Isotopic differences in otoliths of hatchery-reared steelhead

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Steelhead, *Oncorhynchus mykiss*, is an important anadromous fish species around the North Pacific Ocean from northwestern Mexico to eastern Russia. To verify the natural isotopic marks for future otolith research and applications, we sampled 240 steelhead smolts for stable carbon and oxygen isotope ratio analyses (13C/12C or d13C, and 18O/16O or d18O). These steelhead smolts were hatched and reared at the Oregon Hatchery Research Center (OHRC) for 6 to 8 months, with a designed protocol in two river sites (Fall Creek and Carnes Creek) and with two different feeds (commercial and experimental diets). Initial results show that there are significant d13C differences between the commercial and experimental diets in fish feeding, and distinct isotopic differences in fish size and age especially for d18O. In contrast, the isotopic composition between otoliths from Fall Creek and Carnes Creek is only slightly different, indicating some freshwater mixing (from d18O) during the rearing time. Overall these isotopic data and our interpretations provide baseline chemical signatures for the hatchery steelhead, and show the potential to be used for identification of hatchery stocks in steelhead management.

Winter Concealment Behavior of *Oncorhynchus mykiss*

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Winter is commonly seen as a bottleneck for salmonid survival due to unbalanced energetics in cold temperatures, physical disturbance from ice formation or movement, a lack of preferred habitat, or any combination of multiple stressors. Salmonids can avoid some of these stressors by concealing themselves in interstitial spaces in the substrate. Quality of winter concealment habitat is a function of substrate size, water velocity, embeddedness, and temperature. We monitored steelhead (*Oncorhynchus mykiss*) winter concealment behavior using passive integrated transponders and mobile antennas. We identified and rated benthic environment characteristics at the sub-meter scale to define quality winter concealment habitat. Winter concealment is an important life history strategy for juvenile steelhead to maintain their growth rates and survival through harsh winters. Restoration projects that alter the substrate need to be aware of the importance of winter concealment habitat in regions where winter concealment behavior is likely to occur.
Strategies for Salmon Reintroduction

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Development in the Yakima Basin in Washington State caused the extinction of three species of salmon. Sockeye, coho and summer Chinook salmon were all extirpated by the late 1970's. Irrigation reservoir and diversion dams, unscreened canals, agricultural practices, logging, urban development, and overfishing all contributed to the extinctions. The Yakama Nation has worked on reintroduction of all three species beginning in the 1990's. Selection of appropriate brood source for each population is discussed. Different strategies including adult, parr and smolt releases, permanent and mobile acclimation facilities have been tested to determine success and cost effectiveness of various strategies. Results from reintroduction efforts and associated habitat improvements are discussed.

Evaluation of new software for rapid, automated processing of hydroacoustic data for fisheries related applications

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A new processing utility added to BioSonics Visual Acquisition (VisAcq) software was evaluated to determine its relative efficiency and accuracy as a means to rapidly process hydroacoustic data. VisAcq’s Trace Formation (AutoTrack) capability represents a potential paradigm shift in the conventional methods for obtaining fish counts, density and distributional information from hydroacoustic fisheries data sets. Conventional methods involve two primary tasks; data collection and data processing. VisAcq AutoTrack processes during data collection by detecting, classifying and accepting or rejecting echo returns based on user-selected parameters. Fish tracks or traces are automatically formed in near-real time from the accepted echoes and logged or displayed. The new software calculates sample volume, based on distance traveled, range, and beam angle, thus allowing for automated fish density measurements. A hydroacoustic data set collected in Lake Washington, Seattle was processed to determine fish density by depth strata, horizontal and vertical distribution, and total count. Data were processed in real time using VisAcq AutoTrack and post-processed using three other commercially available and widely-used programs. The analysis results across the four different software applications demonstrated that VisAcq Autotrack provides provisional information as accurate as data provided by the other software while eliminating nearly all post processing effort.

