South Bay Salt Pond Restoration Project

Restoring the Wild Heart of the South Bay

South Bay Science Symposium 2013:
Adaptive Management in Action

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Abstracts of oral and poster presentations

Oral Presentation Abstracts (in order of appearance)

Sediment Dynamics Session

1. Does Central Valley runoff control sediment supply to South San Francisco Bay?

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Sediment exchange between far South Bay and the rest of San Francisco Bay is a key component of sediment supply to the South Bay Salt Pond Restoration Project. The U.S. Geological Survey has been continuously measuring suspended-sediment concentration (SSC in mg/L) at the Dumbarton Bridge since 1992 and suspended-sediment flux (kg/s) since 2008. In addition, suspended-sediment discharge from the Guadalupe River and Coyote Creek have been measured since water years 2003 and 2004. In water-year 2009, net sediment transport at the Dumbarton Bridge was to the south toward the project area and 26 times greater than from the local tributaries. In water-year 2010, Bay and watershed supply were nearly identical. In water-year 2011, net sediment transport at the Bridge was to the north at a rate 10 times greater than supply from the local tributaries (Shellenbarger et al. 2013).

These observed differences in the direction of net sediment transport at the Dumbarton Bridge appear to be caused by differing Bay conditions in spring. Highest SSC and flux generally occur in South Bay in spring, as seasonal winds increase, and are often during a spring tide following the peak of the phytoplankton bloom. If springtime water discharge from the Central Valley makes Central Bay fresher than South Bay, the resulting density gradient flushes South Bay and concurrent high SSC amplifies sediment export, as in water-year 2011. If springtime discharge from the Central Valley is small and the salinity of Central and South Bay are similar, South Bay is not flushed and sediment is imported to the project area by tides and wind-driven currents, as in water-year 2009 (Shellenbarger et al. 2013).

These results are consistent with previous hydrodynamic research on South Bay. McCulloch et al. (1970) were the first to describe how freshwater from the Central Valley controls flushing of South Bay. Walters et al. (1985) used current-meter data to further refine this concept. Gartner et al. (1997) observed sediment transport into South Bay followed by a reversal after discharge from the Central Valley freshened Central Bay in March 1995.

In conclusion, large freshwater inflow from the Central Valley in spring results in sediment export from the project area. The timing and magnitude of freshwater inflow from the Central Valley may control sediment supply to the South Bay Salt Pond Restoration Project.

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2. Sediment Dynamics and Vegetation Recruitment in Newly Restored Salt Ponds

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Newly restored wetlands rely on sediment accumulation to raise elevations and create suitable conditions for vegetation establishment. 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 marsh restoration projects will result in impacts to adjacent mudflats. We investigated the rates of vertical sedimentation across Pond A6 over month to year time scales 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 (Reed 1989). For plant recruitment, we measured elevations at Pond A6 using a Real-Time Kinetic Global Positioning System (RTK GPS) and compared these to tidal elevations across Ponds A21 in order to determine threshold elevations for plant establishment. 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/m2/day across the pond, higher than rates from Pond A21 (approximately 160 and 60 g/m2/day in the lower and higher elevation areas of the pond, respectively). The mean pre-breach elevation of Pond A6 was 0.70 ± 0.01 m NAVD88, and two years following tidal restoration, marsh surface elevations ranged from 0.5 to 1.37 m NAVD88. Very few plants have recruited at Pond A6, with plants only occurring along levee borders and no new plants in the broad central area of the pond. At Pond A21, mean elevations were 1.79 ± 0.01 m NAVD88 for Spartina foliosa and slightly higher at 1.95 ± 0.01 m NAVD88 for Salicornia pacifica. Unvegetated areas close to the colonizing edge of S. foliosa were a mean of 1.79 ± 0.01 m NAVD88, with values between 0.91 and 1.93 m NAVD88. Pond A21's plant recruitment is patchy and appears to occur at slightly higher elevations 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 marshes.

3. Restoration with Accelerated Sea Level Rise—Sediment Limited?

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As the rate of sea level rise increases, so does the volume of sediment necessary for successful marsh restoration. Is there a threshold for the rate of sea level rise beyond which there will not be enough sediment for successful restoration of the Alviso Pond complex? Historical behavior of the bay floor, as documented by differencing repetitive bathymetric surveys, reveals that the region south of the Dumbarton Bridge has experienced a net deposition of sediment since the 1850s. The system was depositional to the extent that marshes were sustainable during the mid-1900s when groundwater extraction caused subsidence rates of 1 to 4 cm/yr. The amount of sediment deposited since the 1850s varied over decadal time scales and was equivalent to the amount necessary to raise the bay floor from 0 to 2.5 cm/yr (a sediment volume of up to 1 million cubic meters/yr). Estimates of sediment delivery from local tributaries are relatively small on a regional scale, indicating that the vast majority of this sediment came from north of Dumbarton Bridge. Likewise, our studies of the geomorphic response to the 2010 breaching of the A6 levees show that neither the nearby mudflats nor the sloughs have served as a significant supplier of sediment through erosion. Less than 0.1 million cubic meters was eroded from Alviso and Guadalupe Sloughs during the first two years after breaching. In this talk we will examine different scenarios for sediment demand associated with restoration and a range of projected sea level rise rates and explore potential sediment sources. It is clear that two uncertainties need to be addressed to assess whether there is enough sediment for successful restoration: (1) what is the future import/export of sediment from north of Dumbarton into the far South Bay, and (2) will intertidal mudflat and channel erosion supply a significant amount of the sediment needed?

