Spatial and Temporal Recruitment Patterns of the Freshwater Bivalve, *Corbicula fluminea*, in Suisun Bay and the Sacramento - San Joaquin Delta

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Corbicula fluminea has been shown to limit the availability of phytoplankton and zooplankton biomass to other members of the foodweb. *Corbicula* is an opportunistic bivalve that thrives in disturbed habitats. Thus its presence in the Delta and its invasion abilities are a source of concern for future restoration projects. Although *Corbicula* occurs throughout the Delta, we have little information on its relative success in different habitats in the Delta. To understand *Corbicula's* distribution in the Delta, and its potential for spread, we must first understand where and when this bivalve recruits. Recruitment in this context is the process of a population sustaining itself through juvenile settlement.

Corbicula is a simultaneous hermaphrodite, thereby making it possible for one individual to establish a population. Adults hold unfertilized eggs until there is sufficient food at which time they produce sperm and fertilize the eggs. The larvae (pediveligers) develop in 3-5 days, are brooded in the gills of the adult before release, cannot swim but are found in the plankton for their first 48 hours, and are limited to salinities ≤2. Their small size (200 µm) and mass (0.1 mg dry weight) facilitates re-suspension and transport by currents after they settle. Therefore recruit distribution is a function of adult availability and transport opportunities.

Prior studies reported that *Corbicula* in the Delta had a large spawning peak in spring followed by a smaller fall peak, and that they also successfully recruited into Grizzly Bay in spring. Assuming this, we expect *Corbicula* to expand down-bay in spring but not in fall due to the higher salinity in fall. Recruits were found throughout the Delta and Low salinity Zone in October of 2009, 2010, 2011. However, in May 2011, during a high flow period, *Corbicula* did not recruit downstream into Suisun Bay as was expected.

Keywords: *Corbicula*, recruitment

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 1

Spatial and Temporal Recruitment Patterns of the Estuarine Bivalve *Potamocorbula amurensis* in San Francisco Bay and Delta

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It has been shown that *Potamocorbula amurensis* can limit the availability of phytoplankton and zooplankton biomass to other members of the foodweb in the estuary. It is therefore important to understand the temporal and spatial distribution of this bivalve and what factors favor its growth. A first order question is where and when *Potamocorbula* recruits and how the recruitment patterns change over time. Recruitment in this context is the process of a population sustaining itself through juvenile settlement. In this poster, we discuss the temporal and spatial recruitment patterns of *Potamocorbula amurensis* and hypothesize the causes of the observed patterns.

Potamocorbula is a dioecious (sexes are separate), fecund (45,000-220,000 oocytes), broadcast spawning bivalve with external fertilization, a short lived non swimming trochophore larvae and a motile suspension feeding veliger larvae. Both larval stages have a broad salinity tolerance (2-30). The larvae settle at day 17-19 and thus can be moved by the currents for substantial distances before settling.

Potamocorbula recruitment usually occurs in the western Delta in fall and in the northern estuary in early spring through fall. Recruits have been found throughout Suisun Bay, San Pablo Bay and the Low Salinity Zone in fall of 2009, 2010 and 2011. Larvae have been available to respond to the recent (1999 onward) salinity intrusions into the rivers in fall which resulted in increased recruitment up the rivers in fall 2009-2010.

The effects of wider recruitment may be short lived with recruits dying from stressful conditions such as reduced salinity or may result in an increase in the biomass and abundance in areas that are seasonally stressful for recruits but not for adults. If the individuals grow to adulthood before the seasonal reduction in salinity occurs, the population may expand into previously marginal salinity zones.

