Thermal Metabolic Performance of Wild Juvenile *Oncorhynchus mykiss* in the Lower Tuolumne River: A Case for Local Adjustment to High River Temperature

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Oncorhynchus mykiss and other species adjust to local thermal conditions. We tested the hypothesis that the Tuolumne River *O. mykiss* population below La Grange Diversion Dam is locally adjusted to the relatively warm summer thermal conditions of the Tuolumne River. Locally-caught wild juvenile *O. mykiss* (100-200 mm fork length) were tested, and then safely returned to the river within ~one day. Measurements of each fish's basic oxygen requirements for living (routine metabolic rate; RMR) and how quickly oxygen can be extracted from the water to support tissues of maximally swimming fish (maximum metabolic rate; MMR) were performed in swim tunnel respirometers. Paired measurements of RMR and MMR were obtained for 37 of 44 individual fish tested at 13°C to 25°C. Subtracting RMR from MMR estimates absolute aerobic scope (AAS), the capacity of each fish to supply oxygen to tissues above and beyond the basic routine need. These estimates and factorial aerobic scope (FAS = MMR/RMR) were used to define the optimum temperature range for tested fish.

Over the test temperature range of 13°C to 25°C, RMR increased exponentially with temperature and MMR increased linearly to a lesser degree. As a result, estimated peak AAS was at 21.2°C and the thermal range over which the fish maintained 95% of peak aerobic capacity was 17.8°C to 24.6°C. Between 13 and 23°C, all individual fish maintained FAS >2.0, suggesting fish possess sufficient capacity to perform necessary functions, such as swim, catch prey, digest a meal, avoid predators, etc. The upper thermal tolerance limit (the temperature where AAS is zero) was not determined due to study permit conditions, but must lie above 25°C. This study supports the hypothesis that juvenile *O. mykiss* captured in the lower Tuolumne River are locally adjusted to the relatively warm thermal conditions that typify the summer months in this location.

Keywords: *Oncorhynchus mykiss*; steelhead; temperature; Tuolumne;

Poster Topic: At Risk Species: Fish

Evaluation of the Condition of Wild Delta Smelt (*Hypomesus transpacificus*) Supplemented to the Refuge Population at the Fish Conservation & Culture Laboratory (FCCL)

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The Delta Smelt (DS) refuge population is serving as a genetic bank in case of species extinction in the wild. Each year, the refuge population at the UC Davis Fish Conservation and Culture Laboratory (FCCL) is supplemented with few wild DS (<100) to maintain the genetic integrity and replace lost refuge DS families. Fish were collected from Lower Sacramento River near Sherman Island and Deep Water ship channel in December and early January and cultured till spawning. The aim of this study is to investigate the changes in body weight (BW), fork length (FL) and Fulton's condition index (K) in captive wild DS collected for the 2012-2015 spawning season. The fish were fed with *Artemia* for one week and then weaned to dry feed. FL (g) and BW (mm) were measured two times (March and May) per year. A total of 211 individuals (76 females, 74 male and 62 not-sexed) were analyzed. Mean BW of the fish ranged from 1.98± 0.44 to 2.40±0.60 g, and FL ranged from 63.29 ± 3.75 to 69.83 ±4.52 mm. No significant difference of K values was found during the time that fish were held in captivity (from March to May), which may indicate the condition of fish didn't change during the time being held at the FCCL. For all years studied (except for 2012), the BW-FL relationship showed that captive wild male DS had a negative allometric growth ($b<3.0$) while females had a positive one ($b>3.0$), which indicates females gained weight faster than grew length. Wild DS captured in 2012 had a significantly ($p<0.001$) higher K value (0.85±0.14), indicating fish were healthier than the other years.

Keywords: Delta Smelt, refuge population, weight, length, condition factor

Poster Topic: At Risk Species: Fish

When Salmon go Salty...

