Shorebird Response to Varying Salinity and Water Depth in an Experimental Design in Salt Pond Management

Lacy M. Smith, USGS, lmsmith@usgs.gov
Stacy Moskal, USGS, lmsmith@usgs.gov
John Y. Takekawa, USGS, john_takekawa@usgs.gov
John Krause, CA Dept of Fish and Wildlife, lmsmith@usgs.gov
Renee Spenst, Ducks Unlimited, lmsmith@usgs.gov

San Francisco Bay Estuary supports thousands of shorebirds during fall and spring migration and over winter. These shorebirds rely on foraging opportunities in the bay mud flats and former salt production ponds. The South Bay Salt Pond Restoration Project plans to restore 50-90% of salt ponds to tidal marsh and sediment demand for restoration may reduce the extent of remaining mud flat. Ponds E12 and E13 in the Eden Landing Ecological Reserve were enhanced to provide varying levels of salinity and water depth for increased foraging opportunities. Each pond was divided into three cells and foraging mounds were constructed to provide variation in topography. Our objectives were to understand shorebird use and invertebrate colonization immediately post-construction. We surveyed shorebirds across the cells and within survey plots on foraging mounds during the first winter (Jan-April) post-construction. We measured water quality and collected benthic macro-invertebrate cores and sweep samples on the mounds. Preliminary results show small shorebirds, predominantly Western Sandpiper and Dunlin, were the most abundant shorebirds, with over 5,000 observed across all ponds each month. Small shorebird abundance was greater in high salinity (49.2 psu) cells compared to the lowest salinity (40.8 psu) cells. Small shorebird abundance on foraging mounds ranged from zero to several hundred; however only 10% were observed foraging. We found aquatic invertebrates in our sweep samples and very few benthic invertebrates in our sediment cores; however, we expect additional colonization to occur over time. Our research highlights immediate shorebird use of managed ponds manipulated to provide suitable water depths for roosting and foraging opportunities. Our on-going studies at these experimental ponds will increase our understanding of shorebird spatial distribution in relation to water salinity, depth, and invertebrate composition and will provide managers with key information to optimize ponds for wintering and migrating shorebirds.

Keywords: shorebirds, foraging, experimental design, salt ponds, salinity, water depth, invertebrates
Session Title: Species and Communities I: Community Response to Management **Session Time:** Thursday 1:00PM – 2:40PM Room 306

Emerging Perspectives on Salt Marsh Harvest Mouse Conservation and Management - Ducks, Dikes, and Demographics

Katherine Smith*, UC Davis, California Department of Fish and Wildlife, rasmith@ucdavis.edu
Laureen Barthman-Thompson, California Department of Fish and Wildlife, laureen.thompson@wildlife.ca.gov
Melissa Riley, California Department of Fish and Wildlife, melissa.riley@wildlife.ca.gov
Sarah Estrella, California Department of Fish and Wildlife, sarah.estrella@wildlife.ca.gov

Conservation and management of the salt marsh harvest mouse (*Reithrodontomys raviventris*) has long focused narrowly on presence/absence data. This project is delving deeper into the population dynamics, habitat use and behaviors of the salt marsh harvest mouse than has ever been attempted. Through monthly trapping in paired tidal and managed wetlands, and quarterly diet and habitat use assessments we are working to build a more complete picture of this endangered species. We are specifically looking to improve multispecies management by identifying waterfowl management practices that favor salt marsh harvest mouse conservation. One year into this three year study has yielded exciting preliminary results. During monthly trapping we have seen marked differences in capture rates across seasons with the highest occurring, surprisingly, during the winter. We have also seen interesting trends in population structure, with sex ratios varying across months. Finally, by trapping during the winter we were able to confirm that mice do not vacate managed marshes during the fall flood up, but remain in flooded wetlands even in the absence of emergent land close by. The diet assessment has shown that often salt marsh harvest mice choose foods that are highly preferred by ducks over those we presume they prefer based on trapping data. Through the use of radio telemetry we have observed interesting trends in habitat use, such as mice using vegetation types traditionally thought to be poor quality (such as *Phragmites australis*) when pickleweed (*Salicornia virginica*) is widely available. We have also documented salt marsh harvest mice using a variety of nest types as well as underground refuges, both self made and appropriated from other species.
The emerging perspective on the salt marsh harvest mouse is that it is a much more dynamic species than historical research has revealed, and our management must be equally dynamic.

