# Fall Run Chinook (*Oncorhynchus tshawytscha*) Salmon Upstream Migration in California's Central Valley

H. Steve Taso, California Department of Fish and Wildlife, steve.tsao@wildlife.ca.gov
Robert Vincik, California Department of Fish and Wildlife, robert.vincik@wildlife.ca.gov
Tim Heyne, California Department of Fish and Wildlife, tim.heyne@wildlife.ca.gov

Acoustic telemetry technology has evolved and improved over the past 10 years enabling researchers and agencies to more accurately study the movements of a variety of fish species. In California's Central Valley, researchers and agencies have deployed an array of acoustic hydrophones in conjunction with the use of acoustic tags to study anadromous fish such as sturgeon (*Acipenser spp.*), Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead rainbow trout (*Oncorhynchus mykiss*). These acoustic arrays of receivers cover the length of the freshwater rivers in the Central Valley all the way down to the Golden Gate Bridge and in the Pacific Ocean. California Department of Fish and Wildlife (CDFW) conducted an adult Chinook salmon tracking study using acoustic telemetry targeting the area around the Delta Cross Channel, a man-made canal that moves Sacramento River water into the South Delta. Fifty-eight Chinook salmon were implanted with acoustic tags and released in the San Joaquin River near Jersey Point and Santa Clara Shoal in 2012. Using the detection data that is shared by researchers and agencies, we were able to construct migration timing and pattern of each tagged Chinook salmon.

Adult Chinook salmon spawning migration is poorly understood in California's Central Valley. Limited data is collected about adult salmon spawning migration, timing and movement. Scientists hypothesize adult fall-run Chinook salmon rear in the Delta or river and migrate to spawning ground when river condition is optimal such as increasing river flow and/or decreasing river temperature. Results indicate adult Chinook salmon are capable of traveling between Sacramento and San Joaquin River Basin before they reach their final spawning ground. Salmon exhibit active searching pattern during their upstream migration using different river channel or slough in the Delta, and similar searching pattern is demonstrated in studies conducted in Columbia River Basin.

**Keywords:** Telemetry, Chinook, Upstream Migration, California's Central Valley.

**Poster Topic:** Fish: Chinook Salmon

# Tracking Migration and Survival of Juvenile Winter Run Chinook Salmon in the Sacramento River and Delta

Jason Hassrick, NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, jason.hassrick@noaa.gov
Arnold Ammann, NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, arnold.ammann@noaa.gov
Robert Null, U.S. Fish and Wildlife Service, Robert_Null@fws.gov
John Reuth, U.S. Fish and Wildlife Service, John_Reuth@fws.gov
Sean Hayes, NOAA Southwest Fisheries Science Center, Fisheries Ecology Division, sean.hayes@noaa.gov

Winter run Chinook salmon are state- and federally listed as endangered. In the past six years (2007–2012), spawning escapement has declined, with 3-year cohort replacement rates consistently less than 1.0. In 2011, the estimated total return was 824 fish, the lowest since the early 1990s. The causes of this decline are poorly understood.

We have put in place a system of monitors that will generate new information on salmonid movement and survival at such a fine spatial and temporal scale as to allow assessment of how specific areas and events affect salmonids. Hatchery-raised winter run were acoustically tracked from their source points to evaluate reach-specific survival rates to the Delta and beyond. Winter run are known to spend a larger portion of their life in the river than other runs, potentially pausing at unknown locations for rearing opportunities.

Cumulative survival estimates for 150 winter run smolts tagged in 2013 showed 80% of juveniles died in the upper Sacramento River. We have identified a 55 km region of rearing/holding period for the surviving 20% between Ord Bend and Colusa (Rkm 325). Juveniles remained within this stretch of river as long as 30 - 40 days. Causes of mortality in the upper river are unknown and more acoustic tracking data are needed to increase confidence intervals to determine whether mortality is also high further downstream.

Poor river and/or delta conditions are likely to have impacted salmon survival in recent years. Our findings suggest that juvenile winter run in-river survival is among the lowest of Central Valley Chinook salmon runs. Targeted recovery efforts focused on improving juvenile salmon survival on their way to the ocean should be a high priority for management of Central Valley salmon and can be informed by these high resolution projects that identify areas of peak mortality.

**Keywords:** Winter Run Chinook, Central Valley, Sacramento River, Acoustic tracking, JSATS,

**Poster Topic:** Fish: Chinook Salmon

# Modeling Variability in Central Valley Chinook Populations Using Linked Statistical Life-Cycle Models

Curry Cunningham*, School of Fisheries and Aquatic Sciences, University of Washington, curryc2@uw.edu
Noble Hendrix, QEDA Consulting, LLC, noblehendrix@gmail.com
Ray Hilborn, School of Aquatic and Fisheries Sciences, University of Washington, rayh@uw.edu

Chinook salmon (*Oncorhynchus tshawytscha*) populations spawning in the Sacramento River, CA and its tributaries have demonstrated high variability, and in some cases significant declines in spawning abundance during the past 40 years. The purpose of this research is to provide a quantitative framework for assessing the influence of both environmental and anthropogenic factors on the survival of Chinook populations in the Central Valley. We employ a stage-structured population dynamics model to evaluate the influence these factors have on productivity and capacity limitations resulting from an interaction among co-migrating CV Chinook natural populations in addition to hatchery stocks. The stage transitions are modeled using Beverton-Holt functions, in which the productivity and capacity parameters of the function are further modeled as a function of the hypothesized factors and abundances of co-migrating populations. The population dynamics model generates predicted abundance for returning spawners and out-migrating juveniles in each year as a function of the hypothesized factors and their associated coefficients. The coefficients are subsequently estimated by using a statistical fitting algorithm that minimizes the error between model predictions and observed abundances. Alternative models (hypotheses incorporating different combinations of factors) are compared using the Akaike Information criterion (AICc) to balance model complexity with model fit.

