How to Estimate Trophic Position of Fish from Lag in Contaminant Bioaccumulation

William Beckon, U. S. Fish and Wildlife Service, William_Beckon@fws.gov

For bioaccumulative contaminants, such as selenium, efforts to predict concentrations in organisms at upper trophic levels, based on measurements of environmental exposure, are confounded by the appreciable amount of time it may take for bioaccumulation to occur through various pathways and across several trophic transfers. Yet studies of bioaccumulation have hitherto generally overlooked this lag time, using temporally matched samples of water and tissue, effectively making the unrealistic assumption that bioaccumulation is instantaneous. The study summarized here offers a remedy for this deficiency, demonstrating a simple, objective method of automatically estimating the time required for bioaccumulation, and taking this lag into account to improve predictive modeling of bioaccumulation. This method uses a history of measurements of environmental exposure and tissue concentrations of a contaminant to systematically test a large array of potential lag characteristics, selecting the lag that provides the best regression. The method is demonstrated here using an unusually long-term data set of selenium measurements in water and aquatic organisms in sloughs in the San Joaquin Valley in California. Results indicate that, as expected, more time is required for selenium to bioaccumulate in organisms at higher trophic levels than in those at lower trophic levels. For example, the lag time for the piscivorous largemouth bass (*Micropterus salmoides*) may be more than one year, but only about one month for the filter-feeding threadfin shad (*Dorosoma petenense*). Also as expected, omnivorous organisms display a broader spread in lag time than more specialized feeders. Therefore, the method presented here not only provides a tool for improved prediction of contaminant effects and for more precise targeting of contaminant regulation, it also offers a novel means to estimate both the average trophic level of an organism and its trophic spread (degree of omnivory), when these characteristics are otherwise poorly known.

Keywords: bioaccumulation lag, trophic level, regression, computer program, selenium, trophic spread

Poster topic: Fish Biology, Ecology and Protection

Into the Belly of the Beast: Traditional and Genetic Prey Detection in Liberty Island's Mississippi Silversides

Tricia Bippus, California Department of Fish and Wildlife, Tricia.Bippus@wildlife.ca.gov
Danae Jordan, California Department of Fish and Wildlife, Danae.Jordan@wildlife.ca.gov
Alison Furler, California Department of Fish and Wildlife, Alison.Furler@wildlife.ca.gov
Steven Slater, California Department of Fish and Wildlife, Steve.Slater@wildlife.ca.gov
Gregg Schumer, Cramer Fish Sciences, Gregg@fishsciences.net
Brian Schreier, California Department of Water Resources, Brian.Schreier@water.ca.gov
Melinda Baerwald, University of California, Davis, mrbaerwald@ucdavis.edu

Mississippi Silverside (*Menidia beryllina*) will feed on Delta Smelt (*Hypomesus transpacificus*) larvae in captivity (BM Schreier pers. comm.) and in the wild (Baerwald et al. 2012); however, the effects of predation on a population level are poorly understood. Identification of fish larvae in the stomach of predators is difficult as larvae are small and digest quickly. The purpose of this study was to utilize a novel approach of traditional visual processing followed by genetic testing of Mississippi Silverside stomach contents, with the goal of detecting and quantifying consumption of larval Delta Smelt.

Beach seine sampling was conducted by USFWS's Delta Juvenile Fish Monitoring Program's Liberty Island monitoring study. A total of 49 silversides were collected during March-May 2013. Size of fish ranged 45-89 mm FL (mean = 70 mm FL). Silversides collected in the field were preserved individually in 95% ETOH and stored at -20°C until their gut contents were visually analyzed.

Visual examination of stomach contents was conducted by CDFW Diet Study staff (Stockton, CA), which included removal and emptying of the stomach and identifying and enumerating all items to the lowest possible taxon. Lengths of larger prey items (larval fish, mysids, and amphipods) were recorded. DNA sterile techniques were used throughout the removal and stomach content identification process. The stomach contents and stomach (sans intestine) of each fish was subsequently collected into DNA extraction tubes and sent to Cramer Fish Sciences for genetic analysis using previously developed, species-specific TaqMan assays (Baerwald et al. 2011). Genetic analyses were carried out to determine the presence of Delta Smelt DNA.

The diet composition of silversides, by number, was primarily (95%) cladocerans and copepods. Other items included insects, amphipods, and mysids. Larval fish were not found in stomachs. Absence of Delta Smelt larvae in Mississippi Silverside stomachs was confirmed by DNA testing.

Keywords: Mississippi Silverside, Delta Smelt, Diet, DNA, TaqMan assays, Liberty Island

Poster topic: Fish Biology, Ecology and Protection

Inter-annual Variability of Delta Smelt Fall Growth in Association with the Fall Low-Salinity Habitat Study

James Hobbs, University of California, Davis, jahobbs@ucdavis.edu
Bush Eva, University of California Davis, eebush@ucdavis.edu

- Problem statement: Fall habitat condition in the Low-Salinity Zone of the upper San Francisco Estuary has deteriorated in recent years and has been associated delta smelt abundance. This study investigates the link between fall habitat and growth of delta smelt.
- Approach: We use the otolith increment widths as a proxy of growth during the fall for delta smelt collected in the Fall Midwater Trawl and Spring Kodiak Trawls in two consecutive years of wet and dry years (2005 Dry, 2006 Wet and 2010 Dry, 2011 Wet).
- Results: Fall growth varied considerably among years, with 2010 and 2011 exhibiting higher growth than either 2005 or 2006. Importantly, fall growth did correspond with the position of X2 in the months leading up to and including the fall period. Moreover, higher fall growth corresponded with better recruitment in the following spring.
- Conclusions/Relevance: This study supports adaptive management of fall habitat conditions through the manipulation of fall X2 via freshwater flow management for delta smelt. However, flow management in the fall must be followed by adequate spring habitat conditions to support the production of the next generation; otherwise any benefit provided by freshwater flows in the fall could be lost.

Keywords: FlaSH, Delta Smelt, Otoliths, Growth, X2, Freshwater Flows, Health, Abundance

Poster topic: Fish Biology, Ecology and Protection

Effects of Water Year Type on Juvenile Chinook Salmon Size at Emigration in the Lower Yuba River, California

Paul Cadrett, USFWS, paul_cadrett@fws.gov
Ramon Martin, USFWS, ramon_martin@fws.gov
Elizabeth Campbell, USFWS, Elizabeth_campbell@fws.gov

Most Central Valley rivers in California are regulated by large dams, altering the magnitude and frequency of flood events. Consequently, floodplain habitat is less frequently inundated, reducing the availability of an important habitat type for juvenile salmonids. Studies have shown that juvenile Chinook salmon (*Oncorhynchus tshawytscha*) rearing on floodplains may experience increased growth and survival compared to those rearing in-river. Floodplains can provide high quality food resources, which contribute to faster growth rates. Inundated floodplains and off-channel habitat may also improve survival by providing refuge from predators and increase the amount of available rearing habitat. Annual discharge in the lower Yuba River presently is based on the Water Year Type (WYT) designation from the North Yuba River Index described in the Yuba Accord. Implementation of the Yuba Accord began in 2007 and will continue until at least 2015. Significant differences in daily mean sizes of juvenile Chinook salmon exist across WYT in the lower Yuba River. In general, wet years tend to produce the largest juveniles whereas dry years produce the smallest fish. Increasing the amount of floodplain habitat available to juvenile salmon in the lower Yuba River at a variety of flow conditions could increase the overall size of juveniles. Larger smolts have been shown to have shorter travel times and higher survival through the Yolo Bypass and the Sacramento-San Joaquin Delta. Additionally, substantial scientific evidence for many species of salmonids indicates that the size of fish at ocean entry is an important, if not the primary, indicator of an individual's probability of returning to spawn.

