0.8553**	**0.8625**
Data from Small et al. (2010)							
08EH	Crab Creek	108					
09AZ	Crab Creek	291					
	Crab Creek	**399**	**10.5**	**35 / 14**	**0.018 (0.000)**	**0.8519**	**0.8676**
GAPS v.3.0 data							
	Priest Rapids Hatchery - fall Chinook	**81**	**11.1**	**3 / 2**	**0.015 (0.079)**	**0.8591**	**0.8723**
	Hanford Reach - fall Chinook	**220**	**11.3**	**4 / 0**	**0.010 (0.068)**	**0.8661**	**0.8746**
	Umatilla - fall Chinook	**96**	**11.2**	**17 / 6**	**-0.003 (0.623)**	**0.8719**	**0.8693**
	lower Yakima River - fall Chinook	**103**	**11.0**	**3 / 1**	**0.000 (0.511)**	**0.8724**	**0.8721**
	Marion Drain - fall Chinook	**190**	**10.8**	**9 / 4**	**0.022 (0.001)**	**0.8586**	**0.8782**
	Lyons Ferry Hatchery - fall Chinook	**186**	**10.6**	**7 / 4**	**0.013 (0.033)**	**0.8527**	**0.8641**
	Snake River - fall Chinook	**521**	**11.1**	**0 / 0**	**-0.001 (0.634)**	**0.8720**	**0.8708**
		NA / 2,009					

[a] - Year that samples were collected is identifed by the two numbers in the WDFW GSI code

[b] - based on a minimum of 11 diploid individuals

[c] - adjusted alpha p-value = 0.0006

[d] - adjusted alpha p-value = 0.0002

Table 2. PCR conditions and microsatellite locus information (number alleles/locus and allele size range) for multiplexed loci used for the analysis of Chinook. Also included are the observed and expected heterozygosity (H_o and H_e) for each locus.

PCR Conditions			Locus statistics		Heterozygosity		
Poolplex	Locus	Dye Label	# Alleles/ Locus	Allele Size Range (bp)	H_o	H_e	References
Ots-M	*Ots-201b*	blue	49	137 - 334	0.9474	0.9544	Unpublished
	Ots-208b	yellow	56	154 - 378	0.9523	0.9672	Greig et al. 2003
	Ssa-408	red	32	184 - 308	0.9177	0.9214	Cairney et al. 2000
Ots-N	*Ogo-2*	red	22	206 - 260	0.8526	0.8673	Olsen et al. 1998
Ots-O	*Ogo-4*	blue	20	128 - 170	0.6694	0.7028	Olsen et al. 1998
	Ots-213	yellow	45	178 - 370	0.9430	0.9525	Greig et al. 2003
	Ots-G474	red	16	152 - 212	0.6816	0.6838	Williamson et al. 2002
Ots-R	*Ots-3M*	blue	15	128 - 158	0.7854	0.7938	Banks et al. 1999
	Omm-1080	green	54	162 - 374	0.9517	0.9670	Rexroad et al. 2001
Ots-S	*Ots-9*	red	9	99 - 115	0.6531	0.6543	Banks et al. 1999
	Ots-212	blue	33	123 - 251	0.9205	0.9360	Greig et al. 2003
Ots-T	*Oki-100*	blue	50	164 - 361	0.9500	0.9567	Unpublished
	Ots-211	red	34	188 - 327	0.9325	0.9414	Greig et al. 2003

Table 3. Tests of population differentiation for temporal collections of summer Chinook from natural and hatchery-origin populations in the upper Columbia River. P-values that are highlighted grey are significantly different after Bonferroni correction (Rice 1989). Adjusted alpha p-value was 0.0001 . The H and W in the collection identifier is for wild or hatchery-origin and the two digit number identifes the year samples were collected.

Wenatchee River

	WenW93U	WenW93D	WenH06	WenW06U	WenW06D	WenH08	WenW08U	WenW08D
WenW93U	****							
WenW93D	0.0162	****						
WenH06	0.0033	0.0102	****					
WenW06U	0.3039	0.1642	0.4795	****				
WenW06D	0.0261	0.0160	0.0678	0.5300	****			
WenH08	0.1126	0.0708	0.0073	0.4359	0.0893	****		
WenW08U	0.2115	0.1148	0.4191	0.7243	0.3830	0.8856	****	
WenW08D	0.1915	0.0014	0.7047	0.4928	0.1671	0.7755	0.7665	****

D - collection was downstream of Tumwater Dam; U - collection was upstream of Tumwater Dam

Methow River

	MetW93	MetH06	MetW06	MetH08	MetW08	MetW09	MetH09
MetW93	****						
MetH06	0.3962	****					
MetW06	0.5481	0.4688	****				
MetH08	0.1408	0.1192	0.2052	****			
MetW08	0.8219	0.8937	0.6156	0.3779	****		
MetW09	0.2564	0.4282	0.2502	0.0328	0.7309	****	
MetH09	0.1543	0.5678	0.0547	0.0017	0.0098	0.0073	****

Okanogan River

	OkanW92	OkanW93	OkanH06	OkanW06	OkanH08	OkanW08	OkanH09	OkanW09
OkanW92	****							
OkanW93	0.0066	****						
OkanH06	0.0193	0.0000	****					
OkanW06	0.2843	0.0082	0.0031	****				
OkanH08	0.1290	0.1106	0.0652	0.7329	****			
OkanW08	0.0106	0.0029	0.0082	0.4075	0.7396	****		
OkanH09	0.0187	0.0001	0.0094	0.0551	0.2214	0.0281	****	
OkanW09	0.0527	0.0000	0.0024	0.7130	0.0262	0.0065	0.0002	****

Table 3 continued.

Wells Dam Hatchery

	Wells91	Wells92	Wells93	Wells06	Wells08
Wells91	****				
Wells92	0.5863	****			
Wells93	0.0490	0.0784	****		
Wells06	0.0089	0.0100	0.0542	****	
Wells08	0.0819	0.1088	0.2552	0.0256	****

Eastbank Hatchery - Wenatchee and MEOK stocks

	EBHWen08	EBHME92	EBHME93	EBHME08
EBHWen08	****			
EBHME92	0.8681	****		
EBHME93	0.0251	0.8661	****	
EBHME08	0.0086	0.9563	0.1895	****

Table 4. F_{ST} pairwise comparisons and genotypic tests of differentiation for hatchery- and natural-origin summer Chinook from the upper Columbia River. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

	Wenatchee Hatchery	Wenatchee Natural	Methow Hatchery	Methow Natural	Okanogan Hatchery	Okanogan Natural	Wells Hatchery	Eastbank Wenatchee stock	Eastbank MEOK stock	Entiat River	Chelan River
Wenatchee Hatchery	****	**0.0000**	**0.0011**	**0.0000**	**0.0013**	**0.0010**	0.0015	**0.0004**	**0.0007**	**0.0004**	**0.0072**
Wenatchee Natural	**0.4351**	****	**0.0016**	**0.0000**	0.0014	0.0016	0.0024	**0.0006**	0.0012	0.0009	**0.0068**
Methow Hatchery	**0.3800**	**0.0205**	****	**0.0012**	0.0029	**0.0008**	**0.0027**	**0.0014**	**0.0022**	**0.0019**	**0.0078**
Methow Natural	**0.2237**	**0.6566**	**0.1502**	****	**0.0011**	0.0011	0.0013	**0.0007**	**0.0007**	**0.0008**	**0.0053**
Okanogan Hatchery	0.0001	0.0000	**0.0364**	**0.0008**	****	**0.0010**	**0.0014**	0.0029	**0.0000**	**0.0007**	**0.0055**
Okanogan Natural	0.0000	0.0000	**0.1755**	0.0000	**0.0003**	****	0.0016	0.0023	**0.0005**	**0.0008**	**0.0049**
Wells Hatchery	0.0000	0.0000	**0.0129**	0.0000	0.0000	0.0000	****	0.0036	**0.0006**	**0.0008**	**0.0041**
Eastbank Wenatchee	**0.5261**	**0.4102**	**0.1215**	**0.8404**	**0.0015**	0.0000	0.0000	****	**0.0018**	0.0030	0.0096
Eastbank MEOK stock	**0.0485**	0.0000	**0.4246**	**0.0009**	**0.5786**	**0.0051**	0.0000	**0.0065**	****	**0.0005**	**0.0039**
Entiat River	**0.0565**	0.0000	**0.1795**	**0.0044**	**0.0005**	0.0000	**0.0032**	**0.0039**	**0.0042**	****	**0.0052**
Chelan River	**0.0091**	**0.0026**	**0.0182**	**0.0156**	**0.0048**	**0.0030**	**0.0066**	**0.0059**	**0.0493**	**0.0617**	****

