Poster Abstracts

October 29-30,

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Abstracts for posters presented at the 2013 State of the San Francisco Estuary Conference are compiled in this document. Abstracts are listed by Poster Topic, then sorted by the presenting author's last name. Though many posters have multiple authors, only the presenting author is listed in the table of contents.

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State of the San Francisco Estuary Conference

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Napa River Watershed Sediment TMDL Implementation and Habitat Enhancement

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The Napa River drains an area of approximately 426 mi^2 and extends 55 miles before discharging into San Pablo Bay near the mouth of the Sacramento-San Joaquin estuary, descending from an elevation of 4,344 ft in the Mayacamas Mountains to sea level. Historically, the lower reaches of the Napa River supported a diverse number of habitats including tidal marshes, freshwater marsh wetlands, oak woodland, riparian forests, and grasslands that provided habitat for a myriad of plant and animal species. Based on evidence of widespread erosion and concerns regarding adverse impacts to fisheries habitat, the San Francisco Bay Water Quality Control Board listed the Napa River and its tributaries as impaired by sediment. The Napa River Watershed Sediment TMDL and Habitat Enhancement Plan found that channel incision harms physical habitat structure of the river by reducing the quantity of gravel bars, riffles, side channels, and sloughs, which threatens Chinook salmon, steelhead and other fish and aquatic wildlife species. Since then a diverse group of stakeholders including Napa County, local non-profits, the local community and regulatory agencies have collaborated to develop watershed management and river restoration actions to protect and restore aquatic ecosystem functions and beneficial uses in the Napa River watershed. This poster provides an overview of promising projects and programs that are working to meet the objectives of the Napa River Watershed Sediment TMDL.

Keywords: TMDL Implementation, Napa River, Watershed, Watershed Management

Poster Topic: Napa River Watershed Restoration

Napa River Flood Protection Project: Rare Plant and Project Habitat Monitoring

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Beginning in 2000 the U.S. Army Corps of Engineers and the Napa County Flood Control and Water Conservation District began construction of the Napa River/Napa Creek Flood Protection Project. The primary goals of the Project included providing 100 year flood protection for the City of Napa along 6.9 miles of the Napa River and restoration of large areas of riparian and wetland habitat within the Project area. Long-term monitoring (over a 40-year period) associated with the Project includes systematically and quantitatively measuring changes in vegetation, geomorphology and hydraulics over a 40-year period. This poster focuses on recent habitat monitoring results associated with the Project including focused rare plant surveys for Mason's Lilaeopsis (*Lilaeopsis masonii*) and site wide vegetation/habitat establishment monitoring within a 1000+ acre area of the Project known as the South Wetlands Opportunity Area. In summary, results from the focused Mason's Lilaeopsis surveys indicate a very robust metapopulation on the Napa River that has doubled over a 10 year period while site wide performance standards and habitat creation goals have been met, or will be achieved, over the long-term monitoring period for the Project.

Keywords: Napa River Flood Protection Project, Lilaeopsis (*Lilaeopsis masonii*), Habitat Monitoring

Poster Topic: Napa River Watershed Restoration

Napa River Oakville to Oak Knoll Restoration Project

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The Oakville to Oak Knoll Restoration Project is being developed to restore 9 miles of the Napa River that suffer from channel incision with bank collapse, erosion of channel bedforms (riffles, bars, pools) important to salmonids, and a reduced riparian corridor due to the lack of a functional floodplain. Initiated in 2007 by the California Land Stewardship Institute, this private-public partnership with Napa County is working to achieve voluntary participation among all 34 riverside landowners. The project is nearing the 30% design stage, with anticipated construction to begin in 2014/2015. Over the past year extensive biological, geotechnical, cultural, and geomorphic studies have been completed; a Basis of Design has been developed; 28 restoration projects have been designed; a landowner advisory committee (LAC) has been formed; 5 acres of *Arundo donax* have been treated. Key structural restoration elements of the project include channel widening, floodplain restoration, and addition of large wood and boulder features that will support habitat forming geomorphic processes. Secondary components of the project include biotechnical stabilization, vegetation management, and site revegetation. A long term channel monitoring and maintenance program is being developed by the Napa County Flood Control and Water Conservation District in collaboration with river front landowners. Costs and benefits of the project are being borne equally by landowners, the local Napa community, and state and federal grant programs.

Keywords: River Restoration, Watershed Management, Habitat Restoration

Poster Topic: Napa River Watershed Restoration

Napa River Rutherford Reach Restoration Project

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The Napa River Rutherford Reach Restoration Project is restoring 4.5 miles of the Napa River between Zinfandel Lane and the Oakville Bridge in the middle Napa River watershed. Initiated in 2002, this private-public partnership has achieved voluntary participation by 100% of the 28 riverside landowners. Project implementation is 60% complete, with anticipated completion by 2015. Since construction began in 2009, 3.25 acres of invasive *Arundo donax* have been eradicated; 2.5 miles of agricultural berms have been setback into adjacent vineyards, expanding the riparian corridor and slowing erosive stream flows; 21 acres of native riparian habitat have been restored; 12 acres of slow water habitat for young Chinook salmon and threatened steelhead trout; 55 instream structures have been installed to enhance aquatic habitat; eroding bank length has been reduced by half; and the rate of fine sediment delivery to the channel has been reduced by an estimated 10,154 metric tons/year for 20 years. A long term channel monitoring and maintenance program has been established with the Napa County Flood Control and Water Conservation District financed with dedicated funding from river front landowners. Costs and benefits of the project are being borne equally by landowners, the local Napa community, and state and federal grant programs.

Keywords: River Restoration, Habitat Restoration, Watershed Management

Poster Topic: Napa River Watershed Restoration

Swainson's Hawk (*Buteo swainsoni*) Expands its Breeding Territory in the Napa Valley

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Swainson's Hawk (*Buteo swainsoni*) is listed as threatened under the California Endangered Species Act. In California, Swainson's Hawks primarily nest in the Central Valley. This species recently colonized Napa County and established a breeding site in the southern portion of the Napa Valley in an area with habitat conditions similar to breeding sites in the Central Valley. On July 1, 2013, a Swainson's Hawk nest was found in the Oakville region of the Napa Valley during a pre-construction nesting bird survey for the Napa River Restoration Project. This site is approximately 16 miles north of the previously documented nest site and in an area dominated by dense vineyard development. Swainson's Hawk was "not expected" to occur in this portion of the Napa Valley because vineyards provide marginal foraging habitat for this species. Following discovery of the nest, a 0.25 mile no-work buffer was established around the nest site, and the nest was monitored daily by wildlife biologists. A juvenile Swainson's Hawk successfully fledged from the nest around July 15, 2013. This nest site represents an expansion of the Swainson's Hawk's current breeding range in the Napa Valley.

Keywords: Swainson's Hawk, Napa, Nest

Poster Topic: Napa River Watershed Restoration

Zinfandel Lane Bridge Fish Habitat Improvement Project

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In October of 2011 the County of Napa completed construction of the Zinfandel Lane Bridge Fish Habitat Improvement Project, remediating a historic fish barrier that severely impeded access to approximately 50% of the available spawning and rearing habitat for fall run Chinook salmon and steelhead trout in the Napa River watershed. Working in partnership with the Napa County Resource Conservation District, a final design that provided suitable hydraulic conditions for passage of both adult and juvenile salmonids while also maintaining geomorphic stability of the river channel was developed. The project also includes pre- and post-construction topographic channel surveys and fisheries monitoring including annual adult salmonid spawner and snorkel surveys in the areas upstream and downstream of the project. Topographic surveys to date indicate a minor level of channel incision took place post-project but that the channel has remained relatively stable and no significant bank erosion has been documented; results from fisheries surveys are pending. This project was funded by generous grants from the California State Coastal Conservancy, The Peter A. and Vernice H. Gasser Foundation, and the US Army Corps of Engineers, as well as the citizens of Napa County through Measure A Watershed Improvement Funds.

Keywords: Fish Passage Barrier, River Restoration, Watershed Management

Poster Topic: Napa River Watershed Restoration

Napa River Steelhead and Salmon Monitoring Program: Collecting Fish Population Data for a Vital Bay Area Watershed

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The Napa County Resource Conservation District (RCD) has operated a rotary screw trap in the mainstem Napa River for five years to collect information on steelhead trout (*Oncorhynchus mykiss*) and Chinook salmon (*O. tshawytscha*). This program represents the first outmigrant trapping effort ever undertaken for the Napa River watershed and is intended to help answer the following questions: 1. What is the average size of Napa River steelhead smolts? 2. What is the timing of steelhead and salmon outmigration? 3. What is the composition of the freshwater fish community? 4. Are population trends for steelhead and salmon apparent in the Napa River watershed?

Steelhead smolt sizes and catch rates have been relatively consistent during the past five years with an average fork length of 189mm (std. dev. ±24mm); this large average size would be expected to produce high ocean survival rates. In contrast, Chinook salmon abundance has fluctuated greatly during the same period suggesting that the population is relatively small and may be more susceptible to environmental variability from one year to the next.

Steelhead outmigration from the Napa River appears to peak in April in most years with increased activity during storms. Chinook salmon smolts were collected most regularly toward the end of each sampling season with a peak around early May.

A total of 31 fish species have been collected to date: 14 natives and 17 non-natives. The most abundant native species were Chinook salmon, California roach (*Hesperoleucus symmetricus*), and steelhead/rainbow trout. The most abundant non-native fish species were largemouth bass, bluegill, and golden shiner. Native fish species comprised over 98% of the total catch from 2009-2013.

The Napa RCD and its partners plan to continue monitoring to develop salmonid population indices and track ecological responses to habitat restoration. Annual reports are available at www.naparcd.org.

Keywords: Salmon, Napa River

Poster Topic: Napa River Watershed Restoration

Napa River Sediment TMDL Implementation Tracking and Accounting System

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It starts with a question: What's the status of our fisheries? Are we in compliance with our TMDL? Are public funds making a difference? The answers require intentional and informative data. Napa County, with the help of several partnering agencies and organizations, is developing a Napa River Sediment Total Maximum Daily Load (TMDL) Implementation Tracking and Accounting System (ITAS). The ITAS is being designed to account for required and recommended implementation actions prescribed in the Napa River Sediment Reduction and Habitat Enhancement Plan (TMDL). The objectives of the ITAS are to: 1) identify progress towards achieving TMDL goals and compliance; 2) prioritize implementation actions; 3) inform management strategies; and 4) communicate results to stakeholders, regulatory agencies, funders, and policy makers. The ITAS will be a web-based system to assist the County and other responsible reporting entities in tracking their progress and implementation actions that reduce sediment loading of waterways, improve aquatic and riparian habitat quality, and meet the objectives of the TMDL. The system will track performance measures that demonstrate compliance and relative effectiveness of watershed actions intended to control or reduce sediment delivery to the river system and improve overall stream/river function.

Keywords: TMDL Implementation, Napa River Watershed

Poster Topic: Napa River Watershed Restoration

Assessment Results and Treatment Recommendations of Road-Related Sediment Sources in the Napa River Watershed

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This poster summarizes results from road assessments in the Napa River watershed that quantified sediment volumes that roads produce and identified how roads impact erosional processes. Future erosion volumes were derived using the same methodology that the San Francisco Bay Regional Water Quality Control Board used in its sediment TMDL report which identified the Napa River watershed as being impaired by sedimentation (Napolitano et. al. 2009). Treatments proposed to reduce road-related sediment production were consistent with CA Dept. Fish and Wildlife 'Salmonid Habitat Restoration Manual' and Mendocino RCD's 'Forest and Ranch Roads Handbook.'

Road systems are perhaps the most significant and most easily controlled sources of sediment production and delivery to stream channels (Napolitano et. al. 2009). Regional Water Board estimates that, on average, 50 cubic yards of sediment are produced per mile of road, per year in the Napa River watershed (Napolitano et. al. 2009). Negative effects from excess sediment inputs into streams include, 1) increased water temperatures, 2) lowered dissolved oxygen, 3) increased flooding potential and 4) the loss of adequate salmonid spawning habitat.

Unlike many watershed improvement and restoration activities, erosion prevention and "storm-proofing" of road systems can have immediate benefits to the streams and aquatic habitat. Storm-proofing roads helps to ensure that the biological productivity of the watershed's streams is not impacted by future anthropogenic erosion and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment, rather than depositing additional sediment from managed areas.

Keywords: Road-Related Sediment Sources, Sedimentation, Erosion, Water Quality, TMDL

Poster Topic: Napa River Watershed Restoration

Fish Friendly Farming Environmental Certification Program: A Partnership of Agriculture and the Environment

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Many farmers in northern California are seeking to both comply with a bewildering array of regulations governing their operations and land management and to best manage their land over the long-term. The Fish Friendly Farming Program is a voluntary environmental certification program which provides farmers and ranchers with the tools and resources to comply with water quality and endangered species regulations and to demonstrate their commitment to long-term environmental stewardship of the land. This site-based program offers 3rd party certification from three regulatory agencies: NOAA-National Marine Fisheries Service, Regional Water Quality Control Board, and the County Agricultural Commissioners' office. The California Land Stewardship Institute (CLSI), a non-profit organization based in Napa, operates the FFF program in Napa, Sonoma and Solano Counties. Certification is reviewed every 5-7 years, and certified sites document the implementation of Beneficial Management Practices (BMP) through annual photo-monitoring and record-keeping. Fish Friendly Farming offers an incentive-based method for creating and sustaining environmental quality and habitat on private land with a focus on education and assistance to land managers. For many sites, the FFF Program provides validation of land management practices already in use; for others, BMPs are given implementation timelines appropriate to their degree of complexity. The Regional Water Quality Control Board has recognized the FFF program as providing compliance with the fine sediment TMDLs. By using a rigorous science-based approach, the FFF Program assures that changes to management practices are well thought out and will have the desired results, and that larger efforts such as stream restoration projects undergo thorough analysis prior to implementation. Approximately 120,000 acres are enrolled in the program statewide with over 65,000 acres in northern SF bay watersheds. The program's popularity with growers demonstrates that the collaborative approach is an effective tool for regulatory compliance and habitat restoration.

Keywords: Agriculture, Water Quality, Voluntary, Environmental Certification, Stewardship, Beneficial Management, Sediment

Poster Topic: Napa River Watershed Restoration

57 Years of Reduction in San Jose/Santa Clara Regional Wastewater Facility BOD and Nutrient Loads

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Raw sewage flowed to the Lower South San Francisco Bay from the vicinity of San Jose, Milpitas and Alviso prior to construction of San Jose/Santa Clara Regional Wastewater Facility in 1957. Over the years sewage flows increased with population, but the sewage treatment facility also grew and improved.

Problem Statement: Did Facility expansion and improvements allow sewage treatment to keep pace with population growth?

Approach: Facility effluent data from hard copy reports were compared with Santa Clara Valley population estimates and facility historical reports.

Results: Facility effluent data shows that sewage flows increased dramatically with population from the 1950s through the 1990s, but there has been decline in flows since the late 1990s. At the same time, pollutant loads discharged to the Lower South San Francisco Bay decreased significantly as a result of a series of facility improvements despite the increase in sewage flows into the wastewater facility.

Conclusions: Long-term data collection and periodic resurrection of historic data helps demonstrate the value of public investment in a large wastewater facility and helps document long term impact on the local environment.

Keywords: Wastewater, BOD, TSS, Sewage, San Jose, Milpitas, Alviso

Poster Topic: San Jose/Santa Clara Regional Wastewater Facility: 57 Years of Data Collection

40 Years of Reduction in San Jose/Santa Clara Regional Wastewater Facility Toxic Pollutant Loads

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From its earliest days, the San Jose/Santa Clara Regional Wastewater Facility was designed to remove "conventional pollutants," otherwise known as BOD, TSS, and Ammonia. The Clean Water Act of 1972 and subsequent regulation identified and eventually set concentration limits for 126 additional "toxic pollutants." As a result, the Facility commenced monitoring for heavy metals and some organics in 1975.

Problem Statement: Did Facility improvements have any impact on toxic pollutant removal?

Approach: Trace-level and eventually ultratrace-level monitoring for a suite of toxic pollutants was performed monthly or quarterly. Establishment of ever lower regulatory limits and changes in technology over the decades required changes to laboratory methods. Concerns over some specific pollutants (e.g. copper, PCBs, and mercury) prompted special studies to determine what specific Facility processes were responsible for the removal. Concerns about emerging contaminants added new pollutants to the monitoring list.

Results: The addition of a treatment plant filtration process in 1979 greatly reduced the loads of metals and other particulate-bound pollutants. Continued reductions were measured in the 1980s and 1990s as source control programs were initiated or improved. Changes in laboratory analytical techniques are also responsible for some apparent load reductions.

Conclusions: Overall there has been a substantial reduction in toxic pollutant loads discharged from the facility.

Keywords: Wastewater Treatment, San Jose, Milpitas, Alviso, Toxic Pollutants, Metals

Poster Topic: San Jose/Santa Clara Regional Wastewater Facility: 57 Years of Data Collection

50 Years of Improving Water Quality in Lower South Bay

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The San Jose/Santa Clara Regional Wastewater Facility (Facility) was constructed as a primary-only treatment plant in 1957. Population growth in the 60s and 70s led to decreased water quality in the Lower South Bay. In response to population growth and new regulations, the Facility expanded and improved treatment, adding nitrification and filtration in 1979, and converting to biological nutrient removal (BNR) in 1998. Five decades of changes in receiving water quality in the Lower South Bay in the context of those Facility expansions and improvements helps answer the question: Did Facility expansion and improvements correspond to observed improvements in Lower South San Francisco Bay water quality?
We examined fifty years of ambient receiving water data for dissolved oxygen, water clarity, nutrients, and pH for temporal correlations to key Wastewater Facility improvements.
The 1979 upgrade corresponds to an immediate improvement in effluent BOD, TSS, and ammonia, with corresponding improvements in Lower South Bay dissolved oxygen and ammonia levels. The 1998 conversion to BNR lowered nitrate and phosphate loads to the Lower South Bay and a reduction in ambient nitrate and phosphate concentrations is evident.
Long-term data collection of effluent and receiving water quality clearly demonstrates the benefit of facility improvements.

Keywords: Wastewater Treatment, Water Quality, Dissolved Oxygen, Ammonia Phosphate, Pollutant Loads

Poster Topic: San Jose/Santa Clara Regional Wastewater Facility: 57 Years of Data Collection

Managing Nutrients at Northern California's Only Large Biological Nutrient Removal Facility

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In 1998, the San Jose/Santa Clara Regional Wastewater Facility modified its separate secondary and nitrification processes to a single step-feed Biological Nutrient Removal (BNR) process. Since that time, the facility has achieved a significant level of denitrification and phosphorous removal. Ironically, the amount of nutrient removal was never accurately quantified because the Facility had no effluent limits for nutrients other than ammonia. The impact on nutrient removal of various minor facility process changes made since the late-1990s is not well understood. The Facility optimal operating parameters for nutrient removal are also unknown.

Problem Statement: What conditions optimize nutrient removal in the Facility BNR process?

Approach: Ammonia, nitrate, nitrite, organic nitrogen, and phosphate were measured monthly in Facility effluent prior to, and after, modification to the step-feed BNR process. Both facility influent and effluent were monitored for nutrient concentrations to determine loads removal. Nutrients concentrations were also measured after primary and secondary treatment and at several points through the secondary BNR process to determine where and how nutrients are removed.

Results: The facility removes roughly 60% of incoming nitrogen and well over 90% of phosphorous from wastewater. Factors affecting seasonal variability in nutrient removal are only beginning to be understood.

Conclusion: The Facility's BNR process is very effective in removing nutrients during the warm season. Lower temperature and higher flows among other factors reduce that effectiveness in the winter season.

Keywords: Wastewater, Nutrient Removal, Ammonia Nitrate, Phosphate, Nitrogen, BNR, Nitrification, Denitrification

Poster Topic: San Jose/Santa Clara Regional Wastewater Facility: 57 Years of Data Collection

23 Years of Marsh Growth Downstream of the San Jose/Santa Clara Regional Wastewater Facility

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By the late 1980s, there were concerns that increased freshwater flow from the San Jose/Santa Clara Regional Wastewater Facility was causing downstream marshes to change from predominantly salt marsh to fresh water marsh. Salt marsh provides critical habitat for endangered Salt Marsh Harvest Mouse (*Reithrodontymys raviventris*) and the California Clapper Rail (*Rallus longirostris obsoletus*). To address this concern, the facility contracted with H.T. Harvey and Associates to monitor marsh plant associations in Lower South San Francisco Bay since 1989.

Over 24 years, the extent of salt, brackish, and freshwater marsh plant types was surveyed on 18 occasions. Tidal marshes were mapped in a Main Study Area, composed of 3 reaches (Lower, Transition, and Upper Reaches), and a Reference Area, which is outside the influence of the Plant's freshwater effluent.

The distribution of freshwater marsh in the Upper Reach (closest to the Plant) has remained fairly constant. However, salt and brackish marsh distributions have been dynamic in the Transition Reach and the central portion of the Reference Area. Despite the year-to-year shifts, the proportion of salt and brackish marsh has been similar over time as marsh area increased which suggests that abiotic factors other than the constant discharge from the Plant are responsible for large-scale shifts between brackish and salt marsh. It is likely that rainfall and associated stream flows, sediment deposition, and salinity changes associated with salt pond restoration actions are the primary factors influencing marsh habitat changes.

Since 1989, salt marsh in the Main Study Area increased by 490 acres. In the Reference Area, salt marsh increased 40 acres. Increase in salt marsh coincides with a measured increase in overall marsh area and is likely helped by recent restoration actions associated with the South Bay Salt Pond Restoration Project since 2006.

Keywords: Wastewater, Marsh Habitat, Salt Pond Restoration, Rail, Mouse

Poster Topic: San Jose/Santa Clara Regional Wastewater Facility: 57 Years of Data Collection

Solano Land Trust's Phenology Project

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The project's goal was to develop a self-sustaining citizen scientist phenology monitoring program that increases public participation with the outdoors and with nature and contributes data to nationwide climate change research.

The Solano Land Trust's (SLT) Phenology Program engages volunteers to become citizen scientists and participate in phenological monitoring of the seasonal changes in plants. A grant from the San Francisco Estuary Partnership funded an intern at SLT who developed a training session for volunteer citizen scientists understand phenological data collection. SLT's intern utilized the California Phenology Project of the National Phenology Network website as a tool for establishing a Phenology Program best suited for SLT properties and volunteers. Resources were adapted to create an SLT site-specific protocol, and then presented to new volunteers at several training sessions.

The Phenology Program teaches observational skills and an awareness of our connection to nature. Citizen scientists discover plant form and function and the timing of seasonal plant cycles throughout multiple site visits. These citizen scientists understand that their data uploaded into the nationwide database, will be used by larger organizations in the long term effort to study climate change. They learned how to participate in the Phenology Program, were orientated to selected monitoring sites, and learned how to recruit and train additional citizen scientists so that the volunteer program can keep growing.

Once the training was complete, the newly graduated citizen scientists started to collect data and will contribute their phenological observations to the database year-round. The management implications of this program involve volunteer recruitment, administration, and encouragement of this citizen science activity. This program developed easy to use and understand protocols, stream-lined training sessions, and increased knowledge of local open space and climate change implications.

Keywords: Phenology, Climate Change

Poster Topic: SFEP Watershed Program Small Grants Projects

That's the Tuolumne In My Tap

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"That's the Tuolumne In My Tap" is a free elementary school education program that teaches 4th-6th grade students in the SFPUC service territory (San Francisco, San Mateo County, northern Santa Clara County and southern Alameda County) where their water comes from and why and how to conserve it. The program fosters in students a lasting commitment to the stewardship of their water source, and inspires them, along with their families and school administrators, to reduce water usage at home and at school.

The program includes a classroom visit with an interactive slideshow focusing on where our water comes from, the history and special qualities of the Tuolumne River, the animals that depend on the River, and what we all can do to conserve water. The presentation is based on California content standards in math, science and social studies.

A growing component of "That's the Tuolumne In My Tap" includes organizing field trips and service learning projects. Field trips enable students to experience the Tuolumne River watershed, the Bay-Delta and local watersheds first hand. Service learning projects include local creek and baylands clean-ups, drought-tolerant native plant gardening, and installation of stormwater retention systems.

Keywords: Tuolumne, Hetchy, Conservation, Education, Elementary, SFPUC, BAWSCA, Salmon, Steelhead, Yosemite

Poster Topic: SFEP Watershed Program Small Grants Projects

Restoring Rheem Creek at Wanlass Park

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Urban creeks help conserve biodiversity and provide a wonderful opportunity for human residents to interact with the natural world, but they also suffer from dumping, littering, and non-point source pollution. The Watershed Project is working with the San Francisco Estuary Partnership and other organizations to engage the residents of San Pablo and nearby communities to protect and enhance Rheem Creek at Wanlass Park, and increase appreciation of this biodiversity. Outreach to local schools and churches reaches a diverse audience and enhances general awareness of creeks and water quality issues.

Program participants at Wanlass learn fundamental watershed awareness, and those concepts are reinforced through hands-on stewardship. At volunteer events we discuss the causes and impact of marine debris, and clean up trash from the creek. Volunteers learn how gardening chemicals can have a negative impact on water quality, then control weeds with low impact methods and plant drought tolerant California native plants along the creek bank. We observe birds and butterflies on site, discuss how the native plants improve habitat for birds and pollinators, and participants come away with a greater appreciation of biodiversity and ecosystem services.

Over 100 volunteers have removed 24 cubic yards of invasive weeds from the creek bank and park, and planting of 250 site appropriate California native plants has begun. As the native plants become established, stability of the creek bank will increase and weed maintenance with gas powered tools will decrease, resulting in water quality and air quality benefits. Equally important, individual awareness of the environment will increase among both participants and casual park visitors. Residents will understand their connection to the larger watershed of the San Francisco Bay Estuary, and how to protect it.

Keywords: Watershed Stewardship, Water Quality, Marine Debris, Urban Habitat, Biodiversity

Poster Topic: SFEP Watershed Program Small Grants Projects

A Public Rain Garden Showers Benefits on Napa

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Using funds from Napa County's new rain garden rebate program, a team of local agency and school district staff have spearheaded the development of the first demonstration garden in the Napa River watershed on the campus of Vintage High School. The triangular shaped garden is adjacent to Salvador Creek, and will filter runoff from an adjacent parking lot before it enters the Creek. The creek is highly impacted by urban development, and is currently being restored through the removal of concrete and sediment deposits and addition of native riparian plants. The publicly accessible rain garden was designed and constructed by a collaborative team that included community volunteers, high school students and teachers, local gardening enthusiasts, and a Bay-Friendly qualified professional landscaper. The native plant garden was designed to demonstrate practical examples of principles of bay-friendly gardening, including storm water catchment, drought-tolerance, lawn alternatives, habitat creation, waste reduction, and soil health. The garden will include signage that conveys the environmentally beneficial features of the garden as well as cultural uses of native plants. The garden will play an important role in promoting rain gardens in the community, and their implementation through the County's rebate program. The garden is expected to be a hub of community workshops on bay-friendly gardening, and has already played host to the City of Napa's water-wise landscaping workshops this fall. In addition to being educational, the garden also is expected to reduce pollution loads from entering Salvador Creek, increase infiltration, and expand native riparian canopy.

Keywords: Rain Garden, Demonstration, Stormwater Education, Rainwater Harvesting, Native Plant, Pollution

Poster Topic: SFEP Watershed Program Small Grants Projects

Supporting Volunteer-Led Efforts at Sausal Creek Watershed Restoration Sites

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The Friends of Sausal Creek (FOSC) is a nonprofit 501(c)(3) volunteer-based community organization founded in 1996. Our mission is to engage local citizens in the enhancement of Sausal Creek and its watershed as natural and community resources. We focus on restoring native habitat and on educating children and adults about the benefits of a healthy local ecology. In addition to the restoration workdays and environmental education field trips led by our small staff, our staff supports the efforts of volunteer site leaders at over a dozen watershed sites from the hills to the bay. We also support volunteer-led aquatic insect and water quality monitoring programs. In 2013-2014, our goal is to increase and enhance support for our volunteer restoration site leaders in order to improve the success of the restoration work at each site. We will train and mentor volunteers in order to create a pool of highly qualified volunteers that are available to lead restoration work into the foreseeable future, and to increase biodiversity at the local ecosystems through better training for the volunteer site leaders in restoration techniques and in strategies for volunteer management. New resources and dedicated staff time will also enable interested volunteers to establish new restoration sites and to more easily develop a volunteer base. This poster will highlight the restoration work being done at our volunteer-led sites.

Keywords: Creek Restoration, Native Plants, Invasive Plants, Outreach, Volunteers, Public Education

Poster Topic: SFEP Watershed Program Small Grants Projects

Increasing Community-based Watershed Stewardship in the Gallinas Creek Watershed and Facilitating Collaboration among Marin County Watershed Groups

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As in many Bay Area watersheds, human activities in the Gallinas Creek Watershed pose significant challenges to its creeks, wildlife, and the Bay. The Gallinas Watershed Council seeks to protect this important natural community with its unique array of wildlife and habitats. Watershed marshes support the largest population of endangered California clapper rail in San Pablo Bay and other rare species, and China Camp State Park contains a relatively pristine and ecologically rich remnant of San Francisco Baylands. And yet there remains a widespread lack of understanding among local stakeholders about the importance of watersheds, how watersheds function, where sensitive tributaries are located, and how human activities impact watershed resources. To address this problem, GWC has been undertaking a variety of education, outreach, and regional collaboration efforts.

GWC education and outreach activities include tours of the watershed, cleanups, and outreach at community events. GWC tours allow participants to make a personal connection with the watershed and provide an on-the-ground opportunity to witness and discuss real watershed issues, challenges and potential solutions. Cleanups engage individuals directly in watershed stewardship. GWC also conducts education and outreach at community events. The recent purchase of a realistic, 3-D watershed model offers an engaging and interactive way to educate the public about watersheds, point and nonpoint source pollution, and strategies for reducing human impacts. Finally, GWC seeks to increase the effectiveness of both local and regional efforts to protect watersheds by planning for a regional meeting in fall 2013 that will bring together interested individuals and watershed groups across the county. The purpose of the meeting is to provide a venue for information exchange and collaboration, and to jumpstart a mechanism for continued exchange with the goal of making the watershed approach a more influential part of public dialogue and decision-making.

Keywords: Gallinas Creek Watershed, Education, Outreach

Poster Topic: SFEP Watershed Program Small Grants Projects

Permanente Watershed Tour

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On a clear day in May 2013, 60 participants packed into a bus to tour Permanente Watershed. Connecting and informing the local community with the wonders and complexity of their watershed was the goal of the Permanente Watershed Tour. Participants included creekside residents, city council members, educators, students and environmental leaders. Speakers ranged from open space employees and professors to residents with expert knowledge. The tour had five stops, originating in the foothills and ending near the bay.

Topics:

- Natural dynamics and requirements of a healthy creek and the challenges in residential areas
- Two views on Santa Clara Valley Water District flood protection plans: the District's justification and resident experts counter view to the District's flood plans
- Impact of Lehigh Quarry on the creek and fish habitat
- Review of recent Consent Decree resulting from Sierra Club lawsuit against Lehigh Quarry
- Fish habitat, passage, and the requirements for bringing steelhead trout back to Permanente Creek
- Local historical stories about Permanente from longtime residents
- Climate change and its impact on creeks and waterways
- Discussion of restoration work with creekside company, Google
- A hands on restoration planting activity for tour guests
- Thorough discussion of Burrowing Owl habitat and local conservation work

Physically bringing community members to locations along the creek deepened their understanding and appreciation of this watershed.

Thanks to grants from ABAG/SFEI and sponsorship from Google, ticket price, including lunch, was low at $35 with discounts for students. Participants also received USB Flash Drives with documents and data from the tour. Several flash drives were distributed to a local college and other organizations (NOAA, Sierra Club, Fisheries Consultant) requested copies.

"We conserve only what we love, we love only what we understand, and we understand only what we are taught."

Keywords: Watershed, Education, Steelhead Trout, Burrowing Owl, Restoration, Flood Protection, History

Poster Topic: SFEP Watershed Program Small Grants Projects

South Bay Salt Pond Restoration Project: Adaptive Management in Action

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The South Bay Salt Pond Restoration Project (www.southbayrestoration.org) is the largest wetlands restoration project on the West Coast of the United States. It is unique not only for its size-- over 15,000 acres—but for its location adjacent to one of the nation's largest urban areas, home to over 3 million people. The Project is intended to restore and enhance wetlands in South San Francisco Bay while providing for flood management and wildlife-oriented public access and recreation.