Keywords: chinook, floodplain, rearing, Yuba

Poster topic: Fish Biology, Ecology and Protection

Use of *Menidia berylina* in Determining Impacts of Exposure to Endocrine Disrupting Chemicals in the SSJ Delta

Bryan Cole, University of California, Davis, bjcole@ucdavis.edu
Susanne Brander, University of North Carolina, Wilmington, brandersm@uncw.edu
Ken Jeffries, University of California, Davis, kenmjeffries@gmail.com
Richard Connon, University of California, Davis, reconnon@ucdavis.edu
Gary Cherr, University of California, Davis, gncherr@ucdavis.edu

Populations of pelagic organisms in the Sacramento-San Joaquin (SSJ) Delta and other estuaries have been declining for several decades. We aimed to determine effects of endocrine disrupting chemicals (EDCs) on Inland Silverside, *Menidia berylina*, and further develop this species as a model molecular and genetic species for toxicological assessments. We have developed molecular and biochemical tools for assessing these impacts in *Menidia*. In this study we have monitored the changes in gene expression and protein translation in wild populations of *M. berylina* in the SSJ Delta, near Sacramento, CA over the course of 2 years. We also outplanted naive, lab-reared fish to sites in the SSJ Delta numerous times over the course of 1 year. Using a newly developed microarray for *Menidia,* as well as quantitative PCR on a suite of endocrine-related genes and ELISA to choriogenin protein, we have found that there are significant changes in hormonally regulated gene and protein expression in Silversides in the Delta, and that there is the potential for an impact on fish populations. Results indicate that rivers throughout the SSJ Delta elicited different responses, in terms of gene and protein expression, from each other as well as from control fish. Results were indicative of exposure to EDCs. There were impacts at all times of the year, but the greatest disturbance was observed in the winter months. This is likely due to increased influx of chemicals during the rainy season in that region. The incorporation of temporal aspects into the study was crucial to understanding the impacts of EDCs because the types of chemicals input into the Delta change as different crops are grown and as weather conditions vary throughout the year.

Keywords: endocrine disrupting chemicals, fish populations, toxicology, pelagic organism decline

Poster topic: Fish Biology, Ecology and Protection

Trophic Ecology of Larval Delta Smelt from Liberty Island, 2010-2012

Jeffery Cordell, University of Washington, jcordell@uw.edu
Emily Howe, University of Washington, ehowe2@uw.edu
Charles Simenstad, University of Washington, simenstd@uw.edu

For this project we examined the diets of 212 larval delta smelt (*Hypomesus transpacificus*) containing prey that were captured within the Liberty Island/Cache Slough Complex as part of the Delta Juvenile Fish Monitoring Program. The primary goal was to identify the main prey taxa to compare to previous adult delta smelt diet results and to zooplankton assemblages present within Liberty Island. Diets of the Delta smelt analyzed were similar to those examined from the low salinity zone in the early 1990s and to diets collected more recently in the Liberty Island/Cache Slough Complex. Non-indigenous calanoid copepods dominated the diets in 2010 and 2011, with *Sinocalanus doerrii* more abundant early in the spring and *Pseudodiaptomus forbesi* more abundant later in the spring. In April and May 2012 the non-indigenous calanoids comprised much lower proportions of the diets and native cladocerans were more abundant.

Another goal of our study was to determine whether or not non-phytoplankton detrital material plays an important role in supporting larval delta smelt. Phytoplankton production has traditionally been regarded as the primary source of organic matter supporting these and other planktivorous fishes through pelagic zooplankton secondary production. However, recent food web research using a Bayesian mixing model and trophic enrichment-adjusted multiple stable isotope (MSI) signatures of delta smelt from Liberty Island suggested that the source of organic matter supporting their prey was a mixture of particulate organic matter (POM) from the surrounding Cache Slough Complex and POM and filamentous green algae originating within Liberty Island. We will present MSI results expected to be finalized in summer 2014, from both the larval delta smelt from Liberty Island and two major prey taxa, *Sinocalanus doerrii* and *Pseudodiaptomus forbesi.*

Keywords: larval delta smelt, diets, Liberty Island, stable isotopes

Poster topic: Fish Biology, Ecology and Protection

The Central Valley Spring-Run Chinook Life Cycle Model: A Tool to Evaluate the Impact of Water Project Operations and Habitat Restoration on the Population Dynamics of Threatened Salmon Populations

Flora Cordoleani, UCSC, flora.cordoleani@noaa.gov
Steve Lindley, NOAA, steve.lindley@noaa.gov
Eric Danner, NOAA, eric.danner@noaa.gov

The National Marine Fishery Service (NMFS) science center with support from the US Bureau of reclamation (USBR) has been developing a series of salmon life cycle models to predict the response of Central Valley Chinook salmon populations to water project operations and habitat restoration. They particularly aim at evaluating the effects of the Bay Delta Conservation Plan (BDCP) and the related operations of the Federal Central Valley Project (CVP) and California's State Water Project (SWP) on Chinook salmon populations. First developed for winter-run Chinook the model has been modified for spring-run Chinook salmons, which are listed as threatened under the Federal Endangered Species Act (ESA) since 1999. The differences between spring-run and winter-run Chinook life history are numerous and encompass dissimilarities in adult and juvenile migration timing, maturation strategy and spawning locations. As an example, spring-run adults are the unique one to leave the ocean as immature and hold in high elevation pools throughout the summer before spawning. They also have a specific juvenile life history strategy composed by both young-of-the-year fry that out-migrate soon after emergence and yearling fry that will stay in the Sacramento River Tributaries for a whole year before migrating to the Ocean.

Keywords: spring-run Chinook salmon, threatened, life cycle model, Bay-Delta Conservation Plan

Poster topic: Fish Biology, Ecology and Protection

Tidal Marsh Restoration Attracts Longfin Smelt

Patrick Crain, ICF International and University of California Davis, pkcrain@ucdavis.edu
James Hobbs, University of California Davis, jahobbs@ucdavis.edu
Jon Cook, University of California Davis, joncook@ucdavis.edu

- Problem statement: The Bay-Delta Conservation Plan will seek to restore tens of thousands of acres of tidal marsh habitat with the goal of increasing the abundance of declining native species including the longfin smelt. However; considerable scientific uncertainty surrounds the link between tidal wetland habitat and smelt.
- Approach: This study has been monitoring fish and macro-invertebrate abundance in several restored tidal salt pond habitats in Lower South San Francisco Bay in the Alviso Marsh area since July 2010.
- Results: Monthly otter trawling was conducted from July 2010 to present. In 4-years of monitoring, we counted 218 individuals from YOY to age 2+. Fall and winter months, we persistently found longfin smelt inside restored habitats. Moreover, restored tidal ponds exhibited high abundance of mysid shrimp, the preferred prey for longfin smelt.
- Conclusions/Relevance: This study supports the Bay-Delta Conservation Plans hypothesis that tidal marsh restoration will provide a benefit to longfin smelt. Over a 4-year period longfin smelt utilized restore habitats by migrating from the bay into the restoration ponds to forage. The tremendous productivity of tidal pond habitats will attract native species and support growth of threatened and endangered species.

Keywords: Tidal marsh restoration Longfin Smelt Mysid Shrimp Abundance

Poster topic: Fish Biology, Ecology and Protection

San Joaquin River White Sturgeon Telemetry Study

Jimmy Faukner, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, jimmy_faukner@fws.gov
Zachary Jackson, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, zachary_jackson@fws.gov

White Sturgeon (*Acipenser transmontanus*) migration and spawning in California's Sacramento River has been well documented. Less is known about the migration and behavior of sturgeon within the San Joaquin River system. The use of acoustic telemetry provides an opportunity to gather information on White Sturgeon captured in the San Joaquin River over a wide geographical area and long time span. The information collected from this type of sampling can help determine fish habitat use outside of the capture area, evaluate spawning frequency, spawning site fidelity, and length of stay within a spawning area. White Sturgeon (n = 43) were captured with gill or trammel nets and implanted with acoustic transmitters (10 year tag life) during three sampling seasons (2012 – 2014). Most but not all sturgeon that were captured and tagged displayed post-surgery behavior indicating that they were not severely affected by the procedure. Seven of the fish implanted with acoustic transmitters have returned to the study area in subsequent years which shows that at least a portion of the White Sturgeon found in the San Joaquin appear to display site fidelity. Six fish have been detected in the lower Stanislaus River but the intent of their occupancy is not clear (spawning vs. exploratory behavior). During 2013, five fish over-summered in the study area and outmigrated during a pulse flow in September. The movement of fish into the Stanislaus River during the spring and out of the San Joaquin during the fall coincided with water releases for other purposes. Reservoir releases in the spring that are designed to promote the outmigration of juvenile salmonids may also benefit spawning White Sturgeon.

