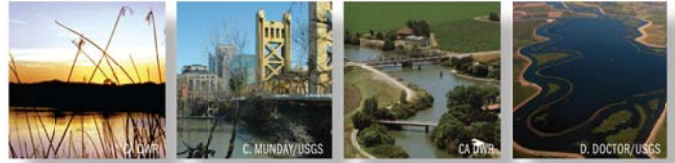


7th Biennial Bay-Delta Science Conference
**Ecosystem Reconciliation:
Realities Facing the San Francisco Estuary**

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Poster Abstracts

Sorted by Topic and Presenting Author

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Seed Ecology and Transplant Success of *Schoenoplectus acutus*, *S. californicus*, and *Typha latifolia* at Liberty Island, California: Applications to Restoration

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Current wetland restoration techniques proposed for the Sacramento-San Joaquin Bay Delta include the consideration of intentionally breaching constructed levees, thus returning land that had been reclaimed for agriculture back to a tidal marsh hydrology. Liberty Island, a post levee-breach freshwater tidal marsh restoration site, is a model area for understanding challenges to successful wetland restoration in California. Understanding the environmental constraints on vegetation establishment, survival, and expansion is necessary to maximize the efficiency and success of future wetland restoration efforts. This study examined hydrologic and edaphic constraints on plant establishment, survival, and expansion at Liberty Island through the implementation of a seed-bank assay and transplant study. The seed-bank sampling and transplant study were conducted in several areas at Liberty Island that varied in hydrology, edaphic characteristics, and elevation. Seed-bank samples were collected over three seasons and allowed to germinate under favorable greenhouse conditions at the University of Louisiana at Lafayette. Over two years the survival success and degree of expansion of three transplant species (and two life stages) was monitored. The seed-bank assay elucidated that a rich species pool of germinable seeds are present at Liberty Island, however, field observations suggest environmental conditions limit seed germination and seedling establishment.

The transplant study revealed strongly significant differences ($P < 0.01$) between species and life history stages regarding survival and expansion, with *S. californicus* and adult transplants (compared to rhizome transplants) performing most successfully. Furthermore, overall vegetative expansion was 2.5 times greater in areas of lesser compacted soils, indicating that historic soil compaction may be a limiting factor on plant establishment in this system. The information gained from these studies will enhance our understanding of marsh restoration processes and plant species responses, which should prove valuable when setting ecosystem restoration goals and trajectories.

Keywords: seed-bank, Liberty Island, soil compaction, vegetative expansion

Poster Cluster Title: BREACH III: Evaluating 'Restoration Thresholds' of Liberty Island 1

Relationship between Elevation, Edaphic Characteristics, and Patterns of *Schoenoplectus californicus* Abundance and Distribution at Liberty Island, California

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The upper Delta wetlands are a dynamic system whose long-term management depends on a greater understanding of the colonization and subsequent expansion of key wetland plant species, including *Schoenoplectus californicus* (tule). To provide a greater knowledge base for local environmental managers, we are conducting an observational field study to determine environmental factors associated with marsh vegetation colonization dynamics as a component of a large, interdisciplinary collaboration. Plots (1-m²) were established along transects in interior marsh, vegetated marsh edge, unvegetated marsh edge, and unvegetated mudflat habitats in both protected and more exposed areas of the east and west sides of Liberty Island. All transects were established in marshes dominated by *S. californicus*. Within each plot, *S. californicus* stem heights and density were determined, as well as soil bulk density, organic matter, nutrient concentration, and soil penetration resistance. Additionally, soil redox potential and elevation were quantified in all plots. Data analysis thus far indicates that lower soil bulk densities and higher plot elevations are correlated with greater *S. californicus* stem densities and heights on the west side of Liberty Island. A general trend towards higher soil nutrient concentrations is discernible in areas that were either recently colonized (<1 year) or not yet colonized by *S. californicus*. Expansion of *S. californicus* in certain areas is occurring at a relatively rapid rate (> 1 m yr⁻¹). We anticipate that expansion of *S. californicus* marshes in Liberty Island may proceed at a slower rate when expanding edges reach a low elevation limit or encounter highly compacted soils, at which time feedbacks between the vegetation and sediment supply will become increasingly important in modulating elevation and soil bulk density. Additional field work to more fully characterize the rooting depth and root morphology at the transect sites in this area is planned for Summer of 2012.

Keywords: Liberty Island, *Schoenoplectus californicus*, tule, vegetation colonization dynamics, elevation

Poster Cluster Title: BREACH III: Evaluating 'Restoration Thresholds' of Liberty Island 2

The Importance of Vegetated Ponds to Water Quality and Phytoplankton Carbon Production in Liberty Island, California

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Liberty Island is a freshwater tidal wetland that is thought to provide habitat and food resources for the endangered delta smelt. However, little is known about the mechanisms that control environmental conditions and carbon production in the wetland. This study was designed to address the question: Do the small vegetated ponds in the upper portion of Liberty Island contribute significantly to the overall water quality and phytoplankton production of the wetland? To address this question, a suite of physical, chemical and biological variables were measured at four locations in three wetland ponds between 2010 and 2011. Continuous measurements of water temperature, pH, specific conductance, dissolved oxygen, turbidity and chlorophyll *a* fluorescence with YSI 6600 water quality sondes provided information on water quality conditions. Continuous phytoplankton carbon production was predicted from continuous Turner Phytoflash photometers, Li-COR underwater light measurements and chlorophyll *a* fluorescence. Continuous and discrete monthly measurements provided baseline information on nutrient availability. Calibration data were collected semi-monthly to monthly throughout the study. Chlorophyll *a* concentration, water temperature, specific conductance and turbidity were greater in the vegetated ponds. On average, phytoplankton cells were growing at 45% to 48% of their maximum potential yield (F_v/F_m) throughout the ponds. Average daily yield was similar among the three ponds at 0.38 ± 0.10 to 0.41 ± 0.11 F_v/F_m and ranged from 70% to 10% of the maximum potential yield. In situ 24 hr light and dark bottle dissolved oxygen incubation studies indicated both the net primary productivity and maximum photosynthetic potential were greater in the vegetated ponds. Phytoplankton production was supported by elevated nitrate, ammonium, soluble reactive phosphorus and silica concentrations that were often greater in the vegetated ponds. Initial findings suggest vegetated ponds are a potential source of suspended solids, salt and phytoplankton carbon to the wetland.

Keywords: freshwater tidal wetland, primary productivity, carbon and material flux, hydrology

Poster Cluster Title: BREACH III: Evaluating 'Restoration Thresholds' of Liberty Island 3

Fish Community Composition and Abundance across a Vegetation Gradient in a Restoring Tidal Freshwater Wetland

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The Sacramento-San Joaquin Delta of the San Francisco Estuary is a highly manipulated ecosystem with structural impacts including levees and water diversions that have occurred over the last century. Several restoration efforts are underway, including at Liberty Island, a breached levee island once used for agriculture that is thought to provide good habitat for fish, particularly species of concern (i.e. Chinook salmon and delta smelt). We evaluated the seasonal and spatial variation of fish community composition and abundance across a habitat gradient. Field sampling occurred at six sites extending across three primary habitat types based on vegetation density and wind exposure. Fish were collected using gill nets in spring 2010, summer 2011 and winter 2012. We collected 388 individual fish representing 21 species, eight of which were native to California. The most abundant species were inland silverside, common carp, bigscale logperch and striped bass. The highest abundances occurred in spring 2010 and summer 2011 and the lowest abundances occurred in winter 2012. In spring, fish abundance was higher in moderately vegetated habitat, while in summer and winter fish abundance was higher in less vegetated, open-water habitat near a levee breach. Non-metric multidimensional scaling indicated that the fish community composition was largely correlated with seasonal (water temperature and specific conductance) and spatial variables (vegetation and distance from a levee breach). Based on our results, we recommend that (i) open water habitat containing low to moderately dense vegetation (which fish may use for spawning and rearing) and (ii) connectivity with adjacent rivers and sloughs (which reintroduces tidal inundation and allows increased access for fish) be considered in designing and managing tidal marsh restoration.

Keywords: Wetland restoration; Tidal marsh; Vegetation gradient; Fish ecology; Community composition

Poster Cluster Title: BREACH III: Evaluating 'Restoration Thresholds' of Liberty Island 4

Spatial and Temporal Patterns in the Diet of Fishes in a Restoring Tidal Freshwater Wetland

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Several restoration efforts are underway in the Sacramento-San Joaquin Delta of the San Francisco Estuary to restore functional ecosystems, especially marshes. Marsh habitat provides structural heterogeneity and has been shown to influence resource use by many fish species. We investigated fish diet across a vegetation gradient at Liberty Island. Field sampling occurred at six sites extending across three primary habitat types based on vegetation density and wind exposure. Fish were collected using gill nets and fyke nets in spring 2010, summer 2011, and winter 2012. Gut contents of 463 individual fish, representing 23 species, were examined. Preliminary results from a two-way analysis of similarities (ANOSIM) based on percent prey biomass showed significant biological differences in diet composition among the five most abundant fish species across seasons. During the spring, inland silversides and delta smelt consumed similar prey items, consisting mainly of chironomids, *Corophium* sp. and calanoid copepods, however during summer, inland silversides consumed mostly insects. Catfish and Carp were the primary demersal species caught in all habitat types and consumed mainly plant detritus and clams, respectively, in all seasons. Striped bass stomachs were fuller in the summer, when they consumed more fish prey, compared to stomachs from spring and winter. Understanding fish habitat use and food resources will allow researchers and managers to gain insight into ecosystem dynamics and habitat quality within this restoring wetland.

Keywords: Wetland restoration; Tidal marsh; Vegetation gradient; Diet; Fish ecology

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BREACH III: Evaluating 'Restoration Thresholds' of Liberty Island

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The purpose of the Breach III study is to provide a predictive level of understanding about how abiotic and biotic factors control vegetation colonization and expansion in a restoring freshwater tidal wetland and how vegetation subsequently affects fish and wildlife populations. The research in this cluster examined vegetation colonization, productivity and water quality, and fish diet and community composition.

Habitat structure is an important factor affecting fish abundance and distribution at multiple spatial scales. Understanding fishes occupy habitats to fulfill one or more life history requirements (e.g., survival, foraging, and reproduction), Breach III researchers hypothesized that fishes within Liberty Island would occur in areas providing predation refuge, food, and/or spawning habitat. Willis, Sloey, and Hester demonstrated expansion and colonization of emergent aquatic vegetation within Liberty Island was positively correlated with lesser compacted soils and higher plot elevations. Lehman et al. showed vegetated ponds within the wetland was a likely source of suspended sediments and phytoplankton to the wetland. We predicted that increases in turbidity and phytoplankton densities could increase food availability of planktivorous and herbivorous fishes and increases in the presence of aquatic vegetation could provide spawning habitat, structural cover, and food for fishes at various life stages. Therefore, we hypothesize there would be discernible relationships between aquatic vegetation and fish composition diet. Whitley and Bollens demonstrated total fish abundance was higher in moderately vegetated habitats during the spring, which can be a result of both spawning and rearing, and non-piscivorous fishes were generally consuming plant detritus and zooplankton. As a result, it is clear freshwater tidally influenced wetlands can provide essential habitat for the survival, foraging, or reproduction of native fishes. Fish abundance can be increased by restoration projects targeting habitats with minimal historical agricultural land use and higher plot elevations allowing for relatively fast vegetation expansion and colonization.

Keywords: Breach III, wetland, restoration, plants colonization, elevation, modeling, fish diet,

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The Integrated Regional Wetland Monitoring Pilot Project: Program Introduction

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Regional tidal marsh restoration efforts aim to support and recover populations of plant, fish and wildlife species. These ecological functions follow successful establishment of a variety of ecological processes in restoration projects. In order to understand the effectiveness of tidal marsh restoration efforts regionally, we must determine which processes are in fact important to establish and the means by which we can measure and quantify these processes. The CALFED Science Program-funded Integrated Regional Wetland Monitoring Pilot Project (IRWM) utilized a four-element strategy: (1) multi-disciplinary, intensive monitoring program covering physical processes, landscape ecology, vegetation, birds, fish, invertebrates, primary production, and nutrients; (2) establish and apply conceptual models to establish hypotheses used to guide field data collection and analyses across these topic areas; (3) sample six sites (four restoration and two natural) intensively from 2003-2005, with sites spanning the estuarine salinity gradient from the western Delta to San Pablo Bay selected based on the conceptual models; and (4) integrate results across disciplines. To date, IRWM researchers have published 10 journal manuscripts with another 20 at various states of preparation, and the work has been drawn upon for efforts such as the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). The integrated publication of ecological functions for estuarine fishes will be completed late 2012. This Introduction poster presents information about the six study sites and will be accompanied by several posters focusing upon a range of the topics covered by this applied research effort. IRWM is contributing essential knowledge to the regional efforts of species and natural community recovery through tidal restoration throughout the entire San Francisco Estuary and Delta.

Keywords: wetlands, monitoring, ecology, physical processes, restoration, fish, birds, plants

Poster Cluster Title: Integrated Regional Wetland Monitoring Pilot Project: New Findings 1

Ecosystem Scale Rates of Primary Production within Salt Marsh Habitats of the Northern San Francisco Estuary

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Salt marsh restoration is hypothesized to provide organic carbon subsidies for estuarine food webs. Organic carbon comes from diverse primary producers that differ in carbon fixation rates as well as areal extent within wetland systems. This study was designed to obtain some of the first estimates of relative contribution of different primary producers to total organic carbon production within a variety of salt marsh habitats in both natural and restoring wetlands of the northern San Francisco Estuary (SFE). We hypothesized that emergent plant production rates exceed those of microalgae (both pelagic and benthic), but overall microalgal contribution to wetland production is greater due to more extensive slough habitat and areal coverage of microphytobenthos. Carbon fixation rates of phytoplankton, benthic microalgae, and low marsh emergent vegetation were measured during the Integrated Regional Wetland Monitoring Project in two natural reference (Coon Island, Brown's Island), and four restoring (Bull Island, Pond 2A, Carl's Marsh, Sherman Lake) estuarine wetlands over the growing season in 2004. Areal (m^2) rates of production were the greatest for low marsh vegetation, while phytoplankton and benthic microalgae rates were one and two orders of magnitude lower, respectively. However, when areal production rates were scaled to the amount of habitat available for each primary producer group, the relative importance of each group varied by location. Given that each primary producer group supports a different subset of estuarine consumers, the type of food subsidy desired should influence the amount of slough, mudflat and low marsh area restored. The large scale wetland restoration activities proposed for the SFE should consider the types of primary producers likely to occupy restored habitats when estimating future foodweb impacts.

Keywords: salt marsh, microphytobenthos, carbon, primary productivity, marsh vegetation, phytoplankton, SAV

Poster Cluster Title: Integrated Regional Wetland Monitoring Pilot Project: New Findings 2

Reassessment of the Role of Tidal Wetland Restoration in Enhancing Populations of Native Fishes

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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. There was particular interest in the possibility that tidal wetland restoration could enhance populations of native fishes, particularly 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 evaluating the role of tidal wetlands with regard to fishes, and it was clear that new studies were needed to reduce uncertainties and quantify the response of fishes to tidal wetland restoration. Since the publication of the paper series, additional studies have been done and several large scale habitat restorations have occurred (e.g., flooding of Liberty Island) or are being implemented (e.g., South Bay salt ponds). We assess this new information and integrate it with the earlier papers to develop a more detailed understanding of the role of tidal wetland restoration in enhancing populations of native fishes. We specifically address studies conducted as part of the Integrated Regional Wetland Monitoring project, which was designed to monitor many aspects of tidal wetland structure and function and which included a two-year intensive field program at wetlands in the western Delta, Napa River, and Petaluma River. Isotope analyses conducted as part of this program demonstrated food web linkages between the tidal marshes and the fish sampled. The results of this reassessment will be of direct interest to resource managers, policy makers, and a variety of stakeholders who are involved in restoration of native fish populations and the functions of restored tidal wetlands.

Keywords: tidal wetlands, native fishes, restoration, San Francisco Estuary, Delta

Poster Cluster Title: Integrated Regional Wetland Monitoring Pilot Project: New Findings 3

Invertebrate Assemblages and Fish Diets of Interior Tidal Marsh Channels in Relation to Environmental Variables and Restoration Status in the San Francisco Estuary

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Recent work in the San Francisco Estuary (SFE) indicates a variety of fish consume marsh-associated benthic, planktonic, and neustonic invertebrates. Stable isotopes and gut contents suggest that marsh-associated macro-invertebrates play a crucial role in translating marsh-derived detritus to higher trophic levels. Marsh ecosystems thus play a potentially critical role in sustaining many fish populations in the SFE. Unfortunately, little is known about how the macro-invertebrate community varies spatially and temporally in the SFE, or how this community responds to environmental variables and marsh restoration status. We address these issues by describing temporal and spatial variations in the assemblage structure and abundance of potential fish prey resources in northern SFE tidal marsh channels, specifically examining benthic and neustonic invertebrates. We also relate fish diets to prey availability, and macro-invertebrate community structure to environmental variables.

Preliminary results indicate that benthic macro-invertebrates were most abundant in the Napa marshes, and lowest in the Delta. Natural reference marshes had slightly more taxa than restoring marshes. Temporal variability in benthic taxa richness was considerably lower than site variability. Neuston composition displayed a marked gradient from east to west, where the dominance of collembolans decreased from 70-85% in the west Delta, to 10% at Carl's Marsh. This coincided with an increase in dipterans and homopterans from east to west. Neuston abundance peaked in the summer, but abundance and community structure was extremely variable across sites and regions. Restoration status does not appear to affect neuston community abundance. Fish diets show considerable spatial and temporal variation, but little effect of restoration status. Our results indicate that community assemblages and fish diets respond more strongly to environmental variables operating at regional landscape scales, as well as seasonal variation, as compared to restoration status or age.

Keywords: tidal marsh, macro-invertebrate community, restoration, fish diet, environmental variables

Poster Cluster Title: Integrated Regional Wetland Monitoring Pilot Project: New Findings 4

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 ($>100 \text{ m}^{-3}$) 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 ($<1 \text{ m}^{-3}$). 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*, *Pseudodiaptomus 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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 5

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 of 2010 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 μ m) 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°C for 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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 11

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, 17 β -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 through VI) 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, 17 β -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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 13

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 $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, $\delta^{34}\text{S}$ 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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 14

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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 16

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

Poster Cluster Title: Low Salinity Habitat in the San Francisco Estuary: From Physics to Fish 17

Water Quality Effects on Survival, Growth and Feeding Performance in Larval Delta Smelt (*Hypomesus transpacificus*)

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The Sacramento-San Joaquin Delta (Delta) is a complex system of tidally-influenced, interconnected waterways that serves as a vital resource to both humans and wildlife. In recent years dramatic population collapses have been observed in a number of fish species, including the federally threatened delta smelt (*Hypomesus transpacificus*). A long history of industrial, agricultural and urban land use in the Delta has led to extensive environmental impacts from the release of anthropogenic contaminants, which have been widely recognized as a factor contributing to recent declines. However, contaminant impacts on delta smelt population dynamics remain poorly understood. The primary objective of this investigation is to assess sub-lethal, pathological and physiological stresses imposed on larval delta smelt by water-borne contaminants in the Delta. Bioassays were conducted using delta smelt eggs obtained from the Livingston Stone National Fish Hatchery's refugial population program. Eggs and larvae were reared in Delta water, and post-hatch survival, growth rate and feeding performance were monitored. During water collection for the bioassay tests additional water samples were collected for contaminant analysis. Samples underwent pyrethroid, organophosphate, organochlorine, and fungicide analysis to determine if sub-lethal impacts are correlated to concentrations of contaminants detected in water from the Delta. Although contaminant concentrations in the Delta may not be acutely toxic to delta smelt, they have the potential to elicit a host of sub-lethal effects that may be impairing growth, survival and reproduction. Assessing these sub-lethal effects will lead to a better understanding of the role contaminants play in recent population collapses.

Keywords: aquatic toxicity, delta smelt, pyrethroid, organophosphate, organochlorine, fungicide

Poster Cluster Title: Organic Contaminants 1

The Effects of a Commonly Used Pyrethroid, Bifenthrin, on the Reproductive Health of Steelhead (*Oncorhynchus mykiss*)

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The Bay-Delta is an important breeding and nursery ground for many species. Habitat quality and contamination of surface waters are limiting factors for ESA-listed fishstocks in watersheds with significant land use. Bifenthrin has received little attention regarding its effects on salmonid populations despite being detected in northern California runoff. While the potential for aquatic toxicity is evident, it is unknown what effect bifenthrin exposure has on the reproductive health of fishes. Plasma sex steroids and gonadosomatic index (GSI) were determined in juvenile steelhead exposed to bifenthrin (low: 0.028 ± 0.006 ug/L; high: 0.719 ± 0.073 ug/L) for 14 days and gonadal tissue was examined histologically. Females exposed to bifenthrin (high dose) had significantly ($p = 0.0251$) elevated estradiol-17 β (E2) levels. There was no difference in testosterone (T; $p = 0.1430$), 11-ketotestosterone (11-KT; $p = 0.0760$) or GSI ($p = 0.1937$). Although ovarian follicle diameter significantly ($p < 0.0001$) increased in bifenthrin-treated fish, widespread atresia was observed throughout the ovary (low dose $91.24 \pm 8.89\%$; high dose $82.76 \pm 10.84\%$). In male steelhead, sex steroids were not significantly altered (E2 $p = 0.0634$, T $p = 0.0833$, 11-KT $p = 0.3057$) after treatment. GSI was reduced ($p = 0.0231$), but the testis did not show measurable histological damage. These data indicate that exposure to bifenthrin results in reproductive dysfunction in female steelhead while males appear to be relatively unaffected. The ecological implications are uncertain, but further study is warranted. Additionally, given the increased urban use of bifenthrin and relatively high levels in the aquatic environment, a more comprehensive understanding of the impact of bifenthrin on wildlife will be imperative for improving risk assessment of pyrethroid use in the Bay-Delta in coming years.

Keywords: Steelhead, bifenthrin, pesticide, reproduction

Poster Cluster Title: Organic Contaminants 2

Monitoring Input of Current-Use Pesticides to the Sacramento-San Joaquin Delta

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Current-use pesticides in the Sacramento-San Joaquin Delta (Delta) are generally detected in seasonal patterns that depend on timing of application and transport mechanism. The two major inputs to the Delta are the Sacramento and San Joaquin Rivers, which drain 34,965 and 61,124 square kilometers, respectively. With large agricultural and urban areas, the two watersheds are a significant source of pesticides to the Delta. Current monitoring studies in the Delta analyze less than half of all pesticides applied in the watershed. The U.S. Geological Survey Pesticide Fate Research Group frequently updates their analytical methods to address changing use and to include newly-registered pesticides. Recent improvements to these methods include the additional analysis of 35 fungicides, six neonicotinoid insecticides, two rice herbicides (clomazone and propanil), and seven pesticide degradates. These analytical methods are currently being used in a monitoring study designed to characterize the input of dissolved pesticides to the Delta. Water samples are being collected from two sites (Sacramento River at Freeport and San Joaquin River near Vernalis) twice a month for one year. These water samples are filtered and are analyzed for over 100 current-use pesticides and pesticide degradates by GC/MS and LC/MS/MS. The results of this study will provide a robust dataset on current-use pesticides entering the Delta. This study will serve as a basis for additional targeted studies, which may focus on particular areas within the Delta, or the seasonality of pesticide occurrence. Future studies in collaboration with toxicologists and fisheries biologists may address the effects of particular pesticides or mixtures on sensitive species within the Delta.

Keywords: pesticides, fungicides, neonicotinoids, Sacramento River, San Joaquin River

Poster Cluster Title: Organic Contaminants 3

The California Water Quality Monitoring Council

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Government agencies, regulated dischargers, and others spend millions of dollars each year monitoring water quality and ecosystems in the San Francisco Bay-Delta. Lacking an agency with over-arching authority to monitor and protect California's water resources, differing organizational mandates resulted in inconsistent monitoring objectives and methods to collect and assess the data, making it impossible to integrate information from multiple studies. And there is no single user-friendly place to access the information. Pursuant to state legislation and an agreement between the California Environmental Protection and Natural Resources Agencies, the California Water Quality Monitoring Council was established to address these problems.

The Council published *A Comprehensive Monitoring Program Strategy for California* to coordinate the water quality and ecosystem monitoring, assessment, and reporting efforts of organizations within and outside state government. Goals are to improve collective efficiency and effectiveness and to ensure that resulting information is available to decision makers and the public via the Internet.

Rather than focus on technical details, such as methods consistency and standard data formats, the Council presented a new solution – provide a platform for intuitive, streamlined access to information that directly addresses users' questions. Under Monitoring Council guidance, collaborative theme-specific workgroups were formed, each developing an Internet portal focusing on one high-level question:

- Is our water safe to drink?
- Is it safe to swim in our waters?
- Is it safe to eat fish and shellfish from our waters?
- Are our aquatic ecosystems healthy?

These are accessed from the *My Water Quality* website (www.CaWaterQuality.net). A number of these efforts directly address Bay-Delta management, including the Estuary Monitoring Workgroup, with an initial focus on the Bay-Delta.

Portal development provides the context to effectively evaluate and resolve monitoring design, coordination, and data access problems— highlighting gaps and inconsistencies in monitoring and assessment methods and data management – within and between organizations.

Keywords: Monitoring Council; theme-specific workgroups; web portals; collaboration
Poster Cluster Title: The Monitoring Council, Its Workgroups, and Web Portals Improve Collaboration to Better Inform Bay-Delta Management 1

Using Web Portals to Present Meaningful Information

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The California Water Quality Monitoring Council is making water quality and associated ecosystem monitoring data more meaningful by improving access to assessment products that answer questions important to regulatory and resource managers and the public. The Council is addressing problems – stemming from inconsistent monitoring and assessment methods, fragmented data management systems, and the absence of global or unified points of access – through a system of theme-specific web portals linked from a single point of access, the *My Water Quality* website (www.CaWaterQuality.net).

Each portal focuses on a specific high-level question (e.g., Is it safe to swim in our waters? Is it safe to eat fish and shellfish from our waters? Are our wetland ecosystems healthy?) that provides access to assessment products that address more detailed questions (e.g., What are the long-term trends at my beach, lake, or stream?). Users can also follow links from these questions to monitoring data at different spatial scales (site, region, statewide), more detailed assessment reports, and legal and regulatory background information.

Portals have been developed addressing the Safe to Swim, Safe to Eat Fish and Shellfish, and Wetland Ecosystem Health questions. A Healthy Streams portal is about to be released. An Estuary Portal is planned to initially address California's largest estuary, the San Francisco Bay-Delta. Each portal integrates data, information, and assessment products from a variety of partners, including state agencies and other public and private partners. In addition to improving access to meaningful information, these portals highlight data gaps and inconsistencies in monitoring and assessment methods. This creates a structure for identifying and prioritizing efforts to address these shortcomings as well motivating the state and its partners to maintain a process of continual improvement. The transparency and efficiency of this approach has improved monitoring program credibility and prompted requests for participation from additional partners.

