Literature Review of White Sturgeon Ecological Interactions

Lance Keller and Steve Hemstrom
Chelan County PUD

The Rocky Reach Fish Forum (RRFF) and Priest Rapids Fish Forum Policy Representatives met on November 6, 2015 to discuss issues surrounding future releases of juvenile white sturgeon into Chelan and Grant PUD's project areas. One of the assignments given by the policy representatives to the technical representatives was to examine available literature (both published and unpublished) and compile a summary of examples of potential ecological interactions between white sturgeon and other resident or anadromous fish species. Additionally, the RRFF met on December 2, 2015 and the technical members agreed that scope of the literature review should also include information on potential ecological interactions, specifically predator-prey, prey base, and competition, from stocking an apex fish predator into an aquatic system. The summary of literature below is Chelan PUD's effort to complete this assignment. The 25 papers summarized below are available to the RRFF and Policy Committees' representatives for review upon request.

Status of White Sturgeon in the Lower Fraser River, British Columbia

In an effort to assist white sturgeon *Acipenser transmountanus* recovery in the lower Fraser River in British Columbia, a stewardship-based monitoring and assessment program was developed by the Fraser River Sturgeon Conservation Society. Trained volunteers collect data on marked and recaptured individuals, with the data being applied to a descriptive population model that estimates population based on size/age group and location. Results as of January 2011 show that abundance decreases have been greatest for juvenile sturgeon under 100 cm fork length. Recruitment decline could be contributed several factors, including destruction of important spawning and early life history rearing habitat, fewer successful spawners due to in-river fisheries, and/or impacts of reduced food supply and ecological imbalances on both early life and adult stages.

Citation:

Nelson, T. C., W. J. Gazey, K. K. English, and M. L. Rosenau. 2013. Status of white sturgeon in the lower Fraser River, British Columbia. Fisheries 38:5 197-209

Diet of First-Feeding Larval and Young-of-the-Year White Sturgeon in the Lower Columbia River

Diet composition of 352 larval and young-of-the-year (15-290 mm in length) white sturgeon *Acipenser transmontanus* were collected from below Bonneville Dam and upstream of the dam in the Bonneville and The Dalles Reservoirs to examine if prey availability during the period when white sturgeon larvae begin exogenous feeding could explain difference in larval survival and recruitment below Bonneville Dam but not above. Fish were collected via trawls, and fish that were collected were preserved in formaldehyde. Fish stomachs were later surgically removed and examined. *Corophium* spp. (freshwater amphipod) were the dominant prey consumed in both the free-flowing and impounded sections of the Columbia River, with the length of *Corophium* spp. eaten by larvae and young –of-the-year sturgeon increasing as sturgeon length increased. Other species found in diets were copepods, Ceratopogonidae larvae, and diptera pupae and larvae, especially at the onset of exogenous feeding. No evidence of larval starvation was found.

Citation:

Muir, W. D., G. T. McCabe Jr., M. J. Parsley, and S. A. Hinton. 2000. Diet of first-feeding larval and young-of-the-year white sturgeon in the lower Columbia River. Northwest Science 74:1 25-33.

Feeding Ecology of Juvenile White Sturgeon (A*cipenser transmontanus)* in the Lower Columbia River.

The feeding ecology of juvenile white sturgeon *Acipenser* transmontanus were examined from April through October 1988 below Bonneville Dam. Juvenile were collected utilizing a semiballoon shrimp trawl at eight sample location between river kilometers 46 and 211. Juveniles captured were divided into two size classes: I (144 to 350 mm fork length) and II (351 to 724 mm fork length). Stomachs were removed upon capture and preserved in formaldehyde. Contents were later identified, counted, and weighed. Benthic macroinvertebrates were also surveyed at each of the eight sample locations. A total of 292 stomachs were examined, with the amphipod *C. salmonis* being most abundant, and more abundant in size class I fish than size class II fish. Other prey found size class I fish included *Corophium spinicome, Neomysis* sp., Chironomidae larvae, and eulachon (*Thaleichthys pacificus*) eggs. Other prey found in size class II fish included bivalve *Coricula fluminea, Corophium spinicorne,* Chironomidae larvae, and eulachon eggs. An index of feeding analysis showed that areas containing juvenile sturgeon contained less food in September-October when compared to May-June or July-August. Even though *C. salmonis* was most abundant in stomach contents, it was not abundant in the benthos collections.