Table 5. F_{ST} pairwise comparisons and genotypic tests of differentiation for fall Chinook. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

	Crab Creek	Hanford Reach Fall	Lyons Ferry Hatchery Fall	lower Yakima River Fall	Marion Drain Fall	Priest Rapids Fall	Umatilla River Fall	Snake River Fall
Crab Creek	****	0.0087	0.0134	0.0079	0.0143	0.0107	0.0073	0.0097
Hanford Reach Fall	0.0000	****	0.0077	**0.0000**	0.0064	**0.0000**	**0.0000**	0.0022
Lyons Ferry Hatchery Fall	0.0000	0.0000	****	0.0063	0.0074	0.0092	0.0062	0.0029
lower Yakima River Fall	0.0000	**0.4140**	0.0000	****	0.0054	**0.0000**	**0.0000**	0.0018
Marion Drain Fall	0.0000	0.0000	0.0000	0.0000	****	0.0067	0.0061	0.0060
Priest Rapids Fall	0.0000	**0.0695**	0.0000	**0.0083**	0.0000	****	**0.0000**	0.0027
Umatilla River Fall	0.0000	**0.4879**	0.0000	**0.4896**	0.0000	**0.2539**	****	0.0011
Snake River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	****

Table 6. F_{ST} pairwise comparisons and genotypic tests of differentiation for hatchery- and natural-origin summer Chinook from the upper Columbia River and fall Chinook. Above the diagonol are the F_{ST} values and below are p-values for the test of genotypic differentiation. Non-significant p-values for the result of the genotypic differentiation test are in bold type and F_{ST} values that are not significantly different from zero are in bold type.

Population Differentiation

	Wenatchee Hatchery	Wenatchee Natural	Methow Hatchery	Methow Natural	Okanogan Hatchery	Okanogan Natural	Wells Hatchery	Eastbank Wenatchee stock	Eastbank MEOK stock	Entiat River	Chelan River
Crab Creek	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hanford Reach Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0349**
Lyons Ferry Hatchery Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lower Yakima River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0074**
Marion Drain Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Priest Rapids Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0642**
Umatilla River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	**0.0579**
Snake River Fall	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 6 continued.

Pairwise F_{ST}

	Crab Creek	Hanford Reach Fall	Ferry Hatchery	Yakima River	Marion Drain Fall	Priest Rapids Fall	Umatilla River Fall	Snake River Fall
Wenatchee Hatchery	0.0158	0.0054	0.0180	0.0056	0.0153	**0.0025**	0.0053	0.0103
Wenatchee Natural	0.0162	0.0059	0.0185	0.0063	0.0157	0.0030	0.0059	0.0102
Methow Hatchery	0.0191	0.0104	0.0248	0.0095	0.0220	0.0069	0.0107	0.0165
Methow Natural	0.0148	0.0057	0.0182	0.0051	0.0148	0.0033	0.0055	0.0101
Okanogan Hatchery	0.0146	0.0041	0.0166	0.0042	0.0151	**0.0016**	0.0041	0.0082
Okanogan Natural	0.0163	0.0064	0.0187	0.0062	0.0170	0.0035	0.0068	0.0113
Wells Hatchery	0.0120	0.0051	0.0135	0.0044	0.0120	0.0028	0.0046	0.0077
Wenatchee stock	0.0184	0.0073	0.0203	0.0074	0.0167	0.0047	0.0084	0.0128
Eastbank MEOK stock	0.0128	0.0036	0.0143	0.0038	0.0135	**0.0019**	0.0038	0.0079
Entiat River	0.0147	0.0059	0.0176	0.0057	0.0156	0.0028	0.0056	0.0100
Chelan River	0.0074	**0.0046**	0.0110	**0.0040**	0.0160	**0.0047**	**0.0035**	0.0072

Table 7. Effective number of breeders per brood year with the largest number of samples of summer Chinook in the upper Columbia River. Brood years with sample size less than 19 individuals (shown in bold type) were not analyzed with exception of the 2008 Wells Hatchery collection. A comparison could not be made between an early and late collection from Wells Hatchery.

WDFW Code	Collection Location	Sample Size	Nb =	CI95(L) =	CI95(U) =
93DD[A]	Wenatchee Natural - upstream	23 / 19	152 / 190	77 / 87	616 / 2,147,483,647
08FV	Wenatchee Natural - upstream	56	162	112	249
93DE[A]	Wenatchee Natural - downstream	39 / 34	145 / 152	94 / 95	256 / 302
08FW	Wenatchee Natural - downstream	67	140	105	199
08FU	Wenatchee Hatchery	60	134	90	213
93EC[A]	Methow Natural	**10 / 15**	---	---	---
08FY	Methow Natural	62	150	106	218
08FX	Methow Hatchery	**9**	---	---	---
93ED	Okanogan Natural	69	142	102	203
08GA	Okanogan Natural	59	127	92	180
08FZ	Okanogan Hatchery	**16**	---	---	---
93DG	Wells Hatchery	**6**	---	---	---
08HY[B]	Wells Hatchery	24 / 39	---	---	---
08MN	Eastbank Hatchery - Wenatchee	88	190	144	263
93DF	Eastbank Hatchery - MEOK	84	171	129	229
08MO	Eastbank Hatchery - MEOK	88	166	126	226

