South Bay Salt Pond Restoration Project

Restoring the Wild Heart of the South Bay

South Bay Science Symposium 2008: Research and Restoration of the South Bay

25 Sept. 2008
Abstracts of oral and poster presentations

Oral presentations

1. Ackerman, Josh[1], John Takekawa[2], Jill Bluso[3], Collin Eagles-Smith[1], Danielle Le Fer[4], and Cheryl Strong[5]

[1]USGS, Western Ecological Research Center, Davis Field Station, jackerman@usgs.gov; [2]USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station; [3]San Francisco Bay Bird Observatory; [4]Jones and Stokes, [5]USFWS, Don Edwards San Francisco Bay National Wildlife Refuge

CALIFORNIA GULL MOVEMENTS IN RELATION TO BREEDING WATERBIRDS AND LANDFILLS: IMPLICATIONS FOR THE SOUTH BAY SALT POND RESTORATION PROJECT

Breeding populations of California gulls (*Larus californicus*) have increased by 37 fold over the past two decades in San Francisco Bay, from less than 1,000 breeding birds in 1982 to over 37,000 in 2007. California gulls are voracious predators of eggs and chicks, and also displace other waterbirds from nest sites. The South Bay Salt Pond Restoration Project is initiating plans to restore several former salt ponds into tidal marsh, including A6 which currently is the largest breeding colony of California gulls in the San Francisco Bay at 24,696 gulls. When A6 is breached, it will become flooded and force gulls to move elsewhere to breed, possibly displacing other breeding waterbirds and potentially increasing already high predation rates.

We radio-marked and tracked 114 California gulls during 2007 and 2008 and obtained >7,000 telemetry locations. Core-use areas of radio-marked California gulls were centered at colonies and the Newby Island and Tri Cities Landfills, as well as several adjacent salt ponds where gulls presumably roosted between meals. Core-use areas of gulls increased from the pre-breeding (4.44 km^2), breeding (5.13 km^2), to post-breeding (8.61 km^2) time periods and were larger in 2007 (6.86 km^2) than 2008 (4.16 km^2). California gulls used landfills most heavily between 6am and 5pm, corresponding to times when organic refuse is exposed during landfill operations.

Our results indicate that California gull movements are dictated primarily by foraging at landfills, and, as a result, other locally breeding waterbirds in the vicinity of gull colonies and landfills are at increased risk to depredation. However, it remains unclear where displaced California gulls from the A6 colony will move to breed after A6 is breached.

2. Becker, Gordon

Center for Ecosystem Management and Restoration (CEMAR), becker@cemar.org

STEELHEAD/RAINBOW TROUT OF THE SOUTH BAY: REVIEW OF THE HISTORICAL RECORD AND RESTORATION EFFORTS, AND IMPLICATIONS OF RECENT RESEARCH FOR MANAGEMENT

Steelhead historically used numerous South Bay streams for spawning and rearing. The species has several traits that have led to its continued presence in the highly modified stream systems of the region, though in greatly reduced abundance. In particular, steelhead juveniles opportunistically rear in estuarine or upland areas, while adults may repeat spawn (i.e., iteropary) and can over-summer given the availability of habitat refugia. Also, "resident" or stream-reproducing *O. mykiss* offer the possibility of a populations' enduring consecutive years of poor conditions vis-à-vis anadromous reproduction.

The availability of juvenile rearing habitat appears to be a key factor in the decreased abundance of *O. mykiss* over time. Major water supply facilities exist in the Alameda and Coyote creeks watersheds that preclude access by steelhead spawners to vast amounts of historically available habitat. Other passage barriers consisting of grade control structures, inadequately sized culverts, and other channel modifications have been, or are being, addressed to allow for fish passage. Additionally, revisiting streamflow management practices is expected to improve rearing habitat conditions in the future.

On-going research should be used to inform management related to steelhead streams of the South Bay. Specifically, studies in recent years are clarifying the relationship between "resident" and anadromous fractions of *O. mykiss* populations within individual stream systems, the understanding of conditions that produce smolts likely to return as spawning steelhead, and appropriate methods for evaluating the effects of water supply operations. Although continuing limitations related to land use practices, climate change, and funding are troublesome, the next ten years may see the considerable effort toward steelhead restoration reflected in runs of more than a few individuals.

3. Callaway, J. C.[1], V. T. Parker[2], L. M. Schile[3], and E. R. Herbert[2]
[1]Dept. of Environmental Science, University of San Francisco, callaway@usfca.edu, [2]Dept. of Biology, San Francisco State University, [3]Dept. of Environmental Science, Policy, & Management, University of California, Berkeley

SEDIMENT DYNAMICS AT THE ISLAND PONDS: INDICATIONS FROM EARLY SALT POND RESTORATION

Many potential wetland restoration sites, including the South Bay salt ponds, have subsided substantially due to groundwater withdrawal, sediment compaction, and/or oxidation of organic soils. If levees are breached and tidal action is returned to these sites, significant sediment accumulation will be necessary in order to build the restoration sites to elevations suitable for plant recruitment. The first restoration efforts for the South Bay Salt Pond Restoration Project occurred at the Island Ponds in winter 2006, and for the past two years we have been monitoring sediment accumulation at Pond A21 in order to evaluate rates of sediment accumulation in the early phases of restoration.

We measured vertical rates of sediment accumulation within the site at 37 stations across the marsh, using the sediment pin method (PVC pipes set approximately 3 meters into the sediment). We also used the dense gypsum layer at the site as a marker of the original pond surface, measuring the newly deposited sediment depths over the gypsum layer. Vertical rates of sediment accumulation were monitored at 1 mo, 3 mo, 6 mo, 1 year and 2 years. Over the first year post-breach, we also measured mass-based rates of short-term sediment accumulation. For mass-based rates, we used a modification of the "filter paper method", with rubberized sampling sheets that were deployed over a two-week tidal period every two months. In addition, we are monitoring early plant recruitment through general observations and photos.

There has been substantial sediment accumulation within Pond A21 since breaching in March 2006, with approximately 12-14 cm of sediment accumulating over the first year in most of the southern half of the pond. Rates decreased in the second year but still were very high (~19 cm accumulated on average over two years in the southern half of the pond). Rates over 20 cm in two years were common at many individual stations. Rates in the northern half of the were variable but lower; however, even at these locations sediment accumulation is orders of magnitude higher than in most natural tidal wetlands. Short-term, mass-based measurements of accumulation over the first year reflected similar spatial variability across the pond. Substantial sediment accumulation occurred throughout most of the year, with little indication of strong seasonality in sediment deposition during the first year. Plant recruitment in year two has been patchy with plants growing primarily along channel and barrow ditch edges. To date we have documented seven species establishing at Pond A21. These results give an indication of the potential for sediment accumulation and plant establishment during the critical initial restoration period for subsided tidal wetlands.

4. Crooks, Stephen
Philip Williams and Associates, Ltd., s.crooks@pwa-ltd.com

CARBON SEQUESTRATION AND TIDAL SALT MARSH RESTORATION

Coastal wetlands provide a wide range of "functions" of support ecologically, and for the benefit human society. Particular interest in carbon sequestration has arisen as it offers a potential mechanism to extract Green House Gas (GHG) constituents from global circulation. Assessments are underway to include tidal wetlands restoration within a carbon credit framework to mitigate for anthropogenic carbon release. However, wetlands restoration does not necessarily lead to a direct reduction in atmospheric GHG levels. Carbon storage and the net balance between GHG (notably carbon dioxide, methane, and nitrous oxide {CO_2, CH_4 and N_2O}) sequestration and emission are spatially variable across the landscape; dependant upon salinity, latitude, ecology, drainage and soil conditions on site, and catchment derived nutrient loading. Using examples from across the freshwater to saline estuarine interface we will review the process of carbon sequestration as well as the potential impacts of wetlands restoration on GHG wetland-atmospheric flux. We will conclude by placing the state of the science, which includes uncertainties, in a context for environmental management.

