Relocating a Historic Cormorant Nesting Colony through Implementation of Nesting Platforms on New East Span of the San Francisco-Oakland Bay Bridge

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Since 1984, double-crested cormorant (*Phalacrocorax auritus*) nesting has been documented on the underside of the original east span of the San Francisco-Oakland Bay Bridge (SFOBB). By 2007, the SFOBB colony had grown to become one of the largest in Northern California with more than 800 nests. Following the Loma Prieta Earthquake in 1989, the California Department of Transportation (Caltrans) began the planning that would ultimately lead to the replacement of the original east span. Recognizing that demolition of the original east span would remove what had grown to become a critical local nesting site for the species, Caltrans decided to construct nesting platforms along the middle of the skyway on the new east span in the hopes that the colony would relocate. The new nesting platforms were completed in 2009 and enticements were installed with the goal of relocating the colony to the new location. Enticements included cormorant decoys, audio broadcasts of cormorant calls, faux nests, nest boxes, and mirrors designed to mimic greater density on the platforms. However, as demolition of the original span began in 2014, the new nesting platforms sat unused as the colony held onto the remaining sections of the original east span. On March 28, 2017, the final span of the original bridge superstructure was lowered, effectively removing the colony's historic habitat. On April 5, 2017, the first cormorant observations on the new platforms were recorded. By May 2017, approximately 600-700 birds were observed roosting and nesting on the new platforms. The double-crested cormorants observed are likely the same population that were using the original east span. Next steps include continued maintenance of the nesting platforms and possibly removal of the enticements that would be unnecessary after the colony has established itself on the new platforms.

Keywords: Bay Bridge, cormorant, nesting, habitat, bird, Caltrans

Poster Topic Species and Communities

Canvasback Movement Patterns and Space Use in Suisun Bay and Marsh

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Suisun Bay and Marsh are integral components of the San Francisco Bay Delta ecosystem and have a long history of waterfowl use. Diving ducks, including canvasback (*Aythya valisineria*) are numerous in Suisun throughout winter, and previous work has demonstrated exchange of diving ducks between Suisun and other SFB sub-bays; however, what drives movement among these sub-bays is unclear. In addition, little is known about habitat use or food quality and availability for diving ducks using Suisun. Our study is designed to evaluate diving duck use of Suisun Marsh and Bay with the ultimate goal of identifying management regimes that may benefit these species. As part of this comprehensive study, we evaluated canvasback movements and space use during winter 2016 and 2017. We captured 33 canvasback in Suisun Bay and Napa-Sonoma Marsh using baited swim-in traps and fitted them with GPS-GSM tracking devices that provide high resolution location estimates. We used continuous-time stochastic Brownian bridge movement models (package BBMM in R 3.0) to evaluate canvasback movements across winter and during spring migration. We also calculated fixed kernel densities at the collective and individual level to evaluate space use. Initial results show differential movement and use patterns between the two study years. In 2016, individuals used a full spectrum of Suisun habitats including shallow shoals, tidal marshes, managed marshes, and static deep-water ponds, and transitioned inland towards freshwater habitats during spring months. Whereas, in 2017 canvasback use of Suisun habitats was limited and individuals moved inland to the Central Valley in early winter, potentially as a result of historic fresh water availability. Given cyclical drought conditions, planned tidal wetland restoration and diminishing freshwater flows to this region, information on diving duck ecology in Suisun can improve our understanding of how projected habitat changes may influence these species in the future.

Keywords: waterfowl, telemetry, habitat use, restoration, drought, freshwater flows