Keywords: White Sturgeon, San Joaquin River, Telemetry

Poster topic: Fish Biology, Ecology and Protection

Survival and initial feeding response of Delta Smelt larvae (Hypomesus transpacificus) exposed to Sacramento- San Joaquin Delta water, April – June 2012 to 2014.

J. Scott Foott, U.S. Fish & Wildlife Service, CA-NV FHC, Scott_Foott@fws.gov
Ron Stone, U.S. Fish & Wildlife Service, CA-NV FHC, Ron Stone@fws.gov
Jennifer Jacobs, U.S. Fish & Wildlife Service, CA-NV FHC, Jennifer_Jacobs@fws.gov
Kevin Aceituno, U.S. Fish & Wildlife Service, EC Sacramento, Kevin_Aceituno@fws.gov
Nicholas Som, U.S. Fish & Wildlife Service, Arcata, Nick_Som@fws.gov

The endemic delta smelt is a threatened species (USFWS 1993) with potential population stressors including reduced freshwater flows, entrainment losses, inadequate food base and competition for food from exotic species, predation by exotic fishes and environmental contaminants. It is difficult to evaluate survival of the small (5-8 μm) pelagic larvae in the Sacramento River system. The USFWS Livingston Stone National Fish Hatchery maintains a refugial broodstock backup to the UC Davis Byron facility but cannot hold multiple generations due to resource limitations. We used excess newly hatched larvae to investigate the effects of delta water quality on 6 day survival and initial feeding response. Due to permit limitations, replicate groups were exposed *in-vitro* to water collected from the Sacramento River near the confluence of Cache slough and deep water shipping channel. Water was analyzed for pesticides and monitored (ºC, DO, pH, EC, NH_4, NTU) over the 6d trials. In comparison to control water, delta water exposure was associated with reduced survival and / or feeding response in **four** of eleven groups during 2012 and 2013. A similar trend has been observed in the spring 2014 trials however analysis is on-going. No difference in pooled whole body acetylcholinesterase activity was observed between exposure groups in 2013. Four fungicides and organophosphate pesticides as well as 2 pyrethroid pesticides were detected in the 2012 and 2013 water samples. No consistent pesticide or elevated ammonia level was associated with impaired survival in 2012 or 2013. This work indicates that delta water quality can have adverse effects on delta smelt larvae. A key question is to determine both the causes and mechanisms of this effect. Excess captive eggs could be used for an in-situ monitoring program to evaluate larval survival each spring.

Keywords: Delta smelt, pesticide, water quality, larval survival

Poster topic: Fish Biology, Ecology and Protection

Age-0 Striped Bass Regional Prey Consumption in the Fall (2011)

Alison Furler, California Department of Fish and Wildlife, Alison.Furler@wildlife.ca.gov
Tricia Bippus, California Department of Fish and Wildlife, Tricia.Bippus@wildlife.ca.gov
Rhonda Paiste, California Department of Fish and Wildlife, Rhonda.Paiste@wildlife.ca.gov
Steven Slater, California Department of Fish and Wildlife, Steve.Slater@wildlife.ca.gov

Striped Bass (*Morone saxatilis*) is one of several pelagic fishes in the San Francisco Estuary that has suffered a severe decline since the early 2000s. The estuary serves as an important nursery for Striped Bass and monitoring the species has proven valuable in gauging the health of the Delta. There is little recent information on Striped Bass feeding habits during early life stages, when individuals are subject to varying prey availability and possible food limitation. This poster will present age-0 Striped Bass' regional use of prey that occurred during fall 2011.

Age-0 Striped Bass (n=243) collected during August-December of 2011 as part of the Fall Low Salinity Habitat Studies (FLaSH), were examined for stomach contents and fullness. Fish were collected by California Department of Fish and Wildlife (CDFW) surveys Summer Townet and Fall Midwater Trawl from Cache Slough (CS), the Sacramento River Deep Water Ship Channel (SRDWSC), and at stations assigned to regions based on surface water salinity (<6, 1-6, and <1 ppt) at time of sampling. Age-0 Striped Bass consumed a diverse group of prey types, the majority as diet by weight being amphipods, mysids, and juvenile fish. Furthermore, occurrence of prey was highly variable among months and regions. For example, Gammarus body type amphipods made up the majority of food found in >6 ppt through <1 ppt, while Corophium body type amphipods dominated stomach contents of fish in the CS-SRDWSC. Fish found in stomachs of age-0 Striped Bass contributed to a large portion of diet by weight due to their size. Additional prey types found in stomachs included the calanoid copepod *Pseudodiaptomus forbesi,* isopods, and insects. Age-0 Striped Bass diet composition during fall 2011 differed considerably from the diet of another FLaSH study species, Delta Smelt (*Hypomesus transpacificus*), which consumed mostly copepods (Slater 2012).

Keywords: Striped Bass, Diet, Mysids, Amphipods, FLaSH, Cache Slough, SRDWSC

Poster topic Area: Fish Biology, Ecology and Protection

The Role of Visual Stimuli and Flow in Green Sturgeon Rheotaxis Behavior

Sean Goodside*, UC Davis, seanofabeach@att.net
John T. Kelly, University of New Haven, jkelly@newhaven.edu
Myfanwy Johnston, UC Davis, merowlands@ucdavis.edu
A. Peter Klimley, UC Davis, apklimley@ucdavis.edu

Green sturgeon in the San Francisco Estuary have been observed utilizing current in an energy-efficient way by "riding" flow in high current areas, and subsequently moving independently of, or even into, the flow of slower currents. The ability to detect direction of flow (rheotaxis) is important when we consider the complex localized movements and migration patterns of green sturgeon. Here, we asked whether or not visual stimuli play a significant role in green sturgeon rheotaxis behavior. Twenty-three juvenile green sturgeon (49 to 59cm in length) were placed in a large tank and exposed to four unique conditions: flow in a dark environment, flow in a lit environment, visual stimuli above the subject, and visual stimuli below the subject. The visual stimuli consisted of a large belt with alternating black and white bands that would run the length of the tank and move at the researchers' discretion. Each fish was exposed to a condition for an average of 12 minutes. The trials started with the flow or belt moving at 1m/s and increase in increments of 0.1m/s every 15 seconds until a maximum flow of 5m/s was reached. We recorded the amount of time each fish spent either positively, negatively, or neutrally oriented with respect to the presented stimulus. Rheotaxis response to each treatment is presented here.

Keywords: sturgeon, rheotaxis, behavior, orientation, flow, experiment, visual

Poster topic Area: Fish Biology, Ecology and Protection

Combining Acoustic Tag and Hydrodynamic Data to Assess Velocity Habitat Suitability for Predatory Fishes in the Sacramento-San Joaquin Delta, California

Marin Greenwood, ICF International, marin.greenwood@icfi.com

Predation of juvenile salmonids within the Sacramento-San Joaquin Delta is a major fish management concern. An important component of habitat for predatory fishes is water velocity. Infrastructure projects (e.g., for water supply) may change river flows and water velocity, but assessing the significance of the changes during planning can be challenging because information on the velocity range occupied by predatory fishes is limited. The present study assessed the velocity range occupied by predatory fishes at the San Joaquin River/Old River junction during April/May 2012. Captured predatory fishes were fitted with acoustic tags and their locations following release were estimated with a hydrophone array. Near-surface hydrodynamic data were collected with side-looking acoustic Doppler current profilers deployed near the river bank, and these data were interpolated to generate two-dimensional velocity fields for a 5-meter-by-5-meter set of grid points every 15 minutes. Each predatory fish tag detection was matched to the velocity estimate that was closest in space and time. Velocity data were binned into 0.05-meter-per-second categories and habitat suitability was evaluated as the number of detections in each velocity category divided by the total number of velocity observations within that velocity category. Channel catfish (n = 5) velocity habitat suitability was greatest at 0-0.05 m/s, intermediate at 0.1-0.25 m/s, and low at >0.3 m/s. Largemouth bass (n = 7) velocity habitat suitability was greatest at 0 m/s and declined rapidly to almost zero at velocity >0.1 m/s, which generally is consistent with published habitat suitability indices. Striped bass (n = 4) velocity habitat suitability was quite uniform across the range of velocity (0-0.45 m/s) encountered, reflecting the species' wide-ranging behavior. Results from this study can be used to give quantitative biological context to modeled velocity changes (e.g., from infrastructure projects) and will be augmented by study of additional species and locations.

