Vegetation Development in a Tidal Marsh Restoration Project during a Historic Drought: A Remote Sensing Approach

Dylan Chapple, UC Berkeley, dylanchapple@berkeley.edu
Iryna Dronova, UC Berkeley, idronova@berkeley.edu

Tidal wetland restoration efforts can be challenging to monitor in the field due to unstable local conditions and poor site access. However, understanding how restored systems evolve over time is essential for future management of their ecological benefits, many of which are related to vegetation dynamics. Physical attributes such as elevation and distance to channel play crucial roles in governing vegetation expansion in developing tidal wetlands. However, in Mediterranean ecosystems, drought years, wet years and their resulting influence on salinity levels may also play a crucial role in determining the trajectory of restoration projects, but the influence of weather variability on restoration outcomes is not well understood. Here, we use object-based image analysis (OBIA) and change analysis of high-resolution IKONOS and WorldView-2 satellite imagery to explore whether mean annual rates of change from mudflat to vegetation are lower during drought years with higher salinity (2011-2015) compared to years with lower salinity (2009-2011) at a developing restoration site in California's San Francisco Bay. We found that vegetation increased at a mean rate of 1979 m^2/year during California's historic drought, 10.4 times slower than the rate of 20580 m^2/year between 2009 and 2011 when the state was not in drought. Vegetation was significantly concentrated in areas closer to channel edges, where salinity stress is ameliorated, and the magnitude of the effect increased in the 2015 image. In our image analysis, we found that different distributions of water, mud and algae between years led to different segmentation settings for each set of images, highlighting the need for more robust and reproducible OBIA strategies in complex wetlands. Our results demonstrate that adaptive monitoring efforts in variable climates should take into account the influence of weather on tidal wetland ecosystems, and that high-resolution remote sensing can be an effective means of assessing these dynamics.

Keywords: drought, restoration, South Bay Salt Pond Restoration Project, vegetation

Poster Topic Habitat Restoration

Environmental Factors that Influence Benthic Macroinvertebrate Prey Resources for Waterbirds in Managed Ponds at Eden Landing Ecological Reserve, South San Francisco Bay

Alison M. Flanagan, U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, aflanagan@usgs.gov
Susan E. W. De La Cruz, U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, sdelacruz@usgs.gov
Laurie A. Hall, U.S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, lahall@usgs.gov

Over 80% of San Francisco Bay's historical wetlands have been lost to habitat conversion, including salt production ponds. Today, the most extensive wetland restoration project on the United States Pacific Coast, the South Bay Salt Pond Restoration Project, has been working to restore these critical habitats to healthy, functional ecosystems for a variety of wildlife. A key objective of this effort is to provide habitat for migratory and resident waterbirds who rely on coastal wetlands for roosting and foraging resources. However, the extent to which management actions can be used to maximize macroinvertebrate prey resources is unclear. This study used multivariate community analyses (RDA and MRT) to evaluate the extent to which environmental factors (i.e., water quality, sediment chemistry, and sediment grain-size characteristics) influence benthic macroinvertebrate community composition in managed ponds at Eden Landing Ecological Reserve in South San Francisco Bay. An emphasis was placed on environmental factors that can be managed through water manipulation (e.g., water depth and salinity). Several environmental factors significantly influenced macroinvertebrate community composition in this study (e.g., pH, salinity, nitrate, sulfur, percent silt, etc.), with salinity and pH explaining the largest proportion of the community variation (~30%). Since salinity is one "manageable" environmental factor, efforts to influence community composition may benefit from modifying pond salinity. In particular, a larger number of taxa occurred at salinities < 44.11 ppt; polychaetes, insects, and copepods dominated salinities ranging from 44.11 ppt to 57.75 ppt; and the only taxa present at salinities exceeding 57.57 ppt were insects and polychaetes. Thus, to maximize taxonomic richness, salinity could be maintained at or below 44.11 ppt, which is near the maximum allowable discharge value. However, for some waterbird species, such as small shorebirds and eared grebes, taxa found in high salinity ponds may provide important foraging resources not found elsewhere.