Poster Topic Species and Communities

Suisun Marsh Waterfowl and Managed Wetland Research Program

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In 2014, the Department of Water Resources (DWR) established the Suisun Marsh Waterfowl and Managed Wetland Research Program to help achieve regulatory requirements while providing data on key biological uncertainties with the overarching goal of improving the management of managed wetlands (duck hunting clubs) to sustain populations of waterfowl and other native species. DWR has developed 10 year contracts with the USGS and UC Davis with the goal of understanding the management needs of waterfowl, native fish, Salt Marsh Harvest mice, Black and Ridgway's Rails, Western Pond Turtles, and raptors in the Suisun Marsh. To date we have attached cellphone tower transmitters on 7 species of waterfowl to document winter habitat use and movements, and on 3 species of waterfowl to evaluate breeding season habitat use and movements. We have deployed audio-detection devices to aid in detecting rails, evaluated Salt Marsh Harvest Mouse use of managed wetlands, and are in the first year of working with UC Davis and USGS to conduct Western Pond Turtle Surveys and Northern Harrier surveys. We will initiate telemetry studies on both species in 2018. Recognizing that to be successful we have to work with over 100 duck hunting clubs in the Suisun Marsh, we have also launched a Human Dimensions study to better understand what may inhibit landowners from implementing management practices on their duck hunting club. For example, is it cost, how the message is delivered, views towards who is delivering the message, or simply attitudes towards conservation and research? Future work includes, examining the role managed wetlands may play as exporters of nutrients (i.e. food) for native fish, and gaining a better understanding of how skunks, raccoons, and other predators of nesting waterfowl and Salt Marsh Harvest mice use the Marsh.

Keywords: Suisun Marsh, Waterfowl, Managed Wetlands, Habitat Management

Poster Topic Species and Communities

Environmental Drivers of Macroinvertebrate Biomass and Waterbird Abundance in Managed Ponds of South San Francisco Bay

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The South Bay Salt Pond Restoration Project, the largest tidal marsh restoration effort on the North American Pacific coast, was initiated in 2007 to restore 50-90% of former salt ponds and benefit tidal marsh species that lost much of their historical habitats. The Project must balance the needs of species that require vegetated tidal marsh with those of waterbirds that depend on non-vegetated mudflats and managed ponds. To inform future management actions designed to sustain foraging and roosting waterbirds, we evaluated waterbird and macroinvertebrate responses to experimentally manipulated water depth and salinity in managed ponds at Eden Landing Ecological Reserve in South San Francisco Bay. We observed 39 species of waterbirds from 11 guilds. The abundance of guilds differed among salinity treatments; small shorebirds were most abundant at high salinities (80 – 120 ppt), medium shorebirds were most abundant at moderate salinities (40 – 80 ppt), and dabbling ducks were most abundant at low salinities (< 40 ppt). Overall, small shorebirds were the most abundant guild, and were strongly influenced by the elevation and exposure of sediment mounds in the ponds. Interestingly, we did not detect a relationship between the abundance of foraging small shorebirds and macroinvertebrate biomass on sediment mounds, suggesting that other factors, such as predator avoidance, may be important drivers of foraging shorebird abundance. Macroinvertebrate biomass was weakly affected by water depth, with the greatest biomass of macroinvertebrates observed at water depths between 10 and 20 cm. This depth is inaccessible to most small and medium shorebirds, suggesting that predation may play a role in limiting macroinvertebrate biomass at shallower depths. Our results support the idea that managing ponds at different salinities and at water depths that maximize the accessibility of mounds could maintain high abundances of foraging and roosting birds from a broad suite of guilds.

Keywords: Foraging ecology, Macroinvertebrate biomass, Salt ponds, Waterbirds, Wetland restoration

Poster Topic Species and Communities

PCB Tissue Concentrations and Benthic Community Impacts at a Carbon Amendment Pilot Study in the Intertidal and Subtidal Zones of San Francisco Bay

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Historical site activities at the Hunters Point Naval Shipyard (HPNS) in South San Francisco Bay resulted in the release of chemicals, including polychlorinated biphenyls (PCBs), to offshore sediments. To inform remedy selection at this urban site, activated carbon (AC) amendments alternatives were evaluated in a pilot treatability study. Two 0.4 acre plots extending from the intertidal to the subtidal zone were treated with either AquaGate + PAC™ or SediMite™ were assessed for their potential to reduce ecological risks associated with PCB-contaminated sediment. Previous treatability studies indicated that AC may be effective at reducing the bioavailability of PCBs to the bent-nose clams (*Macoma nasuta*) in shallow intertidal sediments when aided by mechanical mixing. This study assessed the effectiveness of AC placements without mechanical mixing in deeper water that is more representative of conditions where full-scale remediation is expected. Tissue bioaccumulation, benthic invertebrate community composition, and chemical analyses were measured as indicators of remedy effectiveness. Comparisons were made between baseline, reference, and post-amendment conditions (8 months and 14 months post-placement). PCB tissue concentrations in *Macoma* sp. were measured *in situ* and *ex situ* (bench-top) after 28-day exposures. Developing field exposure chambers that allowed sediments to infiltrate the chambers and expose clams upon deployment and then retrieve the sediment and exposed organisms for chemical analyses was a challenge. Modifying a chamber design used in previous studies by Luthy et al. (2009) proved successful. PCB tissue concentrations were reduced up to 85% in both pilot amendment areas after 14 months with survival greater than 90 percent. Benthic invertebrate communities in test plots were not significantly different from baseline conditions or among treatments 14 months after AC deployment.