Citation:

McCabe Jr., G. T., R. L. Emmett, and S. A., Hinton. 1993. Feeding ecology of juvenile white sturgeon (*Acipenser transmontanus*) in the lower Columbia River. Northwest Science 67:3 170-180.

Effects of Turbidity, Light Level, and Cover on Predation of White Sturgeon Larvae by Prickly Sculpins

Experimental in-lab trials were conducted to examine the effects of turbidity, light levels, and substrate may affect predation on white sturgeon larvae by prickly sculpin *Cottus asper*. Significantly higher levels of white sturgeon larvae were eater at lower turbidity levels, although some larvae were preyed upon at the highest turbidity levels tested. Reduced use of cover was observed as larval size increased, most likely due to the onset of exogenous feeding, increasing foraging behavior. Lowest predation rates were observed with trials the combined the lowest light levels, cover, and smaller larvae. These results suggest that altered river conditions caused by impoundment and other factors (water velocity, habitat alteration) have increased predation on white sturgeon larvae.

Citation:

Gadomski, D. M., and M. J. Parsley. 2005. Effects of turbidity, light level, and cover on predation of white sturgeon larvae by prickly sculpins. Transactions of the American Fisheries Society 134:369-374.

First Record of Predation on White Sturgeon Eggs by Sympatric Fishes

Stomach contents from northern pikeminnow, largescale sucker, prickly sculpin, and common carp were examined for the presence of white sturgeon eggs below The Dalles, John Day, and McNary Dams via bottom trawls and boat electroshockers. Stomachs were removed and white sturgeon eggs were identified and counted. Forty fish were collected (4 northern pikeminnow, 30 largescale sucker, 3 prickly sculpin, and 3 common carp), and seven stomachs were found to contain eggs. Six stomaches contained fewer than 10 eggs each, while one largescale sucker stomach contained at least 70 eggs.

Citation:

Miller, A. I., and L. G. Beckman. 1996. First record of predation on white sturgeon eggs by sympatric fishes. National Biological Service. Cook, Washington.

Laboratory Studies on the Vulnerability of Young White Sturgeon to Predation

White sturgeon ranging from newly hatched larvae to roughly 170 mm total length were exposed to predatory fish (channel catfish *Ictalurus punctatus*, norther pikeminnow *Ptychocheilus oregonensis*, walleye *Sander vitreus*, and prickly sculpin *Cottus asper*) in a laboratory setting. Larger channel catfish (mean total length = 464 mm) and northern pikeminnow (meant total length = 472) ate white sturgeon up to 121 and 134 mm total length, respectively. Similar size walleye consumed almost no white sturgeon, while juvenile walleye (meal total length = 184) ate white sturgeon up to a mean total length of 59 mm total length. Prickly sculpin (mean total length = 126) consumed white sturgeon up to a mean total length of 50 mm. Results show that predation is a likely cause of mortality of age-0 white sturgeon and could be contributing to year-class failures, but could be mitigated for in a stocking program by releasing fish reared to a larger size.

Citation:

Gadomski, D. M., and M. J. Parsley. 2005. Laboratory studies on the vulnerability of young white sturgeon to predation. North American Journal of Fisheries Management 25:667-674.