Keywords: Monitoring Council; theme-specific workgroups; web portals; collaboration

Poster Cluster Title: The Monitoring Council, Its Workgroups, and Web Portals Improve Collaboration to Better Inform Bay-Delta Management 2

The Healthy Streams Portal

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The California Water Quality Monitoring Council (Monitoring Council) is unveiling its fourth My Water Quality internet portal to connect decision makers and the public with water quality and ecosystem health information. The theme of this new portal is “Are Our Stream and River Ecosystems Healthy?” View the new portal from California’s My Water Quality website (www.CaWaterQuality.net) under “Are Our Aquatic Ecosystems Healthy?”

The new California Streams and Rivers Portal includes interactive maps and monitoring data that focus on the location, extent and health of the state’s streams and rivers. Links on the portal’s main page point to short descriptions of key aquatic ecosystem attributes, such as substrate or riparian cover, as well as descriptions of land use impacts on aquatic ecosystem health. The portal address three main topics regarding California streams and rivers: 1) extent of perennial and non-perennial streams; 2) ecological condition, and 3) actions directed towards improvement. An interactive map showing the extent of the statewide stream network allows users to locate streams and rivers in a region or area of interest. The ecological condition section describes how monitoring programs are evaluating the health of California’s streams and rivers. Data from bioassessment, toxicity testing, and fish tissue monitoring programs are displayed via an interactive map. Additional links point to memos, reports and other documents related to data assessment. A third section of the portal addresses actions being taken by state agencies to protect and restore watersheds; such as regulatory programs to manage waste discharges, grant programs to implement restoration projects, and policy development efforts. For those seeking further involvement in restoring healthy watersheds, links to citizen monitoring groups and other volunteer efforts are also provided.

Keywords: Monitoring Council; theme-specific workgroups; web portals; ecosystem condition; collaboration

Poster Cluster Title: The Monitoring Council, Its Workgroups, and Web Portals Improve Collaboration to Better Inform Bay-Delta Management 3

California Estuary Monitor Workgroup Website - A Tool for Integrating Monitoring, Assessment and Reporting

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The California Estuaries Monitoring Workgroup (CEMW) has formed under the guidance of the California Water Quality Monitoring Council (Monitoring Council). The group is focusing on the San Francisco Bay Delta Estuary, but will be expanded to other estuaries as statewide input is received. The goal of the CEMW is to evaluate existing estuarine resource monitoring, assessment and reporting efforts and work to enhance those efforts to improve the delivery of water quality and ecosystem health information to the user, in the form of the California Estuaries Portal (Portal). The CEMW will follow the Monitoring Council's guidance as it develops a Portal that delivers intuitive, streamlined access to estuary ecosystem health information that directly addresses users' questions. The CEMW will review technical and policy aspects of estuarine resource monitoring, tool development, implementation and use of data to improve estuarine resource management.

The San Francisco Bay Delta is the state's largest and most important estuary. Many state, federal and local agencies, universities, regulated dischargers, public water agencies, and water bond grant recipients spend millions of dollars each year monitoring, assessing and reporting on the conditions of the San Francisco Bay-Delta Estuary ecosystem. It is hoped that the CEP can assist with the integration of Bay Delta Monitoring and Science.

Although the public My Water Quality Portal has not been launched, the CEMW launched a separate site to encourage the communication, coordination and collaboration of CEMW participants. The site serves as a resource library and tool box. Information includes project management documents, subject wikis, project summaries, existing data sets, and data query and visualization tools that are under development.

Keywords: Monitoring Council, web portals, collaboration, ecosystem condition, monitoring, assessment, estuary, Delta

Poster Cluster Title: The Monitoring Council, Its Workgroups, and Web Portals Improve Collaboration to Better Inform Bay-Delta Management 4

Data Analysis and Visualization Tools for San Francisco Bay-Delta Ecosystem Management

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Managing the Bay-Delta ecosystem to meet objectives for water supply, water quality, habitat, recreation, flood protection, agriculture, and industry requires timely access to environmental data and information that is specifically formatted to support management decisions at site-specific and landscape scales.

The Wetland Monitoring and Estuary Workgroups of the Water Quality Monitoring Council are developing a set of monitoring and assessment tools to meet these data and information needs with regard to wetlands and related aquatic resources of the Bay-Delta and elsewhere throughout California. The tools – the EcoAtlas and OpenNRM – are being designed to help meet federal and state reporting requirements about wetland extent and condition, hydrologic conditions, and water quality conditions in the system.

This presentation will discuss how these tools are being used to support specific planning, reporting and management actions: compensatory mitigation planning at the landscape scale under ESA/CESA and CWA/Porter Cologne, climate change planning, 305(b) reporting, 1641 reporting and monitoring real time conditions. We will review collaborative efforts to bring Delta and Bay data into a seamless web-enabled environment using the concept of an EcoAtlas and the OpenNRM resource management software. The discussion will demonstrate how to easily access, analyze, synthesize, visualize and collaborate with these datasets in a spatial context.

Environmental information from a range of providers (IEP Bay-Delta Monitoring, DWR, CEDEN, DFG) includes both tabular and spatial data. Example are water quality data from USGS, DWR, and CEDEN, DFG trawls, hydrologic data (CDEC, NWIS), habitat and condition information (CRAM assessments of wetland condition, historical wetlands maps, permitted project information, and the California Aquatic Resources Inventory). The EcoAtlas and OpenNRM tools allow consideration of these data at the landscape scale to facilitate management of the Bay-Delta estuary and surrounding watersheds and to track the performance of the BDCP.

Keywords: Data, web, wetlands, GIS, flow, monitoring, water quality, landscape

Poster Cluster Title: The Monitoring Council, Its Workgroups, and Web Portals Improve Collaboration to Better Inform Bay-Delta Management 5

Climate Change Effects on Cyanobacteria Blooms in the San Francisco Estuary Delta

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Climate change and the associated increase in temperature are predicted to promote cyanobacteria blooms globally. This is evident in some fresh water systems such as China's Lake Taihu, Lake Victoria in East Africa and the Great Lakes of North America and may also be occurring in the San Francisco Delta (Delta). Blooms of toxic cyanobacteria (cyanoHABs) in the Delta have been increasing since 1999 and affect water quality, the estuarine food web and potentially human health. Of the cyanobacteria occurring in the Delta, the cyanoHAB *Microcystis aeruginosa* tends to dominate the community during the summer. With the goal of understanding how the effects of climate change, especially temperature, influence cyanobacterial growth and microbial biogeochemistry, a series of 20-L enclosure experiments were conducted using water collected at sites within the Delta where cyanobacteria have been observed. Enclosures were maintained at different temperatures and monitored over 3-5 days for chlorophyll-a, dissolved inorganic carbon (DIC) and nutrients, as well as phytoplankton community composition. Chlorophyll-a increased in all enclosures, but accumulated more quickly at higher temperatures. DIC drawdown, indicating primary production, was greater in enclosures held at higher temperature. Cyanobacteria responded well to the higher temperatures, compared to other Delta phytoplankton. These data linking the growth of cyanobacteria to elevated water temperature offers insight into changes that may occur in the San Francisco Estuary under climate change scenarios. As observed in China, higher water temperatures will likely result in proliferation of cyanobacteria and possibly cyanoHABs in the Delta.

Keywords: phytoplankton *Microcystis* climate change temperature cyanobacteria cyanoHAB

Poster Cluster Title: Understanding Cyanobacterial Blooms in the San Francisco Estuary Delta: Current Trends, Causes and Implications for Ecosystem Function 1

Nitrogen Uptake Kinetics of *Microcystis aeruginosa* in the San Francisco Estuary Delta

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Blooms of the cyanobacterium *Microcystis* are now a regular feature of the ecology of the San Francisco Estuary Delta from mid-summer through the fall. *Microcystis* blooms can be detrimental to water quality and may negatively affect the health of aquatic organisms because some strains of *Microcystis* produce toxins called microcystins. Despite these problems, relatively little is known about the nutrient uptake ability of *Microcystis*, and why this cyanobacterium can outcompete other phytoplankton taxa. Nitrogen uptake kinetics can be used to evaluate the affinity for uptake of ambient nutrients and kinetic parameters can then be compared with those for other phytoplankton. Uptake of three nitrogenous nutrients (nitrate, ammonium or urea) by *Microcystis aeruginosa* was measured using nutrient depletion and uptake of ¹⁵N-labeled substrates, in both lab cultures and field-collected water samples from the Delta dominated by *Microcystis*. The maximum uptake rates and affinity for these substrates by *M. aeruginosa* will be compared with published values for other phytoplankton taxa, to establish whether the nitrogenous nutrition capability of this cyanobacterium offers a competitive advantage over other algae during conditions of nitrogen-limited growth. Nutrient management, along with other strategies, may be considered as part of a comprehensive plan to control future *Microcystis* blooms.

Keywords: *Microcystis*, *Microcystis aeruginosa*, nutrient uptake kinetics, nitrogen uptake kinetics

Poster Cluster Title: Understanding Cyanobacterial Blooms in the San Francisco Estuary Delta: Current Trends, Causes and Implications for Ecosystem Function 2

Reproductive Success of the Calanoid Copepod *Pseudodiaptomus forbesi* in the Presence of Sublethal Levels of *Microcystis aeruginosa*

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Microcystis aeruginosa blooms have become increasingly frequent in the San Francisco Estuary in the last decade, coincident with a decrease in pelagic organisms. A possible association between these two observations is that copepods, an important food source for many affected pelagic organisms, have impaired survival in *M. aeruginosa* blooms. The toxicity and nutritional inadequacy of the cyanobacteria make it a poor food source to copepods. Even when blooms are not large enough to be lethal, egg production rate and egg hatching success are still negatively affected. This study focuses specifically on the calanoid copepod *Pseudodiaptomus forbesi* and its reproductive success in the presence of low levels of *M. aeruginosa*. The first part of this study compares the egg hatching success of gravid females caught at bloom and non-bloom *M. aeruginosa* sites from the Low Salinity Zone to freshwater locations on the Sacramento and San Joaquin Rivers. In 2011 no *M. aeruginosa* blooms were found, and preliminary results show no significant differences in egg hatching success between sites. The second part of this study will compare toxicity effects on both egg production and egg hatching success of cultured *P. forbesi* exposed to different sublethal levels (2, 4, 6, or 8% of dietary carbon) of either microcystin-producing or non-producing *M. aeruginosa*. If such low toxicity levels are found to have a significant negative effect on reproductive success, then this implies even small blooms of *M. aeruginosa* could impact copepod populations in the San Francisco Estuary. Also, because copepods compose much of their diet, larval and juvenile fish in the Estuary would also suffer from small blooms indirectly.

Keywords: *Microcystis aeruginosa*, copepods, egg hatching success

Poster Cluster Title: Understanding Cyanobacterial Blooms in the San Francisco Estuary Delta: Current Trends, Causes and Implications for Ecosystem Function 3

Isotope Identification of Particulate Organic Matter and Nutrient Sources During *Microcystis* Blooms in San Francisco Estuary

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The factors that have sustained *Microcystis* blooms in San Francisco Estuary since they appeared in 1999 are not understood. It was hypothesized that most of the *Microcystis* colonies and inorganic or organic nutrients that support the bloom originated in the San Joaquin River where the bloom biomass is elevated and that *Microcystis* has an impact on the quantity and quality of dissolved organic carbon production in the estuary. In order to test these hypotheses, stable isotopes were measured biweekly on particulate and dissolved organic and inorganic matter in the water column during *Microcystis* blooms in the summers of 2007 and 2008. At each station, *Microcystis* abundance, dissolved organic carbon, carbon to nitrogen ratio and chlorophyll *a* and toxic total microcystins concentration were measured along with the stable isotopic composition of the particulate and dissolved organic matter fractions, POM- $\delta^{13}\text{C}$, POM- $\delta^{15}\text{N}$ and DOC- $\delta^{13}\text{C}$. The stable isotopes of dissolved inorganic nitrate, $\text{NO}_3\text{-}\delta^{15}\text{N}$ and $\text{NO}_3\text{-}\delta^{18}\text{O}$, and water, $\text{H}_2\text{O-}\delta^{18}\text{O}$ and $\text{H}_2\text{O-}\delta^2\text{H}$, were also measured. The isotope data were supplemented by a suite of physical and chemical water quality measurements including water temperature, specific conductance, pH, dissolved oxygen, total suspended solids and concentrations of the nutrients nitrate, ammonium and soluble reactive phosphorus. Hydrodynamic modeling was used to characterize the percentage of streamflow from riverine sources. *Microcystis* entered the estuary from the San Joaquin and Old Rivers and was associated with a shift in the quality of the dissolved organic carbon. Dual isotopes for nitrate and water demonstrated that nutrients and POM isotopic signals differed for the Sacramento and San Joaquin Rivers and varied along the salinity gradient. The San Joaquin River was the primary source of nitrate while the Sacramento River was the primary source of ammonium to the delta. The ammonium from the Sacramento River was also the primary source of nitrogen for growth of *Microcystis*.

Keywords: *Microcystis*, cyanobacteria, isotopes, water quality, streamflow

Poster Cluster Title: Understanding Cyanobacterial Blooms in the San Francisco Estuary Delta: Current Trends, Causes and Implications for Ecosystem Function 4

Trends of *Microcystis* Abundance and Toxicity in San Francisco Estuary, 2004 to 2008

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Data collected from research studies conducted in 2004, 2005, 2007 and 2008 were used to assess if *Microcystis* abundance and toxin concentration increased over time, what factors controlled bloom initiation and persistence and if there was a long term impact of the bloom on mesozooplankton abundance or toxin content and dissolved organic carbon concentration. *Microcystis* abundance and total microcystins concentration increased over time due to the greater abundance in the dry years 2007 and 2008 than the wet years 2004 and 2005. A bloom occurred in the upstream portions of the delta in the San Joaquin River for all water year types and spread into the western delta during dry years. Total microcystins toxin concentration in *Microcystis* and mesozooplankton tissue increased with bloom abundance. The associations between *Microcystis* abundance and environmental conditions were nonlinear. Bloom initiation required water temperature above 19°C and photosynthetically active irradiance in the photic zone above 500 $\mu\text{M photons m}^{-2} \text{ s}^{-1}$. Persistence of the bloom was associated with a range of conditions, pH greater than 7.5, DIN:DIP ratios between 6 and 13, ammonium, nitrate, soluble reactive phosphorus and chloride concentration of 0.01-0.08 mg l^{-1} , 0.1-0.4 mg l^{-1} , 0.03-0.09 mg l^{-1} and < 700 mg l^{-1} with streamflows in the Sacramento River at Rio Vista near 250 $\text{m}^3 \text{ s}^{-1}$ and reverse streamflows in the San Joaquin River at Jersey Point near 100 $\text{m}^3 \text{ s}^{-1}$. At individual stations, *Microcystis* abundance was closely correlated with turbidity and streamflow. In addition, the importance of elevated water temperature in initiating the bloom and low streamflow in maintaining the bloom indicated that the projected increased frequency and severity of warm temperature and drought in California due to climate change will increase the frequency and severity of *Microcystis* blooms in SFE.

Keywords: *Microcystis*, cyanobacteria, hydrology, nutrients, water quality

Poster Cluster Title: Understanding Cyanobacterial Blooms in the San Francisco Estuary Delta: Current Trends, Causes and Implications for Ecosystem Function 5

Movement Patterns and Site Fidelity of Small Striped Bass in the San Francisco Estuary Watershed

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Small striped bass (n=99; mean fork length= 285 mm) movement and site fidelity within the San Francisco Estuary watershed were assessed using acoustic telemetry. Ninety-nine fish were surgically implanted with acoustic transmitters in June and July 2010 and tracked via stationary receiver (n=300) through October 31, 2011. Fish were tagged on the American (n=11), Sacramento (n=22), and San Joaquin rivers (n=33), the Sacramento Ship Channel (n=15), and Three Mile Slough (n=18).

A common feature was their progressive migration from rivers and sloughs into bays during summer and from bays to sloughs and rivers in the late fall and winter. On average, fish moved greater distances in early summer and early fall. Tidal surfing frequently occurred between the lower and upper sections of San Pablo Strait in summer and Carquinez Strait in the fall and winter. Tidal surfing also occurred between shoals and channels (Kimball Island and Antioch). Preliminary analyses indicate that fish repeatedly select the same migratory routes regardless of season. Route selection was correlated with tidal movement and appears related to flow conditions. Movement timing appears related to schooling behavior. Fish stationed at or near specific locations usually arrived and departed at similar times.

Keywords: striped bass; biotelemetry; movement patterns; San Francisco Estuary Watershed

Poster Cluster Title: Use of Biotelemetry to Assess Behavior and Survival of Fishes in the San Francisco Estuary Watershed 1

Use of San Francisco Bay Habitat by Tagged Special-Status and Recreationally Important Fishes

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The intent of this project was to identify and track fish tagged by any and all investigators (with permission) associated with the California Fish Tagging Consortium, and that were detected on receiver arrays deployed in the South Bay. species tagged include special-status Chinook salmon, steelhead, and green sturgeon, and recreationally important tagged species include striped bass and white sturgeon. The purpose of this Project is 1) to assess the utilization of the South Bay by fish produced in northern San Francisco Bay and Delta, including the Sacramento and San Joaquin river systems, 2) assess the utilization of restored South Bay Salt Pond tidal marsh habitats by those fish species tagged by California Fish Tagging Consortium investigators; and, 3) to determine the regional effectiveness of tidal restoration efforts on these species.

Nine acoustic (VEMCO) receivers were deployed as a gate array along the Dumbarton Railroad Bridge. In addition, six receivers were installed strategically within several newly restored tidal marsh units associated with Alviso Slough and the Island Ponds, and in Coyote Creek to document entrance of any tagged fish into the units, and residency time in the vicinity of each receiver/unit.

Keywords: South San Francisco Bay, salt pond, fish distribution, Dumbarton, Alviso,

Poster Cluster Title: Use of Biotelemetry to Assess Behavior and Survival of Fishes in the San Francisco Estuary Watershed 2

Smolt Behavior in the Sacramento River at a Levee Repair Site

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Since 2010 more than 1000 smolts and four species of predators have been implanted with acoustic tags to study their two dimensional movements in relation to a levee repair site located at RM 85.6. Repair work on this levee began in June of 2006 and made use of more than 80,000 tons of materials. The study primarily focused on juvenile late-fall Chinook, however juvenile steelhead trout were also monitored. Only a handful of predators were implanted with acoustic tags, however our objective with these individuals was to characterize a difference in behavior and movement patterns relative to the tracks of smolts. Two-dimensional track data was used to calibrate a Eulerian Lagrangian Agent Method model. In 2010/2011 season of study positions of smolts were consistently higher in the river channel with the lowest proportion of overall positions calculated occurring along the levee repair site. Also two-dimensional tracks from smolts were highly directional, 91.4% of smolts with more than 5 bearing calculated were found to have a Rayleigh test $p < 0.05$. Average movement rates within the study site were 0.8 m/s. We observed no significant difference in the transit times of smolts near (within 20m) the levee repair site (00:15:25) versus further away individuals (00:14:31) (t-test: $t=0.61$ $df=174$ $p=0.27$). A single smallmouth bass was tagged in 2010/2011, however the behaviors and movements rates of this individual were drastically different than those of the observed juvenile salmonids. The movement rates of the observed predator were lower than of the Chinook (t-test: $t=-42.9$ $df=5994$ $P < 0.01$) and bearings were bimodal primarily showing lateral movement (Rao's Test: $U=223.9$ $p < 0.01$).

Keywords: chinook salmon, Steelhead trout, predators, telemetry, levee repair, fish tracks

Poster Cluster Title: Use of Biotelemetry to Assess Behavior and Survival of Fishes in the San Francisco Estuary Watershed 3

Survival, Movement, and Route Selection of Steelhead Trout in the Sacramento River

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We studied the survival and outmigration patterns of natural and hatchery juvenile steelhead trout throughout the Central Valley. A large-scale array deployed and maintained by the California Fish Tracking Consortium was used to monitor acoustically-tagged smolts as they migrated past receiver locations. Hatchery steelhead trout were monitored from 2006-2011 while natural fish were monitored from 2008-2010. In both 2008/2009 and 2009/10 the timing of outmigration of naturally-produced steelhead occurred later in the year than for hatchery smolts. The transit time of natural steelhead from the Sacramento River to the Golden Gate was faster for both years with less variability. However, under higher flow conditions in 2009/2010, we observed shorter transit times with a decreased range or variability compared to the prior year. The hatchery steelhead trout which successfully navigated from the Sacramento River to the Golden Gate had average movement rates of 2-45 km/d. By contrast, the natural smolts migrated at average rates of 32-52 km/d. Once steelhead reach the Delta, they take one of the following migration routes: Steamboat, Sutter, and Miner Sloughs (western routes), Georgiana and the Delta Cross Channel (interior Delta), or the mainstem Sacramento River. The highest proportion of fish follow the mainstem Sacramento River, while the next highest proportion enter Georgiana Slough. We observed relatively high survival rates in all routes for hatchery fish over 5 years except in Sutter Slough, which had consistently low survival rates (0-0.45). Our data also revealed that natural steelhead had high survival rates through all routes regardless of year.

Keywords: Steelhead trout, survival, route selection, movement rates, telemetry, and salmonids

Poster Cluster Title: Use of Biotelemetry to Assess Behavior and Survival of Fishes in the San Francisco Estuary Watershed 4

Central Valley versus Petaluma/Napa: A Nutritional Examination of Sacramento Splittail

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Sacramento splittail, *Pogonichthys macrolepidotus*, is a native cyprinid of the San Francisco Estuary (SFE) and is a species of special concern by the US Fish and Wildlife Service and the California Department of Fish and Game. Genetic analysis has identified two distinct populations of splittail, the Petaluma/Napa and Central Valley populations. Splittail were examined at the end of fall 2010 and 2011 to examine the differences between these two populations. Splittail was sampled from 6 regions, Petaluma River, Napa River, Carquinez Strait, Suisun Bay, Honker Bay and the Confluence during the migratory period to assess their health and nutritional status before spawning. No splittail were collected in Carquinez Strait suggesting there was no interchange between the two populations. Preliminary results showed that the Petaluma/Napa splittail were in poorer condition and nutritional status than Central Valley splittail for both 2010 and 2011. In particular, splittail collected in the Petaluma River exhibited significantly lower health and nutrition indices than even splittail from Napa River suggesting poorer habitat quality in the Petaluma River.

Relevance: Information presented in this study supports the management of splittail as two distinct populations in the San Francisco Estuary.

Keywords: Sacramento splittail, nutrition, proximate analysis

Poster Topic: Fish Biology, Ecology and Protection

Effects of Flow, Habitat, and Water Quality on Hitch (*Lavinia exilicauda*) Abundance and Distribution within the Sacramento-San Joaquin River Delta

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The Sacramento-San Joaquin Delta is a dynamic ecosystem that is heavily influenced by anthropogenic factors. Native fish abundance can be affected by the alteration of river flows which can impact required habitat, food availability, and water quality.

Beginning in 1976, the U.S Fish and Wildlife Service's Delta Juvenile Fish Monitoring Program (DJFMP) has performed long-term juvenile fish surveys throughout the Sacramento-San Joaquin Delta. The objective of DJFMP is to estimate and monitor the movement, abundance, distribution and timing of fish inhabiting the Bay-Delta estuary and the lower Sacramento and San Joaquin Rivers. In this analysis we used the historical data set (2000-present) and multivariate analyses to model the relative abundance of the native hitch, *Lavinia exilicauda*, in relation to flow stage, physical habitat, and water quality parameters.

Although hitch abundance is low throughout the whole delta system (less than 2% of our catches between the lower Sacramento River and north delta regions), we showed increased relative abundance during high flow events. In terms of spatial and temporal patterns, we demonstrated that hitch use specific portions of the river depending on their life history stage. Just spawned individuals are typically found in the north and central delta regions, downstream of their spawning grounds. Larger individuals are primarily found in warm, slow moving waterways within the lower Sacramento River. Results may help inform water managers to coordinate and minimize the impact of water transfers on native fish populations.

Keywords: Hitch, Sacramento River, river flow, abundance, presence

Poster Topic: Fish Biology, Ecology and Protection

New Genetic Tools and Their Research Applications for Central Valley Chinook Salmon

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Central Valley Chinook salmon have experienced dramatic declines in recent years. Increased scientific understanding of population dynamics and factors contributing to survival and fitness is needed to aid in restoration and recovery efforts. We are developing new genetic resources for Chinook salmon and applying them to a number of studies focused on understanding the biology and ecology of Chinook in the Bay-Delta system. We are identifying thousands of new single nucleotide polymorphism (SNP) markers using next generation RAD-sequencing technology and positioning these SNPs onto a Chinook genetic map. These markers will be used to identify the different runs of Chinook salmon in the Central Valley and their natal origin. These markers will also be used to conduct association studies related to phenotypic traits of conservation importance. In addition to genetic diversity, we are examining epigenetic diversity (DNA methylation) within and among Chinook runs. As temperature is predicted to be an increasing stressor for Chinook in the Central Valley, we are also examining the gene expression profiles of fall run Chinook at increasing temperatures and evaluating thermal tolerances via RNA-sequencing. These new tools will be applied to studies that address pressing research needs for Chinook salmon management in the Bay-Delta system, including identifying run and spawning origin in state and federal fish collection salvage facilities and determining habitat use by juvenile Chinook salmon in the mainstem Sacramento River and Yolo bypass.

Keywords: Chinook salmon, RAD-sequencing, genetic resources, gene expression, SNPs, population structure

Poster Topic: Fish Biology, Ecology and Protection

Spatial Perspective for Delta Smelt: A Summary of Contemporary Survey Data

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We utilized recently available data from the 20-mm Tow-Net and Spring Kodiak Trawl, together with other Interagency Ecological Program and regional monitoring programs to provide a comprehensive description of the range and temporal and geographic distribution of delta smelt (*Hypomesus transpacificus*) by life stage within the San Francisco Estuary, California. Within 21 sampled regions we identified 289,401 survey events at 624 monitoring stations. Delta smelt were observed at 430 stations (69%) in an area from northern San Francisco Bay in the west, to the confluence of the Sacramento and Feather rivers in the north, and to the disjunction of Old and San Joaquin rivers in the south, an area of approximately 51,800 hectares. Delta smelt were observed more frequently and at higher densities (at all life stages) near the center of their range, from Suisun Marsh down through Grizzly Bay and east Suisun Bay through the Confluence to the Lower Sacramento region, and into the Cache Slough region. Delta smelt larvae were observed in the San Francisco Estuary from March through July, sub-juveniles in April through August, juveniles in May through December, sub-adults in September through December, and pre-spawning and spawning adults in January through May. This comprehensive data review provides managers and scientists an improved depiction of the spatial and temporal extent of the delta smelt throughout its range and lends itself to future analysis of delta smelt population assessment and restoration planning.

