Beyond the Vulnerability Study: Moving from Sea Level Rise Adaptation Planning to Implementation in the San Francisco Bay Area

Clesi Bennett*, Center for the Blue Economy, Middlebury Institute of International Studies at Monterey/California State Coastal Conservancy, clesib@miis.edu

Due to the nuanced and local effects of future sea level rise around the San Francisco Bay Area as well as local governments' responsibilities for land use planning and public safety, counties and cities will play critical roles in sea level rise adaptation. However, several hurdles currently prevent Bay Area counties and cities from moving beyond the assessment and planning stage of adaptation. County and city planners lack clear and accessible information on implementing sea level rise adaptation polices. This project attempts to synthesize the current literature and provide local decision-makers with various potential pathways to implementation along with other relevant considerations.

This project exposes local governments to various guiding principles as well as strategy determinants before presenting them with a suite of potential planning, regulatory, market-based, and engineering adaptation tools. The economic, ecological, and social costs and benefits of each tool are compared. Additionally, timeframes, goals, and examples are included for each tool. Legal and scale considerations are also outlined. Lastly, this project includes steps to achieving successful implementation and lessons learned from around the U.S. in order to help San Francisco Bay Area counties and cities become more resilient to the effects of sea level rise.

Student Award Competition: Yes

Keywords: sea level rise, adaptation, counties, cities, climate change, implementation, tools

Poster Topic Climate Adaptation

A New Living Shorelines Project at Giant Marsh: Integration of Restoration Features Across an Elevational Gradient for Sea Level Rise Adaptation

Katharyn Boyer, Romberg Tiburon Center, San Francisco State, katboyer@sfsu.edu

With concern about climate change-induced sea level rise and increased storm surge, the first living shorelines project in San Francisco Bay was installed in San Rafael in 2012, and evaluated habitat values of native oyster and eelgrass restoration at a scale large enough to also test shoreline protection potential. Building on lessons learned from that first project, the State Coastal Conservancy and project partners are developing a new living shorelines project at Giant Marsh near Point Pinole. This project includes numerous restoration elements from the deep intertidal to the eroding tidal marsh shoreline and up to the estuarine/terrestrial transition zone. Oyster reefs and eelgrass will again be included, as will oyster reefs close to shore in concert with plantings designed to enhance native cordgrass establishment and spread. This shoreline also has habitat appropriate for restoration of the federally-endangered California sea-blite, which will be "arbored" to encourage these shrubs to grow tall to maximize high tide refuge for rare birds and mammals. Plantings at the estuarine/terrestrial transition zone will enhance native plant presence at the site. Monitoring of plants, birds, fish, and invertebrates will permit assessment of habitat values of the various treatments, and physical processes such as wave attenuation, erosion, and accretion will be tracked. The project is currently in the permitting phase, with construction planned for 2018. Project elements incorporate an experimental design that will permit rigorous evaluation of multiple treatments relative to controls and pre-project conditions, thus aiding in the design of future projects to enhance habitat while buffering shorelines against erosion.

Keywords: Living shorelines, eelgrass, oyster, sea-blite, cordgrass, adaptation, sea level rise

Poster Topic Climate Adaptation

Delta Fishes and Multiple Stressors: Native and Non-Native Vulnerability to Elevated Temperature and Salinity

Brittany Davis*, University of California Davis, bebjelde@ucdavis.edu
Dennis Cocherell, University of California Davis, decocherell@ucdavis.edu
Ted Sommer, California Department of Water Resources, Division of Environmental Services, Ted.Sommer@water.ca.gov
Randall Baxter, California Department of Fish and Wildlife, Randy.Baxter@wildlife.ca.gov
Anne Todgham, University of California Davis, todgham@ucdavis.edu
Nann Fangue, University of California Davis, nafangue@ucdavis.edu