Keywords: Salt marsh harvest mouse, *Reithrodontomys raviventris*, wetland management, populations, diet
Session Title: Species and Communities I: Community Response to Management **Session Time:** Thursday 1:00PM – 2:40PM Room 306

Diving Duck Response to Multi-Species Pond Management at Eden Landing Ecological Reserve

Susan E. W. De La Cruz, USGS, Western Ecological Research Center (WERC), San Francisco Bay Estuary Field Station, sdelacruz@usgs.gov
Stacy Moskal, USGS, WERC, San Francisco Bay Estuary Field Station, smoskal@usgs.gov
Ashley L. Smith, USGS, WERC, San Francisco Bay Estuary Field Station, alsmith@usgs.gov
Lacy M. Smith, USGS, WERC, San Francisco Bay Estuary Field Station, lmsmith@usgs.gov
Mason A. Hill, USGS, WERC, San Francisco Bay Estuary Field Station, mhill@usgs.gov
Sara Piotter, USGS, WERC, San Francisco Bay Estuary Field Station, spiotter@usgs.gov
John Krause, CDFW, Eden Landing Ecological Reserve, John.Krause@wildlife.ca.gov
John Y. Takekawa, USGS, WERC, SF Bay Estuary Field Station, john_takekawa@usgs.gov

San Francisco Bay is a critical wintering site for waterfowl and shorebirds using the Pacific Flyway. While in the estuary these species rely both on mudflat and salt pond habitats for foraging. The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal marsh restoration project on the Pacific coast, with an objective of maintaining current bird numbers on salt ponds while converting 50 to 90% of them to tidal marshes to benefit endemic species. At the Eden Landing Ecological Reserve (ELER), managers are working to achieve this goal through multi-species management on a subset of ponds. These ponds are drained to create shorebird nesting habitat in the summer and filled for diving duck foraging habitat in the winter. Our objective was to evaluate response of diving ducks and their invertebrate prey to management actions. During the winters (Oct – April) of 2013-2014, we measured diving duck abundance and behavior, benthic invertebrate density and community composition, and water quality in E6A, E6B, E8 and 3 reference ponds. We coordinated with hunters to obtain digestive tracts and examine diets of birds foraging in the ponds. The most abundant divers were scaup (*Aythya affinis and A. marila*) and ruddy ducks (*Oxyura jamaicensis*), and ponds were used mainly for roosting with more foraging in reference ponds. Invertebrate diversity and richness was lowest in treatment ponds prior to flooding in the fall and increased over the winter. The main items in diet samples (n=30) were ostracods and seeds. Results from our study should provide valuable information for managing ponds to benefit multiple species which will be critical to meet restoration goals as the SBSPRP project progresses.

Keywords: diving ducks, benthic invertebrate, diet, salt ponds, restoration
Session Title: Species and Communities I: Community Response to Management **Session Time:** Thursday 1:00PM – 2:40PM Room 306

Rapid Fouling Community Shifts in San Francisco Bay Linked to Climatic Extremes and Water Management

Andrew Chang, Smithsonian Environmental Research Center, ChangAL@si.edu
Christopher Brown, California State Lands Commission, Chris.Brown@slc.ca.gov
Jeffrey Crooks, Tijuana River National Estuarine Research Reserve, jcrooks@tijuanaestuary.org
Gregory Ruiz, Smithsonian Environmental Research Center, ruizg@si.edu

Problem: Human alteration of the hydrological cycle in the western US is resulting in greater variability and extreme interannual fluctuations in freshwater flow. The ecological impacts of extreme climatic fluctuations and human alterations to the hydrological cycle are less well known in downstream, estuarine systems.

Approach: We present results from a thirteen-year study of sessile marine invertebrate communities in San Francisco Bay demonstrating clear links between salinity levels, which are controlled by high and low estuarine outflow extremes, and mechanisms driving community composition and abundance. Using observational and experimental approaches, we assessed the effect of changes in water column conditions on fouling community diversity over thirteen years, including some of the wettest and dryest years in the past half century. We examined correlations between sessile invertebrate recruitment and survival patterns and seasonal variation in salinity and temperature in the Bay. We experimentally manipulated: (1) temperature and salinity levels to assess their effects on survival and community assembly processes, and (2) community composition to examine community assembly processes in the presence and absence of dominant species from wet and dry extremes.