**Keywords:** Life-Cycle Model, Density Dependence, Winter-Run Chinook, Beverton Holt, Stage-Structured

**Poster Topic:** Fish: Chinook Salmon

# The Effects of Flow on Size of Outmigrating Chinook Salmon Smolts in the San Joaquin River

Gretchen Murphey, California Department of Fish and Wildlife, Gretchen.Murphey@wildlife.ca.gov
Crystal Sinclair-Seay, California Department of Fish and Wildlife, Crystal.Sinclair@wildlife.ca.gov

San Joaquin River flows have been severely impacted by dams impounding water for irrigation, on both the main stem and its three northern tributaries. It is generally acknowledged that Chinook salmon are directly impacted by water flow (PFMC, 2012), but there is still disagreement regarding the extent to which flows influence survival of Chinook populations. Studies demonstrate that survival rates of juvenile Chinook improve when they outmigrate at a larger size (Martin and Wertheimer 1989; Bilton 1984; Beckman et al. 1998). We hypothesize that juvenile Chinook salmon migrating through the lower San Joaquin River during wet years are larger than juveniles migrating during dry years which in turn would increase outmigration survival. We used the Vernalis Adaptive Management Plan water year types to select wet years and dry years in an effort to address this essential resource management question. A Kodiak trawl at Mossdale on San Joaquin River has been done since 1988 to monitor and estimate the population of Chinook salmon outmigrating from the Tuolumne, Merced and Stanislaus Rivers. We analyzed that data and determined that forklength of outmigrating juvenile Chinook salmon smolts in the wet years of 2005 and 2006, was in fact greater than in the dry years, 2001 and 2002, supporting our hypothesis that fish outmigrate at an overall larger size in wet years. Using data provided by the California Data Exchange Center we analyzed flows and water temperature in terms of their potential influence on this size shift between water year types. This difference in fish length was not found to be associated with timing of oumigration between water year types. These analyses show that Chinook salmon smolts are outmigrating through the lower San Joaquin River at a larger size in wet years than dry years which in turn has been shown to improve survival.

**Keywords:** Streamflow, Outmigration, Growth, Watershed Management, Chinook

**Poster Topic:** Fish: Chinook Salmon

# Investigating Food Limitation of Planktivorous Fish in the San Francisco Estuary: The Functional Response of Delta Smelt

Lindsay Sullivan, Romberg Tiburon Center for Environmental Studies, ljswr@sfsu.edu
Jorge Ruiz, California State University Stanislaus, jruiz4@csustan.edu
Wim Kimmerer, Romberg Tiburon Center for Environmental Studies, kimmerer@sfsu.edu
Joan Lindberg, Department of Biology and Agricultural Engineering, University of California, Davis, lindberg@steeper.us

Declines in several species of planktivorous fish in the San Francisco Estuary (SFE) have been correlated to changes in the abundance and distribution of their zooplankton prey. These correlations provide evidence that changes in food supply may be contributing to the decrease in fish abundance. Over the past two decades, there has been a shift in the species composition of zooplankton in the SFE from a community dominated by numerous large (>1 mm) calanoid copepods to one dominated by a small (~0.5 mm) introduced cyclopoid copepod, *Limnoithona tetraspina*. Because food intake by the early life history stages of fish is restricted by gape (i.e., what they can fit in their mouths) and detection (i.e., what they can see), the accessibility of prey can be significantly influenced by its size. Thus, we quantified the ingestion of larval and early juvenile delta smelt (*Hypomesus transpacificus*) in laboratory feeding experiments with *L. tetraspina* and a larger calanoid copepod (*Pseudodiaptomus forbesi*) over a range of prey densities (2–120 copepods $L^{-1}$). Ingestion of delta smelt increased as prey density increased until reaching saturation. The rate of increase and value of saturation varied among life history stages and prey species. For all life history stages examined, saturation occurred at much higher food concentrations than is typically observed in the SFE (i.e., IEP zooplankton monitoring program). Understanding the factors that influence growth and survival of the early life history stages of declining fish species, including their functional (function = feeding) response to prey density, is ultimately important to understanding their recruitment success which is necessary to resolve the cause of their decline in the SFE.

**Keywords:** Delta Smelt, *Hypomesus transpacificus*, Copepods, *Limnoithona tetraspina*, *Pseudodiaptomus forbesi*

**Poster Topic:** Fish: Delta Smelt

# Vertical Response of Larval Delta Smelt to Various Environmental Cues

Lindsay Sullivan, Romberg Tiburon Center for Environmental Studies, ljswr@sfsu.edu
Wim Kimmerer, Romberg Tiburon Center for Environmental Studies, kimmerer@sfsu.edu
Joan Lindberg, Department of Biology and Agricultural Engineering, University of California, Davis, lindberg@steeper.us

Larval fish respond differently to different environmental cues, including light and turbidity. The type of response exhibited can have important implications for larval growth and survival. For example, positive phototaxis can increase encounters with prey in surface layers and improve feeding success by increasing visibility; however, it can also increase the risk of predation. Here, we examined the effects of various environmental cues, including light, turbidity, prey, and predators, on the vertical distribution of larval delta smelt (*Hypomesus transpacificus*). Two age groups of larvae (1–7 days post hatch, dph and 15–21 dph) were incubated in columnar Plexiglas tanks (180 cm x 10cm x 10cm) under varying environmental conditions (i.e., light/dark, clear/turbid, prey present/absent, predator cue present/absent). The tanks were marked in 10 cm depth increments, and the number of larvae in each increment was quantified every five minutes for approximately one hour using video observations. Vertical distribution varied between age groups and among environmental cues. Understanding the response of larval delta smelt to different environmental cues will help provide a more accurate description of their habitat, as well as, insight regarding interactions between their predators and prey within the SFE.