Columbia River White Sturgeon Genetics and Early Life History

A laboratory study found that sturgeon utilize a variety of feeding mechanisms and can adapt to different feeding mechanisms. Fry movement towards a food source were shown to be initiated by an olfactory cue, and white sturgeon tested that were 225 mm were shown to use olfactory cues to detect buried live chinook eggs up to 10 mm deep below the surface and rainbow trout fry buried up to 20 mm below the surface. Sturgeon also responded to buried metal objects and wires, suggesting that they also cue in on a live prey's weak electrical field. Sturgeon were also more successful predating upon chinook fry in darker environments and when turbulence was increased around the prey.

Citation:

Brannon, E., A. Setter, J. Altick, and M. Miller. 1987. Columbia River white sturgeon genetics and early life history. BPA Report DOE/BP – 18952-3.

The Committee of the Status of Endangered Wildlife in Canada Assessment and Update Status Report on the White Sturgeon *Acipenser transmontanus* in Canada.

White sturgeon consume a variety of organisms and benthic invertebrates such as crayfish, shrimp, and clams to fish such as lamprey, salmon, eulachon, and smelt. Smaller sturgeon prey on smaller invertebrates, while larger fish prey on mainly fish, both live and dead. In Canada, prey reduction through the loss of anadromous salmon runs and the reduction of downstream nutrient transport has altered the prey availability of native fishes and invertebrates, effecting all life-history stages of white sturgeon.

Citation:

Ptolemy, J., and R. Vennesland. 2004. COSEWIC assessment and update status report of the white sturgeon *Acipenser transmontanus*. Report written for COSEWIC Secretarial, Ottowa, ON.

Upper Columbia White Sturgeon Recovery Plan

The diet of white sturgeon can vary, with fish taking advantage of seasonally available prey items. White sturgeon are primarily benthic feeders of invertebrates and fish, and have been observed actively chasing prey in the water column. Prey items for juvenile white sturgeon include amphipods, isopods, mysids, clams, snails, small fish and fish eggs, while larger white sturgeon feed more on fish including euchalon, anchovy, shad, lamprey, pacific herring, and adult salmon (when/where available). In the lower Columbia River, eulachon are consumed in large numbers in the winter, adult shad and lamprey in the spring and early summer, and salmon when present.

The fish community of the Canadian portion of the Columbia River has been altered since impoundment, with the early fish community being comprised of anadromous salmon and steelhead and pacific lamprey, bull trout, westslope cutthroat trout, and redband trout. The elimination/reduction of the above mentioned species, along with the addition of exotic species such as walleye and smallmouth bass has altered the historical predator prey species abundance.

While adult sturgeon are not known to have any predators in fresh water besides man, juvenile sturgeon eggs, larvae, and juveniles are preys upon by rainbow trout, northern pikeminnow, suckers, and walleye.

Citation:

Upper Columbia White Sturgeon Recovery Plan. 2002

Columbia Basin White Sturgeon Planning Framework

The adult white sturgeon diet has been found to be divers and high in fish content, and illustrates that they likely compete with other piscivorous fishes for food and overwintering habitat with species such as adult bull trout, burbot, northern pikeminnow, and prickly sculpin. Juvenile sturgeon could compete in the same manner with kokanee, whitefish, rainbow trout, burbot, peamoth, suckers, and redside shiners. Intraspecific competition and density-dependent effect on population dynamics are likely to be much more important for white sturgeon than interspecific competition. The potential for intraspecific competition between juvenile and adult is limited by diet shifts, with larger fish taking advantage of their ability to target larger prey including adult lamprey, shad, and salmon.

Citation:

Columbia basin white sturgeon planning framework. 2013. Prepared by CRITFC. WDFW, and ODFW for the Northwest Power and Conservation Council. R. Beamesderfer and P. Anders editors. 285 pp.

Characterization of Adult Pacific Lamprey Swimming Behavior in Relation of Environmental Conditions within Large-Dam Fishways

Pacific lamprey passage was analyzed at Bonneville and John Day dams to indentify potential mechanisms that influence passage in lower fishway sections. Behavior in the Bonneville Dam transition area was found to be influenced by poor attraction flow and the presence of predatory white sturgeon. High white sturgeon densities were also observed in the transition area of the fishway.