We have identified long-term alternatives for the Project, each representing a continuum toward different end-states: one end-state at 50% of the existing ponds converted to managed ponds for waterbirds and 50% restored to salt marsh habitat, and the other end of the continuum at 10% of the existing ponds converted to managed ponds and 90% restored to marsh habitat. The final ratio of managed ponds to salt marsh habitat will depend on the outcome of the Adaptive Management Plan, which will be implemented over the next 40 years. The Plan will allow for lessons learned from earlier phases and applied studies to be incorporated into subsequent stages as management objectives and designs of future actions are revised and implemented.

The Project has completed most of the Phase 1 studies, and much has been learned about key uncertainties. This poster will summarize the results of the sediment, avian, and mercury studies and how managers have revised management actions and restoration designs in response to scientific research.

Keywords: Habitat Restoration, Salt Ponds, Sediment, Avian, Birds, Mercury, Managed Ponds

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Developing Indicators of Health for a Sentinel Species (*Gillichthys mirabilis*) for Salt Marsh Restoration

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The South Bay Salt Pond Restoration Program is restoring 15,100 acres of former salt production ponds into tidal marsh and managed pond habitats to create a mosaic of habitats for migratory shorebirds, waterfowl and fish. **Question:** How do restoration activities affect the health of fish in restoration ponds? We chose the longjaw mudsucker (*Gillicthys mirabilis*), the only fish species to be solely dependent on pickleweed marsh habitats (*Sarcocornia pacifica*), one of the target habitat types for restoration. We use a hierarchical approach to develop indicators of fish health. Metrics at the fish population level include density, abundance, survival and recruitment. Metrics at the individual level include growth, condition factor, disease and deformities, liver weight and abundances of triglycerides (TAG). We monitored their density and recruitment by deploying baited minnow traps. Sites were on the adjacent sides of restoration pond levees along the main sloughs, and inside restoration ponds to compare the health of individuals living inside restored ponds to conditions outside the ponds. We will present results for only the Alviso Marsh and Ravenswood Marsh. The health of the individuals overall was very good for most sites. However fish collected inside restoration ponds generally had higher condition factors, but their survival and recruitment was lower. This indicates that fish quickly colonize the new ponds but due to the lack of suitable pickleweed habitat they move back out of the ponds or are consumed by predators such as leopard shark. We did observe poor condition of mudsuckers inside A8 in 2010 and 2011 and since summer of 2011 we no longer capture the species in this pond. This study provides a baseline for assessing the health of a sentinel species near restoration ponds. Periodic monitoring of individual health indicators could help evaluate the success of salt pond restorations.

Keywords: Restoration, Salt Pond, Fish Health

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Sediment Dynamics in Restored Salt Ponds in San Francisco Bay

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Newly restored wetlands rely on sediment accumulation to raise elevations and create suitable conditions for vegetation recruitment. However, uncertainties exist concerning the rate of sedimentation: if sufficient suspended sediment is available in the San Francisco Estuary waters, or if sediment accumulation in newly restored wetlands will result in impacts to existing habitat. We investigated the rates of vertical sedimentation across Pond A6 using the burial of sediment pins, as well as short-term (two week) mass-based accumulation measurements using a modification of the "filter paper" method. In addition, we measured elevations at Ponds A6 and A21 (one of the Island Ponds) using a Real-Time Kinetic Global Positioning System in order to determine threshold elevations for plant recruitment. Mean deposition at Pond A6 has been very rapid since breaching in December 2010 (47 cm through March 2013), with a mean annual accumulation rate of 20.2 cm/yr. The mean short-term accumulation rate was 234 g/m^2/day across the pond, higher than rates from Pond A21. The mean pre-breach elevation of Pond A6 was 0.70 m NAVD88, and two years following tidal restoration, wetland surface elevations ranged from 0.5 to 1.37 m NAVD88. Very few plants have recruited at Pond A6, with no new plants in the broad central area of the pond. At Pond A21, mean elevations for *Spartina foliosa* were 1.79 m NAVD88 and were slightly higher for *Salicornia pacifica (*1.95 m NAVD88). Unvegetated areas close to the colonizing edge of *S. foliosa* averaged 1.79 m NAVD88, with values between 0.91 and 1.93 m NAVD88. Plant recruitment at Pond A21 is patchy, likely because of the stochastic nature of seed germination and inundation stress on early plant survival. Both sites are developing very rapidly, with accretion rates that are orders of magnitude higher than those found in well-developed tidal wetlands.

Keywords: Wetland Restoration, Sediment Accretion, Sedimentation, Habitat, Development

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

San Francisco Bay Transition Zone Habitat (TZH) Conservation and Management Decision Support System

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A GIS based decision support system (DSS) to identify and prioritize marsh-upland ecotonal habitats (transitions) to assist land managers in restoring and protecting San Francisco Bay's (estuary) tidal marsh ecosystem will be presented. The DSS takes a strategic approach towards decision support, by accounting for the landward migration of high marsh and other transitional habitats in response to predicted sea level rise (SLR). Current documents do not adequately describe ecotonal habitats, quantify the amount needed to aid listed species recovery while allowing for SLR, nor prioritize specific sites for protection and restoration. The DSS combines definitions bioassessment protocols, GIS models of the distribution of TZH at the landscape level, site specific criteria for ranking sites for restoration or protection, and parcels level maps for prioritizing TZH throughout the SF estuary. This toolkit will help managers allocate limited resources on site prioritization, alternative/scenario evaluation, and will include considerations for the influence of future climate change and land-use scenarios. Project findings will be made available on the web through an interactive mapping tool.

Keywords: Wetlands, Decision Support, GIS, Decision Making, Sea Level Rise

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Changes to Bathymetry as Alviso Restoration Progresses: 2010–2013

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An unanswered question in the restoration of salt ponds in South San Francisco Bay is to what degree the breaching of levees will cause local and regional erosion of sloughs, mudflats, and channels. In 2010 the USGS collected bathymetry in the vicinity of the Alviso pond complex including the main channel of South Bay, shallow intertidal mudflats, and Alviso and Guadalupe Sloughs to establish baseline bathymetry prior to the breaching of Pond A6 levees and opening of gates at Pond A8 (Foxgrover *et al.,* 2011). Interferometric sidescan swath mapping was used to generate high resolution (1 m cell size) bathymetric grids of the far South Bay extending east of Calaveras Point to where Coyote Creek meets the railroad bridge, and down Alviso Slough to just past the A8 gates. Between October 2011 and October 2013 we have conducted six additional surveys to monitor bathymetric changes in this region as restoration progresses. The greatest erosion has occurred within Alviso and Guadalupe Sloughs bay-ward of the southern A6 breaches. Erosion on the order of 20+ cm dominates these reaches of the sloughs, and localized erosion directly adjacent to the breaches exceeds 75 cm. Changes within the slough upstream of the A6 breaches are more subtle, and when summed, indicate a net deposition of sediment. Thus far, significant erosion of the nearby tidal flats has not occurred. These data are critical to the adaptive management of phased restoration plans, estimates of legacy contaminants released by restoration-associated scour, and provide insight into morphological evolution of slough/intertidal mudflat/bay systems as levees are breached and the tidal prism increased.

Foxgrover, A.C., Finlayson, D.P., and Jaffe, B.E., 2011, 2010 Bathymetry and digital elevation model of Coyote Creek and Alviso Slough, south San Francisco Bay, California: U.S. Geological Survey Open-File Report 2011-1315, 20 p. and datasets, http://pubs.usgs.gov/of/2011/1315/.

Keywords: Bathymetry, Alviso, Salt Ponds

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Seasonal Variability of Fish and Invertebrate Assemblages in the Alviso Marsh Complex

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The objective of this study was to monitor the spatial and temporal variability of fish species composition and relative abundance in newly restored salt ponds and adjacent slough habitats using boat based trawling (otter trawl), which samples the bottom of slough habitats up to 1 meter of depth. Bimonthly to monthly monitoring was conducted from July 2010 up through March 2013, at 2-3 sites in Alviso Slough, 3-6 sites in Coyote Creek, 3 sites in A21 and A19, and in 1 site in A6. During this period we collected over 13,000 individual fish from 38 species. In addition we have counted over 120,000 invertebrates from over 40 identifiable taxa including rank scoring of 4 taxa (mysid shrimp, amphipods and isopods) which are too numerous to count individually. For this summary we examined the seasonal variability of the 10 most abundant fish species and the most abundant invertebrates (mysid and Crangon shrimp). Distinct seasonal patterns in terms of fish assemblages were apparent with summer species assemblages comprised of juvenile Pacific staghorn sculpin, Northern anchovy and English sole, while the winter assemblage included Pacific herring, American shad and the State threatened longfin smelt. Mysid shrimp were in greatest rank abundance during the winter and into the early summer, while Crangon shrimp were abundant year round; however a clear pattern of recruitment of juveniles occurred during the spring-summer months. These patterns highlight the value of the Alviso Marsh system as a vital nursery area for several key species of the nearshore marine food web (Pacific herring and Northern anchovy) the estuarine food web (Pacific staghorn sculpin and Crangon shrimp) and winter feeding grounds for longfin smelt. This study also observed the greatest abundance of mysid shrimp in the estuary and documents the overall benefits of restoring former salt ponds to tidal marsh habitats.

Keywords: Salt Marsh, Restoration, Longfin Smelt

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

The Effect of Salt Pond Restoration and Management on the Feeding Ecology of the Leopard Shark (*Triakis semifasciata*): The Top Predator in the South San Francisco Bay Estuary

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The South Bay Salt Pond Restoration Program is restoring 15,100 acres of former salt production ponds into tidal marsh and managed pond habitats. Restoration of salt ponds has been done through the breaching of large sections of levees often at locations where former tidal sloughs existed, creating constriction points where large volumes of water flow, creating ideal habitats for predatory fishes to forage, including the Leopard shark (*Triakis semifasciata*). This artificial habitat can provide a unique feeding opportunity as tidally muted systems can harbor large densities of benthic invertebrates and fishes for Leopard sharks to prey upon. In this study we investigate the diet composition and feeding ecology of Leopard sharks in fully tidal restoration ponds and muted tide ponds to determine if these managed ponds could have an effect on the diet and feeding ecology. This study compares the diets of Leopard sharks inside the Ravenswood tidally muted pond SF2 and the tidal pond E9 at Eden Landing Marsh. Thus far we have examined over 20 individuals from SF2 and E9. Interestingly, we found that individuals captured at the same location and time and of similar size can have very different diets, with some individuals feeding solely on pile worms, other preferring crustaceans, and others feeding solely on fish. Generally, Leopard sharks do feed on a variety of prey items; however, the distinctness of the diets suggests that individuals may prefer certain prey items. The diet composition between SF2 and E9 appears to be fairly similar except fish at E9 appear to feed on the longjaw mudsucker, the sentinel species of the South Bay Salt Pond Restorations Fish Monitoring Program. In the future we plan to compare the diets of Leopard sharks to prey availability in the different ponds to determine if diet selectivity is determined by availability.

Keywords: Restoration, Salt Ponds, Managed Ponds, South Bay

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Mercury in Motion: Quantifying Mercury Flux in Alviso Slough

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The ongoing 6,500 hectare wetland restoration project in South San Francisco Bay represents one of the largest wetland restoration efforts in the world. One of the challenges faced by project managers is legacy mercury buried in primary slough channels and former salt ponds within the restoration area. Levee breaches associated with the restoration project are causing vast changes in the hydrology of the restoration area, and these changes are projected to mobilize legacy mercury (Hg) buried in the sloughs and marshes (via slough widening). The current study focused on quantifying Hg flux associated with suspended sediment in Alviso Slough. Surface water samples were collected hourly for 24 hrs (over two full tidal cycles) and were assayed for a suite of Hg species and ancillary parameters used to characterize both the dissolved and particulate phases. This was repeated once during all four seasons and during the 'first flush' event of the 2013/2014 water year. The hourly data was then combined with velocity and suspended sediment concentration data, collected continuously (at 15 minute intervals) from a fixed buoy monitoring station, to calculate Hg and suspended particle flux for the cross-sectional area in that portion of Alviso Slough. Initial results indicate that net sediment and Hg flux, over the 24 hour sampling period, was landwards during March 2013, and baywards during November and December (1st flush event) 2013. The magnitude of net sediment and Hg flux was on the order of tens-of-tons per day and tens-of-grams per day, respectively. Seasonally integrated flux calculations are ongoing and will be presented.

Keywords: Mercury, Salt Pond Restoration

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Mercury in Motion: Using Bathymetric Surveys to Estimate Mercury Mobilization from Scour of Alviso Slough

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A large concern for restoration of the salt ponds bordering Alviso Slough is mercury (Hg) mobilization from buried sediment, a legacy of the New Almaden Quicksilver mines (established in 1847), which ceased operation in 1976. The levee breach of Pond A6 and the opening of adjustable Notch gates at Pond A8, have caused sediment scour in Alviso Slough. The combination of erosion and Hg data allows calculation of the volume of Hg remobilization. We calculated the volume of eroded sediment by differencing a 2012 interferometric swath bathymetric survey taken after breaching and gate opening with one taken in 2010 before breaching or opening. This data was coupled with 200 cm deep sediment core data collected during 2006 and 2012, and subsampled for total Hg. This study used three different methods to estimate the total Hg mobilized by the scour. Method A assigned a zone- and depth-averaged Hg value to each of the four zones along the length of the slough and multiplied those by the observed volume of erosion in each zone. Method B used zone averaged Hg values for each 20 cm sediment depth interval and multiplied this concentration by the corresponding observed volume of erosion for each 20 cm interval. Method C used interpolated values of Hg along the length of the slough for each 20 cm depth interval and multiplied each interval by its corresponding observed volume of erosion. There was close agreement between the three methods, with a range of values of 10.6-12.6 kg for the amount of Hg mobilized since the Pond A6 Breach and the Pond A8 Notch operation (Dec. 2010 and Oct. 2012). There was less Hg mobilization than expected based on prior modeling efforts. However, we expect more Hg to become mobilized, and erosion to continue as the notch gates open wider.

Keywords: Mercury, South Bay Salt Ponds, Restoration

Poster Topic: South Bay Salt Pond Restoration Project: 10 Years of Science

Alameda Creek Riparian Bird Community Occupancy Analyses

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Alameda Creek and its tributaries comprise one of the largest watersheds in the South San Francisco Bay. It provides refuge to a number of special status species, including an array of Neotropical birds. To inform habitat management that promotes biological diversity, bird counts were conducted along a 14 mile stretch of Alameda Creek that flows through Sunol Regional Wilderness Area, in Alameda County. Our avian surveys included three stream reaches that are subject to differing levels of recreational, agricultural (grazing) and hydrological regimens.

We used the Variable Circular Point Count method to survey for birds along three different stream reach sections of Alameda Creek during each breeding season from 2007 through 2011. Over the five year study, 2596 bird detections were recorded, including 62 species (7 Focal Species for Riparian Conservation, and 12 Focal Species for Oak Woodland Conservation). We used Multiple-species hierarchical Bayesian occupancy models to assess species occupancy and richness to identify possible associations with stream reach vegetation and landscape characteristics.

Results indicate that the highest species richness, as well as the highest focal species occupancy and richness, occurred along the upper stream reach section of Alameda Creek where elevation is higher and human activity is much lower. Focal species occupancy is similar between the middle and lower reaches, but both are lower than the upper reach, despite the similarity in vegetation among all three reaches. These results point toward elevation, topography, human use patterns, hydrology, and potentially other large-scale factors influencing bird species richness, abundance, and probability of presence rather than habitat structure and composition. Further investigation is needed to evaluate which of these features are likely drivers of this pattern and how we may be able to manage these areas to maximize biodiversity of our riparian avifauna.

Keywords: Riparian Bird Monitoring, Watershed Management to Maximize Biodiversity

Poster Topic: Birds

Projected Impacts of Climate, Urbanization, and Water Management Scenarios on Ecology and Habitats of Waterfowl and Other Waterbirds in the Central Valley of California

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The Central Valley of California contains some of the most important habitats for waterfowl, shorebirds, and other waterbirds in North America. Waterbird habitats in the Central Valley are dependent on precipitation and snow pack for water supplies. Global climate models indicate substantial changes in temperature, timing, and amounts of precipitation in watersheds of the Central Valley, translating into temporal and spatial variations in many of the driving forces that define the availability and productivity of waterbird habitats. Food availability is a key factor limiting waterbirds during migration and winter, and it impacts body condition and other aspects of waterbird ecology. We developed Central Valley landscape change scenarios based upon precipitation, temperature patterns, and resulting water supplies projected from downscaled climate models, urbanization, and water management scenarios and investigated impacts on habitats and ecology of waterfowl and other waterbirds. For each scenario, we modeled water supplies and demands in the Central Valley using the Water Evaluation and Planning system (WEAP) to quantify future potential water deficit impacting waterbird habitats during migration and winter. WEAP results were translated to available habitat. For each scenario, the computed habitat areas were included in a bioenergetics model to quantify future potential waterfowl food deficits. Initial modeling results focusing on Butte Basin indicate that under some scenarios, water supplies will not be adequate to maintain habitat at the levels necessary to support Central Valley Joint Venture goal populations of waterfowl and result in late-winter food deficits for waterfowl and other waterbirds. Of scenarios we investigated, waterbird habitats and food supplies would be impacted the most by a combination of warm, dry future climate, expansive urban encroachment, and a proposed instream flow requirement for protecting migratory salmonids in Butte Creek. We are currently evaluating additional scenarios and expanding our efforts into other Central Valley regions.

Keywords: Bioenergetics, Central Valley, Climate Change, Habitat, Waterbirds, Water Management, WEAP

Poster Topic: Birds

Estimating a Baseline Condition for Landbirds Within the Sacramento-San Joaquin Delta

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Historically, the Sacramento-San Joaquin Delta (Delta) was a vast, tidally influenced freshwater marsh, with soils rich in peat and alluvium from the upstream watersheds. Levees built along stream channels and reclamation of lands for agriculture, water, and urban development have reduced wetland and riparian land cover types to less than 5% of their historical extent. These changes have resulted in the decline of the fish and wildlife species dependent upon the Delta ecosystem and associated habitats. The implementation of projects associated with the permitting, operation and maintenance of the water delivery and flood management systems, as well as the reversal of subsidence and greenhouse gas reduction, provide an opportunity to restore thousands of acres of the Delta landscape to more natural land cover types such as managed and tidal marsh, and riparian forests. These landscape scale changes may provide significant benefits to multiple wildlife taxa, including landbird communities; however, the current status of terrestrial birds is poorly understood within the region. In order to address this information gap, we have implemented a multiyear study of the bird communities using agricultural and natural landscapes throughout the Delta. Using repeatable, quantitative data collection methods, this study will provide a baseline condition for measuring restoration success, inform adaptive management processes, and provide region-specific information on bird-habitat associations. We have gathered bird community composition and abundance data, and fine-scale habitat characteristics at sampling plots (n=218) within 25 sites throughout the Delta. The findings of this study provide a novel understanding of the landbird communities throughout the Delta and will be important in tracking bird response to the large-scale restoration and conservation efforts currently being planned and implemented.

Keywords: Landbirds, Sacramento-San Joaquin Delta, Monitoring, Adaptive Management

Poster Topic: Birds

Effects of Heron and Egret Colony-Site Disturbance on Subregional Nesting Abundance

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In the San Francisco Bay Area, disturbance by humans and nest predators is an important factor in the dynamics and distribution of heron and egret nesting colonies. Herons and egrets may respond to disturbance events by moving to other nearby breeding colonies, or by leaving a wetland area altogether, leading to a decline in the number of nesting herons and egrets in the surrounding landscape. Therefore, understanding the effects of disturbance at one colony site is important in understanding the dynamic nature of regional heron and egret abundance and distribution. We used time series analyses to investigate the extent to which colony-size fluctuations related to major disturbance events over 20 years affect the abundances of nesting herons and egrets within ten wetland subregions in the northern San Francisco Bay Area. All species exhibited gradual subregional recovery from colony-site disturbance. On average, the number of years needed for a 90% recovery from disturbance was 11 years for Great Blue Heron, 15 years for Great Egret, 5 years for Snowy Egret, and 9 years for Black-crowned Night-Heron. The initial subregional impact of colony-site disturbance was lowest for Great Blue Herons, but their rate of recovery was relatively slow. The fastest recovery rate was exhibited by Snowy Egrets, with only about 60% of the disturbance effect carried over between years. Great Egrets had the slowest estimated recovery rates with about 82% of the disturbance effect carried over between years. Repeated disturbances prolonged recovery times. These models will provide planners and decision-makers with a simple tool for predicting the extent to which an impact to a particular heronry is likely to affect the number of herons and egrets that nest and feed in the surrounding wetland landscape.

Keywords: Heron, Egret, Disturbance, Time Series, Population Dynamics, Resilience, Colonial Waterbirds

Poster Topic: Birds

Tidal Marsh Revegetation by Design
Rapid Habitat Enhancement to Benefit California Clapper Rail (*Rallus longirostris obsoletus*): Two Examples from Eden Landing Ecological Reserve

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The California Coastal Conservancy and U.S. Fish and Wildlife Service San Francisco Estuary Invasive *Spartina* Project is implementing a five year restoration program that focuses on enhancing habitat for California clapper rail (*Rallus longirostris obsoletus*) in areas affected by non-native *Spartina* invasion. Revegetation sites include restored tidal marshes that were heavily invaded by non-native *Spartina* that out-competed native vegetation. After successful removal of non-native *Spartina,* natural recruitment of some native species has been very successful (e.g., perennial pickleweed, *Sarcocornia pacifica*). However, two key components of rail habitat, *Grindelia stricta* and native *Spartina foliosa*, are still missing at some sites. Revegetation focusing on these two key species aims to rapidly enhance existing rail habitat in support of rail populations. ISP designed and implemented plantings that aim to rapidly establish dense, strategically-located patches of vegetation that will benefit nesting, foraging and roosting rails as well as provide high tide refuge.

Whale's Tail South and Cargill Mitigation Marsh (Eden Landing Ecological Reserve) are two adjacent marshes that differ greatly in restoration age. These marshes exemplify the program's approach to revegetation. Once established, *Spartina foliosa* that has been planted on marsh channel banks (Whale's Tail South) and on open mudflats (Cargill) will provide cover for foraging rails that is currently largely absent. *Grindelia stricta* has been planted along marsh channel edges at both sites to provide nesting cover and on berms within Cargill to provide high tide refuge. In addition, several upland transition zone plant species were planted along a levee that separates these sites to provide extreme high tide refuge. 2011-2013 plant installation at Whale's Tail South and 2012-2013 at Cargill totaled over 11,800 plants (*S. foliosa* counted as plugs). Initial survivorship results from the first year of planting informed the planting in the second year (e.g., 41% for marsh plain channel *Grindelia*).

Keywords: Restoration, California Clapper Rail, Invasive Species, Tidal Marsh, Spartina

Poster Topic: Birds

Tidal Marsh Restoration Program in Support of California Clapper Rail in the San Francisco Estuary

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In 2011, the California Coastal Conservancy and U.S. Fish and Wildlife Service San Francisco Estuary Invasive *Spartina* Project undertook an ambitious five-year program to rapidly improve habitat for California clapper rail (*Rallus longirostris obsoletus*) in tidal marshes of the San Francisco Estuary. Program components include: artificial floating islands, constructed high tide refuge islands, rapid intensive revegetation, predator control actions and Bay-wide eradication of invasive *Spartina*. One objective of the program is to intensively plant native marsh vegetation, primarily marsh gumplant (*Grindelia stricta*) and Pacific cordgrass (*Spartina foliosa*), in strategic locations at invasive *Spartina* eradication sites, with the goal of rapidly enhancing cover, nesting, and high tide refuge habitat for rails. While restoration practitioners have previously had success with planting *G. stricta* in the transition zone, there has been less effort planting on the marsh plain. Additionally, there has been little success with *S. foliosa* in the San Francisco Estuary, and new methods had to be tested and developed.

Revegetation sites were selected primarily where there were existing clapper rail populations that would benefit in the near term from habitat enhancement. Other sites were selected based on opportunities to develop field-based propagation techniques and establish propagule sources for adjacent tidal areas. In addition, at some sites high tide refuge islands are being constructed and densely planted. Over the past two years, the Program has installed over 165,000 plants with good success, and 90,000 plants will be installed next season totaling 255,000 plants in the first three planting seasons. The average survivorship for 2011-2012 varied: survivorship for *S. foliosa* surpassed the Program's target survivorship goal of 40% (at one site mean survivorship was 94%). Marsh plain *G. stricta* survivorship overall was 35% (several had survivorship over 50%). Future planting designs and treatments continue to be adapted to meet target survivorship goals.

Keywords: Restoration, Revegetation, Tidal Marsh, Invasive Species, Spartina, California Clapper Rail

Poster Topic: Birds

Breeding Status and Diet Trends of Two California Least Tern Colonies in the San Francisco Bay

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The two largest colonies of the California least tern (*Sternula antillarum browni*) in the San Francisco Bay Area, Alameda Point and Hayward, are located 10 miles apart. The Alameda Point colony, on the former Naval Air Station, Alameda, has grown at an average rate of 8.7% per year since its inception in 1976. Long-term breeding success at Alameda has averaged 0.83 fledglings per breeding pair. Breeding success has varied through time, with improved success in recent years. The Hayward colony is located on an island created from dredge materials in 2001; least terns began appearing at this island in 2003, and successful breeding attempts have been observed since 2006. This colony has grown at an average rate of 42.9% per year. Long-term breeding success has averaged 0.94 fledglings per breeding pair. It is suspected that when Alameda terns experience high disturbance and predation pressure, they move to the Hayward colony to breed (e.g., 2006, 2012), although there are no banded individuals to confirm this. Dropped fish have been collected from both colonies, and silversides (family Atherinopsidae) are the dominant dropped prey at both sites. Hayward terns forage mainly on nearshore species in the shallow marsh waters near their breeding site; Alameda terns forage on a greater variety of species found in Central and South Bay. While Atherinopsids remain the dominant dropped prey, northern anchovy (*Engraulis mordax*) have declined since the 1990s.

Keywords: California Least Tern, Alameda Point, Hayward, Population, Breeding Success, Diet

Poster Topic: Birds

Control of Invasive Exotic Mayweed Chamomile and its Effect on Nesting California Least Terns

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Invasive exotic plants are a major threat to many wild bird species. The rapid colonization of noxious weeds can result in substandard nesting habitat. The Hayward Regional Shoreline located along the eastern shore of San Francisco Bay, supports the second largest California Least Tern (*Sternula antillarum browni)* colony north of Ventura County. However, the rapid growth of Mayweed Chamomile (*Anthemis cotula*) starting in 2007 through the 2011 breeding season became the dominant cover plant creating crowded tern breeding conditions.

Results obtained using the line intercept method yielded a vegetation cover value of 30% (height of 24 cm) in 2007, while the vegetation cover value climbed to 90% (height of 30.25 cm) in 2011. This threefold increase in vegetative cover on the site started attracting nesting waterfowl, mammalian predators, and restricting tern-nesting opportunities by confining them to a few open space areas.

In an effort to reduce the crowded tern nesting conditions and presumably improve their reproductive success, licensed pest control advisers prescribed herbicides that have been proven to be “practically nontoxic” in laboratory conditions to curb this overgrowth of vegetation. Dow AgroSciences contributed a combination of Milestone®, Capstone®, Rodeo® and Dimension® specialty herbicides that were applied using the technical expertise and equipment of Caltrans specialists. During the 2012 tern breeding season the vegetation cover value was less than 10% (height of 23 cm), and a record number of 189 nests were incubated on the site producing 228 chicks. This presentation will highlight the success of this partnership that brought unique skills and resources to the table that accomplished more than any one of them could do alone.

Keywords: Invasive Mayweed, California Least Tern Nest Success, Herbicide Application

Poster Topic: Birds

South Bay Salt Ponds Restoration Project Design Revisions, Informed by Science, Implemented in Design and Construction: Ponds E12-E13 Islands and Foraging/Roosting Mounds

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The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal wetland restoration project on the West Coast and will restore 15,100 acres of industrial salt ponds to a mosaic of tidal wetlands and other habitats. Project goals include reconfiguring 1,600 acres of salt ponds to provide optimal habitat for a variety of waterbirds, including shorebirds. The SBSPRP has enhanced 480 acres of ponds managed as part of the Don Edwards San Francisco Bay National Wildlife Refuge, and is constructing 240 reconfigured acres at Eden Landing Ecological Reserve (ELER). Pond enhancement and reconfiguration has provided nesting areas on islands and levees. On new islands constructed of excavated pond material, drying bay mud results in cracks which are obstacles to use and movement and have resulted in, and may continue to result in, mortality due to loss of chicks in cracks which cannot be exited. Cracking of island surfaces also can limit foraging and roosting. Cracking islands require periodic maintenance to regrade and is expensive and time consuming. At ELER, various construction methods have been employed to ensure new islands do not have cracks, including import of upland fill and various “toppings” such as oyster shells, gravel, and earth treated with lime. Newly constructed "test" islands that have these toppings appear to successfully mitigate cracking and will require less maintenance. Berms are also being constructed to vary slopes in ponds, to maximize foraging and roosting, some of which are submerged and not subject to cracking. Furthermore, island use and successful nesting and fledging may be impacted by location of islands, due to disturbance from trail users, according to recent studies. Therefore, island locations include 600-foot buffers from adjacent public access trails. We continue to use this applied science in planning, designing and constructing current, on-going and future SBSPRP actions.

Keywords: Reconfigured, Managed Salt Ponds, Waterbirds, Islands, Nesting, Foraging, Roosting

Poster Topic: Birds

Controlling Physical and Chemical Characteristics of Habitat Islands in the San Francisco Bay Estuary

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Islands in San Francisco Bay provide important nesting, resting, roosting, and foraging habitat for myriad waterbirds. However, creating islands that can provide persistent high quality habitat without continuous maintenance is challenging. Hyper-expansive soils cause large desiccation cracks when dry which are obstacles to waterbirds at best and death traps at worst. Vegetation growth on islands is undesirable for waterbirds as it limits nesting and other usages. Wind-wave erosion destroys important transitional foraging habitat and impedes island access for unfledged waterbirds. In order to seek solutions to cracking, vegetation, and erosion problems, test islands were constructed at Eden Landing Ecological Reserve. Five different surface treatments were installed on test islands and their physical and chemical properties were studied. Logistics of constructing new islands and modification of existing islands in shallowly flooded ponds with young bay mud soils were also considered. Waterbird usage was observed. Preliminary results indicate that surface treatments can affect cracking, erosion, and vegetation. Also, hauling surfacing material over saturated young bay muds can be unfeasible and expensive. By utilizing one or a combination of surface treatments, island habitat can be enhanced and its usable life extended. Ultimately this results in increased waterbird usage, higher nesting success and chick survival, decreased maintenance, and decreased capital construction costs.

Keywords: Islands, Nesting, Erosion, Desiccation, Foraging

Poster Topic: Birds

Flood Control 2.0: Rebuilding Habitat and Shoreline Resilience Through a New Generation of Flood Control Channel Design and Management

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Flood Control 2.0 is an EPA-funded, multi-partner, four-year project that will advance the science of channel redesign to restore wetland habitat, water quality, and shoreline resilience. This timely project will develop a set of innovative approaches for bringing environmental benefits and cost-savings to flood protection infrastructure along the San Francisco Bay shoreline. The strategy has two complementary approaches that transform costly trapped sediment in local flood control channels into a resource: channel redesign where sufficient adjacent land use flexibility exists, and sediment redistribution for highly constrained channels. Through an interdisciplinary team linking regional science expertise with on-the-ground flood control agencies, the project will advance channel redesign to restore wetland habitat, water quality, and shoreline resilience through demonstration projects at three creek mouths: San Francisquito, lower Novato, and lower Walnut creeks. At a regionwide scale, the project will collect and integrate data on coarse sediment and historical stream characteristics with the results of the local projects.