**Keywords:** Delta Smelt, *Hypomesus transpacificus*, Behavior, Vertical Distribution

**Poster Topic:** Fish: Delta Smelt

# Linking Organismal Tolerances and Transcriptomic Responses to Climate Change Stressors in an Endangered Fish Endemic to the San Francisco Bay-Delta

Lisa Komoroske*, UC Davis, lmkomoroske@ucdavis.edu
Matthias Hasenbein, UC Davis, mhasenbein@ucdavis.edu
Richard Connon, UC Davis, reconnon@ucdavis.edu
Joan Lindberg, UC Davis, lindberg@steeper.us
Nann Fangue, UC Davis, nafangue@ucdavis.edu

The delta smelt (*Hypomesus transpacificus*) is an endemic fish in the San Francisco Bay-Delta and is an important ecological indicator species. Delta smelt have been rapidly declining in the past 30 years due to a variety of physiological and ecological stressors, and climate change is expected to further impact this species by altering regional temperatures and salinities. The delta smelt is also an annual migratory species that encounters differential thermal and salinity regimes across ontogenetic stages. Some studies have investigated whole organism tolerance to these stressors in adults, but little is known about how tolerance thresholds or their mechanistic drivers vary through development. We sought to understand climate change impacts on delta smelt by conducting a series of thermal and salinity exposures on both chronic and acute timescales. We assessed tolerance by measuring loss of equilibrium and proportional survival, and quantified changes in gene expression to evaluate sublethal stress responses. Larval stages (30 and 60 days post-hatch, or dph) of delta smelt exhibited higher thermal tolerance relative to juvenile (150 dph) and adult stages (200 dph), but were more sensitive to salinity than these older stages. Linking tolerance data to transcriptomic profiles, we detected induction of osmotic, oxidative and other sublethal stress responses with increasing temperatures and salinities. Many transcriptomic responses occurred at lower levels and on shorter timescales relative to whole organism tolerance thresholds, and both tolerance and transcriptomic responses differed among life-stages. Therefore, delta smelts' ability to deal with environmental change may depend on the timing and magnitude of abiotic conditions. Our results demonstrate the importance of considering ontogeny as well as mechanistic responses in evaluating sensitivity to environmental stressors in estuarine species of high conservation concern.

**Keywords:** Delta Smelt, Climate Change, Temperature, Salinity, Physiology

**Poster Topic:** Fish: Delta Smelt

# An Updated Conceptual Model for Delta Smelt: Our Evolving Understanding of an Estuarine Fish

Larry Brown, U.S. Geological Survey, lrbrown@usgs.gov
Anke Mueller-Solger, Delta Stewardship Council, anke.mueller-solger@deltacouncil.ca.gov

Delta smelt *Hypomesus transpacificus* has been a species of high management interest in the Sacramento-San Joaquin Delta (Delta) since it was listed under state and federal endangered species legislation in 1993. The Interagency Ecological Program (IEP) formed the Management, Analysis, and Synthesis Team (MAST) in 2012 to address such high priority topics by analyzing and synthesizing available scientific data and providing the resulting information to managers and policy makers. As its initial assignment, the MAST has developed a new conceptual model for delta smelt life history based on previous conceptual models and new information. The report specifically focuses on the recent wet years of 2006 and 2011 and the preceding years of 2005 and 2010 to understand why the wet year of 2011 was associated with an increase in delta smelt abundance indices but the wet year of 2006 was not. The conceptual model recognizes that each delta smelt life stage, and the habitat attributes that affect it, are linked across seasons and contribute to the annual success of the species. Throughout 2011, delta smelt appear to have benefitted from a combination of favorable habitat conditions: high 2010-11 winter outflows reduced entrainment risk, a cool spring allowed for prolonged spawning, a cool summer with good food resources promoted growth and survival, and turbid and productive fall conditions in the large, westward low salinity zone and in the Cache Slough region provided a large habitat area with suitable conditions for maturation. This information will help managers understand the environmental conditions likely needed to increase the delta smelt population. The MAST process provides a useful approach to questions of interest in the Delta.

**Keywords:** Delta Smelt, Sacramento-San Joaquin Delta, Conceptual Model

**Poster Topic:** Fish: Delta Smelt

## Evaluation of Natural Marks to Identify Individual Cultured Adult Delta Smelt

Gonzalo Castillo, U.S. Fish and Wildlife Service, gonzalo_castillo@fws.gov
Marade Sandford, Fish Conservation and Culture Lab , U.C. Davis, mesandford@ucdavis.edu
Joan Lindberg, Fish Conservation and Culture Lab , U.C. Davis, lindberg@steeper.us
Galen Tigan, Fish Conservation and Culture Lab , U.C. Davis, gttigan@ucdavis.edu
Paul Skvorc, Biopar, LLC, pskvorc@biopar.com
Erwin Van Nieuwenhuyse, Bay-Delta Office, Bureau of Reclamation, evannieuwenhuyse@usbr.gov