Citation:

Kirk, M. A., C. C. Caudill, E. L. Johnson, M. L. Keefer, and T. S. Clabough. 2015. Characterization of adult pacific lamprey swimming behavior in relation to environmental conditions within large-dam fishways. Transactions of the American Fisheries Society 11:5 998-1012.

Juvenile Pallid Sturgeon and Piscivorous: A Call for Conserving Native Cyprinids

Abstract:

We examined the diets of age-6 and age-7 hatchery-reared juvenile pallid sturgeon Scaphirhynchus albus (mean fork length [FL] = 538 ± 13 mm [90% confidence interval]; mean weight = 518 ± 49 g) and indigenous shovelnose sturgeon S. platorynchus (mean FL = 525 ± 12 mm; mean weight = 683 ± 41 g) sampled in 2003 and 2004 from the Missouri River above Fort Peck Reservoir, Montana. Diet overlap between juvenile pallid sturgeon and shovelnose sturgeon

was low. Fish were the primary prey of juvenile pallid sturgeon, and aquatic insects were the primary prey of shovelnose sturgeon. Sturgeon chub Macrhybopsis gelida and sicklefin chub M. meeki, two species that have declined throughout much of the Missouri River, comprised 79% of the number of identifiable fish in juvenile pallid sturgeon stomachs. The prevalence of sicklefin chub and sturgeon chub as a food resource of juvenile pallid sturgeon indicates that recovery and management of native cyprinids is a potentially important step in the recovery of pallid sturgeon.

Citation:

Gerrity, P. C., and C. S. Guy. 2006. Juvenile pallid sturgeon are piscivorous: a call for conserving native cyprinids. Transactions of the American Fisheries Society 135:304-609

Distribution of Gulf of Mexico Sturgeon in Relation to Benthic Invertebrate Prey Resources and Environmental Parameters in the Suwannee River Estuary, Florida

Abstract:

The distribution of Gulf of Mexico Sturgeon *Acipenser oxyrinchus desotoi* (Gulf sturgeon) in the Suwannee River estuary, Florida, was examined relative to the distribution of benthic invertebrate prey and environmental variable (salinity, temperature, dissolved oxygen, and sediment type) to determine potential foraging areas within the estuary. Eighteen Gulf Sturgeon (1,279-2,010 mm total length, 15.25-53.25 kg) were captured at the mouth of the Suwannee River during their spring upriver migration in 2001 and surgically implanted with ultrasonic tags. These sturgeon were subsequently tracked as they migrated seaward out of the Suwannee River and into the estuary in fall 2001 and as they returned to the estuary in spring 2002 to migrate upriver again. Invertebrates and sediment type were identified in diver-collected cores from the Suwannee River estuary during spring 2002. Thirteen of the 18 tagged Gulf sturgeon were relocated in the Suwannee River estuary. Eight were located from early November through mid-December 2001 (fall seaward migration). Gulf sturgeon during fall 2001 and spring 2002 were associated with area composed mostly of sand that contained high abundances of known benthic prey, primarily the brachiopod *Glottidia pyramidata* and, secondarily, amphipods *Ampelisca* spp. And brittle stars (Amphiuridae and Ophiactidae). Canonical correspondence analysis and examination of temperature and salinity at relocation positions of Gulf sturgeon during the fall 2001 and spring 2002 suggest differential use of the Suwannee River estuary during the two seasons. Compared with fall, sturgeon in the spring were found closer inshore, where the water was less saline and warmer, and they were concentrated in areas with greater abundance of their primary prey, brachiopods. Specific areas within the Suwannee River estuary therefore appear to be potential spring foraging habitats for threatened Gulf sturgeon.