Results: We show that even modest, decadal extremes in wet and dry climatic conditions drive dramatic, yet predictable shifts in sessile marine invertebrate community composition and abundance. During high flow (wet) years, low salinity levels cause mass mortality in fouling communities, significantly altering community composition and function throughout the estuary. In contrast, during dry years, fouling communities are dominated by non-native species, and sessile species move upstream into areas of the estuary traditionally inhabited by freshwater or brackish communities. Adult organisms' high salinity tolerances allow persistence and continued impacts following recruitment to areas more typically inhabited by freshwater organisms.

Conclusions: Our study shows consistent, predictable community changes driven by environmental changes tightly linked to both climatic change and management regimes.

Keywords: community, diversity, invasions, climate, flood, drought, salinity, outflow, extreme
Session Title: Species and Communities I: Community Response to Management **Session Time:** Thursday 1:00PM – 2:40PM Room 306

Ballast Water Management Compliance of Commercial Vessels Operating in the San Francisco Estuary: A Ten-Year Perspective

Christopher Brown, California State Lands Commission, chris.brown@slc.ca.gov
Raya Nedelcheva, California State Lands Commission, raya.nedelcheva@slc.ca.gov
Jonathan Thompson, California State Lands Commission, jonathan.thompson@slc.ca.gov
Chris Scianni, California State Lands Commission, chris.scianni@slc.ca.gov
Nicole Dobroski, California State Lands Commission, nicole.dobroski@slc.ca.gov

The discharge of ballast water from commercial ships is a well-known and highly documented vector for the introduction of nonindigenous species (NIS) to coastal waters and estuaries. Within California, it is estimated that up to 81% of the state's 257 established aquatic NIS were introduced via commercial shipping. The California State Lands Commission's Marine Invasive Species Program (MISP) has overseen the prevention of NIS release from commercial vessels into California waters since its inception in 2000. A vital information-gathering component of the MISP is the requirement that all vessels greater than 300 gross registered tons and capable of carrying ballast water submit ballast water reporting forms upon departure from each port or place of call in California. These forms detail ballast water management activities for the approximately 10,000 annual vessel arrivals to CA ports, forming a robust data set through which compliance and management patterns can be examined. The use of GIS allows the MISP to assess ballast water management compliance on several levels, including the source and management (i.e. exchange) locations of all reported ballast water discharges into California waters. GIS analyses can also illustrate broad patterns and processes, such as noncompliant ballast water exchange discharge densities by location, which offer greater insight into potential NIS hotspots and areas of increased risk.

Ballast water management compliance data for the approximately five million metric tons of ballast discharged annually into the San Francisco Estuary from 2004-2013 will be presented. Trends involving the quantities and geographies of managed ballast water, where such ballast water has been exchanged, and where it has been discharged will be discussed. Such analyses provide valuable information that can inform the development of more effective ballast water management regulations, as well as inform both retrospective and predictive studies of NIS invasion patterns.

Keywords: invasive species, ballast water
Session Title: Species and Communities I: Community Response to Management **Session Time:** Thursday 1:00PM – 2:40PM Room 306

Trophic Integration of an Invasive Plant: Lepidium latifolium's Impact on the Suisun Song Sparrow Food Webs

Rachel Wigginton*, University of California Davis, rdwigginton@ucdavis.edu
Hildegarde Spautz, California Department of Fish and Wildlife, HSPAUTZ@dfg.ca.gov
Letitia Grenier, State Coastal Conservancy, letitia@letitia.org
Christine Whitcraft, California State University Long Beach, Christine.Whitcraft@csulb.edu