There is a pressing need for developing more dependable individual identification methods for small fishes such as the threatened delta smelt (*Hypomesus transpacificus*). External natural marks to track individuals over time have been examined in very few species. As part of a one-year study, we began evaluating the feasibility of using natural marks for identification of cultured delta smelt produced at the Fish Conservation and Culture Lab (FCCL). Examination of fish revealed several potential areas of interest (AOI) for natural mark assessment. We selected three dorsal view head areas as the main AOIs (pre-, inter-, and post-orbital AOI), where external pigmentation is particularly abundant. To independently evaluate the short-term effectiveness of natural marks, we tagged approximately 300 fish with an individual alphanumeric code (VIA tags) and three photo sessions were completed, each approximately one month apart. We used a digital camera equipped with a macro lens to acquire AOI. A second digital camera was used to obtain lateral whole body images for morphometric analyses. Independent blind tests of natural mark effectiveness by two trained individuals involved visual (naked eye) matching of 30 photos (sessions 1 and 2). We used a qualitative matching-grade criterion to assign a measure of confidence to the visual matching process (4: excellent; 3: good; 2: fair and 1: poor). Initial visual evaluation for the AOI showed: 1) highly diverse pigmentation patterns in each AOI and highest reliance on the inter-orbital AOI for matching images, 2) correct matching in 100% of the images for both blind tests, and 3) average matching-grades for inter-orbital AOI ranging from 3.1 to 3.4, with no matching classified as poor. These initial results support our ongoing project development of automated matching algorithms to identify delta smelt based on natural marks; thus, contributing to priorities such as marking hatchery fish, monitoring and research.

**Keywords:** Natural Marks, Delta Smelt, Fish Marking, Cultured Fish, Monitoring

**Poster Topic:** Fish: Delta Smelt

# Quantify Effects of Temperature on Delta Smelt Behavior

Tien-Chieh Hung, University of California- Davis, thung@ucdavis.edu
Saikrithika Gandhi, University of California-Davis, saikrithi@gmail.com
Swee Teh, University of California-Davis, sjteh@ucdavis.edu
Joan Lindberg, University of California-Davis, lindberg@steeper.us

Delta smelt (*Hypomesus transpacificus)* is listed under both the Federal and California State Endangered Species Acts; however, little is known about their behavioral responses to a range of naturally occurring physical stimuli that may heavily influence their presence or absence in natural habitats. Developing a better understanding of the delta smelt's response to the physical stimuli such as water temperature, salinity, and turbidity under controlled conditions may help interpret fish location in the field. In the present study we have begun investigating the behavioral responses of delta smelt to a wide range of thermal conditions using a shuttle box system. The chambers are connected by a passageway, which allows the fish to have the option to move – to choose a higher or lower water temperature, and the system temperature was increased or decreased manually once every 6 hours. Experimental trials were carried out with groups of ten delta smelt to test the volitional movements of the fish. For fish acclimated to 14ºC, delta smelt appear to show a consistent behavior in avoiding warm temperatures as temperatures reach 23°C, but not at the cold temperatures tested. The fish repeatedly moved from the warmer chamber to the cooler one. For fish acclimated to 17ºC, similar patterns were observed but fish have a higher tolerance to increases in temperature. To gain a better understanding of the effects of temperature on the delta smelt, enzymatic biomarkers such as acetylcholine esterase (AChE) and ethoxyresorufin-O-deethylase (EROD) were obtained from the tested fish, and the results will be presented.

**Keywords:** Shuttle Box, Delta Smelt, Stimulus, Behavioral Response, Biomarker, Conservation Management

**Poster Topic:** Fish: Delta Smelt

# An Update on the Importance of Tidal Marshes to Native Fishes of the San Francisco Estuary

Larry Brown, U.S. Geological Survey, lrbrown@usgs.gov
Judith Drexler, U.S. Geological Survey, jdrexler@usgs.gov
Robin Stewart, U.S. Geological Survey, arstewar@usgs.gov
Darcy Austin, U.S. Geological Survey, dgaustin@usgs.gov
Stuart Siegel, Wetlands and Water Resources, Inc., stuart@swampthing.org

In 2003 a series of papers was published in San Francisco Estuary and Watershed Sciences regarding the potential role of tidal wetland restoration in improving the ecological health and water management of the San Francisco Estuary. Of particular interest was the question of whether tidal wetland restoration might enhance populations of native fishes, including species of concern such as delta smelt *Hypomesus transpacificus*, longfin smelt *Spirinchus thaleichthys*, Sacramento splittail *Pogonichthys macrolepidotus* and Chinook salmon *Oncorhynchus tshawytscha*. At that time, there were few studies of the role of tidal wetlands with regard to fishes, so few conclusions were possible, except that new studies were needed to improve understanding of this relationship. Recent studies, including the Integrated Regional Wetland Monitoring project, have expanded the list of fishes associated with tidal wetlands and associated nearshore habitats from 34 species in 2003 to 80 species as of 2013. Of these fishes, 22 of 28 freshwater resident species were alien but only 8 of 52 brackish/marine species were alien. Studies of trophic processes indicate that tidal marshes contribute directly to the nutrition of resident and transient fishes that access low order tidal channels and that it may be possible to create local regions where organic matter transported out of tidal marshes can contribute to the nutrition of fishes in nearby habitats. However, export of sufficient organic matter to significantly subsidize the diets of fishes inhabiting deep pelagic habitats is uncertain and will likely depend on total area restored and the geographic location of individual projects. Overall, restoring and reconnecting marsh and aquatic habitats of various kinds will likely provide multiple benefits to the estuarine ecosystem, including native fishes. A regional approach to planning and adaptive management is essential for understanding the processes determining successes and failures as tidal wetland restoration efforts move forward.