4. Getting Ahead of Sea Level Rise: use of upland fill material

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In response to research that suggests potentially diminished sediment supply to the San Francisco Bay in the future, and also to accelerate marsh development as a response to future sea level rise, managers have begun to find sources of fill material that are cost effective to use in tidal marsh restorations. Upland fill sources may be the only option to raise pond bottom elevations in areas of the South Bay that are subsided up to 12 feet, and for broad transition zones that are being planned as part of the South Bay Salt Pond Project. Using the experience we have gained from importing over one million cubic yards of import material into the Bair Island Restoration Project, we are planning on continuing this partnership into other areas of the project using the same protocols. The use of dredge material for pond enhancements may be logistically impractical to the far south reaches of the Bay.

Mercury Remobilization and Bioaccumulation Session

5. The South Bay Mercury Project: Using Biosentinels to Monitor Effects of Wetland Restoration for the South Bay Salt Pond Restoration Project

Josh Ackerman, U.S. Geological Survey; Mark Marvin-DiPasquale, Darell Slotton, Collin A. Eagles-Smith, Mark P. Herzog, Alex Hartman, Jennifer L. Agee, and Shaun Ayers; U.S. Geological Survey
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The South Bay Salt Pond Restoration Project plans to convert 50-90% of the former salt evaporation ponds into tidal marsh habitat, yet this large-scale habitat restoration may change the bioavailability of methylmercury in the San Francisco Bay which is known to already have high methylmercury levels in birds and fish. We tested the effect of the Pond A8 restoration by examining the change in mercury concentrations in biosentinal fish and bird

eggs between 2010 and 2011, when most of the restoration activities occurred, as well as before and after the Pond A8 Notch opening on June 1, 2011. We accounted for any ambient changes in mercury concentrations not related to restoration activities by using Reference Ponds that were outside of the restoration area.

We found that mercury concentrations in bird eggs (Forster's Terns) and pond fish (Longjaw Mudsuckers and Threespine Sticklebacks) increased dramatically between years in the Restored Pond A8/A7/A5 Complex, relative to Reference Ponds. In particular, mercury concentrations in Forster's Tern eggs increased between years by 74% (or 1.22 µg/g fww), resulting in 100% of Tern and 14% of Avocet eggs exceeding the 0.90 µg/g fww toxicity threshold in Restored Ponds A7 and A8. Similarly, fish within the Restored Pond A8/A7/A5 Complex also increased relative to the Reference Ponds between years. Yet, after the Pond A8 Notch was opened on June 1, 2011, mercury concentrations in pond fish declined during the following 3 months. Mercury concentrations in Alviso Slough fish were also higher in 2011 than 2010, and, unlike pond fish, increased after the Pond A8 Notch opening, especially in the upstream reaches of Alviso Slough. There were several factors associated with changes in surface water chemistry that appeared to explain these observed changes in biosentinal mercury concentrations.

Our results highlight the effects of wetland restoration actions on mercury cycling and resulting mercury concentrations in birds and fish. These shifts in mercury cycling occurred both within the Restored Pond A8/A7/A5 Complex, as well as in nearby reaches of Alviso Slough after the Pond A8 Notch was opened. Importantly, both bird eggs and fish mercury concentrations increased substantially between years when the restoration actions occurred (relative to Reference Ponds), and the effects depended on the temporal scale. In particular, the increased mercury concentrations in Tern eggs occurred in the year immediately following the restoration actions, but it is still unknown if high mercury concentrations in eggs will continue within the Pond A8/A7/A5 Complex as this restored habitat further develops and the Pond A8 Notch is widened further. We recommend that the South Bay Salt Pond Restoration Project implement a longer-term monitoring plan for mercury in biota and processes to fully evaluate the effect of this and other ongoing wetland restoration projects.

6. The South Bay Mercury Project: Using Small Fish in Alviso Slough to Monitor Downstream Effects of Wetland Restoration in the South Bay Salt Ponds

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This research was a component of a larger USGS-led project to investigate the effects of wetland restoration at Pond A8 on mercury trends. In this UC Davis part of the work, we focused on potential effects outside and downstream of Pond A8, using small, naturally occurring, 'biosentinel' fish to monitor mercury conditions in Alviso Slough. We investigated biosentinel small fish mercury trends in Alviso Slough before and after Pond A8 restoration work. A series of four sites were distributed along Alviso Slough in relation to the restoration construction, plus a reference/control site located in Mallard Slough.

Sampling was done five times between April and October of 2010 (before adjacent restoration work) and again in 2011 (including post restoration collections). We collected two species of local small fish that have been extensively studied in related work: Threespine Stickleback and Mississippi Silverside.

Significant increases were seen in small fish mercury for 1-3 months at the upper Alviso Slough sites during 2011, compared to 2010, following the opening of the Pond A8 Notch (June 2011). These increases happened at the same time the USGS sediment/water team found an increase in bioavailable dissolved methylmercury in upper Alviso Slough water. Results indicate a linkage to the opening of the Pond A8 Notch, with increased mercury movement into the base of the food web in upper Alviso Slough. Increased fish mercury levels were also seen at the most downstream Alviso Slough site, but before opening of the A8 notch, apparently linked to the opening of Pond A6 (Dec 2010). The small fish mercury increases recorded in Alviso Slough during 2011, compared to 2010, were also statistically significant in comparison to the 2010-2011 trend at the control site in Mallard Slough.

Though we have limited data following the restoration perturbations, they indicate that the observed increases in small fish mercury may have been limited to the initial months following restoration work, with subsequent declines to pre-restoration levels. Longer-term trends can be assessed with future monitoring.