Keywords: PCBs, benthic community

Poster Topic Species and Communities

Declining Productivity of Brackish Marsh Plants with Increasing Inundation and Salinity in Suisun Bay

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Inundation and salinity are important drivers of plant distribution and productivity in tidal marshes. Plant physiological stress due to these factors may increase with sea-level rise in the San Francisco Bay-Delta Estuary. We tested the response of several dominant brackish tidal marsh species to elevated salinity and inundation using greenhouse and field experiments during the 2016 growing season. In the field, we grew a high marsh species, *Juncus balticus*, in mesocosms at a range of elevations that varied tidal inundation (5 levels) and at three different initial soil salinities. Under ambient soil salinity, productivity varied unimodally with inundation, peaking at intermediate flooding duration. There was a similar functional relationship between productivity and inundation at higher initial soil salinities, but peak productivity shifted to slightly lower elevations and was reduced in high marsh relative to ambient soil salinity. In the greenhouse we grew potted cuttings of *J. balticus*, *Schoenoplectus americanus*, and *Schoenoplectus acutus* in salinity baths ranging from 0 to 30 ppt to evaluate inter-specific differences in growth responses of these species to salinity stress. Soil salinities in the experiment exceeded salinities in the water baths. Productivity of all species was highest at low salinities (nominal salinity of 0-2 ppt in water baths) and declined several fold in the highest salinity baths. *S. americanus* appeared to be most tolerant to intermediate salinities (10 ppt in water baths), a salinity level that might become more frequent in the Suisun Bay region with future sea-level rise. Our results show that increasing salinity can affect species differently and modify plant growth responses to inundation. Relative sea-level rise could therefore potentially affect vegetated marsh productivity and the relative competitive ability of species as marshes become more submerged and more saline into the future.

Keywords: climate change, sea-level rise, tidal marsh

Poster Topic Species and Communities

Celebrating 30 years of Francisco Bay Wildlife Society: A pilot study on Macroinvertebrate Recolonization at the Bottom of Dredged Stockton Ship Channel, in the California Delta

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San Francisco Bay Wildlife Society has been improving our Estuary for 30 years, including Environmental Education, Research, and Restoration. SFBWS now seeks more science advisors.

California's extensive, marshy Delta includes two largely overlooked, 10~13 -m-deep freshwater ship channels, with portions dredged every 1~>5 years, with macroinvertebrates eaten by protected and other fishes. We hypothesized macroinvertebrates to recolonize slowly after maintenance dredging, with recolonization possibly slowed due to repeated disturbance from large ships passing.

We first tested disturbance to these invertebrates as large ships passed. Remote underwater wide-angle-cameras placed near passing ships, generally showed ship hydrodynamics minimize such bottom disturbance. Narrow channels and side channels focus displaced water into brief erosional currents, yet benthic individuals persisted even there.

Rather than traditional annual sampling for recovery (e.g. from dredging,) we applied approaches from "old-field succession," simultaneously comparing populations at similar channel sites dredged at different times into the past, also compared to naturally deep, never dredged, sites nearby. The latter sites showed periodic erosion and coarser sediment, less comparable to dredged sites upstream. But sites dredged most recently (even 3~9 months earlier) also showed large populations and even large individuals of diverse invertebrates, approaching those in nearby, similar sites not dredged in >5 years, and as dense as even the naturally deep, never dredged sites. Overall population densities averaged ~2000 individuals per m^2, including common tubificid worms, amphipods, and clams.