[A] - calculations were made for samples from brood year 1988 / brood year 1989

[B] - samples were collected from brood year 2003 / brood year 2004

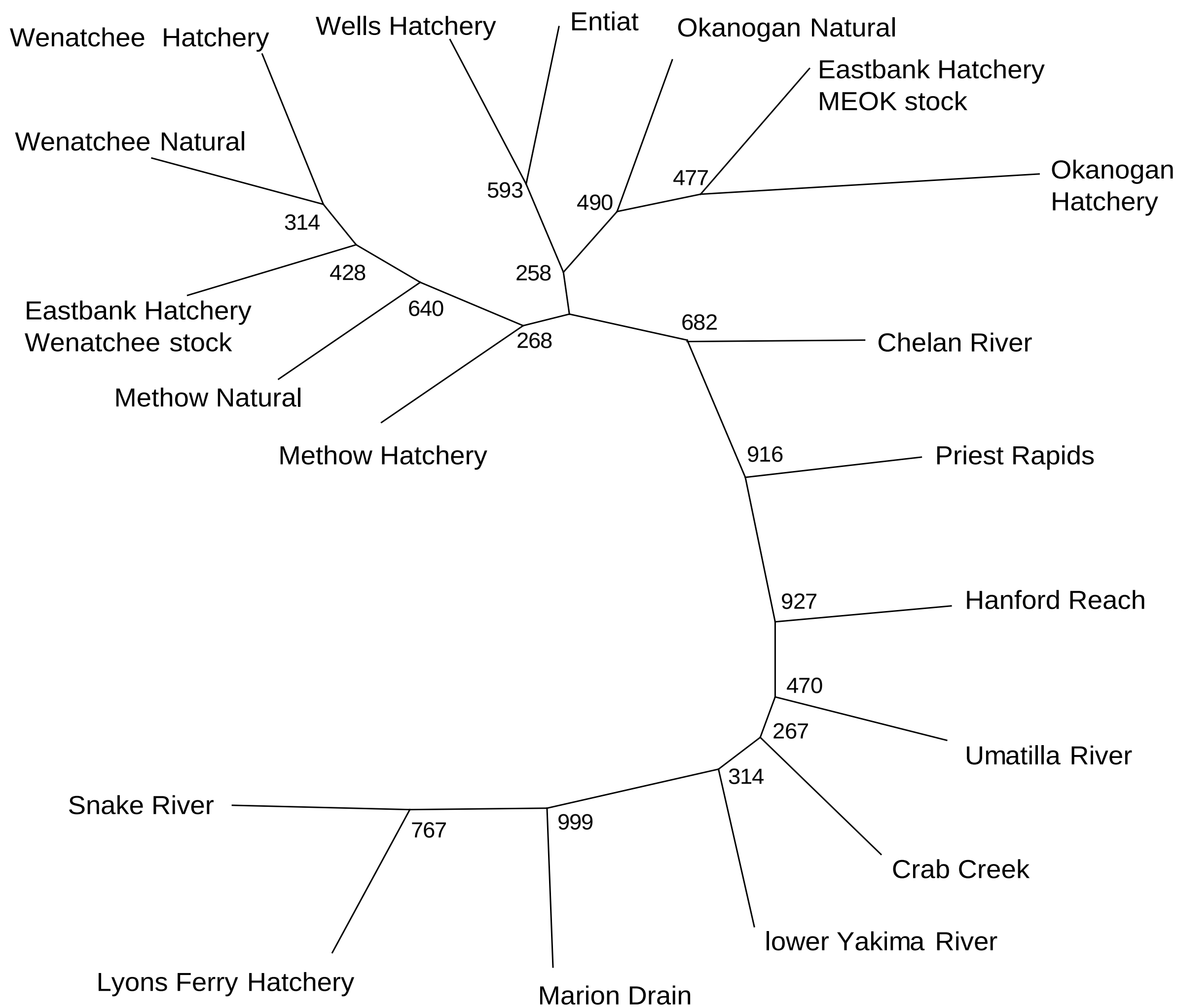

Figure 1. Relationship of natural- and hatchery-origin Chinook collections from the upper Columbia River basin using Cavalli-Sforza and Edwards (1967) chord distance. Bootstrap values are shown at each node.

Appendix L

Summer Chinook Spawning Ground Surveys in the Methow and Okanogan Basins, 2011

BioAnalysts, Inc.℠
4725 North Cloverdale Road, Ste 102
Boise Idaho 83713

January 11, 2012

To: HCP Hatchery Committee

From: Denny Snyder and Mark Miller

Re: 2011 Spawning Ground Surveys in the Okanogan and Methow Basins

The purpose of this memo is to provide information on the hatchery-supplemented natural spawning population of summer Chinook in the Methow and Okanogan basins. This work is part of a larger effort focused on monitoring and evaluating Chelan PUD's hatchery supplementation program. The tasks and objectives associated with implementing Chelan PUD's hatchery M&E plan for 2011 are outlined in several documents (Murdoch and Peven 2005; Peven 2006; Hays et al. 2006). Figures and tables are presented at the end of this memo.

METHODS

Spawning ground surveys were conducted by foot, raft, and aircraft beginning the last week of September and ending mid-November. During aerial surveys an observer recorded the location and number of redds on topographic maps. We did not use aerial surveys on the Methow River because past work has demonstrated that ground counts were more accurate than aerial surveys (Miller and Hillman 1997). Because of the depth of redds, aerial surveys were the only census method used for the Columbia River downstream from Wells (tailrace area only) and Chief Joseph dams. Ground surveys were used to provide more accurate counts and a complete census of Chinook redds within their spawning distribution. Observers floated through sampling reaches and recorded the location and numbers of redds each week. Observers recorded the date, water temperature, river mile, and constructed a drawing of the area where redds were located. A different symbol was used each week to record the number of new and incomplete redds.

To maintain consistency, at least one observer surveyed the same stream reach on successive dates. In areas where numerous summer Chinook spawn, we constructed detailed maps of the river and used the cell-area method (Hamilton and Bergersen 1984) to identify the number of redds within each cell. Cells were bound by noticeable landmarks along the banks (e.g., bridges or trees) or at stream habitat boundaries (e.g., transitions between pools and riffles). The number of redds were then recorded in the corresponding grid on the map. When possible, observers estimated the number of redds in a large disturbed area by counting females that defended their redds. We assumed that the area or territory defended by a female was one redd.

During redd surveys, we sampled carcasses of summer Chinook to describe the spawning population. Biological data included collection of scale samples for age analysis, length measurements (POH and FKL), gender, egg voidance, and a check for tags or marks. These data will be used to assess length-at-age, size-at-age, egg voidance, origin (hatchery or naturally produced), and stray rates. No DNA samples were collected on summer Chinook this year. Information on summer Chinook spawning in the Chelan River was collected by Chelan PUD and is presented in the results.

RESULTS

Methow

There were 941 summer Chinook redds counted within seven reaches of the Methow River (Table 1). One redd was counted in the Chewuch River this year. This was the sixth highest redd count observed in the last 21 years for the Methow River (Table 3). Spawning began the last week of September and peaked the second week of October and continued into the second week of November (Figure 1). Stream temperatures in the Methow River, when spawning began, varied from 7.0-10.0 °C. Peak spawning occurred in reaches (M2-M6) of the Methow River during the second week of October. The lowest reach (M1) had spawning throughout October with a slight peak the third week. Most redds (79%) were located in reaches (M1-M3) downstream from the town of Twisp and in reach (M5) between Methow Valley Irrigation Diversion (MVID) and Winthrop Bridge (Table 1). Few summer Chinook spawned (1%) upstream from the Winthrop Bridge in reaches M6 and M7. Estimated escapement based on redd counts and the sex-ratio observed at Wells Dam during broodstock collection suggests that 2,917 summer Chinook (941 redds x 3.1 fish/redd) escaped to the Methow River.

There were 559 summer Chinook salmon carcasses sampled within the seven reaches of the Methow River (Table 2). Nineteen percent of the fish returning to the Methow River were sampled based on the estimated escapement of 2,917 summer Chinook. Females made up 60% and males 40% of the carcasses examined. Mean percent egg voidance assessed from 335 female carcasses was 97%. Six females (2%) died before spawning (i.e., they retained all their eggs). Ad-clipped hatchery fish made up 48% and naturally produced fish (no ad-clip present) were 52% of the sample collected (Table 2). The distribution of ad-clipped hatchery and naturally produced fish showed that more than half (83%) of the ad-clipped hatchery fish were located in the lower three reaches while naturally produced fish were more evenly distributed with just over half (58%) in the lower three reaches (Figure 2).

Okanogan

There were 1,714 summer Chinook redds counted within six reaches of the Okanogan River (Table 1). This was the third highest redd count observed in the last 22 years for the Okanogan River (Table 3). Peak aerial redd counts (1,203 redds) were about 70 percent of redds counted from the ground. Spawning began the first week of October and continued into the first week of November (Figure 1). Spawning was initiated in the Okanogan River when the stream temperature varied from 12.0-14.0°C. Spawning activity ended after the first week of November (Table 1; Figure 1). Peak spawning in the Okanogan River occurred during the second week of October for reaches O5 and O6 with the lower reaches peaking the following week. Most redds (89%) were located in the upper reaches (O5 and O6) between Zosel Dam and the town of Riverside (Table 1). Estimated escapement (1,714 redds x 3.1 fish/redd) to the Okanogan River was 5,313 summer Chinook.

There were 909 summer Chinook salmon carcasses sampled within 6 reaches of the Okanogan River (Table 2). Seventeen percent of the fish returning to the Okanogan River were sampled based on the estimated escapement of 5,313 summer Chinook. Females made up 55% and males 45% of the carcasses examined. Mean percent egg voidance from 495 female carcasses was 99%. One female died before it spawned. Ad-clipped hatchery fish made up 34% and naturally produced fish 66% of the sample collected (Table 2). Most naturally produced (96%) and ad-clipped hatchery fish (86%) were collected in the upper reaches (O5 and O6) of the Okanogan River closely following the distribution of redds (Figure 2).

Similkameen

There were 1,409 summer Chinook redds counted within the two reaches of the Similkameen River (Table 1). This was the sixth highest redd count recorded in the Similkameen River in the last 23 years (Table 3). The peak aerial count (1,047 redds) was about 74% of redds counted on the ground. Spawning began the first week of October and peaked the second week in October (Figure 5). Spawning was initiated in the Similkameen River when the temperature varied from 12.0-14.0°C. Spawning activity ended by the first week of November (Table 1). Most (86%) spawning occurred in the lower reach from the Oroville Bridge, downstream to the Driscoll channel on the Similkameen River. Estimated escapement (1,409 redds x 3.1 fish/redd) to the Similkameen River was 4,368 summer Chinook.