5. Eagles-Smith, Collin[1], Josh Ackerman[1], Mark Marvin-DiPasquale[2], John Takekawa[3], Cheryl Strong[4], Eric Mruz[4]
[1]USGS Western Ecological Research Center, Davis Field Station, ceagles-smith@usgs.gov, [2]USGS Menlo Park, [3]USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, [4]USFWS Don Edwards National Wildlife Refuge

EVALUATING MERCURY RISK TO BIOSENTINEL WATERBIRDS IN RESPONSE TO SALT POND ENHANCEMENT: IMPLICATIONS FOR ADAPTIVE MANAGEMENT OF THE SOUTH BAY SALT POND RESTORATION PROJECT

The South Bay Salt Pond Restoration Program faces several challenges in its implementation, including the influence of restoration activities on mercury bioaccumulation in wildlife, as well as compensating for the loss of current waterbird nesting habitat due to conversion of salt ponds to tidal habitats. These two topics are coupled by the potential effects of mercury on waterbird reproductive success. The principles of adaptive management are critical to addressing these challenges, and effective adaptive management requires informative monitoring tools. These monitoring tools need to not only elucidate changes in mercury availability in response to management actions, but should be scalable to predict how these changes may influence toxic effects of mercury to waterbird reproduction.

We evaluated space use, diet, mercury exposure, bioaccumulation, reproduction, and risk in waterbirds breeding in the area over a 4-year period (2005 – 2008) to develop a powerful and precise *wildlife-specific biosentinel*, waterbird eggs. We found that mercury levels in fish-eating Forster's terns (*Sterna forsteri*)(6.69 ± 0.37 μg/g dw) and invertebrate-foraging black-necked stilts (*Himantopus mexicanus*)(2.99 ± 0.21 μg/g dw) varied among colonies, but were at or above levels of concern for reproductive impairment (2.5 – 4.0 μg/g dw). In fact, nearly 50% of Forster's terns eggs exceeded hatchability thresholds developed for other species, and mercury concentrations in failed-to-hatch tern eggs (7.98 ± 0.54 μg/g dw) were higher the those in randomly sampled, apparently healthy tern eggs (6.69 ± 0.37 μg/g dw).

We also conducted a pilot salt pond enhancement study to create more waterbird nesting habitat by reducing water levels in Pond A12 to expose islands for nesting, and we monitored mercury levels in water, fish and waterbird eggs from A12 and surrounding control ponds. In response, we documented a strong waterbird nesting effort, with more than 300 American avocet (*Recurvirostra americana*) and nearly 100 Forster's tern nests in A12. However, average mercury levels in waterbird eggs from Pond A12 (avocets: 1.25 ± 0.10 μg/g dw; stilts: 5.51 ± 1.04 μg/g dw; Forster's terns: 6.70 ± 0.56 μg/g dw) exceeded those from all other colonies within the South Bay. These results suggest that continued mercury monitoring in waterbird eggs is important as restoration proceeds, but should be coupled with nesting studies to determine if changes to mercury bioaccumulation effect nest success.

6. Fox, Kathlyn Snyder
Dept. of Environmental Studies, San Jose State University, kathyfox2@gmail.com

SHARING HABITAT: CAN HARBOR SEALS AND RECREATIONAL BOATERS CO-EXIST IN AN URBAN REFUGE?

Harbor seals (*Phoca vitulina richardsi*) that haul out on the banks of Corkscrew Slough within Bair Island (Don Edwards San Francisco Bay National Wildlife Refuge) encounter a variety of boats along the waterway. This study documented the numbers of seals and boats that use Corkscrew Slough and examined seal behavioral responses to boats.

Maximum counts of 50-60 seals were obtained during pupping-molting season. Seals and boaters were present year round, but seals encountered boats less than 1% of the time during observation sessions. Motorized boats represented 49% of traffic and non-motorized 51%, but non-motorized boats caused 68% of flush responses. Seal vigilance levels were similar whether boats were present or absent. While vigilance increased as boats passed the haul out, seals relaxed within 10 minutes of the boats disappearance. Seals were most disturbed by boats that lingered near the haul out and by an extremely loud airboat.

7. Giddings, Sarah N.[1], L.J. MacVean[2], M.T. Stacey[2], and S.G. Monismith[1]
[1]Civil & Environmental Engineering, Stanford University, sarahgid@stanford.edu, [2]Dept. of Civil and Environmental Engineering, UC Berkeley

WET-SEASON CIRCULATION PATTERNS IN FAR SOUTH SAN FRANCISCO BAY AND THE IMPLICATIONS FOR SCALAR TRANSPORT

A month long in-situ experiment at the Dumbarton Narrows in South San Francisco Bay allows us to examine the dominant circulation patterns and the hydrodynamic interactions between shoals and channels. Nine moorings were deployed mid-February through mid March, 2008 including included acoustic Doppler current profilers (ADCP); acoustic Doppler velocimeters (ADV); conductivity, temperature, depth (CTD) sensors at several depths; optical backscatter sensors (OBS); and fluorometers. The mooring information was augmented with high resolution ADCP and CTD transects during representative spring and neap tidal periods as well as continuous visual remote sensing. Throughout the majority of the record, the system behaves as a partially well-mixed estuary exhibiting traditional gravitational circulation with net transport into the estuary in the channel and out over the shoals. Vertical stratification and gravitational circulation increase during neap tides and a storm event leads to an overall freshening of the system. Transverse circulations are largely driven by shoal/channel bathymetry creating differential advection. Differential advection interacts with stratification and leads to frontogenesis in the channel center during flood and along the shoal/channel interface during ebbs. Two events during the period of record exhibit significantly enhanced cross channel circulations, enhanced shoal/channel fronts, enhanced turbidity, and reversed subtidal along-channel circulations. These circulation patterns may affect biological and chemical transport such as the evolution of phytoplankton blooms and transport of scalars such as sediment and pollutants throughout South San Francisco Bay. More generally, understanding the system dynamics and shoal/channel interactions may allow us to better understand how the dynamics may respond to morphological alterations due to restoration.

8. Grenier, Letitia, April Robinson, Jennifer Hunt, Shira Bezalel, Josh Collins
San Francisco Estuary Institute, letitia@sfei.org

USING MARSH WILDLIFE AS MERCURY BIOSENTINELS FOR ADAPTIVE MANAGEMENT OF THE POND A8 RESTORATION TO TIDAL WETLAND

The potential to increase net methylmercury production and bioaccumulation by creating tidal wetlands is a concern for the South Bay Salt Pond Restoration Project. South Bay is already impacted by contaminants, and has the largest mercury mine in North America, the New Almaden Mine, in its watershed. The South Baylands Mercury Project is a multifaceted effort to evaluate restoration and management options for a complex of ponds at the foot of the New Almaden watershed. Water, sediment, and biota were sampled in a three-year effort to assess changes in mercury bioaccumulation that may occur when the ponds are restored to tidal action and, eventually, to tidal marsh wetlands. This presentation will focus on results from the first two years of the biota sampling, describing the development of biosentinel species that indicate mercury bioaccumulation at appropriate spatial and temporal scales, as well as with appropriate habitat specificity to answer the management and restoration-design questions. Resident native goby (*Acanthogobius flavimanus*) and brine fly (*Ephydra* spp.) sentinels indicated that pre-restoration seasonal pond habitat had greater mercury bioaccumulation

than adjacent tidal marsh habitat, which is the restoration endpoint. Obligate tidal marsh sparrow (*Melospiza melodia*) sentinels indicated that variation among tidal marshes in mercury bioaccumulation was significant and increased with increasing distance from the mercury mine source. This inverse relationship is hypothesized to be related to a gradient in marsh characteristics, particularly marsh plain elevation and covariates, such as organic matter.

9. Grijalva, Erik
San Francisco Estuary Invasive Spartina Project, California Coastal Conservancy, Erik@spartina.org

SPARTINA CONTROL PROGRESS IN THE SAN FRANCISCO ESTUARY

In 2008, the California Coastal Conservancy's San Francisco Estuary Invasive Spartina Project (ISP) completed its fifth season of non-native Spartina (*S. alterniflora*) control. The ISP coordinates control of this invasive plant on 168 individual sites along the 9-county tidal marsh shoreline of the Estuary, including permitting, planning, contracting, budgeting and implementation. At the start of the 2008 season, there were an estimated 300 net acres of non-native Spartina remaining scattered in marshes along the Bay shoreline. This is down from the original pre-treatment estimates of up to 2,000 acres in 2004. While the ISP considers the non-native Spartina infestation in the Bay to be controlled, there remain significant challenges to the ISP's stated goal of eradication.