7. An Examination of Mercury Mobilization and Transformation Associated With Wetland Restoration in South San Francisco Bay

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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 buried in the sloughs and marshes (via slough widening). Since 2003, USGS scientists have been involved in multiple projects aimed at understanding how much of this mercury has been or will be mobilized as a result of restoration management actions, how much is coming into the project area from upstream legacy mines, and to what extent do restoration actions exacerbate or mitigate mercury bioaccumulation in the local or regional food web. This presentation will highlight a number of these related mercury studies, both past and ongoing, and give a synopsis of 'lessons learned' to date. Specifically, the presentation will focus on the impact of the initial opening of the Pond A8 notch structure and the breaching of Pond A6 during 2011, and how these management actions affected mercury mobilization and chemical speciation in the restoration area. The insights offered by this body of research has direct implications for wetland restoration efforts that are ongoing and planned in many regions of the San Francisco Bay, its watershed, and globally.

8. Changes in Management of Pond A8 in Response to Mercury Results

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Phase I of the South Bay Salt Pond Restoration Project included several experimental projects aimed to inform future restoration phases. In the Alviso Complex, Ponds A5/A7/A8/A8S (1,440 acres) were opened to the Bay in a controlled manner to test the effects of restoring tidal action to a pond complex with known elevated levels of mercury. The water control structure installed has eight 5-foot wide bays that can each be opened independently. Starting in July 2011, the structure was opened 5-feet wide. In 2012 and 2013, that opening was increased to 15-feet. However, mercury is not the only constraint facing this pond complex, which also must be managed for flood protection and to avoid impacts to migrating salmonids. The presentation will address these conflicting management issues and look forward to future management actions based on the latest data from the mercury studies.

Bird Use of Pond Habitats

9. Waterbird Response to Pond Management

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A major goal and uncertainty of the South Bay Salt Pond Restoration Project is maintaining the migratory, wintering, and resident waterbird populations with a reduced number of salt ponds while restoring 50-90% to tidal salt marshes. To meet these goals, land managers are working on ways to create pond conditions that will support

a higher density of waterbirds on fewer areas. During the Interim Stewardship Plan (ISP: 2003-2008), salinities and water depths were changed within many ponds as required under the transfer agreement. Before and during Phase I restoration (2009-2013), islands were constructed as roosting and nesting habitats in a number of recent restoration project ponds, and water levels and salinities were manipulated to support different species or guilds. In the Programmatic EIS, any restoration converting >50% of ponds to tidal flows was to be guided by survey datasets proving "no net loss" of waterbirds. Thus, USGS conducted monthly waterbird surveys from 2003-2013 to provide the data required for informed adaptive restoration decisions. For example, Alviso Pond A16 initially had salinity values exceeding 80 ppt pre-ISP from 2003 to 2005, and few ducks occupied A16. From 2006 to 2011, the salinity in A16 was lowered to <20 ppt and 2,000 to >12,000 dabbling ducks were counted in A16. In 2012, the salinity once again was allowed to rise in A16, and the duck abundance declined to fewer than 100 birds. In contrast, water levels in Eden Landing Pond E13 were reduced from 54.9 cm depth in 2003 to 3.0 cm in 2011. From 2003 to 2004, there were fewer than 1,000 small shorebirds counted in the pond, while from 2005 to 2011, abundance ranged from 2,500 to 7,000 individuals. Through Phase I restoration, management actions have resulted in increased waterbird abundance, species changes, and redistribution across the pond systems. Overall, total waterbird numbers have grown 100% from <100,000 in 2003 to >200,000 in 2012. The upcoming Eden Landing E12-E13 project will test managing for three saline pond habitats with differing water levels and salinities that may increase densities of invertebrate prey and foraging waterbirds. However, this first phase represents the transitional stage of early tidal marsh restoration in a 50-year project that will develop dense plant communities not suitable for many waterbirds. Thus, to achieve successful restoration actions, especially in light of climate change effects, integrated applied science including waterbird monitoring must remain a critical component to guide the restoration project.

10. California Gull Population Growth and Response to Pond A6 Breach

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Since 1980, the San Francisco Bay Bird Observatory has surveyed gull breeding colonies across the South Bay. This research has documented rapidly increasing numbers of California Gulls, which is the most abundant gull species in the area during the breeding season of many other waterbirds. California Gull populations in the South Bay have increased from only 24 in the early 1980s to over 50,000 in 2012. From 2011 to 2012, the Bay-wide California Gull population increased by nearly 40%, though we observed considerable variability in growth rates from one colony to the next. Simultaneously, we and others have documented declines in populations for many colonially-nesting waterbirds and for shorebird species, including the federally-threatened Western Snowy Plover. Scientists at SFBBO, the USFWS and the US Geological Survey have shown that California Gulls consume the eggs and chicks of other waterbird species. Therefore, the incredibly rapid growth of California Gulls has been identified as one of the most pressing concerns for management of the San Francisco Bay estuary by SFBBO, by federal and state agencies charged with managing this ecosystem, and by the South Bay Salt Pond Restoration Project. In this talk, we will highlight changes in gull population growth at colonies across the South Bay, and discuss factors likely leading to the rapid growth observed at some colonies and slower growth at others. SFBBO has also monitored gull movements through banding of gulls and subsequent resight surveys. We present information on the movements of banded gulls, focusing on responses of gulls to the breach at Pond A6, which formerly housed the largest California Gull colony in the area. Information on what drives gull population growth, and how gulls respond to restoration activities (such as breaches), helps the SBSPRP and land managers predict gull responses to future restoration activities and to manage adaptively.