Keywords: Climate Resiliency, Flood Protection, Habitat Restoration, Multi-Benefit

Poster Topic: Climate Change

A New Geologic Model for Assessing Liquefaction and Related Levee Failure in the Sacramento-San Joaquin Delta

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The Sacramento-San Joaquin Delta is particularly vulnerable to levee failure. A recent investigation commissioned by the Department of Water Resources highlighted how catastrophic multiple levee failures during an earthquake could have major effects not only on life and property in the Delta area, but also on freshwater supplies throughout California. In 2007 a Delta Risk Management Strategy report found that a better understanding of the Delta Quaternary geology is necessary for an accurate risk assessment of earthquake-induced levee failure. The aim of this study is to accurately classify those zones of the Delta at major risk of earthquake-induced flood and levee collapse as a result of seismically-induced liquefaction and ground failure of natural deposits.

Our approach consists of three integrated objectives:
1. Assemble a consistent database;
2. Build a 3D subsurface model and assess spatial distribution of liquefaction potential;
3. Link forms and processes to evaluate the risk of earthquake-induced levee failure.

We have now completed objective 1, obtaining a unified geological map of the Delta region. The map is based primarily on 1:24,000 km scale mapping of the natural and artificial levees and geologic units of the Delta. We have selected the boreholes and the cone penetrating truck data that will permit assessment of the liquefaction-prone subsurface Quaternary sediments. We are focusing on mapping Holocene, shallow sand units.

They key products will be hazard maps (also to be published online) that highlight areas and, importantly, levees, that face higher probability of failure from seismically induced ground deformation. This geological approach to the assessment of levee-failure will enhance risk-assessment in the Delta area, provide information for decision making for a more reliable water supply for California, and improve water quality to protect human health and the environment.

Keywords: Sacramento-San Joaquin Delta, Levee Failure, Liquefaction, Geology, Earthquakes, Flood Control

Poster Topic: Climate Change

Environmental Science Academy Trains Environmental Professionals of the Future

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Global warming, human impacts and dwindling resources challenge planners, politicians and scientists in the Bay Delta region to find sustainable solutions to immediate and long-term problems. How can the environmental professionals of the future be attracted and nurtured in our public schools? The Environmental Science Academy at Oakland High School (ESA), established in 1997, provides a career path in high school for such students. ESA receives funding from the California Department of Education as a Career Partnership Academy (CPA) and adheres to the academy model by providing integrated curriculum, work-based learning, and high academic expectations.

ESA attracts students interested in environmental careers by offering a chance to learn science by doing science at our Lake Merritt Field Station (at the Lake Merritt Boating Center, Oakland Parks and Recreation). ESA students have collected and analyzed basic water quality measures in surface and bottom water at the Lake for 15 years, maintained a database, and produced reports and presentations. Motivational field trips such as white-water rafting, the Catalina Island Marine Institute, and kayaking on Lake Merritt keep students engaged in learning. A team of teachers in core disciplines cooperates to support the students through high school and provide a coherent educational experience focused on STEM disciplines (Science Technology Engineering and Mathematics) and Common Core skills. Our Academy counselor helps students shape post-secondary plans. Community partners in business, non-profit and government sectors advise our teachers and provide internships and job shadowing experiences.

In fifteen years, ESA has succeeded in launching students into careers in geology, hydrology, forestry, fisheries, environmental education, environmental advocacy and outdoor recreation. Students who chose other career paths after high school retain an interest in nature and working toward sustainability. In this poster, we offer statistical summaries and individual stories to document our progress in launching students into environmental careers.

Keywords: STEM, Common Core, Career Partnership Academy, Education, Career Pathway

Poster Topic: Climate Change

Climate Change Effects on Cyanobacteria Blooms (*Microcystis aeruginosa*) in the San Francisco Estuary Delta: Evidence from Experimental Manipulations

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Models of climate change indicate that estuaries will likely contend with both increasing water temperature and increasing salinity (a result of sea level rise). These drivers are hypothesized to promote the occurrence of cyanobacteria blooms globally and shift estuarine algal communities toward cyanobacteria dominance. The San Francisco Estuary Delta (Delta) may already be experiencing just such a shift. Blooms of cyanobacteria 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 summer. With the goal of understanding how temperature and salinity influence cyanobacteria success in the Delta, a series of small bottle experiments were conducted with increasing temperatures or salinities, using field collected phytoplankton including cyanobacteria-dominant assemblages. Cyanobacteria biomass and chlorophyll-a concentration increased at higher temperatures (23°C versus 18°C), compared to diatoms and chlorophyte biomass. Cyanobacteria endured salinities up to 5ppt where as other phytoplankton declined ~50% at the same salinity. These data linking cyanobacteria to conditions associated with predicted climate change provide insight into potential future habitat expansion and microbial community shifts toward cyanobacterial dominance in the Delta.

Keywords: Climate Change, HAB, Microcystis, Salinity, Temperature

Poster Topic: Climate Change

Keeping Our Heads Above Water: Sea Level Rise Adaptation at the Corte Madera Baylands

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This interdisciplinary project is one of the first efforts in San Francisco Bay to investigate how wave attenuation across mudflats and marshes is sensitive to sea level rise, and to examine how management measures could improve baylands resilience to sea level rise and thereby maintain flood risk reduction benefits. Currently, wave heights are reduced by as much as 80 percent as waves travel across Corte Madera Bay and are further reduced as they travel over the Corte Madera marshes. Field measurements and 1-D and 2-D modeling demonstrated that wave attenuation is more sensitive to water level than to wave height or vegetation species. Since wave attenuation is largely determined by water depth, flood risk reduction benefits depend on baylands being able to keep up with sea level rise. Regional marsh accretion models predict that the Corte Madera marshes will drown and convert to mudflats towards the end of the century, and several lines of geomorphic evidence indicate that the Corte Madera Baylands are sediment-limited. Proactive management measures will therefore be needed to preserve high, wide mudflats and marshes and associated ecosystem services such as flood risk reduction in the face of sea level rise. Seven management measures were considered, and using a geomorphic conceptual model as a decision-support tool, four were selected that could decrease mudflat and marsh edge erosion, increase marsh accretion, and provide space for gradual upland transgression. This project provides proof of concept that mudflats and marshes provide a natural, first line of defense against coastal flooding and demonstrates the kind of information and process that can be used to develop ecosystem-based solutions to protect communities.

Keywords: Wave Attenuation, Sea Level Rise, Baylands Resilience, Conceptual Adaptation Strategy

Poster Topic: Climate Change: Shoreline Adaptations

From Local to Global: Sea Level Rise, Tidal Wetlands, and the San Francisco Bay National Estuarine Research Reserve

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The San Francisco Bay National Estuarine Research Reserve (SF Bay NERR) is taking a lead in developing science aimed at understanding how sea level rise impacts tidal wetlands in the San Francisco Estuary (SF Estuary), testing that science through long-term monitoring and modeling future scenarios, facilitating habitat restoration projects that promote tidal marsh transgression into uplands, and engaging in citizen science activities that build awareness and support for investing in climate change adaptation. The SF Bay NERR encompasses two sites: China Camp State Park and the Solano Land Trust's Rush Ranch. Research at SF Bay NERR sites has demonstrated that under moderate to extreme sea level rise, tidal marshes will likely degrade and convert to mudflats. Marsh retreat across the transition zone to adjacent uplands is essential for the survival of these marsh ecosystems. Tidal wetlands at China Camp and Rush Ranch are becoming sentinel sites (or "early detection" sites) with comprehensive, on-going monitoring, including precise vertical control with water-level monitoring, surface elevation tables, and vegetation monitoring. This will yield insight into current and future marsh responses and provide decision-makers the opportunity to initiate timely adaptation measures. Visitors to these and other sites are being empowered to provide visual evidence of exceptionally high "king" tides on shorelines around the SF Estuary. Lessons learned hint at future effects of sea level rise and are being communicated nationally through the NERR System Sentinel Sites Program and the NOAA Sentinel Sites Cooperative. Extending this effort, the SF Bay NERR is also poised to join a new Smithsonian Institution global coastal observatory program. From local to global, the SF Bay NERR is helping to inform the impacts of future sea level rise on tidal wetlands and coastal communities, while stimulating climate adaptation policies that protect the future of these precious resources.

Keywords: Climate, Adaptation, Sea Level Rise, Tidal Wetland, King Tides

Poster Topic: Climate Change: Shoreline Adaptations

Adapting to Rising Tides (ART): Collaborative Sea Level Rise Adaptation Planning on the San Francisco Bay Shoreline

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Adapting to Rising Tides (ART) is a unique, multi-sector/multi-jurisdiction adaptation planning project aimed at increasing the Bay Area's resilience to sea level rise and storm events. Led by the San Francisco Bay Conservation and Development Commission (BCDC) and the National Oceanic and Atmospheric Administration Coastal Services Center (CSC), the project engaged local, regional, state and federal agencies and organizations in a collaborative effort to consider how best to improve shoreline resilience across six cities, one unincorporated community, a number of special districts, and a portion of a county. The project evaluated existing conditions and stressors, conducted a vulnerability and risk assessment, and developed adaptation responses for natural and built assets in four sectors: community land use, transportation, utilities and shorelines. In addition, the project developed, tested and refined adaptation planning methods and tools, and produced guidance on how best to evaluate, communicate and address complex issues associated with sea level rise and other climate change impacts. The project also investigated the issue of adaptation planning scales, and is currently testing the tools and methods developed at a local (e.g. county) scale at a smaller neighborhood scale. The neighborhood scale planning effort will also help to reveal where relationships between land uses, facilities and services may cause secondary vulnerabilities, and where there are synergies and constraints among adaptation options. Lastly, the ART project placed special attention on integrating social equity, economy, environment, and governance into all steps of the adaptation planning process. These efforts resulted in a framework for carrying these "four frames" through the planning process, and in special issue papers on social equity and governance in adaptation planning.

Keywords: Shoreline Resilience, Vulnerability, Risk, Multi-Sector/Jurisdiction Adaptation Planning, Tools, Scales

Poster Topic: Climate Change: Shoreline Adaptations

Regional Sediment Management (RSM) in San Francisco Bay

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Historically, sediment management has focused on specific components of the sediment system, in reaction to human needs (e.g. safe navigation channels, flood control). Regional Sediment Management (RSM) is an approach to manage sediments within the context of the entire system, including sediment sources, movement, and sinks within the system and exchange with the ocean. By enabling a more holistic, scientific, and proactive management approach, RSM will prescribe a management strategy that addresses the system directly rather than indirectly (and therefore imprecisely), through isolated management of the system components.

In 2011, the San Francisco Bay Conservation and Development Commission (BCDC) initialized the development of an RSM program strategy for the study of Bay sediment processes. Initially, the primary task of RSM must be to improve our understanding of Bay sediment processes for the more appropriate management of Bay sediment as resource that is vital to Bay health and our preparedness for climate change impacts and other system stressors. Secondarily, the RSM strategy will coordinate and focus research efforts that address management goals, harmonize management policies by federal, state, and local agencies affecting sediment processes, and educate managers regarding RSM.

In its first two years, the development process has delivered discrete products that have proven both (1) necessary to further RSM strategy development, and (2) independently valuable to a range of stakeholders. Those products include:

- A searchable and annotated library of literature addressing San Francisco sediment dynamics.
- An analysis of management questions, science needs, and priorities, according to an administered survey.
- Several project component initiatives, including the Flood Control 2.0 Project and an RSM focus on Central Bay.

An overview of these products and others under consideration (e.g. the development of a systemic and coordinated mechanism for sustained support of long-term sediment monitoring) are presented.

Keywords: Regional Sediment Management (RSM), Dredging/Mining, Watershed Management, Habitat Resilience, BCDC

Poster Topic: Climate Change: Sediment

The Dirt on the Delta

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The sediment supply to the Sacramento-San Joaquin Delta has been declining for the past 50 years after a nine-fold increase as a result of hydraulic mining of the Sierra Nevada (Wright and Schoellhamer, 2005; Gilbert, 1917). This decline has significant implications for water supply reliability as much of the levee repair material comes from dredged sediment. Sediment in the Delta creates habitat for all the organisms living within it, in addition to securing California's water supply through levee materials. The reduced sediment supply has led to a reduction in turbidity in the waters which negatively impacts some fish species that require turbidity for various lifecycle processes. Sediment also plays an important role in processes that effect of sea level rise on wetlands and floodplains. Understanding of the state of knowledge on sediment supply and deposition in the Delta is imperative to making informed management and policy decisions now and into the future. I compiled a comprehensive review of sedimentation and identified key uncertainties though an examination and synthesis of federal and state agency documents, as well as academic literature for use by policy and decision makers. Natural sediment supply remains unknown, as do the full effects of modification to the system (i.e. dams and channelization). Therefore, the extent to which the decline may continue remains unclear.

Keywords: Sediment, Policy, Management, Water Supply Reliability, Ecosystem Restoration

Poster Topic: Climate Change: Sediment

Spatial and Temporal Variation of Suspended Sediment Concentrations in a San Francisco Estuary Tidal Marsh: Implications for Tidal Marsh Stability in the Face of Accelerated Sea-Level Rise

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Climate change is expected to result in an accelerated rise in sea level over the next 100 years, and coastal wetlands are among the most likely ecosystems to be negatively affected. Tidal marsh stability is linked to sediment accretion, which is directly affected by suspended sediment. In the San Francisco Estuary, legacy mining has contributed to high rates of suspended sediment for decades. More recently, a reduction in suspended sediment has been observed. The purpose of our research has been to enhance understanding of suspended sediment dynamics in a natural tidal salt marsh located within the Estuary. We measured suspended sediment concentrations over 11 spring tidal cycles at a series of stations at low, mid and high marsh locations within China Camp marsh. Sampling occurred at five locations along each station, including in the tidal channel (0 m) and across the marsh surface at varying distances from the tidal channel (1, 3, 5, and 20 m). Our study also examined external factors (i.e., season, tidal height, wind speed, and precipitation) that may influence suspended sediment concentration values and distribution on the marsh. Suspended sediment concentrations at the low station were significantly higher than other stations (low station average = 910 mg/L; mid station average = 142 mg/L; high station average = 170 mg/L). Our data suggests that suspended sediment concentrations at China Camp tidal marsh may be influenced by position in marsh, season, tidal height, wind speed, and cumulative precipitation over a 24-hour period. Presently, suspended sediment concentrations are sufficient for marsh accretion at current sea-level rise rates at China Camp marsh. Nevertheless, marsh stability in the future is uncertain due to accelerated sea-level rise and declining suspended sediment concentrations in the Estuary.

Keywords: Suspended Sediment Concentrations, Climate Change, Marsh Stability

Poster Topic: Climate Change: Sediment

IRWM Solutions for Addressing the Diverse Impacts of Climate Change on Bay Area Water Supplies

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Bay Area water agencies manage a diverse portfolio of water supplies including groundwater, local surface water, imported water, recycled water, and transferred water. This portfolio varies throughout the region with some areas relying heavily on imported supplies, some on local surface supplies, and others relying on a mix. So while changes in temperature and precipitation associated with climate change could have significant impacts on water supplies, those impacts will vary throughout the region due to differences in these water supply portfolios. This poster will depict the supply portfolios for five sub-regions within the Bay Area Hydrologic Region (as defined in the 2009 California Water Plan) and describe the potential impacts of climate change on the three primary supplies: groundwater, local surface water, and imported water. It will also provide an overview of Integrated Regional Water Management (IRWM), how the IRWM framework can help water managers adapt to a changing climate, and how the Bay Area IRWM Plan is addressing climate change.

Keywords: Climate Change, Water Supply, Integrated Regional Water Management

Poster Topic: Climate Change: Water Supply

Balancing the Sacramento-San Joaquin Delta's Coequal Goals in a Climate of Change

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Climate change poses many challenges to California's water supply infrastructure and threatens ecosystem resilience. Facing a future of less reliable water supplies, it is equally important to consider climate change for short term management decisions as it is to consider it in the long term. Already, the effects of climate change have been observed throughout the state, and model projections show that current trends of warming temperatures and sea level rise will continue into the next century. Understanding and synthesizing existing information on the effects of climate change in the Sacramento-San Joaquin Delta is of particular importance because the Delta is the nexus of the state's water supply delivery systems. Furthermore, policy makers and managers must utilize the best available science to inform policies that support the coequal goals of ensuring a reliable water supply and restoring the Delta ecosystem. In the Sierra Nevada and Klamath Mountains, where the majority of the water supply originates, warmer temperatures are shifting precipitation patterns to greater rainfall and less snowfall, reducing snowpack accumulation, and accelerating the timing of snowmelts. These cumulative effects are likely to result in greater flooding in winter and early spring and diminished water supplies and droughts later in the year. As the climate continues to change, balancing flood protection and water storage will be increasingly difficult. Strategies to ensure a more reliable water supply include improving water use efficiency, increasing surface and groundwater storage, and expanding or building new conveyance facilities. Restoring floodplains will reduce the severity of extreme flood events and will have the added benefit of providing critical floodplain habitat that supports the Delta's ecosystems. Additional strategies to improve the resilience of the Delta's ecosystems include increasing habitat connectivity, creating low-salinity and cold-water refugia, and restoring habitats where there is ample accommodation space for upland migration.

Keywords: Climate Change, Water Supply Reliability, Habitat Restoration, Policy Implications, Management

Poster Topic: Climate Change: Water Supply

The Role of Hydrodynamic Transport in Greenhouse Gas Fluxes from a Restored Delta Marsh

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Twitchell Island, an island in the Sacramento-San Joaquin Delta, stands 5 meters below sea level due to more than a century of peat soil loss. Two 3-hectare wetlands established on Twitchell Island over a decade ago and monitored in recent years by the U.S. Geological Survey have rapidly accumulated organic material, effectively reversing the trend of soil loss. The wetlands have also been shown to be a significant source of methane. As more wetlands are restored to Twitchell Island and other Delta islands, questions remain about the variability of their greenhouse gas fluxes and the factors controlling this variability. One often overlooked factor is the hydrodynamic transport of gases through the water column, which can be influenced by wetland design and maintenance operations. We are evaluating the importance of this factor at one of the restored wetlands on Twitchell Island. We measured dissolved carbon dioxide and methane in the wetland water column on a bi-weekly basis. Dissolved gas concentrations were input to a wetland-tailored model for the hydrodynamic transport of gas to the air-water interface. Modeled air-water gas fluxes were then compared with net gas fluxes measured at the wetland via the technique of eddy covariance. We found that hydrodynamic transport, due primarily to thermal convection as the wetland water column cooled at night, was responsible for approximately one third of net carbon dioxide and methane fluxes at the wetland. This finding has implications for the modeling, prediction and management of greenhouse gas fluxes at the restored wetlands on Twitchell Island and other similar wetlands.

Keywords: Wetlands, Greenhouse Gases, Subsidence, Transport, Mixing

Poster Topic: Climate Change: Greenhouse Gas Flux

Maximizing the Climate Change Mitigation Potential of Carbon Farming: Controls on Methane Fluxes in Wetlands of the Sacramento-San Joaquin Delta

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Restoration of highly productive wetlands on drained peatlands in the Sacramento-San Joaquin Delta (Delta, hereafter) can help mitigate climate change by reversing peat loss and accumulating soil carbon (C). However methane (CH_4) emissions arising from wetland soil decomposition greatly reduces the mitigation potential of these ecosystems. To understand the controls on wetland CH_4 emissions we measured gross CH_4 fluxes in freshly collected soils from restored (2 and 10-years old) and natural Delta wetlands. Sites were selected across a range of environmental conditions. We manipulated redox conditions by incubating soil under an anaerobic headspace and investigated the effects on C emissions over 30 days. Soil respiration rate (CO_2 emission), HCl-extractable iron (Fe), mineral nitrogen (NH_4^+, NO_3^-), pH, dissolved organic C (DOC), and soil C:N ratio were measured as explanatory variables.

Methane emissions ranged from no net flux to 4.1 mg C g^{-1} d^{-1}. Gross CH_4 production was highest at the old restored wetland ($P < 0.05$); NH_4^+ concentrations explained approximately 61% of the variability with a strong positive correlation. Surprisingly, gross CH_4 production was unrelated to measures of C availability despite a wide range in DOC and soil C:N ratios ($P > 0.05$). Methane production was strongly positively correlated with the methanogenic fraction (CH_4:CO_2 production; $R^2 = 0.67$), and weakly correlated with total C (CH_4+CO_2 production; $R^2 = 0.22$) flow. Under extended anoxia, dynamics in CH_4 production varied, but we observed a significant relationship between rates of Fe reduction and the absolute change in CH_4 production ($P < 0.01$) indicating that Fe reduction can competitively exclude CH_4 production in Delta soils. In summation, our results suggest that Delta wetland CH_4 emissions are controlled more by small-scale variability in soil redox state—that may be manipulated by appropriate wetland design and management—and less by landscape-scale edaphic factors.

Keywords: Wetlands Restoration, Carbon, Methane Emissions, Management Subsidence

Poster Topic: Climate Change: Greenhouse Gas Flux

Greenhouse Gas Emissions from Agricultural and Restored Delta Peatlands

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The Sacramento-San Joaquin Delta in California was drained and converted to agriculture over a century ago, and since has experienced high rates of soil subsidence due to peat oxidation. To help reverse subsidence and capture carbon there is growing interest in converting drained agricultural land-use types to flooded conditions. Restored wetlands and rice agriculture are proposed as a flooded land-use type with high CO_2 sequestration potential for this region. However, flooding may increase the emission of methane (CH_4) as well as the loss of water via evaporation. We conducted multiple years of simultaneous eddy covariance measurements at conventional drained agricultural sites (a pasture and a corn field) and flooded land-use types (a rice paddy and two restored wetlands) to assess the impact of drained to flooded land-use change on CO_2, CH_4, and evaporation fluxes.

We found that the drained sites were net greenhouse gas (GHG) sources, releasing between 134-299 g-C m^{-2} yr^{-1} as CO_2 and up to 3.3 g-C m^{-2} yr^{-1} as CH_4. Conversely, flooded land-use types were predominantly net sinks of atmospheric CO_2, resulting in either reduced rate of soil subsidence or completely reversing subsidence due to oxidation. However, the restored wetlands and rice paddy were moderate to larger sources of CH_4, with emissions up 21.3 g-C m^{-2} yr^{-1}. In terms of the full annual GHG budget (assuming that 1 g-CH_4 equals 25 g-CO_2 with respect to the greenhouse effect over a time horizon of 100 years), the flooded land-use types were largely neutral or small GHG sinks. The flooded land-use types evaporated 45-95% more water than the pasture or corn sites. Therefore, from a subsidence perspective, restored wetlands and rice appear to provide a benefit for Delta sustainability. However, flooding also has secondary effects on the GHG budget through increased CH_4 production and higher rates of evaporation.

Keywords: Subsidence, Carbon Flux, Evaporation, Wetlands, Rice, Eddy Covariance

Poster Topic: Climate Change: Greenhouse Gas Flux

Microbial Community Composition and Greenhouse Gas Flux in Wetlands of the Sacramento-San Joaquin River Delta

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Wetlands have the potential to sequester large amounts of atmospheric carbon as the result of especially high plant productivity and low decomposition rates. However, wetlands may also become a net source of carbon to the atmosphere if decomposition rates outpace carbon burial. This delicate carbon balance is influenced by the activity of below-ground microbial communities that return carbon dioxide and methane to the atmosphere. The effects of wetland restoration on the metabolic activity and carbon cycling capacity of microbial communities remain unknown. Using next-generation DNA and RNA sequencing, coupled with greenhouse gas monitoring, we profiled the microbial communities from soil samples on Twitchell Island located in the Sacramento-San Joaquin River Delta. We sampled a restored wetland, a corn field, and a series of rice fields to gauge microbial community composition across inundation regimes. Additionally, we monitored shifts in microbial populations over the course of a seasonal flooding cycle at the rice fields. Our results demonstrate relationships among geochemical gradients, availability of electron acceptors, and microbial community composition. Methanogenic archaeal populations were associated with low oxygen sites, high methane production, and the absence of aerobic respiration genes. Our study provides the first genomic glimpse into microbial populations in restored wetlands of the San Francisco Bay Delta and provides a valuable benchmark for future studies in the region.

Keywords: Wetlands, Microbes, Carbon, Methane, Genomics

Poster Topic: Climate Change: Greenhouse Gas Flux

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

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

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

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

Poster Topic: Fish: Chinook Salmon

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

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

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

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

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

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

Poster Topic: Fish: Chinook Salmon

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

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

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

Poster Topic: Fish: Chinook Salmon

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

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

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

Poster Topic: Fish: Chinook Salmon

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

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

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

Poster Topic: Fish: Delta Smelt

Vertical Response of Larval Delta Smelt to Various Environmental Cues

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

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

Poster Topic: Fish: Delta Smelt

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

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

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

Poster Topic: Fish: Delta Smelt

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

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

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

Poster Topic: Fish: Delta Smelt

Evaluation of Natural Marks to Identify Individual Cultured Adult Delta Smelt

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

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

Poster Topic: Fish: Delta Smelt

Quantify Effects of Temperature on Delta Smelt Behavior

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

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

Poster Topic: Fish: Delta Smelt

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

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

Keywords: Tidal Wetlands, Tidal Marsh, Native Fishes

Poster Topic: Fish: Habitat Restoration

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

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

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

Poster Topic: Fish: Habitat Restoration

Lower Yolo Restoration Project

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

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

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

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

Poster Topic: Fish: Habitat Restoration

Suisun Creek Watershed Program

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

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

Poster Topic: Fish: Habitat Restoration

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

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

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

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

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

Poster Topic: Fish: Habitat Restoration

43 Years of Fish Monitoring Data in South San Francisco

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

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

Poster Topic: Fish: Monitoring

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

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

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

Poster Topic: Fish: Monitoring

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

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

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

Poster Topic: Fish: Monitoring

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

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

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

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

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

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

Poster Topic: Fish: Sturgeon

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

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

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

Poster Topic: Fish: Sturgeon

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

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

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

Poster Topic: Fish: Sturgeon

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

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

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

Poster Topic: Fish: Sturgeon

Reconnecting Lower Walnut Creek

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Leveed and channelized in 1963, water flowing through Lower Walnut Creek (LWC) is disconnected from the low-lying land surrounding the mouth of the Creek. Reconnecting Lower Walnut Creek (RLWC) presents a vision for 3 miles of LWC and 1300 acres of surrounding land that takes advantage of the topography, low-risk land, and fading industrial use to promote an ecologically and socially rich reserve. Constructed to increase flood water conveyance, the LWC channel has been threatened with sediment build up requiring expensive and environmentally damaging desilting efforts. A surgical approach to perforating the levees requires a small investment for a large return; meanwhile flood protection is maintained through tidal cleansing. Historically stable estuary sloughs suggest that increasing the tidal prism will increase the amount of water flowing out of LWC, carving a deeper channel that is flushed twice daily with ebb tides. This continual maintenance of the channel indicates more reliable flood conveyance during storm events while increased porosity with the floodplain increases water storage. With increased tidal connectivity, the height of 100 year flood event drops two feet as the channel widens and intertidal habitat can develop. In addition to maintained flood conveyance, RLWC establishes social connectivity for the City of Walnut Creek and nearby periurban communities by linking the last leg of Iron Horse Trail to the Bay with a multimodal trail and drawing people out to the space through an expansive trail network. Further, the project emphasizes the importance of removing and processing a landfill that exists in the former estuary zone and defines a tertiary wastewater treatment area capitalizing on secondarily treated wastewater from a nearby treatment plant. RLWC illustrates the potential of LWC, presenting a new (and old) method to manage flood conveyance with co-benefits including rich habitats, social access, and greater sea level rise resiliency.

Keywords: Flood Control, Habitat Restoration, Social Access, Horizontal Levee, Tidal Connectivity

Poster Topic: Flood Control: Habitat Restoration

Colma Creek: How Does Sediment Removal from a Flood Control Channel Affect Nearby Tidal Wetland Habitats?

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Colma Creek, a tributary to San Francisco Bay, drains urban and undeveloped areas of the northern San Francisco Peninsula including portions of San Bruno Mountain. A period of rapid urbanization in 1960s and early 1970s led to engineered flood control channels, whose sediment management challenges persist today. Horizon Water and Environment is working with the San Mateo County Flood Control District/County of San Mateo Public Works Department (County) to develop a flood control channel maintenance strategy that addresses numerous natural resource management challenges that are common throughout the San Francisco Bay. Key issues addressed through this data collection and planning effort include calculating and mapping sediment volumes and deposition patterns in the flood control channel; evaluating sediment supply to tidal marshes near the mouth of Colma Creek (downstream of the flood control channel); characterizing habitat conditions for endangered species; and assessing potential effects of sea-level rise scenarios. Colma Creek provides a useful microcosm of many of the resource management challenges facing San Francisco Bay watersheds and tributaries. This poster summarizes the data collection effort (and preliminary results) that will help guide the County to develop a sustainable flood control and maintenance strategy for Colma Creek.

Keywords: Sediment, Flood Control, Tidal Wetlands, Colma Creek, Channel Maintenance

Poster Topic: Flood Control: Habitat Restoration

Arroyo Mocho Stanley Reach Pilot Project: Floods, Fish, and Finance

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Problem Statement: The financing of restoration projects can be challenging. Even more challenging is retrofitting engineered channels to function as natural fluvial and ecological environments without giving up flood protection or water supply functions.

Like many arroyos in the Zone 7 service area, the Arroyo Mocho has been mined for aggregate, widened, and straightened throughout the last century to accommodate urbanization. Barriers to anadromous fish passage and channels choked with non-native grasses are a common occurrence—and offer little aesthetic, habitat or water quality benefits.

This Project will demonstrate the feasibility of transforming an earthen trapezoidal channel into a vegetated stream exhibiting natural fluvial and ecological function, while also maintaining its functionality for flood protection, sediment management, and groundwater recharge. It also explores the use of mitigation funds from outside agencies to facilitate construction and long-term maintenance.

Approach: The Project replaces concrete and grouted structures with naturally functioning in-stream rock and vegetative structures to allow potential fish passage and dampen stream velocities. Planting streamside vegetation will further stabilize banks, reduce velocities, and increase habitat value. Deliberately increasing “roughness” within the channel is still considered to be counter to standard flood protection practice; this Project intends to demonstrate that it can help improve habitat function within a trapezoidal channel design without increasing flood risk or adversely affecting sediment transport. Community volunteers will carry out much of the revegetation. Portions of the project are being funded through mitigation dollars from other offsite impacts.

Results: Construction is currently underway.

Conclusions: In light of the non-traditional approach to design, funding, and construction methods (e.g. use of community volunteers), the Project will encourage Zone 7 to expand beyond its conventional methods and experiment with new ways of carrying out its mission.

Keywords: Flood Control, Restoration, Riparian, Water Temperature

Poster Topic: Flood Control: Habitat Restoration

Seasonal Patterns of Three Key Phytoplankton Species in San Francisco Bay

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The Scientific Committee for Ocean Research (SCOR) established a working group to compile, compare and synthesize long-term observations of phytoplankton community variability in coastal estuarine waters organized around a set of first-order questions, including: Do individual phytoplankton species have characteristic seasonal patterns expressed similarly across estuarine ecosystems? As a step towards answering this question for San Francisco Bay (SFB), seasonal patterns of three key phytoplankton species were analyzed based on 900 samples collected from 1992 to 2013. The diatom *Skeletonema costatum* is a cosmopolitan, often dominant, component of coastal phytoplankton biomass, and can develop large blooms in SFB. *S. costatum* has an annual spring bloom in the salty regions of SFB and an elevated baseline biomass year-round relative to other phytoplankton species. Although infrequently, *S. costatum* can also appear in fresher regions of the system suggesting it is a generalist estuarine species. The biomass-dominant dinoflagellate in SFB, *Akashiwo sanguineum*, is detected in a minority of samples except during September-October when it blooms in regions with strong marine influence. Cryptophytes are ubiquitous estuarine flagellates, as is evident in SFB where *Teleaulax amphioxeia* occurred in 70% of all samples and across a broad salinity range (0-32). This was the highest frequency of occurrence of any of the 611 phytoplankton species in our dataset. *T. amphioxeia* demonstrated spatial and temporal variability with a regular spring bloom in the South Bay and a frequent fall bloom in the northern San Pablo Bay. These results not only provide a reference for comparing seasonal patterns of these key species in long-term records from other estuarine systems of interest to the SCOR working group, but also also begin to illustrate the complex patterns of phytoplankton community dynamics in the SFB system.