Citation:

Harris, J. E., D. C. Parkyn, and D. J. Murie. 2005. Distribution of Guld of Mexico Sturgeon in Relation to Bnethic Invertebrate Prey Resources and Environmental Parameters in the Suwannee River Estuary, Florida. Transactions of the American Fishery Society 134:4, 975-990

Feeding Ecology of Juvenile Lake Sturgeon in the St. Lawrence River System

Results from two different dietary sampling efforts of juvenile lake sturgeon *Acipenser fulvescens* in the St. Lawrence River system. Stomach contents were either recovered by gastric lavage or stomach collection via lethal take. Results show that diets consisted of annelids, crustaceans, larval insects, mollusks, and vertebrates (fish and fish eggs). Of the 74 invertebrate prey taxa identified, roughly 50 occurred in more than 5% of the stomach contents. Overall, the most abundant prey ites included malacostracans (mostly amphipods), aquatic insect larvae, mollusks, and annelids (mostly oligochaetes).Results confirmed that juvenile lake sturgeon are generalists and opportunistic benthic feeders, their diet composition is only partly determined by benthos availability, and suggests that there is positive selection for drifting prey.

Citation:

Nilo, P., S. Tremblay, A. Bolon, J. Dodson, P. Dumont, and R. Fortin. 2006. Feeding ecology of juvenile lake sturgeon in the St. Lawrence River system. Transactions of the American Fisheries Society 135:4, 1044-1055

A Gastric Lavage Technique for Characterizing Diets of Sturgeons

Stomach contents from 48 juvenie shortnose sturgeon *Acipenser Oxyrinchus* and 23 juvenile Atlantic sturgeon *A. brevirostrum* in the Hudson River estuary. Major prey items retrieved from shortnose sturgeon stomachs were soft body invertebrates (amphipods, chironomids, and isopods) and shelled organisms (zebra mussels and snails). Polychaetes, isopods, and amphipods were the primary contents retrieved from Atlantic Sturgeon.

Citation:

Haley, N. 1998. A gastric lavage technique for characterizing diets of sturgeons. North American Journal of Fisheries Management 18:4 978-981

Quantifying Latent Impacts of an Introduced Piscivore: Pulsed Predatory Inertia of Lake Trout and Decline of Kokanee

Abstract:

Introduced long-lived predators often cause significant impacts on their prey, but these impacts can be masked from detection due to high “predatory inertia”: time lags in population growth and dietary ontogeny. We evaluated whether predation by introduced lake trout *Salvelinus namaycush* could explain the 88% decline in escapement of kokanee *Oncorhynchus nerka* during 2005–2009 in Lake Chelan, Washington. We quantified the strength and trend of predation impacts with field sampling, a hydroacoustic assessment of kokanee production, and bioenergetics and age-structured population models of lake trout. Lake trout consumption of kokanee exceeded kokanee production, indicating strong predation impacts at the start of the decline. Fully piscivorous lake trout (>550 mm fork length) were responsible for 83% of this predation. The population model predicted that a pulse of strong stocked cohorts crossed this piscivorous size threshold, causing the biomass of fully piscivorous lake trout to expand by roughly 70–300% during 2004–2009 and driving predation pressure to peak levels. Together, these results suggested that lake trout predation was a large and growing source of kokanee mortality during the decline. Counter-intuitively, predation pressure was projected to increase even if the numbers of harvestable lake trout declined, as strong cohorts grew to piscivorous size while succumbing to mortality. Angler catch rates of lake trout declined by 40% during 2004–

2007, as was predicted by the population model; this decline in catch masked the rise in predation pressure. This analysis demonstrates the potential for introduced predators exhibiting high predatory inertia to cause strong, latent impacts on prey that would be unexpected based on harvest trends and prior dynamics alone. Forward-looking monitoring and modeling analyses are clearly advantageous for managers who seek to maintain ecosystems in long-term "balance" by detecting and reversing incipient changes in predation.