Keywords: *Potamocorbula amurensis*, *Corbula*, recruitment, San Francisco Bay, Delta

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 2

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

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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 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*. Since its introduction, *L. tetraspina* has become the most abundant copepod in the brackish reach of the estuary, at times outnumbering all other copepods by a factor of ten. However, the high abundance of *L. tetraspina* is offset by their small size, resulting in a corresponding decline in total prey biomass. 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 L^{-1}). Ingestion of delta smelt increased as prey density increased until reaching satiation. The rate of increase and value of satiation varied among life history stages and prey species. 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*, functional response, *Limnoithona tetraspina, Pseudodiaptomus forbesi*

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 3

Abundance and Distribution of Gelatinous Zooplankton in the Low Salinity Habitat of the San Francisco Estuary

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Until recently, gelatinous zooplankton were not considered important components of the San Francisco Estuary (SFE) foodweb. However, anecdotal evidence, ongoing research, and a few published reports and papers suggest an increase in their abundance over the last 10 to 20 years. Of particular interests are three species of introduced hydromedusae (*Blackfordia virginica*, *Maeotias marginata*, and *Moerisia lyonsi*).All three inhabit the fresh to brackish regions of the estuary, including Suisun Bay, the channels of Suisun Marsh, and the western Sacramento-San Joaquin Delta, and are seasonally abundant throughout late summer and fall. As a result, they overlap both spatially and temporally with several species of planktivorous fish, including delta smelt. Changes in the abundance and distribution of these species may strongly influence interactions between fish and jellyfish, both directly through consumption and indirectly through competition. Here, we report the distribution and abundance of gelatinous zooplankton at 9 stations throughout the upper SFE during late summer and fall of 2010 and 2011. Gelatinous zooplankton and their prey were sampled monthly. While work in four smaller tributaries (see oral presentation by Donald et al.) reports high abundances (>100 m^{-3}) of two species (*B. virginica* and *M. lyonsi*), abundances of these species in the larger bays (San Pablo and Suisun) and rivers (Sacramento and San Joaquin) were significantly lower (<1 m^{-3}). Most of the previous work to define the habitat range (salinity and temperature) of these species has occurred within Suisun Marsh. Extending this work into the open bays will help provide a more accurate habitat description. Additionally, information on the distribution and abundance of gelatinous zooplankton and how these vary with X2 will provide insight regarding the potential for interactions between gelatinous zooplankton and protected fish species within the SFE.

Keywords: jellyfish, *Blackfordia virginica, Maeotias marginata, Moerisia lyonsi*, delta smelt

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 4

Reproduction and Mortality of Key Copepod Species in Low-Salinity and Freshwater Habitats of the San Francisco Estuary

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The San Francisco Estuary (SFE) serves as important habitat for numerous fish species, including delta smelt. Declines in the abundance of several pelagic fish species in the upper estuary have prompted further investigation into foodweb interactions within the low salinity zone (LSZ) and freshwater habitats (e.g., Sacramento and San Joaquin Rivers). The LSZ is characterized by low primary production and an inefficient foodweb. We analyzed zooplankton samples collected in various studies from 1991 to 2011 to estimate copepod reproductive and mortality rates. These estimates are integral to the accurate description of population dynamics and ultimately the availability of copepod prey to higher trophic levels. We focused on three relatively large calanoids (*Eurytemora affinis*, *Pseudodiatomus forbesi* and *Acartiella sinensis*) and one small cyclopoid (*Limnoithona tetraspina*). Egg production rates were persistently low (0-7 eggs female^{-1} d^{-1}) for *P. forbesi*, *E. affinis* and *L. tetraspina*, and higher for the predatory *A. sinensis*. Mortality of copepodites and adults of *P. forbesi* was consistently highest in freshwater and lowest in the LSZ, while mortality of nauplii was high in the LSZ and low in the Delta. These patterns are consistent with higher planktivory by fish on larger copepods in freshwater, consumption of nauplii and competition for food by bivalves in brackish water, and transport of copepods from freshwater to the LSZ. These findings suggest that food limitation plays a significant role in the productivity of zooplankton in the LSZ foodweb, and that abundance of key prey species for delta smelt is maintained by transport from freshwater. Accurately estimating copepod reproduction and mortality is critical for understanding how these key prey species for delta smelt maintain their populations, and therefore how the food environment for delta smelt varies with freshwater flow and other conditions.