Keywords: habitat suitability, predator, acoustic tag, velocity, salmonid

Poster topic: Fish Biology, Ecology and Protection

Determination of Optimal Fish Density in Experimental Systems using Physiological Stress Responses

Matthias Hasenbein* Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine, UC Davis, mhasenbein@ucdavis.edu
Nann A. Fangue, Department of Wildlife, Fish & Conservation Biology, UC Davis, nafangue@ucdavis.edu
Juergen Geist, Aquatic Systems Biology Unit, Department of Ecology and Ecosystem Management, Technische Universitaet Muenchen, Germany, geist@wzw.tum.de
Richard E. Connon, Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine, University of California, Davis, California 95616, USA, reconnon@ucdavis.edu

Fish density in holding systems can elicit stress responses that can greatly affect experimental signal-to-noise ratios, which are crucial in determining and interpreting significance in experiments related to physiological response. Optimal fish densities depend on the species, size and age, and can influence fish growth, behavior, and ultimately survival. Thus prior determination of optimal densities is important for both successful experimentation and aquaculture alike. Density determination is especially crucial for non-model species such as the endangered Delta Smelt (*Hypomesus transpacificus*), for which little-to-no density dependence information is available. The aim of this study was to determine the optimal density ranges for specific experimental vessels routinely used for delta smelt exposures. We maintained juvenile Delta Smelt (60 dph) for a period of 24 h, at five different densities: 7, 14, 28, 42, and 56 fish per 8 L circular fish tanks, at temperatures (15.8°C) and light (40.3 lux) regimes consistent with culture conditions. We assessed whole body cortisol, and transcriptomic biomarkers leading to cortisol production, via the Hypothalamus-Pituitary-Interrenal (HPI) axis. Stress levels (cortisol and change in gene expression) were lowest at densities of 28 and 42 fish per vessel whereas elevated stress levels were observed in lower densities 7 and 14 fish per vessel and highest densities of 56, suggesting an optimal juvenile Delta Smelt density in the range of 28-42 juveniles per vessels. This test further supports anecdotal observations that juvenile Delta Smelt do best when acclimated and cultured in groups rather than individually. We will present this simple but important experimental design for addressing fish densities, utilizing molecular and biochemical endpoints that are easily applicable to a broad range of fish species and exposure vessels.

Keywords: Optimal Fish Density, Stress Response, Cortisol, Molecular Biomarkers, Experimental Biology

Poster topic: Fish Biology, Ecology and Protection

Stress Response to Turbidity and Salinity utilizing Feeding Performance, Biochemical, and Molecular Biomarkers in Delta Smelt (*Hypomesus transpacificus)*

Matthias Hasenbein*, Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine, University of California, Davis, California 95616, USA, mhasenbein@ucdavis.edu
Nann A. Fangue, Department of Wildlife, Fish & Conservation Biology, University of California, Davis California 95616, USA, nafangue@ucdavis.edu
Juergen Geist, Aquatic Systems Biology Unit, Department of Ecology and Ecosystem Management, Technische Universität München, Mühlenweg 22, D-85354 Freising, Germany, geist@wzw.tum.de
Lisa M. Komoroske, Department of Wildlife, Fish & Conservation Biology, University of California, Davis California 95616, USA, lisa.komoroske@gmail.com
Richard E. Connon, Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine, University of California, Davis, California 95616, USA, reconnon@ucdavis.edu

Estuaries are amongst the most threatened and impacted ecosystems in the world and provide a unique habitat for numerous species. Turbidity and salinity are important parameters that play key roles for fish species such as the endangered Delta Smelt. We investigated turbidity (NTU) and salinity (ppt) requirements of Delta Smelt by assessing food intake, whole body cortisol and using a suite of molecular biomarkers involved in cortisol production, specific responses to salinity acclimation, and extreme turbidity (e.g. sodium potassium ATPase and glutathione-*S*-transferase). Physiological data were directly compared to feeding potential, and used towards defining the fundamental niche for delta smelt at adult, juvenile, larval stages. Endpoints indicated that the optimal salinity range for adults was above 0.2 and up to 12 ppt, and for the juvenile life stage from 2 to 6 ppt. Feeding was highly variable in adult Delta Smelt, but was not turbidity dependent. Juvenile feeding was relatively constant between 12 and 120 NTU declining significantly at 250 NTU, while larval fish showed optimal feeding performance between 25 and 50 NTU, with peak ingestion at 35 NTU. No statistical interactions were found between turbidity and salinity. Overall, turbidity affected feeding, likely by impacting the fish`s ability to visualize prey at both high and low turbidity extremes, rather than the measured physiological stress response. Salinity had a stronger effect on the physiological responses and only a minor effect on feeding performance. All life stages responded differently to turbidity and salinity exposure, indicating that the fundamental niche of Delta Smelt is life stage specific. Extrapolation of these findings to field observations could help with ecosystem management decisions in favor of the conservation of this sensitive fish species.
Keywords: Delta smelt, Turbidity, Salinity, Stress Response, Fundamental Niche

Poster topic: Fish Biology, Ecology and Protection

The Toxic Effects of Two New Herbicides on Early Life Stages of Delta Smelt (Hypomesus transpacificus)

Krista Callinan Hoffmann*, UC Davis Vet Med APC, cfcallinan@ucdavis.edu
Marie E. Stillway, UC Davis Vet Med APC, mstillway@ucdavis.edu
Linda A. Deanovic, UC Davis Vet Med APC, ladeanovic@ucdavis.edu
Swee J. Teh, UC Davis Vet Med APC, sjteh@ucdavis.edu

The control of invasive aquatic weeds in the Sacramento/San Joaquin River Delta is necessary for the protection of the environment and its beneficial uses; however safe herbicide use for non-target species must also be established. Two new herbicides, penoxsulam and imazamox, are proposed for use under the water hyacinth, *Egeria densa* and spongeplant pest control programs. Neither chemical has been extensively field tested, so there is some uncertainty regarding their effects on non-target aquatic organisms including the endangered delta smelt, *Hypomesus transpacificus*. Other current use herbicides and adjuvants have been implicated for developmental and endocrine effects in fish. This study assessed the toxicity of penoxsulam and imazamox and the adjuvant, Agridex, on delta smelt embryos and newly hatched larvae. Five replicates of twenty larvae or thirty embryos were tested, and mortality or hatching success was assessed upon test termination after 96-hour exposures and a clean water recovery period of three days (larvae) or until hatched (embryos). Results were analyzed for significant toxicant effects and interactions using generalized linear model statistics. Hatching success was not significantly affected by either of the herbicides or the adjuvant, individually, but there was a significant mixture interaction between imazamox and Agridex causing reduced hatching success at the highest mixture concentrations. Larval survival was affected by Agridex and imazamox alone (but not penoxsulam) after the 96-hour exposure and recovery period, however there was a low magnitude negative interaction between imazamox or penoxsulam in mixtures with Agridex. Results indicate that imazamox and Agridex are toxic to larval delta smelt at high concentrations, while their mixture is antagonistic. On the other hand, high concentration mixtures of imazamox and Agridex impair hatching success in delta smelt embryos, and are synergistic on this endpoint.