A synopsis of the work accomplished in 2008, the current status of the ISP, the distribution of non-native Spartina infestations Bay-wide, strategy for treating the remaining plants, genetic dilution of target populations and methods of treatment will be presented.

10. Knowles, Noah
USGS Menlo Park, nknowles@usgs.gov

ASSESSING INUNDATION VULNERABILITY DUE TO SEA LEVEL RISE

An increase in the rate of rise of mean sea level is one of the primary and potentially most troublesome aspects of projected climate change. To assess potential inundation associated with a projected continued acceleration of sea level rise, the highest resolution elevation data available to-date were assembled from various sources and mosaicked to cover the entire San Francisco Bay region. Next, a hydrodynamic model of the Bay was driven by a 100-year projection of hourly water level observations at the Presidio. This projection was based on a combination of climate model outputs and empirical models and incorporates astronomical, storm surge, El Niño, and long-term sea level rise influences.

Based on the resulting water level and land-surface-elevation data, maps of areas vulnerable to inundation corresponding to specific amounts of sea level rise and recurrence intervals (e.g., a 100-year high-water level with a 1.0m sea level rise) were produced. These maps portray, in detail, areas where inundation will likely be an increasing concern. In Central and South Bays, a key feature is the bay-ward periphery of developed areas that would be newly at risk of inundation. Many of these areas are already behind levees and represent lands that are not currently at risk if these levees breached but would be newly at risk under the future scenario. Nearly all municipalities adjacent to South Bay (or adjacent to wetlands adjacent to South Bay) face this risk to some degree. Other areas such as the San Francisco Airport are not currently leveed but would need to be. Maps of vulnerable areas will be presented and some implications discussed.

11. Latta, Marilyn
San Francisco Bay Subtidal Habitat Goals Project, Ocean Protection Council/State Coastal Conservancy, mlatta@scc.ca.gov

NATIVE OYSTERS IN THE SOUTH BAY: 2006-07 STUDY UPDATE AND CONNECTIONS TO SAN FRANCISCO BAY SUBTIDAL HABITAT GOALS PROJECT

San Jose State University and Save The Bay partnered in 2006-07 to conduct a study of native oyster (*Ostrea conchaphila*) recruitment and settling substrate preferences at six sites in the bay. Two of these sites are near to the South Bay Salt Pond Restoration Project: the Palo Alto Baylands Nature Preserve and the Ravenswood Pier. The project documented native oyster populations and timing of settlement

specifically at these two sites for the first time ever in the bay, and volunteer involvement in the project helped to generate high public interest.

Native oysters are considered keystone species, as they are habitat builders whose shell can create three-dimensional interstitial spaces that are beneficial for a wide variety of invertebrates, fish, and encrusting algae and plants. We know from a limited number of past scientific surveys, excavation of historic Native American middens containing oyster shell, and current tonnage numbers of dredged oyster shell from the San Mateo shoreline, that San Francisco Bay and specifically the South Bay historically had large populations of native oysters. Today we see native oysters persisting in small numbers at multiple locations in the bay, despite impacts from habitat loss, overharvesting, pollution and contamination, and invasive species.

The San Francisco Bay Subtidal Habitat Goals Project is an interagency effort working to establish a comprehensive and long-term vision for research, management, and restoration of subtidal habitats in San Francisco Bay. Many practitioners designing tidal wetland restoration projects struggle to find adequate information to incorporate meaningful enhancements to the subtidal areas of their projects, including shallow water habitats, sloughs and channels, and native shellfish and eelgrass beds.

This talk will include a basic update of the Subtidal Habitat Goals Project, and focus on an overview of the ecology and history of the native Olympia oyster in San Francisco Bay. The talk will include an update on the data generated at the two South Bay sites from the quarterly monitoring events in 2006-07, and key recommendations for how the Restoration Project might consider further protection and enhancement of native oyster populations in the project area, through monitoring and restoration projects at ponds that will be opened to tidal action.

12. MacVean, Lissa J., and Mark T. Stacey
Dept. of Civil and Environmental Engineering, UC Berkeley, lmacvean@berkeley.edu

THE ISLAND PONDS AND COYOTE CREEK: THE INFLUENCE OF RECOVERING PERIMETER HABITAT ON HYDRODYNAMICS IN A TIDAL SLOUGH

The South Bay Salt Pond Restoration Project represents a landscape-scale modification to the perimeter of the South Bay, and will connect vast areas of salt ponds to the tidal influence of the Bay for the first time in decades. These connections will allow marsh to evolve in the ponds as they receive flows, salt, sediment, and nutrients, from the South Bay. Conversely, the South Bay will be impacted by the increased tidal prism and the changed dissipative forcing at its perimeter. We have performed a series of studies at a pilot site, Coyote Creek and the Island Ponds, in order to characterize the effects of exchange with new perimeter habitat on the hydrodynamics in a tidal slough. We collected in-situ data in Coyote Creek from moored and boat-mounted instrument deployments, measuring water velocity, salinity, temperature, and optical backscatter. These experiments provide us with a range of spatial and temporal scales of flow characteristics in Coyote Creek and through one levee breach. With these measurements, we're able to explore the effects of the salt pond breaches on Coyote Creek, and how hydrodynamics and dispersion of scalars, such as salt and sediment, are impacted.

Specifically, the salt ponds serve as traps for water and accompanying scalars, and as flows enter and exit the ponds throughout the tidal cycle, strong local salinity gradients are induced. The relative density differences that result from varying concentrations of salt change the flow field and the mechanisms by which scalars are mixed across and along the channel. This study addresses the initiation of these steep salinity gradients in Coyote Creek, the resultant changes to flows, mixing, and scalar dispersion, and their implications for transport of salt, sediment, nutrients, and pollutants in the restoration areas.

13. Overton, Cory T.[1], and Michael L. Casazza[1], John Y. Takekawa[2], Tobias M. Rohmer[3]
[1]USGS Western Ecological Research Center, Dixon Field Station, coverton@usgs.gov, [2]USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, [3]UC Davis Graduate Group in Ecology

TIDAL INFLUENCE ON HOME RANGE OF AN ENDANGERED SALT MARSH BIRD: THE CALIFORNIA CLAPPER RAIL

Home range and utilization distributions are common products of wildlife telemetry studies and are often vital components for management of endangered species and development of resources selection models. Home ranges and utilization distributions, are often generated from animal locations and analyzed for seasonal changes in space use corresponding to changes in animal behavior or environmental conditions. We used nine months of intensive radio telemetry data to investigate the role of tidal influx, a repeated and short-term environmental change, on space-use by the endangered California clapper rail (*Rallus longirostris obsoletus*). Home range utilization distributions were calculated using fixed kernel methods with the smoothing parameter selected using likelihood cross-validation criterion. Annual home ranges of California clapper rails are small; preliminary estimates of home range average 2.1 ha. Low tide home ranges are slightly larger than high tide home ranges (1.8 ha vs. 1.5 ha); possibly reflecting lower availability of vegetative cover during high tides. Differences in high tide and low tide utilization distributions show areas used primarily during respective tide cycles. Nearly 7% of the annual home range is used predominantly during high tide. Fourteen percent of the annual home range is used predominantly during low tide. Both vegetative cover and foraging behavior are likely mechanisms producing these differences. These techniques require intensive data collection, but will provide endangered species recovery teams with previously unknown information on resource needs. Conservation and management of salt marsh species are likely to be enhanced by better understanding of resource selection relative to tidal inundation.

14. Robinson, Caitlin[1] and Cheryl Strong[2],
[1] San Francisco Bay Bird Observatory, crobinson@sfbbo.org, [2] USFWS Don Edwards San Francisco Bay National Wildlife Refuge

SNOWY PLOVERS IN THE SOUTH BAY: NEST SUCCESS, FLEDGING SUCCESS AND USE OF MANAGED PONDS

The western snowy plover (*Charadrius alexandrinus nivosus*) is a threatened species that nests on dry salt ponds in the San Francisco Bay, most commonly within the South Bay Salt Pond Restoration Project area. The Project aims to support a minimum of 250 breeding plovers within its boundaries; currently ~115 plovers breed within the area. We estimated nest success at Eden Landing Ecological Reserve and the Don Edwards San Francisco Bay National Wildlife Refuge by following nests during the breeding season. Hatching success for all sites combined decreased from 84% in 2004 and 85% in 2005 to 58% in 2006, 49% in 2007 and 53% in 2008. The decrease in nest success was due to high predation rates. In 2007, 42.6% of the nests were depredated (n=89), compared to 10% of the nests in 2005 (n=20), and 4.9% in 2004 (n=59). Nest predation was attributed mostly to common ravens (*Corvus corax*), northern harriers (*Circus cyaneus*), and California gulls (*Larus californicus*). We determined chick fledging success and movements within the salt pond complexes by banding 83 plover chicks in 2008.