Keywords: *Pseudodiaptomus, Limnoithona*, copepod, foodweb, LSZ, reproductive rate, mortality rate, abundance

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Comparing the Growth of *Pseudodiaptomus forbesi*, throughout Various Life Stages, in the Sacramento River and the San Joaquin River Systems

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The calanoid copepod *Pseudodiaptomus forbesi* is an important food source for delta smelt in the Low Salinity Zone (LSZ) of the San Francisco Estuary during summer-fall. Abundance of *P. forbesi* has increased in freshwater and decreased in the LSZ, possibly because of low food availability due to competition for food with other clams or with other copepods (see Kayfetz et al. talk). Copepods grow by molting through a series of fixed stages, and food limitation is typically manifested in extended time to develop from one stage to the next, which is coupled to reduced growth rate. This study investigated the development rate of *P. forbesi* in the LSZ and freshwater habitats of the Sacramento and San Joaquin regions of the Delta. In fall of2010 and 2011 we conducted molt-rate experiments using nauplii and early and late-stage copepodites. Copepods were collected from a freshwater and LSZ station in each river, identified to species and life stage, and incubated in water from the sampling station for 48hrs. Samples were then analyzed to verify stage and determine what fraction had molted. Development times calculated from the fraction molting were longer than those from laboratory studies, suggesting strong food limitation. Development times of nauplii were particularly long (~7days) suggesting a possible artifact of the method for these very small (~100 υm) animals. Copepodites from freshwater sites had longer development times than those from the LSZ sites and preliminary results suggest shorter development times in the San Joaquin River than the Sacramento River. If individuals are remaining in the naupliar stages longer than previously believed, the impact of clam grazing on these vulnerable organisms may be larger than we thought. Understanding the population dynamics of copepods in these habitats will help us understand how these habitats support delta smelt.

Keywords: Copepods, molt-rate, development time

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 6

Old Standards versus New Approaches: Towards Defining the Fundamental Niche of Delta Smelt (*Hypomesus transpacificus*)

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The delta smelt (*Hypomesus transpacificus*) is an endangered pelagic fish, endemic to the San Francisco Bay – Delta and considered to be an indicator species for ecosystem health. Population declines have been observed during the past 30 years. Salinity, temperature and turbidity are three crucial abiotic parameters known to play a significant role in habitat characterization for the delta smelt. Every life stages of delta smelt (i.e. larva, juvenile or adult) are likely to have unique optimal requirements for salinity, temperature and turbidity, and these parameters affect growth, development, and subsequently reproduction. Adult and juvenile fish are exposed to a matrix of turbidity and salinity exposures at environmentally relevant temperatures (10°C for adults and 16°Cfor juveniles) over a period of 24h, after which fish are fed live prey (*Artemia franciscana*) for a 20 min. period. Food intake as well as stress levels are measured as an index of health status within each experimental condition. Fish are dissected and the gut content counted (number of artemia ingested). Whole body homogenates are taken to determine lactate, glucose, and cortisol levels as indicative of stress at the different treatments.

Pilot test with adult fish reveals higher feeding within the range of 10-25 NTU turbidity and 5 ppt salinity as well as at 0 ppt salinity and 10 NTU to which they were acclimated. Data for glucose, lactate and cortisol levels are scheduled for analysis. The research was funded by IEP and started in April 2012, the initial findings will help to improve and adjust the methods. This study aims to characterize an optimal range of abiotic conditions for this sensitive fish species.