Keywords: imazamox, penoxsulam, Agridex, delta smelt, toxicity, hatching, mixture, herbicide, adjuvant

Poster topic: Fish Biology, Ecology and Protection

San Joaquin River White Sturgeon Spawning Survey

Zachary Jackson, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Zachary_Jackson@fws.gov
Jimmy Faukner, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, jimmy_faukner@fws.gov

The primary focus of this study was to determine if sturgeon (genus Acipenser) are spawning in the San Joaquin River in various water-year types by collecting fertilized sturgeon eggs with artificial substrate samplers. Anglers have reported capturing both White Sturgeon (*Acipenser transmontanus*) and Green Sturgeon (*A. medirostris*) in the San Joaquin River upstream from Highway 140. Several researchers have suggested that sturgeon may spawn occasionally in the San Joaquin River during high-water years but this has not been confirmed until recently. Initial documentation of White Sturgeon spawning in the San Joaquin River system occurred in 2011 (wet year type) when fertilized eggs were collected near Grayson, CA. In 2012 (dry year type), a total of 65 eggs were collected from four sites within a 24-km reach from Grayson downstream to near the confluence of the Stanislaus River. However, in both 2013 and 2014 (both critical year types) no eggs were detected within the study area. In addition, larval sampling with a benthic D-net was conducted during 2013 and resulted in no catch of larval sturgeon. Findings to date indicate that White Sturgeon spawn in the San Joaquin River in both wet and dry but not critical years. Although in both 2013 and 2014 it is possible that sturgeon spawned outside the area sampled or spawned in very low numbers that were not detected by our sampling methods. The area surveyed during our study may be an important source of production for the White Sturgeon population in the Sacramento-San Joaquin river system during some years. Understanding the spatial and temporal distribution of sturgeon in the San Joaquin River is vital for the management and recovery of this important species. Further, understanding the physical characteristics of the areas being used by sturgeon will help identify potential restoration actions.

Keywords: White Sturgeon, San Joaquin River, Spawning

Poster topic: Fish Biology, Ecology and Protection

The Sublethal Effects of Chronic Ammonia Exposure in Larval and Embryonic Delta Smelt (*Hypomesus transpacificus*)

Julie Jones*, UC Davis School of Veterinary Medicine, jujones@umail.ucsb.edu
Swee Teh, Principle Investigator at UC Davis: Anatomy, Physiology and Cell Biology: Vet Med, sjteh@ucdavis.edu

The Delta Smelt *(DS) Hypomesus transpacificus* is an endangered species endemic to the San Francisco Bay Delta-Estuary (SFBDE). The ammonia contamination of SFBDE occurring from wastewater treatment plants and agriculture runoff may play a role in *DS* population decline. In order to investigate the sublethal effects of environmentally relevant ammonia concentrations on embryonic and newly hatched larval *DS,* 3-day old embryos were exposed to six different concentrations of unionized ammonia (UIA) at a pH of 7.8. Control was set at 0.76µg/L, while treatments were 9.76, 37.39, 47.42, 90.74 and 115.20 µg/L. Ammonia exposure continued for 14 days, with embryos hatching at day 8 and larval exposure continuing through day 14. Larvae were euthanized on day 14 and fixed in 10% buffered formalin. The condition index and the yolk oil globule area were determined. Significant decreases were evident in both the condition index from the control starting at the highest UIA concentration of 115.20 µg/L and in the yolk oil globule area starting at the lowest concentration 9.76 µg/L. The yolk is separated into a lipoprotein yolk, used for energy and structural development during embryogenesis, and the oil globule, which acts as an energy reserve of calories during larval development. The decrease in oil globule area implies that there is an increase in energy requirements when exposed to UIA. Similar studies on the topic have exhibited an increase in expression of sodium/potassium (NK)-ATPase on gill epithelium in fish that have been exposed to UIA. The up-regulation of NK-ATPase due to increase UIA may be the cause for increased energy use, resulting in decreased oil globule size and decreased condition index. To further investigate, staining for increased expression of NK-ATPase on fixed samples of larvae is planned for the next phase of this study.

Keywords: Sublethal effects of chronic ammonia exposure on Delta Smelt

Poster topic: Fish Biology, Ecology and Protection

Physiological Responses of Delta Smelt to Low Salinity Acclimation

Brittany Kammerer, University of California, Davis, bdkammerer@ucdavis.edu
Randy Baxter, California Department of Fish and Wildlife, Randy.Baxter@wildlife.ca.gov
Swee J. Teh, Aquatic Health Program, University of California, Davis, sjteh@ucdavis.edu

The influence of freshwater (FW) diversion and global climate change reduce Delta outflows in the San Francisco Bay-Delta (SFBD) resulting in decreased size of the low salinity zone (LSZ) and its movement upstream. Decreased LSZ and entrainment as it approaches Delta export facilities is a problem facing pelagic fishes; Delta smelt (DS) is endangered. DS distribute throughout the LSZ and are spawning in FW. To determine salinity effects on DS as they move through the LSZ, we exposed adult DS (3.16±0.36 g, 78.42±2.74mm), fed 2% body mass per day, to salinities 0 to 10 parts per thousand (ppt) increased incrementally at 4 ppt/week over 19 days relative to FW controls. DS (n= 4/tank for 3 tanks/treatment) were weighed, measured, and sampled for analysis of hematocrit and plasma osmolality, gill chloride cell (CC) Na^+/K^+-ATPase (NKA) and apoptosis, and muscle water content at 1, 3, and 4 days post-salinity increase in both treatments. No apparent increase in length ($p=0.466$) or weight ($p=0.397$) occurred, nor did a difference in survival ($p=0.859$) between treatments over time. However, blood hematocrit ($p<0.05$) and plasma osmolality ($p<0.001$) became elevated just after increases in salinity and then decreased back to near FW after 4 days. Likewise, CCs showed increased apoptosis ($p<0.05$), NKA ($p<0.005$), and cell size ($p<0.005$) over time, indicating that renewal to salinity-tolerant CCs occurs. Muscle water content also increased by 3 days post-salinity increase ($p=0.015$), though was not different from FW by 4 days ($p>0.05$), indicating like hematological data, that osmoregulatory changes in CCs regulate DS's transition to brackish water. The process takes days at this rate, and likely comes at an energetic cost. While there are many stressors DS encounter in the SFBD, our data shows that utilization of biomarkers developed in this study have potential for long-term monitoring of DS in response to salinity.

Keywords: Delta smelt, salinity, physiological responses, environmental stressors, low salinity zone

Poster topic: Fish Biology, Ecology and Protection

Screening of Infectious Pathogens in Wild Striped Bass and Delta Smelt Populations using Next Generation Sequencing Technology

Tomofumi Kurobe, UC Davis, tkurobe@ucdavis.edu
Gary Wu, UCDavis, grywu623@gmail.com
Dolores Baxa, UC Davis, dvbaxa@ucdavis.edu
Swee Teh, UC Davis, sjteh@ucdavis.edu

Understanding the prevalence and pathogenicity of infectious agents are important for the protection of wild and captive fish populations. Cell-based screening is traditionally used for virus detection, however this method is not always practical due to the requirement for stable cell lines specific to the host species. The affinity between virus and cell type is another factor for successful virus replication. Although various types of pathogens are likely affecting wild fishes in the San Francisco Estuary (SFE), few infectious agents have been identified. To overcome the difficulties associated with specific identification of fish pathogens, we applied a cutting edge sequencing technology for pathogen screening. Genomic DNA from striped bass and delta smelt caught in the SFE were pooled and used for shotgun sequencing using the MiSeq System (Illumina) at UC Davis Sequencing Core. Over 10 million sequences were generated and processed using various bioinformatics programs for the assessment of sequence quality and assembly, and BLAST similarity search. We successfully obtained DNA fragments showing similarity to infectious fish pathogens such as *Mycobacterium marinum*, herpesviruses, and other environmental isolates. The fish used in this study did not show any clinical signs suggesting they harbored latent infections. Our results suggest that the Next Generation Sequencing Technology will benefit ongoing fish health surveys and the Delta Smelt Conservation Program by providing a tool for quantifying pathogen gene copies as indicators of prior exposure to the pathogen. The latent state (non–lethal DNA carriers) and active infections (overt diseases) are potential risk factors that may alter the health of wild and captive fish populations in the SFE. Pathogens are among the least studied stressors affecting the health of aquatic species with declining populations in the SFE; fits the goal of the Ecosystem Restoration Program.