Beginning in 2006, California Dept. of Fish and Game managed wildlife ponds for breeding plovers. We monitored managed and seasonal control ponds for plover use, nest abundance, and nest success. The mean nests per hectare on managed ponds was higher (0.122 + 0.044 SE, n= 7) than on control ponds (0.082 + 0.026 SE, n= 13).

Current measures of reproductive success indicate that plover populations within the Project will not reach project goals without management efforts to retain and enhance plover breeding habitats. We suggest drying salt ponds for nesting plovers adjacent to high salinity foraging areas for adults with broods. Given the high number of depredated nests, we suggest continuing predator management programs within plover nesting areas.

15. Stacey, Mark[1], Oliver Fringer[2], Jeffrey Koseff[2], Stephen Monismith[2], Thomas Powell[1]
[1] Dept. of Civil and Environmental Engineering , UC Berkeley, mstacey@berkeley.edu, [2] Civil & Environmental Engineering, Stanford University,

HYDRODYNAMIC AND SEDIMENT TRANSPORT MODEL DEVELOPMENT IN SUPPORT OF LONG-TERM MANAGEMENT OF SAN FRANCISCO BAY

The south bay salt pond restoration project will be one of the largest restoration projects of any kind in U.S. history, and will be the largest single estuarine habitat restoration project undertaken to date. The conversion of salt ponds to tidal marsh will provide new habitat for a variety of migratory birds and endangered species. At the same time, however, the restoration of tidal action to such a large area is likely to alter the dynamics in the adjoining estuary in uncertain, and possibly undesirable, ways. This is

particularly true in the "Far South Bay" (the region south of the Dumbarton Narrows), where the area under consideration for restoration is comparable to the surface area of the existing estuary. Further complicating the analysis of the effects of restoration is the fact that climate change will be altering the dynamics of the estuary on a timescale that is similar to the planning horizon for restoration activities. As such, analysis of the effects of restoration must also include consideration of the effects of climate change.

In order to assess the effects of restoration and climate change on the estuary, particularly the tidal, salinity and sediment dynamics, a predictive modeling approach is being developed under California Coastal Conservancy funding. This model, which will be based on the SUNTANS hydrodynamic model, will include state-of-the-art turbulence and sediment models, and will be used to assess how restoration will alter conditions in the estuary adjoining the restoration sites at both the local and regional scales. In this talk, we will summarize the motivation for this study and detail the approach that we are pursuing. Preliminary work has focus on bathymetric data and grid generation, which will be included in the discussion of our general approach.

16. Takekawa, John, Natalie R. Wilson, Susan W. De La Cruz, and Jane O. Anfinson
USGS Western Ecological Research Center, San Francisco Bay Estuary Field Station, john_takekawa@usgs.gov

EFFECTS OF FERRY TRAFFIC ON MIGRATORY WATERBIRDS IN THE SAN FRANCISCO BAY

Commuter ferry routes cross valuable subtidal and intertidal habitats in the San Francisco Bay estuary that support a wealth of natural resources, including large numbers of migratory waterbirds during the winter. When new routes were proposed for the region under a new transit authority in 1999, we initiated studies to evaluate the ecological effects of commuter ferries on rafting waterbirds. The main objectives were to: 1) conduct on-board ferry surveys to assess species-specific buffer distances; 2) examine waterbird avoidance of watercraft in land-based surveys at selected areas; and 3) document distribution of waterbirds along ferry routes with aerial surveys.

On-board ferry surveys were used to determine how waterbirds responded behaviorally to the passage of a commuter ferry. Observers recorded the behavioral response (fly, dive, swim, alert posture) of waterbirds and their distance from the ferry. Surf scoters (*Melanitta perspicillata*), lesser and greater scaup (*Aythya affinis* and *A. marila*), and western and Clark's grebes (*Aechmophorus occidentalis* and *A. clarkii*) were the most abundant species found across all ferry routes, with diving ducks representing the most abundant guild. Behavior response distances ranged from 50-500 m for grebes, 30-900 m for scoters, and 60-500 m for scaup. Most waterbirds showed a behavior response within 300 m, and we used that distance to estimate the zone within which birds were affected. In addition, we used GPS tracking to determine that variation in the path of the ferries was usually 200 m. Thus, we calculated a total effect area along a ferry route from their sum or a distance of 500 m. Affected areas ranged from 2.44 to 75.75 km^2 and included 0.07-14.26 km^2 of shoals preferred for foraging (<4 m deep).

We studied the duration of disturbance of a ferry transit from land-based surveys. At selected sites, we recorded numbers and behavior of waterbirds before and after transit. Scaup densities declined after ferry transit along the Vallejo and Alameda Harbor Bay route, and scoters decreased after passage of the Larkspur ferry. However, patterns were not consistent, probably because birds were responding to several factors such as time-of-day, weather, and other disturbances. When we compared weekday to weekend surveys, we found more waterbirds along routes during the weekdays despite more frequent ferry traffic.

Aerial surveys indicated that diving ducks accounted for 85% of open water birds, dominated by scaup and scoter (90%). Numbers were highest during Nov-Dec in the North Bay, consistent in the central Bay, and lowest in the South Bay. While new commuter ferries may be beneficial at reducing vehicle traffic, they will have an effect on waterbird populations. Although they do not eliminate open water habitats, they may preclude use of it by waterbirds. Thus, our study indicated that effects on waterbirds should be considered when planning new transit routes or increasing their frequency, especially in shoal areas used for foraging.

17. White, Heather and Lynne Trulio
Dept. of Environmental Studies, San Jose State University, hwhite@me.com

WINTERING DUCK RESPONSE TO TRAIL USE AT MANAGED PONDS

As part of the South Bay Salt Pond Restoration Project, some areas that have never experienced human trail use will be opened to trail-based recreation. Before these areas are opened to use, it is important to gauge the potential impact this may have on the migratory ducks that use adjacent ponds for foraging and resting.

To examine this, I created trail use disturbances on levees next to ponds that have never been opened to public access and measured the change in distribution of wintering ducks on the ponds before and after disturbance. Data collection took place during the 2006--2008 fall and winter seasons at the Alviso complex of ponds. Data collection involved two methods: Before/After Disturbance method and Point Count method. The Before/After Disturbance method was based on measuring the distance of ducks from a levee before and after a disturbance along that levee. These data were used to determine if the overall distance of ducks from the levee changed significantly in response to disturbance. The Point Count method was based on measuring the distance of ducks from a levee at 6 individual points along a 500m stretch of levee as trail users were traversing the levee. The goals for these data include: 1) to determine if ducks exhibit a different distance response as the trail user moves down the levee, and 2) to measure how far, on average, different species tend to stay from the source of disturbance.

I completed 30 trials across two data-collection seasons. Ducks present in trials were predominantly diving ducks, with Ruddy Duck (*Oxyura jamaicensis*) the most common species seen. Areas up to 120m from the levee had fewer ducks after the disturbance compared to before the disturbance. Also, duck movement in response to trail use was influenced by hunting in nearby ponds. Distance moved in response to the disturbance varied by species and was used to make buffer zone recommendations for duck species found in the Restoration area.