**Keywords:** Tidal Wetlands, Tidal Marsh, Native Fishes

**Poster Topic:** Fish: Habitat Restoration

# Three Dimensional Modeling of Suspended Sediment and Turbidity Dynamics at a Tidal Marsh Restoration Project in the Cache Slough Region of the Delta

Noah Hume, Stillwater Sciences, noah@stillwatersci.com
Michael MacWilliams, Delta Modeling Associates, michael@deltamodeling.com
Gina Benigno, California Dept. of Water Resources, Gina.Benigno@water.ca.gov
Stuart Siegel, Wetlands and Water Resources, stuart@swampthing.org

In 2010, the California Department of Water Resources (DWR) and the California Department of Fish and Wildlife (DFW) initiated restoration planning at Prospect Island in the northern Delta to meet requirements contained in the US Fish and Wildlife Service (USFWS) biological opinion for continued operations of the State Water Project and Central Valley Project. To address the potential for adverse turbidity reductions in the project vicinity that may affect suitability for Delta smelt (*Hypomesus transpacificus*), a three-dimensional hydrodynamic model, coupled with a wind wave model and a sediment transport and morphology model, was applied to evaluate changes in sediment transport dynamics related to breaching of the levees surrounding Prospect Island. Comparisons included the effects of breach locations upon seasonal suspended sediment transport, the effects of marsh vegetation extent upon particle trapping and re-suspension, as well as relative comparisons of suspended sediment and turbidity levels at key locations in the project vicinity known to support spawning and rearing life stages of Delta smelt.

**Keywords:** Sediment, Turbidity, Delta Smelt, Hydrodynamic, Model, Tidal, Marsh

**Poster Topic:** Fish: Habitat Restoration

# Lower Yolo Restoration Project

Chris Campbell, cbec eco engineering, c.campbell@cbecoeng.com
Chris Bowles, cbec eco engineering, c.bowles@cbecoeng.com

The Lower Yolo Bypass Restoration Project (Project) involves restoring and enhancing approximately 1,700 acres of tidal freshwater wetlands at the southern end of the Yolo Bypass in the northwestern Sacramento/San Joaquin River Delta. According to the San Francisco Estuary Institute, the Project site historically held a uniquely rich location at the intersection of the Putah Creek alluvial fan, historic Yolo Basin floodway and North Delta tidal marshes. The proposed Project seeks to partially restore some of these ecological functions in the current, highly altered landscape and restore as much of the historic hydroperiod diversity as possible. This includes reconnecting historic backwater lake features and removing obstructions to tidal inundation to allow seasonal and tidal waters to drain slowly through the marsh plains.

This Project is being undertaken as partial fulfillment of the California Department of Water Resources' 8,000-acre tidal restoration obligations contained within the 2008 USFWS Delta Smelt Biological Opinion (BO) and the 2009 NMFS salmonid BO. The Project could also serve as partial fulfillment of tidal restoration objectives under the Bay Delta Conservation Plan (BDCP) upon its approval. The primary goals of the Project are (1) to improve habitat conditions for Delta smelt by enhancing regional food web productivity;(2) to improve habitat conditions for salmonids by providing rearing habitats for out-migrating juveniles and migratory habitats for adults; (3) to support a range of other aquatic and wetland-dependent species; (4) provide habitat for establishment of native plant communities; (5) minimize potential for colonization by aquatic weeds, and; (6) preserve existing topographic variability to allow for habitat succession and resilience against future climate change. Construction is scheduled to begin in summer 2014.

This poster presents the Project background, site opportunities and constraints, and design as well as the current status of the Project at the time of the poster.

**Keywords:** Yolo Bypass, Delta Smelt, Salmonids, Tidal Restoration

**Poster Topic:** Fish: Habitat Restoration

# Suisun Creek Watershed Program

Laurel Marcus, California Land Stewardship Institute, laurelm@fishfriendlyfarming.org

The Suisun Creek watershed is a little-known drainage with some of the best habitat for steelhead trout in the Bay Area; however, historically abundant numbers of steelhead trout have declined in the past 40 years. Since 2000, the staff of the California Land Stewardship Institute (CLSI) have been working with private landowners to monitor and improve water quality in the Suisun Creek watershed. The 2004 Suisun Creek Watershed Assessment and Enhancement Plan grew out of a collaboration between Laurel Marcus & Associates, the California Sportfishing Protection Alliance, local landowners, and agencies. This plan identifies priority actions for the watershed, following several years of water quality monitoring and extensive GIS habitat mapping and analysis. Over the past 10 years, CLSI staff have conducted water quality monitoring in the watershed, including water temperature, dissolved oxygen, pH, and specific conductance. In addition, channel topographic surveys, bed material analysis, a fish snorkel survey, benthic macroinvertebrate surveys, a watershed sediment source analysis, and a reservoir release/water temperature study with the City of Vallejo using water from Lake Curry have been completed. The findings of these studies, pointing to high water quality but also excessively high water temperatures, have informed an adaptive management strategy for the watershed. As a result, CLSI is implementing a program of native plant revegetation to increase shade canopy, combined with high release rates from Lake Curry during the hottest summer months. Additional analysis of Lake Curry releases and stream temperatures is recommended. We conclude that analysis of the entire watershed, not just the creek, is the best means of improving fish habitat. Thorough multi-parameter quantitative monitoring should be conducted both prior to initiating projects and over the course of restoration efforts to determine success and inform subsequent actions.