Keywords: Delta smelt distribution, spatial analysis, life stage, observed presence

Poster Topic: Fish Biology, Ecology and Protection

Using Underwater High Definition Video as a Fish Sampling Tool

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To minimize impacts on endangered or rare species, fish scientists are increasingly searching for sampling tools that minimize fish contact, while still collecting meaningful biological data on fish populations (e.g. infrared scanning, sonar imagery, video). Recent advancements in video technology have led to the availability of relatively cheap, high resolution (1080p) waterproof cameras that can easily be adapted to act as fish sampling devices. Here we present an example application in the Yuba River, California, where fixed position cameras were used to observe entrainment risk of juvenile Chinook salmon along a porous dike, and video transects were conducted using cameras suspended from a kayak to index salmon predator densities in a diversion side channel. Video cameras were also paired with underwater lighting to examine diel influences on the behavior of juvenile salmon and their predators. Where high visibility conditions occur, similar methods could be applied in other river systems or for other fish species to examine fish behavior (e.g. spawning, habitat usage), estimate abundance, or index fish community structure.

Keywords: underwater video, fish sampling, methods, juvenile salmon, Yuba River

Poster Topic: Fish Biology, Ecology and Protection

Evaluating Downstream Movement and In-river Survival of Naturally Produced Juvenile Chinook Salmon in the Lower Mokelumne River using Visible Implant Elastomer Tags

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Juvenile Chinook salmon *Oncorhynchus tshawytscha* face numerous sources of mortality prior to emigration from their natal streams. In the California Central Valley, survival of naturally produced juvenile Chinook salmon within Bay-Delta tributaries is an important component of population fitness. A pilot study was conducted in 2011 to determine if Visible Implant Elastomer (VIE) tags were suitable for evaluating in-river survival of juvenile Chinook salmon in the lower Mokelumne River. Results indicated that there were no significant differences in growth and survival between groups of tagged and untagged juvenile Chinook salmon, and the two groups of VIE tagged salmon had tag retention rates of 93% and 95% over a 104-day study period. During the 2012 juvenile Chinook salmon emigration period, the study proceeded as 4,300 naturally produced fall-run Chinook salmon fry were tagged with VIE between January and March at the upstream rotary screw trap on the lower Mokelumne River. Study results will include the timing of downstream movement and recapture rates of VIE tagged salmon, as well as an in-river survival estimate for juvenile Chinook salmon between upstream and downstream trapping locations on the lower Mokelumne River. In addition, the results will be compared with upstream and downstream juvenile Chinook salmon abundance estimates and migration timing, and relationships with environmental variables will be examined. These data will reflect one season of a long-term study examining downstream movement and in-river survival of juvenile Chinook salmon under a variety of environmental conditions.

Keywords: Chinook salmon, survival, juvenile, downstream, emigration, lower Mokelumne River

Poster Topic: Fish Biology, Ecology and Protection

Comparison of Race Compositions Using Length-at-Date Criteria and Genetics for Catch of Juvenile Chinook Salmon at Sacramento and Chipps Island in 2007-2011

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A key component to estimating juvenile abundance of listed races of Chinook salmon in the Delta is to correctly identify the race of juvenile Chinook caught. Length-at-date criteria have been used to classify race in the field; however, this approach is inaccurate. To better estimate the juvenile abundance of listed winter- and spring-run Chinook salmon, fin tissue was collected from juveniles captured in trawl sampling conducted at Sacramento and Chipps Island between 2007 and 2011. Tissues were analyzed using 21 microsatellites to determine race of individuals in the catch. While also not without error, simulations and blind tests indicate that these microsatellites have 98% and 84% respective success rate across all races. The numbers of catch by race were compared using length-at-date criteria and genetic analysis. Results indicate that there is considerable overlap in the juvenile length distributions of the four different races, and hence, the length-at-date criteria do not accurately discriminate between races. As a result, the catch of winter and spring run are likely overestimated using length-at-date criteria, whereas fall and late-fall are underestimated. The results of the analyses will be used to better quantify catch and absolute abundance of winter and spring run at Chipps Island and Sacramento. Improved accuracy for estimating juvenile abundance of these listed species entering and leaving the Delta is fundamental to understanding population status and how to improve survival through the Delta for ecosystem sustainability.

Keywords: Juvenile salmon, race differentiation, genetics, length-at- date criteria

Poster Topic: Fish Biology, Ecology and Protection

Integrating Hydrodynamic Data, Acoustic Telemetry and Simulation Models to Assess and Describe Juvenile Salmonid Migration Behavior and Survival in the Delta

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The relative influence of tides, river inflows, and South Delta exports on flow patterns in California's Sacramento-San Joaquin Delta continues to be a source of confusion and uncertainty for resource managers. A particle tracking model (PTM) has been used to characterize Delta flow patterns and to evaluate entrainment risks for larval fishes and, for the first time in the 2009 National Marine Fisheries Service OCAP Biological Opinion, to evaluate hydrodynamic effects on juvenile salmonids. While PTM results appear sensitive to net water movements over longer time periods (>days), recent findings from acoustic telemetry studies suggest migrating juvenile salmonids respond to instantaneous hydrodynamic conditions; not to daily average flows. Hydrodynamic mechanisms observed in the analysis of existing acoustic telemetry data indicate that the proportion of time flows enter a particular route may be important drivers of juvenile salmonid survival and route selection. The hydrodynamic variables of interest are readily available and provided by the "Delta Simulation Model 2 HYDRO" model with considerable spatial-temporal resolution (every 15 minutes for 500+channel locations). Our analysis indicates that commonly prescribed management actions may not yield desired and expected benefits because actual hydrodynamic conditions differ from conditions which are assumed to exist. For example, we observed little evidence that river inflows or South Delta exports, within the range typically controlled by managers, could substantially alter hydrodynamic conditions likely to cause juvenile salmonids to enter the interior Delta from the mainstem San Joaquin River. Additional acoustic telemetry studies may be necessary to more thoroughly test the relative importance of hypothesized hydrodynamic mechanisms. However, our analysis suggests available hydrodynamic data can be used to model and plan management actions with the greatest potential to enhance juvenile salmonid survival in the Sacramento-San Joaquin Delta.

Keywords: Salmon, Delta, hydrodynamics, routing, exports, inflows, OMR, modeling

Poster Topic: Fish Biology, Ecology and Protection

Thermal Preference of Two Populations of Splittail, *Pogonichthys macrolepidotus*

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Variable water flows through the San Francisco Bay Delta (SFBD) watershed have been linked to fluctuations in the abundance of Sacramento splittail (Cyprinidae). Seasonal air temperatures and the reduction of freshwater inflow into the SFBD correspond with changes in water temperatures. This, coupled with dams and diversions restricting access to spawning and foraging sites, has earned this endemic fish species its current listing as a California Species of Special Concern and former listing as threatened under the US Endangered Species Act. Although recent evidence has established the existence of two genetically distinct splittail populations (a Central Valley population and a Petaluma/Napa Rivers population) there have not yet been any comparative studies to evaluate divergence in physiological traits between populations. Understanding whether these two fish populations have distinct physiological or life-history traits may reveal critical environmental factors(s) important to effectively manage and preserve each population. We measured and compared the thermal preferences of both splittail populations acclimated to 18C, using an annular preference chamber. A fish's preferred temperature often corresponds closely to the optimal thermal range for growth and metabolism, and can help define suitable or unsuitable habitats used by a species at each stage of its life cycle. Preliminary results indicate that the selection behavior of splittail in a horizontal temperature gradient of 13-28C is affected by the presence of another fish in the chamber. Whereas individual splittail in our preference experiments swam through the entire gradient almost continuously, an unusual observation for these types of studies, experiments with multiple fish of the same cohort exhibited less active behavior. Research funding provided by the Delta Science Program.

Keywords: splittail, temperature preference, conservation, ecology, San Francisco Bay Delta, physiology

Poster Topic: Fish Biology, Ecology and Protection

Comparative Laboratory Critical Swimming Performance of Larval and Juvenile Green and White Sturgeon; with a Note on Exercise Conditioning

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Determining the swimming abilities of Sacramento River sturgeon juveniles at specific lengths or ages will be valuable in developing risk models for wild sturgeon in this watershed. Sturgeon swimming performance measures, including larval versus juvenile fish and between species comparisons are poorly represented in the literature (e.g., due to small sample sizes and swimming chamber limitations). We conducted critical swimming velocity (Ucrit) experiments on green (*Acipenser medirostris*) and white (*A. transmontanus*) sturgeon (range 3.7 cm to 50.0 cm Fork length (FL)), using modified recirculating-flow, Brett-style swimming chambers of various sizes. These sturgeons generally increased their Ucrit with increasing FL, except green sturgeon showed a performance plateau near 25 cm FL. Also, exercise-conditioned fish may simulate, more closely, wild specimens compared with non-exercised fish, and their use as proxies for wild fish in laboratory or field experiments was considered. We found that exercise-conditioned (i.e., maintained at ca. 10cm/s velocity) sturgeon did not swim better than non-exercise-conditioned fish, but varied in mass. Future swimming performance research on green and white sturgeon larvae and juveniles will investigate California sturgeons' potential negative interactions with fish-protection screens and louvers. These data will be valuable to Bay-Delta fisheries and water managers in minimizing these fishes' entrainment and impingement risks (e.g., regarding flow criteria, approach velocities) at water-extraction facilities. Research supported by the U.S. Bureau of Reclamation.

Keywords: Ucrit, Swimming performance, *Acipenser medirostris*, *A. transmontanus*

Poster Topic: Fish Biology, Ecology and Protection

Challenges Confronting Juvenile Sacramento River Chinook upon Entering the California Current Ecosystem: Results from NOAA SWFSC Juvenile Salmon Trawls and Acoustic Surveys

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Changing food availability in the California Current Ecosystem is one of several factors that determine Sacramento River salmon abundance, but its relative contribution to recent high variability in returns and fisheries catch is not well understood. In a geographic information system (GIS) framework, we used simultaneous ship-based recordings of continuous krill distributions and direct measures of species richness and abundance to investigate the spatial associations between prey patches (krill “hotspots” of abundance) and the distribution and abundance of genetically identified Sacramento River juvenile Chinook salmon.

Data from three juvenile salmon trawl surveys in July 2010, July 2011 and September 2011 were used for this study. Each survey spanned two weeks and ranged over 52 stations across the continental shelf between San Francisco, California and Newport, Oregon. Echo sounders sampled multiple frequencies and dB differencing was used to identify krill from acoustic backscattering (S_v) within a 10 m buffer below the surface and 5 m above the seafloor. Acoustic data were vertically integrated throughout the water column and horizontally integrated in one nautical mile (nmi) bins using Nautical Area Scattering Coefficient (NASC). In GIS, NASC values were averaged and gridded into 25 km² cells to control for survey effort. Gridded data was smoothed with a kernel density procedure and reclassified into utilization distributions at 10% intervals. By comparing catch richness and abundance with underlying krill hotspots, a spatial regression model revealed that krill hotspots explain little variation in catch richness and abundance, with highest residual variance just outside San Francisco Bay, off Point Reyes and Montara, California. Visual inspection suggests these patterns may be partly attributed to a lag that places krill north and up-current of high catch values. Resolving such patterns will contribute to understanding inter-annual variation in migration routes and survival of Sacramento River Chinook salmon.

Keywords: Sacramento River, Chinook salmon, California Current, Ecosystem, Krill

Poster Topic: Fish Biology, Ecology and Protection

Movement, Survival and Life History of Wild Mokelumne River Steelhead

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Anthropogenic alterations have removed or altered a majority of anadromous habitat of California's central valley. Furthermore, alterations may select against movement and therefore anadromy in steelhead. Here I investigated the movement and related survival patterns of 130 acoustically tagged wild steelhead in 2007 and 2008 using standardized transects along the lower Mokelumne River (LMR). Transects were nested within a larger network of stationary acoustic receivers throughout the LMR and Bay-Delta in collaboration with the East Bay Municipal Utilities District and the California Fish Tracking Consortium. I observed a wide range of movement from no movement over the 218 day study period to successful emigration to the Pacific Ocean. I observed a low degree of anadromy (8%) in tagged individuals. All anadromous emigration occurred in the spring, and was highly correlated with peak streamflows. Resident movement was highest in spring and summer relative to fall and winter. A significant interaction between fork length and home reach in 2007 may be explained by larger fish exploring the habitat variability of upper reaches to maximize growth during spring and summer. Like anadromous emigrants, smaller residents moved more in the spring and summer of 2008 perhaps due to a history of adaptation to a natural snow fed hydrograph. Fish that were observed to move more were more likely to suffer mortality. Thus, with the high instream growth rates of the LMR, benefits of oceanic growth potential may no longer outweigh the demonstrated instream mortality risks and risks of navigating the delta. Mitigating anthropogenic alteration and non-native predator related increased mortality throughout the delta and lower river reaches may help to return the cost-benefit-comparison to select for anadromy. Results here imply the importance streamflow peaks and variability to successful anadromous migrations and the maintenance of life history diversity in this imperiled population.

Keywords: acoustic telemetry, migration, anadromy, *Oncorhynchus mykiss*, salmon, mortality, mobile tracking

Poster Topic: Fish Biology, Ecology and Protection

Steps toward Evaluating Salmonid Predation in the Sacramento River Delta

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Low salmon smolt survival continues to be a problem in the Sacramento River Delta despite efforts to reverse these trends. Predation has been identified as one of the causes of this decline. Acoustic telemetry is commonly used to track the downstream migration of juvenile salmonids and has recently been used to identify predatory behavior in other species.

Over the past decade, fine-scale fish tracks have illustrated migration behavior and survival in river systems throughout California and elsewhere around the world. In recent years as more data has become available from various species via fine-scale 2D and 3D telemetry, new questions have emerged. One of the principal questions of great importance in the Bay-Delta region is: Can we determine whether or not an acoustically-tagged fish has been eaten by a predator? A critical assumption of survival estimation for acoustically tagged migrating species is that the detected tag signals are from distinctly unconsumed and freely migrating fish.

Protocols for determining predatory-like movement has been objectively defined for use in analyzing telemetry data.

In this presentation, we will discuss fine-scale acoustic tag development and current methods for determining predation events. Fish tracks are presented as two-dimensional fish densities superimposed over GPS geo-referenced river environments. Various results will be presented including recent examples of predatory behaviors [e.g., tagged predatory species] and a review of recent advances in data analysis techniques.

Keywords: Predation, acoustic telemetry, behavior

Poster Topic: Fish Biology, Ecology and Protection

Effects of Temperature Acclimation on a Native Minnow; Standard Metabolic Rate and Thermal Limits of Adult and Juvenile Hardhead, *Mylopharodon conocephalus*, Acclimated to 4 Seasonal Temperatures

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The majority of rivers feeding the Sacramento-San Joaquin Delta have been dammed or altered in some way. As a result, the frequency and timing of temperature and flow changes may not reflect historic conditions to which native fishes have adapted. Cold water releases in late summer, when fish are acclimatized to higher temperatures, may impact native fishes in ways that are not fully understood. We conducted a series of laboratory experiments in order to determine the effect of temperature acclimation on the standard metabolic rate (SMR) and the upper and lower thermal tolerance limits (i.e. critical thermal maxima (CTmax) and minima (CTmin) respectively) of adult (N = 80, mean wet weight = 709 g) and juvenile (N = 77, mean wet weight = 4.67 g) hardhead, *Mylopharodon conocephalus* (CDFG and US Forest Service Species of Special Concern), from the American and Feather Rivers, acclimated for 30 days or longer, to 11, 16, 21 and 25°C. SMR and CTmax/min increased with acclimation temperature similarly for both juveniles and adults. These data can be used to develop effective conservation strategies and inform management decision concerning thermal regimes of rivers inhabited by hardhead. Research funded by California Energy Commission Public Interest Energy Research (PIER) Program.

Keywords: Hardhead, Metabolic rate, Thermal Limits, Cyprinidae, Temperature Acclimation

Poster Topic: Fish Biology, Ecology and Protection

Straying of Late-Fall-Run Chinook Salmon from the Coleman National Fish Hatchery into the Lower American River, California

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Anadromous salmon Pacific salmon (*Oncorhynchus* spp.) generally home to their natal streams to spawn. Straying is a natural behavior and can impart adaptive advantages for a fraction of individuals from a population or even for the species. Straying can also occur as a result human intervention. In the winter of 2008/2009, at the end of the Department of Fish and Game lower American River escapement survey for fall-run Chinook salmon, a new pulse of fish began spawning in the river. These fish turned out to be primarily 2006 brood year late-fall-run Chinook salmon strays, from the Coleman National Fish Hatchery, that were part of a Delta survival study using downstream release groups. The American River has not generally supported a late-fall-run and understanding the reason for this unusual behavior is the basis for this project.

This study was based on the hypothesis that salmon released in close proximity to the American River are more likely to stray into the river than fish released farther from the river's mouth. Coded-wire tag release and inland return data for the 2006 brood year were used for this study.

Results indicate that straying increased with proximity of release to the American River and with respect to downstream releases in general. No salmon released in the vicinity of the natal hatchery were recovered in the lower American River. This study indicates that release location should be carefully evaluated if future downstream releases of hatchery salmon are conducted within the watershed. Results of this project can help fisheries managers and researchers make decisions about down-stream release location placement with respect to river tributaries while trying to improve salmon survival in the watershed and through the Delta.

Keywords: straying, homing, salmon hatchery

Poster Topic: Fish Biology, Ecology and Protection

Effects of Nutritional Status on the Temperature Tolerance of Green Sturgeon (*Acipenser medirostris*) Fingerlings

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Effects of global climate change relevant to the San Francisco Bay Delta (SFBD) include increasing water temperature and increasing salinity as a result of sea level rise and seawater intrusion into the SFBD, changes in precipitation patterns, and a smaller snowpack, contributing to a lower spring freshwater runoff. Recent evidence also suggests that the food webs in the SFBD system are changing and that sturgeon diets can shift to reflect availability and abundance of prey items. Because early life stages of green sturgeon spend part of their lives in the SFBD, they may be exposed to fluctuations in environmental temperature, salinity, and experience low nutritional status due to the low quality and quantity of prey organisms. Therefore, the purpose of this study was to address whether green sturgeon fingerlings with lower nutritional status possess the physiological capacity needed to survive and thrive when faced with temperature stress. Sixteen tanks with 30 green sturgeon fingerlings per tank were randomly assigned to one of four feeding rates: 0.25, 0.5, 1.0 and 2.0% BW.d⁻¹. After the 2-week growth trial, the groups receiving more restricted feeding showed a significant reduction ($p < 0.05$) in growth indices (SGR, feed efficiency, proximate composition) and lower plasma protein, glucose, and triacylglycerol levels compared to the non restricted-feeding group. However, swimming performance (Ucrit) tests showed no significant ($p > 0.05$) difference among the treatment groups. Fish from each treatment were used in the determination of critical thermal maximum (CTMax) as an index of whole-organism thermal tolerance. There was no significant difference ($p > 0.05$) in CTMax among the treatments. Fish from each treatment were also sampled for the analysis of liver and muscle RNA/DNA ratios, glycogen, lipid and the levels of heat shock proteins (Hsp 90, 70 and 60).

Keywords: Green sturgeon, climate change, nutritional status, heat stress

Poster Topic: Fish Biology, Ecology and Protection

Environmental Water Management for Lake Curry and Suisun Creek

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Lake Curry is a 10,000 acre-foot municipal water supply reservoir owned by the City of Vallejo and located on upper Suisun Creek in Napa County. The Suisun Creek watershed, with an area of approximately 55 square miles, is one of the least disturbed systems in the San Francisco Bay area and contains no major urban areas. Lake Curry and Suisun Creek, due to their relatively small size, offer the potential for experimentation with reservoir releases and the possibilities for either improvement or harm to creek aquatic habitats for salmonids. The Suisun Creek watershed has been the subject of extensive monitoring and study since 2001 to determine the limiting factors for steelhead trout in the watershed. While these factors vary for each major tributary, high water temperatures limit aquatic habitat values for salmonids throughout the system. In summer 2006, California Land Stewardship Institute staff worked with the City of Vallejo to alter the Lake Curry release regime in order to examine the effects of different release rates on water temperatures at 17 monitoring stations downstream. In addition, water temperatures in the lake were monitored and a model created to determine the volume of cold water available for release under various climatic conditions and at different release rates. The results of this model and the real time experiment will be presented along with the next set of proposed experimental releases and recommendations for future management of Lake Curry for the benefit of salmonid habitat.

Keywords: dam, reservoir, Suisun, steelhead, temperatures

Poster Topic: Fish Biology, Ecology and Protection

Effects of Water Year Type on Juvenile Chinook Salmon Size at Emigration in the San Joaquin River Basin

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Most Central Valley rivers are regulated by large dams and are highly channelized, reducing the frequency of flooding events. Consequently, the amount and accessibility of floodplain habitat may vary considerably across water year types. Annual discharge in the Merced and Tuolumne rivers are based on the Water Year Type (WYT) designation for the San Joaquin Basin. Studies have shown that floodplain habitat is important rearing habitat for juvenile Chinook salmon *Oncorhynchus tshawytscha*. Floodplains provide food resources, which contribute to faster growth rates when compared to fish rearing in the main river channel. This gives these fish obvious advantages in survival and predator avoidance. Significant differences in daily mean sizes of juvenile Chinook salmon exist across WYT ($P \leq 0.01$) in fish sampled in the Merced, Tuolumne, and San Joaquin rivers. Wet years tend to produce the largest juveniles while Dry years produced the smallest fish on average. Increasing the amount of floodplain habitat available to juvenile salmon in these rivers at a variety of flow conditions could increase the overall size of juveniles and lead to higher survival.

Keywords: anadromous, restoration, Chinook salmon, water year, floodplain habitat, San Joaquin

Poster Topic: Fish Biology, Ecology and Protection

Fire, Floodplains and Fish: An Ethnographic Study on *Lavinia exilicauda chi* in Clear Lake California

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For thousands of years, the California landscape has been tended and its resources sustainably harvested. Prior to Euro-American settlement, California Native Americans manipulated the natural environment, particularly plant resources, to meet long-term cultural needs (Stevens 1999). In fact, indigenous people all over the world have been found to be key factors in influencing biodiversity, sustainability, and optimum resource utilization. Historical ecology focuses on this reciprocal interface between humans and the environment in order to further the understanding of landscape transformations over time (Grossinger et al. 2006). It is this fundamental understanding that promotes educated changes and implementations to policy and overall environmental awareness. Our presence within local environs needs to be understood both holistically and scientifically in order for there to be progression towards sustainability. The field of historical ecology does not typically incorporate both archaeological data and ethnoecology into an assessment of historic ecosystems. Archaeological records contain not only demographic information not found in most historical texts, but also environmental information in the form of material culture, paleobotanical, and faunal remains. This study will explore archaeological fish faunal remains, ethnographic data, and traditional knowledge sounding *Lavinia exilicauda chi* and the Pomo Native American people in order to reconstruct the landscape of the lower Clear lake basin and it's watershed prior to Euro-American settlement and alteration. The historical reconstruction proposed will illustrate, within the limitations of the data, how past indigenous traditional management practices influenced both vegetation patterns and probable fish distributions in the Clear Lake area.

Keywords: hitch clear lake Pomo species wetlands river lake sustainable natural

Poster Topic: Fish Biology, Ecology and Protection

Delta Smelt Captive Refugial Population Update and Relevancy, 2012

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The captive refugial delta smelt (*Hypomesus transpacificus*) population, held at the Fish Culture Conservation Lab (FCCL) - University of California, Davis (UCD), was initiated in 2008 with wild-caught captive 2 year-old delta smelt after alarmingly low abundance estimates were reported for the species over several years. Declines in species abundances have been attributed to the highly altered nature (i.e. diking and draining for agriculture, increased water exports, invasive species) of the San Francisco Bay – Delta. The delta smelt is endemic to the upper Bay – Delta, and has been listed as endangered in the State of California. Genetic management of the refugial population, in collaboration with the UCD Genomic Variation Laboratory, is employed to maintain genetic diversity and minimize mean kinship through parentage analysis. The recent spawning season, ending late May 2012, produced the 5th generation. In total, 282 pair crosses were made, through manual expression of gametes and in vitro fertilization, which compares favorably to the target of 250 pair crosses per year. In 2012, 48 wild fish were successfully spawned to supplement genetic diversity and minimize genetic drift in the refugial population. Through the F3 generation, genetic analyses have shown no significant differentiation or loss of genetic diversity between the captive refugial population and the wild population of delta smelt. The captive refugial population of delta smelt is an important safeguard against further species-jeopardy, but stocked fish could perish along with wild fish, and so continued attention to effective Bay - Delta habitat remediation is imperative. The captive refugial population is relevant to Bay – Delta management by demonstrating a successful preservation technique of a native species, which, together with other protected natives, will ultimately contribute to the overall health and sustainability of the ecosystem.

Keywords: Delta Smelt, endangered, captive population, genetic management

Poster Topic: Fish Biology, Ecology and Protection

The Effect of Dietary Methylmercury on Na⁺, K- ATPase Activity and Growth in Central Valley Fall-run Chinook Salmon (*O. tshawytscha*)

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A manipulative experiment was conducted to determine whether methylmercury had the potential to disrupt the physiological processes associated with smoltification in juvenile Chinook salmon. Hatchery salmon from California's Central Valley were fed for 62 days (Apr-Jun) on fish pellets mixed with methylmercury hydroxide concentrations of 0, 1, 3, or 5 $\mu\text{g}\cdot\text{g}^{-1}$. Weight, fork length, condition factor, and Na⁺, K- ATPase measurements were collected every two weeks and a 96 hr seawater challenge was conducted at the conclusion of the experiment. Results from two-way ANOVA indicated no significant differences among treatments for weight ($F_{3,32} = 1.38$; $p=0.280$), length ($F_{3,32} = 0.986$; $p=0.412$), condition factor ($F_{3,32} = 0.239$; $p=0.869$), or mortality. Post-hoc analysis of ATPase activity indicated the 3 and 5 $\mu\text{g}\cdot\text{g}^{-1}$ dietary groups were significantly elevated in early May as compared to the control. The results from the 96 hr seawater challenge indicated weight influenced survival the strongest in the transition from freshwater to seawater. Results from this study indicate methylmercury, a known neurotoxin, can disrupt normal ATPase activity patterns in fall-run Chinook causing potentially undesirable effects in smolt timing. One possible mechanism for this disruption is via the stress induced hormone cortisol.

Keywords: chinook, salmon, methylmercury, ATPase, physiology, smoltification, mercury,

Poster Topic: Fish Biology, Ecology and Protection

Movements, Survival, and Residence Times of Three Native Fish Species in the Yolo Bypass in a Dry Year

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Although the Yolo Bypass floodplain has been demonstrated to benefit a suite of native fishes, particularly in flood years, little is known about how the movement patterns, survival, and residence time of native fishes in the Yolo Bypass. In cooperation with the Department of Water Resources (DWR), we implanted 68 white sturgeon caught in the DWR fyke net, located just below Lisbon Weir in the Toe Drain (the perennial channel that runs along the eastern side of the Yolo Bypass). The sturgeon were implanted with VEMCO V16 coded tags. Separately, twenty-five juvenile chinook salmon (100-125mm FL) and twenty-five juvenile steelhead trout were implanted with VEMCO V5 and V7 coded tags, respectively. The smolts were released 91 river kilometers upstream from the base of the Cache Slough Complex, and monitored with seven VEMCO VR2W 180-kHz monitors within the Toe Drain (a total reach of 38.45 river kilometers). The white sturgeon were monitored within and throughout the Toe Drain and into the San Francisco Bay using an array of VEMCO VR2W 69kHz monitors, including those maintained by the California Fish Tracking Consortium. We calculated residence time in the Toe Drain for the smolts and the sturgeon, as well as rates of survival for the smolts. Variables of consideration for behavioral movement analysis of white sturgeon included sex and fork length.