Drought conditions coupled with climate change are projected to have cascading effects on the California Delta system, including increases in temperature and sea-level rise leading to saltwater intrusion and increased salinity regimes. Little is known about how temperature and salinity stressors interact affecting fish performance. Here, we assessed the capacity of juvenile endangered Delta Smelt (DS, *Hypomesus transpacificus*), invasive Mississippi Silverside (MS, *Menidia beryllina*), and recreationally important Largemouth Bass (LMB, *Micropterus salmoides*) to cope with two co-occurring stressors (temperature *AND* salinity) after an initial single-stressor exposure (temperature *OR* salinity). Critical thermal maxima (CTMax), a measure of upper temperature tolerance, was determined after 0, 2, 4 and 7 days following single and co-occurring stressor exposures. Under control conditions (16ºC, 2.4ppt) CTMax differed among species with MS having the highest CTMax (34.1ºC), DS having the lowest (28.3ºC), and LMB intermediate (32.7ºC). Salinity as a single stressor (12ppt for DS and MS, 8ppt for LMB) had little effect on CTMax, whereas elevated temperature (20ºC) significantly increased CTMax to 35.0ºC (MS), 29.7ºC (DS), and 34.6ºC (LMB). An initial thermal stressor had similar CTMax values in the subsequent co-occurring stressor for DS and MS, whereas LMB showed an additive effect of temperature and salinity such that CTMax further increased to 35.4ºC. An initial salinity exposure rapidly increased CTMax by 1-2ºC in the co-occurring stressor in all species. These data suggest that how salinity influences plasticity in CTMax differs by species, whereas there is a positive relationship between thermal history and CTMax in all species. With increasing frequency and duration of warm Delta water temperatures (summer means of 20-25ºC), it is notable that native DS have upper thermal-tolerance values closest to habitat temperatures (~4-8ºC) compared to non-native species (~10-15ºC). Our hope is that these physiological-health assessments will be useful for future conservation planning for these species.

Student Award Competition: Yes

Keywords: Fish Tolerance, Bay-Delta, Drought, Delta Smelt, Silversides, Largemouth Bass

Poster Topic Climate Adaptation

Transforming the Bay Edge - Strategic Coastal Adaptation Insights from Cost Estimation

Daniella Hirschfeld*, UC Berkeley, daniellah@berkeley.edu
Kristina Hill, UC Berkeley, kzhill@berkeley.edu

In metropolitan regions made up of multiple independent jurisdictions, such as the San Francisco Bay, adaptation to increased coastal flooding due to sea level rise requires coordinated strategic planning of physical and organizational approaches. Here, we present a flexible method for estimating physical adaptation costs along the San Francisco Bay shoreline. Our goal is to identify uncertainties that can hinder cooperation and decision-making. We categorized shoreline data, estimated the height of exceedance for sea level rise scenarios, and developed a set of unit costs for raising current infrastructure to meet future water levels. Additionally, we explored the potential from a cost perspective for ecological systems to play a role in climate adaptation strategies. Using these cost estimates, we explored critical strategic planning questions including shoreline positions, design heights and infrastructure types. For shoreline position, we found that while the shortest line is in fact the least costly, building the future shoreline at today's transition from saltwater to freshwater vegetation is similar in cost but allows for the added possibility of conserving saltwater wetlands. Regulations requiring a specific infrastructure design height above the water level had a large impact on physical construction costs. Finally, our results show that the costs of raising existing walls may represent 70% to 90% of the total regional costs, suggesting that a shift to earthen terraces and levees will reduce adaptation costs significantly.

Student Award Competition: Yes

Keywords: Sea level rise, coastal flooding, cost estimation, adaptation, levees, seawalls

Poster Topic Climate Adaptation

Lessons from the 2014-2015 Drought

Amber Manfree, UC Davis, admanfree@ucdavis.edu
John Durand, UC Davis, jrdurand@ucdavis.edu
Josue Medellin-Azuara, UC Davis, jmedellin@ucdavis.edu
Fabian Bombardelli, UC Davis, fabombardelli@ucdavis.edu
Denise Colombano, UC Davis, dpdecarion@ucdavis.edu
William Fleenor, UC Davis, wefleenor@ucdavis.edu
Jon Herman, UC Davis, jdherman@ucdavis.edu
Richard Howitt, UC Davis, rehowitt@ucdavis.edu
Carson Jeffries, UC Davis, cajeffres@ucdavis.edu
Michelle Leinfelder-Miles, UC Extension, mmleinfeldermiles@ucanr.edu
Robert Lusardi, UC Davis, ralusardi@ucdavis.edu
Brett Milligan, UC Davis, bmilligan@ucdavis.edu
Peter Moyle, UC Davis, pbmoyle@ucdavis.edu
Tom Young, UC Davis, tyoung@ucdavis.edu