**Keywords:** Steelhead, Water Quality Monitoring, Revegetation, Landowners, Adaptive Management, Watershed, Reservoir

**Poster Topic:** Fish: Habitat Restoration

# Observations from Stevens Creek After Five Years of Post-Construction Monitoring

Anne Senter, Balance Hydrologics, asenter@balancehydro.com
Shawn Chartrand, Balance Hydrologics, schartrand@balancehydro.com
Jonathan Owens, Balance Hydrologics, jowens@balancehydro.com

Balance Hydrologics provided geomorphic expertise and stream engineering plan sets for the rehabilitation and realignment of Stevens Creek within Blackberry Farm Park, Cupertino, California. The design intent was to construct a channel with sufficient bankfull width to support natural processes, provide vertical grade control, improve conditions for anadromous steelhead (*oncorhynchus mykiss*) and create a dynamically stable stream course rather than providing a design that attempted to lock the channel into a rigid, engineered corridor. Stream rehabilitation work was completed in 2008.

A program was implemented to meet agency requirements for 5 years of post-construction monitoring to assess bank and channel stability, the sediment transport regime, and steelhead spawning habitat. Constructed boulder structures remain stable, maintaining intended scour to keep pools functional, and provide small jump-height steps. Riffles have coarsened as high flows have transported gravels into bars. Sustained releases from the upstream reservoir during WY2009 and WY2011 created localized areas of erosion. Adaptive management was implemented at an eroding outside bank, where complex log-and-root structures were emplaced to provide protection against most future high-flow events.

The constructed channel has been a successful component of revitalizing Stevens Creek at Blackberry Farm Park. Lessons learned over the 5-year period include: (1) Riffle-pool locations have been maintained, suggesting that conceptualization, development, and construction of the project was well-executed. (2) An upstream supply of appropriately sized gravels is needed to maintain riffles long-term. (3) Boulders were appropriately sized and logs adequately anchored to remain stable for the flows experienced thus far. (4) Managing and quantifying expectations of stability vs. natural adjustment prior to, during, and post-construction is important so that all parties understand conditions under which adaptive repairs may or may not be needed.

**Keywords:** Creek Restoration, Step-Pool Construction, Post-Construction Monitoring, Steelhead Recovery, Adaptive Management

**Poster Topic:** Fish: Habitat Restoration

# 43 Years of Fish Monitoring Data in South San Francisco

Barbara Cebrian-Paskell, Marine Science Institute, b.cebrian.paskell@gmail.com
Chris Cross, Marine Science Institute, chris2.cross@gmail.com
Aaron Tinker, Marine Science Institute, aaron@sfbaymsi.org
Felicia Van Stolk, Marine Science Institute

The Marine Science Institute (MSI) in Redwood City, California is a non-profit educational institution that instructs participants in the ecology and conservation of the San Francisco Estuary (SFE) through experiential learning programs. Daily field trips in the southern SFE aboard an oceanographic research vessel form the core of MSI's curriculum. Three or four fish trawls are conducted each voyage, and trained fish interns collect data on the fish caught in each otter trawl net tow. Fish are identified to species, the standard length is recorded, and individuals of the same species are grouped into size classes and counted. We have collected data from close to one million fish from nearly 10,000 trawls since MSI's founding in 1970. Our initial discoveries include a slight increase in total fish catch per trawl and fluctuations in the diversity of more than 130 species recorded. We found a significant negative correlation between Northern anchovy and Shannon's diversity index. Our records reflect the Pelagic Organism Decline (POD) from 2001-2009, well documented in the northern reaches of the SFE.

**Keywords:** Fish Monitoring, Long-Term Data, San Francisco Bay

**Poster Topic:** Fish: Monitoring

# An Assessment of Beach Seine Capture Efficiency for Fishes Occurring in Littoral Habitat within the San Francisco Estuary

Joseph Kirsch, United States Fish and Wildlife Service, joseph_kirsch@fws.gov

Resource managers rely on abundance and distribution metrics derived from long-term fish surveys to make vital decisions that affect fish population dynamics and assemblage structure within the San Francisco Estuary, California. However, population metrics can be underestimated and biased by the incomplete detection (i.e., false absences) of fishes, which can vary among gear types, species, and environmental conditions. Currently, there is considerable uncertainty regarding if and how the capture efficiency of beach seining varies among fish species and environmental conditions within the San Francisco Estuary. I evaluated the capture efficiency of beach seining conducted by the Delta Juvenile Fish Monitoring Program within the Estuary and lower Sacramento and San Joaquin rivers. Beach seine capture efficiency was measured at a total of 58 sites using a stratified random sampling design combined with fish enclosures and depletion sampling during the spring and summer of 2013. To assess the variability in capture efficiency, data were fitted using conditional hierarchical logistic regression models that represented *a priori* hypotheses. The capture efficiency of beach seines varied substantially among samples (ranged from 0% to 100%). The best approximating models indicated that capture efficiency varied among species and sites. Physical habitat characteristics (e.g., water velocity) were also related to capture efficiency. Preliminary results suggest that beach seining has highly variable capture efficiencies within the San Francisco Estuary and failure to adjust for incomplete detection may bias population metrics. Therefore, capture efficiency sampling should continue to be incorporated into the Delta Juvenile Fish Monitoring Program and other similar monitoring programs to properly quantify and adjust beach seine catch data to develop more robust fish abundance and distribution metrics.