Over the last two decades, human-induced habitat changes, such as urbanization and introduced species, have degraded California's tidal wetlands. *Lepidium latifolium* (perennial pepperweed) is a pervasive invader of California wetlands, potentially altering ecological and community dynamics. This project assesses *L. latifolium*'s impact on food web structure for Suisun song sparrows (*Melospiza melodia maxillaris*) in the brackish tidal marsh of Rush Ranch Open Space Preserve, in the San Francisco Bay-Delta Estuary. Food web structure was assessed through analysis of invertebrate communities (soil infauna and canopy arthropods) and stable isotope analysis of bird blood and feathers. Invertebrate samples were taken in all four seasons within a randomly selected location in the marsh. Suisun song sparrow feather samples were taken in the winter and summer of 2011. Prior to *L. latifolium* bloom and during peak bloom, sparrow blood was sampled to examine tropic shifts associated with *L. latifolium* emergence. The infauna community at the site does not vary with presence of *L. latifolium*, but is structured by phonologic stage of the plant, with habitat zone (ie: fringing marsh, marsh plain, tidal marsh-terrestrial ecotone) significantly impacting abundance in the winter. The canopy-dwelling arthropod community follows a similar pattern of change across season, but this community is also structured by the emergence of *L. latifolium* in the summer. There is an isotopic shift in bird blood between winter (pre-*L. latifolium*) and summer (*L. latifolium* bloom). Mixing models suggest sparrows rely on *L. latifolium*-derived food sources more heavily in the summer months (breeding season) than in the winter months. We predict integration of *L. latifolium* into the food web of Suisun song sparrows, implying *L. latifolium* eradication should be paired with native plant restoration to avoid impacts on sensitive marsh vertebrates.

Keywords: food web, brackish marsh, invasion, *Lepidium latifolium*, Suisun song sparrow
Session Title: Species and Communities II: News from Suisun and the Bay
Session Time: Thursday 3:00PM – 4:40PM Room 306

Variation in Salinity Tolerance among Olympia Oyster Populations: Implications for Restoration in the Face of Climate Change

Jillian Bible*, Bodega Marine Laboratory, University of California Davis, jmbible@ucdavis.edu
Eric Sanford, Bodega Marine Laboratory, University of California Davis, edsanford@ucdavis.edu

Although seldom studied, genetic differences among marine populations may mediate a species' response to climate change. Understanding the extent of local adaptation (when populations become particularly adapted to their local environments through genetic differentiation) in species of special concern is particularly important for conservation and restoration planning in an era of accelerating climate change. We examined whether populations of native Olympia oysters (*Ostrea lurida*) in San Francisco and Tomales Bays are locally adapted to salinity, a factor predicted to shift with climate change. In a first experiment, we spawned oysters from three sites in San Francisco Bay and raised their offspring under common laboratory conditions. These juvenile oysters were then reciprocally transplanted among the three field sites. There was suggestive evidence that oysters of local origin survived better than oysters from other source populations, consistent with local adaptation within a single estuary. In a second experiment, we raised oysters from two sites in San Francisco Bay and one site in Tomales Bay through two generations under common laboratory conditions and then subjected these oysters to different salinity regimes in the laboratory. Oysters from the site with the lowest recorded field salinity had higher survival rates than the other two populations when faced with low salinity in the lab, showing that some populations are more robust against extreme low salinity events. As interest grows in restoring heavily impacted native oyster populations, our results suggest that considering local adaptation may be critical to deciding how and where to conserve and restore native oysters faced with changing ocean conditions. In particular, our results can aid in site selection for restoration, broodstock/source population selection, and prioritizing conservation of stress tolerant genotypes.

Keywords: Olympia oysters, local adaptation, salinity, climate change, restoration
Session Title: Species and Communities II: News from Suisun and the Bay
Session Time: Thursday 3:00PM – 4:40PM Room 306

California Gull Population Growth and Response to South Bay Salt Pond Restoration

Natalie Washburn, San Francisco Bay Bird Observatory, nwashburn@sfbbo.org
Catherine Burns, San Francisco Bay Bird Observatory, cburns@sfbbo.org
Erika Taketa, San Francisco Bay Bird Observatory, etaketa@gmail.com
Karine Tokatlian, San Francisco Bay Bird Observatory, ktokatlian@sfbbo.org
Josh Scullen, San Francisco Bay Bird Observatory, jscullen@sfbbo.org

Since 1980, the San Francisco Bay Bird Observatory (SFBBO) has surveyed gull breeding colonies across South San Francisco Bay. This research has documented rapidly increasing numbers of California Gulls, which are the most abundant gull species in the area during the breeding season of many other waterbirds. California Gull populations have increased from only 24 in the early 1980s to over 50,000 in 2014. 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 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 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 and resight surveys. We present information on the movements of banded gulls, focusing on the responses to restoration of one particular salt pond, 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, helps land managers predict gull response and manage adaptively to the restoration of 15,000 acres of salt ponds in South San Francisco Bay.