There were 866 summer Chinook salmon carcasses sampled within the two reaches of the Similkameen River (Table 2). Twenty percent of the fish returning to the Similkameen River were sampled based on the estimated escapement of 4,368 summer Chinook. Females made up 75% and males 25% of the carcasses examined. Mean percent egg voidance from 649 female carcasses was 99%. No females died before spawning. Ad-clipped hatchery fish made up 72% and naturally produced fish 28% of the sample collected (Table 2).

Chelan River

Chelan County PUD biologists counted 413 redds in the Chelan River area. Spawning activity in the Chelan River began mid-October and peaked two weeks later (Table 1). Spawning ended the fourth week of November. The majority (82%) of spawning occurred in the Powerhouse tailrace and in the habitat channel (Table 1). Estimated escapement (413 redds x 3.1 fish/redd) to the Chelan River was 1,280 summer Chinook.

There were 162 summer Chinook carcasses sampled in the Chelan River area (Table 2). Thirteen percent of the summer Chinook returning to the Chelan River were sampled based on the estimated escapement of 1,280 fish. Females made up 82% and males 18% of the carcasses examined. The sample rate was likely higher for females than the males.

Mean percent egg voidance from 132 female carcasses was 83%. Nine females (7%) died before spawning. Ad-clipped hatchery fish made up 51% and naturally produced fish 49% of the sample collected.

Columbia River

Aerial surveys were used to count the number of redds in the Columbia River. The surveys were conducted downstream from Wells Dam and in Wells pool. The redd counts likely underestimate the true number of redds because peak aerial surveys only count visible old and new redds, spawning may occur in deep water, and some aerial surveys were affected by weather conditions. There were 90 Chinook redds counted in the Columbia River (Table 1). Estimated escapement (90 redds x 3.1 fish/redd) based on aerial surveys suggests that at least 279 Chinook spawned in the Columbia River.

Fifty-two redds were located downstream from Wells Dam in an area that has been documented before (Giorgi 1992). A radio telemetry study conducted in 2011on the movement and migration patterns of summer Chinook suggests that spawning also occurs upstream of Wells Dam in the Columbia River (R. Mann, Washington Department of Fish Wildlife, personnel communication). Many of the radio-tagged summer Chinook resided near the tailrace of Chief Joseph Dam along the right and left banks. An aerial survey in Wells pool located an estimated 38 redds downstream from Chief Joseph Dam between the town of Bridgeport and Foster Creek near the east bank. Observations in this area were difficult because distinct outlines of some redds were not readily apparent and most of the spawning occurred in a large single cluster. This is the second year that redds have been counted with aerial surveys at this location. A single snorkel survey was conducted in November in an effort to count redds in this area. This proved to be difficult due to the depth of redds so no estimate is provided.

There were 8 summer Chinook salmon carcasses sampled in the Columbia River below the town of Bridgeport (Table 2). Seven percent of the fish returning to the Columbia River in this area were sampled based on the estimated escapement of 118 summer Chinook. Females made up 37% and males 63% of the carcasses examined. This area was surveyed only one time for carcasses. Mean percent egg voidance from female carcasses was 100%. No females died before spawning. Ad-clipped hatchery fish made up 25% and naturally produced fish 75% of the sample collected (Table 2).

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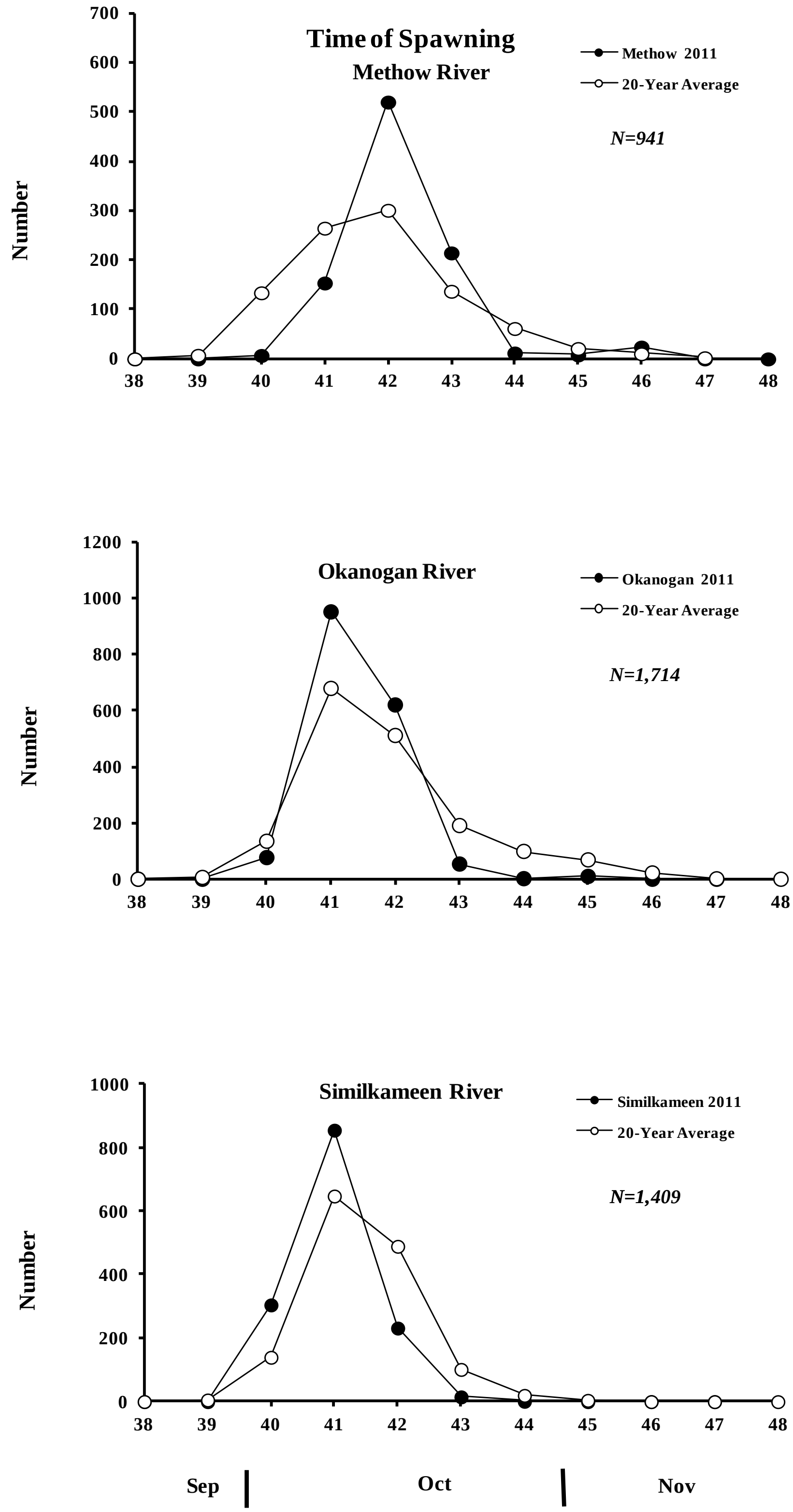


Figure 1. Number of new redds counted each week from mid-September to mid-November. The figure displays the beginning, peak, and end of spawning for summer Chinook in the Methow, Okanogan, and Similkameen rivers in 2011 compared to a 20-year average (1991-2010).