Rapid reappearance of invertebrates after this maintenance dredging may arise from observed drift of shallow vegetation, with dense attached invertebrates, from animal transport from ~2 kt tidal currents, and from "topsoil" slumping into the channel after this form of maintenance dredging at the edge of the ship channel.

Keywords: California Delta, ship channel benthos, fish food resources, invertebrates

Poster Topic Species and Communities

Macroinvertebrate Prey Availability for Fish in Periodically Dredged Areas of Central San Francisco Bay

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Periodic, shallow-water maintenance dredging is necessary to maintain waterways, but it can also remove patches of habitat and disturb benthic macroinvertebrate communities that provide important prey resources for many economically and ecologically important fish species. However, there is a lack of information specific to the San Francisco Bay (SFB) on the degree of benthic community disruption caused by dredging. The goal of this on-going study is to provide insight on the extent to which dredging impacts macroinvertebrate prey resources in bottom-dwelling fish foraging habitat in Central SFB. We are comparing macroinvertebrate communities between periodically dredged (every 1-3 years) and adjacent undredged areas. Benthic core samples are being collected from six shallow (<3.96 m MLLW), soft-bottom (silt/clay soil texture) environments in Central SFB during summer and winter over two years. To assess foraging habitat for key fish species, we are measuring prey abundance, biomass and accessibility. We assume accessibility is limited by macroinvertebrate size (i.e., fish gape size dictates the size of prey consumed) and the depth at which prey occurs in the sediment (i.e., foraging strategies determine if fish can access upper or deep sediments). Thus, we are dividing benthic core samples into shallow (0-4 cm) and deep (4-10 cm) segments, and categorizing identified prey into size classes. Preliminary results suggest macroinvertebrate abundance differed significantly between paired dredged and undredged areas, and by depth category. This study will help clarify whether areas that are dredged periodically have different macroinvertebrate prey availability for fish compared to adjacent undredged areas. With repeated sampling, we can also provide insight on changes in seasonal and temporal post-dredging prey availability.

Keywords: food webs, fish habitat, subtidal habitat, macroinvertebrates, benthos, dredging

Poster Topic Species and Communities

Phenotypic Plasticity and Morphological Variation in a Native Submerged Aquatic Plant

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Morphological variations in widely distributed plants may be driven by phenotypic plasticity or by underlying genetic differences. In the brackish open water region of the San Francisco Estuary (SFE), a population of sago pondweed, (*Stuckenia pectinata*) shows at least two distinct growth forms, which are so different that they were previously thought to be two species. This study confirmed the *S. pectinata* species identity for all morphologies through sequencing of the nuclear ribosomal internal transcribed spacer (ITS) region. I investigated phenotypic plasticity in response to flow variations in a common garden, and found that morphological traits are plastic but distinct morphotypes did not converge. I then used four microsatellite loci to investigate differentiation between the two morphotypes at three sites within Suisun Bay and the western Sacramento-San Joaquin Delta, and two populations from other central California sites for comparison. I found very few multilocus genotypes (unique combinations of alleles across two or more loci), which could be a reflection of low levels of clonal diversity, or a byproduct of low resolution in my methods. Lastly, I investigated the influence of plant morphology on the ecologically important invertebrate epibiont community. I found a positive relationship of plant surface area, leaf count, and leaf density with invertebrate abundance only at the more saline of the two sites sampled, which had a different invertebrate assemblage than the fresher site. Results of this study suggest that the two growth forms may provide different ecosystem functions and services, which could influence management and restoration decisions in the region.