Citation:

Schoen, E. R., D. A. Beauchamp, and N. C. Overman. 2012. Quantifying latent impacts of an introduced piscivore: pulsed predatory inertia of lake trout and decline of kokanee

Selecting Harvest Regulations for Recreational Fisheries: Opportunities for Research and Management Cooperation

Using growth rates of lake trout in similar Colorado reservoirs (Weiler 1982), Lake Granby water temperatures (Martinez 1994), and knowledge of the ontogeny of lake trout feeding habits (Rieman and Myers 1991; Yule and Luecke 1993) we asked, How much prey will a single lake trout consume while it is protected by various length limits? When we looked at the Granby lake trout regulations using this bioenergetics approach, we found that the slot regulations could actually affect the predation exerted by lake trout on kokanee and other prey fishes in the system. Predicted per capita consumption increased from 9 kg for a lake trout growing 0-20 in to 49 kg as for a trout growing 26-36 in (Fig. 2). Population-level consumption estimates under various regulations may not be as striking because even under protection, natural mortality reduces the abundance of the largest lake trout size classes; hence, their overall consumption may be lower than that for more abundant, smaller size classes. Compensatory declines in growth also may occur, and that would increase the amount of prey required to grow through a given predator size. However, striking differences in per capita analysis are cause for concern and show the dire need for more detailed demographic and ecological data on this fishery.

Citation:

Brett M. Johnson & Patrick J. Martinez. (1995). Selecting Harvest Regulations for Recreational Fisheries: Opportunities for Research/Management Cooperation, Fisheries, 20:10, 22-29.

Counterintuitive Responses of Fish Populations to Management Actions

In an effort to measure behavioral responses vs. direct predation effects in a system populated with minnows (prey species) but not a predator/piscivore (northern pike), a lake was divided in half with a fence spanning shore to shore and surface to bottom that would allow the prey to freely move throughout the entire lake, but would confine a predator. Adult northern pike were introduced to the lake on one side of the fence gradually over the duration of a summer, and both sides of the fence were monitored for prey response. Responses were documented as both more rapid and greater than expected, as prey fish not only left the side of the lake populated with pike, but most of the fish emigrated out of the lake via an outlet stream. While some pike were successful in preying on minnows, emigration accounted for 50-90% of the total change in biomass. These result were not predicted models or conventional wisdom of the time.

Citation:

William E. Pine III , Steven J. D. Martell , Carl J. Walters & James F. Kitchell (2009) Counterintuitive Responses of Fish Populations to Management Actions, Fisheries, 34:4, 165-180.

Changes in the Salmonine Community of Lake Michigan and Their Implications for Predator-Prey Balance

Stock assessment methods and bioenergetics calculations were used to assess historical changes in abundance and consumptive demand of a hatchery-supported salmon community in Lake Michigan and ultimately examine the lake's predator-prey balance. With Chinook salmon *Oncorhynchus tshawytscha* being the most dominant salmon predator in the lake, the analysis found density dependent changes in growth, survival, production levels, consumptive demand, and fishery characteristics suggesting that an increase abundance of salmon has led to a decline in predator availability, causing predators to be food limited. High salmon abundance was estimated in the early 1980's while Alewife *Alosa pseudoharengus* abundance steeply declined, causing a mass mortality of Chinook salmon in 1987. Once again, increased salmon abundance and consumption was observed in the early 2000's, the same time Alewife populations were approaching historic low numbers. Even with a reduced stocking approach to attempt to reduce predation on Alewife, actions have not been adequate due to increased survival and natural production of Chinook salmon, a possible result of overall reduction of Chinook salmon abundance.

Citation:

Tsehaye, I., M. J. Jones, T. O. Brenden, and J. R. Bence. Changes in the salmonine community of Lake Michigan and their implications for predator-prey balance. Transactions of the American Fisheries Society 143:420-437.