11. Monitoring Western Snowy Plovers in South Bay Salt Ponds: recent results and future research needs

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The Pacific Coast population of the Western Snowy Plover was listed as federally threatened in 1993. While most coastal-breeding plovers nest on beaches, those in the San Francisco Bay nest primarily on dry salt panne of former salt evaporation ponds. While the South Bay Salt Pond Restoration Project (SBSPRP) will benefit many species by restoring designated salt ponds to tidal marsh or other managed habitat types, one result will be less dry panne habitat available to nesting plovers. Specifically, the SBSPRP has set a target of maintaining 250 breeding plovers within the project area (current estimates range from 130-200 breeding plovers in the entire Bay), so understanding current limiting factors and developing effective management strategies to retain and increase plover numbers and breeding success with reduced dry panne acreage is of great interest.
Since 2003, the San Francisco Bay Bird Observatory has been monitoring plover breeding ecology in close collaboration with the Don Edwards San Francisco Bay National Wildlife Refuge. Our results indicate that predation is the leading cause of nest failure (accounting for 31-55% of apparent losses from 2009-2012), and that nest survival can be affected by many factors, with considerable year and site variation. Nest predators documented by remote cameras include California Gulls, Northern Harriers, Red-tailed Hawks, Common Ravens, Gray Foxes, and Ruddy Turnstones. There is also some preliminary evidence that experimental oyster shell enhancements employed at Eden Landing Ecological Reserve provided some benefit to plover hatching success from 2009-2012, perhaps because of the improved camouflage they offered; however, many uncertainties remain, and further study is needed. Low numbers of banded birds and challenging re-sighting conditions make meaningful estimates of fledging success and dispersal difficult, and we suggest that telemetry or other methods may help to address this knowledge gap. Expanded monitoring will be critical as the SBSPRP moves forward to ensure that plovers retain adequate nesting habitat and are protected from disturbance associated with trail use and restoration-related construction activities.

12. Balancing Waterbird Protection and Public Access

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Wildlife managers must often balance the potentially competing goals of protecting wildlife while providing public access. In the urban South San Francisco Bay area, we studied the response of nesting snowy plovers, wintering shorebirds and wintering waterfowl to trail use. We used an experimental approach—exposing birds to one or two walkers on levees adjacent to wetlands used by these birds. We found bird responses were both species and situation dependent. Snowy plovers, exposed to walkers in areas where trails do not exist, flushed off their nests 72% of the time in response to walkers, but only in 11% of control observations. They flushed at 145m (SE 14m) from trail walkers; the length of time off nest was significantly correlated with the length of time walks took. At sites without existing trails, shorebirds exposed to experimental walkers showed short-term behavioral responses, but numbers and behaviors immediately after our walks did not differ from before the walk. During walks, shorebirds were approximately 25-30m from the walkers. Waterfowl responded more strongly to trail use. Duck numbers were much lower after our experimental walks compared to before the walk, at distances of 100m or more from the levee. Waterfowl did not appear to be habituating to regular trail use at sites with existing trails.

To understand how to balance waterbird responses with public access preferences, we also studied trail user satisfaction with the recreational experience by surveying visitors to South Bay trails. Willing participants provided data on trail user demographics, activity types, level of satisfaction, trail features and public access funding priorities. Over four seasons, we collected 568 user surveys--207 from new South Bay Salt Pond (SBSP) Restoration

Project trail locations and 361 at existing trails adjacent to the three pond complexes. The qualities of the experience visitors enjoyed the most included solitude, uncrowded setting and wildlife, while the physical features visitors most valued were overlooks or view areas, parking, maps/signs, and restrooms. The top capital funding priority was the completion of the Bay Trail and connections to other local trail systems. Beyond this priority, trail users wanted improvements to trail maps and mileage markers, access to drinking water, more restrooms and benches for resting. Equally important to the survey respondents were maintenance and cleanliness of the existing trail system. We provide recommendations, synthesizing this visitor information with the results of our waterbird studies, to assist SBSP managers in balancing wetland habitat restoration and wildlife-oriented public access.

13. Changes in Management of Ponds in Response to Bird Research Results

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The SBSPRP is committed to maintaining numbers of waterbirds that currently utilize the existing managed ponds. However, the jury is still out as to how much of the landscape needs to maintained and managed as ponds in order to facilitate a healthy population of these birds. Research from USGS, SFBBO, and other groups are helping us to determine this balance, but there are many challenges related to pond management and the sometimes conflicting needs of different species of wildlife. Monthly bird surveys from USGS and SFBBO give us important information on seasonal use of ponds by specific birds throughout the year. Nesting surveys by the same groups allow us to track how our water management influences reproductive success, and how newly constructed islands are functioning. From SJSU and colleagues we better understand the need for buffers to limit human disturbance effects. Managing ponds is difficult given logistical, financial, seasonal, and permit constraints and the inherent differences in each pond. Managed ponds also need to be maintained in the landscape for the foreseeable future. The SBSPRP has started up a Pond Management Working Group to discuss ways to share management and research information in a more timely fashion and to plot out our best course of action going forward. Monitoring and research is critical to the success of the SBSPRP.

Bird Use of Islands Session

14. Factors Influencing Breeding Waterbird Use of Islands in San Francisco Bay

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Salt ponds of South San Francisco Bay provide critical breeding habitat for many waterbirds. Islands within salt ponds are especially important, as they provide nesting habitat for large numbers of locally breeding waterbirds, especially Forster's Terns and American Avocets. Thus, preserving and enhancing salt pond island nesting habitat is necessary to achieve the South Bay Salt Pond Restoration Project goal of maintaining current populations of breeding waterbirds. The USGS has been monitoring waterbirds in San Francisco Bay for several years and has amassed considerable data on more than 14,000 waterbird nests, including nest distribution and abundance, habitat use, and nest success rates. In coordination with our waterbird nest monitoring activities, over the past two breeding seasons we have investigated in great detail island morphometry (perimeter, area, and elevation) and vegetation structure and distribution to evaluate how these factors affect nest abundance, nest-site selection and nest success of breeding waterbirds. Islands were the main nesting habitat, with more than 80% of Forster's Terns and 60% of American Avocets nesting on salt pond islands. The number of nests increased with island size up to a point and, thereafter, larger islands supported few additional nests. Although Avocet and Terns often nest on multiple islands within a single pond, a greater number of islands within a pond did not correlate well with more nests per pond, suggesting that a few islands in each of several ponds may be more advantageous than many islands within a single pond. We also evaluate island shape, perimeter to area ratio, and island elevation on nest

abundance and nest success rates. The results of this study will provide scientific support for adaptive management actions to maintain waterbird populations as future phases of the SBSP Restoration Project are implemented.