Principles of trout management in Arizona

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The definition of principle is a basic truth, law or assumption. I reviewed twenty years of survey and creel data in the White Mountains of Arizona to identify principles of trout management. These principles were:

**Partners for Fisheries Monitoring Program in Bristol Bay, Alaska**

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Bristol Bay has nine (9) major river drainages and is home to five salmon species as well as many other anadromous and non-anadromous fish populations. In 1997 and 1998 the State and Federal governments declared Bristol Bay an economic disaster area due to failed salmon runs. The Fisheries Resource Monitoring Program was established in 2001 within the US Fish and Wildlife Service, Office of Subsistence Management; to increase the quantity and quality of information available for management of subsistence fisheries. With funding from US Fish and Wildlife Service, the Bristol Bay Native Association’s Partners Program (est. 2002) implements summer fisheries internship projects, and works with member tribes to implement research projects to study and enumerate subsistence fisheries stocks while advancing local ability to be involved in fisheries resource management in Bristol Bay. Some of the past projects include stock assessment of various fish populations; salmon runs; and distribution, seasonal movement and life history of humpback whitefish. Exploring and implementing new manageable techniques of monitoring changes in Bristol Bay fishery resources is one of our goals. Our future projects will examine cumulative effects of climate change on subsistence fishery resources, their uses, and how these resources are managed.

**The effects of non-native brook trout on coho salmon recolonization of the Elwha River, WA**

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Competition between riverine salmonids influences behavior, distribution, and abundance of sympatric species. Niche partitioning occurs in habitats where species have coevolved, but the introduction of nonnative species can lead to increased competition for resources. The removal of the Elwha River dams provides an unprecedented opportunity to study novel native-nonnative salmonid interactions. During upriver recolonization, anadromous salmonids will encounter established nonnative brook trout (Salvelinus fontinalis) populations stocked after dam construction. Brook trout and juvenile coho salmon (Oncorhynchus kisutch) have several life history commonalities, including emergence time and habitat preference. These ecological overlaps suggest that the two species might compete for space and resources in environments where they have neither coevolved nor partitioned available niches. Surveys of the Elwha River and its tributaries indicate that brook trout and juvenile coho salmon are often sympatric on a coarse scale, but the species do not share fine-scale habitats in the summer. Results from dyad competition trials in laboratory streams suggest that juvenile coho salmon are competitively dominant to brook trout, regardless of size difference between individuals. Trials also indicate that coho salmon are often competitively dominant even when outnumbered by brook trout, further suggesting that coho salmon are superior competitors for food resources.

**Yakama Nation: Lake Cle Elum Sockeye Adult Reintroduction Project**

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The Yakama Nation (YN) developed the Master Plan for reintroduction of anadromous fish above the reservoirs in the Yakima Basin. The dams: Bumping, Kachess, Keechelus, Cle Elum, and Tieton, were never equipped with fish passage facilities. Four of the five reservoirs were originally natural lakes and historically supported Native American fisheries for sockeye salmon and other anadromous and resident fish. Of these Cle Elum has the best habitat above the reservoir for this fish passage project. The project goal is to collect 1,000 to 10,000 adults annually to be transferred directly to Cle Elum Lake. The YN prefers a mix of Okanogan and Wenatchee stocks when relocating adults to initiate the reintroduction. We believe the reintroduction plan should utilize all potential donor stocks to maximize the chance of success in reestablishing sockeye in an area that has been absent of anadromous sockeye salmon for over 100 years. The two donor stocks exhibit different life history and migration behavior patterns. This genetic and phenotypic diversity is a desirable attribute that allows natural adaptation/selection processes to determine which donor stock is a better fit to the current Yakima Basin environment.

Coldwater fisheries responses to hypolimnetic oxygenation lake restoration

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Hypolimnetic oxygenation can alter coldwater fisheries dynamics within deep eutrophic lakes limited by a summertime oxygen/temperature habitat squeeze. By eliminating hypolimnetic hypoxia, oxygenation expanded suitable Rainbow and Brook Trout habitat in North Twin Lake, our study lake located on the Colville Confederated Tribes’ Reservation in Washington State. Trout immediately utilized the oxygenation-created habitat, occupying a greater range of significantly deeper depths when compared to our un-oxygenated reference, South Twin Lake. Zooplankton dynamics also changed significantly with their hypolimnetic hypoxic refuge eliminated and sediments oxygenated. Zooplankton were found more evenly distributed throughout the water column in oxygenated North Twin compared to South Twin where they continued to exhibit a noticeably stronger diel vertical migration. Additionally, Chaoborus sp. abundance increased in sediments and decreased in the water column during oxygenation. The expansion of trout habitat and shifts in zooplankton food resources resulted in North Twin trout preying more on pelagic Daphnia spp. compared to our reference South Twin where trout preyed more on littoral amphipods. Habitat and diet changes have not resulted in significant growth or condition increases for Rainbow or Brook Trout. However, oxygenation benefits may be realized by increased Rainbow Trout survival, but more data is required for conclusive results.