Accounting Explicitly for Predation Mortality in Surplus Production Models: an Application to Longfin Inshore Squid

Abstract:

One approach to better account for ecosystem considerations in fisheries science is to incorporate ecological interactions into conventional stock assessment models. The longfin inshore squid *Loligo pealeii* is one of two squid species of ecological and commercial significance in the northwest Atlantic Ocean. A surplus production model with quarterly time steps was fitted to longfin inshore squid total removal (fishing and predation removal) and tuned with fishery-dependent, fishery-independent, and predation-dependent indices to examine the effect of incorporation predation into a single-species model. Total consumption of squid by all predatory fish exceeded the landings in most years of this analysis. The model output indicated that biological reference paints for longfin inshore squid differ considerably when predation removals are included. It appears that by not including predation, the model underestimates stock biomass and overestimates fishery surplus production. Short-term stochastic projections of such estimates demonstrate that increasing predation mortality and fishing mortality will decrease the biomass of longfin inshore squid. Failing to account for predation when performing stock assessments for longfin inshore squid and other similar forage species may misrepresent reference point estimates and result in management advice that could lead to biomass declines. We envision that the approach presented here will provide requisite information and a useful example towards improving the current modeling practices for longfin inshore squid and similar forage species.

Citation:

Moustahfid, H., M. C. Tyrrell, and J. S. Link. Accounting explicitly for predation mortality in surplus production models: an application to longfin inshore squid. Nort American Journal of Fisheries Management 29:1555-1566.

Modeling Management Scenarios and the Effects of an Introduced Apex Predator on a Coastal Riverine Fish Community

Ecopath with Ecosim was used to model the potential impact of flathead catfish *Pylodictis olivaris* on the native fish community of Contentnea Creel, a large tributary to the Neuse River in eastern North Carolina using empirical data from North Carolina coastal plains rivers. Simulation showed that the introduction of flathead catfish would result in declines of biomass of 30% in the anadromous shad and native insectivore groups and roughly 50% decline in the anadromous and native piscivore groups after reaching equilibrium. The invasive scenario predicted flathead catfish to become the dominant piscivore by functional group biomass in less than 50 years. Declines were observed in species groups competing with flathead catfish for available prey resources. The model also showed positive responses in native fish biomass once flathead catfish harvest/removal efforts were increased as part of a broader ecosystem restoration effort.

Citation:

Pine III, W. E., T. J. Kwak, and J. A. Rice. 2007. Modeling management secnarios and the effects of an introduced apex predator on a coastal riverine fish community. Transactions of the American Fisheries Society 136:1, 105-120

Foraging Modes of Predators and Behaviors of Prey Determine the Outcome of Multiple Predator Interactions

A mesocosm was used to observe the interactions between largemouth bass *Micropterus salmoides* (cruising predator) and muskellunge *Esox masquinongy* (an ambush predator) and prey that exhibit different antipredator behavior, bluegill *Lepomis macrochirus* and fathead minnow *Pimephales promelas*. Capture rates of prey were higher for the ambush predator when both predators were present in the mesocosm due to a greater encounter frequency than when the muskellunge was only tested. Bluegills were found to alter their behavior during predator treatments by changing their activity levels and habitat usage. Predator foraging styles and prey behavior need to be considered to understand natural food webs, as a positive synergy of both ambush and cruising predators by increasing predation events.

Citation:

Carey, M. P., and D. H. Wahl. 2011. Foraging modes of predators and behaviors of prey determine the outcome of multiple predator interactions. Transactions of the American Fisheries Society 140:4, 1015-1022.

Prey Supply and Predator Demand in a Reservoir of the Southeastern United States

The annual prey supply and predator demand distributions were analyzed for the fish assemblage in the Norris Reservoir, Tennessee, to assess potential prey densities. Prey supply was defined as the surplus biomass that could be removed without affecting future prey generations and was limited to cohorts consumed by predators. Demand was represented by the annual consumption by the predator community (piscivorous fishes) and was estimated with bioenergetics models. Stomach contents of striped bass, smallmouth bass, spotted bass, largemouth bass, black crappie, and walleye were examined to gather data on diet analyses. Results showed that clupeids and *Lepomis* spp. made up over 80% of the overall prey fishes consumed. Prey supply-predator demand ratios were found to have median values of 2.9:1 and 2.3:1 for two sample periods for August 1996 to July 1997 and August 1997 to July 1998 respectively. Historical analysis showed that supply-demand ratios were less than 1:1 32% of the time. Supply-Demand ratios may be skewed as predators cannot capture all prey with 100% efficiency.