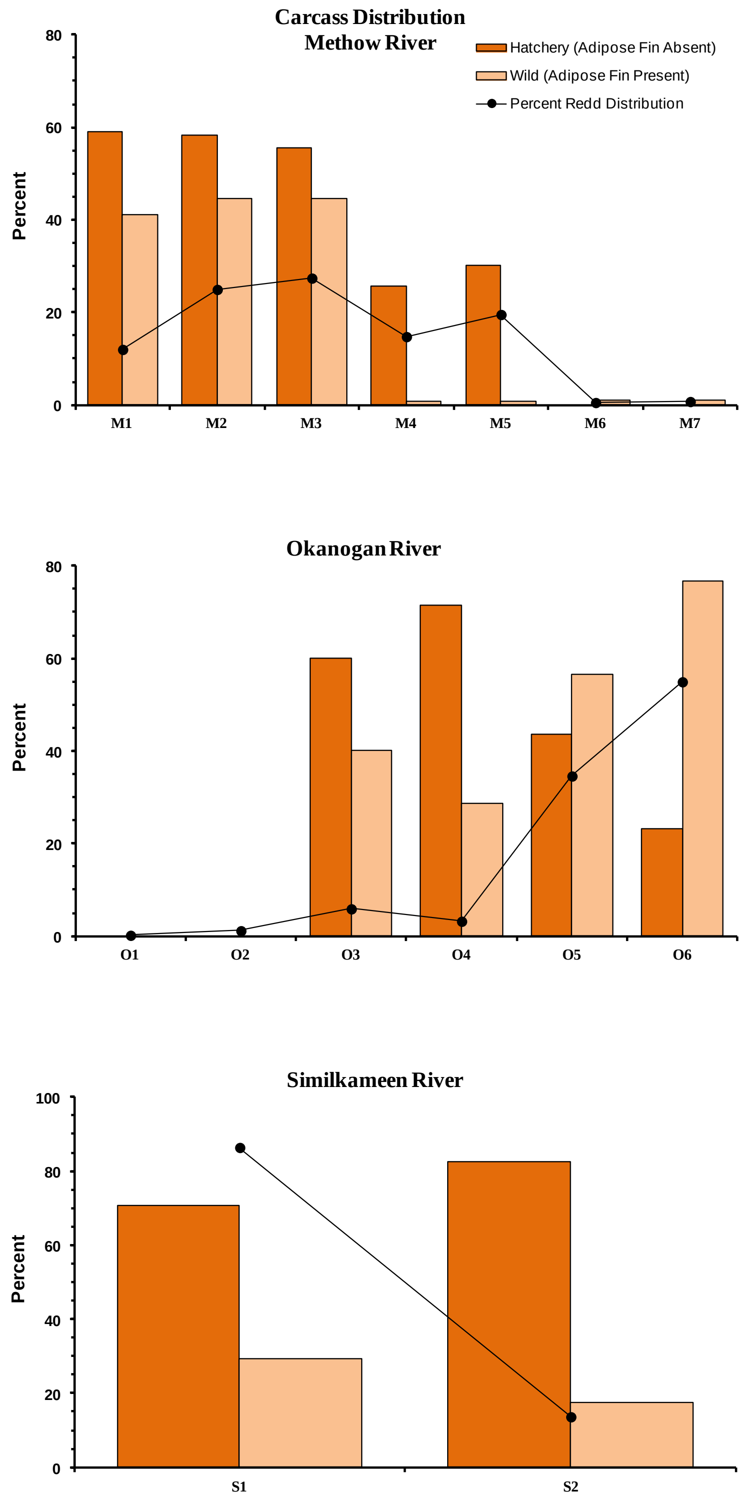


Figure 2. Percent distribution of ad-clipped hatchery and naturally produced fish plotted against the percent distribution of redds observed in reaches of the Methow, Okanogan, and Similkameen rivers, 2011.

Table 1. Number of summer Chinook redds observed each week within the Methow, Chewuch, Okanogan, Similkameen, Chelan, and Columbia rivers, 2011. Dashes indicate no survey occurred.

Reach	Location (Rkm)	Sep	Oct				Nov			Total	Percent
		24-1	2-8	9-15	16-22	23-29	30-5	6-12	13-19		
		39	40	41	42	43	44	45	46		
Methow River											
M1	0.0-25.0	0	2	31	56	0	0	24	-	**113**	**12**
M2	25.0-45.9	0	69	106	52	0	8	0	-	**235**	**25**
M3	45.9-63.6	3	42	141	60	12	0	0	-	**258**	**27**
M4	63.6-75.8	0	26	100	13	0	0	-	-	**139**	**15**
M5	75.8-84.2	0	13	140	31	0	0	-	-	**184**	**20**
M6	84.2-87.2	0	2	3	0	0	0	-	-	**5**	**1**
M7	87.2-90.2	4	0	0	3	0	-	-	-	**7**	**1**
Total		**7**	**154**	**521**	**215**	**12**	**8**	**24**	**0**	**941**	**100**
Okanogan River											
O1	0.0-27.2	0	0	0	1	1	0	1	-	**3**	**0**
O2	27.2-41.9	0	0	5	10	0	0	5	-	**20**	**1**
O3	41.9-49.4	0	0	45	45	9	2	0	-	**101**	**6**
O4	49.4-65.4	0	0	20	32	3	0	0	-	**55**	**3**
O5	65.4-91.4	0	29	337	210	13	0	4	-	**593**	**35**
O6	91.4-129.6	0	48	544	322	28	0	0	-	**942**	**55**
Total		**0**	**77**	**951**	**620**	**54**	**2**	**10**	**0**	**1714**	**100**
Similkameen River											
S1	0.0-2.9	0	277	729	197	13	1	0	-	**1217**	**86**
S2	2.9-9.1	0	28	127	35	2	0	0	-	**192**	**14**
Total		**0**	**305**	**856**	**232**	**15**	**1**	**0**	**0**	**1409**	**100**
Chelan River											
Powerhouse Tailrace		0	0	5	52	58	15	29	33[1]	**159**	**42**
Columbia R. Tailrace		0	0	3	16	13	7	5	4	**48**	**13**
Pool		0	0	5	16	5	1	1	0	**28**	**7**
Habitat Channel		0	0	6	38	48	38	8	7	**145**	**38**
Total		**0**	**0**	**19**	**122**	**124**	**61**	**43**	**11**	**380**	**100**
Columbia River (below Wells Dam and below Chief Joseph Dam)											
828.0-829.6		-	0	0	0	22	0	30	0	**52**	**100**
875.9-876.4		-	0	0	0	0	0	38	0	**38**	**100**
Total		**0**	**0**	**0**	**0**	**22**	**0**	**68**	**0**	**90**	**100**
Chewuch River											
0.0-9.8		0	0	1	-	-	-	-	-	**1**	**100**

[1] Two new redds were counted on 11/28. These two redds were added to week 46.

Table 2. Number and percent of hatchery (ad-clipped) and naturally produced (not ad-clipped) summer Chinook collected in Methow, Chelan, Columbia, Similkameen, and Okanogan rivers, 2011.

Reach	Location (Rkm)	Ad-Clipped Hatchery				Naturally Produced				Reach Total
		Male	Female	Total	Percent	Male	Female	Total	Percent	
Methow River										
M1	0.0-23.8	15	18	33	59	13	10	23	41	**56**
M2	23.8-43.8	40	38	78	58	27	29	56	42	**134**
M3	43.8-63.7	29	83	112	55	22	68	90	45	**202**
M4	63.7-72.3	8	12	20	26	34	24	58	74	**78**
M5	72.3-80.1	2	23	25	30	29	29	58	70	**83**
M6	80.1-83.0	0	0	0	0	5	0	5	100	**5**
M7	83.0-96.1	0	0	0	0	0	1	1	100	**1**
Total		**94**	**174**	**268**	**48**	**130**	**161**	**291**	**52**	**559**
Okanogan River										
O1	0.0-27.2	0	0	0	0	0	0	0	0	**0**
O2	27.2-42.0	0	0	0	0	0	0	0	0	**0**
O3	42.0-49.4	25	8	33	60	8	14	22	40	**55**
O4	49.4-65.5	9	1	10	71	3	1	4	29	**14**
O5	65.5-91.4	71	86	157	43	83	121	204	57	**361**
O6	91.4-124.6	66	45	111	23	149	219	368	77	**479**
Total		**171**	**140**	**311**	**34**	**243**	**355**	**598**	**66**	**909**
Similkameen River										
S1	0.0-2.9	130	401	531	71	80	141	221	29	**752**
S2	2.9-9.2	5	89	94	82	2	18	20	18	**114**
Total		**135**	**490**	**625**	**72**	**82**	**159**	**241**	**28**	**866**
Chelan River										
Chelan R.		15	67	82	51	14	66	80	49	**162**
Total		**15**	**67**	**82**	**51**	**14**	**66**	**80**	**49**	**162**
Columbia R. below Chief Joseph Dam										
Columbia R.		2	0	2	25	3	3	6	75	**8**
Total		**2**	**0**	**2**	**25**	**3**	**3**	**6**	**75**	**8**

Table 3. Historical aerial and ground redd counts of summer Chinook in the Methow, Okanogan, and Similkameen rivers, 1957-2011.