Keywords: Next Generation Sequencing Technology, striped bass, delta smelt, Mycobacterium, herpesviruses

Poster topic: Fish Biology, Ecology and Protection

Reproductive Biology of Female Delta Smelt and Their Life History Model in the San Francisco Delta

Tomofumi Kurobe, School of Veterinary Medicine (SVM), Department of Anatomy, Physiology, and Cell Biology (DAPCB), UC Davis, tkurobe@ucdavis.edu
Micheal Park, SVU, DAPCB, UC Davis, michaelowenpark@gmail.com
Shawn Acuña, Metropolitan Water District of Southern California, SAcuna@mwdh2o.com
Ramos Alejandro, SVM, DAPCB, UC Davis, aruiz@ucdavis.edu
Alireza Javidmehr, SVM, DAPCB, UC Davis, ajavidmehr@ucdavis.edu
Dolores Baxa, SVM, DAPCB, UC Davis, dvbaxa@ucdavis.edu
Saikrithika Gandhi, SVM, DAPCB, UC Davis, saikrithi@gmail.com
James Hobbs, Wildlife, Fisheries and Conservation, UC Davis, jahobbs@ucdavis.edu
Alan Conley, SVM, Dept. of Population Health and Rep., UC Davis, ajconley@ucdavis.edu
Swee Teh, SVM, DAPCB, UC Davis, sjteh@ucdavis.edu

Problem Statement: Delta smelt (*Hypomesus transpacificus*) is a pelagic fish species endemic to the San Francisco Delta, which has been listed as endangered under Federal and State regulations. Understanding reproductive biology is critically important for protection of the endangered fish species.
Approach: In this study, we established accurate scoring criteria for female maturity levels based on histological changes in ovary and analyzed the reproductive status for the 2011 cohort, caught from December 2010 through April 2011.
Results: Staging based on histological examination revealed that 1) delta smelt oocytes underwent dramatic maturation changes in late February through April, and 2) delta smelt migrate towards low salinity zones (< 1 PSU) for spawning. The presence of postovulatory follicles and various stages of immature oocytes (Stage 2 to 3) in the ovary suggest that delta smelt are multi-spawning species, capable of reproducing several times over the course of their lives. Results indicate that our method provides a powerful approach to evaluate reproductive fitness of delta smelt. Furthermore, we will attempt to consolidate findings from the past scientific publications and propose a delta smelt life history model for their migration pattern and reproductive fitness in the San Francisco Delta.
Conclusion/Relevance: Information presented in this study enhances understanding of delta smelt's reproductive biology, migration pattern, and possible spawning ground, which can be further used to support management programs to protect their wild populations.

Keywords: Delta Smelt, Reproductive Biology, Migration Pattern

Poster topic: Fish Biology, Ecology and Protection

Use of Video Cameras in Monitoring

Katrina Martens, Cramer Fish Sciences, katrina.martens@fishsciences.net
Paul Bergman, Cramer Fish Sciences, pbergman@fishsciences.net
Kirsten Sellheim, Cramer Fish Sciences, kirstens@fishsciences.net
Joseph Merz, Cramer Fish Sciences, jmerz@fishsciences.net

Video cameras are commonly used as a tool to monitor organism behavior; however, the use of underwater video has become more prevalent in recent years for fisheries applications as video cameras have become smaller, higher resolution, more cost-effective, and more customizable. Stationary video cameras coupled with other passive monitoring equipment (i.e., infrared, sonar, electronic counters, etc.) have become commonplace for use at resistance board weirs, passageways, and fish ladders. Sites with direct power have the luxury of connecting high-resolution video cameras to computers, digital video recorders (DVR), and motion detection software to reduce user review time.

This poster describes applications, and challenges, of underwater video as a technique to quantify and observe aquatic organisms in riverine habitats. We describe several studies that have used video technology to quantify salmonids and non-native predators, document spawning activity of an endangered fish species, and experimentally test utilization of habitat structures by juvenile salmonids within habitat restoration sites. These studies have implications for both short- and long-term monitoring efforts and for habitat restoration project design.

Keywords: Restoration, monitoring, video, central valley, salmon

Poster topic: Fish Biology, Ecology and Protection

Employing Multiple Strategies to Restore Connectivity, Fish Populations and Aquatic Habitat in the Cosumnes, Mokelumne and Calaveras Rivers

Donald Ratcliff, US Fish and Wildlife Service, Anadromous Fish Restoration and National Fish Passage Programs, donald_ratcliff@fws.gov

The Cosumnes, Mokelumne and Calaveras rivers differ significantly in many respects yet are all uniquely tied to conditions in the Sacramento – San Joaquin Delta due to their close proximity and relatively short anadromous reaches. A combination of habitat improvements, aquatic passage projects and water management operations has been employed recently in these systems to improve connectivity and increase the production of salmonids within each system individually and all systems collectively. A review of ongoing and planned future projects and efforts to address limiting factors to connectivity and production in these three rivers will be presented. In the Cosumnes River, upstream passage of adult salmonids was viewed as the highest priority limiting factor and the last two non-natural barriers in the system were addressed in 2010 and 2011. In the Mokelumne River, spawning and rearing habitat limitation and inadequate migration flows are currently being addressed via habitat restoration projects and adaptive management of water releases and facility operations within the river and beyond. On the Calaveras River, adult and juvenile passage and limiting migration flows are being addressed through fish passage improvements and coordinated flow releases when possible. In addition to the efforts on individual systems, opportunities to restore floodplain habitats that will benefit juveniles from these three systems and other Central Valley rivers are being developed. These efforts shown positive results in fish populations and significantly increased the ability to accomplish challenging projects. While an ever increasing set of demands is placed on these systems that make fisheries and aquatic habitat management challenging, collaborative efforts to manage each system individually and all systems collectively shows great promise to protect and enhance important aquatic resources. These improvements will be an important part of the success of larger-scale efforts to restore and manage resources throughout the Bay-Delta system.

Keywords: Cosumnes, Mokelumne, Calaveras, Connectivity, Passage, Flow Management, Collaboration

Poster topic: Fish Biology, Ecology and Protection

2014 Georgiana Slough Floating Fish Guidance Structure Performance Evaluation

Ryan Reeves, California Department of Water Resources, Bay-Delta Office, ryan.reeves@water.ca.gov

In response to a 2009 NMFS Biological and Conference Opinion for the Long-Term Operations of the Central Valley Project and State Water Project, DWR has been investigating engineering optionsto reduce the diversion of juvenile salmonids into the interior and southern Delta where survival is lower. In 2011 and 2012 DWR led an evaluation of a non-physical barrier using Bio-Acoustic Fish Fence™ (BAFF) technology at the divergence of Georgiana Slough and the Sacramento River. During these studies, it was observed that the probability of outmigrating salmonid entrainment into Georgiana Slough was significantly reduced; and that the observed entrainment probability was dependent on salmonid cross-stream distribution with or without the barrier. It was hypothesized that similar or improved entrainment reduction could be achieved by simply re-distributing a portion of the fish away from Georgiana Slough. Based on this hypothesis, DWR conducted a study in 2014 utilizing a simpler technology —a floating fish guidance structure (FFGS). A primary component of the 2014study experimental design was to release uniquely tagged (acoustic tags) juvenile late fall–run Chinook salmon into the Sacramento River near the City of Sacramento, approximately 33 miles upstream of Georgiana Slough and track their movements near the FFGS and throughout the larger Delta system. The study design included a total of 25 hypotheses that were formulated to inform the following study objectives: assess reach-scale route selection and survival of juvenile Chinook salmon; assess temporal distribution of juvenile Chinook salmon at arrival in FFGS area; assess predation and predatory fish behavior in the vicinity of the FFGS; assess far-field movements of predatory fishes and Chinook salmon juveniles; assess alternative hypotheses specific to barrier function; and compare effectiveness of the FFGS and the BAFF technologies and between years. The poster presentation will provide preliminary results of the study as well as future management directions.