Keywords: Phytoplankton, Seasonal Patterns, Community Dynamics, Skeletonema, Akashiwo, Teleaulax

Poster Topic: Food Webs

Contrasting Pathways for Trophic Structuring in the San Francisco Estuary

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Several distinct mechanisms affect whether qualitative changes in resources at one trophic level propagate upward in pelagic food webs. Owing to changes that have occurred in the composition of the pelagic community in the upper San Francisco Estuary (SFE), there is intense scientific and management interest in understanding the extent to which resource quality at lower trophic levels (e.g., nutrients, phytoplankton) influences community composition at higher trophic levels (e.g., zooplankton, fish). Biochemical mechanisms potentially affecting food quality and trophic transfer of materials and energy include differential synthesis and transfer of essential fatty acids and other biomolecules, chemical (often inducible) forms of consumer avoidance (e.g., unpalatability and toxicity), chemical "warfare" (allelopathy), and ecological stoichiometry (imbalances between the elemental composition of consumers and elemental ratios in their resource bases). Behavioral and anatomical traits of consumers (such as foraging behavior, feeding apparatus of fish and invertebrates, vertical migration) can constrain resource use and, to a certain extent, "insulate" organisms at one trophic level from some of the qualitative changes that occur further down the food web.

In this study, several pathways and constraints for the upward propagation of effects of resource quality are illustrated with conceptual models, using key pelagic organisms from the upper SFE in examples. The conceptual models were used to evaluate the types of information that could potentially distinguish between different underlying mechanisms for observed community structure. Results include identification of data gaps and suggestions regarding study design for future research on determinants of pelagic food-web structure in the SFE.

Keywords: Pelagic Food Web, Nutrients, Plankton, Trophic Structure, Consumer, Nutritional Quality

Poster Topic: Food Webs

Assessing Phytoplankton Physiology in San Francisco Estuary with the PhytoFlash™ Active Fluorescence Probe

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The ability to monitor phytoplankton physiology in situ would greatly benefit ecologists and mangers studying food webs in San Francisco Estuary/Delta (SFE). Previous phytoplankton assessment in the SFE has been done using extracted chlorophyll a concentrations, microscope identification or by analyzing nutrient uptake rates. These laboratory measures generally rely on discrete sampling, which limits spatial and temporal habitat coverage, and can be relatively costly and time consuming. An alternative measure of phytoplankton physiology in situ utilizes natural fluorescence emission from chlorophyll, which can vary in response to environmental conditions such as light and nutrient levels. Active fluorescence probes use controlled light pulses to investigate the efficiency of electron flow through Photosystem II of the photosynthetic light pathway, a useful indicator of algal health. Active fluorescence measurements have been used to investigate photosynthetic function in plants, oceanic phytoplankton and cultured phytoplankton. Relatively little work has tested the application of bio-optical fluorescence probes in estuaries. This study involves testing the capabilities of the PhytoFlash^{TM} active fluorometer (Turner Designs) for investigating phytoplankton physiology in situ in the turbid SFE. The PhytoFlash^{TM} can be deployed from boats or moorings, and monitor field phytoplankton assemblages continuously and in real time. A series of experiments were conducted in order to validate instrument performance across an estuarine gradient, with particular interest in assessment of nutrient stress conditions on phytoplankton physiology. Preliminary results provide some practical guidance for deployment of the PhytoFlash^{TM} for monitoring and experimental work, highlighting both potential strengths and limitations for future field investigations of phytoplankton nutrient physiology in the turbid and variable SFE.

Keywords: Nitrogen, Algae

Poster Topic: Food Webs

How Do Edaphic Characteristics Influence Native Pacific Cordgrass (Spartina foliosa) Restoration Success across Tidal Elevations?

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Restoring native cordgrass (*Spartina foliosa*) is a critical step in reestablishing important ecosystem functions following eradication of invasive hybrid cordgrass in the San Francisco Bay. Among the most essential functions is providing foraging and nesting habitat for the federally endangered California Clapper Rail (*Rallus longirostris obsoletus*) as well as supporting numerous species as part of the benthic food web. We investigated the effects of tidal elevation (inundation), herbivory, sediment conditions, porewater salinity and porewater sulfide on the success of restoring native *S. foliosa.* Large-scale outplanting occurred at three sites with dissimilar hydrology. Planting occurred along an elevation gradient to test inundation limits to survivorship. Native cordgrass was planted in paired caged and uncaged plots to test the effect of herbivory. Growth and edaphic characteristics were monitored on a quarterly basis. Preliminary results indicated inundation time and caging are significant factors in survivorship at two sites, but did not explain variation in survivorship at the third site. Sulfide and salinity varied across elevations and among sites; however, neither of these factors were associated with initial survivorship rates. Continued sampling will test the influence of salinity and sulfide by the end of summer 2013, since pilot plots in August 2012 had large spikes in mortality of plants associated with field soil conditions. Mean survivorship and the parameters that limited growth varied among marshes, and inundation and herbivory played an important role in survival. Understanding the limits on native cordgrass survival will aid the large-scale restoration efforts underway in San Francisco Bay.

Keywords: Cordgrass, Spartina, Foliosa, Salinity, Inundation, Pore Water

Poster Topic: Habitat Restoration: Climate Change

When Will the Bay Reach Highway 37?

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Reclamation and conversion for agriculture, urban development, and salt production over the past 150 years led to the loss of approximately 82% of historic marshes in the San Pablo Baylands. During the past decade the US Fish and Wildlife Service (Service), Ducks Unlimited (DU), the State of California, and a coalition of partners have made significant progress towards acquiring and restoring a large proportion of these lands. Cullinan Ranch is among the few large remaining publicly-owned tracts between the Napa River and Sonoma Creek still requiring restoration. Cullinan Ranch Restoration Project broke ground in 2011 and will restore over 1,500 acres of former diked and farmed baylands back to tidal habitat. Once complete, a sea of blue will be visible along the north side of Highway 37, extending for 3.3 miles.

Originally acquired in 1991 with intention of immediate tidal restoration, implementation was delayed by the recognition that breaching levees would result in flooding nearly one mile of Highway 37 under combined high wind and high tide events. The Service and DU worked together on a project design to maintain the current level of protection for Highway 37 once the levees are breached.

Two major challenges must be overcome prior to breaching levees:

- Obtaining a Caltrans encroachment permit to build acceleration and deceleration lanes to access the site along Pond 1 levee; and
- Optimizing ability to import dredged sediments to raise the elevation of a portion of the site to jumpstart wetland habitat development.

DU engineers continue to work with Caltrans to obtain an encroachment permit while minimizing construction costs. Concurrently DU is implementing a novel approach to importing dredged sediments for beneficial reuse by permitting an offloading facility on the Napa River, and is seeking ways to ensure that if they build it, the sediments will come.

Keywords: Estuarine, Tidal Wetland Restoration, Beneficial Reuse, Endangered Species, Baylands

Poster Topic: Habitat Restoration: Climate Change

Evolution of Community-Based Restoration Techniques for Transition Zone Habitat at Eden Landing Ecological Reserve

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The transition zones between the coastal marshes and upland areas of San Francisco Bay are critical habitat for hundreds of species, some of which are threatened or endangered. Transition zones are integral habitat for wildlife as they move between marshes and uplands during high tides and storm surges. These areas provide a food source for insects, birds, reptiles, and small mammals. A vast majority of coastal marshes have been filled in for development or converted into salt ponds and agricultural lands, and adjacent transition zones have become severely degraded and condensed into fragments of their historic ranges.

Save The Bay has used community volunteers to remove non-native and invasive species and to restore transition zone habitat on narrow levees slopes of the Bay for over 13 years. Using Eden Landing Ecological Reserve as a model, we demonstrate how our restoration approach has adapted over time to meet restoration goals to increase transition zone habitat in the Bay. Save The Bay managed three separate transition zone projects over a six-year period at Eden Landing Ecological Reserve. Over the six-year period, Save The Bay has expanded our strategy from restoring narrow levee slopes to include restoring transition zone habitat on broad, gentle slopes and shifting to an emphasis on site-specific plant diversity. We use a mix of native annual and perennial grasses and native plants to create a dense habitat mosaic. This recent work can be applied to existing and future transition zone restoration designs.

Keywords: Transition Zone, Native Plants, Tidal Marsh, Restored Levee

Poster Topic: Habitat Restoration: Climate Change

Up-scaling Wetland CO2 and CH4 Exchange in the Sacramento-San Joaquin River Delta

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Returning land in the Sacramento-San Joaquin River Delta to wetlands can help reverse land subsidence by maintaining plant productivity while drastically reducing the rapid peat decomposition that has occurred since this region was drained for agricultural use in the 1850s. Rebuilding peat soils will help to both protect California's water supply and mitigate globally rising atmospheric CO_2 concentrations. The more anaerobic soil environment of wetlands, however, promotes methane (CH_4) production, a 25x more potent greenhouse gas than CO_2. It is therefore important to understand the impact of wetland restoration on both these gases to evaluate both subsidence reversal and climate change mitigation goals. To this end, measurements of wetland gas exchange via the eddy covariance method can quantify ecosystem-scale sequestration or emission of CO_2 and CH_4. The ultimate goal of these measurements is to predict the effects of wetland restoration on Delta-wide fluxes of these important greenhouse gases. Wetlands, however, are spatially variable ecosystems, varying in substrate, plant species, plant density, and open water fraction, to name a few. Extending site-level measurements to other areas therefore requires attributing spatial variability in CO_2 and CH_4 exchange to respective sources and identifying spatially available indicators of this change. This poster presents preliminary results evaluating the spatial variability of CO_2 and CH_4 fluxes in two restored Delta wetlands and how this variability can be up-scaled to region-wide estimates using remotely sensed indicators.

Keywords: Subsidence Reversal, Wetland Restoration, Climate Change Feedbacks, Greenhouse Gas Flux

Poster Topic: Habitat Restoration: Climate Change

Direct Measurements of Wind-Water Momentum Coupling in a Tule Marsh

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Wetland restoration is already underway in many parts of the California Delta. Among the numerous ecological benefits of restoration is carbon sequestration. As emergent vegetation (like tule) thrive, carbon dioxide in the atmosphere is removed and converted into biomass that gradually replenish the soils. Forecasts and management strategies, however, rely on accurate knowledge of gas exchange between the atmosphere and the wetland ecosystem. Our previous work show the rate of gas transfer across the air-water interface is affected by the amount of water column mixing caused by winds penetrating through the plant canopy. Here, we present the first direct measurements of this within a wetland. This work in Twitchell Island shows that under the conditions measured, momentum is imparted into the water from wind stress and that this wind stress interacts with the surface waters in an interesting way. By correlating three-component velocity signals from a sonic anemometer placed within the plant canopy and from a novel Volumetric Particle Imager (VoPI) placed in the water, we measure how much kinetic energy actually makes it through the canopy and into stirring the water column.

Keywords: Delta, Wetland, Gas Exchange, Measurements, VoPI

Poster Topic: Habitat Restoration: Climate Change

Modeling Suspended Sediment Transport and Geomorphic Processes at a Breached Delta Island

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This poster presents modeling work investigating the physical processes which drive the transport of suspended sediment at Liberty Island, a former agricultural island which has been allowed to evolve naturally following a catastrophic levee failure in 1998. Sediment transport processes play a major role in shaping estuarine ecosystems. Sediment deposition contributes to the growth and expansion of mudflat and vegetated marsh habitats, and elevated suspended sediment concentrations are thought to play an important role in creating habitat for threatened native fish species such as delta smelt.

The Cache Slough region and Liberty Island in particular have been observed to have elevated suspended sediment concentrations relative to the rest of the Delta. In order to better understand the processes driving these elevated suspended sediment concentrations, we have developed a coupled 2D-hydrodynamic (Delft3D) and wind-wave (SWAN) model representing the northwest portion of the Delta, encompassing Liberty Island and surrounding channels. The model is used to predict the re-suspension, transport, and deposition of suspended sediment. The model is forced with a range of inputs, including tides, wind, Sacramento River discharges, and flows down the Yolo Bypass. The model has been run for several representative time periods allowing us to explore both seasonal variations and long term trends at the site.

The model results provide insight into the relative importance of wind-waves, tidal currents, and river discharges in driving the deposition, transport, and re-suspension of suspended sediments, helping us better understand the expected patterns of landscape and habitat evolution in this important part of the Delta.

Keywords: Freshwater Tidal Marsh Restoration, Liberty Island, Suspended Sediment

Poster Topic: Habitat Restoration: Climate Change

Interactions Between Waves, Sediment, and Turbulence on a Shallow San Pablo Bay Mudflat

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Observations of tides, turbulence, and wind-waves on a shallow mudflat in northern San Francisco Bay illustrate the mechanisms that control shear stresses on the bed and drive sediment resuspension in this estuarine environment. Measurements spanning the transition from intertidal to subtidal mudflat were collected in the spring of 2011 in San Pablo Bay. During wind events, wave-driven bed shear stresses elevated concentrations of suspended sediment near the bed such that stable density stratification was induced. Density variations were attributed to suspended sediment concentration since salinity and temperature were largely uniform throughout the water column. Direct measurements of the buoyancy flux were provided by each of five ADVs on three instrument frames and demonstrated the dynamical relevance of the stratification to the turbulence field with values 1-10% of shear production. Contrary to expectations, increased near-bed turbulent shear stresses were observed during these stratification events, and shear production was heightened in particular. The observed increases in velocity shear in the lowest 30 cm of the water column during wind events were attributed to return flows generated by set-up at the coast from wind shear and Stokes transport, which enhanced the offshore flows on ebb tides. The increased shear production resulting from event-scale wave dynamics augmented bed shear stresses, reinforcing the impact of waves on sediment resuspension. The data illustrate that there were layered feedbacks between wind waves, sediment resuspension, and turbulent motions, and that wave events lead to stable stratification and a very energetic turbulence field in which the buoyancy flux became an important factor in the balance of turbulent kinetic energy.

Keywords: Waves, Turbulence, Sediment, Stratification, Mudflat, Intertidal, Stokes Drift

Poster Topic: Habitat Restoration: Climate Change

Restoration Progress Toward Regional Goals in the San Francisco Baylands

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Fifteen years after the publication of the Bayland Ecosystem Habitat Goals Project (1999) and as part of the Bayland Ecosystem Habitat Goals Update (BEHGU, 2014) project, the San Francisco Estuary Institute has analyzed the net losses and gains in bayland habitats since c. 1800, highlighting contributions due to restoration and enhancement activities. The Goals Project established amounts and types of habitats needed to establish a healthy and vibrant Bay ecosystem. These goals were based on the historical (c.1800) and the current (1998) extent of tidal habitats, opportunities and constraints for restoration, and wildlife requirements, among others. Bay Area restoration/enhancement activities began to not only meet these goals, but also provide beneficial uses such as cleaner water, flood protection, more wildlife, and beautiful places to be in nature in the heart of our urban region. More than 190 restoration/ enhancement projects have been planned or implemented around the Bay. By 2009 over 20,000 acres of restored or enhanced habitat had been completed. It is projected that the Bay Area will see an additional 48,000 acres of restored or enhanced tidal marsh due to future restoration efforts.

Performing a Region-wide net habitat change analysis allows us to better understand how these numbers compare to the Region's 1999 goals and provides a planning tool for identification of areas with additional enhancement/restoration potential. Time stamps for the net change analysis include circa c.1800, 1997, 2009 as well as a Post-restoration estimate that considers all known restoration projects with a high likelihood of implementation in the next 5-30 years. Datasets and information used in the net habitat change analysis include the Historical Baylands, Modern Baylands , the Bay Area Aquatic Resource Inventory (BAARI), and a combination of EcoAtlas Projects, San Francisco Joint Venture Project Tracking, and restoration expert narratives.

Keywords: Bayland, Restoration, Habitat, Tidal, Landscape Change, Planning, Enhancement, Marsh

Poster Topic: Habitat Restoration: Climate Change

Current Status of Olympia Oyster Populations in the San Francisco Estuary

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The Olympia oyster, *Ostrea lurida*, is a target of restoration efforts in the San Francisco Estuary. A better understanding of population fluctuations could significantly aid restoration outcomes and improve resilience to future climatic changes. As part of a project connecting applied science and restoration efforts, we generated a snapshot of the current status of oyster populations in the estuary, comparing it to previous snapshots under different environmental conditions.

We investigated oyster population dynamics using surveys at sites from San Pablo Bay to the South Bay over a five year period spanning recent dry and wet extremes, including the end of a three-year drought in 2009 and higher flow conditions in 2011.

Over five years, oyster abundance and sizes differed significantly along the salinity gradient, with maximum densities usually occurring in the northern-central portion of the estuary. After a three-year drought, maximum oyster densities in 2009 occurred in brackish waters near China Camp State Park. Two years later, high winter freshwater flow coincided with complete mortality of the oysters in this region, with maximum density of living oysters thereafter occurring downstream of China Camp.

Regional temperature and salinity variation correlated with the timing of the onset and peaks in fecundity and settlement. Juvenile oyster settlement varied geographically, with greatest settlement in upstream areas, coinciding with maximum adult densities during warmer periods. Following die-offs upstream in 2011, settlement began later and maximum settlement rates were halved. Maximum settlement was highest on the west side of the estuary, though maximum fecundity occurred in the east.

Great fluctuations in North Bay population densities occurred as high settlement was balanced against the inability of local populations to survive wetter winters. In contrast, South Bay populations had steady demographic rates, possibly making this area an important buffer against fluctuations in freshwater flow and other environmental changes.

Keywords: Oysters, *Ostrea lurida*, Salinity, Temperature, Demography, Freshwater Flow

Poster Topic: Habitat Restoration: Living Shorelines

Effects of an Environmental Stressor on Oysters: Using a Scientific Approach to Restoration Planning

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The Olympia oyster, *Ostrea lurida*, is a species of restoration interest in San Francisco Bay, Elkhorn Slough, and other estuaries along this same coast. Our goal is to produce science-based planning tools so that restoration practitioners can best select sites for successful oyster restoration that will be resilient to climate change. Here, we present targeted scientific research that will be incorporated into these tools. We investigated oyster threshold response to a specific climate related stressor, salinity, using laboratory mesocosms. Realistic treatment levels of both low salinity intensity and duration of exposure were chosen based on historical outflow volume and frequency records from San Francisco Bay and encompass both current conditions and more extreme conditions. Adult oysters were collected from a central and a north San Francisco Bay site that have different salinity regimes. Both oyster survival and food intake varied with respect to low salinity intensity and duration of exposure, and also between source populations. These results indicate that climate change effects on salinity are likely to impact oyster performance and should be incorporated into restoration planning. Next, we will combine these data with information we are collecting about oyster responses to other stressors in the laboratory and in the field to generate predictions about which sites and source populations are best suited for restoration efforts. Using this information along with stakeholder input, we will then produce restoration planning tools to aid practitioners and policy-makers in selecting sites for oyster restoration now and under projected future conditions.

Keywords: Climate Change, Environmental Stressors, *Ostrea lurida*, Restoration Planning

Poster Topic: Habitat Restoration: Living Shorelines

Managing for Resilience in the Face of Climate Change: A Collaborative Approach to Oyster-Restoration Research 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 coastal resources to climate change. To design effective strategies, they need restoration-planning tools based on robust science. In two Central California estuaries, we are engaged in a collaborative, joint fact-finding approach to understand the responses of native oysters (*Ostrea lurida*) to climate-change and other anthropogenic stressors. We used an online questionnaire, one-on-one interviews, and focused workshops to ensure that our research informs decisions made by restoration practitioners and resource managers and that work products are understandable and easy to use. End-user partners are also engaged in data collection at three field sites. Across 11 field sites in San Francisco Bay and 9 sites in Elkhorn Slough (Monterey County), we are collecting data on a suite of physical and biological parameters and on oyster performance. Our study sites span a wide range of environmental conditions, allowing us to examine the effects of multiple real-life factors on oyster recruitment, growth, fecundity, and survival. Laboratory experiments are being used to measure oyster response at various life stages to stressors expected to become more extreme as a result of climate change: higher air and water temperatures, lowered salinity, lower dissolved oxygen and sediment burial. Field and lab data indicate that adult and juvenile oysters are particularly vulnerable to lowered salinity; low dissolved oxygen reduced growth but did not result in higher mortality. In the field, oyster density and recruitment were negatively correlated with very high water and air temperatures, and summer and fall recruitment were positively associated with high chlorophyll a (a proxy for food supply) in the spring. These results will be used to construct a “score card” for site selection and a practitioners’ guide for oyster restoration/conservation now and into the future.

Keywords: Climate Change, Anthropogenic Stressors, *Ostrea lurida*, Restoration Planning, Collaboration

Poster Topic: Habitat Restoration: Living Shorelines

Avian and Benthic Invertebrate Responses to Eelgrass and Native Oyster Restoration 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-project monitoring at each site from Nov 2011-April 2012, and post-project monitoring from September 2012-April 2013. Our primary objective was 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. Both pre- and post-project avian densities were highest at Hayward treatment and control sites where small shorebirds predominated and reached densities of >2300 birds/ha during peak periods in January of both years. At San Rafael, densities of black oystercatcher and several wader species increased significantly at treatment plots in comparison to pre-treatment and control densities. Bivalves predominated at Hayward and more than doubled in the treatment area during the post-project period. The number of unique taxa at the San Rafael site increased from 14 representing 6 classes to 22 representing 8 classes. Our preliminary results suggest that some avian and invertebrate species may be responding to oyster and eelgrass habitat restoration.

Keywords: Benthic Invertebrates, Eelgrass, Native Oysters, Living Shorelines, Restoration

Poster Topic: Habitat Restoration: Living Shorelines

Invertebrate and Fish Responses to Eelgrass and Oyster Restoration in a San Francisco Estuary Living Shorelines Project

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The San Francisco Estuary has historically supported a high diversity of fish and aquatic invertebrates. Intertidal habitats with complex physical structure are considered especially productive, providing foraging and shelter opportunities for multiple life stages. This research is being conducted to monitor the response of these populations to the restoration of intertidal habitat including eelgrass (*Zostera marina*) and native oyster (*Ostrea lurida*) in the Estuary. The CA Coastal Conservancy's San Francisco Bay Living Shorelines: Nearshore Linkages project (LSP) is the first project in the Estuary to implement these intertidal habitat restoration techniques at a scale large enough (30m x 10m plots) to provide quantifiable physical results in addition to biological results. Living shorelines have been used throughout the world to reduce physical impacts on shorelines, while simultaneously providing habitat to intertidal invertebrate and fish species. Quarterly invertebrate and fish monitoring was conducted in the restoration plots for four rounds prior to oyster restoration (Oct 2011-July 2012) and has continued after restoration (July 2012-current). Quarterly monitoring has been conducted for seven rounds prior to eelgrass restoration (Oct 2011-Apr 2013) and has continued after restoration (April 2013-current). Monitoring is conducted using a series of traps, seines, and vacuum sampling. Preliminary results have shown a trend of increase in species richness and abundance within the restoration plots compared to the control plots. We have observed a shift from a predominance of mudflat species (e.g., mud-flat crab, *Hemigrapsus oregonensis*) to species that have been shown to use eelgrass and oyster habitats as nursery or foraging grounds (e.g., juvenile Dungeness crab, *Metacarcinus magister*). This monitoring will further help to determine the relative and interactive effects of adding eelgrass and oyster reefs to restore habitat structure.

Keywords: Eelgrass, Oysters, Living Shorelines, Habitat Restoration, San Francisco Estuary, Invertebrates

Poster Topic: Habitat Restoration: Living Shorelines

Acoustic Fish Telemetry at the San Rafael Living Shorelines Oyster Reef

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Creating habitat for fishes is a chief goal of oyster reef restoration projects in the San Francisco Estuary. Oyster restoration reefs, such as the SF Bay's Living Shorelines Project's reef near San Rafael, provide physical structure that supports a robust local food web offering foraging opportunities for many fish species. The nooks and crannies of the reef can provide nursery and refuge habitat for fishes. Determining which fish species are utilizing this restoration site and quantifying their use of the site is the problem that we are investigating.

To approach this problem we have applied the tools of hydroacoustic telemetry. In December, 2012, we installed an array of 25 VEMCO VR2W acoustic receivers (69 kHz and 180 kHz frequencies) around the oyster reef to detect and quantify the presence of tagged fish. Receivers were arranged in such a way that any tagged fish would likely be detected by at least three receivers. Detections at multiple receivers allow the calculation of the fish's position within the reef. Receivers were also installed at a smaller reef near the Marin Rod and Gun club for comparisons.

Fish are tagged by multiple academic researchers and agencies so that their movements within and beyond San Francisco Estuary can be tracked. Out-migrating salmonids (chinook and steelhead) and other species of concern such as green sturgeon, white sturgeon, striped bass and cow sharks are implanted with acoustic transmitters.

In June, 2013, we downloaded data from all of our receivers. Our preliminary results show that at least eight tagged fish visited this oyster reef over the study period. Our analysis will determine which specific fish used the reef and provide a track of their position within the reef structures.

Our results will help guide future oyster reef restoration projects to maximize benefits to important fish species.

Keywords: Acoustic Telemetry, Receivers, Transmitters, Tagged, Chinook, Steelhead, Sturgeon, Living Shorelines

Poster Topic: Habitat Restoration: Living Shorelines

Evaluating Oyster-Restoration Substrate Performance Between and Within Two Restoration Sites in San Francisco Bay

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Most restoration efforts for native oysters (*Ostrea lurida)* in California involve the provision of hard substrates to increase natural larval recruitment. Different types, sizes, and configurations of such substrate have been used, but have not been compared in a rigorous study design. In the ideal, substrates should encourage oyster recruitment, growth, and survival, while remaining relatively free of non-native foulers and sediment. As part of a larger "living shoreline" project, we compared the performance of native oysters across five substrate types at two restoration sites in San Francisco Bay. Four substrate types constructed from "baycrete" (cement and locally dredged shell)—modular interlocking oyster blocks, stacks of small oyster domes (Oyster Reef Balls), large oyster domes (Bay Reef Balls), and large segmented oyster domes (Layer Cakes)—and stacks of Pacific oyster shell in mesh bags were deployed at the sites in summer 2012. Data collected show large variation in oyster recruitment between the two sites. Within each site, there is little difference in oyster density across the substrate types, but oyster numbers are consistently highest on north and vertical faces, and at lower tidal elevations, suggesting that thermal stress is a factor in oyster recruitment and/or survival at these sites. We also compared oyster growth and longer-term survival, measured sediment accumulation, and enumerated other species that have recruited to the deployed substrates, including small fish, algae, and sessile and mobile invertebrates. We tested for interactions between oysters and native eelgrass, which was planted as part of this restoration project, examined effects of the restoration project on the natural oyster populations at each site, and looked for community-level effects such as fish use of the restored sites. This project adds to our understanding of restoration methods both in terms of increasing oyster populations and habitat creation.

Keywords: Oysters, Habitat Restoration, Living Shorelines, Eelgrass, Substrate, Methods

Poster Topic: Habitat Restoration: Living Shorelines

Evolving the Bed: Physical and Geomorphic Processes of the San Francisco Bay Living Shorelines Nearshore Linkages Project

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Mitigating shoreline erosion with biologically self-sustaining habitats would lessen the need for intrusive shoreline protection infrastructure in bays and estuaries. 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. Understanding changes to the physical and geomorphic processes in the project area is key to evaluating the impacts to shoreline and mudflat habitats. Waves, currents, and the resultant sediment transport will cause a geomorphic response on the shoreline and bed while the morphology of the bed will affect wave shoaling and sedimentation rates.

Waves, currents, sedimentation/erosion, and substrate composition are being investigated at four experimental 32 m x 10 m plots in San Rafael Bay. Turbidity of the water column is also being measured. The plots consist of an oyster reef, an eelgrass planting, a combination of oyster-eelgrass elements, and a control plot of native mudflat. Wave and current monitoring instruments were deployed for 6 weeks in spring 2013 to provide data for a Boussinesq wave model that examines wave attenuation by the reef structures. Sedimentation rates and substrate stability were calculated from high-resolution topographic surveys of the bed. The wave model and sedimentation rates provide guidance for future designs of reefs on how they attenuate waves and impact sediment trapping.

Keywords: Wave Attenuation, Mudflat, San Rafael Bay, Sedimentation, Living Shorelines

Poster Topic: Habitat Restoration: Living Shorelines

How Do Transplant Source, Restoration Site Constraints, and Herbivory Interact in Reintroduction Efforts of Native Pacific Cordgrass (*Spartina foliosa*) in the San Francisco Bay?

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Planting native cordgrass (*Spartina foliosa*) is an essential part of restoring tidal marsh vegetation to the central portions of San Francisco Bay. In this region, native cordgrass was extirpated by the highly invasive *Spartina alterniflora* and its hybrids with S*. foliosa*. Restoration of native cordgrass follows highly successful control of non-native *Spartina*. However, revegetation attempts have been complicated by three factors: (i) a paucity of native cordgrass populations available for transplant, (ii) altered marsh characteristics following hybrid invasion and removal, and (iii) Canada Goose herbivory. In 2011-2012, we explored the relationship between restoration site characteristics, parental source of *S. foliosa* transplants, and plant caging. We transplanted plugs from four donor marshes into five restoration sites, pairing caged and uncaged material, and monitoring growth responses monthly. After one year, it was clear that herbivory pressure varies greatly between restoration marshes. Marshes with resident geese had low survivorship of uncaged plots (<7%), but caged plots had high survivorship (>75%). In marshes with limited grazing pressure, caging did not hinder survivorship, but did decrease plant performance. The source of transplants had strong effects within some of the restoration sites. In 2012-2013, we further explored the interaction between source of transplant material and edaphic conditions. Plants were collected from eight widespread marshes, genetically tested using microsatellites, and grown in identical nursery conditions. Despite the fact that we did not detect genetic variation between source populations, plants from different sources varied greatly in growth characteristics after 10 months of nursery growth. Preliminary monitoring after planting in the field further suggests that the source of transplant material strongly influences survivorship, although this was not predictable from patterns in the nursery beds. We conclude that both goose exclusion and transplant source selection should play an important role in ongoing native cordgrass restoration.

Keywords: *Spartina foliosa*, Restoration, Cordgrass, Herbivory, Revegetation

Poster Topic: Habitat Restoration: Wetlands

Is Restoration of Salt Marshes Enhanced by Proximity to Established Native *Spartina*?

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Establishing Pacific cordgrass, *Spartina foliosa*, is vital to the success of large scale tidal marsh restoration in the San Francisco Bay. However, since the 1970s, introduced *Spartina alterniflora* and its highly invasive hybrids with *S. foliosa* have established throughout many wetlands baywide. Prior to eradication efforts, restored marshes located near the introduction site in the central bay were typified by a dense monoculture of non-native *Spartina.* As distance from the epicenter increased, higher rates of native recruitment were observed, especially in restoration marshes near established native clones. The importance of localized recruitment is supported by an Invasive *Spartina* Project (ISP) drift card study in which most cards were recovered close to the release location, with only a few cards traveling over 100 km. In this study, we use genetic tools to determine the influence of local populations of established *Spartina* clones on the genotypic identity of recruiting seedlings. In this ongoing study, we are sampling seedlings at four classes of sites: (i) untreated areas dominated by hybrids, (ii) previously treated areas that have been outplanted with nursery-grown *S. foliosa*, (iii) naturally occurring mixed stands of native and hybrid plants, and (iv) stands of naturally occurring *S. foliosa*. We sample populations in 12 distinct geographic locations in the central and southern portion of the San Francisco Bay using a suite of 16 diagnostic microsatellite markers to identify young clones and nearby established clones as hybrid or native. We test for similarity of genetic composition using a Bayesian approach in *Structure*, and with summary statistics in AMOVA. The results demonstrate the potential for active management of nearby *Spartina* hybrids to positively affect the long-term recruitment trajectory of invasive plants in San Francisco Bay wetlands.