Keywords: Delta smelt, turbidity, salinity, temperature, ecological niche

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 7

FLaSH: Otolith Growth and Migratory History

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The Fall Low Salinity Habitat (FLaSH) study examined the potential effects of habitat quality on the health, nutrition, and reproductive status of delta smelt, *Hypomesus transpacificus*, in the San Francisco Estuary (SFE). In collaboration with California Department of Fish and Game (CDFG) long-term fish monitoring surveys, the Summer Tow Net, Fall Midwater Trawl and the Spring Kodiak Trawl this study utilized the growth rate in formation in fish ear bones to assess the benefit of increased fall out flow on fall specific growth rates for the 2011-2012 yearclass and previous yearclasses. In addition we examined the otolith geochemistry to assess the migratory history and residence time of individual delta smelt in different saline habitats for 2011. Our preliminary assessment of fall specific growth suggests the 2011-2012 yearclass experienced the best growth conditions in the recorded study period. Moreover fall specific growth rates were found to be high among different saline habitats for delta smelt. Otolith geochemistry suggested all delta smelt in the 2011 yearclass were born in freshwater and a majority of fish collected in the fall had spent at least a short percentage of their life in the Low-Salinity Habitat.

Conclusion/Relevance

Delta smelt in the fall of 2011 experience good habitat conditions and experienced the fastest fall growth rates measured to date. Good fall growth rate could be an indicator of health and reproductive fitness and provide for successful recovery of the delta smelt population.

Keywords: FLaSH, Delta Smelt, otolith

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 8

FLaSH: Nutritional Status of Delta Smelt, *Hypomesus transpacificus*

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The Fall Low Salinity Habitat (FLaSH) study examined the potential effects of habitat quality on the health, nutrition, and reproductive status of delta smelt, *Hypomesus transpacificus*, in the San Francisco Estuary (SFE). In collaboration with California Department of Fish and Game (CDFG) long-term fish monitoring surveys, the Summer Tow Net, Fall Midwater Trawl and the Spring Kodiak Trawl, the FLaSH has been investigating delta smelt health occupying the SFE. This study examined the potential effects of habitat quality on the condition and nutrition of delta smelt. Preliminary results indicate that the 2011 was a 'good' habitat year when examining condition (condition, gonadosomatic and hepatosomatic indices) and nutritional indices (RNA/DNA and triglyceride concentration). Preliminary data shows that RNA/DNA ratios increased from fall to winter while triglyceride concentrations were variable. Indications on the condition of delta smelt will be discussed in regards to nutritional status. Condition indices were consistent throughout the study suggesting that the delta smelt were at relatively similar condition throughout the surveys. Gonadosomatic and hepatosomatic indices increased from fall 2011 to spring 2012 confirming that delta smelt are maturing reproductively.

Relevance: Information presented in this study examines the concepts outlined by the FLaSH to determine the effect of habitat quality on the health of delta smelt and potentially other species of management concern in the upper San Francisco Estuary.

Keywords: FLaSH, delta smelt, nutrition, triglyceride, RNA/DNA

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 9

FLaSH: Enzymatic and Histopathologic Biomarker of Delta Smelt, *Hypomesus transpacificus*

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The Fall Low Salinity Habitat (FLaSH) study examined the potential effects of habitat quality on the health, nutrition, and reproductive status of the delta smelt (*Hypomesus transpacificus*) within the San Francisco Estuary. In collaboration with California Department of Fish and Game (CDFG) long-term fish monitoring surveys, the Summer Tow Net, Fall Midwater Trawl and the Spring Kodiak Trawl, the FLaSH has been investigating delta smelt health occupying the SFE. This study examined the effects of xenobiotics on delta smelt, *Hypomesus transpacificus* in the San Francisco Estuary (SFE) using biochemical and histopathologic biomarkers. Acetylcholinesterase (AChE), Sodium Potassium Adenosine Triphosphatase (Na^+K^+ ATPase) and Ethoxyresorufin O- Deethylase (EROD) can be used as biomarker of exposure to metal, organophosphate (OP), carbamate pesticides, Polycyclic Aromatic Hydrocarbon (PAH) and Poly Chlorinated Biphenyls (PCB's) contaminants in aquatic biota. These enzymes when combined with histopathology have the potential to serve as a biomarker of toxic stress and to serve as sensitive parameters for testing exposure of organisms to toxicants. At this stage of our study the results obtained showed significant depression in AChE and Na^+K^+ ATPase activity in fish collected from Suisun Bay and Honker Bay suggesting contaminant etiology. EROD and histopathology analysis for randomly selected samples is in progress and results will be incorporated. These results will serve as baseline information to study the health status of delta smelt. Further analysis of OP pesticides in water using Elisa method would help us to confirm the presence of OP contaminants in the delta and those affecting the fish health.