Keywords: acoustic tag, salmonid, Georgiana Slough, fish barrier

Poster topic: Fish Biology, Ecology and Protection

Identifying When Tagged Fishes Have Been Consumed By Piscivorous Predators: Application of Multivariate Mixture Models to Movement Parameters of Telemetered Fishes

Jason Romine, USGS, WFRC, CRLL, jromine@usgs.gov
Russell Perry, USGS, WFRC,CRRL, rperry@usgs.gov
Samuel Johnston, Hydroacoustic Technology Inc., sjohnston@htisonar.com
Chris Fitzer, Environmental Science Associates, Inc., CFitzer@esassoc.com
Steve Pagliughi, AECOM, Steve.Pagliughi@aecom.com
Aaron Blake, USGS, CAWSC, ablake@usgs.gov

Consumption of telemetered fishes by piscivores is problematic for telemetry studies because tag detections from the piscivore could introduce bias into the analysis of telemetry data. We illustrate the use of multivariate mixture models to estimate group membership (smolt or predator) of telemetered juvenile Chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead trout (*O. mykiss*), striped bass (*Morone saxatilis*), smallmouth bass (*Micropterus dolomieu*) and spotted bass (*M. punctulatus*) in the Sacramento River, CA, USA. First, we estimated two types of track statistics from spatially explicit two-dimensional movement tracks of telemetered fishes: the Lévy exponent (b) and tortuosity (τ). Second, we hypothesized that the distribution of each track statistic would differ between predators and smolts. To estimate the distribution of track statistics for putative predators and smolts, we fitted a bivariate normal mixture model to the mixed distribution of track statistics. Lastly, we classified each track as a smolt or predator using parameter estimates from the mixture model to estimate the probability that each track was that of a predator or smolt. Tracks classified as predators exhibited movement that was tortuous and consistent with prey searching tactics, whereas tracks classified as smolts were characterized by directed, linear downstream movement. We correctly classified 90% of the *Micropterus* species and 72% of the striped bass as predators. For tagged smolts, 80% of Chinook salmon and 74% of steelhead trout were not classified as predators. Mixture models proved valuable as a means to differentiate between salmonid smolts and predators that consumed salmonid smolts. However, successful application of this method requires that telemetered fishes and their predators exhibit measurable differences in movement behavior. Our approach is flexible, allows inclusion of multiple track statistics and improves upon rule-based manual classification methods.

Keywords: Telemetry, predation, Striped bass, Micropterus, Chinook salmon smolt

Poster topic: Fish Biology, Ecology and Protection

Finding the Females: Developing a Novel Tool to Investigate the Skewed Bay Delta Striped Bass Sex Ratio

Andrea Schreier, Department of Animal Science, University of California Davis, amdrauch@ucdavis.edu
Brian Schreier, California Department of Water Resources, bschreie@water.ca.gov
Scott Brandl, Department of Animal Science, University of California Davis, scbrandl@ucdavis.edu
Ted Sommer, California Department of Water Resources, Ted.Sommer@water.ca.gov

Recruitment of Bay Delta Striped Bass (*Morone saxatilis*), an apex predator and economically important sport fish, has been decreasing despite a stable adult population. A trend in declining female abundance on the Sacramento River spawning grounds from 1970s - 2008 and decreases in female size and age suggests that reduced egg availability may have contributed to low recruitment. The cause of female decline is unknown, although it is hypothesized that environmental factors or sex specific behavioral differences may be responsible. We propose to develop a novel tool that will allow biologists to test alternative hypotheses about the decline in Striped Bass female spawners. Here, we provide updated sex ratio data for the 2014 Striped Bass spawning run and describe proposed research to design a genetic sex marker that will non-invasively determine the sex of Striped Bass of any size/age class using only a small tissue sample. Currently Striped Bass sex ratio data is collected through dissection of ripe adults harvested on the spawning grounds but a genetic sex marker would allow biologists to determine sex of immature individuals and pinpoint the spatial and temporal extent of the sex ratio skew. Once the cause of the female Striped Bass decline is determined, managers can develop strategies to increase female abundance and restore recruitment to preserve this popular sport fishery.

Keywords: Striped Bass, Recruitment, Sex Ratio, Sex-Specific Behavior

Poster topic: Fish Biology, Ecology and Protection

Juvenile Salmonid Utilization of Floodplain Rearing Habitat after Gravel Augmentation in a Regulated River

Kirsten Sellheim, Cramer Fish Sciences, kirstens@fishsciences.net
Clark Watry, Cramer Fish Sciences, clarkw@fishsciences.net
Ben Rook, Cramer Fish Sciences, rook_ben@hotmail.com
Steven Zeug, Cramer Fish Sciences, stevez@fishsciences.net
John Hannon, U.S. Bureau of Reclamation, jhannon@usbr.gov
Julie Zimmerman, U.S. Fish and Wildlife Service, julie_zimmerman@fws.gov
Karin Dove, Cramer Fish Sciences, karin.dove@fishsciences.net
Joseph Merz, Cramer Fish Sciences, jmerz@fishsciences.net

Gravel augmentation is used in sediment-starved streams to improve salmonid spawning habitat. As gravel is added to river channels, water surface elevations rise in adjacent areas, activating floodplain habitat at lower flows and with greater frequency, potentially affecting the quantity and quality of juvenile salmonid rearing habitat. We analyzed five years of juvenile Chinook salmon *Oncorhynchus tschawytscha* and steelhead *O. mykiss* data from snorkel surveys before and after gravel augmentation in a regulated river in California's Central Valley. We measured the quality and quantity of rearing habitat (current velocity and areal extent of inundated riparian vegetation) following gravel placement and tested whether these factors affected juvenile abundance.

Gravel augmentation increased floodplain extent, and rearing habitat conditions (current velocity, vegetative cover) improved significantly. Juvenile abundance increased significantly for both species following augmentation; however, the strength of the relationship between abundance and habitat variables was greater for smaller fish. These results suggest that, in addition to enhancing salmonid spawning habitat, gravel augmentation can improve rearing habitat where channel incision and/or regulated hydrographs disconnect floodplains from main river channels.

Keywords: habitat improvement, fishery resources, restoration, rivers, salmon

Poster topic: Fish Biology, Ecology and Protection

Determining the Feasibility of Fish Passage, Calaveras Dam Replacement Project, California

Jonathan Stead, URS, jon.stead@urs.com
Craig Freeman, San Francisco Public Utilities Commission, cfreeman@sfwater.org
Steve Leach, URS, steve.leach@urs.com
Susan Hou, San Francisco Public Utilities Commission, shou@sfwater.org

The Calaveras Dam Replacement Project involves design and construction of an embankment replacing the 220ft-high Calaveras Dam, which impounds Calaveras Reservoir, the largest drinking water storage reservoir in the San Francisco Bay Area, for the San Francisco Public Utility Commission (SFPUC) Hetch Hetchy Regional Water System. The dam is located in a region containing sensitive habitats and special-status species, including Central California Coast Steelhead. Regulatory requirements for construction of the replacement dam prompted SFPUC to evaluate dam operations and aquatic habitat conditions in the watershed. In pursuit of project approval, the project team evaluated fish passage issues (both man-made and natural) downstream, at, and upstream of the replacement dam in order to identify feasible measures that SFPUC could implement as part of the project and balance with water supply requirements. One complicated alternative--a fish ladder over the replacement dam--was examined, demonstrated to be infeasible, removed from consideration by regulatory agencies, and dropped as a proposal by members of the concerned public. Other fish passage options at alternate locations were examined and determined to be feasible and consistent with the operation of the replacement Calaveras Dam, leading to acquisition of required resource agency permits for construction and operation of the project, as well as gaining support of the project by members of the concerned public. Early initiation of the studies conducted at other locations in the watershed was critical to provision of information in a timely manner that allowed completion of the environmental and permitting processes without delays to the overall project schedule.

Keywords: fish passage, Calaveras, Alameda Creek, steelhead, dam, watershed, permit, SFPUC

Poster topic: Fish Biology, Ecology and Protection

Does Gravel Size Influence Benthic Macroinvertebrate Density, Biomass and Feeding Guild Composition?