Year	Methow		Okanogan		Similkameen	
	Aerial	Ground	Aerial	Ground	Aerial	Ground
1956	109	--	37	--	30	--
1957	451	--	53	--	30	--
1958	335	--	94	--	31	--
1959	130	--	50	--	23	--
1960	194	--	29	--	--	--
1961	120	--	--	--	--	--
1962	678	--	--	--	17	--
1963	298	--	9	--	51	--
1964	795	--	112	--	67	--
1965	562	--	109	--	154	--
1966	1,275	--	389	--	77	--
1967	733	--	149	--	107	--
1968	659	--	232	--	83	--
1969	329	--	103	--	357	--
1970	705	--	656	--	210	--
1971	562	--	310	--	55	--
1972	325	--	182	--	64	--
1973	366	--	138	--	130	--
1974	223	--	112	--	201	--
1975	432	--	273	--	184	--
1976	191	--	107	--	139	--
1977	365	--	276	--	268	--
1978	507	--	195	--	268	--
1979	622	--	173	--	138	--
1980	345	--	118	--	172	--
1981	195	--	55	--	121	--
1982	142	--	23	--	56	--
1983	65	--	36	--	57	--
1984	162	--	235	--	301	--
1985	164	--	138	--	309	--
1986	169	--	197	--	300	--
1987	211	--	201	--	164	--
1988	123	--	113	--	191	--
1989	126	--	134	--	221	370
1990	229	--	88	47	94	147
1991	--	153	55	64	68	91
1992	--	107	35	53	48	57
1993	--	154	144	162	152	288
1994	--	310	372	375	463	777

Year	Methow		Okanogan		Similkameen	
	Aerial	Ground	Aerial	Ground	Aerial	Ground
1995	--	357	260	267	337	616
1996	--	181	100	116	252	419
1997	--	205	149	158	297	486
1998	--	225	75	88	238	276
1999	--	448	222	369	903	1,275
2000	--	500	384	549	549	993
2001	--	675	883	1,108	865	1,540
2002	--	2,013	1,958	2,667	2,000[a]	3,358
2003	--	1,624	1,099	1,035	103	378
2004	--	973	1,310	1,327	2,127	1,660
2005	--	874	1,084	1,611	1,111	1,423
2006	--	1,353	1,857	2,592	1,337	1,666
2007	--	620	1,265	1,301	523	707
2008	--	599	1,019	1,146	673	1,000
2009	--	692	1,109	1,672	907	1,298
2010	--	887	688	1,011	642	1,107
2011	--	941	1,203	1,714	1,047	1,409

APPENDIX P
2012 CHELAN FALLS SUMMER CHINOOK BROODSTOCK COLLECTION PILOT STUDY

STATE OF WASHINGTON
DEPARTMENT OF FISH AND WILDLIFE
FISH PROGRAM-SCIENCE DIVISION
SUPPLEMENTATION RESEARCH TEAM
3515 Chelan HWY. Wenatchee, WA 98801
Voice (509) 664-3148 Fax (509) 662-6606

November 14, 2012

To: Rock Island Habitat Conservation Plan Hatchery Committee

From: Chris Moran, WDFW

Subject: 2012 Chelan Falls Summer Chinook Broodstock Collection Pilot Study

Project Proposal

In mid-July, CCPUD began discussions with WDFW regarding the feasibility of conducting summer Chinook collections near the Chelan Falls Acclimation Facility. The goals were simply to see if we could collect hatchery fish there; with the long term goal of determining if we could establish hatchery broodstock collection efforts in the Chelan River area for the Chelan Falls summer Chinook program (formerly Turtle Rock). Since releases via net pens and circulars have occurred for the last 4 years, our efforts were also aimed at determining if the Chinook that could be collected were from Chelan Falls summer Chinook releases.

Collection Methods

Methods identified for this effort were:

- Beach Seines
- Fyke Nets
- Tangle Nets
- Hook and Line
- Purse Seine

Due to limitations associated with time constraints, coordinating site access, and gear acquisition the following methods were utilized:

- Tangle Netting
- Hook and Line
- Eastbank Outfall (EBO)

Tangle nets were used on September 24th and October 3rd. Nets were set at dusk and retrieved the following morning. Based on observations of approximately 75 Chinook swimming around the powerhouse area in late August, we attached a 60' tangle net to the "no trespassing" float line, parallel to shore, in 25-30' of water on September 24th. Attaching the net parallel to shore was intended to avoid a situation where the net became overloaded with fish. An alternative site was chosen for our October 3rd set since larger schools of fish were no longer observed in the powerhouse area. Several fish were observed surfacing near the attraction waters of the Chelan Falls Acclimation Facility outfall pipe. Based on this, we set a 100' tangle net diagonally downstream attached to the middle portion of the net pens to a small tree on the opposite bank.

On September 21st we conducted 3 hours of hook and line fishing with three rods in the water utilizing various types of recreational gear. We troll fished in the Columbia River, in the area between the confluence of the Chelan and Columbia Rivers to the Highway 97 Bridge, in waters 25'-110' in depth.

In the process of sorting out logistics for the project, the EBO was identified as a potential collection site. Prior to being able to sample with other gear types in the Chelan River area, we tested a small seine in the EBO on August 28th with promising results. We conducted two more collection events at the EBO on September 11th and October 3rd based on these initial findings.

Results

On September 11th, we caught a total of 2 mini-jack summer Chinook with hook and line gear. Recovered CWT codes revealed that these fish were 2010 broodyear (BY) Wenatchee summer Chinook released from Dryden Pond earlier this spring.

At the EBO on September 11th, 21st, and October 3rd we caught 56, 74, and 44 summer Chinook respectively (Table 1). Of the 122 heads sampled, we were able to read 114 CWT's and determined that the majority of them came from the 2008 BY Turtle Rock, and Chelan Net Pen releases (Figure 1). There were 21 fish that were identified as Wenatchee River releases. One Chiwawa spring Chinook was found as well as one Similkameen (Okanogan) summer Chinook. The only fish found that did not spend some portion of its life history at the Eastbank Hatchery was a fish released from the Wells Hatchery summer Chinook programs. The vast majority of fish captured in the EBO were males; only 18 fish were female (Figure 2). The age classes of these fish were comprised mainly of age 4 fish (2008 BY) with several age three fish as well (Figure 4). We did capture and release 3 ad-present Chinook and one ad-present hatchery coho (CWT present).

Table 1. Results of collection attempts by date and method (*tangle net hours are "wet net" hours not man hours).

Date	Method	Hours	# of staff	Total Hours	# of Chinook	Fish/hr
28-Aug	EBO	1.50	8	12.00	56	4.67
11-Sep	EBO	1.00	8	8.00	74	9.25
21-Sep	H+L	3.00	3	9.00	2	0.22
24/25-Sep	Tangle Net	13.00	2	13.00*	0	0.00
03-Oct	EBO	0.75	8	6.00	44	7.33
03/04-Oct	Tangle Net	14.00	3	14.00*	4	0.29

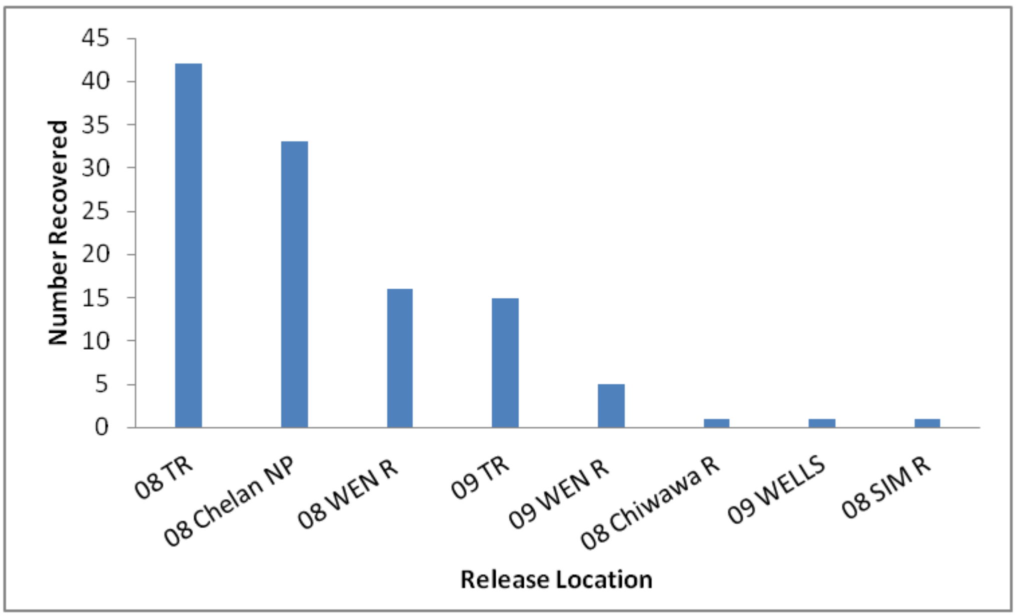


Figure 1. Total number of Chinook by broodyear and release location based on CWT recoveries from EBO.