Statement of Relevance: This data will provide significant understanding of the relative importance of different toxic contaminants that affecting the fish health in the SFE.

Keywords: FLaSH, delta smelt, enzymatic biomarkers, histopathology, habitat

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 10

FLaSH–Harboring Mycobacterium and Other Pathogens in Delta Smelt: Comparison between Populations Collected in 2010 and 2011 and Relationship to Environmental Factors in the San Francisco Bay Delta

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Monitoring for the presence of pathogens and diseases among fish species of concern in the upper San Francisco Estuary is a component of the Fall Low Salinity Habitat (FLaSH) study at UC Davis in collaboration with the California Department of Fish and Game. Pathogens, diseases, and host health status are one of the least studied stressors affecting threatened species in the San Francisco Estuary, but are intricately related to the health of the entire ecosystem. In the last decade, the presence of a chronic and untreatable bacterial infection (*Mycobacterium*) has been observed among refugial populations and laboratory-based research programs for delta smelt. Although *Mycobacterium* is ubiquitous infecting a wide spectrum of aquatic and terrestrial organisms including humans, it is also a disease agent in certain species of concern in other ecosystems such as the Chesapeake Bay. Hence, the incidence of this infectious pathogen among wild populations of delta smelt collected in 2010 and 2011 was investigated during the FLaSH study.

Fish health as broadly characterized in this study consists of a multi-tiered approach of measurements in terms of growth, fecundity, histopathology, nutritional status, and induced impairments due to pathogens/diseases. Microbial organisms isolated from various fish species were identified by traditional microbiological and molecular approaches. Multivariate analysis will be conducted to determine which combination of predictor variables in the environment may play significant roles in the susceptibility of delta smelt to *Mycobacterium* and other pathogens. We will also determine if freshwater outflow in the fall of 2011 altered the incidence and potential linkage of pathogens to other indices of fish health in the delta.

Relevance

By understanding how environmental changes can affect the role disease pathogens play, we may be better able to devise effective mitigation strategies to help save endangered and threatened species.

Keywords: delta smelt, Mycobacterium, pathogens, multivariate analysis, fish health, molecular approaches

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FLaSH: Maturity of Delta Smelt, *Hypomesus transpacificus*

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The Fall Low Salinity Habitat (FLaSH) study examined the potential effect habitat quality has on the health, nutrition, and reproductive status of the delta smelt (*Hypomesus transpacificus*) within the San Francisco Estuary. This poster presentation focuses on maturity and sex hormone level of delta smelt which are potentially affected by habitat quality via food availability. Currently, the reproductive status of the delta smelt is assessed by gross examination of their gonads based solely on their size and color. This method provides rapid screening of delta smelt maturity stage in the field and therefore is commonly utilized in ongoing delta smelt monitoring programs. However, the criteria used are subjective and is not always accurate in evaluating the maturity of delta smelt. To facilitate our understanding of the maturity and the reproduction of this threatened fish species, a more accurate method is warranted to support current delta smelt monitoring and restoration programs. Our research method included a histological examination as well as the quantification of the sex hormone, 17β-estradiol (E2), for delta smelt females from year class 2011. Histological examination of delta smelt oocytes allowed us to accurately differentiate delta smelt females into 6 major Stages (I throughVI) with subclasses (Early, Middle and Late) for Stage III and IV. In addition, a shift in fish maturation and an elevation of E2 levels were also observed in concordance with sampling time. These results are congruent with previous findings regarding the life history of the delta smelt. Future possibilities and utilization of our delta smelt scoring method will be discussed.

Relevance: Information presented in this study examines the concept that high fall freshwater outflow can benefit the health and reproductive performance of delta smelt and potentially other species of management concern in the upper San Francisco Estuary.