Keywords: Yolo Bypass, white sturgeon, salmonids, outmigration, telemetry, animal movement, floodplain

Poster Topic: Fish Biology, Ecology and Protection

Juvenile Salmon Response to Levee Repair on the Sacramento River

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California Department of Water Resources (DWR) and the United States Army Corps of Engineers (USACE) are engaged in levee repair focused on preventing levee erosion and flooding. The repairs also include features to improve the fish habitat including shallow water benches and instream woody material. However, there remains uncertainty about how fish respond to these features. In addition, questions regarding which enhancement provides the most benefit to fish also remain. To address these questions, we investigated fish movement using acoustic tags at river mile 85.6. Approximately 100 detailed 2D fish movement tracks were collected in the vicinity of the repair site. We also collected detailed bathymetric and hydraulic data and developed a 3D computational fluid dynamics (CFD) model of the levee repair site. We then developed a fish movement model using the Eulerian-Lagrangian-Agent Method (ELAM) and used the fish movement data from the 2D acoustic tag tracks for calibration of modeled fish movement. The fish movement model matched observed travel times and spatial distribution accurately. The fish movement model suggests that the levee repair has a strong effect on fish movement at small spatial scales. Modeled fish move faster when in proximity to the levee and alter their spatial distribution by shifting their position in the river and moving away from the repair site. Before fish arrive in the Bay-Delta they must move through hundreds of miles of river where levees impact the habitat. Thus fish may arrive in the Bay-Delta in poor condition and be subject higher mortality. Given the prevalence of levees on the Sacramento system and it is important that we consider how fish habitat considerations be integrated to repair projects. More broadly, we are developing a management tool that will allow for scenario analysis at small (10 m) and large (100 km) of river.

Keywords: levee, ELAM, fish movement, fish tracking

Poster Topic: Fish Biology, Ecology and Protection

When to Bolt: Fry or Smolt? Estimating Survivorship of Juvenile Salmon Migratory Life Histories Using Otolith Strontium Isotopes

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The maintenance of life history diversity is critical for the persistence of salmonid populations and is central to recovery efforts. Juvenile salmon leave their natal rivers at different sizes, ages, and times of the year and it is thought that this life history variation contributes to population sustainability. Preserving and restoring diversity of life history traits depends in part on the environmental factors affecting their expression. Rotary-screw traps (RST) at Caswell have indicated that during years when spring flows are high, large numbers of fry size Chinook salmon emigrate from the Stanislaus River, presumably rearing downstream in the San Joaquin, delta and/or estuary. In drier years fewer fry sized Chinook are collected at the Caswell trap. It remains unclear whether fry (<55mm), parr (56-75mm) or smolt (>76mm) outmigrants contribute disproportionately to the adult spawning population and whether this is influenced by hydrologic regime.

This study utilizes Sr isotopes ($^{87}\text{Sr}/^{86}\text{Sr}$) in adult Chinook salmon otoliths (earbones) to bridge the information gap between how river conditions influence juvenile outmigration patterns and survivorship of life history strategies in different years. A total of 200 paired otolith and scale samples were used to reconstruct and compare size-specific out-migration patterns of juvenile salmon in an 'Above Normal' (2000) and a 'Below Normal' (2003) water year type. For each returning adult, the size that it had emigrated from the Stanislaus River was reconstructed by coupling otolith $^{87}\text{Sr}/^{86}\text{Sr}$ with otolith radius measurements. To determine the relative success of the fry, parr and smolt-sized outmigrants, we compared their proportions within the juvenile RST samples with those reconstructed in the adult returns from the same cohort.

Keywords: Salmon, Otolith

Poster Topic: Fish Biology, Ecology and Protection

Central Valley Steelhead Draft DRERIP Conceptual Model

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The draft Central Valley steelhead conceptual model describes, in both text and figures, the major stressors on the steelhead populations in the Central Valley of California. Following the DRERIP format, the model ranks the importance of each population stressor, our relative understanding of the relationship between each stressor and the success of a population, and the certainty that a particular stressor is important to this species.

The conceptual model reviews the literature on the ecology, life-history, historic and current distribution, management, and current status of this distinct population segment (DPS) of steelhead. The model covers the key stressors impacting survival and growth at each life-stage, including egg and alevin, parr, smolt, post-smolt, adult, and kelt. Specific ecological issues addressed include historic and current distribution, the question of residency vs. anadromy in Central Valley *O. mykiss*, and life-history variation within and among populations including age at smolting, age at maturity, repeat spawning, and the poorly understood “half-pounder” strategy. Management questions addressed include the role of hatchery supplementation, migration barriers, and water temperature regulation. The goal of the model is to create a common, agreed-upon, qualitative model of the life-history of Central Valley steelhead, which can be used to help guide future analyses, monitoring, and research.

Keywords: steelhead, biology, model, management, life-history, stressors

Poster Topic: Fish Biology, Ecology and Protection

Advances in Longfin Smelt Culture Development

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Following the population decline of longfin smelt and listing as threatened in the San Francisco Bay Estuary, the Fish Conservation and Culture Lab (FCCL) has been developing methods to rear longfin smelt through all life stages for research purposes. Using culture methods based on those developed for delta smelt in our laboratory, longfin smelt are reared in intensive culture (recirculating and biofiltered systems with temperature control). Over the last 3 years the FCCL has received a few mature broodfish (US Fish and Wildlife Service) annually and, using in vitro fertilization, produced eggs, larvae, and juveniles. Survival has improved from nearly zero at 40 days post hatch to some individuals reaching the 1-year mark. However, longfin are difficult to obtain and are dissimilar enough from delta smelt to present some problems in culture. Two current fish husbandry problems are the low number of gravid longfin broodfish received each year and the fact that these mature fish and the older juveniles are not weaning to a dry commercial diet. In the 2012 season only two gravid females were successfully spawned. The dependence on live prey species, which is poor in nutrients and difficult to maintain over winter, results in inefficient fish production and poor fish condition. A demand for research animals currently exists, and FCCL hopes to meet the demand in a few years. The FCCL has tested eggs and larvae under several saline-exposure conditions and expects to continue this line of inquiry. Animals are requested by collaborators and researchers at University of California - Davis to address bioenergetics, behavior, salinity-exposure, and tagging studies. Results from this suite of research studies will help delineate migratory patterns, areas of favorable environmental conditions, and energy expenditures for wild fish – all highly relevant to Bay-Delta management.

Keywords: Longfin Smelt, fish culture, captive rearing

Poster Topic: Fish Biology, Ecology and Protection

Influence of Food Web Dynamics on Mercury Bioaccumulation in Nesting Seabirds

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The Farallon Islands are located 28 miles west of San Francisco and support the largest colony of breeding seabirds in the contiguous United States; however, reproductive performance in many seabird species has been declining over the past several decades. Mercury remains one of the most pervasive contaminants along California's coast due to historic mining and atmospheric deposition. To investigate mercury bioaccumulation in seabirds we analyzed eggs from three species nesting on Southeast Farallon Island: Cassin's auklet (*Ptychoramphus aleuticus*), rhinoceros auklet (*Cerorhinca monocerata*) and pigeon guillemot (*Cepphus columba*). In addition to eggs, we analyzed a variety of fish and invertebrates that nesting seabirds feed on. To assess trophic position and feeding location egg and diet samples also underwent carbon and nitrogen stable isotope analysis. Results indicate both pigeon guillemot and rhinoceros auklet eggs have mercury concentrations that exceed the lowest observed adverse effects level of 0.50 µg/g (fresh wet weight) for impaired avian egg hatchability, suggesting that seabirds breeding on Southeast Farallon Island are being exposed to levels of mercury that could be contributing to observed population declines. Further, isotopic analysis indicates that mercury bioaccumulation in seabirds is impacted by both trophic position and feeding location.

Keywords: Mercury, Bioaccumulation, Stable Isotopes, Avian Egg

Poster Topic: Food Webs

In Situ Measurement of Ammonium Utilization by Phytoplankton to Determine the Impacts of Nutrient Loading on the Base of the Delta Food Web

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High concentrations of NH_4^+ in the San Francisco Bay-Delta Estuary have been hypothesized to inhibit the growth of larger phytoplankton such as diatoms, which are an important food source to zooplankton at the base of the pelagic food web. The primary goal of this research is to use stable isotope approaches to distinguish NH_4^+ and NO_3^- utilization at the base of the food web in a range of habitats extending from fresh water portions of Sacramento River through San Pablo Bay. Preliminary results from transects sampled over a range of hydrologic conditions between 2007 and 2010 indicate shifts in the $\delta^{15}\text{N}$ composition of the bulk particulate organic matter (POM) where $[\text{NH}_4^+]$ increases downstream of the SRWTP and again where $[\text{NH}_4^+]$ decreases near the confluence of the Sacramento and San Joaquin Rivers. However, interpretation of $\delta^{15}\text{N}$ of bulk POM as a proxy for $\delta^{15}\text{N}$ of phytoplankton is complicated by the fact that the C:N ratios of bulk POM often increase to values greater than 8 downstream of the San Joaquin – Sacramento River confluence, suggesting that in this region of the estuary bulk POM includes a significant proportion of terrestrial detrital material. Given the interest in understanding nitrogen source utilization in this portion of the estuary, work is currently underway to isolate algae from bulk POM using flow cytometry prior to isotopic analysis. $\delta^{15}\text{N}$ values from isolated algal samples will allow downstream changes in nutrient source utilization to be distinguished from mixing of different POM sources. Because considerable bulk POM isotopic data have been collected over the last ten years, greater understanding of the relationship between $\delta^{15}\text{N}$ -POM and $\delta^{15}\text{N}$ of isolated algal and terrestrial fractions will allow for improved use of the bulk POM isotope record to understand the potential link between historical changes in phytoplankton nutrient utilization and Delta POD.

Keywords: ammonium, nitrate, phytoplankton,

Poster Topic: Food Webs

Creating an Adaptive Management Decision-Making Framework to Address Uncertainties in Delta Habitat Restoration: Tidal Marsh Productivity Exports, Aquatic Food Webs, and Delta Smelt

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Restoring freshwater tidal marsh habitat in the Sacramento-San Joaquin Delta is likely to produce a multitude of ecosystem benefits, including creation of habitat for native terrestrial and aquatic species, many of which are federally or State-listed threatened or endangered. However, there is significant uncertainty associated with the relative magnitude of some of the key proposed benefits of restoring tidal marsh in the Delta, including its value to native fish for spawning, foraging, and rearing, and the timing and magnitude of the contribution of tidal marsh exports to the pelagic food web. There is critical need for an adaptive management strategy to guide planning for large-scale restoration targeted to benefit native fish species, including development of an experimental phased approach to implementation, to resolve uncertainties, and to use new knowledge to adjust our expectations and guide future actions.

We propose an adaptive management approach to implementing landscape-scale tidal marsh restoration, focused on resolving uncertainty related to tidal marsh contributions to the pelagic food web in support of delta smelt. We also propose key ecosystem monitoring metrics, outcome targets, and a decision-making process for responding to success or failure of pilot restoration projects.

Keywords: Adaptive management, delta smelt, food web, tidal marsh, restoration

Poster Topic: Food Webs

Comparing Copepod Adult and Naupliar Feeding using Epifluorescence Microscopy and a High-throughput Microplate Assay

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Despite extensive research on feeding by adult copepods, only a handful of studies have addressed feeding by nauplii, the smallest, larval stages of the copepod life cycle. In aquatic systems, copepod nauplii can outnumber adults by several orders of magnitude, and their high numerical abundance suggests that they play an underestimated role in aquatic food webs. We hypothesized that copepod nauplii eat different types and sizes of food particles, because they differ markedly from adults in size, morphology, and feeding and swimming behavior. We tested this using three very different copepod species: *Pseudodiaptomus marinus*, *Epilabidocera longipedata* and *Oithona davisae*. We offered nauplii and adults various types and sizes of phytoplankton, including a chlorophyte, haptophyte, cryptomonad, two diatoms, and two dinoflagellates. We then assessed the copepods' feeding capability on these prey by inspecting their guts under epifluorescence microscopy for evidence of chlorophyll pigment. For phytoplankton that were consumed, feeding rates were estimated for adults and nauplii using a high-sensitivity microplate-based chlorophyll assay we developed. Our results suggest both diet overlaps and contrasts between feeding capabilities of nauplii and adults. These differences in feeding appear to be related to the shape, motility, or size of prey particles and differences in the copepods' ability to ingest the prey during nauplius vs. adult life stages. Information gathered about naupliar feeding is useful for determining the relative impact that copepods have on foodwebs throughout their entire life cycle. Furthermore, methodologies developed during this project will be valuable for researchers interested in using rapid methods to measure feeding by zooplankton.

Keywords: Copepods, nauplii, larva, larvae, foodweb, foodwebs, epifluorescence microscopy, microplate reader, assay

Poster Topic: Food Webs

The Bay Delta has Undergone Similar Food Web Changes to Other Systems Globally Following Changes in Nutrient Loads

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The San Francisco Bay Delta has undergone many changes in food web structure over the past several decades, including increases in macrophytes and invasive clams, shifts in dominance of planktivorous and piscivorous fish, and increased frequency of harmful cyanobacteria blooms. Many of these changes have been described as driven primarily by the wide range in effects of invasive species and alterations in habitat. However, changes in nutrient concentrations and nutrient ratios over time also fundamentally affect biogeochemical nutrient dynamics that can lead to conditions conducive to invasive species. In particular, changes in nitrogen: phosphorus ratios can “open niches” for new species, which, in turn, can alter habitat or biogeochemical cycling of nutrients, which further alter the potential success of various species. Several other aquatic ecosystems around the globe, from Europe to Australia and the US, have exhibited similar changes in food webs over time linked to similar nutrient changes as in the Bay Delta. Nutrient stoichiometry is thus suggested to be a significant driver influencing food webs in the Bay Delta mediated by positive and negative feedbacks between physiology, biogeochemistry, and organism dominance. Here, comparisons of other global ecosystems are made with the Bay Delta in terms of 1) changes in state from a system with high chlorophyll *a* and high pelagic productivity to one dominated by macrophytes, when phosphorus was reduced; 2) associations between high macrophyte production, invasive bivalves, piscivorous fish, and *Microcystis* growth, and 3) reductions in invasive species following targeted nitrogen reduction measures.

Keywords: global comparisons, nutrient stoichiometry, food web changes over time

Poster Topic: Global Perspectives

Environmental Foresight Through Computational Chemistry: to Avoid Wasting Resources through Implementing Changes that Turn out to be Bad Ideas

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Environmental issues have traditionally been discovered in hindsight after time lags of years to decades of industrial or consumer use of new chemistries. While choices of new materials and routes for accomplishing a technological goal are often driven to avoid newly discovered environmental issues, lack of data often prevents the best economic and planning decisions to be made when alternatives are introduced.

In this work, computational and estimation based methods are used to investigate potential environmental impacts of chemicals, particularly hydrofluoroethers (HFEs), while also retroactively looking at existing chemicals to see if we really do understand the impacts, even now. This work has predicted global warming potentials of a large number of HFEs. However, the definition of global warming potential assumes that all environmental impacts of a species are due to the presence of the original chemical released into the environment, and the retroactive look at chemicals currently in use will examine whether that definition is valid. The environmental degradation pathways of HFEs have been hypothesized but not quantified or validated to date. We predict formation rates and atmospheric lifetimes of likely daughter species of HFEs, and other heavily used compounds, in order to evaluate the environmental consequences after initial degradation in the atmosphere through hydroxyl radical attack. This work also estimates water solubility of species to identify if rain-out is a primary route for removal of parent or daughter species. We estimate octanol-water partition coefficients as a proxy measure of estimating bioaccumulation potential. HOMO-LUMO energy gaps are estimated to potentially correlate with toxicity data as it is developed in the future. Finally, kinetic rate constants of the degradation pathways are estimated using transition state theory. This complete set of evaluative tools gives more insight into potential environmental implications of replacing hydrofluorocarbons (HFCs) with HFE technologies, while expanding prior knowledge.

Keywords: Hydrofluorocarbons Technology, Computational Chemistry, Environmental Degradation, HOMO-LUMO gap

Poster Topic: Global Perspectives

San Francisco Estuary and Watershed Science: Bridging Regional and Global Perspectives through Sound Scholarly Publication

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Now in its eighth year of publication, the online journal *San Francisco Estuary and Watershed Science* has continued to provide local researchers and policy-makers with critical information about this complex, highly managed, and ecologically important region. A fundamental part of the journal's aims and scope is to present science that highlights connections or discrepancies between regional and larger-scale processes and their joint effects on the Bay-Delta ecosystem and its management. For example, Malamud-Roam et al. evaluated regional to global climatic effects in their 2007 paper,

Holocene climates and connections between the San Francisco Estuary and its watershed.

Research that compares Bay-Delta systems and processes to those in other areas of the globe are also well cited among the journal's published articles. These include articles on open water processes of the San Francisco Estuary (Kimmerer 2004), a tree-ring reconstruction of the salinity gradient in the northern SF estuary (Stahle et al. 2011); and benthic assemblage variability in the upper SF estuary (Peterson and Vayssieres 2010). We present that the online journal serves a vital purpose for the Bay-Delta research community--to facilitate discussion and further knowledge about the science and policy surrounding the ecological issues of the region--and to reflect how they differ, mimic, and interplay with the same kind of academic research and debate being conducted on a global scale.

Keywords: scholarly publication, online journal, peer-review, regional focus, global connections

Poster Topic: Global Perspectives

Rush Hour or Clear Sailing? Traffic Patterns of Commercial Vessels Arriving to San Francisco Bay-Delta from 2010-2012

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It is estimated that up to 81% of California's 257 established nonindigenous species (NIS) were introduced via commercial shipping, both through ballast water discharge and release of associated biofouling. The Marine Invasive Species Program (MISP) at the California State Lands Commission (CSLC) has diligently pursued the prevention of NIS release from commercial vessels into California waters. Gaining an understanding of the types of vessels entering the state and their behavior once here, is a critical first step in understanding the potential risks posed by this vector.

CSLC has jurisdiction over vessels entering California waters that are 300 gross registered tons or greater and are capable of carrying ballast. Data collected from ballast water management reports from these vessels arriving to ports within the San Francisco Bay-Delta, including the freshwater ports of Stockton and Sacramento, from 2010 through 2012 will be presented. These data, combined with information on the last port of call and hull husbandry practices, are useful in assessing potential NIS transfers to San Francisco Bay-Delta.

Keywords: shipping, invasive species, ballast

Poster Topic: Human Consequences

Delta Working Landscapes

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The Delta Protection Commission's Delta Working Landscapes program encourages farmland to be utilized as valuable habitat by providing opportunities for private landowners to incorporate wildlife friendly farming with current agricultural practices. Currently, attention and effort is being focused on restoring the natural habitats of the Sacramento-San Joaquin Delta to support aquatic and terrestrial wildlife that may have negative impacts to the Delta's economy and culture. Working Landscapes projects provide benefits over traditional ecological restoration projects as the land remains in agricultural production, thus continuing to contribute to the overall economic sustainability of the Delta while encouraging local citizens to serve as environmental stewards of the landscape.

Approach: Delta Working Landscapes approaches these problems through a variety of methods. Planting vegetative buffers along irrigation ditch banks and hedgerow plantings improve water quality by reducing runoff of pesticides and sediment. Farm cultural practices which can benefit for wildlife friendly agriculture, such as rice, corn and wheat fields have been identified and have implemented seasonal flooding and restoration to increase winter wildlife habitats. These projects have additionally supported water quality improvement, salinity control, subsidence reversal, and weed control.

Results: The Delta Working Landscapes projects improve the environmental quality of existing landscapes in the Delta; coordinate programs with local farmers to understand the social, economical, environmental and governmental policy hurdles and incentives to perform conservation practices; and communicate to farmers the advantages of implementing wildlife friendly agricultural practices.

Conclusions / Relevance

- Partnerships between public and private efforts are possible
- Delta farmers have a strong interest in agricultural and wildlife conservation
- Delta farmers understand the importance of improving the existing quality for future generations
- Working Landscape Projects can be the key for a sustainable Delta

Keywords: Delta, Protection, Commission, Delta, Working, Landscape

Poster Topic: Human Consequences

California State Parks' Gateway>Base Camp>Adventure Strategy

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The Sacramento-San Joaquin Delta and Suisun Marsh's landscape and the economic base of its communities may change significantly over the coming decades because of natural and human pressures. Island farms drive much of the region's economy but limit public access to the shoreline. Waterways, parks, wildlife refuges, marinas, historic communities and pleasant country roads seem to be hidden from, but are well within reach of, millions of Californians and other visitors. These wonderful places to relax outdoors, go boating, learn about and enjoy nature, or appreciate the food, culture and history of the region could be expanded and enhanced to provide many more recreation opportunities for residents and visitors.

The Recreation Proposal for Sacramento-San Joaquin Delta and Suisun Marsh summarizes existing recreation opportunities in the region and presents California State Parks' recommendations for protecting, enhancing and expanding them in ways that support the economic sustainability of the region's communities. Investing in recreational facilities and programs will benefit the region's economy by improving the quality-of-life for residents and attracting more visitors to experience the Delta and Suisun Marsh's recreation assets and authentic character.

We found that many state and local agencies, environmental organizations and businesses contribute to the rich diversity of existing recreation amenities, yet hold the key to many untapped opportunities. Enhancing and expanding recreation opportunities in the region will require collaboration and partnerships between governments at all levels, not-for-profit organizations and the business community.

When recreation providers implement the **Gateway>Base Camp>Adventure Strategy**, described in this poster, it will help more people discover and enjoy the region's recreation opportunities while reducing costs that are increasingly difficult to support. Working together will contribute to the area's economic vitality, supporting jobs, growing businesses and improving the quality of life that makes the region an attractive place to live, visit and do business.

Keywords: Recreation, Culture, Tourism

Poster Topic: Human Consequences

The 3 C's: Communication, Collaboration, and Coordination

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There is no greater source of conflict in California than water management and policy. This is compounded by imperfect communication. The Department of Fish and Game (DFG) Water Branch (WB) tackles these issues by facilitating coordination, collaboration, and communication with the goal of minimizing the amount of conflict in government agencies (state, local and federal) surrounding the management of our State's water and the diverse flora and fauna that depend on that liquid gold.

DFG WB works with local, state and federal partners to better facilitate communication, collaboration and coordination amongst government agencies involved with the management and policy decisions for California's water. Programs or plans that DFG WB collaborates and coordinates with, in either their development or implementation (or both) are the: Central Valley Project Improvement Act – Anadromous Fish Restoration Program and others, Department of Water Resources FloodSAFE California Initiative, California Water Plan, Bay Delta Conservation Plan, Delta Plan, and more.

Through these efforts, we have been able to better integrate DFG's mission and goals into the plans, programs, and projects of other government agencies. Likewise, DFG has sought feedback from others to better facilitate the development of DFG programs, plans or projects that reflect the goals and objectives of other governing agencies. Thus, we can eliminate the need to "reinvent the wheel" and to integrate and synthesize policies, plans and projects so that we are all working together in a more effective manner.

Lessons can be learned from successes and failures, and applied to future and on-going efforts. In order to reach a sustainable ecosystem, government agencies and the general public will have to find a way to get past conflicts – this cannot be done without understanding where and why the conflicts occur and finding a better and more collaborative way to resolve them.

Keywords: Communication, Collaboration, Facilitation, ERP, FloodSAFE, CVPIA, AFRP

Poster Topic: Human Consequences

Private Landowners, a Utility District, and the Feds: A Working Partnership to Benefit Rare Species on the Mokelumne River

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The loss of suitable habitat is one of the major factors in most threatened and endangered species decline. The US Fish and Wildlife Service (USFWS) and East Bay Municipal Utility District (EBMUD) worked with landowners within the Mokelumne watershed to draft a Safe Harbor Agreement (SHA) that was feasible. Within the Mokelumne River watershed, 4 land owners have entered into the USFWS SHA, totaling 28,042 acres. Species and associated habitat included are: California red-legged frog (*Rana aurora draytonii*) (CRLF); California tiger salamander (*Ambystoma californiense*) (CTS); and Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB). During the course of the SHA, over 3000 elderberry plants were planted along with associated native species. Efforts have been made to connect isolated stands of existing elderberry bushes. A total of 2.11 acres of breeding ponds and 129 acres of moist refuge habitat have been created or enhanced for CRLF and CTS. One of the new ponds was colonized by CTS within three years. We have found that land owners tend to be willing to work with the USFWS when the SHA program is explained and demonstrated, and technical expertise is offered. The drafting of the SHA to include protection for their neighbors was one of the critical components of the agreement.

Keywords: Safe Harbor Agreement, Utility Company, Restoration

Poster Topic: Human Consequences

The California King Tides Initiative –Raising Awareness about the Impacts of Sea Level Rise through Photography, Public Participation, and Social Media

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Scientists widely agree that sea-level rise is occurring, and will lead to an increase in flooding and permanent inundation. For Bay-Delta communities, sea-level rise could have serious adverse consequences to human health, the economy, and natural resources. In the short-term, the impacts of sea-level rise will be eclipsed by extreme high tides and storm events. These events provide a preview of how higher water levels could affect the Bay-Delta on a regular basis as sea-level rise occurs.

Bay-Delta managers and scientists are often tasked with the difficult job of effectively communicating compelling messages about sea-level rise, extreme storm events and emergency preparedness to diverse audiences. The King Tides Photo Initiative is an ongoing public engagement project aimed at raising awareness on sea level rise and extreme storm. Spearheaded by a coalition of non-profit and government entities, including the California Coastal Commission, San Francisco Bay National Estuarine Research Reserve (NERR), Gulf of the Farallones National Marine Sanctuary, the California Coastkeeper Alliance, the Tijuana River NERR and the Thank You Ocean Campaign, the Initiative encourages citizens to photograph the high water and coastal hazards associated with King Tides (or the highest winter tides) and to share these images through social media. These pictures preview how our shorelines are changing and what daily tides may look like in the future. In addition, the images create a powerful argument for proactive planning to create resilient coastal ecosystems and communities, today and in the future. Images from the Initiative have been used as an effective and powerful communication tool for managers and scientists. This poster will present images and findings from the Initiative, and will encourage Bay-Delta managers and scientists to participate in the Initiative by engaging others, taking photos or using the images in communication materials.

Keywords: King Tides, Sea Level Rise, Public Participation

Poster Topic: Human Consequences

Mapping Eelgrass, Surface Geology and Bathymetry Concurrently Utilizing High Frequency Side-Scan Sonar

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Recent increased requirements for the monitoring of Eelgrass stands in California waters have put a spotlight on the need to accurately and efficiently map areas that contain this valuable resource. Traditional means of mapping Eelgrass and other benthic habitat types have proved to be inefficient and time consuming resulting in maps that are incomplete and expensive to produce.