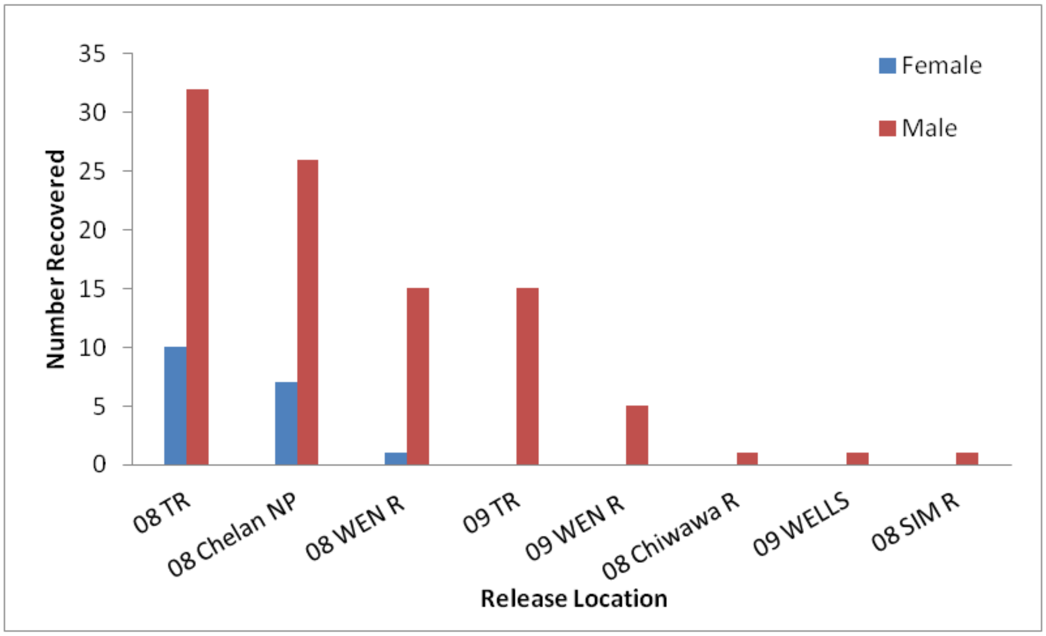


Figure 2. Total number of male and female Chinook by broodyear and release location based on CWT recoveries from EBO.

We did not capture any fish in our tangle nets on our September 24th/25th set. Our October 3rd/4th set captured 4 summer Chinook; 2 were ad-present and released alive, the other 2 were hatchery origin. CWT codes from these fish revealed ’07 and ’08 BY Rocky Reach and Turtle Rock releases (Figure 3).

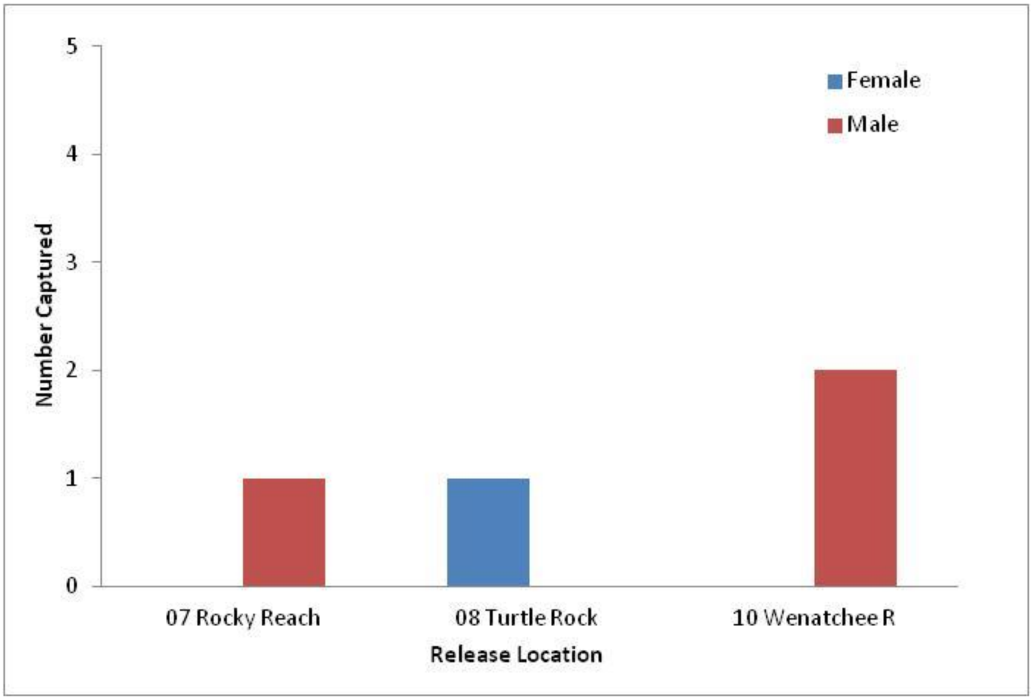


Figure 3. Origin and sex of summer Chinook captured via Tangle Nets and Hook and Line.

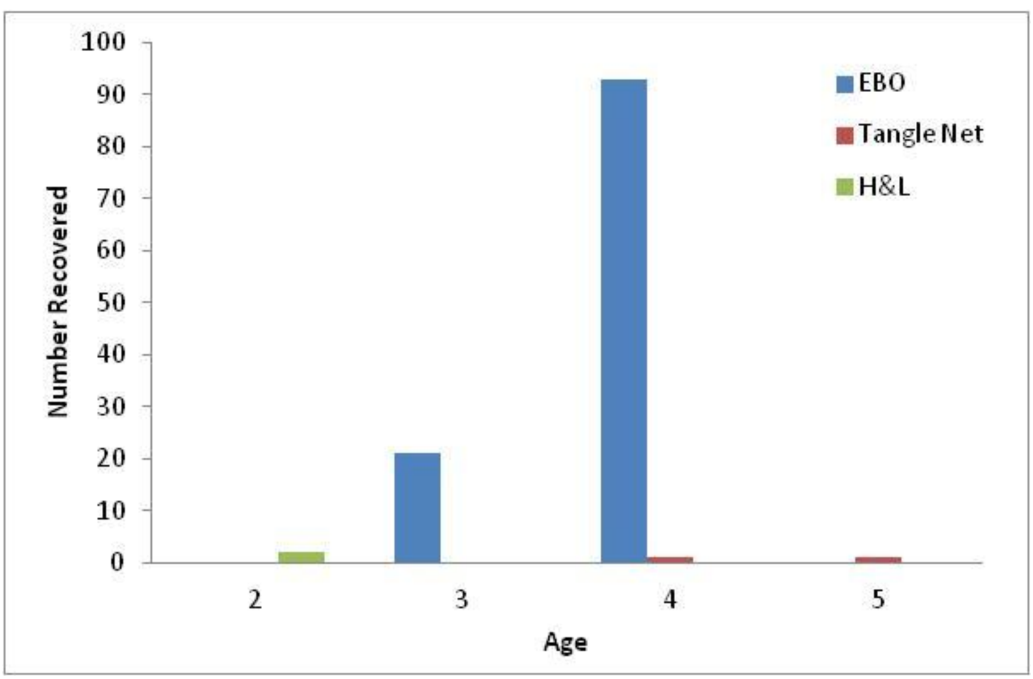


Figure 4. Age class of summer Chinook collected for the Chelan Falls Pilot Study by gear type based on CWT recoveries.