The 2014-2015 drought tested the bounds of water infrastructure, water management strategies, and ecosystems in the Sacramento-San Joaquin Delta (the Delta) and throughout the state of California. The future will undoubtedly bring more droughts to the region, including more extreme events. Capturing lessons learned is a critical task in preparing to effectively manage water and systems in future droughts in this region, which is central to California's water supply needs and provides habitat for several native, endangered, and migratory species.

A series of interviews were conducted with key managers and stakeholders to better understand drought-response management actions and their effects on the Delta ecosystem, water supply, and agriculture and economy. These interviews provide unique insights on what went right, what went wrong, and how adjustments in management could improve water supply reliability and ecosystem resilience in the next drought. Interview content and background information are synthesized in a concise report for Delta managers and scientists.

The synthesis report provides and overview of drought-related management decisions and summarizes lessons learned. This includes an assessment of how science was used to inform decision-making, how impacts of actions were studied, and take-home messages considered critical by those most closely involved in Delta water management. Key findings and infographics will be incorporated into poster.

Keywords: Drought, Sacramento, San Joaquin, Delta, water, economy, environment, ecosystem, hydrology

Poster Topic Climate Adaptation

Understanding the Broader Consequences of Tidal Wetland Loss for Sea Level Rise Adaptation Planning: San Mateo County Case Study

Hayden Maya, Point Blue Conservation Science, mhayden@pointblue.org
Sam Veloz, Point Blue Conservation Science, sveloz@pointblue.org
Leo Salas, Point Blue Conservation Science, lsalas@pointblue.org
Dennis Jongsomjit, Point Blue Conservation Science, djongsomjit@pointblue.org
Nathan Elliott, Point Blue Conservation Science, nelliott@pointblue.org
Julian Wood, Point Blue Conservation Science, jwood@pointblue.org
Nadav Nur, Point Blue Conservation Science, nnur@pointblue.org
Hilary Papendick, San Mateo County Office of Sustainability, HPapendick@smcgov.org
Kelly Malinowski, State Coastal Conservancy, kelly.malinowski@scc.ca.gov

Sea level rise vulnerability assessments are increasing in California as a result of state and local government led climate adaptation efforts. Due partly to the proliferation of fine-scale coastal flood models, standardized approaches have emerged for assessing vulnerability of built assets (e.g., roads, buildings, utilities). However, habitat changes and lost ecosystem services are more difficult to quantify because (1) ecosystems are dynamic, requiring more sophisticated modeling of projected temporal changes, and (2) there is no consensus on which services and metrics should be quantified. The disparity makes it challenging for decision-makers to integrate natural and built assets into coastal adaptation planning. Risk to natural systems can be underrepresented, skew prioritization of vulnerable assets toward the built environment, and fail to adequately account for benefits derived from natural ecosystems (e.g., coastal protection, carbon sequestration). Focusing on tidal wetlands in San Mateo County, we are quantifying projected changes in a selection of functions and services that (1) represent a range of ecological and societal benefits, and (2) can best leverage existing data, models, and literature to provide the best available science within the time constraints of decision-making. Ecosystem services include tidal marsh habitat resiliency, population viability of indicator bird species, coarse-level assessment of carbon sequestration capacity, and wave attenuation benefits for coastal defense. Composite maps of projected future changes allow identification of wetlands with high current value that are projected to remain high under a range of future conditions (i.e., resilient) as well as those likely to degrade in the near-term (i.e., vulnerable). In partnership with San Mateo County and the California Coastal Conservancy, the results will be integrated into coastal adaptation and climate action planning processes at the county-level and in the broader San Francisco Bay region, and disseminated as a case study approach more broadly.