Jamie Sweeney, Cramer Fish Sciences, jamie.sweeney@fishsciences.net
Joseph Merz, Cramer Fish Sciences, jmerz@fishsciences.net
Kirsten Sellheim, Cramer Fish Sciences.net, kirstens@fishsciences.net

There has been an increase in river restoration projects on regulated California Central Valley rivers due to undesired anthropogenic effects (e.g. dams, diversions, agriculture, levees and urban development). These effects interrupt and reduce the quantity and quality of bed sediment substrates necessary for anadromous salmonid spawning and also reduce essential ecosystem processes important to rearing juvenile salmonids. Aquatic macroinvertebrate production is an example of an ecosystem process that has been altered because assemblage richness and composition is generally influenced by substrate size. Aquatic macroinvertebrates play a pivotal role in river ecosystem functions including prey sources for juvenile anadromous salmonids. Gravel augmentation is a widely accepted technique for restoring anadromous salmonid spawning habitats throughout the Central Valley. We examined the effects of gravel augmentation on colonization and composition of aquatic macroinvertebrates by comparing density, biomass and community structure among three different substrate sizes (small, medium and large) in a gravel augmented area on the lower American River, a regulated Central Valley stream. Our observations show that large gravel produced significantly higher macroinvertebrate density than small and medium substrate which suggests that larger gravel may support increased forage production for juvenile salmonids. Large gravel has lower total surface area, but provides more stable substrate and interstitial spaces that are accessible to both macroinvertebrates and juvenile salmonids. Although larger sized gravel had a higher density of benthic macroinvertebrates, the biomass did not differ significantly between medium and large gravel. Therefore, because medium-sized gravel produces more optimal spawning habitat, it may ultimately be the most appropriate strategy for augmentation to simultaneously enhance habitat and prey productivity for multiple salmonid life stages.

Keywords: Restoration, ecology, habitat, salmon, macroinvertebrate communities, density, Central Valley

Poster topic: Fish Biology, Ecology and Protection

An Integrated Approach for Health Assessment of the Endangered Delta Smelt (*Hypomesus transpacificus*)

Swee Teh, Aquatic Health Program, sjteh@ucdavis.edu
Randall Baxter, California Department of Fish & Wildlife, Randy.Baxter@wildlife.ca.gov
Dolores Baxa, Aquatic Health Program, dvbaxa@ucdavis.edu
Steve Slater, California Department of Fish & Wildlife, Slater, Steve@Wildlife.ca.gov
Tomofumi Kurobe, Aquatic Health Program, tkurobe@ucdavis.edu
Alejandro Ruiz Ramos, Aquatic Health Program, aruiz@ucdavis.edu
Georgia Ramos, Aquatic Health Program, tigresaramos@gmail.com
Gary Wu, Aquatic Health Program, grywu623@gmail.com
Shawn Acuna, Metropolitan Water District of Southern California, SAcuna@mwdh2o.com
James Hobbs, Wildlife, Fish and Conservation Biology, jahobbs@ucdavis.edu

Biological monitoring of the health of wild fish populations is challenging, especially when dealing with a small and sensitive fish such as the endangered delta smelt (*Hypomesus transpacificus*), a species of management concern and an important indicator species of the health of San Francisco Estuary ecosystem. To maximize the range of health information for smelt, we conducted multiple tissue collections and bioassays from individual fish, which from a large number of fish was a huge task to accomplish in field and laboratory settings and required enormous time and manpower. Here, in contrast with the traditional approach, we report an integrated approach of establishing the health status of an individual smelt by assessing a large suite of biological endpoints using a liquid nitrogen preservation method. Fish were obtained from the long-term monitoring surveys in collaboration with the California Department of Fish and Wildlife. Individual fish wrapped in a pre-labeled aluminum foil was immediately flash-frozen in liquid nitrogen and transported to UC Davis at the end of each field day. Flash-frozen fish were stored in liquid nitrogen to accommodate weekly necropsy schedules where multiple organs of individual fish were processed for aging, body and organ conditions, diseases, enzymes, histopathology, nutrition, and reproduction. Parallel tissues (fresh vs. frozen) were compared for each biological endpoints to evaluate the diagnostic accuracy of our method. Integrating multiple biological endpoints from a single fish will improve our understanding of fish health following exposure to multiple environmental stressors and if the cumulative responses may provide insights to vita functions such as growth, survival, and reproduction. Research to develop a qualitative understanding of physicochemical and contaminants stressors directly affecting the growth, survival, and reproduction of delta smelt fits the goal of the Ecosystem Restoration Program.

Keywords: Delta Smelt, Indicator Species, Flash-Frozen, Individual Health Assessment

Poster topic: Fish Biology, Ecology and Protection

Health of Juvenile Delta Smelt (*Hypomesus transpacificus*) in Summer 2012 and 2013

Swee Teh, Aquatic Health Program, sjteh@ucdavis.edu
Alejandro Ruiz Ramos, Aquatic Health Program, aruiz@ucdavis.edu
Steve Slater, California Department of Fish and Wildlife, Slater, Steve@Wildlife.ca.gov
Randall Baxter, California Department of Fish and Wildlife, Randy.Baxter@wildlife.ca.gov
Dolores Baxa, Aquatic Health Program, dvbaxa@ucdavis.edu
Tomofumi Kurobe, Aquatic Health Program, tkurobe@ucdavis.edu
Sai Krithika, Aquatic Health Program, saikrithi@gmail.com

This one-year study examines the health status of juvenile delta smelt (*Hypomesus transpacificus* sampled from the 2012 and 2013 Summer Townet Survey of the California Department of Fish and Wildlife from certain regions of interest: Suisun Bay, Sacramento and San Joaquin river confluence, and the Cache slough/Sacramento Deep Water Ship Channel (CS/SDWSC). Water temperature during fish collection (June and August) was higher in 2012 than in 2013. Compared to 2013, juvenile smelt in 2012 were relatively: 1) smaller, weighed less, and have lower hepatosomatic and condition indices), 2) lower in primary long-term reserve energy (muscle triglyceride) for growth and maturation, 3) lower in secondary short-term reserve energy (liver glycogen) for tissue repairs and growth, and 4) lower in stomach fullness, sum of prey wet weight, and %stomach body weight. When juveniles are separated by size, fish with 26-34 mm total length (TL) showed lower stomach fullness, sum of prey wet weight and muscle triglyceride in 2012 than 2013. Although fish at the 35-55 mm TL range had lower stomach fullness and sum of prey wet weight, they exhibited a higher muscle triglyceride in 2012 than 2013. Across regions, juveniles capture at CS/SDWSC had relatively lower stomach fullness, sum of prey wet weight, and muscle triglyceride in 2012 than 2013, regardless of size. As water temperature has a significant effect on fish metabolism, the lower temperature may have provided better habitats or potentially more food resources for juvenile smelt. Although multi-stressors generally impacted the health of juvenile smelt in the summer of both years, the fish showed greater nutritional capacity (in terms of energy reserve and stomach fullness) in 2013. These results suggest that the state of nutritional health may alter the severity of stressor effects, overall contributing to a relatively healthier juvenile smelt in summer of 2013 than in 2012.

Keywords: Juvenile delta smelt, summer townet, triglyceride, stomach, temperature

Poster topic: Fish Biology, Ecology and Protection

Warming Water Temperatures in California's Central Valley: Potential Effects on Upstream Salmonid Habitat Conditions

Rick Wilder, ICF International, rick.wilder@icfi.com
Cathy Marcinkevage, National Marine Fisheries Service, cathy.marcinkevage@noaa.gov

Elevated water temperature associated with future climate change has the potential to become a major stressor for Central Valley salmonids with restricted access to cooler historical spawning and rearing habitat. In this study, we assessed effects of water temperature increases due to climate change over the next 50 years on threatened and endangered salmonids in the upper Sacramento, Feather, and American rivers. To assess effects, we employed a novel "degree-day/degree-month" technique that combines both the frequency and magnitude of exceedance of modeled water temperatures above regulatory water temperature thresholds under current and future climate conditions. Our analysis predicts that salmonids will experience a consistent two- to three-fold increase in suboptimal temperature conditions during much of their upstream freshwater residence within the next 50 years. We offer potential management solutions for improving the likelihood of sustaining Central Valley salmonid fisheries in the future, including expanding upstream habitat, promoting life history diversity, and altering water management strategies. We found that our analytical technique could be an effective screening tool for biological evaluation because of similarities in results to more elaborate biological models, but without the additional effort needed to run those models.

Keywords: climate change, salmonids, water temperature, modeling, threshold, degree-day

Poster topic: Fish Biology, Ecology and Protection