Environmental Data Solutions (San Rafael, CA) has taken advantage of recent advances in high-resolution Side-Scan Sonar and combined this technology with bathymetric surveying and precise Real-Time Kinematic GPS on one survey platform. The result is the ability to concurrently map bathymetry, benthic habitat types, and seafloor geology in one pass of the survey vessel.

Keywords: Eelgrass, Bathymetry

Poster Topic: Integrative Applied Science

The State of San Francisco Bay 2012: Updated Indicators for Freshwater Inflows and Fish

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Ecological indicators, which integrate large amounts of data and synthesize scientific understanding of ecosystem function, are essential tools for managing the San Francisco Estuary. Indicators are useful to characterize conditions and trends, develop and evaluate adaptive management, and report management and protection results to scientists, resource managers, decision makers and the public. In this presentation I provide updated results for the freshwater inflow and fish indicators from the San Francisco Estuary Partnership's *State of the San Francisco Bay 2011* report. The freshwater inflow index uses six indicators to evaluate 82 years of data on the amounts and patterns of inflows from the estuary's Sacramento-San Joaquin watershed, comparing actual inflows to estimated unimpaired inflows that would have occurred without the effects of dams and water diversions. The fish index evaluates 31 years of data for fish abundance, diversity, species composition and distribution for different regions in the estuary, from Central Bay near the Golden Gate to Suisun Bay. Results show that inflow conditions declined since 1960s, with substantial reductions in the amounts and variability of annual and seasonal inflows. Overall inflow conditions have been mostly "poor" for the past several decades and, in essence, the estuary is now being subjected to chronic drought conditions. The condition of the Bay's fish community has declined since the 1980s in most regions of the estuary, with the most severe declines in Suisun Bay reflecting degraded habitat and ecological conditions in the upstream reach of the estuary. These results show that current management of the estuary is not meeting goals that have been adopted by either the local National Estuary Program or the state legislature. However, these indicator metrics and their results can, and should, inform ongoing efforts to develop restoration and management plans to reconcile state-mandated co-equal goals for ecosystem restoration and reliable water supplies.

Keywords: indicators, ecological health, freshwater flows, fish, San Francisco Bay

Poster Topic: Integrative Applied Science

CHaMP in California: Applications of a Standardized Fish Habitat Monitoring Protocol

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Changes in stream channels that affect fish production have been difficult to document using standard habitat monitoring techniques even though detecting such changes is critical to status/trend and restoration project effectiveness monitoring. The Columbia Habitat Monitoring Program (CHaMP) is developing and implementing a standard set of fish habitat monitoring methods for status, trend, and project effectiveness monitoring. CHaMP includes standardized and customizable study designs, habitat monitoring protocols, data capture and management tools, and data quality control and quality assurance tools. The CHaMP protocol utilizes a total station to conduct precise topographic surveys of the stream channel from which digital elevation models (DEMs) can be produced. DEMs are analyzed using the River Bathymetry Toolkit and other models. The topographic surveys are supplemented by other habitat data including invertebrate drift, large woody debris, solar input and water temperature, stream discharge, substrate composition, fish cover, and riparian structure which help to characterize features of channel units that may affect site-scale fish production.

Results from sampling at over 700 wadable stream sites in 2011 and 2012, the first two years of implementation, will be discussed, including application by the California Department of Fish and Game and Campbell Timberlands Management in three streams in Mendocino County using a spatially balanced random sampling design (for status/trend monitoring) and BACI design for effectiveness monitoring. We also discuss the utility of the River Bathymetry Toolkit, DEM of difference, and net rate energy intake models for long term regional monitoring and applications in wetlands/estuary channel habitat monitoring and in restoration project effectiveness monitoring, all of which are relevant to Bay-Delta managers seeking to restore stream and estuary channel habitat for salmonids and other fishes.

Keywords: fish habitat monitoring, restoration project effectiveness, topographic surveying, watershed, salmonids

Poster Topic: Integrative Applied Science

Integrated Water Operations and Multi-Species, Multi-Performance Indicator Ecosystem Effects Analysis: The San Francisco Delta Ecological Flows Tool (DeltaEFT)

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As demonstrated in recent EIR/S applications for the North-of-the-Delta Offstream Storage Investigation and the Bay Delta Conservation Plan, the Ecological Flows Tool (EFT) clearly communicates the trade-offs for representative performance indicators of multiple focal species. EFT currently supports two eco-regions: (1) SacEFT (www.dfg.ca.gov/ERP/signature_sacriverecoflows.asp) for characterizing the ecological consequences of management-related changes in flow and temperature regime and channel restoration activities on the middle and upper Sacramento River and (2) DeltaEFT for the San Francisco Delta. TNC and ESSA Technologies have recently completed version 1 of the Delta Ecological Flows Tool (DeltaEFT). TNC's effort to extend EFT to the Delta has emphasized detailed reviews of pre-existing biophysical relationships (e.g., DRERIP, BDCP, SWRCB, POD research) as well as support from expert-led workshops to prioritize, vet and customize indicators. Delta flow management scenarios (inflow regimes, conveyance alternatives, gate operations, export pumping rates, sea-level rise) are evaluated in DeltaEFT by linking physical variables to important Delta habitat conditions and focal species targets such as: Brazilian waterweed suppression, invasive overbite clam suppression, invasive Asiatic clam suppression, Chinook/steelhead (multiple run types) smolt development & growth, smolt predation mortality, smolt temperature stress, an index of delta smelt habitat suitability, delta smelt entrainment risk, and tidal wetland inundated area and salinity/inundation regimes. In addition to enabling rapid comparative scenario evaluation (climate change, alternative conveyance and operations), DeltaEFT provides guidance on both target flows (to maximize the related ecological benefits) and avoidance flows (to reduce negative consequences), bracketing the range of discharges to be evaluated experimentally. The presentation provides results from recent applications of DeltaEFT to BDCP alternatives, including summarizing trade-offs among Delta species, and highlighting the significance of future climate change adaptation strategies.

Keywords: Ecological flows, environmental flow assessment, functional flow assessment, integrated modeling

Poster Topic: Modeling

Using Conceptual Models to Evaluate Delta Restoration Actions

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State and federal agencies, in collaboration with other partners, are working to improve ecosystem health in the Bay-Delta watershed, increase abundance of native species, and rehabilitate natural processes through protection and/or restoration of habitats. Due to uncertainties inherent in our understanding of dynamic ecosystems, restoration activities should be implemented within a science-based, transparent, and formal adaptive management process. Conceptual models represent a critical component of this process, in that they formalize and apply current scientific understanding, and provide a venue through which to identify areas of uncertainty, identify possible restoration actions, develop expectations, assess likelihood of success, define monitoring needs, and evaluate tradeoffs associated with different management actions. The Adaptive Management Planning Team and Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) developed an initial suite of life history and ecosystem conceptual models and a scientific evaluation process to assess outcomes of proposed restoration actions in the Delta. The models were developed using a common approach and a robust set of tools so that this process would support consistent application of adaptive management. An early use of the models and evaluation process was to evaluate draft conservation measures for the Bay Delta Conservation Plan. Current application of these models and scientific evaluation process is focused on evaluating restoration options at Prospect Island. This process provides for critical review of restoration options so that managers may weigh the potential outcomes, geographic and temporal scale, reversibility, and overall opportunity for learning associated with different restoration actions. Additionally, it allows for evaluation on whether a pilot scale effort is warranted or if a more aggressive restoration effort should be undertaken.

Keywords: Conceptual Models, Adaptive Management, Delta, Restoration, DRERIP

Poster Topic: Modeling

Delta and Longfin Smelt Bioenergetics: Determining Maximum Consumption

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Delta and longfin smelt abundance in the San Francisco Estuary has declined dramatically since the 1980s. Individual-based population life-cycle models (IBMs) were developed for both species to explore the population response to various environmental and management scenarios. However, key data gaps exist for the bioenergetics (growth) components of both IBMs, necessitating laboratory studies to determine the quantity of food consumed by delta and longfin smelt. The objectives of the first part of this study were to create rearing conditions required to study the temperature-dependent food consumption by various life stages of smelt, and to develop a methodology to estimate the daily food consumption. An aquaculture facility, consisting of three independent recirculating systems with four tanks each, was constructed and tested. Cultured juvenile and adult delta smelt were used to develop methods to assess diel feeding patterns and gastric evacuation times and rates. Adult and juvenile delta smelt were successfully maintained in the new aquaculture facility. Three experimental groups of adult fish were held simultaneously at water temperatures of 9, 13 and 17°C. Stomach contents from juvenile and adult delta smelt were successfully retrieved by dissection. Both smelt life stages fed actively during multiple feeding events throughout the day, but no consumption occurred during nighttime hours. Gastric evacuation of juvenile and adult delta smelt after satiation feeding was completed after approximately 21 and 28 hours, respectively, and an exponential model was the best fit to describe gastric evacuation over time. Application of a feeding model indicated that daily consumption by adult delta smelt at a water temperature of 10°C averages approximately 1% of the fish wet weight. Methods presented here will facilitate the establishment of temperature and size dependent consumption components of bioenergetics models for both species.

Keywords: Delta smelt, longfin smelt, bioenergetics, IBM, consumption, gastric evacuation,

Poster Topic: Modeling

Delta Simulation Model (DSM2) Grid Extension

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The Delta Simulation Model (DSM2) grid was extended to the Golden Gate Bridge to allow for its use in simulating sea level rise, island flooding and other scenarios in which significant seawater intrusion is anticipated.

The Delta Simulation Model 2 (DSM2) is a one-dimensional hydrodynamic and water quality model of the Sacramento-San Joaquin Delta. In its standard form, DSM2's geographic extent encompasses I-Street (Sacramento) to the north, Vernalis to the south, east side streams (around I-5) to the east, and Martinez to the west. Although suitable to simulate many Delta modeling scenarios, the western boundary at Martinez is inadequate when significant ocean water intrusion is expected, such as in sea level rise and flooding of Delta islands, particularly those located close to the western boundary.

To use DSM2 to study scenarios in which seawater incursion is predicted, the DSM2 grid was extended to the Golden Gate Bridge through a series of arcs and "reservoirs". These arcs and reservoirs were designed to simulate the volume and salt transport through the bays west of Martinez. This extended grid was calibrated and tested against historical records and RMA simulations of extensive Delta islands flooding.

Modeling tests and extensive sensitivity analyses indicate that DSM2 with the extended grid perform reasonably well, and was found to be reliable for comparative analyses.

Keywords: salt transport, salinity intrusion, hydrodynamic modeling, water quality

Poster Topic: Modeling

Stanislaus River Floodplain Area versus Flow Relationships

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The problem we are trying to solve is to quantify the relationship between flow and floodplain area on the Stanislaus River. The approach we are using is to develop a two-dimensional hydraulic model of most of the Stanislaus River, using previously collected LIDAR and SONAR data, to simulate total wetted area for flows ranging from 250 to 5,000 cfs. The resulting total wetted area versus flow graph is then examined to determine the flow at which floodplain inundation begins, as shown by an inflection point in the graph. The total wetted area at this flow is subtracted from the total wetted area at higher flows to determine the inundated floodplain area at each flow. The main findings are that, for two of the four segments we have completed modeling for, floodplain inundation starts at 1,250 cfs, and increases fairly linearly with increasing flow. The scientific and management implications of our findings are providing a method to quantify the benefits of high spring flows for floodplain inundation. Our findings provide insight as to flows that are needed to sustain the floodplain inundation aspect of the Stanislaus River ecosystem.

Keywords: Floodplain Flow modeling

Poster Topic: Modeling

A Framework for Developing Stream Flow and Thermal Regimes for Multiple Salmonid Species in the Central Valley

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Stream flow and temperature are critical factors in the conservation, protection, and recovery of endangered or threatened anadromous fish species in the Central Valley. These factors are interrelated as temperature is often controlled by stream flow, particularly in rivers regulated by reservoirs. Flow is a major determinant of physical habitat and transport. We use the flow regime concept for developing instream flows for anadromous fish. The concept recognizes that biologically important flows include not only flow magnitude, but also frequency, timing, duration, and rate of change of flows. Seasonal, inter annual, and spatial variability, to which anadromous fish are adapted, are as important as quantity. The flow regime approach also considers flows required for maintaining or improving important ecosystem functions, for example, migration cues, habitat connectivity and diversity, stream channel morphology and geometry, and stream temperature.

Water temperature influences growth and feeding rates, metabolism, development of embryos and alevins, timing of life history events, and the availability of food. For protecting and recovering vulnerable populations (e.g., endangered or threatened), we use optimal water temperatures for each of their life stages. These optimal temperatures serve as the base of setting water temperature criteria for the listed species. Water temperature data from monitoring stations are analyzed and compared with temperature criteria. Using statistical or process-based models, we estimate how much water would be required to meet the established temperature requirements. Using developed models and weather forecast, we are able to provide advice for real-time water operations to maintain adequate stream temperatures for anadromous fish. Flows for sustaining optimal water temperatures are particularly important in warm seasons when flow is low and air temperature is high.

The final environmental flows are the integration of instream flows derived from the flow regime approach with temperature sustaining flows.

Keywords: Environmental flow, instream flow, water temperature, salmonids, water operations

Poster Topic: Modeling

Advancement of Bathymetry in the Sacramento-San Joaquin Delta

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Historical information concerning the water depths and river geometry of the Delta is inconsistent and of variable quality. Moreover, this information, known as bathymetry, changes over time, causing old data to be less and less representative. As bathymetry is a key input to a wide array of models from many disciplines, using old data can result in errors in the scientific community's basic understanding of the scientific processes in the Delta.

However, the application of new data collection technology by DWR scientists has allowed for the rapid detailed mapping of sloughs throughout the Delta. With the use of an R2 Sonic multibeam echosounder for depth collection and a Trimble R8 for RTK positioning corrections, higher quality data is gathered which allows for both better model inputs and, when mapped, the appearance of subtle bathymetric features.

Datasets showcasing this modern bathymetry include areas of Middle River, Lower Mokelumne River, Columbia Cut, Turner Cut, Miner Slough, and the Sacramento Deep Water Ship Channel, among other locations of interest in the Delta.

Bathymetric information is a basic building block for many different environmental, fisheries, hydrodynamic, engineering, geological, and sediment studies that aids project implementation. Hydrodynamic modelers, biologists, engineers, geologists, construction inspectors, reclamation districts, and ecological scientists depend on detailed, up to date bathymetric information. Thus, the collection of accurate, current data by DWR aids the scientific community's fundamental understanding of the processes in the Delta.

Keywords: bathymetry, modeling, DWR, mapping, GIS, subsurface, riverbed, GPS, RTK, multibeam

Poster Topic: Modeling

Application of an Ecosystem-Scale Selenium Model to the San Francisco Bay-Delta Estuary

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Ecosystem-scale selenium modeling frames a site-specific occurrence of selenium; quantifies selenium exposure of fish and birds through foodweb biodynamics; and narrows uncertainties about how to protect it by integrating a system's ecology, biochemistry, and hydrology and a species' physiology and ecotoxicology. The most important regulated estuarine sources of selenium are 1) internal inputs of oil refinery wastewaters from processing of crude oils at North Bay refineries; and 2) external inputs of irrigation drainage from agricultural lands of the western San Joaquin Valley conveyed mainly through the San Joaquin River. We present here a quantitative example of the application of ecosystem-scale selenium modeling for the Bay-Delta. The questions addressed in the example are: What are the implications for ecosystem concentrations of selenium if a fish tissue and/or wildlife selenium guideline is implemented (a guideline based upon selenium concentrations in a predator)? More specifically, what changes in dissolved or particulate selenium concentration in the Bay-Delta would be necessary to achieve the selected tissue concentrations in predators? Agencies have traditionally regulated contaminants on the basis of dissolved concentrations, and managed inputs from different sources based upon their implications for dissolved concentrations (e.g. total mass daily loadings). This example ties the new concept of tissue guidelines to the traditional concept of dissolved-concentration-based management. Inherent in every regulatory guideline are assumptions about the environment being regulated. The model allows an explicit evaluation of the implications of different assumptions. The specificity of illustrated scenarios demonstrates that enough is known about the biotransfer of selenium and the interconnectedness of habitats and species to set a range of limits and establish an understanding of the conditions, biological responses, and ecological risks critical to management of selenium in the Bay-Delta.

Keywords: selenium, foodweb biodynamics, ecosystem-scale modeling, North Bay

Poster Topic: Modeling

Nutrient Loads in Rivers and from Point Sources Used to Develop a SPARROW Model for California and Adjacent States, U.S.A.

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Sources of, and factors affecting, the transport of total nitrogen (TN) and total phosphorus (TP) are being evaluated for a study area that covers most of California and some areas in Oregon and Nevada by using the SPARROW model (SPATIally Referenced Regression On Watershed attributes) developed by the U.S. Geological Survey. Mass loads of TN and TP calculated for monitoring sites at stream gauging stations are regressed against factors affecting land to water transport, including fertilizer use, recharge, atmospheric deposition, stream characteristics, and other factors, to understand how TN and TP are transported under average conditions. SPARROW models have been used successfully in other parts of the country to understand how nutrients are transported and how management strategies can be formulated, such as with Total Maximum Daily Load (TMDL) assessments.

Fertilizer use, atmospheric deposition, and climatic data were obtained for 2002, and loads for that year were calculated for monitored streams and point sources (mostly from wastewater treatment plants). The stream loads were calculated by using the adjusted maximum likelihood estimation method (AMLE). River discharge and nutrient concentrations were de-trended in these calculations in order to eliminate the effect of temporal changes on stream load. Effluent discharge information, and TN and TP concentrations from point sources, were obtained from USEPA databases and from facility records. TN and TP point-source loads were estimated at some sites by using effluent discharge information.

Annual loads to the Delta for both TN and TP are highest from the Sacramento River because of the greater discharge of that river, although daily concentrations tend to be higher in other regions, such as the San Joaquin Valley. Wastewater facilities, located mostly around large cities near the Delta, San Francisco Bay, and southern California account for 75% of the point source TN and TP loads throughout the study area.

Keywords: SPARROW, model, Nutrients, point sources, water quality, loads,

Poster Topic: Modeling

Assessment of Watershed Analysis Risk Management Framework (WARMF) Model Data from Sacramento and San Joaquin Watershed

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The Department's Bay-Delta Office (BDO) uses the WARMF model to generate inflow boundary conditions for Delta Simulation Model 2 (DSM2) simulations of water quality in the Sacramento-San Joaquin Delta. The Municipal Water Quality Investigation (MWQI) branch was asked by the BDO to find flow, DOC or TOC data for stations where the WARMF model lacks these data, or there is a concern that the WARMF data are incorrect. Data were gathered the period from January 1990 to December 2010. In total, there were 183 supplemental flow stations identified at 114 WARMF model locations, and 304 supplemental DOC and TOC stations identified at 225 WARMF model locations. Data and reports including maps and graphs were provided to BDO.

Keywords: Watershed, Analysis

Poster Topic: Modeling

Improvements in CVP/SWP System Operational Planning: High Acuity Simulation Platforms to Better Capture Hydrological Sensitivity

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Problem Statement:

Current system operations planning models across the CVP/SWP use monthly timesteps and incorporate simplifying assumptions for hydrologic processes. Although models like CALSIM II have been improved over time, existing models are limited in their ability to address complex regulatory requirements, a shifting hydrologic regime, and the need to balance environmental indicators. Advances in computational capabilities now mean that new models can be developed to overcome these limitations, to address future hydrologic uncertainty, and to greatly improve modeling accuracy.

Approach:

Several model development steps are proposed. First, we propose a physics-based hydrologic representation of the upper basin source areas using kinematic wave propagation, and incorporating the snowmelt energy balance, representative elementary area (REA) principles, variable source area (VSA) contributions, in-basin storage, vadose/phreatic interrelationships, isotopic information on source fluxes, and other factors. Second, to represent future hydrologic conditions and move toward “real-time” simulations, we would develop alternatives to the traditional use of historic hydrologic records. The model would rigorously express physical runoff functions and retain operational, regulatory, demand, and facility information. We propose to also refine initial boundary conditions, including reservoir carryover, basin antecedent moisture, groundwater storage, potentiometric surfaces, etc. Third, we propose a deliberate shift to a daily timestep for all model functions. Fourth, reservoir temperature, stratification, and basic water quality simulations would be incorporated into the model framework.

Relevance:

A new integrated model would: (1) re-assess upper basin hydrology given accelerated hydroclimatic signals; (2) move to real-time CVP/SWP simulation and Bay-Delta response; (3) provide alternatives to the use of historic hydrologic records; (4) develop contemporary *worst-case* and *extreme event* sequences; (5) use daily timesteps for operations, reservoir water quality, and flow routing; and (6) re-evaluate existing model frameworks to affirm proper representations of land use, accretions, depletions, new facilities, and groundwater relationships.

Keywords: operations modeling, hydrology, climate change, flow routing, reservoir water quality

Poster Topic: Modeling

The Effects of Managing for Waterfowl Migration on Greenhouse Gas Emissions

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In the Sacramento – San Joaquin Delta, harvested cornfields make up nearly 80% of the area intentionally flooded during the winter for waterfowl migration along the Pacific Flyway. Given the importance of cornfields for seasonal flooding and crop production, additional information is needed to assess changes in soil moisture on greenhouse gas (GHG) emissions from Delta soils. Flooded conditions can increase methane emissions, having a global warming potential 25 times that of carbon dioxide, while suppressing carbon dioxide flux. In November of 2011, the United States Geological Survey constructed an eddy covariance tower at a winter flooded cornfield on Staten Island, located near Walnut Grove, owned by The Nature Conservancy. In the spring of 2012, a second tower was constructed on an adjacent field that remains fallow during the winter months. Both towers are identical, and capture carbon dioxide, latent, sensible, and ground heat fluxes, as well as a suite of radiation measurements. A LI-COR Open Path Methane Analyzer was installed on the flooded flux tower at installation. Once the flux tower in the fallow field was operational, the methane analyzer was exchanged between sites approximately every two-weeks.

Preliminary results suggest that the flooded treatment reduces carbon dioxide emission, while magnitudes of methane emissions increase throughout the flooding duration, peaking as water is removed from the field in early spring. We added six soil chambers to each field treatment in late spring of 2012 to isolate soil GHG emissions of carbon dioxide and methane from the flux tower and to measure the emissions of nitrous oxide. Continuous GHG emissions from the flooded site starting in November of 2011 and from the fallow field starting in the spring of 2012 will be presented along with the chamber results from the summer growing season from both fields.

Keywords: Greenhouse Gases, Eddy Covariance, Waterfowl Migration, Agricultural

Poster Topic: Physical Processes

How Small-Scale Hydrodynamics in Tidal River Junctions Affect Dispersion

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In branching channel networks, such as might be found in the Sacramento-San Joaquin River Delta, channel junction flow dynamics may significantly impact large-scale dispersion. We focus on the structure and variability of several tidal junction flow features to understand how small-scale dispersion at junctions adds up to large-scale, network dispersion.

Observations made in August 2011 and May/June 2012 at four tidal junctions (Sacramento River and Three Mile Slough; Three Mile Slough and San Joaquin; Old River and San Joaquin; and Georgiana Slough and Mokelumne) display complex small-scale hydrodynamics. A combination of Acoustic Doppler Current Profile (ADCP) boat transecting at four junctions and moored ADCPs over a spring-neap tidal cycle at one junction provides observations of spatial and temporal variability of the flow structures. In conjunction, drifter studies at two junctions were completed to survey how tidal river junctions affect near-field dispersion. Results are corroborated with numerical simulations using the SUNTANS model.

These measurements show that junction dynamics are highly variable over a few hours with the formation and decay of shear mixing layers and separation, recirculation, and subduction zones. Small-scale junction flow features appear to be linked mostly to plan-form geometry and depth variations. These preliminary observations indicate that large-scale hydrodynamics models of the Delta may produce erroneous dispersion results unless small-scale flow features at junctions are properly parameterized.

Keywords: tidal junctions; flow features; dispersion; hydrodynamics; recirculation zones; mixing layers

Poster Topic: Physical Processes

Sediment Characteristics of Managed Flood Control Channels in Southern San Francisco Bay

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Construction of flood control channels on many of the rivers and creeks draining to San Francisco Bay (California, USA) was prompted by the combination of the rapidly urbanizing Bay Area and the series of large regional devastating storms in the 1950s. The primary objective of these channels was routing floodwaters to the Bay; transport of sediment and other beneficial uses such as wildlife habitat were often overlooked. Consequently, due to the constructed dimensions (shape, width, depth, gradient), these channels have been filling with sediment. In order to maintain floodwater capacity, managers must de-silt the channels, which can be very expensive and require difficult-to-obtain permits. In addition, removing the sediment from the channels prevents that sediment from ever reaching the Bay margin, and potentially being reworked and deposited in tidal flats or marshes.

Data on the in-channel deposited sediment (volume, location, grain size) is lacking in the Bay Area. The present study represents a first step of data collection on a regional scale to better understand sediment in managed flood control channels. Between December 2009 and February 2012, bulk sediment samples were analyzed for grain size distribution from the Alameda Creek Flood Control Channel (ACFCC), Old Alameda Creek (OAC), and San Lorenzo Creek (SLC). The average grain size (D50) was 2.5mm, 0.014mm, and 3.4mm in ACFCC, OAC, and SLC, respectively. The differences reflect a combination of factors including source characteristics, depositional environments, and fluvial-tidal transition influences. In each respective channel, tidal samples contained a higher percentage of silt and clay than fluvial samples. In-channel structures such as tide gates and stilling basins were also shown to have strong effects on grain size. The data from this study can be used to support numerical modeling efforts, explore alternatives to de-silting, and find alternative applications for the removed sediment, such as wetland restoration.

Keywords: sediment, flood control channel, grain size

Poster Topic: Physical Processes

Hydraulic Interactions Between a Meandering River Channel and its Floodplain During an Overbank Flood

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Understanding hydraulic interactions between rivers and floodplains is a prerequisite for determining how geomorphic processes shape complex aquatic and riparian habitats and for informing management and restoration strategies. Flows between channels and floodplains are generally thought to be highly three-dimensional due to the presence of secondary circulation cells and helical flow patterns observed in laboratory experiments, yet few field datasets exist to test or validate existing conceptual models. Flow over and through floodplain vegetation has also been difficult to characterize at the field scale.

We took advantage of a remarkably long and stable 5-year flood discharge to measure flow fields across the floodplain and in curved reaches of the gravel-bed Merced River to document the hydraulic interactions between the channel and floodplain. We then developed, calibrated and validated a quasi-3D hydrodynamic model of the flows in order to expand the interpretation of the results. Due to spatial variability in both topography and flow resistance, the modeling required detailed mapping of the channel-floodplain surface and vegetation with a terrestrial LiDAR scanner and RTK GPS units.

The results highlight three general aspects of the hydraulic interactions during an overbank flow event: (1) the flow field in the channel was largely two-dimensional with only weak helical flow patterns; (2) flow velocities rapidly decelerated as water was decanted from the channel onto the floodplain where the velocity magnitude was roughly 20-30% of the average channel velocity; (3) dense vegetation along the channel margins enhanced channel velocities but reduced them on the floodplain, while floodplain areas with sparser riparian vegetation were subject to higher erosive forces where chutes are beginning to form.