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Recent research has improved our understanding of the distribution of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) around the California Central Valley system during rearing and outmigration to the ocean, however, it is notoriously difficult to link these data with adult survivors in order to identify the most successful strategy(s). By analyzing strontium isotopes in the otoliths (earstones) of adults after they have returned to spawn (i.e., focusing on the subset of "successful" individuals) we can retrospectively identify the size and age of individuals at the point at which they entered the estuary as juveniles. We have carried out size analyses using otolith isotope data from fall, spring and winter run adults, incorporating more than a decade of returns and spanning a large variety of hydrologic conditions. We have cohort-matched these isotopic analyses with size and distribution data from the Juvenile Fish Monitoring Program to attempt to identify broad patterns in juvenile phenotype expression and survival. Preliminary analyses have implied greater size variation at freshwater exit in wetter outmigration years, which may increase resilience to environmental perturbations via a portfolio effect. The ecological and management implications of these findings will be discussed, particularly in terms of hatchery release practices.

Keywords: Chinook salmon, otolith, strontium isotopes, outmigration, life history diversity, portfolio

Poster Topic: At Risk Species: Fish

An Investigation into Differences in Early Growth and Life History Strategies of Delta Smelt, *Hypomesus transpacificus*

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Previous studies conducted under the Fall Low Salinity Habitat (FLaSH) study have shown three different life history strategies among delta smelt. Using the data collected from the Interagency Ecological Program (IEP) long-term fish monitoring surveys the Fall Midwater Trawl and the Spring Kodiak Trawl, we further investigate the different life history strategies of delta smelt. Very little is known about any potential growth, morphological and/or behavioral difference in individuals with varying life history strategies. Here we investigate whether there is any connection between early growth rates, encompassing the first 90 days, and resident versus migrating life histories and look at inter-annual variability in this pattern.

Relevance: Understanding how delta smelt growth may influence movement pattern and life history strategies can assist in making informed decisions about habitat use and water management.

Keywords: Delta Smelt, Fall Low Salinity Habitat

Poster Topic: At Risk Species: Fish

Longfin Smelt Distribution, Abundance and Evidence of Spawning in San Francisco Bay Tributaries

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The Longfin Smelt Project Work Team has identified a suite of studies that would expand our current understanding of Longfin Smelt distribution, abundance, abundance trends, spawning location(s), and the relationship between Delta outflow and Longfin Smelt abundance (e.g. Kimmerer 2002). The UCD Davis Fisheries Research Team launched a field survey in 2015 to document the geographic extent of Longfin Smelt adult distribution and larval rearing in San Francisco Bay tributaries. In four tributaries, (Napa River, Sonoma Creek, Petaluma River & Coyote Creek) Longfin Smelt adults are sampled using an otter trawl while larvae are sampled using DFW's Smelt Larval Survey sled bi-weekly from January-April. In January and February of 2015, adult Longfin Smelt were found at the upstream extent of each bay tributary, with Coyote Creek having the highest catch. Larval Longfin Smelt were found in Napa Slough, Steamboat Slough and Mud Slough in the Napa River Marsh, and at several locations in the Petaluma River. No larval Longfin Smelt were found in Coyote Creek. Although the catch of Longfin Smelt in SF Bay tributaries during the spawning season was low in 2015, spawning and successful rearing of young in the Napa and Petaluma marshes of San Pablo Bay may be associated with the strong fall abundance to X2 relationship. Future studies will include developing otolith chemical fingerprints of SF Bay tributaries to determine proportions of the adult population originating from different natal areas of the estuary.

Keywords: Longfin Smelt, POD, X2, Restoration, Napa River, Petaluma River

Poster Topic: At Risk Species: Fish

Using Next-generation Sequencing to Identify Copepod Diets in Delta Smelt Habitat

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Food web interactions are fundamental characteristics of ecosystems. In California's Sacramento-San Joaquin Delta, endangered delta smelt, *Hypomesus transpacificus*, eat planktonic copepods. Copepods eat microplankton, but the food web interaction between copepods and microplankton is poorly understood; traditional prey sampling methods provide too little taxonomic resolution. Moreover, copepod species can have different feeding patterns, which can change in time and space. We use next-generation sequencing (NGS) to describe the microplankton community and copepod diets in a key delta smelt habitat, the Cache Slough Complex (CSC). Our results provide new insights into the food web that supports delta smelt and other fish species in the Delta. This project is part of a larger study of zooplankton abundance and species composition in the CSC.