Keywords: sea-level rise, tidal marsh, adaptation, accretion, climate change, ecosystem services

Poster Topic Climate Adaptation

Sensitivity of the San Francisco Bay Ecosystem to Future Scenarios

Emma Nuss, San Francisco Estuary Institute, emman@sfei.org
Rusty Holleman, San Francisco Estuary Institute, rustyh@sfei.org
Zhenlin Zhang, San Francisco Estuary Institute, zhenlinz@sfei.org
David Senn, San Francisco Estuary Institute, davids@sfei.org

Ambient nutrient concentrations in San Francisco Bay are high relative to many urbanized estuaries, yet at present the classic symptoms of eutrophication are typically not observed in the Bay. The source of this resistance is hypothesized to be a combination of the light limiting effects of suspended sediments and the presence of benthic grazers, both of which exert strong controls on the phytoplankton population. However, observations in recent years suggest that this resistance may be declining. We present the design of and preliminary results from a study on the range of likely ecological trajectories of the Bay. These trajectories are a result of trends and forecasts of forcing conditions ranging from upwelling and sea surface temperature to stratification and sediment supply. A collection of simplified and complex models are used to investigate these conditions and their effects on eutrophication and other undesirable phenomena, such as harmful algal blooms. The myriad sources of uncertainty and intermittency necessitate a probabilistic, risk-based approach. Understanding how the dynamics of nutrients, hydrodynamics, and biology interact under a rich set of future scenarios will be crucial for mitigation and forward-looking stewardship of the Bay.

Keywords: Nutrients, San Francisco Bay

Poster Topic Climate Adaptation

Testing a Novel Adaptation Strategy in a Coastal Salt Marsh

Evyan Sloane, State Coastal Conservancy, evyan.sloane@scc.ca.gov
Victoria Touchstone, U.S. Fish and Wildlife Service, victoria_touchstone@fws.gov
Richard Nye, U.S. Fish and Wildlife Service, richard_nye@fws.gov
Christine Whitcraft, CSU Long Beach, christine.whitcraft@csulb.edu
Richard Ambrose, UCLA, rambrose@ucla.edu
Karen Thorne, USGS, kthorne@usgs.gov
Glen MacDonald, UCLA, macdonal@geog.ucla.edu
Jason Keller, Chapman University, jkeller@chapman.edu
Mayda Winter, Southwest Wetland Interpretive Association, swiaprojects@aol.com

Coastal wetlands around the world are threatened by sea-level rise (SLR). While current research demonstrates that many, but not all, wetlands in California are keeping pace with SLR via sediment accretion, this resiliency is expected to only resist SLR projections for 2030 and likely 2050. To ensure wetland resilience for 2100 and beyond, wetland management must incorporate a range of tools at various scales. The Seal Beach National Wildlife Refuge (Refuge) encompasses 911 acres of remnant saltwater marsh in the Anaheim Bay estuary and is a perfect location to test a new SLR adaptation strategy, sediment augmentation, where a thin-layer of sediment is placed on a marsh plain to raise elevations. The Refuge is currently experiencing elevated rates of SLR (~3Xs higher than other California wetlands; 6.23 mm/yr) due to subsidence and with Orange County's imminent plans to dredge the adjacent harbor; this is the perfect opportunity to test sediment augmentation. This project placed 8-10 inches of clean, dredge material on approximately 8-acres of low-elevation (*Spartina*-dominated) marsh. Sediment was transported by floating pipe and placed on the marsh plain using a rainbow sprayer. One year of pre-construction monitoring, started in April 2015, and five years of post-construction monitoring will determine the effectiveness of sediment augmentation at the Refuge. The monitoring program will assess augmentation effects on elevation and sediment dynamics, creek morphology, carbon sequestration including greenhouse gas flux, invertebrates, emergent and submerged vegetation, and avian communities. Preliminary results demonstrate that native cordgrass and picklweed species have begun to colonize along the project site boundary and tidal creeks have begun to reform. The results of this project will be shared via trainings hosted by the USFWS for potential utilization throughout California's salt marsh systems.

Keywords: Salt marsh, wetland, sea level rise, sediment

Poster Topic Climate Adaptation