Keywords: Hybrid, Invasive, Cordgrass, Spartina, Microsatellites, Genetics, Recruitment, Restoration, Salt Marsh

Poster Topic: Habitat Restoration: Wetlands

South San Francisco Bay Three-Dimensional Sediment Transport Modeling

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The San Francisco District of the US Army Corps of Engineers is considering the beneficial use of dredge material in South San Francisco Bay (South Bay) by investigating sediment dispersal at potential beneficial locations within the South Bay. Beneficial locations include mudflats and breached salt ponds south of Dumbarton Bridge. The UnTRIM Bay-Delta hydrodynamic model has been coupled with the Simulating WAves Nearshore (SWAN) wave model and the SediMorph sediment transport model to evaluate nine dredge material placement scenarios. The UnTRIM-SWAN-SediMorph modeling system has been calibrated and validated throughout San Francisco Bay and the Sacramento-San Joaquin Delta by comparing model runs to available field data. Simulation results from the modeling system show potential benefits for dredge material placement in the South Bay as briefly described herein. The farther south of Dumbarton Bridge that dredge material placements are located, the more deposition of sediment within beached salt ponds occurs. Dredge material placements in the middle of the far South Bay and just north of Pond A6 of the Alviso salt ponds will supply equal amounts of sediment to the combined salt ponds and mudflats. Between 83 and 96% of the dredged material placed south of Dumbarton Bridge was retained in the Far South Bay and nearly all of the sediment was retained in the South Bay. A simulation of future conditions, which includes the breaching of more salt ponds and sea level rise of 0.2 meters, indicates that when more salt ponds are breached the percentage of dredged material deposited within the breached ponds also increases. Results from this modeling work will support the San Francisco District's Regional Dredged Material Management Plan (RDMMP) and the Regional Sediment Management (RSM) program. The RDMMP will identify dredged material placement locations for the San Francisco District's operation and maintenance dredging.

Keywords: Sediment Transport, San Francisco Bay, Hydrodynamic Modeling, Dredge Material

Poster Topic: Habitat Restoration: Wetlands

Seed Dispersal in the Eden Landing Salt Ponds Complex: The Influence of Landscape, Site, and Time on Seed Arrival

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Recently breached tidal marsh restoration sites offer the opportunity to study the factors that contribute to plant community establishment. While channel development and sediment accretion are two of the main factors driving the development of newly breached restoration sites, both interact with seed supply to structure newly emerging plant communities. Seed supply has been studied in the North Bay, but no published studies have explored seed dynamics in restored salt ponds in the South Bay. This study will look at the influence of geographic distance and microtopography on seed dispersal in Whale's Tail, Old Alameda Creek, North Creek, Mt. Eden Creek and E8A marshes. Analysis will focus on two spatial scales: alpha diversity of species within each marsh and beta diversity of species between marshes. Active dispersal will be assessed by collecting seeds deposited by tide and wind using seed collection mats. Similarity indices and distance decay analysis will be used to determine how seed composition is related to standing vegetation community, time since breach, soil seedbank, distance from seed source, tidal influence and topographic heterogeneity. Understanding these dynamics will help land managers plan restoration efforts and assess conditions under which direct application of propagules may be necessary. Seed collection for this project will begin on September 1st, 2013, and this poster describes project design and implementation of initial steps.

Keywords: South Bay Salt Ponds, Seed Dispersal, Wetland Restoration

Poster Topic: Habitat Restoration: Wetlands

Hayward Shoreline: Observations from an Evolving Landscape

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Public access, endangered species habitat, and wetland restoration all intersect on Hayward Shoreline. When planning restoration projects including plans for sea level rise, observations of past landscape level changes can help frame expectations. The time interval necessary to detect landscape level change is variable. The direct effect of the removal of water control structures and levee breaching can take 1-2 days, while the development of ecosystem complexity associated with a given physical change can take years as measured by tidal channel network density and marsh plain revegetation.

At the time of the 1856 coast survey, public access on Hayward Shoreline equated to access for hunting, fishing and commerce via deep channels extending to Roberts Landing and Eden Landing. Salt pannes in the back marsh area east of the shoreline were precursors to the formal salt making enterprise that once included using pine boughs to crystallize salt on. Between 1937 and 1982 the Oliver Brothers made salt on a 190 acres bisected by construction of Highway 92 and the bridge. The Hayward Area Recreation and Parks District purchased the northern 153 acres of the Oliver Brothers salt works and implemented a 324 acre restoration project in 2001-03 that included habitat enhancement for nesting western snowy plovers, completion of the Arthur Emmes segment of the Bay Trail, increased tidal flushing by replacing failed culverts with a bridge and added or improved water management options for the Salt Marsh Harvest Mouse Preserve.

The poster maps the development and progression of the tidal channel network and influence of levees, the effects of dredged material reuse on vegetation establishment, the ability to maintain salinities and western snowy plover nesting habitat and the quantity and quality of HARD's public access and education programs.

Keywords: Hayward Shoreline, Wetland Restoration, Planning, Western Snowy Plover, Public Access

Poster Topic: Habitat Restoration: Wetlands

Studying Germination of *Distichlis spicata* for Seeds with South San Francisco Bay Provenance

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Saltgrass (*Distichlis spicata*), a co-dominant species in salt marsh, transitional and alkali grassland habitats is a top candidate in restoration projects because of its high value for wildlife and its grazing tolerance. Saltgrass is an aggressive clonal colonizer but revegetation by direct seeding may be in many occasions more efficient especially when it is combined with other species seeding. However, limited availability of local saltgrass seed stock and low germination rates are challenges associated with the use of direct seeding for this species in the San Francisco Bay area. In 2012, we located four seed producing saltgrass populations in the South Bay and conducted a series of nursery experiments to identify the best conditions for recruitment. Unlike many studies, which found that seed scarification and/or cold stratification may increase germination rates, we found that scarification decreased germination and that constant warm temperatures with no wet cold stratification improved seed germination. Seed germination was also significantly different among the four seed collection sites. Our results support that saltgrass recruitment from direct seeding may be over 70% when temperatures are above 18 degrees Celsius on irrigated fields. A separate series of nursery experiments showed that other salt marsh plant species like Seaside heliotrope (*Heliotropium currasavicum*) and Alkali weed (*Cressa truxilensis*) show the greatest germination rates under similar conditions. Field experiments that will test the effect of seed provenance, seeding time and irrigation regime on seeding success are necessary to determine the most efficient, applicable method for seeding success.

Keywords: *Distichlis spicata*, Germination, San Francisco Bay, Restoration, Nursery, Salt Marsh

Poster Topic: Habitat Restoration: Wetlands

Using Landscape Ecology Metrics to Assess Changes in San Francisco Bay-Delta Estuary Tidal Marsh from Past to Present in Support of Regional Landscape-Scale Restoration

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The San Francisco Bay and the Sacramento-San Joaquin Delta are often studied and managed as distinct entities. However, the Bay and Delta function as a unified and complex estuary, which crosses several ecologically significant gradients (i.e. tidal influence, salinity, and vegetation). These gradients are important when planning for restoration of wildlife corridors and interconnected habitats. While current regional management and restoration efforts emphasize a landscape-scale approach to restoration, few tools are available that illuminate what large, interconnected habitat restoration should look like for the region and Estuary as a whole.

To inform these efforts, the San Francisco Estuary Institute performed multiple landscape ecology analyses of tidal marsh in the Bay and Delta. These analyses—including marsh patch size distribution for clapper and black rails (*Rallus longirostris* and *Laterallus jamaicensis*), nearest neighbor distance, edge-to-core habitat ratio, and habitat adjacency—were performed in parallel on historical and contemporary datasets of the Estuary's aquatic resources. The landscape metrics derived from these analyses allowed us to quantify the extent, distribution, and connectivity of historical tidal marsh, analyze net changes between c. 1800 and 2009, illustrate the current configuration of habitat for key species, and identify areas with enhancement/restoration potential. The Estuary has experienced net decreases in the number of marsh patches > 100 ha (the size below which rail densities are known to decrease) and in the relative proportion of core habitat. Only four of the 35 large marsh patches in the Estuary are within the Delta (representing 6.1% of the Estuary's core marsh habitat). As a whole, this work allows for assessment of the region's progress towards targets established by the Baylands Ecosystem Habitat Goals and Bay Delta Conservation Plan. It is notable for its synthesis of complementary regional datasets and its application across the whole San Francisco Estuary, from Bay to Delta.

Keywords: Landscape, Ecology, GIS, Historical, Estuary, Habitat, Patches, Restoration

Poster Topic: Habitat Restoration: Wetlands

The Sonoma Creek Enhancement Project: Habitat Improvements and Mosquito Source Reduction in a North Bay Centennial Tidal Marsh

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The Sonoma Creek tidal marsh, which fringes the western bank of Sonoma Creek near the confluence with San Pablo Bay in Sonoma County, routinely ponds water for long periods following spring tides and storm events when high waters become trapped in a large basin in the marsh interior and between a series of abandoned levee alignments along the western marsh boundary. The water that ponds in these areas leads to high mosquito production rates and reduced vigor and cover of marsh vegetation, which reduces habitat quality for the endangered California clapper rail, threatened California black rail, and other marsh-dependent species. The degree of ponding at this site, and the resulting mosquito production and habitat degradation, are exacerbated by the fact that the Sonoma Creek marsh is a centennial tidal marsh (formed over approximately the past 100 years from the Sierra Nevada hydraulic mining sediment load) and lacks the extensive tidal channel networks characteristic of ancient San Francisco Estuary tidal marshes. The San Pablo Bay National Wildlife Refuge, in collaboration with Audubon California, the Marin-Sonoma Mosquito and Vector Control District, and Wetlands and Water Resources, Inc. has developed the proposed Sonoma Creek Enhancement Project to address these issues. The project includes the construction of several enhancement elements to improve conditions at the site by (1) improving tidal exchange within the wetland interior, (2) reducing the extent of continuously ponded areas, (3) providing high-tide refugia within the marsh interior, and (4) creating marsh-upland transitional habitat along the Tubbs Island perimeter levee at the western edge of the project site. The project is currently undergoing regulatory review and construction is planned to begin in summer/fall 2014, pending the receipt of all required permits. The poster presents the current project design, proposed implementation timeline, and updates on the regulatory compliance process and funding status.

Keywords: Wetland Restoration, North Bay, Transition Zone, Tidal Wetlands

Poster Topic: Habitat Restoration: Wetlands

Sonoma Baylands Wetlands Demonstration Project: Lessons Learned Over 15 Years of Monitoring

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Funded in partnership between the U.S. Army Corps of Engineers and the California State Coastal Conservancy, the Sonoma Baylands project was enacted to test the application of dredge material to accelerate tidal wetlands restoration. In all 303 acres of wetland were created. Physical and biological success criteria, established by a review committee, formed the basis of monitoring that is now its 15th year, representing one of the most comprehensive, long term monitoring programs for a tidal wetlands project.

Sonoma Baylands is considered a "second generation" project, designed using lessons learned from smaller previous projects, and is now contributing to the science being used in "third generation" projects such as the restoration at Hamilton, Napa Salt Ponds and South Bay Salt Ponds. Here, strict criteria on the elevation of placed dredge material, to within the colonization zone of tidal wetland vegetation, were specified to accelerate marsh building while maintaining soft sediment conditions to support channel formation. Experimental wave berms were included for their role in reducing wind wave disturbance of vegetation colonizing the mudflat, and to protect the perimeter level from erosion. A channel cut designed to provide full tidal connection to the bay was not constructed over concerns of disturbance to endangered species in natural marsh outboard of the restoration site.

Monitoring demonstrates that the site is following an evolutionary path towards tidal marsh restoration. The evolution of the site was initially stalled, impaired by inadequate capacity of undersized channels to drain tidal waters. Predictions that natural scour would occur were correct, and after a 5 year delay, full tidal connectivity allowed the progressive transition from mudflat to vegetated marsh. Populations of feeding birds have shifted in composition, as the site has evolved from standing water, to increasingly vegetated conditions. Fish counts are in line with data collected bay wide.

Keywords: Restoration, Marsh, Channel, Erosion, Accretion, Colonization, Monitoring, Dredge

Poster Topic: Habitat Restoration: Wetlands

Factors Influencing Vegetation Expansion and Transplant Success at the Liberty Island Restoration Site in the Sacramento/San Joaquin Delta, California

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The development of effective and sustainable wetland restoration approaches is contingent on understanding the colonization and expansion dynamics of the targeted plant species. We employed a combination of observational and manipulative studies at the Liberty Island tidal freshwater marsh restoration site in the Sacramento/San Joaquin Delta to elucidate those factors controlling vegetation dynamics at the site, particularly in regards to *Schoenoplectus californicus* (tule). Our approach had multiple components, including: 1) seed bank assay, 2) field transplant study of *S. californicus, S. acutus*, and *Typha latifolia*, as well as a 3) field transect study and 4) vegetation lateral expansion study at multiple locations. The seed bank at the site included viable seeds for a greater number of species than is currently represented in the emergent wetland plant community, which indicates that environmental conditions limit the successful germination and persistence of many of the species in the seed bank. Transplant establishment using adult transplants was much more successful than with rhizomes, likely because of greater flooding tolerance of adult transplants. All three species assessed were able to establish; however, *S. californicus* displayed the highest transplant survivorship and rapidly became the dominant species, exhibiting high rates of vegetative expansion. The transect study of *S. californicus*-dominated marshes revealed a range of soil conditions, marsh platform and marsh edge elevations, and rates of vegetative lateral expansion across locations at Liberty Island. The history of the site in combination with current hydrologic and exposure gradients appear to be exerting substantial influence on plant community dynamics and rates of expansion. Our findings illustrate the importance of recognizing multiple environmental factors that may exert influence on life history stages to varying degrees, as well as the dynamic interactions between the plant community and the abiotic environment when considering restoration thresholds.

Keywords: Liberty Island, Tules, Restoration, Seed Bank, Plant Establishment, Vegetative Expansion

Poster Topic: Habitat Restoration: Wetlands

Ecosystem-Scale Rates of Primary Production within Wetland 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 the relative contribution of different primary producers to total organic carbon production within open water and tidally flooded wetlands of the northern San Francisco Estuary (SFE). Carbon fixation rates of phytoplankton, microphytobenthos, and low marsh emergent vegetation were measured in two natural and four restoring estuarine wetlands over the growing season in 2004. Areal (m^2) rates of carbon fixation were the greatest for low marsh vegetation, while phytoplankton and microphytobenthos 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 open water channel, mudflat and low marsh area restored. Large-scale wetland restoration activities should consider the types of primary producers likely to occupy restored habitats when estimating future food web impacts.

Keywords: Salt Marsh, Primary Production, Microphytobenthos, Phytoplankton, Restoration

Poster Topic: Habitat Restoration: Wetlands

Restoration of Bair Island Complex Nears Completion

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Substantial progress has been made towards implementing the Bair Island Restoration and Management Plan. The tides were recently restored to Middle Bair Island. This was the second completed component of a larger restoration project aimed at restoring 1,400 acres of the entire 2,600-acre Bair Island complex. Historically, the island complex (Inner, Middle, and Outer Bair Islands) was part of a large expanse of tidal wetlands that extended along the southeastern edge of San Francisco Bay. The island complex was diked for agriculture in the late 1800s. In 1946 the area was converted to salt production, which continued until 1965, though the legacy of wetland conversion remains.

The goal of this 848-acre project was to restore a more natural tidal hydrologic regime and salt marsh habitat on Middle Bair Island. To complete the restoration, several specific construction activities were required: flow constrictors were constructed in Smith and Corkscrew Sloughs to limit sedimentation in Redwood Creek; internal and perimeter levee breaches were excavated to restore tidal exchange to remnant tidal sloughs within the island; and internal borrow ditches were blocked with earthen ditch blocks in select locations to direct tidal flow into historic slough channels. A newly constructed pedestrian bridge now provides access to Inner Bair Island, and a future phase will provide trail access to observation platforms offering birds eye views of the island complex.

Keywords: Tidal, Estuarine, Wetland Restoration, Endangered Species, Public Access

Poster Topic: Habitat Restoration: Wetlands

The Contribution of Vegetated Ponds to Phytoplankton Carbon and Material Flux in the Freshwater Tidal Wetland Liberty Island

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Liberty Island is a freshwater tidal wetland thought to provide habitat and food resources for the endangered delta smelt and other fish species of interest in San Francisco Estuary. However, little is known about the mechanisms that control environmental conditions and material production within the wetland. This study addressed the question: Do small vegetated ponds contribute habitat and are they a source of carbon and material to this freshwater tidal wetland? To address this question, continuous measurements of water temperature, specific conductance, turbidity, pH, dissolved oxygen and nutrients were used to characterize the water quality and material flux in three wetland ponds between 2010 and 2011. Daily average carbon production rate was computed from continuous measurements of chlorophyll fluorescence, phytoplankton yield and underwater light. Concentrations were combined with continuous flow measurements to quantify material flux among the wetland ponds. Over the year-long study, daily average chlorophyll *a* concentration, primary productivity, water temperature, specific conductance, turbidity, soluble reactive phosphorus and dissolved organic nitrogen were greater in the vegetated ponds. Vegetated ponds also exported suspended solids, salt and chlorophyll and carbon to ponds within the wetland and adjacent river channels. Vegetated ponds contrasted with the large open water pond which stored material. Chlorophyll, suspended solids and salt flux were dominated by advective flow in the vegetative pond and tidal flow in the open water pond. Chlorophyll flux was further influenced by carbon production rates which increased on flood tide. Although their percent contribution to the total material flux of the wetland was small, the elevated primary productivity and chlorophyll concentration plus their export to ponds within the wetland contributed significantly to the wetland production. This study provided information needed to assess the amount of material and carbon wetland restoration projects can contribute to the estuarine food web.

Keywords: Liberty Island, Freshwater Tidal Wetland, Material Flux, Carbon Production

Poster Topic: Habitat Restoration: Wetlands

Spatial Heterogeneity in Flow Paths in a Dense Delta Marsh

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We use a novel 3D submersible camera to measure the velocity of surface water flow in a Typha-Schoenoplectus marsh. Our goal is to understand spatial heterogeneity in the surface water velocities caused specifically by the geometry within a dense stand of emergent vegetation. For this reason, we work in a marsh that has relatively simple boundary conditions: one inlet, one outlet, near-constant depth (non-tidal), and an apparently homogeneous distribution of plants. Notably, there are no known "channels" in this marsh, i.e. neither contiguous paths that are free of vegetation nor contiguous paths in which the peat surface is lower than average. This site is located on Twitchell Island, in the "West pond" of the experimental carbon capture wetland project run by the Department of Water Resources and USGS. We perform a series of velocity measurements along a transect that bisects the marsh. From these we assess the spatial variability of flow velocity. We compare this to the temporal variability in velocity caused by wind gusts, which force the water via both surface shear and through a "honami" coupling.

Keywords: Freshwater Wetland, Flow Velocity, Particle Tracking, Honami

Poster Topic: Habitat Restoration: Wetlands

Salinity Pattern in Indian Estuaries Regulating Alien Anisakid Species Invasion in Fish

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The emerging challenges from change in the salinity pattern in estuarine zones to trigger the transmission of invasive species of zoonotic significance, from coastal wetlands in the Central West coast of India (showing wider host specificity), to the fresh water of river Ganges (showing stricter host specificity in *Rita rita*), have been noticed. The anisakid species, *Iheringascaris goai* (Malhotra et al., 2011) was recorded since 2001, from sharks, *Rhyncodon typus* and catfish, *Arius maculatus* and *I. inquies* (Linton) recorded earlier. The molecular analysis, including 18S rRNA and coI, of these and one other anisakid worm indicated emergence of morphological peculiarities, and hence diversity of species, under the environmental influence. Wide variations in salinity *vis-à-vis* seasonal periodicity at Mandovi estuary revealed 37-40 ppt during summer period (May-June), while 29-34 ppt salinity occurred in rainy and winter periods. Jhingran (1991) emphasized that in Zone IV (i.e. estuarine zone of Rupnarayan near Bay of Bengal), salinity decline occurred after construction of Farakka Barrage (1975 upto 1977), because of freshwater being flushed into estuarine water. But later, in the Zones II and III during 1988-1992 and 1994-1998, the salinity values escalated, and these fluctuations resulted into change in fauna as well as vegetation. Heavier dredging operations before 2001 to facilitate Shipping Corporation of India activities, could easily become an instrument of changed copepod fauna due to major shifting of sand from the bottom to the surface of the riverine stretch from Haldia (West Bengal) upstream River Ganges upto Saraswati Ghat at Allahabad (Uttar Pradesh). Thus, extension of predominant freshwater characteristics of the estuarine zone in the areas upstream River Ganges could have facilitated the outreach and survival of changed intermediate copepod host populations up to Allahabad. This possibly facilitated sudden survival and establishment of a newer anisakid species that possessed the characteristics of the invader anisakid genera from the Arabian Sea.

Keywords: Invasive Species, Indian Ocean, River Ganges

Poster Topic: Invasive Species

Population Persistence of the Invasive Suspension-Feeding Bivalves *Potamocorbula amurensis* and *Corbicula fluminea* in San Francisco Estuary: What Can We Learn about Future Spread and Impacts?

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The invasion of *Potamocorbula amurensis* into San Francisco Estuary was remarkably successful, and it affected ecosystem function almost immediately. We know less about the immediacy of the effect of *Corbicula fluminea* when it invaded in the 1940s, but we know that both bivalves can reduce phytoplankton biomass in the present system. Today, these two invasive bivalves overlap in the biologically sensitive low salinity zone and they jointly populate the system from the Delta to San Pablo Bay.

Here, we use the California Department of Water Resources (DWR) spatially intensive benthic sampling program (GRTS) to examine the biomass distribution of both species in spring and fall of 2007 through 2012 to identify the environmental factors associated with their distributions. We show that the location of the dominant region of overlap is mostly controlled by the salinity distribution at the time of larval clam settlement. However, post-juvenile clams may persist outside this location due to increasing salinity tolerance in adult clams which accounts for the wide range of overlap of adult clams. Variability in the magnitude of biomass and grazing rate is related to environmental conditions during reproduction and growth seasons in the present year and extreme environmental events in the prior year for both species. The grazing rate to tissue mass relationship is non-linear and the grazing rate is relatively larger in *P. amurensis* than in *C. fluminea* for a similar biomass. Thus, the biomass distribution of each species does not directly translate to a similar distribution of grazing rate. We calculate biomass, grazing rate, and water turnover rate for all sampling periods. We augment the spatial data and supply temporal context to the spatial data with time series data from the DWR Environmental Monitoring Program stations that are sampled monthly.

Keywords: Bivalve, *Corbicula, Potamocorbula*, Grazing Rate, GRTS, San Francisco Estuary

Poster Topic: Invasive Species

Three Non-native Jellyfish in the San Francisco Estuary: Distribution, Abundance, and Potential Impacts

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Three species of jellyfish indigenous to the Black Sea (*Blackfordia virginica, Maeotias marginata,* and *Moerisia lyonsi*) have become established in low-salinity habitats of the San Francisco Estuary (SFE). All three jellyfish spatially and temporally overlap with protected planktivorous fish, and share a similar diet consisting primarily of copepods. This study quantifies the distribution and abundance of all three species within four brackish-water tributaries of the SFE from early summer to late fall during 2010 and 2011. Jellyfish and their prey were sampled weekly or biweekly and environmental variables were recorded. The upper quartile abundance for *B. virginica* was 95 medusae m^{-3} in 2010 and 115 medusae m^{-3} in 2011, exceeding previous reports of <5 medusae m^{-3}. The upper quartile abundance of *M. marginata* (2 medusae m^{-3} in 2010 and 2011) and *M. lyonsi* (13 medusae m^{-3} in 2010 and 50 medusae m^{-3} in 2011) are similar to previous reports. Information on abundance was combined with feeding rates measured in the laboratory (*B. virginica* and *M. marginata*) or taken from the literature (*M. lyonsi*) to estimate predation impacts. The highest potential impact was 20–60% of the water column cleared per day estimated for *B. virginica,* which is higher than the population growth rates of their copepod prey. As a result hydromedusa populations in the SFE have the potential to locally depress copepod populations, potentially reducing prey available for protected species of fish.

Keywords: *Blackfordia virginica, Maeotias marginata, Moerisia lyonsi*, Abundance, Feeding, Gelatinous Zooplankton

Poster Topic: Invasive Species

Abundance and Distribution of Gelatinous Plankton in the Northern 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 gelatinous zooplankton may strongly influence their interactions with fish, including consumption of fish eggs and larvae and competition for zooplankton prey. Here, we report the distribution and abundance of gelatinous zooplankton at 9 stations throughout the northern SFE during late summer and fall of 2011 and 2012. While work in four smaller tributaries (see Donald et al.) reports high abundances (>50 m^{-3}) of two species (*B. virginica* and *M. lyonsi*), abundances of these and other species in the larger bays (San Pablo and Suisun) and rivers (Sacramento and San Joaquin) were significantly lower (<1 m^{-3}). Most of the previous work to define the habitat range (salinity and temperature) of these species has occurred within Suisun Marsh. Extending this work into the open bays will help provide a more accurate habitat description. Additionally, information on the distribution and abundance of gelatinous zooplankton and how these vary with X2 will provide insight regarding the potential for interactions between gelatinous zooplankton and protected fish species within the SFE.

Keywords: Jellyfish, Invasive Species, *Blackfordia virginica, Maeotias marginata*, *Moerisia lyonsi*

Poster Topic: Invasive Species

Salinity Tolerance of the Copepod *Pseudodiaptomus forbesi*

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Distributions of estuarine organisms are dictated in part by physiological tolerances to salinity, but salinity is not the only factor that determines where species are found. Historical records from the Interagency Ecological Program long-term zooplankton monitoring program show that the introduced calanoid copepod *Pseudodiaptomus forbesi* was once abundant across a broader range of salinity than where it is currently found in the San Francisco Estuary (SFE). Previously this copepod was abundant from freshwater to waters of salinity 5 and higher, however now it is generally found in waters less than salinity 5 and is most abundant in waters of salinity less than 1. This study examined how salinity affects both the survival and reproduction of this copepod, as knowledge of reproductive parameters is crucial to understanding and predicting population dynamics. Laboratory experiments on the acute salinity tolerance of this species indicated that it is physiologically capable of tolerating a much wider range of salinity than it currently inhabits in the SFE. Furthermore, experiments on reproductive output of *P. forbesi* indicate that it is more productive at salinities around 5-8 than it is at salinities 0-2, yet in the SFE it is far more abundant at the lower salinities. This study presents an example of an estuarine organism whose distribution is not shaped by physiological tolerance to salinity but rather by other factors such as interspecific interactions. Understanding the factors that affect species distribution allow for more accurate modeling of the system under current and future conditions. In particular, since copepods are an important lower-trophic link, understanding the distribution of copepods provides insight into the resources available to higher trophic levels.

Keywords: Salinity, Copepod, Distribution, Delta, *Pseudodiaptomus*, Ecology, Physiology, Invasive

Poster Topic: Invasive Species

Assessment of Revegetation of Tidal Marshes Following Invasive Spartina Control

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The colonizing of non-native species of *Spartina alterniflora* (smooth cordgrass) across the San Francisco Bay Estuary presents a conflict between balancing removal efforts while maintaining habitat for sensitive species such as the California Clapper Rail (*Rallus longirostris obsoletus*). Understanding tidal marsh's ability to revegetate following invasive *Spartina* control, is one component in understanding population trends of Clapper Rails in the Bay, while helping guide future efforts to control invasive *Spartina*.

To investigate the revegetation of San Francisco Bay marshes, we compared vegetation assessments collected in 2005, prior to the main *Spartina* eradication efforts, to assessments in the same marshes in 2011, post-eradication. Vegetation cover in the 2005 sampled plots used estimates generated from aerial imagery; this method was also applied to a subset of the 2011 plots, to compare accuracy to field collected data. The sampled plots could then be compared for changes in vegetation cover and composition of species. To investigate how *Spartina* control affected the Clapper Rail, we examined within and between marsh site use, in relation to vegetation cover in 2005.

A total of 183 points were examined for changes in cover and species composition. The comparison between aerial estimates and field estimates for 90 of the 2011 points were similar, averaging an 8.18% difference. Results show significant declines in *Spartina* cover, and increases in native vegetation, particularly *Sarcocornia pacifica* (perennial pickleweed).

Results show marshes possess the ability to rebound relatively quickly from invasive *Spartina* control, and native vegetation will recolonize the historic marsh plain. While we know the Clapper Rail is sensitive to local habitat changes and that there appeared to be a population wide impact following *Spartina* control, investigating this relationship using this dataset provides a novel approach to inform management of invasive *Spartina* and maintain viable Clapper Rail populations.

Keywords: Invasive Cordgrass Control, Spartina, Clapper Rail, Passive Revegetation, Tidal Marsh

Poster Topic: Invasive Species

Approaching Eradication of *Spartina densiflora* from the San Francisco Estuary: Successful Adaptive Integrated Pest Management

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Spartina densiflora (Chilean cordgrass) was introduced along Corte Madera Creek, Marin County in 1975 as part of a wetland restoration. Misidentified as a variant of native *Spartina foliosa* (Pacific cordgrass), it was subsequently imported from Humboldt Bay where it had been introduced in dry ballast deposited there during the 19th century timber trade with South America, sparking an infestation now dominating 2000 acres.

By 2004, *S. densiflora* dominated much of the Corte Madera Creek marshes and had spread throughout east Marin and across to eastern San Pablo Bay. The Invasive *Spartina* Project and Friends of Corte Madera Creek Watershed began treatment on these infestations in 2004-2006, relying predominantly on imazapyr herbicide in the initial years to gain control of the problem. Several major challenges to eradication quickly became evident. Entry into many infested marshes was restricted until the end of endangered California clapper rail breeding season on September 1, but *S. densiflora* sets seed by July, so that initial timing made it impossible to stay ahead of the infestation. To make matters worse, imazapyr produced extremely variable results on *S. densiflora*, although it worked exceptionally well on ISP's main target, hybrid *S. alterniflora.* Imazapyr arrested plant development in established monocultures of *S. densiflora*, but full mortality was rarely achieved, and seedlings/small plants with a higher root to leaf surface area ratio presented similar issues.

These mixed results required adaptation of the IPM strategy, combining multiple treatment tools and approaches to achieve success. In 2009, mowing was evaluated on the persistent, half-dead biomass remaining at monocultures of previously-sprayed *S. densiflora*. This elicited fresh green growth from plants that were still alive, identifying targets for retreatment with imazapyr or digging. Around the Estuary, treatment shifted to purely manual removal by ISP biologists to exhaust the seed bank and maintain an eradication trajectory.

Keywords: *Spartina*, *Spartina densiflora*, IPM, Integrated Pest Management

Poster Topic: Invasive Species

HACCP (Hazard Analysis and Critical Control Point Planning): A Risk Management Tool to Decrease the Movement of Invasive Species

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Without appropriate planning, activities that take biologists and their equipment to different habitats, including habitat restoration, monitoring, biological surveys, or collections, could be pathways for the spread of nonindigenous species. It is our responsibility as natural resource professionals to strive to do no harm by understanding invasive species pathways and developing plans to prevent future spread.

Hazard Analysis and Critical Control Point (HACCP) planning is a five-step tool that manages the risk of moving invasive species during natural resource management activities. The steps involve recognition of non-target, or potentially invasive, species, risk management and assessment of potential pathways, identification of critical points where there may be a risk of introducing a non-target species, and development and evaluation of control measures used to reduce this risk to an acceptable level. By following these steps, HACCP is designed to identify high-risk activities and focus attention on those actions needed to close open pathways. Plans documenting the risk posed by an activity for moving invasive species, as well as control methods used to reduce these risks, give managers the opportunity to weigh the benefits from natural resource actions against the risk of invasion. HACCP plans also create a reference source for documenting best management practices and procedures that can be shared with others to reduce this risk of invasion through pathways with similar characteristics

In 2011, an updated HACCP course was completed that incorporates comments and suggestions from previous courses (please visit http://www.haccp-nrm.org for more information). In addition to the standard HACCP course which focuses on the development and implementation of HACCP plans, a new Train the Trainer course has been developed for new HACCP instructors. Upcoming course information is available from the U.S. Fish and Wildlife Service's National Conservation Training Center located in Shepherdstown, West Virginia.

Keywords: HACCP, Invasive Species

Poster Topic: Invasive Species

Compliance of Ballast Water Management for Commercial Ships Operating in the San Francisco Estuary

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The discharge of ballast water from commercial ships is a well-known and highly documented vector for the introduction of nonindigenous species (NIS) to California waters, especially within the San Francisco Estuary (SFE). It is estimated that up to 81% of California's 257 established aquatic NIS were introduced via commercial shipping, both through ballast water discharge and/or release of associated biofouling. In order to address this, the California State Lands Commission's Marine Invasive Species Program (MISP) has pursued the prevention of NIS release from commercial vessels into California waters since 2000. A vital information-gathering component of the MISP is the requirement that vessels submit ballast water reporting forms upon departure from each port or place of call in California. These forms detail ballast water management activities for the approximately 3,700 vessel arrivals to SFE ports each year, forming a robust data set through which compliance and management patterns can be examined. An analysis of ballast water management compliance at SFE ports from 2008-2012 will be presented including geographic and temporal analyses of source and exchange patterns of ballast water that is eventually discharged within the estuary. The analysis will also include a description of how these data are used to help MISP staff to reduce the risk of future NIS introductions.