Keywords: plankton, foodweb, genetics, copepod, predation

Poster Topic: At Risk Species: Fish

Quantifying Factors that Influence Salmon Smolt Predation in the San Joaquin River

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Telemetry studies that track downstream migration and mortality of salmonids in the Central Valley have demonstrated high mortality rates (80-99%) during emigration through the freshwater and estuarine portions of the watershed. In recent years, estimated survival rates for juvenile Chinook salmon in the lower San Joaquin River declined to approximately 5%, despite increased river flows and reduced spring water exports. The hypothesized cause of these low survival rates is a combination of factors that includes predation by non-native fishes. Although predation has been suggested as a major cause of salmon smolt mortality, there is insufficient research in the San Joaquin Delta to rigorously evaluate this hypothesis. Before any potential management actions might be considered, more studies are needed to quantify predator density, movement, and predation rates, as well as examine how environmental and anthropogenic factors influence predation of salmon smolts. To address this research need, a predation study took place over two years (2014-2015) in the San Joaquin River in collaboration with the DWR, DFW, USFWS, USGS and USBR. This study revolved around a predator density manipulation in nine 1-km river reaches (3 control; 3 predator removal; 3 predator addition). Effects were assessed before/after manipulations with 1) release of >3000 acoustically tagged Chinook salmon and steelhead smolts, 2) capture/release of acoustically tagged predators (striped bass, largemouth bass, channel catfish, and white catfish), 3) quantification of relative salmon smolt predation using drifting Predation Event Recorders (PERs) in each of the study reaches, 4) quantification of predator density and fish habitat using hydroacoustic imaging, 5) determination of prey items using genetic analysis of predator stomach contents, and 6) species diversity and abundance surveys. A total of 2,846 predators were captured and removed/relocated from 70 hr of electrofishing over two years. Preliminary results indicated spatiotemporal hotspots of predation within the San Joaquin River.

Keywords: salmon, predators, striped bass, largemouth bass, channel catfish, white catfish

Poster Topic: At Risk Species: Fish

Gonadal Fatty Acid Indices of Enzymatic Activity and Ratios in Wild Delta Smelt *Hypomesus transpacificus*

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Reproductive biology studies on gonadal fatty acid enzymatic activity are useful to determine essential or conditionally essential fatty acid deficiencies. Indices of enzymatic activity may be obtained from product-to-precursor ratios of fatty acids. Ovaries of 97 delta smelt at stage 4 Late were selected from the Spring Kodiak Trawl Survey (SKT) years 2012, 2013 and 2014 and were analyzed for their fatty acid profiles using a Gas Chromatography with Flame Ionization Detector system. Stations of the SKT covered the Deep Water Ship Chanel and Cache Slough (DWSC & CS), Confluence and Suisun Marsh. Indices of Enzymatic Activity of Delta 6 and 5 desaturase (D6D and D5D) and Elongase-5 from n-6 and n-3 fatty acids, and docosahexaenoic acid/arachidonic acid (DHA/ARA), DHA/eicosapentaenoic acid (EPA) and alpha linolenic acid/linoleic acid (ALA/LA) ratios were calculated.

Results show higher enzymatic activity of D6D, D5D and elongase-5 (C22:5n-3/C20:5n-3) for the n-3 products than for the n-6 products. By contrast, Elongase 5 for C20:4n-3/C18:4n-3 was lower than for C20:3n-6/C18:3n-6. Considering fish distribution, gonads from the DWSC & CL show relatively low DHA/ARA, DHA/EPA and ALA/LA ratios, and enzyme activity of D6D of the n-6 fatty acids, and Elongase-5 and D5D of the n-6 and n-3 fatty acids show an increase. Increase in D6D, D5D and elongase-5 activities have been related to diets deficient in DHA and ALA in rats. By contrast, D5D in Suisun marsh is relatively low, which suggests DHA and ARA formation is met. DHA and ARA are important in neuronal development and fish reproduction.

Our results suggest that indices of enzymatic activity may identify essential fatty acids requirements in delta smelt gonad such as docosahexaenoic acid and alpha linolenic acid in the Deep Water Ship Chanel and Cache Slough regions, and that food in Suisun marsh may be of better fatty acid quality.

Keywords: D6D, D5D, Elongase5, Reproduction, DHA, Enzyme Activity Indices

Poster Topic: At Risk Species: Fish