The modeling approach used here provides a means of anticipating patterns of flow and vegetation density after floodplain management and during the longer-term development of channel and floodplain complexity.

Keywords: river channel flow, overbank flow, meandering, riparian vegetation, floodplain rehabilitation

Poster Topic: Physical Processes

Distributed Hydrological Modeling Using High Resolution Precipitation Products

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NOAA's Hydrometeorology Testbed (HMT) program has applied hydrologic modeling tools as an adjunct to Quantitative Precipitation Information (QPI) activities in order to: a) evaluate the accuracy of the QPI fields, b) advance the science for hydrologic modeling at the watershed scale, and c) demonstrate integration of "natural" flows as inputs to obtain "managed" water flows. This paper will summarize results obtained to date per these objectives. HMT hydrologic modeling activities have focused on the North Fork American River (NFAR) basin and the Russian-Napa River (RNR) basins. A distributed hydrologic model (DHM) has been applied to represent the spatial variability of precipitation forcings, and land surface and soil moisture response processes. The Research Distributed Hydrologic Model (RDHM) is the primary tool for modeling unregulated flows.

A DHM provides a way to assess the accuracy of gridded Multi-Sensor Precipitation (MSP) mappings by accounting the total watershed budget. The NFAR DHM was applied to evaluate a variety of precipitation fields generated by radar-only, gage-only, and radar-gage combinations. A seminal contribution was also made for tracking the snow level (SL) of storms in the Sierras; above the SL there is snow accumulation, below the SL there is rain which runs off. Application of the DHM to the RNR basins was used to make comparison between the distributed and lumped modeling approaches. Coupling of the hi-res MSP fields with the DHM provided significant advantages in comparison to a lumped approach mainly because the DHM yields flow predictions at any location. Ensembles of MSP fields were also applied to assess prediction uncertainty.

Keywords: distributed hydrologic modeling, high-resolution precipitation forcings, prediction uncertainty

Poster Topic: Physical Processes

Sediment Transport on the San Joaquin River Below Friant Dam, WY2010 and WY2011

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The San Joaquin River Restoration Program (SJRRP) was authorized in 2006, with a primary goal to restore fish habitat in the San Joaquin River from Friant Dam more than 220 km downstream to the Merced River confluence. One major objective of the SJRRP is to manipulate flow releases from Friant Dam to restore geomorphic processes, leading to improvements in fish habitat. In support of this objective, five sediment monitoring stations have been established by the USGS, located at Highway 41, Skaggs Bridge, Gravelly Ford, Chowchilla Bifurcation, and Mendota Pool. At each station, bedload, suspended sediment, and bed-material are collected as well as flow discharge and velocity. The sediment data from WY2011, a wet year, combined with the sediment data from WY2010, a relatively dry year, provide one of the first opportunities to investigate measured sediment transport on this river. The results of this analysis found that bedload samples from the highest flows occasionally contain large amounts of gravel, though most are dominated by sand. One initial result of interest is that the bedload exhibits intermittent gravel transport (16mm – 64mm) at relatively low flows - as low as 600 cfs in the upper gaging sites. This finding is in contrast to earlier 1D modeling studies that suggested much higher flows were needed for gravel mobilization. The middle site, Gravelly Ford, has the largest bedload transport rates (>10x larger than other sites), representing a discontinuity in downstream sediment transport. The bed-material data collected in WY2011 have a distinct pattern of coarsening through the large flow events of WY2011 at the two upper gaging sites (from nearly 100% sand to ~50% gravel), suggesting either a limitation in sand supply or local source of sand supply. The sediment data presented here are a critical tool for restoration planning and assessment of SJRRP efforts.

Keywords: Sediment Transport, Geomorphology, San Joaquin River, River Restoration, Instream Flows.

Poster Topic: Physical Processes

Contrasting Snowpack Trends in the Sierra Nevada

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Reports of a general decrease in western USA mountain snowpack attributed to global warming have been widely published in recent years. This is not universally true. Southern Sierra snowpacks have generally shown an increase during the past 60 years while the northern Sierra pack has decreased. In both northern and southern regions the portion of water year runoff during the April through July snowmelt period has decreased, although less so in the southern Sierra basins. This paper will review these contrasting trends and examine possible reasons including elevation and precipitation patterns. Part of the answer is that increases in winter precipitation have a larger influence on winter snowpack accumulation in the southern Sierra because of generally higher elevations than in the north. However, water year runoff does not seem to be changing much. These shifts, if they continue, will have an impact on usable water supply and reservoir operation.

Keywords: Sierra snowpack, runoff shifts, trends in precipitation and runoff

Poster Topic: Physical Processes

Numerical Simulations of the Effect of Small-Scale Flow Features on Dispersion within Channel Junctions

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Although the oscillatory motion of the tides in the presence of complex channel networks is the dominant source of dispersion in the Delta, little is known about how small-scale features such as mixing layers and separation zones at junctions alters this dispersion. To study the effect of small-scale flow features on the large-scale tidal dispersion, we present results of numerical simulations of Georgiana Slough (GS), a representative field site due to its geometric simplicity and ease of access for field measurements. GS is comprised of four channels characterizing confluence and diffuence behavior that exhibits flow separation, secondary circulation, and mixing zones. Using the SUNTANS model, we employ high-resolution, nonhydrostatic numerical simulation to simulate these small-scale flow features. Results are validated with field observations and we discuss the impact of the small-scale flow features on the large-scale dispersion.

The results suggest that the coarse resolution of existing models and use of the hydrostatic assumption may ignore important effects of junction-scale flow features on network dispersion. Understanding how junction mixing affects network dispersion is vital towards improvement of modeling efforts to simulate and analyze the effects of Delta management operations.

Keywords: Georgiana Slough; nonhydrostatic hydrodynamic models; dispersion; junctions; SUNTANS; secondary circulation;

Poster Topic: Physical Processes

5 Million Cubic Meters of Channel Change in the Yuba River and the Processes That Made It Happen

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Quantification of changes in channel morphology provides a means for monitoring and analyzing fluvial sediment budgets relevant to ecosystem services. Analyses of these segment-scale budgets and their associated process mechanisms have been moving away from the traditional cross-section based surveys and towards the dense-resolution, near-census survey approach, which allows for detailed stratifications of the topographic changes at multiple spatial scales (i.e., segment, reach, and morphologic unit). Digital elevation models (DEMs) of ~35-km of the lower Yuba River (LYR) were used to calculate topographic changes for the period 1999-2009. While the channel segment exhibits a relatively small overall sediment output, the scour/fill volumes were found to vary widely at the reach and morphologic unit (MU) scales. The dynamism experienced at the smaller spatial scales is a result of differences in the processes of topographic change. From the difference of DEMs, a suite of channel change processes (CCP) (e.g., bank migration, avulsion, bar emergence, downcutting, and in-channel fill) was delineated within ArcGIS using an objective classification metric. The areal patterns and volumetric rates of change of each CCP were then analyzed at multiple spatial scales. For example, overbank scour processes are dominant within the segment; however, in-channel downcutting scours more sediment volume in the uppermost and lowermost reaches. At the MU scale, pools experience ~3 times higher scour rate than riffles, an indication of channel self-maintenance and resilience. Also, the dominant scour process within pools is downcutting, as compared to lateral bank migration for riffles. In summary, the LYR is a highly dynamic system, and the identification and analyses of the CCP at multiple scales provide insight into river management and restoration strategies within the Sacramento Valley.

Keywords: Channel Change; Sediment Budget; Scour Fill Processes

Poster Topic: Physical Processes

Going Native: Evidence that High Flows Expand the Spatial Distribution of Native Fish in the Yolo Bypass

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The Yolo Bypass provides the largest contiguous floodplain habitat for native fishes in the Sacramento-San Joaquin Delta. Previous work has documented the timing of floodplain use by native species, but relatively little analysis has been done on the spatial variation of habitat use within the Bypass. Since 1998, the Yolo Bypass fisheries monitoring program run by the Department of Water Resources (DWR) has conducted a year-round beach seine survey to determine species composition and habitat use in the Bypass. Sites are sampled on a biweekly basis year-round in the Toe Drain, the tidal perennial channel located on the eastern edge of the Bypass. With tributary inputs and a tidal weir (Lisbon Weir), the Toe Drain has substantial spatial and seasonal variation in temperature, conductivity, flow, and tidal influence. Since the project's inception, sampling has consistently occurred below Lisbon Weir with more intensive sampling throughout the Bypass during months of floodplain inundation. In 2011 and 2012, more intensive sampling above and below Lisbon Weir was conducted to improve our understanding of fish community patterns along a broader tidal gradient. Catch data from 1998-2012 showed that native fishes represented 29% of the total catch during the spring months (March-June), but this proportion varied substantially among years. The native fish assemblage was largely dominated by Sacramento splittail *Pogonichthys macrolepidotus* (50%) and Chinook salmon *Oncorhynchus tshawytscha* (14%) in most years, especially during years of substantial floodplain inundation. More extensive surveys in spring 2011 and 2012 indicated that the proportion of native fish was highest during periods with increased flow, with native fish species exhibiting a broader distribution (both above and below Lisbon Weir). Our analyses provide information useful to managers seeking to understand floodplain habitat use for migratory and resident native fishes.

Keywords: Yolo Bypass, Floodplain, Native, Habitat, Flow, Toe Drain, Lisbon Weir, Beach Seine, Inundation, Spatial Distribution

Poster Topic: Species and Communities

Effects on Water Quality and Nutrient Cycling by a Large, Native Unionid Mussel (*Anodonta* spp.) in a San Francisco Bay Watershed and Reservoir

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Freshwater mussels filter phytoplankton, bacteria, and other particulate organic matter from the water column, and excrete nutrients in the form of urine and feces, which contain ammonium and phosphorous compounds; nutrients that often limit primary productivity in aquatic ecosystems. In San Andreas Reservoir, a drinking water reservoir south of San Francisco, relatively dense populations of native freshwater *Anodonta* mussels (belonging to the *californiensis/nuttalliana* clade) are coexisting with invasive clams (*Corbicula fluminea*), among dense invasive aquatic plants (*Myriophyllum spicatum*). *Anodonta* mussels are also found locally in Alameda Creek, the Sacramento River, and in other waterbodies in the Bay-Delta watershed. Although many nutrient cycling experiments have focused on invasive species, fewer studies have focused on native mussels and resource managers want to know what effect these native mussels are having on water quality in the reservoir. To answer this question, *Anodonta* mussels were collected from the reservoir and brought to a temperature-controlled environmental chamber, scrubbed free of biofilms, and placed in deionized water. Water samples were collected at time steps over a period of five days and analyzed for ammonium, orthophosphate, and total phosphorus. Present data, for spring conditions, indicate that at 12°C, larger (~ 8 cm) individual *Anodonta* mussels excrete ammonium at a rate of ~4.8 µg NH₃ / g (shell-free dry weight) / hour, and orthophosphate at a rate of ~1.7 µg PO₄ / g (shell-free dry weight) / hour. These nutrient excretion rates are similar to other unionid mussels such as *Lampsilis radiata siliquoidea* in watersheds of the Eastern United States.

Keywords: Unionidae, *Anodonta*, freshwater mussels, nutrient cycling, water quality

Poster Topic: Species and Communities

Biodiversity Effects of *Spartina* Control

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In 2003, the State Coastal Conservancy's San Francisco Estuary Invasive *Spartina* Project (ISP) began testing use of the herbicide imazapyr for the treatment of the invasive salt marsh grass *Spartina alterniflora x foliosa*. To assess the efficacy of ground and aerial-based treatment by imazapyr, and to identify any non-target impacts on adjacent vegetation, permanent plot monitoring was initiated in 2004 at 22 marshes. Monitoring was expanded to 56 marshes by 2006. Plots were monitored annually for stem counts of invasive *Spartina* (the target of control efforts) and percent cover of all vegetation. Results indicate that imazapyr is effective in reducing the stem count and cover of invasive *Spartina*, and that biodiversity of native vegetation increases within 2-3 cumulative years of treatment. These results indicate that any non-target effects of imazapyr on adjacent vegetation are insignificant to overall recovery of tidal marsh plant biodiversity, even in the short term. This information has been useful in designing effective treatments for and minimizing the non-target effects from invasive *Spartina* control efforts and is relevant as the ISP seeks to complete its goal of eradication of invasive *Spartina* in the coming years.

Keywords: *Spartina*, biodiversity, herbicide, invasive

Poster Topic: Species and Communities

Determining Habitat Relationships and Estimating Abundance of California Clapper Rail in Spartina-Invaded Marshes in the SF-Bay Estuary

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The endangered California clapper rail (*Rallus longirostris obsoletus*) is an obligate tidal marsh bird in the San Francisco Bay Estuary. Loss of tidal wetlands over the past century reduced the abundance of this cryptic rail to critical levels, necessitating the listing of the subspecies as endangered in 1973. Since then, much of the remaining clapper rail habitat has been significantly altered by the invasion and subsequent removal of non-native *Spartina* species, a known ecosystem engineer. Annual survey counts of the California clapper rail are used to inform management decisions as well as estimate temporal population trends in tidal marshes and tidal marsh restoration in the San Francisco Estuary. However, clapper rail survey counts are highly variable, creating a problem for managers trying to understand population trends and the response to management actions such as the control of non-native *Spartina* cordgrass species. We used clapper rail point count survey data collected by the Invasive *Spartina* Project from 2010 to 2012 to identify the factors that contribute to imperfect detection. We used occupancy modeling to determine the habitat relationships of the California clapper rail within the study area. We used repeated counts to determine the relationships between habitat characteristics and estimates of clapper rail abundance. Results of our analysis can be used to monitor changes in abundance over time at marshes undergoing non-native *Spartina* control. By incorporating imperfect detection, determining habitat relationships and estimating abundance, results from our analysis can be used to better inform stakeholders on evaluating management and conservation decisions.

Keywords: California clapper rail, endangered species management, occupancy, abundance, invasive *Spartina*

Poster Topic: Species and Communities

Increased Bird Species Richness and Diversity at Restored Sites within the Sacramento-San Joaquin Delta

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Riparian and wetland habitats of the Sacramento-San Joaquin Delta provide an important but greatly reduced resource for birds. In light of large-scale planning efforts targeting the restoration and enhancement of these habitat types, a region-specific understanding of bird use within the Delta landscape is needed. In an effort to begin to address this information gap, we surveyed bird populations and vegetation characteristics at 18 habitat enhancement project sites within the Delta region during May and June of 2011 and 2012. Bird species occurrence, richness, and diversity were assessed and compared at sample plots located in 7 pre-restoration and 11 post-restoration sites. Land cover at the plots consisted of cropland (n=17), irrigated pasture (n=26), ruderal or fallow land (n=13), and riparian and wetland (n = 59). We found a large shift in species composition of the bird community when comparing pre- to post-restoration sites. Mean species richness at the plot level was significantly higher at riparian and wetland ($6.52 \pm 0.36se$) and ruderal or fallow sites (4.76 ± 0.67) versus sites with cropland ($2.77 \pm 0.36se$) or irrigated pasture ($2.96 \pm 0.32se$). We found similar results for mean species diversity. Riparian and wetland sites with habitat enhancements or mitigation had significantly higher mean richness and mean diversity at the plot level, indicating that these sites provide habitat resources to a richer and more diverse bird community compared to pre-construction sites. All estimates were lower than those found by similar studies in more intact, riparian-wetland systems with higher connectivity, indicating that Delta riparian and wetland habitats can be improved upon. The findings of this study allow us to evaluate the success of habitat restoration and enhancement projects, to understand changes in community composition and abundance due to restoration, and will inform future restoration planning with region-specific information.

Keywords: Avian, Riparian, Delta, Richness, Diversity,

Poster Topic: Species and Communities

Extended Layups of Commercial Vessels Operating in California Waters: Implications for Vessel Biofouling and Nonindigenous Species Introductions

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Fouling of aquatic organisms on the submerged surfaces of vessels can be a potent vector for the introduction of nonindigenous species into new areas, including California. Vessel biofouling has been implicated as a vector in up to 60% of the introductions into California. Additionally, about 65% of California's established nonindigenous species were first documented to occur in San Francisco Bay.

It is believed that the longer and more frequently a ship remains in a single area, the more likely it is to potentially accumulate biofouling organisms on its submerged surfaces. Unfortunately, reports of increased numbers of commercial ships being anchored and laid up across the world have become commonplace over the past few years - one side effect of the current world economic downturn. Since January 2008, the California State Lands Commission (Commission) has been collecting information on the hull husbandry practices and fouling-related voyage characteristics of the commercial fleet operating in California. Preliminary analysis of the data collected in 2008, 2009, 2010 and 2011 suggest sharp increase in both the frequency and length of extended layups from 2008 to 2009 and steady levels in the following years. This increase is being driven by certain vessel classes, including auto carriers, passenger ships, container ships, and barges. These trends of increasing frequency and duration of stationary periods will be discussed, along with an evaluation of the geographic locations where these layups are occurring and implications for species introductions. The Commission will use this information on vessel voyage characteristics and hull husbandry practices in conjunction with Commission-funded fouling research to guide the ongoing development of policy on the management of vessel biofouling in California.

Keywords: Biofouling, Nonindigenous species, commercial vessels, ship layups

Poster Topic: Species and Communities

Investigating Causes of Rarity in the Endemic Suisun Thistle

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The highly urbanized San Francisco Estuary contains 90% of California's remaining coastal wetlands, as well as high concentrations of both invasive and rare species. One rare species, the Federally-listed Suisun thistle (*Cirsium hydrophilum* var. *hydrophilum*), is restricted to two populations in which the invasive perennial pepperweed (*Lepidium latifolium*) has an increasing presence. This research explores why the Suisun thistle is rare and which management actions would be appropriate to protect it. We are investigating two potential limitations: competition with pepperweed, and intrinsic constraints during specific life history stages. To address competition with pepperweed, a removal experiment is being conducted and plant and soil responses assessed. To identify key life history stages, seed set, seed dispersal, and seed germination are being quantified under various environmental conditions.

Preliminary results show that monthly pepperweed removal (by clipping) increases cover of native species. Suisun thistle growth did not show a response, but we are continuing to track if there is increased growth, survival, and reproduction in the next generation. Additionally, there is a trend of increasing soil salinity following pepperweed removal, indicating that it may be modifying the soil environment.

In the field, Suisun thistle seed set varied by location and with the presence of an unidentified larval seed predator. In the lab, seeds germinated readily with an inverse response to increasing salinity; seeds also remained viable after two weeks of inundation in tanks. Additional work is underway to quantify wind and water dispersal, determine environmental factors that correlate with seed set, and identify seed predators.

This research will allow managers to protect the Suisun thistle during vulnerable life stages and in critical locations. Additionally, it will allow them to design restoration plans for Suisun Marsh that are informed by the biology and ecology of a sensitive but understudied species.

Keywords: invasive, endangered species, Suisun Marsh, pepperweed, brackish, rare plant, management

Poster Topic: Species and Communities

Regional Distribution and Habitat Associations of California Black Rail (*Laterallus jamaicensis coturniculus*) in the Sacramento-San Joaquin Delta

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Historic survey work aimed at documenting the distribution and status of state threatened California Black Rail (*Laterallus jamaicensis coturniculus*) has largely overlooked the Sacramento - San Joaquin Delta. During March, April, and May of 2010-11, we conducted playback surveys to assess the status of the species within appropriate habitats of the central Delta region. We detected Black Rails at 20 of 46 sites, primarily on in-stream islands with dense vegetative cover. In an effort to begin to understand region-specific habitat and land cover characteristics where the species was found, we analyzed remotely sensed vegetation datasets. We considered land cover at two spatial scales, site-specific and landscape. At the site-specific scale, we found percent cover of freshwater emergent vegetation, valley riparian forest, and size of site to positively affect the probability of detecting rails. On a landscape scale, we found more natural land cover, including freshwater emergent, valley riparian and annual grassland, and less of cropland and riverine cover types surrounding occupied sites. We also found differences in mean site size - sites where Black Rails were detected were significantly larger (13.44 ha, $SE = 2.05$) than locations where no rails were found (4.13 ha $SE = 0.56$). While these results provide increased understanding of Black Rail distribution and habitat associations in the Delta, conservation planning efforts would be better informed with a more comprehensive and robust sampling effort. This should include field measurements of fine-scale habitat characteristics such as vegetative cover, composition, and structure, to provide a clearer understanding of the status of the species within the region.

Keywords: California Black Rail, Sacramento-San Joaquin Delta, habitat associations

Poster Topic: Species and Communities

Vegetation-Associated Macroinvertebrate Communities in the Sacramento-San Joaquin Delta

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The Sacramento-San Joaquin Delta is increasingly plagued with dense swathes of submerged aquatic vegetation. The spread of invasive aquatic macrophytes such as Brazilian water-weed (*Egeria densa*), Eurasian watermilfoil (*Myriophyllum spicatum*), and others has been concomitant with an increase in the importance of littoral food webs and the increases in abundance of littoral fishes such as largemouth bass (*Micropterus salmoides*). Although aquatic vegetation and nearshore fish communities have received increased attention, little is known about the macroinvertebrate communities supported by these introduced species. Using a modified Marklund sampler we collected samples from nine Delta locations in order to characterize the communities of macroinvertebrates that occur in conjunction with submerged aquatic vegetation. We found that amphipods dominated the biomass of nearshore vegetation communities, while chironomid midges and coenagrionid damselflies were the abundant insect contributors. Macroinvertebrate assemblages varied with vegetation communities and with environmental conditions. This study is important because vegetation-associated macroinvertebrates play a large part in littoral food webs and are the dominant diet item for most nearshore juvenile fishes.

Keywords: Delta, macroinvertebrates, submerged aquatic vegetation, amphipods

Poster Topic: Species and Communities

Managed Shoreline Retreat by Reconstruction of an Estuarine Beach at Aramburu Island, Richardson Bay

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Estuarine beaches composed of coarse sediments (sand, shell fragments, gravel) were formerly widespread in Central San Francisco Bay, where they occupied a narrow upper intertidal zone between tidal flats and wave-cut scarps in salt marshes or uplands. Artificial bay mud levees and armored (riprap) shores have generally replaced estuarine beaches as the shoreline interface type between bay mudflats, marshes, and terrestrial lowlands. The Aramburu Island Habitat Enhancement project serves as a demonstration project for reconstructing estuarine beaches to manage wind-wave erosion of shorelines in public open space lands with habitat and recreational uses. This artificial island in Richardson Bay was constructed from hillslope fill and dredged Bay material in the 1960s, and over decades eroded continually by progressive retreat of an unstable, vertical wave-cut scarp. The Aramburu beach design was based on empirical data collected on beach slope, sediment size distribution, and fetch at reference beaches around San Francisco Bay. Three different beach design approaches were implemented to reflect different combinations of beach slope and grain size and material type. The beach was constructed in fall 2011 by (a) grading back the shoreline profile; (b) building low micro-groin features from small boulders and woody debris to provide low, partial barriers to longshore drift, and (c) depositing different mixtures of sand, gravel, cobble, and oyster shell hash along the reconstructed shoreline in ratios based upon estimated incident wave energy. Gravel, sand, and shell were thoroughly reworked by waves during the first series of high tides immediately following placement, forming a series of self-constructed berms and minor swash bars. Following multiple winter storms with southeasterly (maximum fetch) wave approach, the berm profile persisted. Initial results suggest that shoreline nourishment with coarse sediment, sized to match local wave energy, appears to be a feasible strategy for managing erosion in recreational or habitat-priority bayshores.

Keywords: shoreline erosion, shoreline retreat, beach restoration

Poster Topic: Sustainable Habitats and Ecosystems

Predicting Impacts of Global Climate Change on Native and Invasive Submerged Aquatic Vegetation in the San Francisco Estuary

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Native submerged aquatic vegetation (SAV) provides refuge and nursery habitat for estuarine organisms. Native SAV faces several disturbances, including SAV introductions and a changing climate. In the San Francisco Bay and Sacramento-San Joaquin Delta (the Estuary), temperatures are predicted to rise by 2°C by 2090. Salinity levels are projected to rise due to salinity intrusion from sea-level rise and decreasing freshwater inputs. It is uncertain how the native SAV, *Stuckenia filiformis* (fineleaf pondweed), will interact with the dominant SAV invader, *Egeria densa* (Brazilian waterweed), as temperatures and salinities change. Through a series of mesocosm experiments, we are evaluating the roles of salinity and temperature on *Stuckenia* and *Egeria*. The first experiment tested a range of salinities (0, 5, 10, and 15 ppt) and an elevated temperature of 25 °C on *Egeria*. Treatments represent current and potential future regimes in the Estuary. The first experiment is one of four temperatures (20, 23, 25, and 28 °C) to be tested. After two weeks, all *Egeria* died in the 15 ppt tanks. *Egeria* in the 10 ppt treatments decayed over the course of one month with an 85% decrease in total shoot length. The 5 ppt treatment demonstrated growth, with a 2.5% increase in new shoots. Plants in the 0 ppt treatment performed best, developing a total of 28% new shoot growth. Our results differ from past research where *Egeria densa* biomass greatly declined in salinities as low as 5 ppt. We hypothesize that elevated temperature may increase salinity tolerance of *Egeria* but will further evaluate this possibility at the different temperatures. These experiments will be repeated with *Stuckenia filiformis*. In an era of changing climate, these data will help to predict how distributions of native and non-native SAV will shift, and help to inform conservation and restoration efforts in the Estuary.

Keywords: climate change, submerged aquatic vegetation, salinity, temperature, and invasive

Poster Topic: Sustainable Habitats and Ecosystems

Nearshore Linkages: The Roles of Native Oysters and Eelgrass as Living Shorelines in the San Francisco Estuary

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The San Francisco Bay Living Shorelines: Near-shore Linkages Project is a multi-objective habitat restoration pilot project with the overarching goal to create biologically rich and diverse subtidal and low intertidal habitats, including eelgrass and oyster reefs, as part of a self-sustaining estuary system that restores ecological function and is resilient to changing environmental conditions. This project builds on previous work by members of our team that advanced restoration methodologies and understanding of constraints and opportunities for both eelgrass and native oysters. Such habitat features, if scaled up beyond previous projects, have the potential to positively influence physical processes (such as waves and sediment transport) that determine shoreline morphology. In this project, we are further testing restoration methods, restoring critical eelgrass and oyster habitat, testing the individual and interactive effects of restoration techniques on habitat values, and beginning to evaluate effects on shoreline processes. Plots (32 x 10 m) of oyster substrate alone, eelgrass alone, or the two together in an additive design, are being compared to un-manipulated control plots along the San Rafael shoreline in the first phase of the project. Preliminary data show that restored habitat structure promotes increased abundance of numerous organisms relative to bare substrate, and that oyster settlement substrate (Pacific oyster shell bag mounds) in combination with eelgrass plantings alters the invertebrate community composition relative to either habitat alone. Small plots (1-m², n=5) at San Rafael and along the Hayward shoreline (near Eden Landing Ecological Reserve) testing various oyster restoration substrates (including SF Bay-derived "baycrete" reef balls and interlocking "castle" blocks) are resulting in differences in native oyster recruitment by substrate and by site. This project will advance our understanding of restoration methodologies with an eye towards both habitat creation and shoreline protection in an era of rising seas and increasing storm surges.