Keywords: restoration, managed habitats, food webs, multivariate analysis, macroinvertebrate communities, benthos

Poster Topic Habitat Restoration

Reconstructing an Estuarine Beach at Aramburu Island – Shoreline Design Performance Five Years Post-Construction

Daniel Gillenwater, Gillenwater Consulting, dan@gillenh2o.net
Roger Leventhal, Marin County, Flood Control Division, RLeventhal@marincounty.org
Peter Baye, Annapolis Field Station, botanybaye@gmail.com
Courtney Gutman, Audubon California, ccalkins@audubon.org
John Takekawa, Audubon California, jtakekawa@audubon.org
Stuart Siegel, Siegel Environmental, stuart@swampthing.org

The Aramburu Island Shoreline Enhancement Project in Richardson Bay, Marin County serves as a demonstration of a “living shoreline” approach to sea-level rise adaptation. The design was based upon data collected on beach slope, sediment size, and fetch at reference beaches around San Francisco Bay and implemented to inhibit wind-wave erosion of an estuarine shoreline with habitat and recreational uses. Three different beach designs were implemented to reflect different combinations of slope, grain size, and material type. Construction occurred in fall 2011 by grading back the shoreline profile, building low "micro-groins" from small boulders and woody debris to provide partial barriers to longshore drift, and depositing different mixtures of sand, gravel, cobble, and oyster shell hash along the shoreline in ratios based upon estimated incident wave energy. Shoreline geomorphology and bird use were monitored at the site over five years following construction to assess design performance and to understand sediment transport dynamics, resilience of the constructed beach forms, and change in habitat values. The geomorphology monitoring involved qualitative beach condition surveys, shore-normal topographic transect surveys, and drone-based photogrammetry surveys, which present a promising new approach for low-cost, high-resolution terrain mapping and geomorphology change detection at beach restoration sites. In the five years since construction, there has been significant longshore transport of finer-grained beach materials (sand and shell), and concomitant changes in beach morphology. Materials stripped from updrift areas have deposited along spits and behind longshore drift barriers at downdrift locations, creating a changing mosaic of habitats. Despite these changes, the enhancements have provided protection against the high rates of pre-project erosion along most of the shoreline and have provided valuable habitats for shorebirds. Bird use of the enhanced shoreline has increased significantly over pre-project conditions in terms of both abundance and species richness.

Keywords: beach restoration, shoreline geomorphology, soft engineering, living shorelines

Poster Topic Habitat Restoration

The Interagency Development of an EcoRestore Adaptive Management Program

Karen Kayfetz, Delta Stewardship Council, Delta Science Program, karen.kayfetz@deltacouncil.ca.gov
Maggie Christman, Delta Stewardship Council, Delta Science Program, maggie.christman@deltacouncil.ca.gov
Tricia Lee, Delta Stewardship Council, Delta Science Program, tricia.lee@deltacouncil.ca.gov
Lauren Hastings, Delta Stewardship Council, lauren.hastings@deltacouncil.ca.gov

The California EcoRestore initiative calls for the restoration and enhancement of 30,000 acres of habitat, primarily floodplain and tidal marsh, in the Delta and Suisun Marsh by 2020. As part of this initiative, the Interagency Adaptive Management Integration Team (IAMIT), comprising agency and stakeholder scientists and technical management staff, was charged with developing a white paper describing existing adaptive management resources, how those resources link together, and what resources are currently lacking. The white paper was developed in 2016-2017 and concludes with a series of recommendations for developing a complete, integrated, and financially supported adaptive management program for EcoRestore. We present here the recommendations of the white paper, which integrate existing efforts to enhance coordination, synthesis and evaluation, information sharing, and communication. The desired outcome of implementing these recommendations is a program that 1) supports individual restoration projects, 2) considers local and system-scale effects, 3) sets a stage to evaluate impacts of restoration actions at multiple time and spatial scales, and 4) has an organization structure wherein acquired knowledge is effectively communicated and used for development of subsequent goals, objectives and management actions. While the scope of the program is initially limited to integration of current EcoRestore projects, implementation of the recommendations will provide a strong foundation for a robust, long-term adaptive management program for habitat restoration, based on scientifically rigorous modeling, monitoring, research, and assessment methods.