**Keywords:** Beach Seine; Efficiency; Sample Design; Bias; Monitoring; Fish; Littoral

**Poster Topic:** Fish: Monitoring

# Effects of Flow Magnitude and Duration on Age-0 Sacramento Splittail Abundance in the San Joaquin River Basin

Joseph Kirsch, U.S. Fish and Wildlife Service, joseph_kirsch@fws.gov
Ramon Martin, U.S. Fish and Wildlife Service, ramon_martin@fws.gov
David LaPlante, U.S. Fish and Wildlife Service, david_a_laplante@fws.gov

Most Central Valley rivers are heavily influenced by large dams, artificial flow regimes, and channelization. Consequently, the quantity and accessibility of floodplain habitat for fishes has been reduced and may vary considerably across water year types. Floodplain habitat is known to provide important spawning and rearing habitat for several native fish species occurring within the San Francisco Estuary, including the Sacramento splittail (*Pogonichthys macrolepidotus*). Studies have demonstrated that recruitment success of the Sacramento splittail is dependent on prolonged floodplain inundation during wet years, particularly within the San Joaquin River Basin. Although the viability of Sacramento splittail depends on floodplain habitat, there is great uncertainty regarding the amount of river discharge needed to achieve proper floodplain access. We evaluated the relative importance of different flow conditions on Sacramento splittail recruitment within the lower San Joaquin River. Starting in 1994, juvenile fish catch data were collected from April to June at ten fixed long-term beach seine monitoring sites within the lower San Joaquin River. Concurrent flow data were obtained from the Vernalis gauging station. We used general linear models that represented *a priori* hypotheses to evaluate the relative importance of different flow conditions to mean annual age-0 Sacramento splittail catch densities. Modeling results indicated that the recruitment success of Sacramento splittail is influenced by both the duration and magnitude of river discharge and not just mean flow. Therefore, the viability of floodplain dependent species will likely depend on flow regimes that incorporate both the duration and magnitude of river discharge required by native floodplain fishes.

**Keywords:** Sacramento Splittail; Water Year; Floodplain; San Joaquin River; Discharge

**Poster Topic:** Fish: Monitoring

# Effects of Nutritional Status on Fingerling Green Sturgeon (*Acipenser medirostrus*) High Temperature Tolerance and Aerobic Swimming

Christine Verhille, UC Davis. Wildlife Fish and Conservation Biology, cverhille@ucdavis.edu
Seunghyung Lee, UC Davis. Animal Biology, sshlee@ucdavis.edu
Liran Haller, UC Davis. Animal Biology, lhaller@ucdavis.edu
Silas Hung, UC Davis. Animal Biology, sshung@ucdavis.edu
Nann Fangue, UC Davis. Wildlife Fish and Conservation Biology, nafangue@ucdavis.edu

Green sturgeon (*Acipenser medirostrus*) are encountering altered temperatures, water flow and prey abundance in the San Francisco Bay Delta (SFBD). Considering green sturgeon is a species of concern in California and the endangered species act lists the southern population segment as threatened, knowledge of their tolerance of these combined stressors is important to SFBD biodiversity management. Therefore, we investigated the physiological capacity of fingerling green sturgeon (60 g) to endure high temperature or water flow with diet restriction.

Four replicate groups of thirty green sturgeon were assigned to and raised for two weeks on one of three diet rations ranging from 2% (expected optimal) to 0.25% of body weight per day. At the end of the two-week trial, growth, nutritional indices, cellular heat shock response, critical thermal maximum and critical swimming velocity were assessed for each ration group.

As expected, fish weight gain increased and nutritional status improved with ration. Percent body weight gain ranged from 57.7 ± 7.3% to -1.3 ± 0.7% for the highest to lowest rations. Weight gain was reflected in whole body (lipid, moisture and protein composition and energy content) and plasma (glucose, protein and triacylglycerol) nutritional indices, which significantly improved from the lowest to highest ration. Although low rations did not affect critical thermal maximum (34.4 ± 0.1 $^{o}$C) or critical swimming velocity (54.9 ± 1.9 cm $s^{-1}$), they may have suppressed the cellular response to warming.

We concluded that, though short-term poor nutritional status did not impair acute high temperature tolerance or aerobic swimming performance, it may impair the cellular stress response, suggesting long-term stress tolerance may be more profoundly affected by the nutrition of fingerling green sturgeon in the SFBD. We recommend future studies on effects of long-term dietary restriction on green sturgeon including assessments of cellular level responses and chronic stress tolerance.

**Keywords:** Sturgeon, Temperature, Swimming, Climate Change, Nutrition, Stress

**Poster Topic:** Fish: Sturgeon

# Feed Restriction Affects Osmoregulation in Green (*Acipenser medirostris*) and White (*A. transmontanus*) Sturgeon Juveniles

Liran Haller, Department of Animal Science, University of California, Davis, hallerliran@gmail.com
Seunghyung Lee*, Department of Animal Science, University of California, Davis, sshlee@ucdavis.edu
Jun Ho Lee, Department of Marine Bio-Materials and Aquaculture/Feeds & Foods Nutrition Research Center, Pukyong National University, Korea, aquafisher@naver.com
James Fadel, Department of Animal Science, University of California, Davis, jgfadel@ucdavis.edu
Silas Hung, Department of Animal Science, University of California, Davis, sshung@ucdavis.edu
Nann Fangue, Department of Wildlife, Fish and Conservation Biology, University of California, Davis, nafangue@ucdavis.edu