Poster presentations

1. Aceituno, Kevin[1], Terry Adelsbach[1], Collin Eagles-Smith[2], John Henderson[1]
[1]USFWS, Environmental Contaminants Division, kevin_aceituno@fws.gov, [2]USGS, Western Ecological Research Center, Davis Field Station

USING FORAGE FISH TO ASSESS MERCURY BIOACCUMULATION IN AQUATIC SYSTEMS

Historic mining activity has led to a legacy of mercury contamination in the San Francisco Estuary. The most toxic form of mercury, methylmercury, is of primary concern due to its bioaccumultive potential in aquatic food-webs. Forage fish occupying low trophic positions represent a critical step in methylmercury bioaccumulation in fish, wildlife and humans. Temporal and spatial variations in mercury bioavailability effect bioaccumulation patterns in these fish, making them useful bio-monitoring tools in aquatic systems. Our goal was to use forage fish sampled from the Don Edwards San Francisco Bay National Wildlife Refuge to assess trends in mercury bioaccumulation in the aquatic food-web. We examined total mercury (THg) concentrations for five species of fish, Mississippi silverside (*Menidia audens*), topsmelt (*Atherinops affinis*), longjaw mudsucker (*Gillicthys mirabilis*), northern anchovy (*Engraulis mordax*) and rainwater killifish (*Lucania parva*). To compare THg among site and species, we used analysis of covariance with species and site as categorical predictors and standard length as a continuous predictor. Results indicate THg differed among species and among sites. THg concentrations were also compared to San Francisco Bay TMDL fish tissue objectives determined to protect human health and aquatic wildlife. Mean THg concentrations for all species exceeded the aquatic wildlife objective (0.03 ppm THg, wet weight) applied to fish 30-50 mm in length. The human health target (0.20 ppm THg, wet weight) applies to sport fish 600 mm in length, however, mean THg concentrations in northern anchovies and Mississippi silversides exceeded this value. Our preliminary findings suggest that life history strategies and developmental patterns are important factors affecting mercury bioaccumulation. Understanding these factors is essential to accurate assessment of mercury bioaccumulation in aquatic food-webs.

2. Gavin Archbald, Katharyn Boyer
Biology Dept., San Francisco State University, Romberg Tiburon Center for Environmental Studies, gavinarchbald@gmail.com

EVALUATING THE POTENTIAL FOR SPREAD OF AN INVASIVE FORB, ALGERIAN SEA LAVENDER, IN SAN FRANCISCO BAY SALT MARSHES

Invasive species threaten to alter the outcome of San Francisco Bay's tidal marsh restoration efforts. In 2006 and 2007, Algerian sea lavender (*Limonium ramosissimum*), a salt tolerant invasive forb prevalent

in southern California marshes, was found in restored and disturbed marshes in San Francisco Bay. While this suggests future restoration sites are at risk of invasion by *L. ramosissimum*, the extent to which the plant has invaded and the elevational range of greatest potential impact is unknown. To address these questions, we located and mapped invasive *Limonium* populations in San Francisco Bay and are surveying soil and vegetation parameters in 3 invaded marshes. Mapping results show all eight populations of *L. ramosissimum* are clustered on the southwest edge of the Bay with the largest populations centrally located- suggesting spread is occurring north and south along the Bay's western edge. Initial survey results of three invaded marshes show *Limonium* is present in the high marsh and is commonly interspersed with *Sarcocornia pacifica*, *Jaumea carnosa*, *Distichlis spicata* and *Grindelia stricta*, indicating *Liminium*, unlike many other invasive plants, is not restricted to marsh edges. Near total monocultures occur in the high marsh where *Limonium* grows on average 8 cm taller and produces 22 more flowers per plant than in mid marsh elevations, suggesting rare species growing at high marsh elevations are at greatest risk. The results of these studies will help determine where, within future restored marshes, invasions are likely to occur.

3. Athearn, Nicole[1], Jill Demers[2], Joel Shinn[1], Caitlin Robinson[2], Sam Scott[2], John Takekawa[1], and Cheryl Strong[3]

[1]USGS, Western Ecological Research Center, San Francisco Bay Estuary Field Station, nathearn@usgs.gov, [2]San Francisco Bay Bird Observatory, [3]USFWS, Don Edwards San Francisco Bay National Wildlife Refuge

BIRD DISTRIBUTION AND ABUNDANCE IN THE SOUTH BAY SALT POND RESTORATION PROJECT AREA

In 2003, the USFWS and the California Dept. of Fish and Game acquired over 10,700 ha of commercial salt ponds in San Francisco Bay for the purpose of restoring tidal wetlands. However, San Francisco Bay estuary has been recognized as a site of hemispheric importance for migratory birds, and salt ponds support large numbers of migratory and wintering shorebirds and waterfowl. One goal of the South Bay Salt Pond Restoration Project is to maintain existing ecological value for waterbirds, but information is needed to ensure that habitat requirements of large numbers of waterbirds can be met with reduced salt pond acreage. The USGS and the San Francisco Bay Bird Observatory have conducted integrated monthly bird monitoring at salt ponds in the South Bay. We have mapped the distribution and abundance of major waterbird species throughout the region in order to document long-term use patterns and track changes in the region over time. This long term salt pond monitoring data has continuing importance for restoration planning processes as well as adaptive management of the ponds.

4. Basson, Galli, and Lynne Trulio

Dept. of Environmental Studies, San Jose State University,galli92@gmail.com

SALT MARSH HARVEST MOUSE ABUNDANCE AND MICRO-HABITAT SELECTION IN A MANAGED MARSH

As a result of habitat destruction in the San Francisco Bay, the endemic salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) was listed as an endangered species by the USFWS in 1970 and the California Dept. of Fish and Game in 1971. The Don Edwards National Wildlife Refuge in the San Francisco Bay provides important habitat for the salt marsh harvest mouse and the proper management of this habitat is crucial to protecting and recovering their population. The objective of this study is to determine the abundance and micro-habitat preferences of the salt marsh harvest mouse by collecting data on salt marsh harvest mouse density, sympatric rodent species density, vegetation composition, and pickleweed salinity at the 25 acre Warm Springs Mouse Pasture located in south Fremont.

The USFWS will use information gained from this study to benefit the goals of the Recovery Plan for the salt marsh harvest mouse. Specifically, recommendations from this study will be implemented under the Warm Springs Mouse Pasture Water Management Plan to increase habitat quality for salt marsh harvest mice. Findings from this study will also be used by the South Bay Salt Pond Restoration Project which will manage and restore up to 15,100 acres of wetlands in the South Bay. The research proposed here is designed to help the USFWS increase population numbers of this endangered species.

5. Bearman, Josh[1], Carl Friedrichs[1], Bruce Jaffe[2], and Amy Foxgrover[1&2]

[1]Virginia Institute of Marine Science, jbearman@vims.edu, [2]USGS, Santa Cruz

FACTORS CONTROLLING TIDAL FLAT MORPHOLOGY IN SOUTH SAN FRANCISCO BAY BETWEEN THE 1890S AND 2005

There is currently a project underway to restore many of the man-made salt ponds along the shores of South San Francisco Bay back to tidal marsh, potentially reestablishing these areas as sinks for South Bay sediments. While there have been recent studies examining the evolution of newly restored marsh areas in the South Bay, there have been no recent projects focusing on the expected response of valuable tidal flat environments adjacent to the restored marshes. To help fill this void, this project seeks to characterize South Bay tidal flat morphodynamics, both spatially and temporally, through examination of historic morphologic variability and change along with variations in external forcings.

Spatial and temporal trends in profiles of South Bay tidal flats are examined using bathymetric and LIDAR data collected between the 1890s and 2005. Eigenfunction analysis reveals a dominant mode of morphologic variability related to the degree of convexity or concavity in cross shore profile – classically indicative of tidally dominant, sediment rich, or wave dominant, sediment poor conditions, respectively.

Two opposing areas of equilibrium shape – north/south of a constriction in estuary width located at the Dumbarton Bridge – are highlighted by the first mode of variability in the Eigenfunction analysis, accounting for 90% of the overall spatial variation in tidal flat shape. Additionally, the eigenfunction scores which quantify the spatial pattern of increasing/decreasing convexity in the inner/outer estuary are correlated to spatial variability in fetch length, sediment grain size, recent erosion/deposition, and tidal height.

Trends for morphologic change between 1890 and 2005 in twelve geographically diverse regions within the South Bay are compared to temporal trends in sediment discharge, mean sea level, diurnal tidal range, and Pacific Decadal Oscillation Index (as a proxy for storminess). Overall, convex vs. concave profiles were favored in the inner vs. outer estuary throughout the entire historical period. Furthermore, tidal flat morphology of the outer estuary displayed a steady increase in concavity with time. The trend of increasing concavity in the outer-estuary flats was consistent with temporal changes in hindcasted sediment discharge from the Central Valley. Although consistently convex, tidal flats located in the inner portions of the South Bay exhibited greater complexity in their degree of convexity through time, and temporal changes could not easily be correlated to a given external physical forcing, suggesting a possible role for more localized variations in sediment supply.