Keywords: Nonindigenous Species, Ballast Water, Commercial Shipping

Poster Topic: Invasive Species: Commercial Vessels

Risky Business: Comparative Nonindigenous Species Risk from Vessels at San Francisco Estuary Ports

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Nonindigenous species (NIS) are organisms introduced through various human activities to an area where they do not naturally or historically occur. Once established, NIS can have severe ecological, economic, and human health impacts on the receiving environment. One of the most severely invaded ecosystems in North America is the San Francisco Estuary (SFE); roughly 65% of California's currently established marine NIS were first documented in the SFE. In coastal environments, commercial shipping is the most important vector of NIS introductions, contributing up to 79.5% of introductions to North America and up to 81% in California. Commercial ships transport organisms through two primary mechanisms: ballast water and vessel biofouling. The State Lands Commission Marine Invasive Species Program (MISP) tracks vessel arrivals at seven commercial port regions within the SFE. These arriving vessels pose varying levels of risk for introducing NIS from ballast water discharge and biofouling accumulation. Analyzing data collected by the MISP on vessel ballast water and biofouling management from 2008 to 2012 will allow us to identify patterns in management for the vessels arriving in the SFE. These management patterns can help us understand the potential invasion risk within the estuary.

Keywords: Nonindigenous Species, Ballast Water, Biofouling, San Francisco Estuary, Invasion Risk

Poster Topic: Invasive Species: Commercial Vessels

Hull Husbandry Patterns of Commercial Vessels Operating Within the San Francisco Estuary: Implications for Vessel Biofouling and Species Introductions

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Commercial shipping is a major industry within the San Francisco Estuary (SFE), as more than 3700 vessels arrive annually to the seven major ports within the SFE. Because shipping is a global industry, this activity brings goods, jobs, and revenues to California from all over the world. Unfortunately, shipping also brings nonindigenous aquatic organisms from all over the world into the SFE through the combined shipping-related mechanisms (vectors) of ballast water and biofouling. Once established, these nonindigenous species (NIS) can have deleterious effects on their receiving environment.

It is widely recognized that the SFE is one of the most heavily invaded water bodies in the world, with approximately 200 aquatic NIS (excluding vascular plants and vertebrates) currently established. This pattern is partially a result of the heavy shipping traffic to ports within the SFE, as up to 62% of currently established NIS in SFE are attributed to biofouling as a likely vector. In order to address the continued risk of NIS introduction through the vessel biofouling vector, the California State Lands Commission's Marine Invasive Species Program has been collecting annual ship-reported biofouling management data from each vessel operating in the state. An analysis of this multiyear dataset will be presented, describing patterns in vessel biofouling management specifically for the vessels that operate within the SFE. The analysis will also include a description of how these data are being used to inform the development of biofouling management regulations for vessels operating in California, to reduce future NIS introduction risk.

Keywords: Invasive Species, Nonindigenous Species, Biofouling, Shipping, Vessels, Vector, Vector Management

Poster Topic: Invasive Species: Commercial Vessels

Quantifying External Nutrient Loads to San Francisco Bay

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Nutrient loads to and concentrations in subembayments of San Francisco Bay are comparable to or greater than those in other estuaries that experience beneficial use impairment due to nutrient over-enrichment. The combination of high nutrient availability and changes in environmental factors that regulate the Bay's response to nutrients has generated growing concern about whether areas of the Bay are trending toward, or may already be experiencing, nutrient-related impairment. To help inform nutrient management considerations, we estimated external nutrient loads to the Bay from multiple point and non-point sources, evaluated how those loads vary spatially and temporally in magnitude and speciation, and assessed the relative importance of various sources. On an annual-average basis, all considered sources combined for loads of 75000 kg d^{-1} dissolved inorganic nitrogen and 6000 kg d^{-1} phosphate Bay-wide. Treated wastewater effluent from the 42 publicly-owned treatment works (POTW) that service the Bay Area's 7.2 million people contributed 34000 kg d^{-1} ammonium, 12000 kg d^{-1} nitrate, and 4000 kg d^{-1} phosphate. The dominant sources of N and P loads, and the form of N, varied substantially among subembayments. In southern subembayments, POTWs were the dominant N and P sources. Exchange with the coastal ocean has the potential to be a substantial net source of nutrients, but remains poorly quantified and highly uncertain. Although stormwater loads estimates developed to date are highly uncertain, in most subembayments and during most of the year stormwater nutrient loads were substantially less than POTW loads, with potential exceptions being loads to northern subembayments. The San Joaquin and Sacramento Rivers, which enter the northern Bay through the Delta after draining ~40% of California, deliver approximately 90% of the Bay's freshwater inputs, and have the potential to be large and seasonally-dominant nutrient sources to northern subembayments, potentially constituting 25-30% of annual-average Bay-wide loads.

Keywords: Nutrients, External Loads, Seasonality, Spatial Variability

Poster Topic: Nutrients

Nutrient Exchange in Northern San Francisco Bay Sediments: Rates, Environmental Controls, and Impacts of Invasive Bivalves

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Algal production in the Northern San Francisco Bay region is sustained by direct inputs of nutrient elements and both water column and sediment nutrient recycling. Differential retention and recycling of sediment nitrogen and phosphorus may lead to changes in nutrient effluxes to the overlying water and have consequences for the productivity and composition of phytoplankton communities. Using core incubations, we have measured the net exchange of nitrogen, phosphorus and oxygen at the sediment water interface of Sacramento-San Joaquin Delta and Suisun Bay tidal environments, including microbial denitrification and benthic microalgal production during late spring and summer. Additional measurements have been made of oxygen penetration, bioirrigation, invasive bivalve biomass, and pore water chemistry. Most sites have moderate rates of sediment metabolism, nutrient efflux and denitrification, with high rates of benthic microalgal photosynthesis in shallow water Delta environments. Sites with invasive bivalves (*Corbicula fluminea, Potamocorbula amurensis*) have higher rates of sediment metabolism and nutrient exchange. The observed rates of nutrient recycling and denitrification are consistent with low algal biomass. These data suggest that Bay-Delta sediments are important sites for nutrient recycling, transformation and retention. These data will help inform nutrient models and contribute to our growing understanding of sources and fates of nutrients in this system.

Keywords: Nutrients, Sediment-Water Exchange, Denitrification, Invasive Bivalves, Sediment, Nitrogen, Phosphorus

Poster Topic: Nutrients

How Anthropogenic Nutrients from Wastewater Treatment May Contribute to Low Phytoplankton Productivity and Blooms in the San Francisco Estuary

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For the last 20 years, studies of water quality and phytoplankton in the San Francisco Estuary (SFE) focused on measuring nutrient concentrations and chlorophyll with relatively few direct measurements of primary production and virtually no estimates of nutrient uptake. The paradigm was that the elevated inorganic nutrients (mostly anthropogenically derived) had no impact on blooms. However studies suggest that the chemical form of inorganic nitrogen (N) and nitrogen to phosphorus ratio in SFE waters may influence algal production and the occurrence of blooms as well as food web composition. With increasing human population, anthropogenic N loads to estuaries are increasingly in reduced forms (ammonium; urea) resulting from wastewater treatment rather than oxidized forms (nitrate). Ammonium may a) inhibit the potential for phytoplankton blooms (oligotrophication) by preventing access to nitrate and b) shift phytoplankton functional groups away from diatoms to phytoplankton that are more ammonium-tolerant. We evaluated whether N redox state and N:P stoichiometry would influence SFE phytoplankton by measuring nutrient uptake and primary productivity in experimental enrichments with combinations of ammonium, nitrate and P. Added ammonium consistently inhibited nitrate uptake and promoted the growth of cryptophytes. Nitrate enrichment and low N:P conditions favored diatoms. Phytoplankton altered N:P assimilation in response to experimentally manipulated N : P availability. These findings provide a revised view of how changes in estuarine nutrient loading due to wastewater treatment practices can influence eutrophication responses.

Keywords: Phytoplankton, Nitrogen, Ammonium

Poster Topic: Nutrients

Reinventing Water Infrastructure in the Face of Uncertainty: An Integrative Approach to Nitrogen Management in the San Francisco Bay

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Recent data suggest that the San Francisco Bay is at a growing risk of eutrophication. As a result, protection of the ecosystem may require reducing the mass of nitrogen released to the Bay. Stakeholders have expressed interest in new approaches for controlling nitrogen discharges that realize co-benefits, such as habitat restoration, protection from sea-level rise and simultaneous removal of other contaminants. There is currently considerable uncertainty about the cost and efficacy of such innovative control strategies. In contrast, the performance of traditional approaches to managing nitrogen by controlling point sources (i.e., adding additional unit process to existing wastewater treatment plants), which tend to be energy intensive and vulnerable to climate change impacts, are known with a high degree of certainty. To assess the merits of investing in new types of urban water infrastructure that achieve both nitrogen reduction and co-benefits that are important to key stakeholders, a multi-criteria decision-making approach was used for assessing different scenarios relevant to the Bay. The analysis compares the use of engineered wetlands for treatment of municipal wastewater effluent, riparian buffer strips for treatment of nitrogen in agricultural runoff and green infrastructure on the eastern side of the city of San Francisco for treatment of urban runoff and minimization of combined sewer overflows with conventional forms of nitrogen control at municipal wastewater treatment plants. The analysis identifies the need for additional data to decrease uncertainty and give decision-makers confidence in investments in new forms of infrastructure. Pilot projects can serve as laboratories to fill data gaps while simultaneously familiarizing the community with the co-benefits associated with new forms of urban water infrastructure.

Keywords: Nutrients, Nitrogen, Stormwater, Decision-Making, Wetlands

Poster Topic: Nutrients: Nitrogen

Nitrogen Pollution in Tilden Park's Lakes and Ponds

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Nitrogen is one of the major nutrients for plant growth. Through this project I hoped to understand the effects that nitrogen pollution from humans and cows has on lakes and ponds in the Bay Area watersheds, specifically evaluating surface waters in Tilden Park, a 2,079 acre regional park. I sampled four ponds: a pond off of the Nimitz way trail, an area which is used to graze cattle; Jewel Lake, which is below the little farm; Lake Anza a bathing area; as well as Wildcat Creek which runs between Lake Anza and Jewel Lake. I hypothesized that the pond off of Nimitz Way would be most affected by nitrogen pollution as it would be contaminated with cow manure, followed by Jewel Lake as it would gather run off from the livestock, Lake Anza would be next as the urine from the bathers contains urea and therefore nitrogen, the cleanest would be Wildcat Creek as it is a protected stream whose bacteria would filter the nitrogen. In addition, to find out how nitrogen pollution from outside sources affected the algae within the ponds, I incubated test tubes of surface water with different sources of nitrogen in the laboratory. To measure nitrate in ponds, I prepared a cadmium reduction column and used a spetrophometer to measure the colorimetric changes. Concentrations of nitrate in these surface waters ranged from 0.5 to 6.5 x 10^{-6} M, with the highest concentrations observed at Wildcat Creek. Based on the results of this experiment, I found that nitrogen pollution from humans and livestock in Tilden Park can result in an increase in algae growth.

Keywords: Nutrients, Nitrate, Watersheds, Tilden Park

Poster Topic: Nutrients: Nitrogen

Nitrogen Removal and Energy Recovery with the Coupled Aerobic-Anoxic Nitrous Decomposition Operation (CANDO)

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The Coupled Aerobic-anoxic Nitrous Decomposition Operation (CANDO) is a new wastewater treatment process that removes and recovers renewable energy from reactive nitrogen (NH_4^+). The process consists of three steps: (1) NH_4^+ oxidation to NO_2^- (2) NO_2^- reduction to N_2O, and (3) N_2O conversion to N_2 with energy recovery by using N_2O as an oxidant in biogas combustion.

This work demonstrates steps (1) and (2) at the bench-scale treating synthetic and real anaerobic digester supernatant, and step (3) at full-scale on a biogas-fed internal combustion engine. Step (1) is demonstrated by a continuous flow partial nitrifying reactor that oxidizes >85% NH_4^+ to NO_2^-. Step (2) is demonstrated by two strategies: (1) a biological strategy favoring microorganisms that store polydroxybutyrate, then oxidize it to reduce NO_2^- to N_2O, and (2) an abiotic strategy where carbonate green rust reduces NO_2^- to N_2O. For the biological strategy, NO_2^- supplied from the partial nitrifying reactor is reduced to N_2O, with acetate as the electron donor, achieving 60-80% conversion over multiple cycles. For the abiotic strategy, a closed loop Iron cycle couples carbonate green rust oxidation with NO_2^- to N_2O reduction, and then regenerates the oxidized Iron back to carbonate green rust with Fe(II) from an acetate-fed microbial community, achieving >90% N_2O conversion. Step (3) is demonstrated by N_2O injections in a full-scale biogas engine that increase power output by 4-8% (7-14% N_2O by volume). Many processes recover energy from waste COD as CH_4; but none recovers energy from waste nitrogen. As compared to conventional nitrification/denitrification, CANDO is expected to decrease oxygen demand, decrease biosolids production, increase organic matter for biogas production, and recover energy from nitrogen waste.

Keywords: CANDO, Wastewater, Nutrients, Energy Recovery

Poster Topic: Nutrients: Nitrogen

Is Urea of Water Quality Concern in the San Francisco Estuary?

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Increasing anthropogenic sources of nitrogen as urea from agriculture and wastewater have resulted in elevated urea concentrations in many estuarine and coastal environments. This has the potential to adversely affect coastal and estuarine environments. The San Francisco Estuary (SFE) is strongly influenced by agriculture and a large metropolitan area. However, little data is currently available regarding urea concentrations in the SFE or the potential ecological effects of increased urea to the estuary. Nearly one thousand discrete measurements of urea concentration, along with other water quality data (macro-nutrients and chlorophyll-*a*) have been made throughout the northern SFE for the past six years. In contrast to some other estuaries, urea is generally less than 1µM-N urea, representing a small percentage of the nitrogen pool. Additionally, a preliminary set of urea uptake measurements (using 15N-labeled urea) suggest that both ammonium and nitrate are larger contributors to phytoplankton nitrogen uptake in the estuary. These results suggest a limited role for urea in phytoplankton-nutrient dynamics in the SFE.

Keywords: Urea, Phytoplankton, Nitrogen, Estuary

Poster Topic: Nutrients: Nitrogen

Measurements and Potential Significance of Urea as a Nitrogen Source for HAB Species in San Francisco Bay, California: A One Year Pilot Study

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Since 1968 the U.S. Geological Survey has maintained a program of research and observation in San Francisco Bay. The program includes measurements of dissolved inorganic nutrients, but organic forms of nutrients including urea are not regularly measured and their concentrations are unknown. Urea is important because it can promote growth and toxicity of harmful algal bloom (HAB) phytoplankton species. We conducted a one-year study of monthly sampling in 2011 to measure urea concentrations at five stations chosen to represent the major sub-embayment of varying hydrography and nutrient chemistry: South Bay, Central Bay, San Pablo Bay, Suisun Bay and the Sacramento River. Each station had maximum urea concentrations in February. The South Bay, Central Bay and San Pablo Bay stations saw urea concentrations above a threshold (1.5 µM) that promotes growth of some HAB-forming dinoflagellates and flagellates. South Bay concentrations exceeded the threshold in December, February, August, and September (1.5-2.5 µM) and maintained the greatest overall mean concentration (1.3 µM). Samples were above the threshold in Central Bay in January and February (1.7 and 3.0 µM respectively) and San Pablo Bay in February (2.0 µM); both stations sustained low values during the other months (0.1-1.2 µM). The Suisun Bay and Sacramento River stations always had low concentrations (0.2-1.3 µM). Based on previous studies and these new findings, we conclude that urea is a potentially significant nitrogen source for phytoplankton in marine-influenced regions of San Francisco Bay. The urea concentrations measured in South Bay, Central Bay and San Pablo Bay are comparable to those seen in research linking urea to HAB species. These results warrant inclusion of urea in monitoring programs and further studies to identify the sources of urea in San Francisco Bay.

Keywords: Nutrients, Urea, Harmful Algal Bloom Species, San Francisco Bay

Poster Topic: Nutrients: Nitrogen

Nitrogen and Chlorophyll A Flux Between a Restored Tidal Wetland (Blacklock Marsh) and an Adjacent Bay in Suisun Marsh

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Large-scale wetland restoration has been proposed for the northern San Francisco Estuary and Delta as a means to improve water quality by mitigating anthropogenic nutrient loads and to increase organic matter production as food resources for zooplankton and planktivorous fish. Presently, few studies exist that demonstrate such improvements will occur with wetland restoration in the SFE. The goal of this ongoing study is to quantify nutrient and chlorophyll-a exchange between a recently restored wetland (Blacklock Marsh) and the adjacent open water habitat (Little Honker Bay) within the Suisun Marsh complex. In June 2013, we began testing the hypothesis that Blacklock Marsh acts as a sink for dissolved inorganic nutrients and as a source of chlorophyll-a for Little Honker Bay. Samples of surface water were collected hourly over a tidal cycle at a breach in a levee surrounding the marsh. Preliminary data show higher nitrate concentrations in samples taken on flood tides than those taken during ebb tides, suggesting that biological and/or physical processes within the marsh decrease nitrate. Additional analysis of measurements made in summer 2013 will be used to quantify nutrient and chlorophyll-a flux in Blacklock Marsh to better constrain nutrient and organic matter budgets. Budgetary findings from this study may assist management in making decisions about future wetland restoration projects.

Keywords: Wetland Restoration, Water Quality, Organic Matter Production, Nitrogen, Chlorophyll A

Poster Topic: Nutrients: Nitrogen

The Oro Loma Ecotone Project: Nitrogen Removal in a Constructed Wetland Habitat on San Francisco Bay

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Results from recent studies of San Francisco Bay suggest that it may be necessary to reduce the mass of nitrogen discharged by municipal wastewater treatment plants. Conventional approaches for nitrogen control, such as biological nutrient removal, tend to be energy intensive and expensive. As an alternative, it may be possible to use managed natural systems to remove nitrogen from wastewater while simultaneously obtaining co-benefits including improvement of wetland habitat and adaptation of coastal systems to the effects of sea-level rise. To assess the potential for achieving nitrogen removal in a managed natural system, the Oro Loma Sanitary District plans to build a demonstration project at its treatment plant in San Lorenzo on the East Bay. The Oro Loma Ecotone Project will employ a sub-surface constructed wetland to remove nitrate from wastewater effluent through denitrification and plant uptake on a 180-meter wide sloped surface adjacent to the treatment plant. Experiments will be conducted in a series of test-strips to determine the effects of fill material and plant species on nitrogen removal and habitat creation. Data collected as part of the project will also provide information needed to assess the costs and benefits of applying this approach in other coastal systems located along the Bay.

Keywords: Nitrogen, Nutrients, Wetlands, Sea-Level Rise, Ecotone, Habitat Restoration

Poster Topic: Nutrients: Nitrogen

Does Nitrogen Form Make a Difference in the Amount of Nitrogen Algae Take Up? Some Forms are More Equal than Others

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One of the common assumptions in nutrient ecology is that algae will use the same total amount of nitrogen (N) whether the N is provided in chemically oxidized (e.g. nitrate) or reduced (e.g., ammonium, urea) form. Indeed, when cells are growing under conditions of balanced or acclimated growth, and when cells are growing at maximal growth rates (set by culture conditions of light, temperature, etc.), it is fully expected that the total N taken up by cells will be the same regardless of the form provided (assuming that species has the necessary transporters and other physiology). On the other hand, uptake and growth are more typically uncoupled in natural conditions. Under those conditions, there is evidence that at elevated concentrations of NH_4^+, inhibition of NO_3^- uptake can result in an actual decrease in total N uptake and in primary productivity. Using data from nutrient-enriched mesocosms, with samples collected from both the Sacramento River and Suisun Bay at different seasons, we show that total N uptake indeed differs on time times from hours to days when cells are provided nitrate, ammonium or a combination and whether those treatments were balanced in phosphate availability. These results show that total N uptake does vary with the form of N substrate, a finding that has relevance to the discussion over nitrification of wastewater effluent.

Keywords: Nitrogen, Ammonium Inhibition, N Productivity

Poster Topic: Nutrients: Nitrogen

Nitrogen Uptake by the Bloom-Forming Blue-Green Alga, *Microcystis aeruginosa*, in the San Francisco Estuary Delta

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In the last decade there has been an apparent increase in frequency and intensity of the harmful cyanobacterial bloom-former *Microcystis aeruginosa* in the San Francisco Estuary Delta (Delta), the heart of California's water infrastructure. It has been suggested that anthropogenic nitrogen, specifically ammonium and urea, may promote these blooms. Currently, little is known about which chemical forms of nitrogen are used by *M. aeruginosa* in the Delta. Nitrogen uptake kinetic experiments with field-collected *M*. *aeruginosa* were conducted using four ^{15}N-labeled substrates (nitrate, ammonium, urea and glutamic acid). Maximum biomass-specific uptake rates were highest for ammonium (up to 74.3 x 10^{-3} h^{-1}) and lowest for glutamic acid (< 2.0 x 10^{-3} h^{-1}). *M. aeruginosa* showed preference (i.e. greater uptake) for nitrogen in the following order: ammonium, urea, nitrate, glutamic acid. *M. aeruginosa* does not appear to be nutrient-saturated at ambient field concentrations of ammonium, urea or nitrate, indicating a potential for enhanced growth with future increases in nitrogen. Uptake parameters (Ks and Vmax) obtained from this study were compared to published values for other phytoplankton taxa and indicated that *M. aeruginosa* has a competitive advantage for ammonium uptake over other phytoplankton. The preference by this fairly recent newcomer to the Delta for reduced forms of nitrogen may explain its success in an environment influenced by a growing human population and the accompanying increased anthropogenic nitrogen loading from waste water treatment and agricultural practices. Understanding which forms of nitrogen *M. aeruginosa* utilizes most efficiently will be useful for informing management to mitigate these blooms, which may have negative effects on the Delta food web.

Keywords: *Microcystis aeruginosa*, Nutrient Uptake Kinetics, Increased Nitrogen, Ammonium, Cyanobacterial Bloom

Poster Topic: Nutrients: Nitrogen

Do Ammonium/Nitrate Conditions Play a Role in the Initiation of Spring Blooms in South San Francisco Bay?

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Recent studies of nutrient conditions and phytoplankton bloom initiation in the northern San Francisco Estuary (SFE) reveal a predictable pattern: 1) with improved irradiance, algal ammonium uptake causes a decline in ammonium concentration, enabling 2) a larger pool of DIN, nitrate to be assimilated by phytoplankton that results in 3) rapid chlorophyll accumulation that outpaces dispersive or grazing losses leading to a phytoplankton bloom. Do spring blooms in South SFE (South Bay) follow a similar sequence? South Bay is different from the northern SFE in at least two respects: 1) a lagoon type circulation resulting in longer residence time and 2) a discharge of advanced secondary treated effluent with high nitrate concentrations. In 2008, the spring bloom in South Bay followed the pattern observed for the northern SFE. Ammonium declined (~15 μmol L^1 to <1 μmol L^1), along with nitrate (~50 μmol L^1 to zero) and chlorophyll increased (5 to >40 μg L^{-1}). Silicate declined from 85 μmol L^1 to zero signifying substantial diatom production. Contouring the nutrient and chlorophyll concentrations on location and time axes showed the progression of the bloom from south to north with the declines in silicate and nitrate and increase in chlorophyll tracking the contour where ammonium = 1 μmol L^{-1}. Nitrogen uptake rates measured using 15N showed the same inhibition of NO_3 uptake by NH_4 observed in the northern SFE. The keys to large spring blooms in South Bay are, in addition to favorable irradiance conditions, a high ratio of nitrate to ammonium and long residence time allowing ammonium to be reduced to low levels that enable rapid uptake and full utilization of the large NO_3 and $Si(OH)_4$ pools by diatoms.

Keywords: Phytoplankton, Ammonium, Silicate, Diatom, South Bay

Poster Topic: Nutrients: Nitrogen

Restoring a Sense of Hope: Involving High School Students in Conservation

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Increasing challenges of habitat loss, climate change, and the disconnect between the public and these issues provides environmental educators the opportunity to offer science-driven, solution-oriented activities. Point Blue Conservation Science (Point Blue) has made great strides towards addressing these issues through our community-based restoration program, Students and Teachers Restoring A Watershed (STRAW)**.** This year we added a component to address these issues with high school students, an age group underserved by environmental programs. Focusing on climate change, ecological restoration, and the scientific method, we built a new science curriculum around one of STRAW's sites, the Hamilton Wetland Restoration Project in Novato, California**.** We engaged 150 high school students and 30 4th grade students. High school students worked with peers, professionals and elementary students in the field to plant native vegetation in a designated upland transition zone. In class Point Blue restoration specialists, biologists, and educators delivered lessons on wetlands, soil, climate change, ornithology and history of the Hamilton site. Students learned field skills to collect baseline bird and soil data to monitor ecosystem response to the restoration. Students followed Point Blue's standardized area search protocol during the waterbird surveys. Students sampled soil salinity and texture along designated transects. Next year students will collect data using the same methods, post levee breach. We assessed student progress and our ability to meet our objectives this first year by administering a pre and post-program assessment to all 150 high school students and leading a post-program pizza lunch discussion with a cross-section of students. Our goal by the end of 2014 is to develop a successful model to involve high school students in the solution to climate change and other environmental problems through habitat restoration and scientific monitoring.

Keywords: Restoration, Bird Monitoring, Native Vegetation Planting, Student Education, Citizen Science

Poster Topic: Public Education & Outreach

Digging Into Restoration Technology: Implementing Next Generation Science Standards in Student Wetland Restoration Programs

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Recognizing a need to incorporate higher level science curriculum into our Education Program offerings, Save The Bay designed Digging Into Restoration Technology (D.I.R.T.) to engage students in hands-on data collection of soil characteristics along an elevation gradient. Now entering its third year, D.I.R.T. has reached six Bay Area schools and over four hundred students. This program incorporates service learning, biology/chemistry principles, and technology utilization into a multi-day field experience conducted at active restoration sites on the shores of San Francisco Bay. Using SPARK data collectors and Hanna salinity meters, students sample soil pH, salinity, soil moisture and GPS coordinates along transects in both restored and unrestored sites. Back in the classroom, students analyze data electronically and upload graphical results to Save The Bay's web-based classroom extension, the Virtual Marsh: www.virtualmarsh.org.

Upon publication of the Next Generation Science Standards, we adapted the D.I.R.T. curriculum to align more closely with the core ideas and practices of these standards. Major modifications include the addition of Simpson's Biodiversity Index sampling, as well as a more deliberate focus on drawing connections between soil characteristics and plant life to inform student recommendations for future restoration plans.

This poster examines the challenges and successes encountered throughout the three year evolution of the D.I.R.T program, focusing specifically on the use of the Next Generation Science Standards to guide curriculum refinement.

Keywords: Community Based Restoration, Outdoor Education, Next Generation Science Standards

Poster Topic: Public Education & Outreach

Community Outreach, Education, and Mobilization of Volunteers for Native Oyster Reef Restoration

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The Watershed Project's Living Shoreline Program connects the community with a habitat that's often unexplored, the intertidal and subtidal ecosystems of San Francisco Bay.

The program's largest restoration project to date, a native oyster reef at Point Pinole Regional Park, provided the community with an opportunity to contribute their time, energy, and enthusiasm to improving the future health of the Bay.

Volunteers, each with their own particular interests in the project, helped to construct 100 oyster reef balls. This process involved the mixing of oyster shell and sand that had been dredged from the Bay with cement to create BayCrete. The mixture was then poured into molds to create the reef balls.

The Watershed Project begins each workday with volunteers sharing the following environmental story: the past, present, and future of Olympia oysters in San Francisco Bay. Volunteers then understand the context for their service and how each person is enhancing the Bay for years to come.

The Living Shoreline Program used various methods for volunteer recruitment, including our monthly E-newsletter, our in-house email list, personalized email lists, flyering at local environmental events, and community presentations. Our public outreach resulted in engaging 26 community volunteers. Out of those 26 volunteers, 9 people came back to volunteer an additional 22 times. Our volunteers contributed a total of 144 hours.

It speaks to the success of the program that volunteers repeatedly come back to perform work that involves being outdoors, getting dirty, and heavy lifting. We make every effort to connect and build relationships with our volunteers. We understand that providing a positive experience, combined with doing something worthwhile for the environment helps create environmental stewards.

(When the project is completed in August, I anticipate our recruitment numbers to increase to approximately 50 volunteers and 251 hours)

Keywords: Outreach, Native Oysters, Reef Balls, Restoration, Public Education, Point Pinole

Poster Topic: Public Education & Outreach

Clean Creeks, Healthy Communities: A Trash Reduction Pilot Program

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Coyote Creek, in San José California, is a ribbon of natural open space running through the heart of the heavily urbanized Santa Clara Valley. In central San José the creek is heavily impacted by trash pollution from litter, illegal dumping, and homeless encampments. The trash and poor condition of the riparian corridor harms water quality, dissuaded residents from use of the area, and impacts the surrounding environs.

In 2011 the City of San José received a grant from the U.S. EPA Water Quality Improvement Fund for a pilot project, Clean Creeks, Healthy Communities, to partner with organizations and agencies beyond the environmental field to collaboratively address the different causes of the trash pollution and reconnect the community to the creek. This project is based on the idea that detrimental behaviors occurring in the creek corridor are synchronistic and contribute to both degradation of water quality and blight in the area. The intent of the project is to reach a tipping point in the condition of the creek whereby community members gain appreciation of the creek as a community asset and are able to sustainably deter trash-generating behaviors through ongoing activities.

This poster will examine the strategy behind the Clean Creeks, Healthy Communities project and discuss the accomplishments and challenges the project has encountered at the mid-point of the project term.

Keywords: Trash, Illegal Dumping, Homeless Encampments, Volunteers, Outreach, Cleanup, Stewardship

Poster Topic: Public Education & Outreach

Tide Gate Closures Affect Dissolved Oxygen in Lake Merritt

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Tidal flushing in Lake Merritt, a tidal lagoon, is managed by the Alameda County Flood Control District at the Lake Merritt Flood Control Facility. The Facility provides a tidal barrier to flow between the Lake and the Oakland Harbor. Tide gates are closed at low tide when a 50% or greater chance of rain is forecast to prevent flooding as high tides meet fresh water inflows from storm run-off. The gates may remain closed for several days. Recently, the gates have been closed during construction of improvements to the Lake Merritt Channel funded by Measure DD.

The Lake Merritt Institute's "Dissolved Oxygen White Paper "(2002) called attention to the negative impact of tide gate closure on dissolved oxygen in the lake. It made recommendations for operating the gates to reduce impact on aquatic wildlife. Efforts to monitor the dissolved oxygen levels in the lake have consisted of brief contracted monitoring by the City of Oakland and the weekly volunteer monitoring by Oakland High School's Environmental Science Academy (ESA) students during the academic year.

To explore the effect of tide gate closure on dissolved oxygen, we 1) examined tide charts from the Lake Merritt Flood Control Facility from June-December 2012 and 2) analyzed ESA's 15-year data set to see when and where dissolved oxygen levels dropped below the standard of 5 ppm.

Our data indicate that closing the gates lowers the dissolved oxygen significantly, especially at the bottom of the water column. Organisms that cannot move may experience long periods of hypoxia. It suggests that we will not see benefits of widening the Lake Merritt Channel until closures are reduced. A more precise understanding of freshwater input from the watershed after rains is needed to respond adaptively to increased precipitation with climate change.

Keywords: Dissolved Oxygen, Monitoring, Tide Gate, Tidal Range, Measure DD

Poster Topic: Public Education & Outreach

San Francisco Historical Ecology Transect Exhibit

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To engage the general public with the ecology and history of the Bay Area, The Exploratorium science museum undertook a study to create an exhibit highlighting landscape change over time on the San Francisco Peninsula.

The Exploratorium collaborated with scientists from San Francisco Estuary Institute and a UC Berkeley PhD student/artist-in-residence to research and illustrate contemporary and historical conditions along a transect stretching from the Bay Bridge to the Golden Gate Bridge. The illustrated transect explores the transformation of San Francisco's northeastern corner from initial European settlement (c. 1850) to today, revealing changes in surface conditions, underground infrastructure, habitat patterns and shoreline gradients. The team referenced a wide range of historical and contemporary sources including initial accounts of European explorers, the earliest U.S. Coast Survey maps, geologic and soil borings over time, city infrastructure documentation, ecologic research studies, the latest NOAA bathymetry surveys, image libraries and expert opinion.