15. Migratory and Wintering Waterbird Use of Islands within the South Bay Salt Ponds

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The South Bay Salt Ponds Restoration Project plans to restore 50-90% of the former salt production ponds to tidal marsh while maintaining the wintering, migratory, and breeding populations of waterbirds that use the managed ponds. To meet these goals, land managers are working on ways to create pond conditions that will support a higher density of waterbirds on fewer areas. The restoration project has incorporated habitat elements within restoration designs to enhance pond use by waterbirds. These elements include islands within managed ponds to provide high tide roosts and nest sites for ground-nesting birds. From October 2010 to September 2012, we studied habitat factors related to use of islands by non-breeding waterbirds. We conducted monthly surveys to record waterbird abundance and behavior on each of 59 islands within 15 ponds. We examined the abundance of waterbirds in relation to specific island features including elevation, slope, aspect, and island perimeter-to-area ratio, as well as proximity to bay, levee, and upland. Across the two years, we recorded over 9,000 small shorebirds, 10,000 medium shorebirds, 5,500 ducks, 7,500 gulls, and 65,000 pelicans and cormorants. Islands within Eden Landing Pond E2 and Alviso Pond A1 supported the highest abundance of waterbirds. Our findings suggest that certain island features are related to higher waterbird abundance. We used these results to compare pre-restoration project numbers of waterbirds from surveys during the Interim Stewardship Plan to those projected to occur with 10% to 50% of ponds remaining if the restoration project includes habitat elements for waterbirds in each pond. Finally, we discuss these findings in light of the uncertainty of climate change effects on the restoration project.

16. Response of Waterbirds to Salt Pond Enhancements and Island Creation in the San Francisco Bay

Stacy M. Moskal, Scott A. Shaffer, John Y. Takekawa and Lacy M. Smith; U.S. Geological Survey San Francisco Bay Estuary Field Station
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Historically, San Francisco Bay supported the largest salt pond complex on the Pacific coast of North America, and these areas have been used by large numbers of migrating and wintering waterbirds for more than a century. In 2003, salt ponds in the South San Francisco Bay were purchased with a goal of restoring 50%-90% of the 6100 ha of former salt ponds to replace lost tidal marsh habitats. However, a major challenge for the restoration project has been maintaining the abundance of non-breeding waterbirds in a smaller footprint of managed ponds. Thus, in 2009-2010, Pond SF2 was enhanced with 30 islands of two different shapes and water control structures that provided muted tidal flows with shallow water depths predicted to benefit waterbirds. To assess how non-breeding waterbirds responded to these enhancements, I used a spatial grid (50 m x 50 m) to survey SF2 weekly from October to May, 2010-2012 and examine waterbird use. Of the 262,932 non-breeding waterbirds observed, only 12%-15% used the islands depending on tide. Island size, shape, or both predicted the presence or relative abundance of some foraging guilds, whereas island slope, perimeter, and distance to mudflat did not improve the model's predictions of relative guild abundances. My results indicated that waterbirds were attracted to areas with shallow water depths; however, the constructed islands were not used by a large number of waterbirds.

17. E12-E13 Design Revisions, Informed by Science, Implemented in Design and Construction: Island Design and foraging/roosting enhancements

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As the SBSPRP continues to implement Phase One Projects, project and land managers are incorporating recommendations and other considerations from on-going monitoring or completed studies into the design of each subsequent project. Current and future restoration actions will continue to open former ponds to full tidal action, while remaining ponds are managed to provide optimum conditions, as practicable. The objective of pond management/operations is to increase foraging and roosting opportunities by providing important energy resources for waterbirds, particularly during high abundance periods in migration and winter seasons when energy demand is greatest (hundreds of thousands of shorebirds and tens of thousands of waterfowl). Similarly, ponds also provide nesting habitat for various waterbird guilds, particularly for resident species such as American avocet, black-necked stilt and various terns, as well as threatened and endangered species, notably western snowy plover. Other factors such as public access can affect bird use of the ponds as well, therefore, it is important to consider buffer distances for public access features to ensure adequate suitable habitat is available for successful nesting and roosting.

Poster Abstracts (alphabetical by primary author's last name)

1) 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.

2) 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. The success of restoration actions on fish species can be quantified in several ways, species assemblage, abundance, & nursery function. To monitor 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 measurements of whole body composition as well as the quantification of the abundance of trigycerides (TAG) in the muscle tissue an indicator of fat storage and energy potential. Longjaw mudsuckers depend on burrows in the mud banks and remain in the creeklets at low tide, being able to uptake oxygen through vascularization of the buccal cavity. We monitored their density and recruitment by deploying baited minnow traps (3-5) per creeklet, with 3-5 replicate creeklets. 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. For this study we chose sites at pond A6, A8 and A21 in the Alviso Marsh, SF2 at the Ravenswood Marsh, Outer Bair Island, at the Whales Tale marsh and inside the restored E9 pond at Eden Landing. Here we present results for only the Alviso Marsh and Ravenswood Marsh as other sites produced too few fish. 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 that fish quickly colonize the new ponds but due to the lack of suitable pickleweed habitat they either move back out of the ponds or are

consumed by predators such as leopard shark and bat ray. 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.