Keywords: adaptive management, restoration, Delta, coordination, synthesis, evaluation, sharing, communication

Poster Topic Habitat Restoration

Habitat Development on the Napa River: Napa County Flood Protection Project Restoration Progress

Megan Keever, Stillwater Sciences, megan@stillwatersci.com
Sara Gabrielson, Stillwater Sciences, sgabrielson@stillwatersci.com
Rob Thoms, Stillwater Sciences, rthoms@stillwatersci.com
Jeremy Sarrow, Napa County Flood Control & Water Conservation District, Jeremy.Sarrow@countyofnapa.org

In the Napa Valley of California, a series of over-bank flooding events by the Napa River during the latter half of the 20th century resulted in cumulative economic damage in excess of 500 million dollars. As a result, the Napa County Flood Protection Project (Project) was initiated in 1964 with the U.S. Congress' authorization of a large-scale flood protection project along a six-mile reach of the main stem Napa River and a 1.4-mile reach of Napa Creek within the City of Napa. This flood control and riverine restoration project was jointly designed by the U.S. Army Corps of Engineers (USACE) and Napa County Flood Control and Water Conservation District (District); phased implementation began over 15 years ago and received widespread attention for the innovative "Living River" approach to flood attenuation – achieving 100-year level flood protection by connecting the river to its historical floodplain. Conversion of the Project area from the previously diked agricultural baylands to a mosaic of tidally influenced wetlands required levee removal and breaching, lowering levees, and channel modifications to create flood terraces. Restoration goals included creating and restoring brackish emergent marsh, tidal mudflats, seasonal and emergent wetlands, shaded riverine aquatic habitat, riparian forest and scrub-shrub, high-value oak woodlands, and grasslands. Systematic monitoring is occurring over a 40-year period and was first conducted by USACE before transferring responsibility to the District in 2012. In 2012 and 2017, on behalf of the District, Stillwater Sciences conducted vegetation monitoring studies to document changes in vegetation, soils, and hydrology of the restored area. We present our findings, track progress toward the 40-year goals of the project, and provide information that is useful for guiding adaptive management.

Keywords: restoration, flood control, levee removal, floodplain, wetlands, vegetation monitoring

Poster Topic Habitat Restoration

Benthic Microalgae Primary Production Modeling: A Test Run for the San Francisco Estuary

Tricia Lee, Delta Stewardship Council- Delta Science Program, tricia.lee@deltacouncil.ca.gov

Benthic microalgae (BMA) are mud-dwelling photosynthesizers that facilitate many different ecosystem services and influence the benthic-pelagic relationship. These services include such things as provision of oxygen to the benthic microbial community, sediment stabilization, nutrient mitigation, and food web support for both pelagic and benthic zones. However, in the San Francisco Estuary (SFE) the BMA are not frequently studied for how these processes factor into ecosystem functioning. An article by Cloern et al. (2016) highlighted the importance of understanding all primary producing groups and their role in historic estuarine ecosystem functions to plan effective habitat restoration in the SFE.

Presented here are measured rates for a growth season of benthic primary production in First and Second Mallard Branch, Suisun Marsh, CA (data from Louise Lee 2016)- a site that exhibits historic SFE geomorphology with dendritic and dead-end sloughs. The rates are then used to scale primary production rates to an annual production by BMA, and further scaled to habitat extent using an irradiance-based ecophysiological model by Pinckney (1994). Such models as these should be further examined for complete integration into ecosystem restoration planning efforts and refined for the SFE system.

Keywords: Primary Production, Benthic Microalgae, Landscape Scale

Poster Topic Habitat Restoration

Oxygen Dynamics across Scales in Lower South Bay

Lissa MacVean, San Francisco Estuary Institute, lissam@sfei.org
Rusty Holleman, San Francisco Estuary Institute, rustyh@sfei.org
Zephyr Sylvester, San Francisco Estuary Institute, zephyrs@sfei.org
David Senn, San Francisco Estuary Institute, davids@sfei.org