A set of criteria for establishing dependence between morphology and external factors was created, using results of a stepwise multiple regression. Using this criteria, trends sediment supply from the Central Valley were found to have a consistency with temporal trends in outer-estuary tidal flat shape. Inner-estuary flat shape change was found to be consistent with local patterns in rainfall (as a proxy for local sediment discharge) in the innermost regions, and with recent deposition or erosion in all other regions.

6. Foxgrover, A.C. [1] and Jaffe, B. E. [2]
[1] Virginia Institute of Marine Science, [2] USGS Pacific Science Center, Santa Cruz, bjaffe@usgs.gov

IS THERE ENOUGH SEDIMENT AVAILABLE TO RESTORE SALT PONDS WITHOUT ADVERSE EFFECTS? INSIGHTS FROM HISTORIC BATHYMETRIC CHANGE IN SOUTH SAN FRANCISCO BAY

A primary concern for restoration of salt ponds in South San Francisco Bay is whether there is enough sediment available to restore the ponds without adverse impact upon existing habitats. In addition to its large scale (15,000 acres), restoration is further complicated by an increased sediment demand caused by subsidence of the southernmost ponds (up to 2 m) as a result of excess ground water withdrawal from the 1930s to 1960s. Successful restoration of the South Bay salt ponds will depend largely upon the amount of sediment available within the system.

To assess long-term spatial and temporal variations in sedimentation processes we analyzed a series of six hydrographic surveys collected from 1858 to 2005 in South Bay. We modeled the surface of the bay floor over time to quantify net sedimentation volumes, rates of sediment deposition and erosion, changes in tidal flat extent, and alterations in morphology.

Net sedimentation over the past 150 years oscillated between periods of net deposition and erosion. Net sedimentation varied spatially within the bay; the region south of the Dumbarton Bridge is the only area that experienced net deposition throughout all of the time periods. The most recent period, 1983 to 2005, was marked

by a net deposition of sediment and growth of intertidal flats south of the Dumbarton Bridge, while north of the bridge, there was infilling of the main channel and slight erosion of the shallows.

This research documents how South San Francisco Bay has evolved over the past 150 years as a result of numerous anthropogenic and natural processes. Analysis of the spatial and temporal distribution of deposition and erosion within South San Francisco Bay will help formulate restoration strategies that minimize negative impacts upon existing habitats.

7. Jaffe, B. E.,[1] and Foxgrover, A.C. [2]
[1] USGS Pacific Science Center, Santa Cruz, bjaffe@usgs.gov, [2]Virginia Institute of Marine Science

WILL RESTORATION OF SOUTH SAN FRANCISCO BAY SALT PONDS RESULT IN INTERTIDAL FLAT LOSS?

An unresolved question in restoration of salt ponds in South San Francisco Bay is whether opening ponds will create a sediment sink that results in significant loss of intertidal flats. Analyses of a series of bathymetric surveys of South San Francisco Bay made from 1858 to 2005 reveal changes in intertidal flats that provide insight into the pre-restoration sediment system and allow assessment of the likely effects of restoration on intertidal flats.

From 1858 to 2005, the total intertidal flat area in South Bay decreased by about 25% from 69.2 +6.4/-7.6 km^2 to 51.2 +4.8/-5.8 km^2. The spatial variability is correlated to the energy available to erode sediments and sediment supply to the flats. Intertidal flats to the north of Dumbarton Bridge, where waves are larger, tended to decrease in area whereas those in the quiet environment south of the bridge did not. Likewise, larger waves along the eastern shores of the bay caused greater decrease in intertidal flat area there than on the western shores. To the south of Dumbarton Bridge, a region with abundant sediment supply, intertidal flat area was stable or increased during the study period, with the largest increase from 17.6 +1.7/-2.5 km^2 to 24.2 +1.0/-1.8 km^2 occurring from 1983 to 2005.

The low energy environment and abundant sediment supply make it unlikely that restoration will result in significant intertidal flat loss south of Dumbarton Bridge. Loss to the north, a higher energy environment without an abundant sediment supply, is more likely. Improved understanding of sediment input to South San Francisco Bay, especially from Central Bay, how it is likely to change in the future, its redistribution within the bay, and ultimately its effect on intertidal flat area is needed to effectively manage the restoration of South San Francisco Bay salt ponds.

8. Johnston, Dave
H. T. Harvey & Associates, djohnston@harveyecology.com

YUMA MYOTIS FORAGING BEHAVIOR OVER THE SAN FRANCISCO BAY ESTUARY

Although alarming declines of bat populations are increasingly documented, in fact, quantitative information on the population status and ecology of bat species in the San Francisco Bay Area is lamentably scarce. Observations of three colonies of Yuma myotis (*Myotis yumanensis*) that occur along tidal areas of the South San Francisco Bay suggest that these bats regularly forage over tidal waters as well as brackish and saltwater marshes. Dietary analysis of five fecal pellets from each of four Yuma myotis roosting approximately 40 m from Alviso Slough ate 32% Diptera, 1% Lepidoptera, and 67% Hemiptera (reticulated water boatman [*Trichocorixa reticulate*]). Acoustic monitoring of bats with an ANAbat 6 bat detector and Z-Caim recorder suggested that bats foraged over open water and above alkali bulrush (*Scirpus robustus*) dominated brackish water marsh. As natural roosting habitat is degraded or lost in metropolitan areas, we must continue to take advantage of opportunities to convert abandoned or relic structures into potential roosting habitat. In Spring of 2008 an abandoned concrete silo on the Don Edwards San Francisco Bay National Wildlife Refuge was converted into potential bat roosting habitat complete with a heat pump, solar panels to run the heat pump, and data loggers to monitor the temperatures at the various bat boxes spiraling down inside the silo and in additional spaces on the outside of the silo. Potential bat species that may use the structure for roosting habitat include the Yuma myotis, California myotis, (*Myotis californicus*) Mexican free-tailed bat (*Tadarida brasiliensis*), and the pallid bat (*Antrozous pallidus*).

9. Marvin-DiPasquale, Mark[1], E. Kakouros[1], J.L. Agee[1], M.H. Cox[1], L. Windham-Myers[1], L. Grenier[2], and J. Collins[2]
[1]USGS, Menlo Park, CA; [2]San Francisco Estuary Institute, Oakland, CA.

THE SOUTH BAYLANDS MERCURY PROJECT: MERCURY STATUS OF POND A8, ALVISO SLOUGH AND ALVISO MARSH, BASED ON SEDIMENT

As part of the South Bay Salt Pond Restoration Project, construction is slated to begin in 2009 on a size-adjustable notch in the levee between Pond A8 and Alviso Slough. In preparation and to establish pre-construction conditions, an assessment of mercury (Hg) concentrations and chemical form was conducted in 0-2 cm surface sediment of Alviso Slough (main channel and fringing marsh), Pond A8, and in 17 additional reference marsh sites throughout the South San Francisco Bay. Total mercury (THg) and methylmercury (MeHg) concentrations were highest overall within Pond A8. Vegetated marsh sites along Alviso slough also had almost 2-fold higher average THg and inorganic 'reactive' mercury ($Hg(II)_R$) compared to the combined group of reference marsh sites, although MeHg concentrations were not significantly different between Alviso and reference marsh groupings. Across all sites, $Hg(II)_R$ concentration was related to sediment oxidation-reduction conditions, such that the most chemically reducing sites (e.g. Pond A8) had the lowest percentage of $Hg(II)_R$ (0.08 ± 0.06 % of THg) and the most chemically oxidized sites (e.g. vegetated marshes) had the highest percentage of $Hg(II)_R$ (2.4 ± 1.4 % of THg). In spite of the lower $Hg(II)_R$ concentrations in Pond A8, the higher MeHg concentrations in this habitat (compared to both vegetated marshes and Alviso Slough main channel) appears to be driven by high rates of microbial activity that are stimulated by the high loading of readily degraded organic matter, in the form of phytoplankton. We predict that by facilitating the tidal flushing of Pond A8, and thus decreasing the amount of phytoplankton deposition to the benthos, MeHg concentrations in surface sediment will eventually decrease within Pond A8.