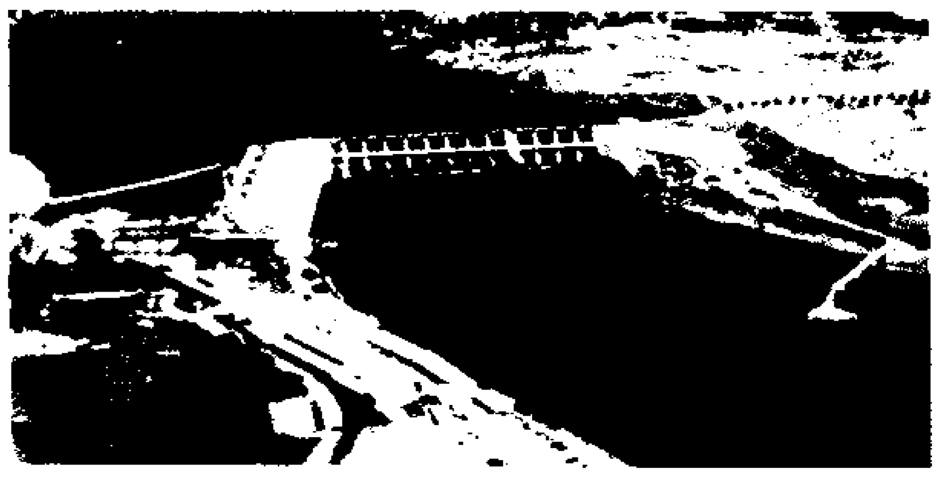
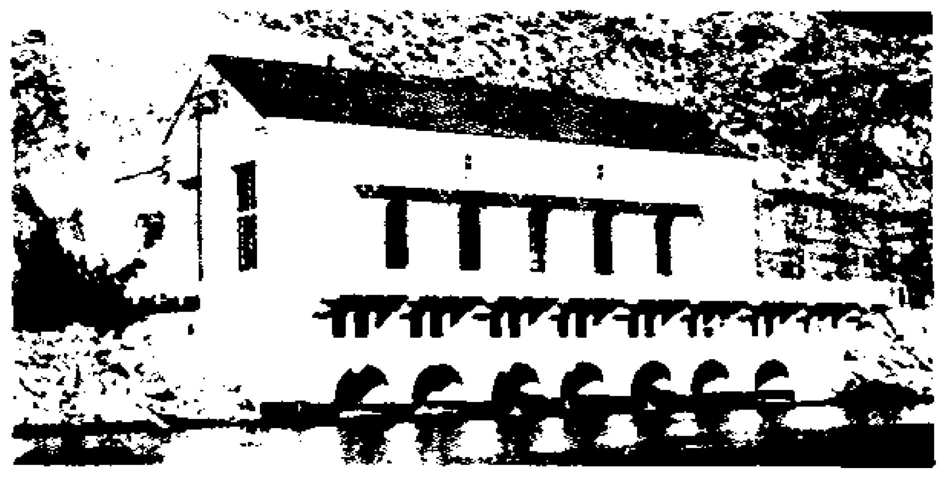
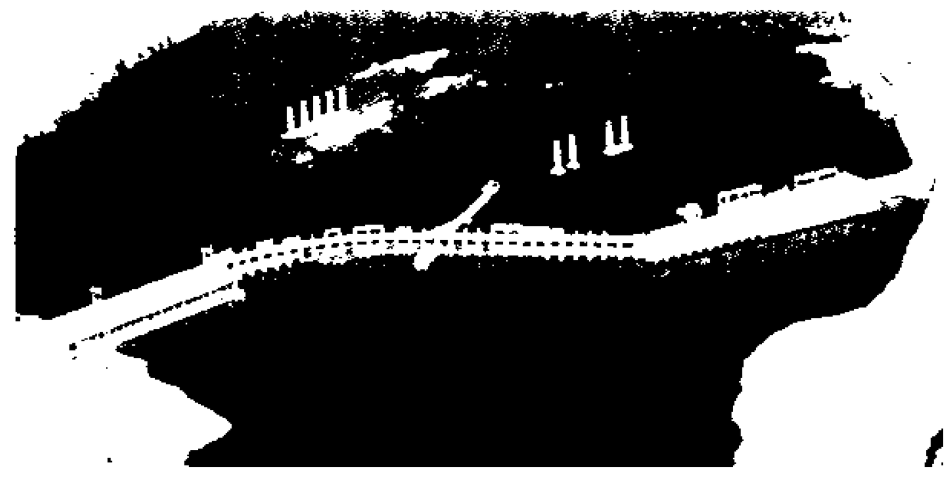
Conclusions

Netting adult broodstock in the Chelan River when river temperatures can be 70 degrees Fahrenheit is more stressful for fish as fish are actively stressed while being netted, sampled, and transported to the Eastbank Hatchery in comparison to alternative options. Additionally, netting would require substantially more man hours to accomplish, would be costly in the long run due to increased hours and travel times involved, and is more dangerous to staff than an adult return rack would be. Although collection attempts in the Chelan River were not extensive or conclusive, results from this year's sampling clearly point to an alternative collection method that is suitable for the Chelan Falls summer Chinook program.

Based on our limited results this year, we feel confident that the EBO could provide all of our broodstock needs for the Chelan Falls summer Chinook program. Minimal improvements to the EBO would need to be made to ensure fish passage for collecting a full summer Chinook program. Along with the EBO being an effective collection site that minimizes costs, we would also have the ability to surplus excess hatchery fish to food programs, tribal parties, or nutrient enhancement programs. In addition to efficient broodstock collection and surplusing options, we could minimize the stray rate of hatchery fish released from the Eastbank Hatchery Complex. Strays found in the EBO could be included in the Chelan Falls summer Chinook broodstock or surplused as described above. Hatchery staff could operate and run the trap daily to guarantee minimal holding time of fish, and quickly transport broodstock to the adult ponds at Eastbank, which are adjacent to the outfall itself.

To further assess the viability of the EBO as an acceptable location to collect broodstock it is recommended that collections/sampling occur the beginning of July 2013 to mimic regular broodstock collection programs. Earlier start dates would most likely increase capture rates of female summer Chinook and may provide more robust encounter rates for spring Chinook and likely steelhead as well. The Volunteer Channel at Wells Hatchery could still be utilized as a backup location to collect fish if need be. With minor improvements to the EBO the entire Chelan Falls summer Chinook program could be captured right at Eastbank by a more fish friendly, safe, and economical method.

APPENDIX Q
ROCKY REACH HYDRO PROJECT HABITAT CONSERVATION PLAN 2012 ANNUAL FINANCIAL REPORT, PLAN SPECIES ACCOUNT

MEMORANDUM

DATE: January 18, 2013

TO: Becky Gallaher, Natural Resources Contract Coordinator
Keith Truscott, Director - Natural Resources

FROM: Debbie Litchfield, Treasurer/Director – Treasury

RE: Rocky Reach Hydro Project Habitat Conservation Plan
2012 Annual Financial Report, Plan Species Account

In accordance with Section 7.4.3 of the Rocky Reach Habitat Conservation Plan attached is the 2012 year end annual financial report of the Plan Species Account activity completed by Chelan County Public Utility District No. 1.

Chelan County PUD
Rocky Reach Hydroelectric Project
Habitat Conservation Plan
Plan Species Cash Account Activity
Annual Financial Report Per Section 7.4.3
Reporting Period: 1/1/2012 - 12/31/2012

CHELAN COUNTY POWER

Beginning Balance:	**1/1/2012**		**$ 1,905,051.82**
Transfers In:			
Rocky Reach Funding		338,959.00	
Interest Earnings		4,617.04	
Total Transfers In			343,576.04
Transfers Out:			
Payments		(185,535.38)	
Bank Service Fees		(85.95)	
Total Transfers Out			(185,621.33)
Ending Balance:	**12/31/2012**		**$ 2,063,006.53**

The Plan Species Account was established per the Rocky Reach Habitat Conservation Plan, Section 7.4. Interest earnings shall remain in the Account in accordance with Appendix E, Section 7.4.1.