This representation of a slice of the city through time invites the public to investigate land use change by juxtaposing historic and present-day views and relating well-known landmarks such as the bridge towers, the Embarcadero seawall, Coit Tower, or Fort Mason piers to past land forms, vegetation, and wildlife. The scale of human impact on the landscape is emphasized and compared with the time scales of geologic formations. A curated collection of illustrations, diagrams, photographs and first-hand accounts help contrast the dynamics of these two vastly different landscapes from the perspectives of ecologic function (such as sand dune formation and habitat), physical processes (such as bridge scour) and human use (such as shipping and commerce). To correlate direct observation of the local landscape with the interpreted data, the transect is presented as a large-scale mural in the Exploratorium's Bay Observatory, in close proximity to the study area.

Keywords: Historical, Ecology, Shoreline, Change, Land Use, Museum, Education, Art, Urbanization

Poster Topic: Public Education & Outreach

Design and Implementation of a Hands-On Water Engineering Challenge for a Public Science Center: An Interdisciplinary Collaboration of Scientists, Engineers, and Museum Staff

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An interdisciplinary team of graduate students and a postdoctoral scholar from the University of California, Berkeley and Stanford University collaborated with museum educators from the Ingenuity Lab at the Lawrence Hall of Science in Berkeley, CA to create a hands-on, engineering design challenge. The challenge investigated managing stormwater in cities with watersheds like that of the San Francisco Bay. The exhibit was showcased for nine days in February 2013, and more than 1000 visitors participated in the challenge. Participants designed and built a portion of a city landscape using simple materials and tested their city's ability to retain stormwater, prevent flooding, and capture pollutants, while considering ecological impacts on the bay. Visitors iteratively improved their designs to better use green infrastructure to protect the bay, often designing multiple city landscapes. Ingenuity Lab staff considered the challenge a success because it appealed to both female and male children, and visitors stayed an average of 32±14 minutes, a relatively long time compared to typical museum exhibits. Moreover, survey responses demonstrated visitors' understanding of the issues and terminology of infiltration and runoff, as well as the importance of green infrastructure in urban design. This collaboration allowed the design team to distill their work down to basic concepts and provided Ingenuity Lab visitors with a relevant, real-world engineering problem. In this way, the public was exposed to local stormwater management and its impact on aquatic ecosystems, influencing them to further pursue the issue.

Keywords: Public Education, Stormwater, Green Infrastructure, Museum

Poster Topic: Public Education & Outreach

Change Our Disposable Plastic Waterways

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Human litter, plastics and other marine debris are some of the greatest threats to marine life today. Since 2009, Wood Middle School 6th grade SLWRP (service-learning waste reduction project) classes have worked at study sites at Crown Memorial Beach to collect and analyze marine debris with a focus on nurdles. Over 5,000 nurdles have been sent to Dr. Hides Takada for analysis through the International Pellet Watch Program. Students work 1 x 1 meter plots, collecting nurdles, polystyrene, cigarette filters, and other harmful debris that affects ocean food webs. Wood School is a third year recipient of a NOAA Ocean Guardian Grant to facilitate this work. Our Mission Statement is: practice environmental awareness to use less, recycle more, and to protect the San Francisco Bay ecosystems from pollution. Our service-learning work is a collaboration among StopWaste.org, ACOE SLWRP, and East Bay Regional Park District. In 2009-10, students worked with park staff through the process from design to installation of a colorful educational sign about plastic pollution at Shoreline Drive and Grand Street on Crown Beach. Our nurdles data can be viewed at www.pelletwatch.org. In May 2011, Wood SLWRP Program received a Congressional Award from Congressman Sam Farr for its outstanding work in environmental education supporting ocean health. When students lead by teaching others about ocean literacy, powerful learning, civic responsibility, and community pride abounds. Service-learning collaborations such as those above are rewarding for students and community while contributing to the physical, chemical, and biological integrity of the San Francisco Bay estuary and its ecosystems. Transportation costs are the most prohibitive barrier to student service work. Agencies should seek grants or awards to assist schools in accessing service opportunities within the estuarine system.

Keywords: Marine Debris, Nurdles, Hydrophobic, Polystyrene

Poster Topic: Public Education & Outreach

California Estuary Monitoring Workgroup: Using Web Portals to Improve Scientific Understanding

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After the initial portal launch in fall 2013, the California Estuary Monitoring Workgroup (CEMW) will continue efforts to develop the public portal, improve web-based collaboration tools, enhance access to environmental monitoring data, and identify performance measures (ecosystem health indicators with target goals). Learn why you should, and how you can, be part of this collaborative effort, involving multiple government agencies and non-governmental organizations, working toward improved estuarine science, restoration, and protection of beneficial uses.

Keywords: Estuary, Web Portal, Tool, CEMW, Public, Science Communication, Collaborative, Data

Poster Topic: Public Education & Outreach

California Environmental Data Exchange Network: Standardizing Data for Statewide Integration and Assessment

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Several recent efforts in California to understand critical environmental issues such as the decline of pelagic fish in Sacramento-San Joaquin Delta have met with little success. A large part of the failure is due to the lack of access to water quality data or the poor quality of available data. Partly as a response, the state of California developed the California Environmental Data Exchange Network (CEDEN), a data storage and management system designed to facilitate integration and sharing of data collected throughout the state (www.ceden.org). CEDEN's mission is to simplify and improve access to California's water quality monitoring data by integrating, standardizing and displaying data from the State's many diverse monitoring and data management programs.

To share data, CEDEN uses its own query tools, as well as online portals such as the Federal water quality exchange (WQX, http://www.epa.gov/storet/) and the California Water Quality Monitoring Council's My Water Quality portals (http://www.waterboards.ca.gov/mywaterquality/). CEDEN uses a Regional Data Center approach, where a local contact for a designated region of California is available to assist data providers. There are currently four Regional Data Centers (RDCs) across California that provide tools and guidance for submitting data. There are minimum data requirements for submitting data and data templates are available for most data types.

Data from the following programs (plus many more) are currently available through the CEDEN online query tool: Surface Water Ambient Monitoring Program, Irrigated Lands Regulatory Program, San Francisco Bay Regional Monitoring Program, Fish Mercury Project, EPA EMAP, CCAMP, TMDL projects, and Southern California Bight monitoring program. The State Board is working with DWR, USGS, and USBR to integrate their data sets to CEDEN online tools.

CEDEN is moving forward with its efforts to store and share data which are available to address critical issues and aid in the development of California water policy.

Keywords: Data Management, Water Quality, Portal Public, Access

Poster Topic: Public Education & Outreach

Building a Regionally Coordinated Assessment Framework for the San Francisco Bay Joint Venture

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The mission of the San Francisco Bay Joint Venture (SFBJV) is to protect, restore, increase and enhance wetlands, riparian habitat and associated uplands throughout the region to benefit birds, fish and other wildlife. The SFBJV has worked towards habitat acreage-based goals as established in its 2001 Implementation Plan. Hundreds of millions of dollars have been spent since 2003 on habitat conservation, restoration, and enhancement activities thought to benefit wildlife populations. To date, success has been measured primarily through acreage tallies of target habitats included within project boundaries. Yet, these do not link wildlife response or other measures of habitat quality to the activities of these projects. Efficacy assessments with measurable outcomes at multiple scales, particularly at the regional scale, are needed.
In 2011, with extensive input from the scientific community, the SFBJV created the first phase of a "Monitoring and Evaluation Framework" (Framework) for the region designed as the first step in the process to link actions taken by the SFBJV partners to measurable results on the landscape. The SFBJV is now using "Open Standards for the Practice of Conservation" (OS) as the planning tool to develop effective and measurable conservation strategies in the context of changing landscapes. This poster describes the process and shows excerpts from the model currently under development to addresses riparian habitats within the region.
This example demonstrates how OS can be utilized in this context to set integrated conservation target goals, threat and strategy objectives linked to measurable indicators for effective and accountable conservation actions.

Keywords: Joint Venture, Monitoring, Riparian, Habitat, Conservation, Targets, Wildlife Response, Assessment

Poster Topic: Regional Habitat Monitoring and Assessment

Measuring Wetland Canopy Leaf Area Index from Hemispherical Photography: First Results in the Delta and Strategies for Spatial Interpolation

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Leaf area index (LAI; one-sided leaf area per unit ground area, m2 m-2) is one of the important characteristics of vegetation canopies used in the analyses of plant-atmosphere carbon and water exchange, ecosystem productivity and energy transfer. Previous studies have measured LAI extensively in "upland" terrestrial landscapes and explored methods to up-scale field measurements to regional levels with satellite and airborne remote sensing data. However, in wetland regions (including California Sacramento-San Joaquin Delta, hereafter the Delta), much uncertainty still exists about spatial and temporal variation in canopy properties as well as the best strategies to monitor them remotely. This poster presents results from our pilot assessment of LAI in portions of the Delta and Suisun Marsh and preliminary statistical relationships between field-measured canopy properties and spectral indicators of vegetation greenness from the National Aeronautics and Space Administration (NASA) Landsat-8 satellite (30 m pixel size). LAI was measured from in situ hemispherical photography from late May to September 2013 in a range of sites representing brackish tidal marshes, restored freshwater marshes, rice agriculture and a pepperweed-infested pasture. We discuss variation in LAI and feasibility of the measurement techniques with respect to dominant plant species, canopy structure, site history, disturbance regime and spatial heterogeneity. We further outline the next steps towards regional-scale LAI interpolation with satellite image archives.

Keywords: Wetland Vegetation, Canopy, LAI, Vegetation "Remote Sensing," Restored Tidal, Agriculture

Poster Topic: Regional Habitat Monitoring and Assessment

Marin County Progress Toward Integrated NHD Local Resolution and NWI Local Features

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Marin County has been developing detailed terrain models and hydrologic analysis to support the generation of Local Resolution features for National Hydrography Dataset (NHD) throughout the county and adjacent drainages. Terrain from several bathymetric and airborne LiDAR surveys have been integrated into a seamless topographic-bathymetric surface with 50cm gridding. Very considerable effort has been expended to develop hydrologic enforcement (HE) lines that connect all outfalls to upland drainage, branching through low-flow pathways that integrate pipes, ditches, reservoirs, and fluvial channels. The HE lines are used to constrain the location of flow lines generated by ArcHydro from a 1m grid surface. Flow lines are attributed by flow accumulation at frequent intervals along their length, which supports flow regime classification. The HE features are also a source of NHD feature codes (FCode) used to classify the modeled flow lines.

In addition to tideland classification from topography and orthoimagery, terrain surface local minima identify spillway-level areas for inland ponds and reservoirs. Together with the drainage structure provided by NHD Local Resolution, these features produce local-resolution National Wetland Inventory (NWI) features with BAARI-compatible classifications.

The target map accuracy for urban areas in this work is 1:2400, and with LiDAR-derived terrain, we consistently exceed 1:4800 map accuracy. Tideland features are interpreted as polygons at typical 1:300 screen scale, HE features are sketched in rural areas at 1:800 screen scale, and in urbanized areas at 1:250 screen scale.

Keywords: National Hydrography Dataset Local Resolution, National Wetland Inventory, ArcHydro, BAARI

Poster Topic: Regional Habitat Monitoring and Assessment

A Method of Identifying Reference Condition in Riparian Forests, and Establishment of Monitoring Protocols for Restoration Project Assessment

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Problem Statement: Reference sites are frequently used in restoration design, yet reference *condition* is rarely incorporated into project monitoring or adaptive management. This limits our ability to achieve genuine recovery of damaged systems, and suggests that restoration in general may not be achieving maximal results for its investment. We propose to use aggregated reference information from a set of riparian forests and woodlands in near-pristine watersheds to establish goal conditions for restoration projects.

Approach: Twenty-one reference-condition sites, representing "best achievable condition" in the state, were sampled via census method for woody species and tree size class, along transects of consistent size (121 by 15 m). Census method allows for derivation of exact relative abundance, size class distribution, species richness, and species accumulation (i.e. species- area curves) for these reference forests. These data also allow us to forecast species richness over longer transects (up to 1800 meters), which informs species-richness targets for restoration sites.

Results: The study identified several common characteristics of minimally disturbed riparian forests. Each reference site fell into an alliance defined in the *Manual of California Vegetation* per alliance membership rules. Reference forests follow clear patterns of relative abundance: most reference sites contain fewer than 4 dominant species and many more minor species than dominants. Woody species richness ranged from 10 to 19 species per transect and averaged 15 species. The data also reveal reference condition for trees per acre and size class distribution. Finally, the study determined that species richness can be modeled from a known transect to a larger site to forecast target species richness for restoration sites.

Conclusions: This study presents a specific definition of reference condition and establishes reference metrics for riparian vegetation from contemporary reference sites. From these, reference condition indices can be derived and used guide restoration, management, and assessment.

Keywords: Reference condition, Riparian Forests, Reference Sites, Restoration, Monitoring

Poster Topic: Regional Habitat Monitoring and Assessment

Delta Habitat Projects Database: Tracking Restoration and Mitigation Projects For Improved Coordination

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Delta habitats are mere remnants of what once existed, so restoration is a priority for myriad State and federal agencies and non-profit organizations. Evolving delta planning efforts (e.g., Delta Plan, Delta Conservancy, Fish Restoration Program Agreement, FESSRO, Bay Delta Conservation Plan) have discrete restoration and mitigation targets and goals, that guide the identification and acquisition of properties from willing sellers. These large scale planning efforts require tools to coordinate restoration planning and evaluation.

A GIS database (and map) of current and planned restoration projects in the Sacramento San Joaquin Delta, was developed by DWR FESSRO Delta Levees in 2011 to facilitate agency/ stakeholder coordination and enhance our understanding of existing projects and planning efforts. The database is currently being reviewed and updated through an interagency effort lead by the Department of Water Resources and the Delta Conservancy. A crosswalk and list of queries are being developed to improve functionality and data sharing with other project tracking tools, such as the EcoAtlas, San Francisco and Central Valley Joint Ventures, and Natural Resource Projects Inventory. The goal is to make the database usable to a wide group of project participants and to facilitate project evaluation and synthesis. Enhancing the Delta Habitat Projects Database with a consistent set of attributes and augmenting project descriptions, will improve restoration coordination and the ability to track progress toward landscape level restoration and monitoring goals. We invite comment and critique as we complete the database design effort and develop summary maps and reports.

Keywords: Sacramento-San Joaquin Delta, Habitat Restoration, Mitigation, Status, Trends, GIS

Poster Topic: Regional Habitat Monitoring and Assessment

Cleaning the Drain: Lessons Learned from the Pacific Commons Storm Water Treatment Wetland, Fremont, California

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High-quality monitoring data is critical to understanding the effectiveness of best management practice designs in decreasing concentrations and loads of key pollutants discharged to San Francisco Bay. Constructed in 2007, the Pacific Commons storm water treatment wetland is the final treatment component in the management of urban runoff from the 515-acre Pacific Commons commercial/industrial development in Fremont, California, which drains to San Francisco Bay. The wetland is complex: over half of the 10-acre surface area is vegetated marsh. Five years of monitoring indicate that the wetland substantially reduces concentrations of key runoff pollutants. Concentrations and loadings copper and zinc, were significantly ($p<0.05$) higher in influent runoff than in wetland outflows. Concentrations of nitrate-nitrogen and total nitrogen were also significantly higher in inflows but nitrogen loadings at the inlet and outlet did not differ significantly. Concentrations and loadings of total phosphorus and total suspended solids also did not differ significantly between the inlet and outlet. Monitoring revealed that approximately 25% of the inflow to the wetlands was non-storm baseflow, likely runoff from landscape irrigation. Presumably, this lack of dilution also explains why influent nitrate-nitrogen concentrations were significantly higher in baseflow sampling events than under storm conditions. Despite the existence of a high-flow bypass, the wetland treated over 99% of the runoff from the development during the 5-year period. The bulk of outflows comprised water which had entered the wetland prior to the storm event and been subject to treatment of varying duration. These results demonstrate that while large, well-designed treatment wetlands, such as the Pacific Commons wetland, can successfully reduce dissolved copper and zinc concentrations and loadings, to San Francisco Bay, their effectiveness in reducing nitrogen and phosphorus loadings is more questionable. Focused monitoring, like that undertaken at Pacific Commons, are critical to audit wetland performance in protecting valued natural resources.

Keywords: Stormwater Treatment Wetland, Design, Fremont, Nitrates, Copper, Zinc, Monitoring

Poster Topic: Stormwater Runoff: Contaminant Removal

Our City Forest Green Streets Program

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Bay Area cities are faced with the daunting task of retrofitting existing streets to treat stormwater and to comply with increasingly stricter stormwater regulations. Most solutions are expensive and require considerable engineering. Urban forestry nonprofit Our City Forest (OCF) and the City of San José are partnering on a strategy that provides an affordable, yet effective option to begin addressing these concerns.

Since 1994, OCF has engaged 150,000+ volunteers in implementing thousands of urban plantings. These projects have installed 65,000+ trees within parks, schools yards, and street parkstrips, removed 136,000+ square feet of impermeable paving, and improved watershed health in myriad ways.

To expand impermeable surface removal efforts, OCF launched their Green Streets program in early 2013. This pilot program focuses on removing large sections of concrete from parkstrips and planting them with native and drought-tolerant plants. OCF obtained a State Natural Resources grant plus a City of San José matching contribution for Green Streets, starting with several projects in downtown San José. The Hedding Street Project, the program's largest project to date, was a collaboration between OCF and the City of San José to improve the streetscape along busy Hedding Street. Roughly 350 square feet of impermeable surface was removed from parkstrips adjacent to the new bike lanes, “unpaving the way” for 122 volunteers to plant 215 drought-tolerant street trees and shrubs.

The watershed and water quality benefits of each Green Streets project may be small, but the collective benefits of all the projects are significant. The program provides a model for other cities interested in attaining these benefits within current budget constraints and without the need for large-scale engineering or long-term planning. This strategy engages residents and increases their awareness of watershed issues. This might just be how to best garner community support for future large projects.

Keywords: Watershed Management, Stormwater Runoff, Impermeable Surfaces, Urban Forestry, Green Streets

Poster Topic: Stormwater Runoff: Contaminant Removal

Mercury in the Mix: An In Situ Mesocosm Approach to Assess Relative Contributions of Mercury Sources to Methylmercury Production in the Sacramento-San Joaquin Delta

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Mercury (Hg) contamination is considered one of the greatest threats to the Sacramento-San Joaquin Delta and the San Francisco Estuary ecosystems. This threat is primarily driven by the transformation of Hg by native bacteria into the more toxic and biologically available form, methylmercury (MeHg), in the wetlands and sediment of the Delta. To effectively manage this threat, a quantitative understanding of the relative contribution of the different Hg sources to MeHg formation is needed. While current models indicate that 1-2% of the Hg entering the Delta arrives through atmospheric deposition (wet and dry), it is has been long held that this mercury source is likely very reactive once deposited. On the other hand, mass balance estimates indicate 90% of the Hg entering the Delta arrives adsorbed to suspended particles from tributary discharge, but this source is thought to be less reactive. We conducted an in situ mesocosm dosing experiment where different Hg sources to the Delta (atmospheric, dissolved riverine and suspended sediment) were “labeled” with different stable Hg isotopes and added to mesocosms within four different wetlands. We measured six time points from each mesocosm, one prior to the spike and five after the spike: 30 minutes, 1 day, 3 days, 7 days and 27 days. Preliminary results from this experiment suggest that aqueous Hg sources (Hg introduced with precipitation and filtered river water) is more (10-1,000x) available to methylating microbes than particle bound Hg. Consequently, although direct atmospheric Hg deposition may contribute a small portion of the total Hg loading to the Delta, it may contribute to a substantial portion of the MeHg production within the Delta. These findings suggest that efforts to control MeHg in the Delta should consider the relative contribution of the different Hg sources to MeHg production in addition to the current loads analysis approach.

Keywords: Mercury, Methylmercury Production, Loads, Atmospheric Deposition, Reactive Hg

Poster Topic: TMDL Implementation

Investigation of Oxygen Consuming Materials Effecting a Dissolved Oxygen TMDL in the San Joaquin River's Deepwater Ship Channel near Stockton, CA

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To maintain agriculture production and water supplies, large-scale landscape and hydrologic modifications have been made in the Sacramento-San Joaquin Delta, leading to loss of ecosystem function. In the San Joaquin River (SJR) and estuary, discharge of oxygen demanding substances, eutrophication, low flows, and channel deepening have combined to create regional anoxic conditions, negatively impacting critical fish habitat. The Deep Water Ship Channel (DWSC) located on the SJR adjacent to Stockton, has had intermittent low DO conditions for decades. As a result of the low DO impairment, the State Water Resource Control Board has implemented a total maximum daily load (TMDL) for oxygen-consuming substances in the SJR at Stockton and defined DO impairment as when DO concentration falls below water quality criteria. As part of the TMDL, studies were conducted to identify sources of oxygen demanding substances to the river and investigate how to better allocate responsibility for DO impairment. In this study, a combination of direct measurements and results from model simulations using the WARMF and Link-Node models were used to examine the causes of DO impairment in the DWSC. Major sources of oxygen demand include demand from the SJR upstream of the DWSC, Stockton's wastewater treatment facility (WWTF), and urban tributaries. The Link-Node model was also used to examine the DO impairment caused by dredging the river at Stockton to over 30 feet deep (i.e. the DWSC). By comparison to baseline simulations which include all factors, oxygen impairment attributable to each factor was quantified. Model results suggest that WWTF improvements have reduced the contribution of the WWTF to the DO impairment and that the role of the DWSC in promoting impairment may be underestimated. Import of phytoplankton from the SJR is important, but impacts appear moderated by the lack of flow associated with low DO events.

Keywords: TMDL, San Joaquin River, Dissolved Oxygen

Poster Topic: TMDL Implementation

EPA Actions to Accelerate Bay-Delta Water Quality Improvement through TMDL Implementation

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EPA published the San Francisco Bay Delta Action Plan (Bay Delta Action Plan) in August 2012 and identified the following seven priority activities to advance the protection and restoration of aquatic resources and ensure a reliable water supply in the San Francisco Bay Delta Estuary:

- Strengthen estuarine habitat protection standards
- Advance regional water quality monitoring
- Accelerate water quality restoration through Total Maximum Daily Loads
- Strengthen selenium water quality criteria
- Prevent pesticide pollution
- Restore aquatic habitats while managing methylmercury
- Support the development of the Bay Delta Conservation Plan

This poster discusses EPA's efforts to accelerate water quality improvement and minimizing the negative impacts to aquatic life from contaminants and other stressors in the Bay Delta Estuary by working with California Water Boards to strengthen implementation of Total Maximum Daily Load (TMDLs) water quality improvement plans.

TMDLs are an important catalyst for restoring impaired water quality and protecting aquatic life. There are nine adopted TMDLs in the Bay Delta Estuary watershed that address contaminants (pesticides and selenium) and stressors (low dissolved oxygen) considered potential contributors to aquatic ecosystem collapse and abrupt fish population declines.

Although TMDLs in the Bay Delta Estuary have succeeded in reducing pollutant loads, they also illustrate challenges to fully attaining water quality standards. Therefore, EPA is supporting efforts to strengthen TMDL implementation that include:

- Assess TMDL implementation progress
- Expand the use of watershed plans and decision tools
- Develop tracking and accounting tools

This poster is focused on our work assessing water quality improvement progress by implementing TMDLs.

Keywords: TMDL, Water Quality Restoration, Protecting Aquatic Life

Poster Topic: TMDL Implementation

A Real-time Monitoring System to Track, Predict and Map the Distribution of Buoyant Pollutants in San Francisco Bay

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San Francisco Estuary drains 40% of the total area of California and supports a large surrounding metropolitan population. Waters of this large urbanized estuary are subjected to episodic discharges of buoyant pollutants, which include floating debris (plastics, derelict fishing gear), oil, and dissolved or suspended contaminates (organic chemicals, heavy metals, bacteria) carried within low-density water releases (sewage and storm drain outfalls). Buoyant pollutants can harm marine animals, leach toxic pollutants, endanger human health, pollute shorelines, and damage wetland habitats, while hurting recreation, business, and tourism in the process. Over 30 water bodies around the Bay Area have been identified as heavily impacted by floating pollutants and have been placed on the state's list of impaired waters.

The ultimate solution to the problems of buoyant pollutants is to eliminate their introduction into the environment, which involves documenting the mode, seasonality, and sources of pollutants. In the short-term there also is a need to mitigate the impacts of buoyant pollution released to the environment. To plan and implement these efforts requires knowledge of the transport, concentration, and distribution of buoyant pollutants once introduced into bay surface waters.

Our project aims to develop the science and systems for continuous and real-time water monitoring to identify, track and predict trajectories of buoyant pollutants, determine shoreline areas likely to be impacted, and identify waters in the estuary where buoyant pollutants tend to concentrate. The project leverages existing current mapping and water quality technology combined with leading data analysis and visualization tools. Potential project outcomes include using project outputs as planning and management tools for public health warnings, to help guide development, restoration, and disaster mitigation decisions, and to minimize environmental and economic impacts of floating pollutants. We will present the results of a pilot study from our project conducted in central San Francisco Bay.

Keywords: Oil Spills, Outflows, HF Radar, Water Quality, Buoyant Pollutants, Monitoring

Poster Topic: Water Quality

Continuous Monitoring of Dissolved Oxygen in San Francisco Bay

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Since passage of the 1972 Federal Clean Water Act, reported dissolved oxygen (DO) concentrations in San Francisco Bay (Bay) are routinely above the 5mg/L standard important for supporting biota, with few reported episodes below this concentration. However, long-term monitoring efforts have measured DO only in the main channel of the estuary by research vessel, and only at weekly to monthly sampling intervals. For this study we conducted the first high temporal resolution deployment of dissolved oxygen sensors in both the main channel and the perimeter of the Bay. Four optical DO sensors were deployed near bottom and sampled every 15 minutes for a year: two in the main channel (depth>12m) and two in the estuary perimeter (depth<5m). Main channel sites included one in the upper estuary near the primary freshwater inflow and one in the lower estuary near the ocean boundary; estuary perimeter sites included one at the mouth of a tidal creek in Central Bay and one in a tidal slough in South Bay. The resulting time series for main channel sites showed DO concentrations which always exceeded 5mg/L, whereas during spring, summer, and fall the tidal slough exhibited sustained hypoxic conditions (<3mg/L) and the tidal creek daily minima dropped below 5mg/L. Compared to sites in the main channel, those along the estuary perimeter demonstrated greater variability in DO concentrations at seasonal, tidal, and especially diurnal time scales. At the tidal slough site, DO concentrations varied at the spring/neap time scale, with consistently lower concentrations during neap tides indicating tidally varying transport and system metabolism. These time series are the first to concurrently document the contrasting DO patterns in the main channel versus the shallow periphery of the Bay, with results highlighting the value of high temporal resolution sampling and the importance of measurements in the shallow habitats.

Keywords: Dissolved Oxygen, Water Quality, Continuous Monitoring

Poster Topic: Water Quality

Concentrations of Pesticides Entering the San Francisco Bay-Delta through the Sacramento and San Joaquin Rivers, 2012-2013

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Current-use pesticides pose a threat to aquatic organisms in the San Francisco Bay-Delta. During a year-long study, water samples were collected twice per month from sites representing the two major river inputs to the Delta: Sacramento River at Freeport and the San Joaquin River near Vernalis, and analyzed for over 100 pesticides and degradates. Thirty six pesticides or degradates were detected during the study (15 herbicides, 11 fungicides, 6 insecticides and 4 degradates). The average number of pesticides detected in Sacramento River samples was six, while the San Joaquin River samples contained an average of nine pesticides. The most frequently detected compounds were the herbicides diuron (75%), hexazinone (100%), metolachlor (63%), and simazine (64%), the fungicides, azoxystrobin (82%) and boscalid (50%), and the herbicide degradates 3,4-DCA (95%) and DCPMU (43%). Insecticides were detected infrequently during the study. Pesticide concentrations ranged from less than the method detection limits to near 1 microgram/liter (hexazinone). In nearly all samples, herbicides accounted for the majority of the total, per sample, pesticide burden. For those compounds detected at both sites, average and maximum concentrations were generally greater in San Joaquin River samples. Pesticide detections and concentration trends showed seasonal patterns consistent with the timing of pesticide applications in the Sacramento and San Joaquin river watersheds. Results from this study show that mixtures of current-use pesticides enter the Delta throughout the year from the Sacramento and San Joaquin rivers. These data represent the most current and comprehensive survey of current-use pesticides entering the Delta, and will be of value to scientists and resource managers working to understand the role of contaminants and the toxicity of pesticide mixtures to species of concern in the region.

Keywords: Pesticides, Water Quality, Herbicides, Insecticides, Delta

Poster Topic: Water Quality

Fifteen Year Volunteer Water Quality Monitoring Project at Lake Merritt

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Water quality at Lake Merritt is important to ecologists, state and federal regulators (State Water Quality Board and the U.S. Environmental Protection Agency), City and regional managers, conservationists and the general public. Lake Merritt is a tidal lagoon in the center of a city of 400,000 people, the center of a 4,650 acre highly urbanized watershed. Excessive nutrients from urban run-off and poor tidal circulation have been problems historically, continuing to today. In 1999, Lake Merritt was cited by the U.S. E.P.A. under the Federal Clean Water Act for excessive nutrients leading to low dissolved oxygen and for trash. It has remained on the TMDL 303 (d) list through the latest report in 2010.

Until 1995, the Alameda County Flood Control District supported monthly water testing from several lake stations and made annual reports. However since then, only short-term professional testing from single sensors has been carried out. Measure DD was passed by Oakland Residents in 2002 in an effort to improve water quality at the lake and make it more accessible to water recreation and to native species. A restoration of the shoreline as a demonstration mudflat and other projects are underway. In looking to the future, it would be helpful to know recent historical dissolved oxygen levels and other water quality measures levels in the lake and how they vary at different locations, depths in the water column, and seasons.

Environmental Science Academy at Oakland High School has conducted weekly volunteer monitoring of Lake Merritt from 1997 to the present from September to June. The accumulated water quality data provide a baseline with which to compare future improvements and climatic changes.

Keywords: Volunteer Monitoring, Measure DD, Dissolved Oxygen, Salinity, Temperature, pH, Clarity

Poster Topic: Water Quality

Using Biosentinels to Assess Mercury Risk in Wetland Restoration Projects

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Methylmercury contamination in food webs is one of the primary water quality issues in the San Francisco Bay. Wetlands have been shown to be important sites of MeHg production and there is concern that wetland projects may result in increased Hg bioaccumulation. Biosentinel monitoring can be used to provide a direct link between marsh projects and the protection of marsh wildlife at risk of mercury contamination. Here we present data from the first year of a two-year project that uses a region-wide approach to monitoring wetland restoration in San Pablo Bay. Our data showed concentrations above levels of concern in most species. The design for this project was developed with input from a Science Advisory Group consisting of experts in biosentinel monitoring for mercury and the ecology of potential biosentinel species. The approach and sampling plan were also vetted with local stakeholders, who expressed interest in the following four management questions:

1. *What is the current potential for impairment of beneficial uses due to methylmercury in each major habitat of interest in the North Bay intertidal habitat restoration projects?*
2. *How will the status of impairment due to methylmercury in each major habitat of interest change over a timescale of years in response to the project?*
3. *How do the status and trends in impairment due to methylmercury at this project compare to status and trends in impairment in other project and non-project wetlands in the region?*

4. *Will tidal marsh restoration introduce a problematic amount of methylmercury into the Bay?*

Biosentinel data can answer these management questions in a cost-effective way.