10. Rogoff, Dana A.[1,2], Stefan Leuko[1], Stefan Green[3] and Lynn J. Rothschild[1]
[1]NASA Ames Research Center, Ecosystem Science and Technology Branch (SGE), Dana.A.Rogoff@nasa.gov, [2]SETI Institute, Carl Sagan Center for the Study of Life in the Universe, [3]Dept. of Oceanography, Florida State University

SALINITY IDENTIFICATION USING PIGMENT CHARACTERIZATION OF MICROBES OVER A GRADIENT IN THE SOUTH SAN FRANCISCO BAY SALT PONDS

How can you tell the salinity of a body of water simply by looking at it? The physical color of a salt pond is an indicator but within this color are major differences, relating to salinity and microbial population, that we cannot see with the human eye. Spectroscopic identification, including remote sensing, can identify those differences. Pigments in auto- and heterotrophic microbes play a primary role in determining the color of these ponds. As the salinity increases, microbe populations change. "Normal" microbes, those typically found in brackish and ocean water, are indicators of lower salinities and express the main photosynthetic pigment, chlorophyll *a*. Once salinity increases and reaches levels higher than these "normal" microbes can tolerate, new microbes arise with different pigment characteristics. They express pigments not found in lower salinity ponds such as carotenoids, salinixanthin and/or bacterioruberin that change the physical water color.

We sampled various ponds with different salinities in the South San Francisco Bay and performed pigment extractions to gather spectra, indicating the predominant pigments in each pond. To corroborate pigment results, we used microscopy and molecular screening techniques to identify the populations of microbes. There is a correlation between archaeal and bacterial halophiles and their pigments bacterioruberin and salinxanthin, respectively, to ponds pink in color (i.e., higher salinity). Green ponds with lower salinity have corresponding pigment peaks indicating mostly chlorophyll *a*-containing organisms, as would be expected. Green, orange and pink ponds in between extreme low and high salinities can have a mix of microbial populations – their pigment can then be separated out using spectroscopy and salinity can then be inferred.

Over the years of restoration, these data could play a role in gathering salinity information when sampling of ponds is not an option. Remote sensing parallels pigment spectroscopy results - microbial populations and salinity can then be determined without the need of sampling every pond.

11. Schacter, Carley[1], Caitlin Robinson[1], Danielle LeFer[2], Jill Demers[1]
[1]San Francisco Bay Bird Observatory, cschacter@sfbbo.org, [2]Jones & Stokes

COLOR-BANDING CALIFORNIA GULLS IN SOUTH SAN FRANCISCO BAY

The California gull (*Larus californicus*) breeding population in the South San Francisco Bay salt ponds has increased from approximately 12 nests in 1982 to over 45,000 nesting birds in 2008. The plan of the

South Bay Salt Pond Restoration Project to restore 16,000 acres of salt ponds, including the A6 salt pond in Alviso, the site of the largest gull colony, into tidal marsh or other habitats will likely cause gulls breeding at A6 to move to new nesting sites. In turn, gulls may displace current breeding populations of terns and shorebirds.

We color-banded California gulls to examine their current movements among colonies and landfills, and to observe how and where gulls from displaced colonies disperse after the A6 levee is breached. In particular, we will address what proportion of gulls disperses to other established colonies, newly created habitat, or outside of the South San Francisco Bay. These results will help to inform adaptive management decisions for the restoration.

In 2008, we used noose mats to trap and band 277 California gulls on the A6 colony (226 adults and 53 immatures) with field-readable numeric bands. During the breeding season (May – July) , we conducted weekly re-sighting surveys at six sites known to be the site of current or former California gull colonies (in Alviso, Mountain View, Eden Landing, Mowry and Coyote Hill), as well as two local landfills frequented by large numbers of gulls (Newby Island and Tri Cities). We will continue monthly breeding season surveys before, during, and after the breaching of the A6 levee and use the re-sighting data to assess the dispersal of gulls from the A6 colony. Understanding the dispersal of California gulls after the breaching of A6 will aid in the mitigation of any effects this may have on breeding populations of other local waterbirds.

12. Schraga, Tara S.[1], Julien Thébault[1,2], James E. Cloern[1], and Eric G. Dunlavey [3]
[1]USGS Menlo Park, tschraga@usgs.gov, [2]IUEM-UBO, France, [3]City of San Jose, Environmental Services Dept.

PRIMARY PRODUCTIVITY AND CARRYING CAPACITY OF A FORMER SOUTH SAN FRANCISCO BAY SALT POND

As part of the South San Francisco Bay Salt Pond Restoration Project, a number of open water ponds are being retained as habitat for waterbirds. This study describes the first measurements of ecosystem metabolism in these new systems and estimates their ecological value as feeding habitat for birds. We used the oxygen rate of change method to determine ecosystem metabolic parameters from high resolution time-series of dissolved oxygen concentration. Areal gross primary production (8.17 g O_2 m^{-2} d^{-1}) was roughly double the world's most productive estuaries. High rates of phytoplankton photosynthesis were balanced by equally high rates of community respiration (8.25 g O_2 m^{-2} d^{-1}). Metabolic equilibrium was delicately poised: sharp irradiance and temperature shifts triggered short term photosynthesis reduction resulting in oxygen depletion. We converted net primary production (NPP) into potential carrying capacity of the forage biota that support targeted pond waterbirds. NPP was processed through pelagic and benthic food webs, both food webs included efficient algal-based and inefficient detrital trophic pathways. The result of all primary production being routed through simple food webs was high potential forage production and energy supply to waterbirds, equivalent to 11–163 million planktivorous fish or 19–78 billion small estuarine clams within the 330-ha pond between May and October. Food quantity does not necessarily equal quality and these systems have the potential to produce toxic or inedible algae. Our study provides the first measurement of primary production in the open water ponds of San Francisco Bay and presents a novel approach for transforming primary production into forage production as a metric of an ecosystem's energetic carrying capacity.

13. Schlipf, Robert, Andree Greenberg, Brian Wines, Wil Bruhns, and Shin-Roei Lee
Regional Water Board, San Francisco Bay Region, rschlipf@waterboards.ca.gov

MAINTAINING WATER QUALITY WHILE RESTORING SOUTH BAY SALT PONDS TO WETLANDS

The South Bay Salt Pond Restoration Project is designed to restore thousands of acres of wetland habitat lost in the San Francisco Bay Region over the past 200 years. The long term success rate for projects on this scale is unknown, and one of the main problem presented to managers is how to maintain existing habitat and create new habitat while protecting water quality. Managers must also consider risks to native ecosystems, recreational opportunities, and flood prone areas with large urban populations.

Resource managers and scientists in the San Francisco Bay Region have developed goals for wetlands and related habitats to restore high functioning systems. In the decade since the release of the *San Francisco Baylands Ecosystem Goals*, thousands of acres of former wetlands have been purchased for restoration

which involves, at the least, establishing the correct hydrology to be phased over many years, and to be monitored effectively for success.

The South Bay Salt Pond Restoration Project is currently undergoing review by regulatory agencies, but the Initial Stewardship Plan for opening up ponds to tidal circulation has been largely successful in maintaining existing habitat for shorebirds and waterfowl. However, excessive algal growth in former salt ponds has resulted in low dissolved oxygen levels and some fish kills within these ponds. Various methods are being tried to prevent future water quality problems, such as increasing tidal marsh restored from former salt ponds while reconfiguring existing ponds to encourage bird use.

Restoration is benefiting important species such as the salt marsh harvest mouse, California clapper rail, Chinook salmon and other species that share similar habitats. Regional and site specific monitoring are important to track potential water quality impacts (e.g., low dissolved oxygen, mercury bioavailability), to maintain healthy biological species, and to prevent the spread of contaminants and aggressive non-native plants and animals. San Francisco Bay salt pond restoration has important implications for the preservation of native species and habitat, and for protecting humans from storms and sea-level rise.

14. Scott, Sam, Caitlin Robinson, and Jill Demers
San Francisco Bay Bird Observatory, sscott@sfbbo.org

BIRD USE OF SALT PONDS MANAGED FOR SALT PRODUCTION IN THE SOUTH BAY

In 2003, California's Dept. of Fish and Game and the USFWS purchased 15,100 acres of salt evaporator ponds from the Cargill Salt Company in the South San Francisco Bay and initiated the largest restoration effort on the West Coast. Currently, Cargill still retains mineral rights on 22 salt ponds that are not included in the restoration, located on the east side of the South Bay. Even though these ponds are not currently included in the restoration project, it is important to know how birds currently use these ponds to have a better understanding of how the various species will react to the future landscape-level habitat changes. To that end, we have conducted monthly high tide bird surveys, monitored water quality, and recorded water depth on these 22 ponds since September 2005.