Keywords: Delta smelt (Hypomesus transpacificus), Maturity, Staging, 17ß-estradiol

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 12

Particle Concentration, Size and Composition Dynamics in the San Francisco Estuary

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Concentration, size, and composition of suspended particles have significant effects on San Francisco Estuary (SFE) pelagic habitat. Continuous measurement of particle size distributions (PSDs) and particle composition (i.e. organic or inorganic) and light attenuation illuminate important changes to the pelagic ecosystem. Continuous, real time measurement of PSDs with concurrent measurement of waves and currents exposed dynamics of in-situ aggregation and disaggregation. The ability to measure particle dynamics is important, as it leads to improved understanding of ecosystem organization in the SFE. Novel optical in-situ instrumentation and methods were utilized to identify and differentiate particle information in real-time. Optical scattering and attenuation coupled with particle size and concentration measurements were utilized to better understand the composition and variability of the particles and were paired with acoustic Doppler measurements to study the transport of these particles. Here, we present results from two studies conducted in Grizzly Bay and Liberty Island, showing particle concentration, size and composition over multiple tidal cycles and wind wave events, showing formation of flocs in the size distribution of suspended material in the water column.

Keywords: particle size distribution, particles, aggregation, disaggregation

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Comparison of Water Chemistry and Isotopic Trends in Steamboat and Miner Sloughs with Mainstem Sacramento River

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Much attention is currently focused on understanding sources of nutrients and organic matter in the Sacramento River and Delta downstream of Sacramento River Water Treatment Plant (SRWTP). Although considerable chemistry data exists for the mainstem portion of the Sacramento River, there is very little data for Steamboat and Minor Sloughs. The flow in these sloughs is diverted from the mainstem Sacramento River downstream of SRWTP, and their combined flow constitutes about half of the flow to Rio Vista. These sloughs have not received much attention because it was generally assumed that the chemical evolution of the water passing through the sloughs would be about the same as water traveling down the mainstem Sacramento River. Considering the variations in tidal influence, land use, and travel time in the sloughs, it is quite possible that the waters in the sloughs evolved differently from the mainstem of the Sacramento River.

This study was conducted to test the hypothesis that the chemical and isotopic evolution of the water passing through the sloughs might be significantly different from the mainstem. Samples were collected monthly at 13 stations from January through April 2010 and from April through December 2011. Samples were collected from sites on the mainstem, on each slough, and on important tributaries in Cache Slough. Analyses included major ion chemistry, chlorophyll, and $\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$ and the C:N ratio of particulate organic matter (POM). We find that the trends in water chemistry and evolution of POM through the sloughs are similar to those in the mainstem Sacramento River. Excursions from the trends occurred during flooding of the Yolo Bypass. Although source variations, travel times, and tidal effects are complicating factors in the sloughs, it appears that treating the sloughs as chemically similar to mainstem Sacramento River water is a workable assumption.

Keywords: Stable Isotopes, Water Chemistry, Particulate Organic Matter

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Improved Monitoring of Water Quality in the San Francisco Estuary: The Application of Continuous Nitrogen and Phosphorus Monitors in Liberty Island

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Nutrients play an important role in terrestrial and aquatic ecosystems; for example, they drive primary production, which in turn affects the health of pelagic organisms that rely on primary producers for their energy. In the San Francisco Estuary (SFE), complex and highly variable hydrodynamics makes it particularly challenging to understand how nutrient cycling relates to primary productivity. In-situ instruments, capable of making continuous measurements, coupled with water quality measurements can aid in unraveling the interaction of tidal and wetland influences on nutrient transport in the SFE. We developed an in-situ monitoring system, currently deployed in Liberty Island, consisting of commercially-available optical and physical sensors designed to measure nitrate (NO3) and ortho-phosphate (ortho-P) along with ancillary water quality and hydrologic data. The agreement of real time data with discrete sample data is a measure of the quality of our in-situ system. The nitrate sensors revealed variability in concentrations ranging from 20 to 40 µM, with highest values during high tide and lowest values during low tide. The ortho-P sensors showed concentrations ranging from 0.9 to 1.3 µM PO4 and, like NO3, high values occurred concurrently with high tides and low values with low tides. The sensors showed limited influence from fouling or drift and the resolution of the sensors allowed for measuring fine scale variability due to tidal cycles or diurnal uptake, for example. Results show that these instruments can be used to make highly resolved measurements of nutrient concentrations that can be coupled with other continuous and discrete measurements to better quantify the timing and drivers of changes in water quality.