Keywords: eelgrass, oyster, Olympia, Zostera, wave, erosion, sediment, restoration, shoreline

Poster Topic: Sustainable Habitats and Ecosystems

Carbon Sequestration and Sediment Accretion in San Francisco Bay Tidal Wetlands

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Because of their location at the land-water interface, tidal wetlands play a critical role in relation to climate change. Sea-level rise will affect the long-term stability of tidal wetlands, depending on the magnitude of future increases in sea level and the ability of individual wetlands to accumulate sediment and keep pace with these changes. In addition, tidal wetlands can influence climate change by accumulating soil carbon, and there is growing interest to incorporate restored tidal wetlands into the state's carbon trading program. We measured sediment accretion and carbon sequestration rates at six natural tidal wetlands representing the salinity and geographical range of the San Francisco Bay Estuary. These sites also serve as analogs for long-term carbon sequestration in restored wetlands. We collected six cores at each natural wetland (two transects with three stations each). This approach allowed us to identify spatial variation both within and among wetlands in the Estuary. Cores from natural wetlands were dated using ^{137}Cs and ^{210}Pb profiles. Although accretion rates could not be measured at restored wetlands, cores were also collected from two restored wetlands for comparison of soil organic matter and bulk density. Most sites accreted 0.3-0.5 cm/yr, with slightly higher rates of accretion at low marsh stations. Carbon sequestration rates averaged approximately 80 g/m²/yr over the 100-year time span of ^{210}Pb and were slightly higher for ^{137}Cs -based rates. Variation in long-term carbon sequestration rates across sites and stations was much smaller than the variation in mineral inputs, with few significant differences in carbon sequestration rates. Based on these data, tidal wetlands within the Estuary are keeping pace with current rates of sea-level rise, although long-term sustainability is less certain. In addition, rates of carbon sequestration from this study could be used as a baseline for carbon sequestration in restored tidal wetlands within the Estuary.

Keywords: carbon sequestration, restoration, tidal wetland, climate change

Poster Topic: Sustainable Habitats and Ecosystems

Restoring Soil Ecology and Native Plant Communities in Former Salt Pond Ecotone

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Restoring unique or heavily disturbed ecosystems often requires novel approaches to break the cycle of invasion and establish self-sustaining native plant communities. This experiment measures the effects of “compost tea” inoculated with local soils and wood chip mulch on native plant performance and seed establishment in salt marsh transitional ecotone communities at Eden Landing Ecological Reserve, a part South San Francisco Bay Salt Pond Restoration Project. Soils collected from local reference and restoration sites were used to inoculate a liquid “compost tea” blend to encourage the development of bacterial and fungal communities in a recently excavated area dominated by invasive species. Study plots were planted with *Grindelia stricta*, *Bacharis douglassii*, *Leymus triticoides* and *Artemesia Californica*, native shrub and grass species common to transition zone restoration. All plots were seeded with 15 different native species in a hydro-seeding mix. For each species, plants were planted at a distinct elevation in a block design and treated with bare soil, mulch, compost tea, a combination of compost tea and mulch, and a control with no alteration.

Plots were subsequently monitored for plant height and crown volume, native seed sprout rate from the hydro-seeding mix, soil nitrogen and total fungal and bacterial activity. It is predicted that plants treated with mulch and compost tea will have superior plant crown volume, higher rates of native seed sprouting, higher fungal and bacterial activity and lower nitrogen due to immobilization, and that treatments containing compost tea alone will show better results than plants treated with mulch alone. By testing novel restoration techniques in the former salt pond transitional ecotone, this study aims to develop land management practices in the tidal marsh ecotone and inform restoration efforts in the South Bay Salt Pond Restoration Project.

Keywords: South Bay Salt Ponds, Ecotone, Native Plants, Restoration, Soil Ecology

Poster Topic: Sustainable Habitats and Ecosystems

Current and Planned Restoration in the Delta and Suisun Marsh

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The Sacramento-San Joaquin Bay-Delta estuary has experienced a severe decline in the condition of its natural resources and species that depend on them; thus, the Delta and Suisun Marsh have been and continue to be high-priority areas for restoration. With numerous restoration efforts having been implemented or being planned in the Delta and Suisun Marsh, it is important to have a spatial overview of these efforts to facilitate coordination and develop ecosystem connectivity. A GIS database of current and planned restoration projects was developed and that spatial information is displayed in this poster. Where available, pertinent information such as habitat type restored and project status is shown. The hope is that this information will assist in the efficient use of resources to facilitate and optimize restoration of natural communities and ecological processes in the Delta.

Keywords: Restoration, Geographical Information Systems, database

Poster Topic: Sustainable Habitats and Ecosystems

Avian and Benthic Invertebrate Responses to Eelgrass and Native Oyster Restoration: Pre-Monitoring for the Living Shorelines Near-Shore Linkages Project

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The San Francisco Bay Living Shorelines Near-shore Linkages Project is a multi-objective habitat restoration pilot project with the overarching goal to create biologically rich and diverse subtidal and low intertidal habitats, including eelgrass and oyster reefs, as part of a self-sustaining estuary system that restores ecological function and is resilient to changing environmental conditions. Phase I includes using a pilot-scale, experimental approach to establish native oysters and eelgrass at sites in Hayward and San Rafael. The USGS WERC San Francisco Bay Estuary Field Station conducted avian and benthic invertebrate pre-monitoring at each site from Nov 2011-April 2012, and will continue monitoring after treatments are installed in summer 2012. Our primary objective is to determine species and guild specific responses to restored habitat relative to control areas and pre-treatment conditions using a Before-After Control-Impact (BACI) design. We conducted high and low tide avian surveys twice monthly to record avian densities, instantaneous behavioral scans, and focal behavioral observations. To relate waterbird densities and behaviors to prey availability, we sampled invertebrates by taking 3 replicate benthic cores every 150-m along transects running perpendicular to shore. During pre-monitoring we recorded 55 avian species from 8 foraging guilds. Avian densities were highest at Hayward treatment and control sites, where small shorebirds predominated and reached densities of 2316/ha during their peak in January. Altogether we found 17 unique taxa representing four phyla and six classes of invertebrates at treatment and control sites, with highest densities and biomass at Hayward sites. Bivalves predominated at Hayward and provided the largest source of energy available to birds, while the San Rafael site had much lower invertebrate densities dominated by amphipods. These comprehensive baseline datasets will be used to understand species responses to restoration methodologies designed to protect shorelines while increasing habitat values for biological communities in the Bay.

Keywords: habitat restoration, subtidal habitats, migratory birds, shoreline resiliency, monitoring, invertebrates

Poster Topic: Sustainable Habitats and Ecosystems

Rhodia's Success Comes From More Than Science

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North Bay wetlands have been diked and drained for centuries to make land for development, including industries that left remnant pollutants in soils and water. Drained, subsided marshland and contaminated soils were two of the restoration challenges in the Peyton Slough Remediation and Restoration Project on Carquinez Strait in Martinez, California. Remediation, restoration, and successful management of urban-wildland interfaces is constrained by infrastructure. In 2003 Rhodia Inc. launched a remediation project to restore tidal wetlands by rerouting Peyton Slough, removing legacy side-cast dredged materials, capping the slough at approximately MHW, and 3 years after construction completion muted, seasonal tidal action was restored to upstream diked historic tidelands.

Annual post construction monitoring demonstrates the project's success in the tidally influenced, remediated areas. Water quality and habitat objectives established for the project are being achieved, exhibiting how a cap-in-place design can successfully contain contaminated soils, facilitate the restoration of approximately 18 acres of wetland and creation of 6 acres. Revegetation has been particularly successful, with 10-year vegetation cover and composition goals being met after 5 years.

In remediated, diked historic tidelands, the reintroduction of tidal action has required constant vigilance and adaptation as Rhodia and other stakeholders have worked to restore wetland without compromising existing infrastructure. Pipelines, subsided roadways, and culvert constrictions adjacent to the restoration present challenges; the elevation difference between the marsh and the roadways is less than one foot. The objective is to obtain daily marsh plain inundation, without flooding roadways or other infrastructure. With daily and seasonal tidal variation greater than the 1-foot freeboard, water management is critical and labor intensive. Relevant lesson –positive stakeholder relationships are valuable: 2011-12 rain patterns coupled with renewed stakeholder cooperation and resolve resulted in successful winter water management for the first time.

Keywords: wetland remediation, restoration, Carquinez Strait, diked historic tidelands,

Poster Topic: Sustainable Habitats and Ecosystems

McCormack-Williamson Tract

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The U.S. Army Corps of Engineers CALFED Levee Stability Program provides a short-term strategy to address flood management and ecosystem restoration projects within the Sacramento-San Joaquin Delta. McCormack-Williamson Tract was purchased by The Nature Conservancy (TNC) for ecosystem restoration and the protection of wildlife in the study area and a Final EIR was prepared by CA Department of Water Resources (in coordination with TNC) to specifically address flood risk and ecosystem restoration.

The McCormack-Williamson Tract levees are constrained in height by a legal agreement and as a result the tract floods during high water events. If sufficient water accumulates, a downstream flood surge occurs when other portions of the levees are overtopped or fail. This flood surge poses a risk to lives, property, and infrastructure in adjacent areas. With this project there is an opportunity to reduce the risk to life and property from flooding or catastrophic breaching of the McCormack-Williamson Tract levee and to provide ecosystem restoration.

One alternative for consideration is to lower the height of the eastern levees (which would induce controlled flooding of the tract), reduce the height of the southwestern levee (which would reduce the potential for a flood surge when those levees are overtopped), increase the height of levees on adjacent islands to reduce flood risk, and install a new levee to protect the transmission tower. This alternative would also create tidal, intertidal, and shaded riverine habitat, providing ecosystem restoration benefits.

The McCormack-Williamson Tract project provides a unique opportunity to explore alternative methods and approaches to flood management and ecosystem restoration in the Delta.

Keywords: Ecosystem Restoration, Flood Management, Tidal, Levees, The Nature Conservancy, USACE

Poster Topic: Sustainable Habitats and Ecosystems

Managing for Resilience in the Face of Climate Change: A Scientific Approach to Targeted Oyster Restoration in San Francisco Bay and Elkhorn Slough, CA

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Coastal managers and decision-makers are faced with the challenge of designing conservation and restoration strategies that enhance the resilience of valued coastal resources to climate change. To design effective strategies, they need restoration-planning tools based on robust science. Critical questions include: What is the impact of climate-related stressors on valued resources relative to other anthropogenic stressors? How will climate-related stressors interact with other anthropogenic stressors? How does population connectivity influence resilience to climate change?

We are addressing these three questions for native Olympia oysters (*Ostrea lurida*) in San Francisco Bay and Elkhorn Slough. Our ultimate goal is to increase the resilience of oyster populations by improving restoration planning in light of climate change. We are taking a collaborative, joint fact-finding approach to this work, involving restoration practitioners and resource managers in the development and implementation of the research and in the creation of data products and management recommendations. Initial measurements of both climate change-related stressors and other anthropogenic stressors at multiple sites in each estuary reveal significant geographic variation in the mean and range of most stressors. Field surveys of oyster recruitment, density, size distribution and fecundity also indicate existing differences among study sites. We will combine these data with information about oyster responses to multiple stressors in the laboratory and emerging assessments of population connectivity via trace element microchemistry to generate predictions about which sites and source populations are best suited for restoration efforts. We then will produce restoration planning tools to aid practitioners and policy-makers in the selection of sites where oyster restoration is most likely to be successful under projected future conditions.

Keywords: anthropogenic stressors, joint fact-finding, *Ostrea lurida*, population connectivity, restoration planning

Poster Topic: Sustainable Habitats and Ecosystems

Ecosystem Restoration Program Overview

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The Department of Fish and Game, United States Fish and Wildlife Service, and National Oceanic and Atmospheric Administration Fisheries Service are the implementing agencies for the Ecosystem Restoration Program (ERP). The ERP vision is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta and its watersheds to support stable, self-sustaining populations of diverse species for all life stages.

ERP is at the forefront of restoration efforts in the Delta and its watersheds, awarding over \$700 million in restoration grants to more than 500 projects since its inception in 1995. ERP has acquired or restored over 82,000 acres of habitat Program-wide and is currently managing over 70 projects ranging from research to full-scale implementation. ERP has funded and will continue to fund projects that will have an important impact on restoration and management practices.

To compliment these restoration activities, ERP is actively engaged in the development of performance measures and an adaptive management framework. Performance measures assess how restoration projects and related resource management activities support and fulfill ERP Strategic Goals and Objectives. The process of developing and refining the measures includes use of DRERIP conceptual models and oversight and review through a peer review process.

Communication, coordination, and collaboration with other agencies and organizations involved in Delta issues are extremely important to keep the science current and relevant. These efforts have allowed ERP to integrate its vision and goals into plans, programs, and projects of other agencies and organizations. ERP has sought feedback from these stakeholders to facilitate the development of efforts that reflect the goals and objectives of other governing agencies. ERP eliminates the need to “reinvent the wheel” while integrating and synthesizing policies, plans and projects to ensure collaborative and effective working partnerships.

Keywords: Ecosystem Restoration Program, Grants, Performance Measures, Conceptual Models, Coordination

Poster Topic: Sustainable Habitats and Ecosystems,

Developing Tools for Landscape-Scale Restoration in the Delta

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Current regional management and restoration efforts in the Delta emphasize a landscape-scale approach to restoration. However, few tools are available that illuminate what large, interconnected habitat restoration should look like for the region, or how to design projects that successfully provide desired ecological functions. An understanding of landscape-scale pattern, process, and ecological function in the Delta under more natural (early 1800s) conditions can help managers and scientists develop appropriate, practical, and effective landscape restoration strategies that support desired ecological functions in the future. We are applying findings from a recently completed study of the Delta's historical ecology to help establish a regional guiding vision of landscape-scale restoration. Paired with contemporary knowledge and in coordination with a selected group of expert scientists we are: (1) performing an analysis of historical and contemporary habitat mapping to identify metrics that define landscape components and are reflective of valued ecological functions; (2) using the analysis to describe historical ecological functions of the Delta and compare past to current functions; and (3) developing and communicating landscape-scale conceptual models, restoration principles, and assessment metrics that illustrate potential future landscapes and highlight possible restoration constraints and opportunities. This tools will help create larger functional landscapes that are more resilient to future change.

Keywords: landscape connectivity, restoration, resilience, ecological functions, historical ecology

Poster Topic: Sustainable Habitats and Ecosystems

Towards a Better Understanding of the Carbon Balance of a Grazed Pasture in the Sacramento-San Joaquin Delta, California Using Continuous Measurements of Soil CO₂ Concentration and Soil Respiration

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Soil respiration is an important component of the terrestrial carbon cycle, and is the primary process by which carbon is lost from drained soils in the Sacramento-San Joaquin Delta, California. Understanding the processes and factors controlling soil respiration, and reducing the uncertainties associated with its measurement is essential to improving estimates of carbon budgets of terrestrial ecosystems in the Delta. In this study, we measured CO₂ concentrations at various depths in the soil in a drained, grazed pasture on Sherman Island using solid-state CO₂ sensors, and assessed the ability of the soil CO₂ gradient method to estimate continuous soil respiration. Briefly, the soil CO₂ gradient method estimates soil respiration by using both measurements of vertical gradients of soil CO₂ concentration and modeled CO₂ diffusivity in soil. Rates of soil respiration from the grazed pasture ranged between 1 and 5 $\mu\text{mol m}^{-2}\text{s}^{-1}$ throughout the study. In addition, soil respiration was found to increase exponentially with temperature, in agreement with other studies. Finally, results from this study highlight the importance of selecting and testing the appropriate model for estimating CO₂ diffusivity in soil as large differences (up to an order of magnitude) in soil respiration were observed depending on which CO₂ diffusivity model was used. Soil respiration is an important process to consider when determining the carbon balance of ecosystems. The results from this study contribute to a better understanding of the factors that control soil respiration in terrestrial ecosystems in the Delta. This study will also be used to improve the partitioning of net carbon fluxes that we measure using the eddy covariance technique into carbon gains and losses from the ecosystem, which will result in better estimates of the carbon budget of conventional drained land-use types in the Delta.

Keywords: Soil respiration, Soil CO₂ concentration, carbon balance, Soil CO₂ diffusivity

Poster Topic: Sustainable Habitats and Ecosystems

Ecosystem Restoration Program Signature Project Highlight

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ERP is at the forefront of restoration efforts in the Delta and its watersheds, awarding over \$700 million in restoration grants to more than 500 projects since its inception in 1995. ERP has acquired or restored over 82,000 acres of habitat program wide and currently manages over 70 projects. ERP has funded and will continue to fund projects that have an important impact on restoration and management practices.

ERP has funded a diverse set of projects that provide multiple benefits that address ERP Strategic Goals and Objectives. These projects have made significant progress toward understanding species requirements, habitat restoration strategies, ecological process rehabilitation, and stressor reduction in the Bay-Delta system. Examples of the types of ERP funded projects include habitat restoration, fish screens to reduce entrainment, removal of fish barriers to improve fish passage, projects to improve ecosystem water and sediment quality, at-risk species assessments, and hydrodynamic studies of sediment transport and flow regimes.

Scientific and management implications of ERP funded projects are numerous and range from providing technical assistance for development of the Delta Plan and the Bay-Delta Conservation Plan, to bridging data gaps, and prioritizing Bay-Delta system restoration needs. Reporting findings and achievements is an important step in moving towards a healthy Delta ecosystem. ERP is committed to knowledge transfer and communication of project success for future application.

Keywords: Ecosystem Restoration Program, Grants, Coordination

Poster Topic: Sustainable Habitats and Ecosystems

Effects of Flooding and Anaerobic Conditions on Soil Greenhouse Gas Emissions in the Sacramento-San Joaquin Delta

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Land subsidence following a 150-year history of reclamation and drainage in the Sacramento-San Joaquin Delta has resulted in significant emissions of carbon to the atmosphere in the form of the greenhouse gas carbon dioxide. Up to 50% of the carbon-rich peat soils have been lost. Such great losses jeopardize the sustainability of present drained land-use and undermine efforts to reduce California's carbon dioxide emissions. Controlled wetland restoration has therefore been proposed to address the dual concerns of land subsidence and carbon loss. Methane and nitrous oxide, two potent greenhouse gases, are however often emitted in greater quantities when soils are flooded and soil redox changes from oxic to anoxic. We therefore investigated how the total greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide) may change as Delta soils change redox regime following flooding. We collected organic-rich soils from a pasture on Sherman Island and sampled trace gas emissions in a 3-week laboratory incubation using flooding and anaerobic headspace treatments. We found that anaerobic conditions and flooding suppressed carbon dioxide emissions by 50%. In contrast however we found that nitrous oxide emissions were stimulated temporarily in the anaerobic treatments. Interestingly we did not observe significant methane emissions even after a 3 week anaerobic incubation suggesting it may take a significant amount of time for methane production to become significant following wetland re-flooding. We conclude that flooding significantly suppresses carbon dioxide emission rates and that wetland restoration may be an effective measure in the Delta to reduce carbon losses. We also stress however that flooding can stimulate production of other greenhouse gases and the magnitude and temporal dynamics of these emissions warrant further investigation.

Keywords: carbon methane emissions wetland restoration land-use soil flooding

Poster Topic: Sustainable Habitats and Ecosystems

Accelerating Sea Level Rise: Potential Responses of Tidal Wetlands

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Problem statement: Tidal wetlands are likely to face significant impacts in the coming century as sea level rises and salinity levels shift within the SF Bay Estuary. Maintaining pace with sea-level rise will require accumulation of both mineral and organic matter.

Approach: We have evaluated surface sedimentation rates at a range of wetlands across the salinity gradient within the Estuary. We have also measured above and belowground productivity and decomposition rates to evaluate the role of organic matter accumulation.

Results: Wetlands within the Estuary are accumulating enough sediment to keep pace with current rates of SLR (average accretion= 3-6 mm/yr) and are likely to maintain elevations with moderate increases in SLR. Aboveground and belowground biomass and productivity are inversely related to salinity. Rates of decomposition are rapid with up to 90% loss of organic matter after one year, but more organic matter remains in more saline sites. The salt marsh dominant *Salicornia pacifica*, however, decomposed at a faster rate than other species. While decomposition rates in saline sites are similar or higher than rates in freshwater sites, productivity is up to several times greater in freshwater sites leading to higher observed soil OM content. Interestingly, the peak in aboveground biomass occurs in the fresh wetland while the peak in belowground biomass occurs at the brackish wetland.

Conclusions: As long as suspended sediment concentrations remain constant, tidal wetlands will maintain themselves as SLR accelerates moderately. Projected increases in salinity, however, and the apparent overall trend of declining suspended sediment entering and leaving the Delta suggest that tidal wetlands may eventually lag behind SLR. Plant productivity and elevation distributions are being used to calibrate the Marsh Equilibrium Model (MEM) which can be used to predict marsh stability under a range of sea-level rise scenarios.

Keywords: climate change, tidal wetlands, sediment accretion rates, decomposition, productivity

Poster Topic: Sustainable Habitats and Ecosystems

Bird Response to Delta Restoration: Fine Scale and Landscape Variables that Determine Success

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Studies of bird populations and their responses to habitat and landscape attributes at interior Sacramento-San Joaquin Delta restoration sites (Grizzly Slough, Decker, Sherman, and Twitchell Islands) are limited. In light of plans for large scale restoration of riparian and freshwater habitats in the Delta, an understanding of what constitutes successful restoration for Delta bird communities is extremely important. We conducted point count and vegetation surveys at 14 mitigation/restoration sites (n = 70) located within the north and west Delta during May and June, 2011 and 2012. Sites included various habitat types including shrub scrub, riparian, and freshwater marsh. We evaluated bird species composition and richness, and also tested regression models that related these variables to 1) fine-scale habitat attributes (tree and shrub species richness, tree and shrub percent cover, herb cover and non-native species richness), 2) landscape attributes (area, area to perimeter ratio, and age), and 3) adjacent land cover (grassland, crop, riparian, wetland and water). We found that mitigation/restoration sites attracted a wide array of native bird species including listed species, but species richness and diversity were low compared with larger and more contiguous riparian areas (i.e., Cosumnes River Preserve). Bird species abundance and richness were significantly lower at sites that were linear versus non-linear, smaller versus larger, younger versus older, and at sites with non-native versus native vegetation. Though both fine-scale habitat and landscape attributes were useful in predicting bird species abundance and richness, fine-scale vegetation attributes (e.g., tree richness, percent non-native (weedy) species) and habitat quality appeared more important than landscape context for predicting the abundance of certain bird species. These findings are used to provide guidance for restoration design and to suggest further research.

Keywords: Delta ecosystem restoration, freshwater, riparian, bird communities, songbirds. landscape, connectivity

Poster Topic: Sustainable Habitats and Ecosystems

Lower Yolo Bypass Tidal Marsh Restoration Project

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The Lower Yolo Bypass Restoration Project involves restoring approximately 1,200 acres of tidal freshwater wetlands at the southern end of the Yolo Bypass in the northwestern Sacramento/San Joaquin River Delta. The Project area historically supported freshwater tidal marsh and lowland transitional habitats. This Project is being undertaken as partial fulfillment of the DWR 8,000-acre tidal restoration obligations contained within the 2008USFWS Delta Smelt Biological Opinion and the 2009 NMFS Salmonid Biological Opinion for operations of the State Water Project and Central Valley Project delta facilities and under the 2009 DFG Incidental Take Permit for Longfin smelt. The Project could also serve as partial fulfillment of tidal restoration objectives under the Bay Delta Conservation Plan upon its approval. The primary goals of the Project are (1) to improve habitat conditions for delta smelt by enhancing regional food web productivity and (2) to improve habitat conditions for salmonids utilizing the Yolo Bypass by provide rearing habitats for out-migrating juveniles and migratory habitats for adults. The secondary goals are (3) to support a range of other aquatic and wetland-dependent species, including Sacramento splittail, and (4) to provide ecosystem functions of the Delta tidal marsh – floodplain – seasonal wetland – lowland grassland interfaces. The restoration design consists of constructing an extensive tidal slough network across the property to provide for high levels of marsh-aquatic connectivity and the lowering of lands just above high tide elevations to expand the footprint of restored tidal marsh. Construction is scheduled to begin in summer 2013.

Keywords: wetland, restoration, tidal, Delta, Yolo Bypass, delta smelt, salmon, splittail

Poster Topic: Sustainable Habitats and Ecosystems

Restoring Prospect Island: Application of Adaptive Management

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The Department of Water Resources is planning the 1,600-acre Prospect Island restoration in the northwest Delta. Restoration to tidal marsh and tidal aquatic will partially fulfill DWR's obligations under the delta smelt and salmonid biological opinions on State Water Project and Central Valley Project operations for 8,000 acres of tidal restoration, by providing food web productivity and rearing habitats in a region established as important to these and many other species. Restoration will also fulfill larger restoration targets of the Bay Delta Conservation Plan. Restoration faces intriguing opportunities and challenges for how to provide fisheries benefits given (1) site topography – about one-third resides below emergent marsh vegetation heights, (2) site vegetation cover – it is mostly emergent wetland and riparian vegetation nearly 15 years after agricultural use discontinued, unlike nearby Liberty Island that was essentially a barren field when it breached, and (3) possible constraints on locating levee breaches along the Deep Water Ship Channel and/or Miner Slough. Restoration planning will apply the fruits of recent years' efforts advancing the science for Delta restoration, recovery of the many species and natural communities at great risk, and potentially interfering stressors, using that science in combination with site conditions to generate and evaluate a wide range of design options. The selected restoration alternative will in itself be an adaptive management study site. In addition to providing target ecological functions, the restoration needs to avoid or minimize problems with invasive species, adapt to climate change, and examine potential impacts to water quality, navigation, access to an adjacent property, flood conveyance, seepage onto Ryer Island, and levee erosion.

Keywords: restoration, wetlands, pelagic, delta smelt, salmonids, DWR, Cache

Poster Topic: Sustainable Habitats and Ecosystems

Fire, Floodplains and Native Fish: Ethnoecology of the Cosumnes River

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Traditional Resource Management is an influential supplement to overall restoration policy and management practices. The Cosumnes River is located in the northeastern portion of the Sacramento-San Joaquin Delta of Central California. Prior to European settlement, this area was Plains Miwok territory, supporting an estimated population density of 57 individuals per square mile along riparian areas. Overall floodplain biodiversity and native fish productivity benefited from burning and other traditional management practices utilized by Native Californians. Ethnographic and archaeological data were used to reconstruct pre-European settlement traditional management practices. Ethnographic data was gathered from historical literature and local Miwok informants. Archaeological data from four Cosumnes River sites dating to the Late Period (1200 to 100 B.P.) were analyzed and compared to records of modern fish abundance and floodplain habitat modifications. This study synthesizes data from fish ecology, four archaeological ichthyofaunal site remains, ethnographic sources, and traditional knowledge to reconstruct the landscape of the lower Cosumnes River watershed prior to Euro-American settlement. Results indicate that traditional management practices, such as burning and harvesting plant materials in the floodplain, may have increased the productivity of floodplain rearing habitat, thereby increasing fish growth and reducing fish mortality. Loss of traditional tending practices compounded by widespread degradation of habitat, alteration of flows, and introduction of exotic species has resulted in the catastrophic decline of most California native fish species. Minnows and other native fishes that were originally abundant in lowland lakes, tule marshes, sloughs and slow moving sections of the river have diminished significantly or disappeared from pre-European settlement numbers. Based on this synthesis of multiple sources of information, it is likely traditional practices optimized habitat vitality for native fish species, attributing to higher fitness levels towards fluctuating environmental conditions.