We found that salinity and depth of ponds varies over the course of the year and the use of these ponds by different guilds of birds is directly correlated with the depth and salinity at a given time. On average, the Coyote Hills ponds had the lowest salinity levels, and the highest species richness out of all of the ponds, which indicates that the greatest variety of birds prefer the lower salinity ponds. Salinity levels increased as water depth decreased, which in most cases resulted in the higher salinity ponds having the most exposed islands, thus increasing the number of resting birds. Of all birds observed throughout the entire salt pond complex, 71% were resting, and in the Mowry ponds, which are the highest in salinity, 88% of birds observed were resting. Our results indicated that salt ponds are an important resting and foraging habitat during high tide, when waterbirds can no longer feed in the bay or tidal marshes.

Each guild of birds has their own set of requirements. For example, small to medium-sized shorebirds need low water levels with plenty of exposed islands during migration and winter, while higher water levels with lower salinity ranges are used by dabbling ducks, diving ducks and fish eaters. It is in the interest of the South Bay Salt Pond Restoration Project to maintain a large variety of habitats to suit the needs of all of these different species.

15. Thomson, David[1], Genie Moore[1], Giselle Block[2], Lisa Infante[3]
[1]USFWS, Don Edwards San Francisco Bay National Wildlife Refuge, d.x.thomson@gmail.com, [2]USFWS, San Pablo Bay National Wildlife Refuge, [3]Midpeninsula Regional Open Space District

WHERE SAN JOSE MEETS THE BAY: BAYLAND ECOTONE RESTORATION RESEARCH

What if no methods are available to implement restoration plans? If no methods are available that help native plants thrive in the face of problems such as invasive weed competition, or intensive browse pressure, then restoration goals may never be realized. This has been the experience of two units of the San Francisco Bay NWR Complex over the past decade with their attempts to control invasive weeds and restore the bayland's ecotone. This pilot study underway at the Don Edwards NWR Environmental Education Center is intended to research implementation with the goal of creating methods that could be utilized to restore these habitats.

The restoration goals include several different habitats within the 10-acre site. The most intensive testing is occurring within four of those acres, which are designated as alkali grassland in the site's vegetation management plan. Two methods of pre-seeding weed abatement are being tested: an intensive stale seedbed method used by farmers and a less intensive method utilized by the Midpeninsula Open Space District. Four soil treatments are being factorially applied to the area: tilling, composting, rolling (compaction), and applying straw. The treatments are based on synergistic rationales rooted in both invasive weed and native grassland ecologies. The area will be drill seeded during the first week of November. The project will be ongoing for several years, and will include introducing plug plantings into the grassland in the near-term and possible periodic fire management in the long-term.

16. Windham-Myers, Lisamarie, Mark Marvin-DiPasquale, Jennifer L. Agee, Marisa H. Cox, and Evangelos Kakouros

USGS, Menlo Park, lwindham@usgs.gov

MERCURY CYCLING ALONG ALVISO SLOUGH MARSH – THE IMPORTANCE OF ELEVATION AND VEGETATION ZONE

The conversion of a subset of South Bay salt ponds to restored tidal marsh is a key goal of the South Bay Salt Pond Restoration Project. However, there remain concerns regarding the extent to which increased marsh acreage might lead to increased regional production of toxic methylmercury (MeHg). Previous studies have suggested that wetland plant community composition and structure can impact mercury (Hg) cycling in the saltmarsh setting, and that the high marsh zone may be a particularly important zone for MeHg production. The current study examines Hg cycling processes in surface sediments (0-2 cm depth) of three elevationally-distinct subhabitats, dominated by either cordgrass (low-marsh), bulrush (mid-marsh), or pickleweed (high-marsh). To determine the influence of vegetation within these subhabitats on MeHg production, we compared the same plant and sediment factors between experimental plots ($2m^2$) with plants removed, to control plots with undisturbed vegetation in both July and October 2007. Plant rooting depths were greatest in bulrush communities, and overall root densities were low (<5% of sediment volume) in all sites except where pickleweed dominated (17±2%). Still, root densities were correlated with both MeHg concentrations and labile carbon for microbial fuel, both of which were greatest in pickleweed-dominated high marsh sediments. Devegetation led to 20% lower MeHg sediment concentrations and up to 90% lower MeHg production rates, as assessed by radio-labelled ^{203}Hg laboratory incubations. This devegetation effect appears to be largely driven by the decrease in active root exudation of fermentative labile carbon (e.g. lactate, acetate). Although pools of reactive mercury were high within the Alviso marshes (up to 5% of THg), these subsiding, mineral-dominant marshes along Alviso Slough were found to produce 4- to10-fold less MeHg than nearby exposed benthos of Pond A8. We suggest that the availability of labile carbon drives MeHg production in these subhabitats, and carbon availability is relatively low in the mineral-dominant, oxic marsh sediments of Alviso Slough, as compared to exposed benthos of Pond A8 and historic high-elevation salt marshes of North San Francisco Bay.

17. Woo, Isa[1], Rachel J. Gardiner[1], Rune Storesund[2] and John Y. Takekawa[1]

[1]USGS Western Ecological Research Center, San Francisco Bay Estuary Station, iwoo@usgs.gov, [2]Engineering Dept., UC Berkeley

COMPOSITE DIGITAL ELEVATION MODEL FROM TERRESTRIAL LIDAR AND DIGITAL ORTHOPHOTO DATASETS: ACCURACIES AND ERRORS ASSOCIATED WITH SURVEYING A VEGETATED LAKEBED

The Tolay Creek Watershed drains approximately 13,200 acres (5,360 ha) along the northern edge of San Francisco Bay. Surrounded by a mosaic of open space, conservation easements, and public wildlife areas, the majority of the watershed was acquired for land conservation and for restoration of its natural habitat values. As part of the restoration planning process, we used terrestrial LiDAR (Light Detection and Ranging) to produce a digital elevation model (DEM) of the vegetated lakebed and adjacent areas. Unlike airborne LiDAR, terrestrial LiDAR does not have multiple returns from which ground elevations can be identified. On the other hand, terrestrial LiDAR is more economical for relatively small areas and can be more accurate because the laser unit is stationary. Terrestrial LiDAR is ideal for unvegetated areas with an accuracy of approximately 2-3 cm for bare surfaces; however, errors will increase as sites become vegetated. Here we present survey and interpolation errors associated with a vegetated lakebed.

We conducted 22 scans, which produced millions of LiDAR data points. These data were visualized and post-processed in I-SITE Studio software (v. 3.0 beta). We distinguished ground elevation from

vegetation height with a 1.5m topographic filter. In areas of dense vegetative cover, we supplemented the coverage with an existing digital orthophoto elevation dataset (produced by Delta Geomatics Corp, provided by Sonoma County Regional Parks). Prior to integrating the datasets, we gathered 369 elevation points throughout the densely vegetated lakebed with an RTK GPS (Leica Smartpole 1200) and RTKMax service to georeference the rover. These points were used to ground truth the digital orthophoto and terrestrial LiDAR elevation datasets from which errors were calculated. We adjusted the terrestrial LiDAR dataset with the difference from the RTK GPS (mean + se; 0.58 + 0.03m). Compared to our ground truthing points, the digital orthophoto produced more accurate elevations (0.15 + 0.02m, vertical accuracy at 95% confidence interval 0.52m), probably because vegetation was allowed to grow after cessation of farming activities, and this vegetation was registered by the terrestrial LiDAR scans (0.0 + 0.03m, vertical accuracy at 95% confidence interval 0.71m).

We then interpolated data points using inverse distance weighting in ArcGIS (Spatial Analyst, ESRI) and generated a DEM of the entire lakebed. We analyzed model errors by cross-validation in which we compared predicted elevations to measured elevations. The data interpolation in the DEM fit measured elevations well: digital orthophoto with $R2 = 0.9995$ and terrestrial LiDAR with $R2 = 0.9974$. DEMs consist of real errors from field data as well as from data interpolation used in models and we recommend that both errors be reported. Since vegetation signals may not be entirely filtered out, terrestrial LiDAR may provide opportunities for examining vegetation structure.