Keywords: nutrients, phosphate, nitrate, in-situ

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 15

Influence of Light Attenuation on Euphotic Zone Depth and Visibility Range During Fall/Winter X2 Surveys of the San Francisco Estuary (SFE)

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The depth dependent distribution of light in the water distinctly influences ecosystem and habitat structure by providing light energy for phytoplankton growth and allowing for visual recognition of prey. While light has a distinct bottom-up influence on food webs in the SFE by controlling euphotic zone depth, aquatic vision research has revealed that light also imposes top-down control by affecting a predator's vision. In this study, we measured light attenuation (KPAR (m-1)) and visibility range (m) in the turbid environment of the SFE during monthly 'X2' survey cruises (October 2011-April 2012) to determine the impact of the light regime on the spatial distribution and quality of habitat for phytoplankton and Delta smelt.
Light attenuation and visibility were controlled to first order by concentration of particles. From fall to spring, mean light attenuation increased (1.3-5.3 m-1) and euphotic zone depth decreased (3.8 – 1.1m) during the monthly surveys consistent with strong winter mixing. Light attenuation was reduced and visibility range increased toward more riverine habitats in the eastern Delta reaching monthly minimums in the Lower Sacramento River. In contrast, maximum light attenuation, most reduced euphotic depth, and decreased visibility range were found in Grizzly Bay throughout the surveys.

While photosynthetic potential of the SFE decreased, the reduced visibility range afforded by turbid environments during spring also provided Delta smelt with shelter from piscivorous predators. For planktivorous Delta smelt, reduced visibility indicated that particle (food) encounter rate was enhanced. In contrast, visibility range indexed to piscivorous adult Large-mouth bass body size during the surveys declined 67% (1.5-0.5 body lengths) resulting in greater shelter for Delta smelt. This suggests that the light environment not only plays a significant role in structuring habitats for primary production but also strongly influences successful recruitment of Delta smelt.

Keywords: light attenuation, euphotic zone, visibility, Delta smelt, phytoplankton, habitat structure

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Water and Particle Properties as Measures of Habitat Quality

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Aquatic habitat quality in the Delta is determined by interactions between nutrients, suspended sediment, water, and light. Together, these habitat attributes affect the food supply by controlling algal production and species distribution; affect the food web structure by influencing energy transfer and grazer community composition; and affect fish distributions by altering foraging behavior and predation. The variation in these attributes across the Delta is commonly observed as variations in, for example, chlorophyll, turbidity, and secchi depth, which have been related to algal, zooplankton, and fish abundance. Our project examines these relationships in greater detail using a suite of new optical techniques that directly measure light transmission properties as well as algal and particle size and abundance. One purpose of the study is to identify the simplest optical water quality measurements that may best be used in a continuous real-time in-situ monitoring network of habitat quality.

We conducted profile measurements and collected samples at 25 stations from Suisun Bay to Cache Slough in conjunction with the 2011 Fall Mid-Water Trawl program; sampling at the same time and location as the fish collection activities. We found a large tidal dependency and large spatial variability for the parameters measured. For example, the chlorophyll concentration and median size of large suspended particles (including algae and flocs) increased upstream, in contrast to turbidity and salinity which showed the opposite trend. Distributions and interactions between measured parameters will be presented in combination with results of more traditional water quality measurements and from analysis of discrete water samples. The optical measurements will be used as part of an effort to establish relationships between readily-measured habitat quality indices and direct measurements of fish and community structure.

Keywords: nutrients, water, light, suspended sediment, optical techniques

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