Keywords: Ethnoecology, Eco-cultural Restoration, Traditional Resource Management, Cosumnes River, Native Fish

Poster Topic: Sustainable Habitats and Ecosystems

A Protocol for Monitoring the Vegetation of the Tidal Marsh Ecotone

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The intertidal-upland ecotone is a zone of decreasing tidal influence, extending landward from tidal marshland or tidal flat up to or slightly beyond the maximum landward effect of tidal waters on plant community structure. The ecological functions of this ecotone have been gaining recognition within the regional community of natural resource scientists and managers. This protocol is designed for assessing the ambient condition of vegetation and the effectiveness of vegetation management in the ecotone. We collected data of multiple plant species at different positions in the ecotone, under various management regimes to identify plant species richness, which species dominate the ecotone, how richness and dominance vary across the ecotone, and how they vary with restoration design. We are assessing trajectory of plant species cover at each site over time. Analyses planned for summer 2012 will examine a three year dataset at five marsh restoration sites around San Francisco Bay. The goal of the analysis is to assess the effectiveness of restoration in achieving lasting increases in native plant cover.

Keywords: Tidal Marsh Ecotone Vegetation Protocol Wetland Upland Transitional

Poster Topic: Sustainable Habitats and Ecosystems

**Dream Blue: Bay Ocean Delta You - Unified Region Wide Pollution Prevention
Public Outreach for the San Francisco Bay Delta**

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The poster will feature a new regionwide brand for stormwater and wastewater pollution prevention outreach to the general public in the San Francisco Bay-Delta-Ocean region. Since early 2011, stormwater and wastewater agencies in the nine-county Bay Area have been working together on a new, unified approach to pollution prevention outreach. The Bay Protection and Behavior Change Consortium collaborates on regional behavior change campaigns in order to achieve message effectiveness and cost efficiencies in reaching and influencing shared audiences. To embed a Bay protection message in the region's collective psyche and promote greater clarity between personal behavior and Bay water quality, a unifying brand was developed that will overarch permit specified topical campaigns that roll out over the next decade. The brand will be brand-new and launching in Fall of 2012.

Keywords: outreach pollution prevention brand wastewater stormwater regional communications Bay Delta

Poster Topic: Sustainable Habitats and Ecosystems

'Reactive' Inorganic Mercury: A Critical Examination of Preservation and Storage Techniques

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Mercury (Hg) studies in the Sacramento-San Joaquin Delta and San Francisco Bay and elsewhere suggest that 'reactive' (stannous chloride reducible) inorganic mercury (Hg(II)_R) in sediment is a reasonable proxy measurement for the *in situ* pool of inorganic Hg(II) that is truly available to bacteria that produce toxic methylmercury (MeHg) from Hg(II). This study rigorously tested the effects of sample handling, holding time, and storage temperature (prior to Hg(II)_R analysis), with the goal of identifying an optimal sample treatment and preservation protocol for Hg(II)_R analysis. Because specific sediment properties such as organic content, grain size, redox conditions, water content, and total reduced sulfur concentration can affect Hg(II)_R concentration, sediment with a range of these parameters was collected from four distinct Hg-contaminated regions surrounding the Sacramento-San Joaquin Delta and San Francisco Bay. For all sites, there was a statistically significant difference in Hg(II)_R concentration related to sample holding time (0 to 180 days), but no significant difference related to sample storage temperature (-80 to 5 °C). Samples exposed to oxic conditions did not differ significantly in Hg(II)_R from those subsampled in a glove bag under anoxic conditions. The results from this study will be used to develop a standard set of practices with respect to sediment sub-sampling and preservation when Hg(II)_R is a targeted analyte. Hg(II)_R was identified in the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Hg Conceptual Model as an important driver affecting the fate and transport of Hg in the Sacramento–San Joaquin Delta ecosystem.

Keywords: Reactive inorganic mercury, methylmercury, sediment, preservation and storage techniques

Poster Topic: Water and Sediment Quality

Transfected vs. Native: The Potential for Conflicting Measurements of Endocrine Activity from Different Cell Line Types

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The U.S. Environment Protection Agency has recently recommended that endocrine disruptor screening be conducted on contaminants of emerging concern (CECs), and that wastewater be monitored to assess compounds with potential endocrine activity entering aquatic ecosystems. CECs include the synthetic pyrethroid bifenthrin; due to its broad usage and aquatic toxicity range, and the pharmaceutical ibuprofen, which is not fully metabolized by humans and can enter the sewage system as the parent compound or metabolites. Bifenthrin has been shown to have both estrogenic and anti-estrogenic properties *in vitro* and *in vivo*, and ibuprofen is known to mediate levels of prostaglandin, a lipid mediator that plays multiple roles in reproduction. High throughput screening utilizing cell lines that evaluate the potential for estrogenic or androgenic activity is now a preferred method of prioritizing CECs for further assessment; however, results from cell lines of different origins are often conflicting. Conflicting results may occur between assays such as the CALUX that natively express the estrogen or androgen receptor and those such as the yeast estrogen / androgen screen (YES / YAS) that are transfected with these receptors. Additionally different responses may be seen depending on the concentration used, considering the sensitivity of endocrine responses. As such, to date the majority of *in vitro* assays have used concentrations of bifenthrin and ibuprofen that are much higher than levels detected in the environment. We will present comparative results from tests conducted on environmentally relevant concentrations of bifenthrin and ibuprofen in two *in vitro* systems, the CALUX and YES/YAS, determining their contribution to estrogenic and androgenic activity in aquatic ecosystems, as well as differences in the quantitation of estrogenic or androgenic potency between these two assay types.

Keywords: YES assay, CALUX assay, bifenthrin, ibuprofen, contaminants of emerging concern

Poster Topic: Water and Sediment Quality

Evaluating Copper Toxicity in the San Francisco Bay Delta and Estuary: Copper Speciation and Dissolved Trace Metal Concentrations

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Dissolved trace metal concentrations, and in particular dissolved copper concentrations, are elevated in the San Francisco Bay Estuary, generating concern for copper toxicity to microorganisms in the bay. Surface (~1 m) samples were collected from North San Francisco Bay Delta and Estuary in November 2008 and April 2011 in collaboration with the U.S. Geological Survey Water Quality of San Francisco Bay monitoring program. Additional samples obtained from the San Joaquin River and Suisun Slough in November 2008 were analyzed and used in mixing experiments to evaluate freshwater copper-binding ligand sources to North San Francisco Bay. All samples were collected and processed following trace metal clean protocols to avoid sample contamination, and were filtered through 0.4 μm pore size polycarbonate track-etched membrane filters in a positive pressure clean hood. Total dissolved trace metals (Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn) were determined using magnetic sector inductively coupled plasma mass spectrometry following pre-concentration through a Nobias-chelate PA1 resin. Competitive ligand exchange-adsorptive cathodic stripping voltammetry (CLE-ACSV) with multiple analytical windows was employed to determine dissolved copper speciation and to evaluate the potential for copper toxicity in the estuary. For all trace metals measured, dissolved concentrations were elevated within North San Francisco Bay compared to adjacent coastal waters, with the highest trace metal concentrations measured during the higher salinity November 2008 sampling. Dissolved copper was found to be strongly complexed by organic ligands throughout the estuary during both sampling exercises. The complexation of dissolved copper by strong organic ligands reduced the bioavailability of ambient dissolved copper while high concentrations of weaker ligands buffered against copper toxicity at increasing copper concentrations. Bioavailable Cu^{2+} concentrations were found to be below toxicity thresholds ($\sim 10^{-11}$ M) for phytoplankton in all samples.

Keywords: San Francisco Bay Estuary; copper toxicity; ligands; dissolved trace metals

Poster Topic: Water and Sediment Quality

Effects of Triclocarban on the Life-Cycle of the Medaka (*Oryzias latipes*) Fish Model

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Triclocarban (TCC) is a common antibacterial additive in personal care products. As a result of extensive human usage and incomplete removal by wastewater treatment plants, TCC has been detected at levels as high as 6.75µg/L in surface waters in the United States. Due to its frequent detection in US surface waters, TCC has become a matter of widespread concern. The objective of this study is to investigate the chronic effects of TCC using the medaka fish model. A full life cycle chronic toxicity test was initiated by exposing 1-day-old embryos to 5 ug/L of TCC continuously for 5 months until full maturation. Growth was assessed by weight and length at multiple time points. Differences in weight and lengths between exposed and control fish were observed. Expression of vitellogenin, a female egg yolk precursor protein, was measured to assess the reproductive health of males. Significant up-regulation of vitellogenin was observed in male fish exposed to TCC at 5 months, indicating potential estrogenic effects due to TCC exposure. Gene expression analysis by qPCR also supports activation of estrogen- related genes, which are responsible for female reproduction. Fertility and fecundity of chronically exposed fish were evaluated through crossbreeding experiments. Fertility in pairs with one or both exposed parents was significantly lower than pairs with both control parents suggesting impaired reproduction from an environmentally relevant level of TCC exposure. These findings observed at the molecular and phenotypic levels significantly advance the understanding of adverse effects due to TCC exposure. Results from this study will be useful in predicting population effects of TCC and provide insight on its environmental impact. A better understanding of TCC toxicity can be used to initiate monitoring of TCC in the Delta. Steps can be taken to control TCC contamination and protect the Bay-Delta ecosystem.

Keywords: Triclocarban, Japanese medaka, life-cycle study, reproduction

Poster Topic: Water and Sediment Quality

Surface Sediment Characteristics of the San Francisco Bay Coastal System

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Sedimentary characteristics play a major role in determining the ecologic and economic health of estuarine ecosystems. Sediments influence habitat composition, toxin transport, turbidity, and overall water quality, as well as economic vitality through navigational dredging, aggregate mining, shoreline management, and restoration activities. Despite its importance, knowledge of surface sediment characteristics throughout San Francisco Bay is limited. Although detailed sedimentary studies have been performed in select locations throughout the bay, the only extensive maps of the entire estuary are based upon a limited number of samples that were likely collected over a large time span using different devices and analyzed with varying procedures. From 2010 to 2012 over 400 surface sediment samples were collected from the bay and seafloor, area beaches, and all major drainages throughout San Francisco Bay and along the adjacent Pacific Coast. These samples were collected as part of a larger research project working to establish the primary sources, sinks, and pathways of sediment throughout the region. We present surface sediment maps of grain size characteristics (size, sorting, carbon content, etc.) derived from the analyses of hundreds of sediment samples recently collected throughout the region.

Keywords: surface sediment, grain size

Poster Topic: Water and Sediment Quality

Decentralized Water Disinfection and Designing Low Cost Clean Water Technology in Developing Countries

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Access to improved water supply is the key purpose of this proposed paper. With the goals of designing low cost, low maintenance tool where little work requires to be done to explore intermediate options between promoting household point-of-use (POU) water treatment technologies (treating drinking water in the home) and city-wide networked water treatment (piped water to individual households); this paper has been developed. According to the WHO statistics it has been found that about 7 million people die every year due to contaminated and infected ground water; as well as 1.4 billion people are affected by the water shortage lack of having adequate supply of potable drinking water. Due to environmental pollution, excessive population growth, lack of proper resource management, and increasing rate of water consumption essentially it can be derived that 60% of the developing countries will not have enough drinking water by the year 2050. The paper will also address this technology gap by developing and evaluating low-cost, in-line chlorination systems; by designing and prototyping appropriate system tools having user acceptability and strategic partnerships that can help in reducing contamination of drinking water in low-income areas of developing countries. With the objectives of automated dosing, low cost, minimal behavior change, no electricity requirement, intermittent supply serving hundred households the paper has been produced. Though on the large-scale technologies for desalination and water disinfection are already installed in many different countries and are working reliably but in rural areas cause of maintenance requirements, lack of improvement skills the promoted ideas do not work out satisfactorily. So the proposed paper plan and idea would be a milestone addition having affordability of rural areas throughout the developing countries.

Keywords: Decentralized Water Disinfection, Chlorination Systems, Point of Use (POU) technology.

Poster Topic: Water and Sediment Quality

Mercury Cycling in Permanent Wetlands in the Yolo Bypass Wildlife Area: A Mass Balance Approach

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Managed seasonal wetlands often show patterns of elevated methylmercury (MeHg) concentrations and fluxes relative to other habitat types. Proposals to increase total acreage of seasonal wetlands in the Sacramento-San Joaquin Delta through restoration efforts may have unintended consequences of increasing MeHg in water, sediment, and biota. In this study, we investigated the potential for water quality improvement using permanent wetlands as treatment ponds. We utilized two existing permanent wetlands in the Yolo Bypass Wildlife Area in addition to constructing nine replicate large scale experimental permanent wetlands which allowed for controlled studies of mercury cycling. Weekly mass balance models for both the existing and experimental permanent wetlands were calculated. These models yield the net mass reductions of MeHg and relative importance of internal processes such as photodegradation, sediment water exchange, and particulate settling within the wetlands. Results indicate the permanent wetlands act as treatment ponds reducing levels of MeHg in drain water from managed seasonal wetlands. This information is useful to wetland restoration efforts and wetland managers as a way to mitigate MeHg loads from managed wetlands.

Keywords: Mercury cycling; Wetlands; Yolo Bypass; Methylmercury

Poster Topic: Water and Sediment Quality

Is Particulate Organic Matter a Driver or a Reflection of Changing Dynamics in the Delta?

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Sources, quality, and cycling of particulate organic matter (POM) in the Sacramento-San Joaquin River Delta are poorly understood. Prior studies offer qualitative clues as to allochthonous vs. autochthonous sources, but little is known about how POM abundance and quality interact with habitat characteristics affecting fish abundance and distribution. We sampled for particulate and dissolved organic matter (DOM) at stations in Grizzly Bay, Honker Bay, Suisun Bay, the Sacramento River, and Cache Slough in conjunction with monthly fish surveys during the fall/winter of 2011-12 in order to quantify and characterize DOM and POM concentrations and compositions across the hydrograph, using lignin biomarkers and other tracers to identify sources and estimate processing. Lignin is uniquely produced by vascular plants, with the potential to distinguish between terrestrial vs. algal sources of POM in the Delta, and between different terrestrial sources. We assessed sources and processes within the Delta and interactions between DOM and POM. We will discuss factors that contribute to seasonal changes in POM concentration and composition, the extent to which total POM is supported by vascular plant and aquatic sources, and the extent to which DOM and POM cycling are coupled through similar sources and sorption/desorption processes.

Keywords: DOM/POM cycling, estuary, fish habitat

Poster Topic: Water and Sediment Quality

To and From: The Intricacies and Challenges of DWR's Tidal Flow Monitoring

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The availability of highly reliable, accurate flow data in the Delta is a very important tool to policymakers, modelers, and environmental managers. Flow data serves as a foundational tool that other high-order questions rely on. Our group is trying to improve upon the accurate collection of flow data to precisely calibrate tidal flow monitoring stations using the index-velocity method.

Some of the challenges we face in collection and calculation of flow data are: constantly changing river state as data collection is happening, aquatic plants interfering with vertical beam level data, and channel traffic such as cargo ships and recreational boating traffic.

To address these challenges, we focused on enacting procedural improvements in data collection processes, increasing accuracy of peripheral measurements using partnerships with other groups, technological improvements to the latest sensors, and processing improvements such as filters and auxiliary sensors.

The Delta is a complex system in a constant state of flux; Channels are constantly eroding and depositing with the seasonal variations. One step we have taken to address these variations is to partner with our office's bathymetry group. They provide us highly accurate bathymetry data to create precise cross-sections that allow our group to quickly react to channel changes by modifying the stage-area equations. Another Delta issue we face is the quantity of aquatic growth produced, interfering with our stage measurements. As such, we have implemented the use of a barometric pressure sensor to provide ambient-corrected pressure to the data logger, allowing us to correct water level measurement errors.

Our poster shows some of the challenges we face with tidal flow monitoring and steps that we are employing to improve upon our data accuracy.

Keywords: flow, Delta, tidal, data collection, river, monitoring, measurement, index-velocity, accuracy

Poster Topic: Water and Sediment Quality

Varnished Serpentinite on the Floor of San Francisco Bay

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Serpentinite clasts recovered from dredge hauls in San Francisco Bay during commercial sand mining operations are typically covered with a dark, shiny varnish. Such a varnish is not developed on clasts of the same material from the nearby ocean and bay shores. Energy dispersive X-ray analysis of a varnished pebble showed little significant difference in composition between the varnish and the interior of the pebble. The time of immersion in seawater required for the varnish to develop is not known, however, a simple experiment indicates that it may begin within approximately one year.

Keywords: serpentinite, varnish, diagenesis, submarine

Poster Topic: Water and Sediment Quality

Mercury in California Lakes and Reservoirs: Factors Influencing Bioaccumulation in Black Bass

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Mercury contamination in California lakes and reservoirs has resulted in elevated fish Hg concentrations which are above safe consumption limits for humans. This study investigated total and methyl mercury in water, sediments, and black bass (largemouth, spotted, and smallmouth bass) in several of California's lakes and reservoirs. The objectives of the study were to 1) investigate correlations between a variety of ecosystem factors and mercury in black bass; and 2) investigate the relationship between total mercury in sediments and mercury in black bass using additional data resources. Several variables were significantly correlated with black bass. These factors were total mercury in sediments and surrounding watershed soils, chlorophyll *a*, and specific conductivity. There was a significant relationship between total Hg in sediments and Hg in black bass ($R^2 = 0.42$; $p < 0.001$). We suggest total mercury in sediments play a much greater role in black bass mercury bioaccumulation in California lakes than previously considered.

Keywords: Mercury; Fish; Bioaccumulation; Lakes and Reservoirs

Poster Topic: Water and Sediment Quality

Salmonella in the Delta: Implications for Human Health, Ecosystem Services, and Resource Management

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Pathogenic microorganisms in the Sacramento/San Joaquin Delta (Delta) have the potential to jeopardize human health, particularly through body contact recreational activities (REC-1). Pathogens contained in irrigated and non-irrigated runoff from animal agriculture are of specific concern to resource managers. Understanding potential sources of and trends in the occurrence of microbial contaminants is of vital import to the established water quality goals laid out in the Central Valley Basin Plan. A major microbial water quality study was conducted from 2006-2008 at 88 sites located throughout the Delta in an effort to optimize future monitoring efforts by the State Water Resources Control Board. Sites were surveyed each month for standard water chemistry, hydrology and microbial contaminants; one of which was *Salmonella* spp. Statistical and geospatial analyses were performed to determine patterns in the occurrence and concentration of *Salmonella* as a function of season, stream flow, and geography. *Salmonella* was present in 14.9% (n=1740) of water samples. Occurrence and concentration (MPN/100mL) were seasonally dependent; the likelihood of detecting *Salmonella* was greatest during the snow-melt season (April-June). Concentrations of *Salmonella* were highest in samples from the Consumnes-Mokulemne drainage areas, particularly near the pleasure boating communities of Locke and Walnut Grove. *Salmonella* occurrence was negatively associated with the exceedance of REC-1 standards for *E. coli* and Enterococcus, suggesting that current water quality monitoring criteria are inappropriate for predicting risk to human health from exposure to Delta waters. These results, with others, will be discussed in detail placing particular emphasis on management implications and potential impacts to current ecosystem services.

Keywords: Salmonella, water quality, Delta, bacteria, pathogens, GIS, ecosystem services

Poster Topic: Water and Sediment Quality

Biomarker and Stable Isotope Analysis of Reservoir Sediments Offer Insights into Watershed Processes Influencing Organic Carbon Accumulation in Englebright Lake

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Although trends of declining suspended sediment concentrations in the Sacramento River and decreasing sediment and total organic carbon accumulation in the Delta have been attributed to the construction of dams and reservoirs in the Sacramento-San Joaquin River watershed, there have been no studies examining carbon accumulation in reservoir sediments in California. This study investigates the accumulation and composition of organic carbon in two sediment cores collected from the Englebright Lake reservoir on the Yuba River, a tributary to the Sacramento River. Between 1941 and 2002 approximately 200kg of organic carbon accumulated in Englebright Lake. Lipid biomarker data, including fatty acids and sterols, and stable carbon isotope data were analyzed in sediment cores and compared to biomarker and isotope data from end-member samples collected throughout the Englebright Lake watershed. These data show a positive relationship between the maximum monthly discharge and organic carbon accumulation, suggesting that during periods of high discharge, especially floods, the delivery of organic material to the lake increases. Biomarker analyses of organic carbon reveal that terrestrial plants dominate the organic carbon sources. Signatures from algal sources were also detected but at much lower levels. Relative to end-member stable carbon isotope values, including terrestrial soils, plant materials, and water samples, the stable isotope values for sediment core samples were most similar to soil samples taken near roads and developments. These data suggest that even though individual biomarker components reveal the dominance of terrestrial plant sources, erosion of soil from the surrounding watershed is likely the primary process by which this material is delivered to the lake. The study of organic carbon accumulation in reservoirs offers a high-resolution analysis of the impacts of climate and anthropogenic change that may provide data needed to characterize the impacts of water storage and dams on organic carbon delivery to the Delta.

Keywords: organic carbon; lipids; stable carbon isotopes; dams; Englebright Lake

Poster Topic: Water and Sediment Quality

Discarded Plastics and Priority Pollutants: A Multiple Stressor in Aquatic Habitats

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Hazards associated with plastic materials concern environmentalists, scientists, industry and policy makers. Plastics are questioned for their safety due to adverse effects reported from additives and some of the monomers that make up the material itself. In aquatic habitats, plastic pollution is reported globally along the waste stream from freshwater and coastal habitats to the open ocean. Several organisms across multiple trophic levels ingest plastic debris. The material poses a threat to wildlife, and in addition may be another medium for exposure to priority pollutants. Plastic waste sorbs priority pollutants such as persistent organic pollutants (POPs) and trace metals from surrounding waters and thus threatens organisms as a multiple stressor. To understand hazards of plastic debris in aquatic habitats we asked: 1) what is the fate of POPs to different types of plastics, and 2) what are consequences of plastic ingestion for fish. Using field experiments replicated over space and time, we measured sorption of PCBs and PAHs to five types of mass-produced plastics (HDPE, LDPE, PP, PET and PVC) in San Diego Bay. Next, we exposed adult Japanese medaka (*Oryzias latipes*) to three dietary-exposure treatments (control, diet spiked with 10% virgin LDPE and diet spiked with 10% ocean-exposed LDPE) for 1- and 2-month periods and examined several toxic endpoints including: changes in gene expression, transfer of pollutants from plastic to fish tissue, and histopathology. We found that different types of plastics sorb different concentrations of PAHs and PCBs ($p < 0.001$) suggesting that some plastics may be less hazardous as aquatic debris. Results gathered to date regarding contaminant transfer and resulting toxicity to medaka will also be presented. Plastic pollution has been reported in watersheds globally and thus is an important contaminant of concern to quantify and begin to examine potential hazards of this multiple stressor in the Bay-Delta ecosystem.

Keywords: plastic, marine debris, persistent organic pollutants, micro plastic

Poster Topic: Water and Sediment Quality

Water Quality Report Card for the Lower Sacramento River

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Measuring the health of the Sacramento River (River) can be accomplished by evaluating indicators of physical, chemical, and biological condition. Measuring River health to address policy, regulatory, and management needs requires interpreting conditions in the environment relative to reference healthy and unhealthy conditions. This study describes the first report card on health of the Lower Sacramento River, in terms of water quality. The approach was based on several key components: 1) health was measured relative to defined numeric targets (“distance to target” approach); 2) all indicators were normalized on a “distance to target” scale of 0 (unhealthy) to 100 (healthy); 3) normalization took into account non-linear responses of ecological outcomes to water quality conditions (e.g., juvenile fish survival response to changing water temperature). This health evaluation is based upon measuring status and/or trends in these indicators: water temperature, nutrients (ammonia, nitrate, phosphate), turbidity/suspended sediment, dissolved oxygen, mercury in fish, fecal bacteria, and chlorophyll a (phytoplankton). Indicator scores ranged from a low of 35 (suspended sediment), to a high of 99 (ammonia toxicity). Water temperature conditions were good (low) when averaged over the year, with periods during the summer when temperatures are generally too high for young salmon and Delta smelt. Nutrient conditions, including ammonia a constituent of wastewater, were good relative to toxicity thresholds, but need more investigation relative to the needs of the Delta food web. Turbidity conditions were poor (low turbidity) for most of the year, with periods of higher turbidity (beneficial for in-migrating Delta smelt) during Winter and Spring. Dissolved oxygen conditions were good (high concentrations), except for late summer and early winter when concentrations were lower. Mercury conditions (2006 data) were moderate, meaning that limitations on fish consumption are needed. Fecal bacteria (E. coli) were present during limited times of the year, conditions are usually good.

Keywords: water quality, food web, wastewater, indicators

Poster Topic: Water and Sediment Quality

Development of a Statewide Mercury Control Program for Reservoirs

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Mercury is negatively impacting the waters of California. More than 180 rivers, reservoirs, and estuaries in California are designated as impaired by mercury because they have fish mercury concentrations that pose risks to human and wildlife consumers. Mercury control programs have been developed for the San Francisco Bay, the Delta, and several California rivers and reservoirs. However, control programs still need to be developed for more than 100 mercury-impaired reservoirs and rivers. Implementing mercury control programs for upstream reservoirs and rivers is a key component of the effort to reduce mercury inputs to, and achieve safe fish mercury levels in, the Bay-Delta.

The State Water Resources Control Board and Regional Water Quality Control Boards are working together to develop a Statewide Mercury Control Program for Reservoirs. Mercury impairment is due to several inter-related factors: sources of inorganic mercury; conditions in reservoirs that cause conversion of inorganic mercury to methylmercury and its subsequent bioaccumulation in fish; and fish species present.

The project involves: identifying mercury sources to the reservoirs; evaluating reservoir, watershed, and fisheries conditions; determining the linkage between reservoir fish mercury levels, reservoir and watershed conditions, and mercury sources; and identifying controllable factors that determine reservoir fish mercury levels. These analyses build on the robust scientific foundation established for the mercury control programs for the Bay, Delta, and other water bodies.

Statistical models have been developed to explain reservoir fish tissue concentrations. Important factors in explaining fish mercury in California reservoirs include: sediment, soil, and aqueous total and/or methyl mercury; chlorophyll-a; the ratio of methylmercury to chlorophyll-a; reservoir depth, elevation, and water level fluctuations; mine density; and percent forest, vegetation, and open water. Controllable mercury sources include upstream historic mines, surface water discharges from municipal sources and urban areas, and atmospheric deposition from industrial activities.

Keywords: mercury, methylmercury, reservoirs, lakes, atmospheric deposition, mines, urban runoff, fisheries

Poster Topic: Water and Sediment Quality