Keywords: California Gulls, population growth, South Bay Salt Pond Restoration Project
Session Title: Species and Communities II: News from Suisun and the Bay
Session Time: Thursday 3:00PM – 4:40PM Room 306

Seeds, Space and Time: Assessing Plant Community Dispersal Dynamics in the South Bay Salt Pond Restoration Project

Dyan Chapple*, UC Berkeley, dylanchapple@berkeley.edu
Katharine Suding, UC Berkeley, suding@berkeley.edu

In many tidal wetland restoration projects, un-assisted dispersal of seeds is expected to drive the development of plant communities. While sites are quickly colonized by pioneer species, the development of diverse plant communities may take much longer. Previous studies in lower salinity marshes in the North SF Bay indicate that un-assisted seed dispersal is likely to support the development of diverse communities, however evidence from higher salinity wetlands in Southern California show that seed availability may be greatly constrained in restoration projects. While un-assisted dispersal is the primary means of plant development in the South Bay Salt Pond Restoration Project, no detailed assessment of dispersal yet exists for newly breached areas. Here, we test two hypotheses related to seed dispersal at 3 restored and 3 reference sites at Eden Landing Ecological Reserve (ELER) in Hayward, CA: H1) Seed communities will exhibit evidence of distance decay of similarity, whereby areas geographically closer will be more similar in composition than those farther away H2) Reference sites will have overall higher densities of salt marsh seeds than restoration sites. To test H1, we examine the transition between a freshwater influenced area and an adjacent salt marsh area. We use Mantel tests to test for evidence of spatial autocorrelation, finding that both vegetation communities and seed communities are significantly influenced by space, supporting H1. Using paired t-tests, we find partial support for H2. Density of salt marsh species is significantly different between restored and reference sites in seed bank samples, but not in seed mat samples. This may be because drought limited seed production during the previous growing season, and points to the importance of seed bank development in restoration. These findings indicate that introducing dispersal-limited species into restoration projects may provide important local sources of propagules for developing sites.

Keywords: Salt Ponds, Restoration, Plant Communities, Dispersal, Diversity
Session Title: Species and Communities II: News from Suisun and the Bay
Session Time: Thursday 3:00PM – 4:40PM Room 306

Abiotic and Biotic Drivers of Native Pondweed (*Stuckenia* spp.) Distribution in Suisun Bay and the West Delta

Katharyn Boyer, Romberg Tiburon Center, San Francisco State University, katboyer@sfsu.edu
Evyan Borgnis, Romberg Tiburon Center, San Francisco State University, elborgnis@gmail.com
Jen Miller, Romberg Tiburon Center, San Francisco State University, millerj@sfsu.edu
Melissa Patten, Romberg Tiburon Center, San Francisco State University, mvpatten@gmail.com

Over 1200 acres of native pondweeds (*Stuckenia* spp.) support high abundances of invertebrates along the migratory path for fish species of concern in Suisun Bay and the west Delta, yet patterns and processes in these beds are poorly understood. We explored abiotic and biotic factors that may influence current distribution and abundance patterns through field surveys and mesocosm experiments. We evaluated patterns in water quality parameters over a one-year period in both *Stuckenia*-dominated beds in Suisun Bay and invasive *Egeria densa*-dominated beds in the west Delta, and conducted experiments testing salinity tolerance, turbidity effects, and competition between *Stuckenia* and *Egeria*. Field data suggesting salinity is a major driver of plant distributions were supported by mesocosm results showing *Stuckenia* biomass increased 4-fold over 3 months at salinities of 0 and 5, doubled at 10, and maintained biomass at 15. In contrast, *Egeria* declined 5-fold in biomass at a salinity of 5 relative to the fresh water treatment, and decomposed within 3 weeks at salinities of 10 and 15. Competition may also be important in determining distributions at low salinities, as *Egeria* presence led to a 75% decrease in *Stuckenia* biomass in fresh water, while at a salinity of 5, a decline in *Egeria* performance coincided with a doubling of *Stuckenia* shoot density. Effects of turbidity tested on the two species showed enhanced growth and flowering for both under simulated future conditions of higher light availability. In addition to aiding in our understanding of current distribution and abundance patterns for native and invasive SAV within the low salinity zone, these results can help to predict future patterns under a variety of scenarios of management and climate change.

Keywords*:* *Stuckenia*, Egeria, Suisun, salinity, turbidity, Suisun, SAV
Session Title: Species and Communities II: News from Suisun and the Bay
Session Time: Thursday 3:00PM – 4:40PM Room 306