Decreased food availability and elevated salinity are key environmental stressors influencing fish populations; however, the physiological consequences of their interaction in sturgeon species are unclear. Green and white sturgeon, both native species to the San Francisco Bay Delta (SFBD),are species of special concern, and the southern distinct population segment of the green sturgeon is listed as threatened in the Sacramento river system. To test the hypothesis that poor nutrition negatively affects osmoregulation, juvenile green and white sturgeon at 222 (202g) and 209 (204g) days post hatch respectively, were randomly assigned to four feed-restriction groups (12.5, 25, 50, 100% of optimal feeding rate for four weeks). Subsequently, fish were acutely exposed to salinities of 0 (control), 8, 16, and 24 (for white sturgeon), or 32 ppt (for green sturgeon), and sampled at three time points (12, 72, or 120 hours). Salinity treatment corresponded to environmental salinities juvenile sturgeons are likely to encounter as they out-migrate from their natal freshwater streams. Fully-fed white sturgeon exhibited high mortality at salinities above 24 ppt while green sturgeon showed no mortalities at 32ppt, thereby setting the highest salinity treatments for the study. Our data indicate that feed restriction, salinity concentration and exposure time significantly affected hematological indices (hematocrit, hemoglobin), plasma values (osmolality, $Na^+$, $K^+$, $Cl^-$, glucose, lactate) and enzymatic activity (gill and pyloric caeca $Na^+$/ $K^+$ ATPase) in both species with the largest disturbances seen at the highest salinity treatments across all feeding regimes. Additionally, the interaction of feed restriction and acute salinity exposure of the highest salinity treatment resulted in high mortality in green sturgeon while no mortality was observed in white sturgeon. Evaluating the interactions of these environmental stressors and their implications on the physiological tolerance of native sturgeon populations is critical for ecosystem management decisions in the rapidly changing SFBD system.

**Keywords:** Green Sturgeon, White Sturgeon, Feed-Restriction, Nutritional Status, Osmoregulation, Salinity Tolerance

**Poster Topic:** Fish: Sturgeon

# Effects of Restricted Feeding on Nutritional Status of Juvenile Green Sturgeon (*Acipenser medirostris*) and White Sturgeon (*A. transmontanus*)

Seunghyung Lee*, Department of Animal Science, University of California Davis, sshlee@ucdavis.edu
Liran Haller, Department of Animal Science, University of California Davis, hallerliran@gmail.com
Christine Verhille, Department of Wildlife, Fish and Conservation Biology, University of California Davis, cverhille@ucdavis.edu
Nann Fangue, Department of Wildlife, Fish and Conservation Biology, University of California Davis, nafangue@ucdavis.edu
James Fadel, Department of Animal Science, University of California Davis, jgfadel@ucdavis.edu
Silas Hung, Department of Animal Science, University of California Davis, sshung@ucdavis.edu

Green and white sturgeon are native species to the San Francisco Bay Delta and are facing environmental changes such as increasing water temperature and increasing salinity due to global climate change. Recent evidence suggests that increasing water temperatures may disrupt the synchrony between phytoplankton and zooplankton blooms and may lead to altered prey abundance for sturgeon. As a result, the nutritional status of both sturgeon species may be affected, with species-specific patterns between the truly anadromous green sturgeon and the semi-anadromous white sturgeon likely. Therefore, the purpose of this study was to examine the effects of restricted feeding in green and white sturgeon by measuring several indices of nutritional status. Juvenile green (202 g; 222 dph) and white sturgeon (204 g; 209 dph) were reared for 4-weeks on one of four feeding rates (FR): 12.5, 25, 50 and 100 % of optimum FR determined by a FR model. Specific growth rates of green and white sturgeon were both significantly affected by the FR treatments ($p < 0.05$), however specific growth rate of green sturgeon below the 50 % FR was significantly lower than white sturgeon. Although white sturgeon whole-body protein was not significantly affected by the FR treatments, green sturgeon in the 12.5 % FR treatment had significantly lower whole-body protein than the other FR treatments. Whole-body lipid and energy values of green sturgeon and white sturgeon were significantly affected by the FR treatments, however the lipid and energy values of green sturgeon were significantly lower than those of white sturgeon in all the feeding rate treatments. Therefore, we conclude that juvenile green sturgeon have a different patterns of energy utilization compared to white sturgeon, and that juvenile green sturgeon may be more sensitive to altered food webs than juvenile white sturgeon

**Keywords:** Green Sturgeon, White Sturgeon, Climate Change, SFBD, Restricted Feeding, Osmoregulation

**Poster Topic:** Fish: Sturgeon

# Evidence of Niche Partitioning among Green Sturgeon (Acipenser medirostris) and White Sturgeon (A. transmontanus) in the San Francisco Bay Watershed

Emily Miller*, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, eamiller@ucdavis.edu
A. Peter Klimley, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, apklimley@ucdavis.edu

Green and white sturgeon (*Acipenser medirostris* and *A. transmontanus,* respectively) are sympatric sister taxa that have a long history of coexistence . They have relatively similar life histories, however, the green sturgeon is anadromous and makes long oceanic migrations while the white sturgeon is semianadromous and is generally confined to estuaries. Even within the estuary there are differences in their use of the watershed in space and time. This study will describe the differential resource-use and evidence for niche partitioning among adult, sub-adult, and juvenile green and white sturgeon in the San Francisco Bay, Sacramento-San Joaquin Delta, and Sacramento River. We implanted ultrasonic transmitters (Vemco Ltd) in individuals (41 green sturgeon, 160 white sturgeon) from 2010 to 2012 and detected their movements using an array of stationary monitors throughout the watershed. Approximately 95% of the green sturgeon and 88% of white sturgeon have since been detected. Using this detection data, we analyzed spatio-temporal movement patterns among each species and size-class. Within species comparisons demonstrated that juveniles, subadults, and adults were distributed differently in the system. Between species comparisons demonstrated that subadults and adults of each species differed in their distribution but juveniles did not. Additionally, we used a classification and regression tree (CART) analysis to predict the presence of sturgeon using environmental correlates. Based on these analyses, we will evaluate evidence of spatio-temporal niche partitioning among the two species.

**Keywords:** Green Sturgeon, White Sturgeon, *Acipenser*, Niche Partitioning, Acoustic Telemetry

**Poster Topic:** Fish: Sturgeon