Keywords: SAV, plasticity, pondweeds, microsatellites, morphology, invertebrate, epibiont, *stuckenia*

Poster Topic Species and Communities

Spatiotemporal Characterization of Microbial Communities Controlling Estuarine Nitrogen Cycling in the San Francisco Bay-Delta

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Nitrogen (N) availability is an important factor controlling productivity in estuaries. Yet, little is known about how environmental changes affect the diversity, abundance, distribution, and activity of N-cycling microbes. Using deep 16S rRNA and metagenomic sequencing through the Joint Genome Institute (JGI), we are investigating the structure and function of nitrogen and carbon cycling communities in San Francisco Bay, which receives high anthropogenic N input. Water samples span the estuarine gradient, from high-nutrient riverine regions to brackish transition zones to marine regions, and were collected during monthly USGS water quality monitoring cruises. Through JGI, we have assembled 88 16S rRNA amplicon libraries from bottom water samples collected approximately monthly from April 2013 to March 2014. By coupling genomic approaches with environmental data collected by USGS, we hope to gain insights into how environmental factors impact microbial communities and specific biogeochemical processes in the water column. We are particularly interested in nitrification, an important process linking decomposition of organic N to anaerobic "nitrogen loss" processes. Previous work in our laboratory has characterized nitrification functional genes (e.g., amoA) and biogeochemical rates from many of these samples, facilitating comparisons between 16S rRNA diversity and relative abundances to functional gene abundance and metabolic rates. We also seek to elucidate positive and negative co-occurrence between N-cycling taxa using network analysis.

Student Award Competition: Yes

Keywords: geomicrobiology, nitrification, thaumarchaea, ecology, nitrogen

Poster Topic Species and Communities

Seasonal and Spatial Patterns of Macroalgal Dominance in San Francisco Bay Eelgrass (*Zostera marina*) Beds

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Eelgrass (*Zostera marina*) beds in San Francisco (SF) Bay provide habitat for invertebrates and support the refuge needs or food webs of resident and migratory fish and birds. Benthic macroalgae and epiphytes (algae attached to eelgrass leaves) in eelgrass beds also provide habitat and food but can compete with the eelgrass for light and nutrients. Over several years of monitoring SF Bay eelgrass beds, we had observed high abundances of algae at times, but these primary producers had not been quantified; hence, we had no basis for understanding their values or potential for harm to eelgrass. We assessed abundance and composition of algae in four eelgrass beds during six sampling events over two years. We found a highly variable mosaic of species and large seasonal and spatial fluctuations in biomass (two to four-fold). In addition, we found that at certain locations and seasons, macroalgae reaches abundances documented in other regions as detrimental to eelgrass. However, we posit that these high abundances of palatable algae, as well as the numerous invertebrates present on or within the algal mats, play an important role in energy transfer to higher trophic levels. We conclude that eelgrass does not always contribute the most biomass or physical structure within eelgrass beds, and suggest that previously undocumented high abundances of macroalgae warrant further study in order to understand the full picture of primary production and trophic transfer within these beds, as well as potential impacts to eelgrass.

Keywords: eelgrass, *Zostera marina*, macroalgae, San Francisco Bay, primary producer

Poster Topic Species and Communities

A Spatiotemporal Assessment of Benthic Community Composition in a San Francisco Bay Mudflat

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Most benthic organisms are limited in mobility and thus cannot easily relocate to more suitable habitats. As such, benthic communities are excellent indicators of environmental change. With widespread restoration efforts and sea-level rise concerns throughout San Francisco Bay, identifying the most important environmental drivers of benthic community variation in this region is timely. This study provides an in-depth analysis of an extensive benthic dataset collected from a subtidal shoal in the South Bay. Benthic community-habitat relationships were evaluated using a combination of multivariate regression tree (MRT) and redundancy analysis (RDA) to determine the extent to which temporal (sampling month and year) and environmental factors (distance from shore, inundation, sediment chemistry, sediment grain size, and chlorophyll *a*) explain community composition in this region. Of the environmental variables examined, distance from shore and inundation explained the largest proportion of the community variation (34.0 and 21.8% in RDA, respectively). Yet, there were no temporal effects on community composition observed. In this study, the community-habitat relationships appear to be robust to temporal variation, but factors associated with distance from shore, including inundation, will be directly impacted by sea-level rise. Thus, future efforts that evaluate the extent to which communities respond and adapt to sea-level rise could be valuable. Results of this study will provide important information about benthic community-habitat relationships that can potentially have bottom-up implications for higher trophic foragers, such as waterbirds and benthic foraging fishes.

Keywords: food webs, multivariate analysis, macroinvertebrate communities, benthos, sea-level rise

Poster Topic Species and Communities