3) Nearshore linkages: the roles of native oysters and eelgrass as living shorelines in the San Francisco Estuary

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The San Francisco Bay Living Shorelines: Near-shore Linkages Project is a multi-objective habitat restoration pilot project with the overarching goal to create biologically rich and diverse subtidal and low intertidal habitats, including eelgrass and oyster reefs, as part of a self-sustaining estuary system that restores ecological function and is resilient to changing environmental conditions. This project builds on our previous work that advanced restoration methodologies and understanding of constraints and opportunities for both eelgrass and native oysters. Such habitat features, if scaled up beyond previous projects, have the potential to positively influence physical processes (such as waves and sediment transport) that determine shoreline morphology. In this project, we are further testing restoration methods, restoring eelgrass and oyster habitat, testing the individual and interactive effects of restoration techniques on habitat values, and beginning to evaluate effects on shoreline processes. Plots (32 x 10 m) of oyster substrate alone (shell-bag mounds), eelgrass alone, or the two together in an additive design, are being compared to un-manipulated control plots along the San Rafael shoreline in the first phase of the project. Preliminary data show that restored habitat structure at this site promotes increased abundance of numerous organisms relative to bare sediment, with a number of native invertebrates reproducing on the oyster substrates. Native oysters have recruited in large numbers to the shell bag mounds, particularly on north-facing, vertical, or lower-elevation surfaces that likely minimize thermal stress. Birds such as black oystercatcher and several wader species increased in density at treatment plots in comparison to pre-treatment and control densities. Two large wind-wave events in March and April 2013 at the San Rafael site led to preliminary findings of reduced waves in plots with added structure at particular water elevations during the tidal cycle. Small plots (1-m2, n=5) at San Rafael and along the Hayward shoreline (near Eden Landing Ecological Reserve) testing various oyster restoration substrates (including SF Bay-derived "baycrete" balls and interlocking blocks) are permitting comparisons of native oyster recruitment by substrate and by site. Preliminary data show much greater oyster recruitment at San Rafael than at Hayward, and little difference in recruitment among the concrete substrates. This project will advance our understanding of restoration methodologies with an eye towards both habitat creation and shoreline protection in an era of rising seas and increasing storm surges.

4) Late Holocene marsh expansion in Southern San Francisco Bay, California: implications for the use of historic baselines as restoration targets

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Currently, the largest tidal wetlands restoration project on the US Pacific Coast is being planned and implemented in southern San Francisco Bay; however, knowledge of baseline conditions of salt marsh extent in the region prior to European settlement is limited. Here, analysis of 24 sediment cores collected from ten intact southern San Francisco Bay tidal marshes were used to reconstruct spatio-temporal patterns of marsh expansion to provide

historic context for current restoration efforts. A process-based marsh elevation simulation model was used to identify interactions between sediment supply, sea-level rise, and marsh formation rates. A distinct north-south age gradient was found: expansion of marshes in the central portion of southern San Francisco Bay dated from 500 to 1500 calendar years before present, while expansion of marshes in southernmost San Francisco Bay dated from 200 to 700 calendar years before present. Thus, much of the tidal marsh area mapped by US Coast Survey during the 1853–1857 period were in fact not primeval tidal marshes that had persisted for millennia but were recently formed landscapes. Marsh expansion increased during the Little Ice Age, when freshwater inflow and sediment influx were higher than during the previous millennium. Marsh expansion also increased during European-American settlement, when land use changes, such as the introduction of livestock, led to increased watershed erosion, and sediment delivery. These results provide a valuable perspective on salt marsh restoration and sustainability in South San Francisco Bay. Generally turbid conditions, the large acreages of salt marsh mapped in the late 1800s, and positive response to rapid sea level rise in the mid-twentieth century (due to groundwater overdraft) have built a perspective of South Bay salt marshes that suggest a very robust sediment supply, and thus a strong capacity for re-vegetation and sustainability. However, our results suggest that during the prehistoric past, conditions may have been more challenging, and may caution against extremely ambitious acreage restoration goals.

5) Landscape Analysis of the South Bay

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In the face of climate change and sea level rise, understanding the current challenges and opportunities for species and habitat migration is essential for long and short-term environmental planning. The South Bay Salt Ponds (SBSP) project is in the process of addressing these adaptation questions through ongoing adaptive management. To help inform this effort the San Francisco Estuary Institute (SFEI) performed multiple landscape ecology and net landscape change analyses for the tidal habitats in the San Francisco South Bay. This work provides a general understanding of the extent, distribution, and fragmentation of current tidal habitats through a net change analysis and the following landscape ecology analyses: patch size distribution, nearest neighbor distances, channel sinuosity, and core to edge habitat ratios. These metrics illustrate the current configuration of tidal marsh habitat for key species and areas with enhancement/restoration potential. The net change analysis summarizes the project's net loss and gains in bayland habitats from pre-European settlement to post-restoration. Time stamps used in the net change analysis include circa 1850, 1997, 2009, and "Post-restoration", an estimate of expected habitat based on the current understanding of all active and planned SBSP and other restoration projects. This time series allows managers to not only compare to where we've been, but it also serves as part of the blueprint for future management actions. Datasets used in the landscape ecology and net change analyses were developed by SFEI and include the EcoAtlas Historical (c. 1850) and Modern (1997), the Bay Area Aquatic Resource Inventory (BAARI) (2009), and Wetland Tracker ("Post-restoration Estimates") datasets.