Keywords: Mercury, Biosentinels, Monitoring

Poster Topic: Water Quality: Mercury

Past to Present: The Use of Bivalves to Reflect Past Methylmercury Concentrations and Develop New Directions for the Future of San Francisco Bay

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Long-term trends in methylmercury (MeHg) concentrations in bivalve tissues were assessed using museum specimens. There are no long-term studies on the concentrations of MeHg in organisms at the base of the food chain. To fill this gap, museum bivalves (*Musculista senhousia* and *Potamocorbula amurensis*) were analyzed from the California Academy of Sciences (CAS) and United States Geologic Survey (USGS), which were preserved in formalin or ethanol. Thus, we examined the effects of preservation on MeHg concentrations in tissues. In our preliminary analyses, MeHg concentrations increased slightly after 1 week of preservation, but more time points are needed. In our analysis of the southern reach of estuary, MeHg concentrations in *M. senhousia* collected from the Dumbarton Bridge, were highest in October 1975 (median= 231.3 ng/g_{dw}) but declined in the early 1990s (median= 37.7 ng/g_{dw}). Methylmercury concentrations in *P. amurensis* collected from the Dumbarton Bridge remained constant between 1991 and 1994 (median= 62.1 ng/g_{dw}), but they were 3-4 times higher than *M. senhousia* when the two species were collected on the same day. High mercury loadings at the Dumbarton Bridge may have led to the concentrations measured in bivalves in the 1970s, and subsequent regulations may have led to the observed declines. In contrast to the South Bay, data from San Pablo Bay in the northern reach of the estuary found that MeHg concentrations were similar in *M. senhousia* (median= 78.6 ng/gdw) and *P. amurensis (*median= 57.2 ng/gdw) collected on the same day in 2001. We are currently analyzing stable isotopes to determine if feeding niche could be attributed the changes in MeHg concentrations. The use of museum bivalves may elucidate historical trends in the estuary and mobilize future directions in understanding the influence loadings and ecology have on MeHg bioavailability at the base of the food chain.

Keywords: Methylmercury, Trends, Bioaccumulation, Tissues, Ecology, Loadings

Poster Topic: Water Quality: Mercury

Treatment of Surface Waters with Metal Based Coagulants to Reduce Total and Methyl Mercury Concentrations, Loads, and Bioavailability

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With the recent passage of laws regulating concentrations and loads of mercury (Hg) and methylmercury (MeHg) in surface waters, there is a need to develop management practices that will reduce their inputs from both point and non-point sources. Coagulation with metal based salts is a practice commonly employed by drinking water utilities to remove particles and dissolved organic matter (DOM) from solution. Because dissolved Hg is associated with particles and DOM, it follows that Hg should also be removed during the coagulation process and end up associated with the organo-metal precipitate, termed floc. The effectiveness of iron- and aluminum-based coagulants for removing both inorganic (IHg) and MeHg, respectively, from solution was recently demonstrated in laboratory studies conducted on agricultural drainage waters of the Sacramento-San Joaquin Delta: dissolved concentrations of MeHg decreased by 80% while IHg decreased by 97% following coagulation. To test the field application of this technology, nine wetland treatment cells were constructed in the central Delta. This replicated field experiment includes three inflow water treatments: (1) iron sulfate addition, (2) polyaluminum chloride addition, and (3) untreated controls. Water entering (post-treatment) and exiting (after passage through) these treatment cells was sampled monthly over a 1-year period for total Hg and MeHg in both the aqueous dissolved and particulate phases. Initial results confirm that coagulant addition is removing Hg (total and methyl) from solution and sequestering it in the floc. Seasonal factors, such as changes in DOM concentration, appear to affect the efficiency of the treatment removal. Related studies will provide information about the biogeochemical processes occurring within the wetland cells in the presence and absence of the flocculated material. If proven effective, coagulation—either alone or in association with constructed wetlands—may be a feasible technique to reduce surface water IHg and MeHg concentrations and bioavailability.

Keywords: Mercury, Methylmercury, Remediation, TMDL, Coagulation, Wetland, Organic Matter, Carbon

Poster Topic: Water Quality: Mercury

Applying Sediment Quality Assessment Protocols to San Francisco Bay Samples

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The California State Water Board recently adopted a set of narrative sediment quality objectives (SQOs) alongside a standardized assessment framework to determine the impact of chemical contamination on benthic communities. The SQO assessment framework was applied to samples from the San Francisco Bay Regional Monitoring Program's 2008 through 2012 sediment cruises and to samples taken in 2011 from two known toxic hotspots in San Francisco Bay's creek channels. The framework uses multiple lines of evidence (chemistry, toxicity, and benthic community composition) to assign a station assessment based on the severity of biological effects and the potential for chemically mediated effects. The goal of the study was to determine spatial and temporal trends in sediment quality throughout the Bay. The two creek channels, Mission Creek and San Leandro Creek, remain clearly impacted, with the extent of the contamination lower in samples closer to the creek mouths. Unlike the two toxic hotspots, severe impacts on the benthic community were not observed in the open Bay. Although over half of the Bay was listed as impacted (54%), the level of contaminant related impacts was either small or uncertain for 75% of the affected area. Sediment quality differed between subembayments, with San Pablo Bay possessing the best sediment quality and South Bay and Suisun Bay exhibiting the poorest sediment quality. For all of the subembayments, sediment quality was driven by biological effects (primarily toxicity) rather than chemical exposure. The SQO assessments indicate that sediment quality may have improved over time, with the number of impacted sites decreasing from 82.5% in 2000 to 54% from 2008 through 2012. Overall, the narrative SQOs provided a general spatial and temporal picture of sediment quality in San Francisco Bay.

Keywords: Sediment Quality Objectives, Contaminants, Moderate Toxicity, Multiple Lines of Evidence

Poster Topic: Water Quality: Sediment

In Situ Measurements of Suspended Sediment Diffusivity by 3D Particle Tracking

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San Francisco Bay often appears brown. Its high suspended sediment concentrations give it the potential to move and mix large amounts of sediments from one environment, such as an urban stormwater outflow, to another, such as a wetland undergoing restoration. These sediments can carry with them persistent, bioaccumulative and toxic chemicals such as PCBs, mercury, or emerging contaminants.

To predict sediment fate, almost all physical models describe the transport of suspended sediment with the advection-diffusion equation, which requires knowledge of the water currents and the diffusivity of sediment. Methods for estimating diffusivity to use in the model are not typically satisfying, and there remain fundamental questions about the accuracy and applicability of the typical approximation methods.

We have developed a new tool that measures diffusivity directly, and we deployed it for the first time near the Berkeley shore. This region has highly active sediment and is important for transfer of sediment-associated contaminants, and allowed us to begin to investigate the relationships between wind, waves, tides and turbulence with sediment diffusivity. This proof-of-concept deployment gives us valuable preliminary information about sediment and contaminant transfer at the margins of the Central Bay. It also provides the foundation for future investigations of the behavior of sediment diffusivity in different environments and the underlying theory of solute diffusivity in real-world conditions.

Keywords: Suspended Sediment, Diffusivity, Transport, Particle Tracking

Poster Topic: Water Quality: Sediment

Impacts of Endocrine Disrupting Chemicals on *Menidia beryllina*, a Resident Fish in the Sacramento-San Joaquin Delta

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Populations of pelagic organisms in the SSJ Delta have been declining for several decades. The aim of this project, funded by the Delta Science Council, is to determine to what extent endocrine disrupting chemicals (EDCs) may be responsible for this pelagic organism decline. EDCs are chemicals that are typically used for one purpose, such as certain types of herbicides and pesticides, but also interfere with the natural process of hormone signaling or function. Such a disruption can have wide-ranging impacts on animal populations and development, and the situation in the Delta is made significantly more complicated due to the mixture of chemicals from run-off as well as wastewater as well as unrelated changes in environmental conditions can all impact endocrine function. As a model species for this study, we have chosen the Inland Silverside, *Menidia beryllina*, a non-native fish that can tolerate a wide range of salinities and environmental conditions, making it an excellent choice for studying EDCs in the Delta. In this study we have monitored the changes in gene expression and protein translation in both wild populations and lab-reared Silversides throughout the seasons. Incorporation of this temporal aspect into the study is crucial to understanding the impacts of EDCs because the types of chemicals input into the Delta change as different crops are grown. We have found that there are changes in hormonally regulated gene and protein expression in Silversides in the Delta, and there is the potential for an impact on fish populations.

Keywords: Endocrine Disrupting Chemicals, Pelagic Organism Decline, Pesticides

Poster Topic: Water Quality: Emerging Contaminants

Emerging Contaminants in the San Francisco Estuary: Pharmaceuticals and Personal Care Product Ingredients

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Pharmaceuticals and personal care product ingredients (PPCPs) are detected frequently in US waterways, creating concern for their potential to impact wildlife as well as humans. PPCPs can enter waterways through wastewater treatment plant (WWTP) effluent, stormwater, and groundwater. Forty-six Bay Area WWTPs likely provide the primary pathway for these contaminants to enter the Bay. The Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) has monitored select PPCPs in Bay surface water, sediment, and biota since 2002. In 2006, the RMP analyzed South Bay surface water for 39 pharmaceuticals, 18 of which were detected at levels comparable to those observed in similar studies of receiving waters. A 2010 follow-up study of five sites located throughout the Bay found that out of the 104 PPCPs analyzed, 31, 10, and 17 were detected in water, sediment, and mussels, respectively. Concentrations of PPCPs in Bay samples were generally an order of magnitude or more below concentrations expected to elicit toxic effects in aquatic organisms. However, a few exceptions deserve special attention, including plasticizers bis(2-ethylhexyl) phthalate and butylbenzyl phthalate, and the antibiotic sulfamethoxazole. In general, the majority of toxicity data currently available for PPCPs are based on acute effects studies, and the potential for sub-lethal effects, as well as those triggered by chronic exposures or exposures to mixtures of contaminants, remains a concern. The RMP is considering future studies that will expand the number of PPCPs analyzed in Bay samples following an evaluation of recent data on aquatic toxicity and detections in similar ecosystems.

Keywords: Pharmaceuticals, Personal Care Products, Phthalates, Sulfamethoxazole, Emerging Contaminants

Poster Topic: Water Quality: Emerging Contaminants

Transcriptome Sequencing and Gene Expression Analysis for the Health Assessment of Inland Silversides

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The San Francisco Estuary (SFE), along with the Sacramento/San Joaquin River Delta system, in California is heavily influenced by anthropogenic activity. Additionally, the SFE is one of the most invaded ecosystems in the world. Because many of the small-bodied native fishes in the SFE are listed as threatened or endangered, we have begun using the non-native inland silverside (*Menidia beryllina*) as an indicator species in the system. The inland silverside is an estuarine fish species approved by the US EPA for toxicity testing. We have sequenced the transcriptome of the inland silverside and have been developing molecular tools that include qPCR assays and a 44,000 feature oligonucleotide microarray (Agilent Technologies) to assess the cellular effects of exposure to ecologically-relevant stressors in the SFE. We conducted single-compound 14-day exposure studies on inland silversides using environmentally-relevant concentrations of ibuprofen and bifenthrin, emerging contaminants of concern in the SFE. Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID) that is continually introduced to the aquatic environment via wastewater effluent. Bifenthrin is a pyrethroid pesticide that is demonstrated to have estrogenic and anti-estrogenic effects on fish and is commonly detected in rivers that feed into the SFE. Both of these compounds are commonly detected in the aquatic environment at low concentrations and can elicit complex physiological responses in fishes. Preliminary data show that ibuprofen increased the expression of hormonally-responsive genes associated with hormone (estrogen, androgen and thyroid) receptors in inland silverside; however these responses were non-monotonic. Bifenthrin exposure resulted in decreased expression of those same genes suggesting an overall anti-estrogenic effect. We used newly developed molecular tools to show that even at low environmentally-relevant concentrations, chronic exposure to ibuprofen and bifenthrin elicit cellular responses in the inland silverside that potentially affect reproductive output, and therefore may cause physiological responses in numerous wild fishes in the SFE.

Keywords: Inland Silverside, Ibuprofen, Bifenthrin, Microarray, qPCR, Transcriptome sequencing, Contaminants

Poster Topic: Water Quality: Emerging Contaminants

2013 Temporary Transfer of 64,735 Acre-feet by Delta Export: A Wee Bit Reasonable to Ignore or Cumulative Fishery Impacts that Deserve to be Mitigated?

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In 2013 the State Water Resources Control Board (Board) approved eleven petitions for temporary transfer totaling 64,735 acre-feet. All were approved without conditions for fishery protection beyond what is already required by water rights decisions, court decrees, biological opinions, etc. In each petition the Board made a finding of "no unreasonable effect on fish, wildlife, or other instream beneficial uses". The policy and management question here is: Is a determination of these transfers having no unreasonable effect on fish, wildlife or other beneficial uses appropriate in 2013 given the long-term ecological crisis delta fisheries are in? While regulatory standards are being met, is that good enough?

The temporary transfer of northern California water from those who can substitute groundwater and forego their surface supplies for users south of the delta is a means to lessen the economic impact of statewide water shortages. These temporary but regularly repeated transfers via export are in addition to the huge amounts of non-temporary exports. Transfer water must pass through the estuary and be pumped at facilities known for decades to perform poorly and directly and indirectly devastate fish.

For years the Board has approved most, if not all, transfer petitions. As such, no incremental mitigation for adverse environmental impacts for either estuarine or riverine impacts has been required for these above-baseline exports.

The author identifies and explains significant adverse environmental effects to both estuarine and riverine fishery resources deserving some measure of mitigation. The author also contends that the finding on these transfers as having "no unreasonable effect on fish… " is in itself unreasonable given the dire ecological health of the estuary yesterday, today, and tomorrow.

Keywords: Temporary Transfers, State Water Resources Control Board, Cumulative Impacts, Exports

Poster Topic: Water Use and Management

The State of the Bay 2013: Updated Indicators for Freshwater Inflows, Ecological Processes, Open Water Habitat, and Fish

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In 2011, the San Francisco Estuary Partnership released the State of the San Francisco Bay Report, a science-based assessment of the health of the estuary. This poster provides updates for several of the indicators presented in that report. The San Francisco Bay estuary is important spawning, nursery and rearing habitat for a host of fishes and invertebrates, a migration corridor for anadromous fishes like salmon, steelhead and sturgeon, and breeding and nesting habitat for waterfowl and shorebirds. Freshwater flows into the estuary have been altered by dams, water diversions, with resultant changes in the flow-driven ecological processes, open water estuarine habitat and the estuary's fish community. Here we report the latest evaluations of indicators developed by the San Francisco Estuary Partnership to track status and trends of Bay ecological attributes of the estuary.

The indicators include the following:

- The **Freshwater Inflow Index** uses six indicators to evaluate the alteration in the amounts, timing and patterns of freshwater inflow to the estuary from the Sacramento-San Joaquin watershed, comparing actual inflows to estimated unimpaired inflows.
- The **Flood Events Indicator** measures the occurrence of high flow events, >50,000 cfs which are a key driver of physical and ecological processes in the estuary and its watershed.
- **The Open Water Estuarine Habitat Indicator** measures the quantity and quality of open water estuarine ("low salinity") habitat, defining "good" habitat as X2<65 km during the spring (Feb-June).
- The **Fish Index** uses measures of abundance, diversity species composition and distribution to evaluate the condition of the estuary's fish community in four different regions of the Bay.

Keywords: Indicators, Freshwater Inflow, State of the Bay

Poster Topic: Water Use and Management

Dispersion Mechanisms of a Tidal River Junction in the Sacramento-San Joaquin Delta, CA

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In branching channel networks, such as might be found in the Sacramento-San Joaquin River Delta, channel junction flow dynamics contribute to large-scale dispersion. Flow transports through a junction largely arise due to phase differences in each of the junction's contributing channels. Field observations in the Georgiana Slough junction, which is composed of the North and South Mokelumne Rivers, Georgiana Slough, and the Mokelumne River, showed that flow phasing differences in this junction arise due to operational, riverine, and tidal forcing. A combination of Acoustic Doppler Current Profile (ADCP) boat transecting and moored ADCPs over a spring-neap tidal cycle (May-June 2012) monitored both spatial and temporal variability, respectively. Two complementary drifter studies enabled assessment of local transport through the junction to identify small-scale intra-junction dynamics that may be important to mixing. Field results are corroborated with numerical simulations using the SUNTANS model to demonstrate the importance of flow phasing for junction transport and mixing. Different phasing of inflows to the junction results in scalar patchiness which is characteristic of tidal trapping. Small-scale flow features such as separation zones, shear layers, and mixing zones were observed and may play an important role in intra-junction mixing. The study period coincided with both open and closed gate operation at the Delta Cross Channel (DCC). Synthesis of field observations and modeling efforts suggest that opening the DCC could cause greater transport to the inner Delta.

Keywords: Junction Mixing, Flow Phasing, Tidal Trapping, Delta Cross Channel

Poster Topic: Water Use and Management

Water Quality Modeling in an Overground Rainwater Cistern Particularly for Long Term Storage for Cooling Applications

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Evaporative cooling technologies work well in hot dry climates because their total energy consumption is approximately 30% less than air cooled air conditioning systems. However, evaporative cooling systems require a continuous water supply on the order of 2 gal/hr/ton of cooling delivered. On-site rainwater harvesting can be a good alternative water source for evaporative cooling applications. Because of the very low hardness of rainwater, scale formation is minimized. This extends the system life and increases the system efficiency, which consequently decreases water and electricity consumption while maintaining optimal performance by preventing the need for unnecessary chemicals to be added for water softening. This approach could help manage urban residential stormwater runoff while providing an alternative residential water source.

To examine the effect of long term storage of rainwater on bacterial growth patterns, a 2500-gallon tank was used to collect rainwater from a residential composite shingle roof. During November and December 2012, the tank was filled with rainwater. The rainwater is currently being stored for summer use and the water quality is being examined on a weekly basis. The effect of the storage time on water quality is being monitored by recording the pH, electrical conductivity, total hardness, turbidity, dissolved oxygen, temperature, coliforms, dissolved organic carbon, nutrients, and metals. In this study, twelve water temperature sensors and one air temperature sensor are recording temperature variation both for water and air. The initial results indicate that if rainwater is collected and stored appropriately, the concentration of indicator bacteria after six months of storage (due to death and decay) will be much lower than initial concentrations. Therefore, rainwater will need minimal treatment for prior to use. The results obtained in this experiment will determine the feasibility of using stored rainwater in evaporative cooling systems.

Keywords: Rainwater Harvesting, Roof-Runoff, Water Quality, Potable, Microbial Growth

Poster Topic: Water Use and Management

Napa Sonoma Marsh Restoration Recycled Water Pipeline Project

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The North San Pablo Bay region has very limited surface water and groundwater supplies. Demands for urban, agricultural, and environmental water are stretching existing water supplies to their limits and limiting the region's ability to provide a reliable, sustainable, and economical water supply. As cities and farmers grapple with these problems, state and federal partners are restoring approximately 640 acres of former bittern ponds to wildlife habitat as part of the Napa Sonoma Marshes Restoration Project. Tidal wetlands of the San Pablo Bay estuary serve a vital ecological role as nurseries for fisheries and breeding and wintering areas for migratory waterbirds. Finding a reliable source of non-saline water is essential to rehabilitating these wetlands and the proven technology of using high-quality recycled water will greatly help in meeting the region's water resource needs.

The Sonoma Valley County Sanitation District (SVCSD) is constructing 3.5 miles of pipeline to bring tertiary-treated recycled water to two bittern ponds in the Napa Sonoma Marshes Restoration Project area. This pipeline will provide between 1,100 and 1,700 AFY of recycled water for restoration of the bittern ponds, off-setting the use of slough water and thereby accelerating the restoration timeline. The pipeline will also provide future opportunities for off-setting use of potable surface and ground water used for agricultural irrigation in the region. We will discuss the collaborative partnerships and planning necessary to bring recycled water to the restoration project and outline the benefits to restoration and agricultural activities in the north San Pablo Bay region.

Keywords: Recycled Water, Water Supply, Salt Marsh, Restoration, Napa Sonoma Marsh

Poster Topic: Water Use and Management

Using Source Control to Reduce Salinity in Recycled Water

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The Palo Alto Regional Water Quality Control Plant (RWQCP) delivers recycled water for landscape irrigation. Prior to 2013, the recycled water averaged 950 ppm total dissolved solids which caused public concern regarding irrigation of sensitive trees. The RWQCP set a goal of 600 ppm TDS based on source water levels and reasonable contribution from use. A study was conducted to determine the potential sources of excess salinity. Trunklines in low-lying areas along the Bay had higher levels presumably due to saline groundwater intrusion. Staff developed a sampling methodology to locate the exact areas of infiltration, designed, assembled and deployed 22 continuous monitors to record temperature and conductivity. Specific locations requiring sewer rehabilitation were identified, resulting in a major sewer relining project in Mountain View. Additional conductivity monitoring was conducted following the sewer lining project to evaluate the repair project's success in reducing salinity levels that will allow use of this sustainable source of water to expand. TDS levels in the final effluent are now lower than prior to the relining projects, showing that source control can be a cost effective tool to reducing salinity in recycled water.

Keywords: Recycled Water, Conductivity, TDS, Sewer Lining

Poster Topic: Water Use and Management

Seeking True Replacement Costs, as Long-Term Value of Fresh Water around Over-Exploited San Francisco Estuary

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Long-term vs. (widespread, entrenched) short-term economics are needed to conserve and restore valuable natural resources, now being overexploited, particularly in densely populated areas. We around San Francisco Bay have unusually high levels of education, income, and property values, which can lead to proper management of available resources, human population, and consumption. Water is like many natural resources: now overexploited, and increasingly valuable, more than most humans can really afford, including indirect and other external costs. We might attempt to trade energy for water via desalination or "purification" (anti-viral?,) but other resources would continue to be overexploited, further, with disastrous side-effects. These authors apply ecological concepts, and resource values as supply vs. demand, equal at a human Carrying Capacity, as the maximum sustainable number of humans, if we all conserve. We use literature to actually calculate that (maximum) human Carrying Capacity in three different ways, which all agree: we have greatly exceeded our Carrying Capacity as human populations, and our Carrying Capacity is decreasing. Total consumption will decline dramatically, voluntarily or not.

Humans must transition from short-term (growth) ecological r selection to long-term ecological (sustainable) K selection. For natural resources, replacement costs apparently go up, as does value, as supplies dwindle.

Current policies have pursued even more siphoning off of most of the average available precipitation and river flows, for human uses. But more sustainable, environmental needs of that same water cannot keep being sacrificed, losing natural life-support systems (for humans too) such as natural watersheds. Sooner, rather than later, growth must halt, and REVERSE more and more. Solutions require education for far less consumption, and immediate (already expensive) restoration of our natural resources. It is cheaper and easier to conserve and restore those resources earlier, including water. Continued over-exploitation of our resources, is short-sighted and probably disastrous, in the longer-term.

Keywords: Water, Resources, San Francisco Estuary, Restoration, Economics, Population, Carrying Capacity

Poster Topic: Water Use and Management

New Bankfull Geometry Relations for Inland South Bay and Inland Monterey Bay, Central California

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We developed bankfull geometry curves for relatively non-urbanized watersheds of the inland South Bay and inland Monterey Bay, using data collected at approximately 80 stations over the past 4 decades by our staff, Santa Clara Valley Water District staff, and several other researchers with documented methods. Bankfull geometries are an important geomorphic metric used in channel restoration design.

Core regression equations covering inland Santa Clara and Monterey Counties plus the Pajaro watershed, are:

Bankfull cross-sectional area (ft^2)

$$A = 10.95D_a^{0.68} \quad (1),$$

Bankfull width (ft)

$$W = 11.80D_a^{0.31} \quad (2),$$

where D_a is drainage area (mi^2).

These relations differ appreciably from existing San Francisco Bay Area regional curves previously developed by Leopold and others (1964; updated by Dunne and Leopold, 1978) and Riley (1999, updated 2003). Curves that we concurrently developed for non-urbanized streams in the Santa Cruz Mountains drainages to the west and north beginning with the Soquel and Los Gatos basins did not differ from the relations developed by Leopold, Dunne and others; the older relations merit continued application in these areas.

Development of these new bankfull geometries illustrates the importance of mean annual rainfall in bankfull relations; the new curves—in drier areas—translate into channel geometries with smaller bankfull sections. They also show more variability than the existing curves, which we attribute to a greater extent of regulation and channel incision, as well as more friable soils in a more episodic semi-arid environment. The new preliminary curves will be tested with additional carefully-controlled measurements in the coming years.

Keywords: Bankfull Geometry, Hydraulic Geometry, Creek Restoration, Channel Incision, Flood Protection

Poster Topic: Watershed Management

Potential Management Strategies along Arroyo Mocho and Arroyo las Positas Based on Historical Ecology

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In Livermore-Amador Valley, urbanization and hydromodification over the past two centuries have created a highly altered stream network and given rise to a variety of stream management challenges, including sedimentation, channel incision, and riparian habitat loss. These changes have impaired the ability of the stream network to provide valued ecosystem services such as flood protection, groundwater recharge, and wildlife habitat. This study, which will contribute to the Zone 7 Water Agency's updated Stream Management Master Plan, applied recent research on the historical ecology of the Alameda Creek watershed to investigate current management challenges for Arroyo Mocho and Arroyo las Positas. Historical landscape patterns and processes were analyzed to identify potential underlying causes of management challenges, create conceptual models showing changes in physical and ecological controls, and devise landscape-scale restoration strategies.

Along Arroyo Mocho, the conversion of historically braided reaches to single-threaded channels has likely reduced in-channel complexity and contributed to downstream sediment deposition. Artificial augmentation of base flows, coupled with urban development on the surrounding floodplain, has resulted in a narrowed riparian corridor dominated by dense hydrophytic vegetation. Along Arroyo las Positas, channelization and increases in impervious surfaces have likely increased flow velocities, leading to channel incision. In addition, urban development has reduced and fragmented rare wetland habitats in the Springtown alkali sink. To address these challenges and increase the resilience of the stream network, several landscape-scale strategies are recommended: 1) Restore braided channel morphology and floodplain connectivity in selected reaches of Arroyo Mocho to promote in-channel sediment storage; 2) Preserve remaining vernal pools and other wetland habitats of high conservation value within the Springtown alkali sink, and; 3) Implement Low Impact Development (LID) strategies to manage stormwater runoff and mitigate channel incision and sedimentation. These strategies will need to be modeled prior to implementation to assess cumulative landscape impacts.

Keywords: Arroyo Mocho, Arroyo las Positas, Landscape-Scale Restoration, Stream Management Resilience

Poster Topic: Watershed Management

The Integrated Regional Wetland Monitoring Pilot Project: Overview

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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 and Ecosystem Restoration 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 17 journal manuscripts, three book chapters, and another seven 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 2013. This Introduction poster presents information about the IRWM purpose, approach, and the six study sites. 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: IRWM, Tidal Wetland Restoration, Tidal Wetland Monitoring, Ecosystem Restoration

Poster Topic: Watershed Management

Enhancing Regional Capacity for Habitat Restoration Project Tracking, Assessment and Reporting

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This project will expand current wetland project tracking capabilities for monitoring and assessment of California's aquatic resources to meet the project tracking, assessment, and reporting needs for current and planned habitat restoration in the San Francisco Bay-Delta and Central Valley. The main tasks include identifying additional data fields and functionality needed; incorporating identified needs into the statewide system, EcoAtlas, and modifying existing tools; and incorporating regional habitat conservation databases into EcoAtlas. The final product will be an expanded system that meets current and projected needs for tracking and analysis of landscape change and measurements of success of these efforts within the regional context. Additional data, queries and mapping functionality will allow for better analyses of changes in wetland extent and condition; landscape-scale conservation planning efforts; prioritization of restoration areas; evaluation of progress toward meeting conservation objectives; partnership establishment; and leveraging of restoration resources. By providing the tools needed to track and analyze landscape change and measure success of these efforts, we will improve our ability to conserve important habitats strategically in the future.

Keywords: Habitat Restoration, Tracking, Assessment, Monitoring, Mapping, Database

Poster Topic: Watershed Management

CRAM: New Online Management Tools for Uploading and Accessing Wetland Condition Information

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The California Rapid Assessment Method (CRAM) is a cost-effective and scientifically proven tool for assessing the health of wetlands and riparian habitats. It is designed for assessing ambient conditions within watersheds, regions, and throughout the State. Adopted by State agencies and NGOs, CRAM is actively in use to inform wetland condition. CRAM can also be used to assess compensatory mitigation and restoration projects to help evaluate the performance of wetland and riparian protection policies and programs.

Developed through the CRAM Steering Committee and Wetland Monitoring Workgroup of the Water Quality Monitoring Council, the new online management tools include a robust database, improved data entry functionality, multiple ways to access results, and a redesigned website. The new database was designed to store data from different versions of CRAM, support future updates and changes to the methodology, track the various training courses and reference sites, and dynamically render the metric and attribute information in the data entry forms. In addition to being easier to maintain, the new entry forms enable better tracking of practitioners conducting assessments and uploading of photos and documents. The greatly improved mapper functionality allows for better versatility in data entry. Practitioners can digitize a new polygon, upload a KML or shapefile, and edit polygons. In turn, CRAM visitors can access and download CRAM data in several ways: a pdf report summarizing an assessment, raw results associated with a practitioner, and all public CRAM assessments presented in EcoAtlas. Additionally, the redesigned website provides training information, CRAM resources and documents, and the ability to search for trained practitioners.

The tools were developed with regular input from a user group to ensure the developed functionality met the needs of users, while focusing on easier tool maintenance by using a database to store the information displayed in the entry forms and website.

Keywords: Wetland Condition, Rapid Assessment Method, Online Data Entry Tools

Poster Topic: Watershed Management

EcoAtlas: An Online Management Support Tool for the Delta and San Francisco Bay Ecosystem

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Effective management of the Bay-Delta ecosystem requires synthesis of multiple data types related to wetland extent and condition. Consideration of 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.

EcoAtlas is an online tool developed through the Wetland Monitoring Workgroup of the Water Quality Monitoring Council to enable integration of a wide range of data in order to meet federal and state reporting requirements about wetland extent and condition, restoration activity, and water quality conditions in the system. It complements the Monitoring Council's more publicly targeted Wetlands Portal. We will present how this online tool can be used to aggregate and synthesize the data needed to support specific planning, reporting and management actions: compensatory mitigation planning at the landscape scale, climate change planning, and 305(b) reporting. Its interactive maps and project tracking tools enable users to easily access, analyze, synthesize, and visualize different data sets in a spatial context.

EcoAtlas serves both spatial and tabular data. Spatial layers include historical wetlands maps, permitted project information, and maps of current wetlands extent via the California Aquatic Resources Inventory. Additionally, data from surveys of wetland condition using the California Rapid Assessment Method and CEDEN can be displayed spatially in the map.

A Landscape Profile tool allows users to explore a particular area of interest and summarize salient information about the condition and extent of streams, wetlands, lakes, and their surrounding riparian areas. The summary includes aquatic resource extent, wetland condition results, restoration activity, threatened or endangered species, and land use and census information. EcoAtlas can be used to create a complete picture of aquatic resources in the landscape by integrating information important to California's wetlands.

Keywords: Landscape Profiles, Wetland Project Tracking, Data Synthesis, Data Visualization

Poster Topic: Watershed Management

Reflections on 12 Years of Dredged Sediment Management in SF Bay and Future Directions

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In response to environmental concerns, the San Francisco Bay Long-Term Management Strategy (LTMS) for the placement of dredged material in the San Francisco Bay Region was formed in 1990 as a multiagency cooperative program to coordinate dredging activities within San Francisco Bay and the disposal/reuse of material at specific sites around the Bay. This program's goals, when established, were to: maintain navigable channels and manage disposal of dredge material in an economic and environmentally sound manner; maximize the beneficial reuse of dredge material; and establish a cooperative permitting framework. The LTMS program recently completed a 12-year transition period to reduce in-Bay disposal, which called for a periodic step down in the allowable in-Bay disposal volume over the last 12 years. At the beginning of the LTMS transition period, the in-Bay disposal volume was 2.8 mcy and each successive step down called for a reduction of 387,500 cy every three years.

The program just completed the final step down allowing a total annual disposal of up to 1.25 mcy of sediment at in-Bay disposal sites plus a 250,000 cy contingency volume if needed in any one year period. Throughout this 12-year transition period, the program has successfully implemented many of the original goals including: implementation of transition, increased alternatives to in-Bay disposal, restoration of 2,090 acres of habitat, streamlining sediment testing and regulatory permitting. Less progress was made on securing funds to reduce the costs of upland disposal efforts. Overall, the LTMS program is performing well and has met most of the original program goals. Based upon the overall success of the program to date, the LTMS Management Committee decided to move forward with the existing program goals with flexibility to incorporate new information and adapt to changing situations around the San Francisco Bay Area.

Keywords: Beneficial Reuse, Dredging, Long-Term Management Strategy

Poster Topic: Watershed Management