Citation:

Reborn, S. W., L. E. Miranda, and M. T. Driscoll. 2007. Prey supply and predator demand in a reservoir of the Southeastern United States. Transactions of the American Fisheries Society 136:1, 12-23.

Resources Miracles and Rising Expectations: A Challenge to Fishery Managers

“Predatory inertia" is the term Kitchell and Crowder use (1986) to describe the 2-5-year lag that occurs between the stocking of salmon and subsequent predation on its primary food source, the alewife. If salmon stocking continues unabated during the lag years, disaster will strike once the predators begin catching the prey. The alewife population may be insufficient to meet the demand. Predatory inertia fits the idea of rising expectations revolutions in two ways. First, public expectations are likely to continue to rise during the lag period, and managers would be pressured to increase stocking levels since no alewife shortage had (yet) appeared. Second, just as the predatory inertia lag will prevent an effective response by resource managers (the stock has already collapsed), the notion of rising expectations suggests that it will be difficult to adjust public expectations to a new, less optimistic, reality. The "cascade of effects stemming from piscivory-induced changes in the [Lake Michigan] food web" (Kitchell and Crowder 1986, p. 209) could thus be accompanied by a revolution of rising expectations by sport fishermen.

Citaion:

Gale, R.P. (1987) Resource Miracles and Rising Expectations: A Challenge to Fishery Managers, Fisheries, 12:5, 8-13, DOI: 10.1577/1548-8446(1987)012<0008:RMAREA>2.0.CO;2

Sustainability of Hatchery-Dependent Salmonine Fisheries in Lake Ontario: The Conflict between Predator Demand and Prey Supply

Abstract:

The offshore fish community of Lake Ontario is presently dominated by intensively managed, nonnative species: alewife *Alosa pseudoharengus* and rainbow smelt *Osmerus mordax* at the planktivore level and slocked salmonines at the piscivore level. Salmonine stocking rates per unit area of Lake Ontario are the highest in the Great Lakes, and fishery managers are concerned about the sustainability of the fishery under present stocking policies, particularly with the recent collapse of the Lake Michigan fishery forchinook salmon *Oncorhynchus tshawytscha*. In this paper, we describe and present the results of a simulation model that integrates predator demand estimates derived from bioenergetics. prey and predator population dynamics, and a predation model based on the multiple-species functional response. Model reconstructions of historical alewife biomass trends and salmonine diets corresponded reasonably well with existing data for the period 1978-1992. The simulations suggest that current predator demand does not exceed the threshold beyond which alewife biomass cannot be sustained, but they indicate that the sustainability of the prey fish community is extremely sensitive to fluctuations in overwinter survival of alewife; an additional mortality of 25% in a single winter would be sufficient to cause the collapse of the alewife population. The model includes a number of assumptions and simplifications with a limited empirical basis; better estimates of salmonine survival rates, an evaluation of the importance of spatial and temporal interactions among predators and prey, and incorporation of the effects of recently observed declines in system productivity at lower trophic levels would significantly increase confidence in the model's projections.

Citation:

Michael L. Jones , Joseph F. Koonce & Robert O'Gorman (1993)
Sustainability of Hatchery-Dependent Salmonine Fisheries in Lake Ontario: The Conflict between Predator Demand and Prey Supply, Transactions of the American Fisheries Society, 122:5, 1002-1018, DOI: 10.1577/1548-8659(1993)122<1002:SOHDSF>2.3.CO;2