6) Restoring Soil Ecology and Native Plant Communities in Transition Zone Habitat Adjacent to a Former Salt Pond

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Restoring unique or heavily disturbed ecosystems often requires novel approaches to break the cycle of invasion and establish self-sustaining native plant communities. This experiment measures the effects of "compost tea" inoculated with local soils and woodchip mulch on native plant performance and seed establishment in saltmarsh transition zone communities at Eden Landing Ecological Reserve, a part South San Francisco Bay Salt Pond Restoration Project. Soils collected from local reference and restoration sites were used to inoculate a liquid "compost tea" blend to encourage the development of bacterial and fungal communities in a recently graded area dominated by invasive species. Study plots were planted with *Grindelia stricta, Baccharis glutinosa, and Elymus*

triticoides, native shrub and grass species common to transition zone restoration. All plots were seeded with 15 different native species in a hydro-seeding mix. For each species, plants were planted at a distinct elevation in a block design and treated with bare soil, mulch, compost tea, a combination of compost tea and mulch, and a control with no alteration. Plots were subsequently monitored for plant height and crown volume. Contrary to expectations, mulch alone produced the highest growth response, indicating that soil communities do not likely limit the establishment of restoration species. By testing novel restoration techniques to create transition zone habitat adjacent to a nearly restored former salt pond, this study aims to develop land management practices and inform future design of tidal marsh transition zone restoration projects.

7) 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 plant communities in newly developing restoration sites. 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, 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 current work describes project design and implementation of initial steps.

8) Bathymetric change surrounding the Alviso pond complex: 2010 - 2013

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An unanswered question in the restoration of salt ponds in South San Francisco Bay is to what degree breaching will cause local and regional erosion of sloughs, mudflats, and channels. In 2010 the USGS mapped the 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 notch. Since 2010 we have conducted five additional surveys to monitor bathymetric change 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 south of the A6 breaches are more subtle and, when summed, indicate a net deposition of sediment. These data are critical to adaptive management of restoration plans, estimates of legacy contaminants released by restoration-associated erosion, 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, available at: http://pubs.usgs.gov/of/2011/1315/.

9) San Francisco Bay Transition Zone 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.

10) Using Interpretation as an educational and outreach tool with the South Bay South Bay Salt Pond Restoration Project:

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The South Bay Salt Pond Restoration Project restores wetlands essential for bird habitats, flood control, and the beauty of the area. Humans have a natural desire to connect to and understand the world around them; interpretive techniques help to facilitate this need. Interpretive Programs in: talks, didactic boards, or guided tours can educate the public on what they are seeing and why; inspiring them to care and become involved. In my poster I will present some of the ways interpretive tools are used as public outreach, in classrooms, walks, or lectures. Interpretive tools can give a synergistic approach knowledge and enjoyment of the outdoors, assisting to further preserve the wetlands, as the public understands the impact we all have on the environment and the pivotal role we each play in preserving it.

11) Tidal Marsh Revegetation by Design: Rapid Enhancement of Habitat to Benefit California Clapper Rail (*Rallus longirostris obsoletus*)

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The Coastal Conservancy's San Francisco Estuary Invasive *Spartina* Project (ISP) is in the midst of implementing a five year large-scale restoration program that focuses on enhancing habitat for California clapper rail in areas affected by non-native *Spartina* invasion. Revegetation sites include primarily recently restored tidal marshes that were heavily invaded by non-native *Spartina,* which outcompeted native marsh vegetation during vegetation establishment. After removal of non-native *Spartina,* natural recruitment of some species of native marsh vegetation has been very successful. However, two key components of clapper rail habitat, *Grindelia stricta* and native *Spartina foliosa*, are still missing or are present in very low numbers at some sites. Revegetation focusing on these two key species aims to rapidly enhance existing clapper rail habitat in support of existing rail populations. With the help of a Technical Advisory Committee, the ISP designed and implemented plantings that aim to establish dense, strategically-located patches of vegetation that benefit nesting, foraging and roosting

clapper rail as well as provide high tide refuge. To maximize plant survivorship and vigor, locations appropriate for each plant species were selected (e.g., appropriate elevation).

Whale's Tail South and Cargill Mitigation Marsh, part of the California Department of Fish and Wildlife's Eden Landing Ecological Reserve, are two adjacent sites that exemplify the program's approach to revegetation. *Spartina foliosa* has been planted on marsh channel banks and, once established, will provide cover for foraging rails that is currently largely absent at these sites. *Grindelia stricta* has been planted along the edges of marsh plain channels at both sites to provide cover for nesting rails as well as on berms within Cargill Mitigation Marsh to provide high tide refuge cover. In addition, several upland transition zone plant species have been planted along a levee that separates these two sites to provide extreme high tide refuge cover.

12) 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, and 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 isotopods) 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 abundance invertebrates (mysid and Crangon shrimp). Distinct seasonal patterns fish assemblages were apparent with summer species assemblages comprised of juvenile Pacific staghorn sculpin, Northern anchovies and English sole, while the winter assemblage included Pacific herring, American shad and the State threatened longfin smelt. The mysid shrimp (comprised of several species) was in greatest rank abundance during the winter and into the early summer, while Crangon shrimp were abundance 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.

13) 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 to create a mosaic of habitats for migratory shorebirds, waterfowl and fish. Restoration of salt ponds has been done through the breeching 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 top native predator the Leopard shark (*Traikis semifasciata*). Managed ponds for birds creates a tidally muted system where in many cases large fish such as the Leopard shark can enter and remain during low tide, when the fish would normally have to retreat to the bay with the outgoing tide. 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. The stomach contents of leopard sharks were recovered using gastric lavage (water is injected into the stomach cavity until the contents are evacuated) and preserved in 95% ethanol. While gastric lavage may not recover all of the gut contents, it is a non-lethal method of determining diet composition, and the preferred alternative to killing large number of individuals. Thus far we have examined over 20 individuals from SF2 and E9. Leopard sharks are described as a generalist predator feeding on a variety of benthic invertebrates and fishes. Interestingly, we found that individuals captured at the same location, time and similar size can have very different diets, with some individuals feeding solely on pile worms, while other preferring crustaceans (shrimps and crabs) while others were feeding only on fish, thus in general 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; however 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.

