## South Bay Salt Pond Restoration Project: Adaptive Management in Action

Laura Valoppi, U.S. Geological Survey, Laura_Valoppi@usgs.gov
John Bourgeois, State Coastal Conservancy, jbourgeois@coastalconservancy.ca.gov
Cheryl Strong, U.S. Fish and Wildlife Service, cheryl_strong@fws.gov

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

Micah Bisson*, UC Davis, mgbisson@ucdavis.edu
James Hobbs, UC Davis, jahobbs@ucdavis.edu
Jonathan Cook, UC Davis, joncook@ucdavis.edu
Peter Moyle, UC Davis, pbmoyle@ucdavis.edu
Shawn Acuna, UC Davis, scacuna@ucdavis.edu

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

John Callaway, University of San Francisco, callaway@usfca.edu
Lisa Schile, Smithsonian Environmental Research Center, schilel@si.edu
Evyan Borgnis, San Francisco State University, elborgnis@gmail.com
Gavin Archbald, H.T. Harvey & Associates, garchbald@harveyecology.com
Max Busnardo, H.T. Harvey & Associates, mbusnardo@harveyecology.com
Ron Duke, H.T. Harvey & Associates, rduke@harveyecology.com

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

Brian Fulfrost, Brian Fulfrost and Associates, bfaconsult@gmail.com
David Thomson, San Francisco Bay Bird Observatory, d.x.thomson@gmail.com

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

Amy Foxgrover, USGS Pacific Coastal and Marine Science Center, afoxgrover@usgs.gov
Bruce Jaffe, USGS Pacific Coastal and Marine Science Center, bjaffe@usgs.gov
Theresa Fregoso, USGS Pacific Coastal and Marine Science Center, tfregoso@usgs.gov

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

James Hobbs, UC Davis, jahobbs@ucdavis.edu
Pat Crain, UC Davis, fishguy122@gmail.com
Jonathan Cook, UC Davis, joncook@ucdavis.edu
Nick Buckmaster, UC Davis, ngbuckmaster@ucdavis.edu
Peter Moyle, UC Davis, pbmoyle@ucdavis.edu
Felipe La Luz, UC Davis, falaluz@ucdavis.edu

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

Pedro Marinho*, UC Davis, pcmarinho@ucdavis.edu
James Hobbs, UC Davis, jahobbs@ucdavis.edu
Peter Moyle, UC Davis, pbmoyle@ucdavis.edu
Jonathan Cook, UC Davis, joncook@ucdavis.edu

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

Mark Marvin-DiPasquale, USGS, mmarvin@usgs.gov
David Schoellhamer, USGS, dschoell@usgs.gov
Maureen Downing-Kunz, USGS, mdowning-kunz@usgs.gov
Greg Shellenbarger, USGS, gshellen@usgs.gov

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 (1$^{st}$ 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

Theresa A. Fregoso, USGS, tfregoso@usgs.gov
Amy C. Foxgrover, USGS, afoxgrover@usgs.gov
Bruce E. Jaffe, USGS, bjaffe@usgs.gov
Mark Marvin-DiPasquale, USGS, mmarvin@usgs.gov

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