The southern-most embayment of San Francisco Bay is nutrient-enriched and strongly tidal. Persistent low primary productivity in the Bay distinguishes it from other enriched estuaries (Chesapeake, Long Island Sound, e.g.), and the driving mechanisms are not fully understood. Lower South Bay (LSB) is surrounded by former salt ponds, most of which have been fully or partially reconnected to the tidal influence of the Bay to facilitate salt marsh restoration. These ponds are transected by tidal sloughs that serve as a conduit between the Bay and the ponds. Continuous observations of oceanographic and water quality parameters, including dissolved oxygen (DO), at seven sites in the Bay and sloughs show that water quality was controlled by a combination of physical and biogeochemical processes. Concentrations of DO in the open Bay were largely driven by tidal advection, where low DO occurred on the lowest, summer tides, suggesting that oxygen was consumed in the margins at the limit of the tidal excursion, and a low-DO water mass was exported to the open Bay on ebb tides. The shallow, quiescent ponds with muted tidal exchange had the highest primary productivity, and in summer months, were a source of chlorophyll and DO-enriched water. Between the tidally-controlled open Bay and the reaction-driven ponds, the sloughs exhibited strong interactions between physical and biogeochemical processes. Here we present the results of two research objectives: (1) to use observations to characterize the mechanisms controlling DO concentrations in the ponds, sloughs, and open Bay, and (2) to separate physical and biogeochemical DO fluxes to estimate respiration at our measurement locations. These analyses inform conceptual and numerical models of hydrodynamic and nutrient-driven processes in LSB, as scientists and managers consider the Bay's current energy balance and how it might change in the future.

Keywords: dissolved oxygen, managed ponds, nutrient-enriched

Poster Topic Habitat Restoration

Preliminary Exploration of Methane Flux from the South Bay Salt Pond Restoration Project

Haley Miller*, Chapman University, mille316@mail.chapman.edu
Glenn Woerndle, Chapman University, woerndle@chapman.edu
Cassandra Medvedeff Zalman, Chapman University, medvedef@chapman.edu
Jason Keller, Chapman University, jkeller@chapman.edu

Coastal wetlands are incredibly valuable environments due, in part, to their ability to sequester and store carbon over long periods of time. There is a growing interest among coastal managers to capitalize on this carbon storage capacity to drive restoration and conservation efforts in the context of emerging carbon markets. The South Bay Salt Pond Restoration Project (SBSPRP) is the largest tidal wetland restoration effort on the West Coast, launched in 2004 with an objective to restore 15,100 acres of industrial salt ponds in the south of the San Francisco Bay back to natural habitat. While wetlands are extremely efficient carbon sinks, they also have the ability to produce and emit greenhouse gasses like methane. Previous studies suggest the production and emission of methane from costal wetland ecosystems may be suppressed by the availability of sulfate in tidally-influenced systems with salinities above 18 ppt. This study used static chambers to measure methane fluxes from salt ponds undergoing various management regimes and an associated, restored marsh in the SBSPRP. Samples were collected in November 2016, January 2017, March 2017, and June 2017, with an additional sampling scheduled for August 2017. Our results suggest that some of the larger salt ponds are releasing measurable amounts of methane throughout year, including systems with salinities above 18 ppt. A better understanding of spatial and temporal variability of methane fluxes from the SBSPRP is necessary to better understand the role that these coastal ecosystems play within global climate change.

Student Award Competition: Yes

Keywords: blue carbon, restoration, methane, South Bay Salt Pond Restoration Project

Poster Topic Habitat Restoration

Expanding the Capacity of Unmanned Aerial System to River Restoration

Toby Stegman, cbec, t.stegman@cbecoeng.com
Rusty Barker, cbec, r.barker@cbecoeng.com
Chris Bowles, cbec, c.bowles@cbecoeng.com

The accessibility of unmanned aerial systems (UAS), to both the private and public sectors, affords numerous opportunities to monitor and restore a variety of hydrological processes. Specifically, estuary ecosystems stand to benefit from rapid monitoring campaigns and inexpensive aerial survey techniques. To even further accelerate the use of UAS within the private sector, the Federal Aviation Administration implemented new regulations for commercial UAS in the late summer of 2016, which foster new opportunities for development in a rapidly growing market. Here, we present several examples of how our use of UAS and Structure-from- Motion and multi-special aerial images are used to support river restoration over a range of fluvial environments, extending from estuaries to high-energy gravel-bed systems along the Lower American River and Yuba Rivers in California. We will demonstrate how this technology was deployed to develop high resolution digital elevation models for existing conditions in project design and two-dimensional hydraulic modeling. In addition, we also explore conventional passive optical remote sensing techniques (i.e., multi-spectral aerial images) acquired through UAS platforms, to facilitate bathymetric mapping, image classification, and plant health mapping. UAS technology holds the potential to allow watershed managers a wide range of tools to study, plan, and restore the Estuary's habitats.

Keywords: UAS, UAV, Remote Sensing, Restoration, Multi-Spectral, SfM, Structure-from-Motion, drone, NDVI

Poster Topic Habitat Restoration