14) Shifts in Marsh Vegetation in the Lower South Bay Since 1989

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The City of San Jose (City) has contracted with H.T. Harvey and Associates to monitor marsh plant associations in Lower South San Francisco Bay since 1989. In the past 24 years, this monitoring has been conducted 18 times as a requirement in the NPDES wastewater discharge permit for the San Jose/Santa Clara Regional Wastewater Facility (Plant). The marsh vegetation monitoring requirement was prompted by concerns that the Plant's freshwater effluent may convert salt marsh into freshwater marsh. Salt marsh provides critical habitat for endangered Salt Marsh Harvest Mouse (Reithrodontymys raviventris) and the California Clapper Rail (Rallus longirostris obsoletus).

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. Since 1989, salt marsh in the Main Study Area has increased substantially (490 acres), whereas in the Reference Area, salt marsh increased marginally (40 acres). Brackish marsh decreased slightly in both Main and Reference Areas by 23 and 50 acres respectively. The increase in salt marsh and decrease in brackish marsh are likely due to restoration actions associated with the South Bay Salt Pond Restoration Project.

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. In fact, the proportion of salt and brackish marsh has been similar over time between these areas, which suggests that abiotic factors other than the constant discharge from the Plant are responsible for the large-scale shifts between brackish and salt marsh. It is likely that rainfall (and associated stream flows), variability in mean sea level, and salinity changes associated with salt pond restoration actions are the primary factors influencing marsh habitat conversion.

15) 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 one 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 help to answer these management questions in a cost effective way.

16) Creating Tidal Marsh-Upland Transitional Plant Communities at Pond A6

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Pond A6 was restored to tidal action in December of 2010. Part of the restoration design included scraping one foot from the levees to improve growing conditions for plants in preparation for aerial hydroseeding with 28 species of native grasses and broadleaf plants. Seeding was implemented in late October 2011, which was followed by a drought that lasted until mid-January 2012. Results were necessarily poor, so our monitoring focus switched to describing results from the second rain season (2012-13) to see if the seed persisted. Although much of the higher elevations remained barren this year there was some recruitment, so we focused our monitoring on describing the conditions that appear to have promoted recruitment. These included slope, aspect, microtopography (i.e. surface roughness), and soil compaction. We have summarized these results and created recommendations for construction specifications that should improve growing conditions and the success of future restoration projects.

17) Conserving San Francisco Bay's waterbirds: three decades in a rapidly changing landscape

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The San Francisco Bay estuary provides critical habitat for over one million waterbirds annually. Although the landscape has been altered for well over a century by increasing levels of urbanization, and by the historic establishment of evaporator ponds for salt production, it remains heavily used by waterbirds. The area also hosts the west coast's largest tidal wetlands restoration project; the South Bay Salt Pond Restoration Project is implementing a plan to convert thousands of acres of salt ponds into tidal and managed wetland habitat. While the restoration to tidal marsh will increase habitat for many species, it also will reduce the overall habitat available for waterbirds. Through adaptive management, the Project is committed to maintaining historic levels of waterbirds in this landscape. To inform these efforts, the USFWS, San Francisco Bay Bird Observatory, USGS and UC Davis have partnered to assess changes in bird population levels and community composition for nine

waterbird guilds. Data collected during the early 1980s were compared with current data to identify significant changes that have occurred over 30 years. We identified significant increases in populations for some guilds, such as gulls, and declines at all or some locations for other guilds such as divers, terns and grebes. We provide recommendations for the Project's development and for future adaptive management to ensure abundant and diverse waterbird communities.

18) Tidal Marsh Restoration Activities in Support of California Clapper Rail in the San Francisco Estuary

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In 2011, the California Coastal Conservancy's Invasive Spartina Project undertook an ambitious 5-year program to rapidly improve habitat for California clapper rail (*Rallus longirostris obsoletus*) in tidal marshes of the San Francisco Estuary. The program components include: artificial floating islands (USGS), constructed high tide refuge islands (H.T. Harvey), rapid intensive revegetation, predator control actions and continued Bay-wide eradication of invasive Spartina.

One major 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 or near invasive *Spartina* eradication sites, with the goal of rapidly enhancing cover, nesting, and high tide refuge habitat features for the rails. While restoration practitioners have previously had success with planting *G. stricta*, there has been little success with *S. foliosa* in the San Francisco Estuary, and new methods had to be tested and developed. Over the past 2 ½ years, the Invasive *Spartina* Project Revegetation Program has installed over 108,000 native tidal marsh plants with good success, and we are preparing to install another 79,000 plants next season.

The revegetation program targets planting *G. stricta* on the marsh plain and around the perimeter of islands and berms and S. foliosa along marsh interior channels and on the mud-flat transition zone. Most revegetation sites were selected because there were existing clapper rail populations that would benefit in the near term from habitat enhancement. Other sites were selected based on restoration work already underway by project partners or the opportunity 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 with *G. stricta*, perennial pickleweed (*Salicornia pacifica*), and saltgrass (*Distichlis spicata*). In 2011-12 and 2012-13, 29,209 (*S. foliosa* counted as stems; 20,997 as plugs) and 79,160 *(S. foliosa* as stems; 46,144 as plugs) plants were installed respectively. The average survivorships for 2011-2012 varied across all sites, species, planting design and treatments (e.g., pot size, planting design, caging method). The mean marsh plain *G. stricta* survivorship across all sites was 35%. Several sites had *G. stricta* survivorship over 50%. The average 2011-12 survivorship for *S. foliosa* was greater than 40%. Future planting designs and treatments continue to be adapted to meet target survivorship goals.