Using Monitoring and Models to Help Manage the Evolving Marshes of the San Francisco Estuary

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Monitoring of marsh evolution, together with accretion models developed with that data, are tools that can help resource managers understand and manage marshes as sea levels rise and sediment supplies diminish. Tools such as these, focused on organic productivity and soil profile processes, can identify vulnerabilities of existing marshes. For instance: will existing marshes accrete rapidly enough to keep up with sea level rise?; if they don't, how rapidly may they "downshift" from marsh to mudflat?; how sensitive are marshes to changes in sediment supply and salinity regime? Work by PRBO and ESA PWA shows how these vulnerabilities may manifest around the Bay and provide guidance on evaluating marsh resilience.

Monitoring and models focused on inorganic sedimentation can assist in the planning of new restorations. Accretion modeling of Ponds A9-A15 in the South Bay, for the USACE Shoreline Study, demonstrates the influence of initial elevation and timing of breaching on marsh evolution. These results were used to optimize the phasing and timing of the breaching of individual ponds to increase the likelihood of project success. On a larger scale, accretion modeling has been used to assess the demand for sediment from all the existing and planned marshes in the South Bay and how this may impact future sediment budgets.

The next step is to use these tools to help develop adaptation measures that increase marsh resiliency to sea level rise. For instance, measures have been suggested that feed sediment to a marsh by placing fine sediment on adjacent mudflats and allowing it to be reworked by wave action. Measures may also include reconnecting tidal marshes to upland ecotones to allow transgression. Examples from around the Bay will be given of how accretion models allow managers to make judicious choices of which adaptation measures to implement and when.

Keywords: "sea level rise", "tidal marshes", accretion, resilience, modeling, adaptation

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The Data and Monitoring Needs of Marsh Sustainability Models Currently Being Used in the SF Estuary

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The Wetland Accretion Rate Model for Ecosystem Resilience (WARMER) and Marsh98, are models of marsh elevation at a point that incorporate biological and physical processes of vertical marsh accretion and have been applied to tidal saltmarshes in San Francisco Estuary. These models are tools used to better our understanding of the threat of rising sea level on marsh sustainability and habitat quality. Both models incorporate dynamic processes of relative sea-level rise, inorganic sediment accumulation, and organic matter accumulation. WARMER also incorporates elevation dependent production, decomposition, and compaction, in evaluating changes in marsh surface elevation. In order for WARMER to be applied in a particular setting, the local elevation, inundation regime, sediment porosity, decomposition, mineral sediment accumulation and organic matter accumulation parameters are needed. Marsh98, as applied to estuary sub-regions by PRBO, also requires local elevation and inundation regime together with estimates of suspended sediment concentration and organic matter accumulation for each region and applied to a seamless elevation map of the Estuary.

The quality of model inputs can have major impacts on model outputs for both models. A detailed sensitivity analysis of WARMER and the results of Marsh98 both indicate that sediment supply and the rate of sea-level rise are the primary drivers of salt marsh sustainability within the Estuary. Most of the modeled scenarios indicate that changes in elevation will degrade habitat quality on decadal timescales and that degradation will accelerate in the latter half of this century as the rate of sea-level rise accelerates. Model scenarios would be improved with better inputs related to (1) local estimates of relative sea-level rise and future tide range,(2) estimates of spatial and temporal variability of sediment supply to and accretion within the marsh, and (3) species specific organic matter accumulation and decay information.

Keywords: Marsh sustainability, sea-level rise, monitoring, numerical model

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Understanding How Climate Change and Associated Extreme Storm Events Affect Wildlife Populations: Implications for Monitoring

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Coastal salt marshes are projected to be disproportionately impacted by climate change, including sea-level rise and changes in storm frequency and intensity. Extreme storm events will affect salt marshes by altering inundation duration and depth, changing suspended sediment supply and habitat availability for wildlife. Although the San Francisco Bay Estuary is severely fragmented and modified, it is one of the largest tidal salt marsh complexes in California and contains important habitat for federal and state-listed wildlife species. The maintenance and expansion of habitat is crucial to the successful recovery of these wildlife species, but it remains unknown how storm flooding may impact these populations. Using site-level water level monitoring within salt marshes, we were able to observed two local storm surges that resulted in extreme sea level heights in 2010 and 2011 at three salt marshes within the San Francisco Bay Estuary. Duration of salt marsh inundation during the storm episodes was respectively 1.8 and 3.1 times more than normal for that time of year. At peak storm surge, over 65% in 2010 and 93% in 2011 of the available vegetated habitat for wildlife was under water, increasing predation and drowning risk. In addition, the lowest recorded sea level pressure in the last 30 years for this region was measured during the storm in January 2010. This water level monitoring allowed the assessment of storm impacts on available habitat for the California black rail (*Laterallus jamaicensis coturniculus*) during breeding season. Results from storm monitoring and implications for salt marsh wildlife and management will be presented.

Keywords: salt marsh, climate change, sea-level rise, storm, endangered species, management

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NOAA Sentinel Sites Program: Monitoring Effects of Climate Change on Tidal Marshes in the San Francisco Estuary and Beyond

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Sea level rise and other aspects of climate change are expected to threaten the viability of tidal marshes worldwide. The National Oceanic and Atmospheric Administration (NOAA) selected San Francisco Bay as one of five national pilot sites for a new program to provide for early detection of effects of climate change on coastal areas. The National Estuarine Research Reserve System (NERRS), a collaboration between NOAA and the coastal states, supports this program by providing for long-term monitoring of effects of sea level rise and other climate-related stressors on tidal marsh elevation, hydrology, water quality and biological communities. The NERRS coordinates nationwide data collection within 28 estuarine reserves around the country using standardized monitoring protocols to inform future research, conservation, restoration and resource management.

In the San Francisco Estuary, these monitoring efforts occur at the two NERRS reference sites of China Camp State Park in San Pablo Bay and Rush Ranch Open Space Preserve in Suisun Marsh. The NERRS monitoring programs build on a rich history of ecological research within these sites to provide critical data on marsh responses to climate change, including variation in marsh surface elevation, inundation frequency and duration, tidal currents, water temperature, salinity, pH, turbidity, meteorological conditions, and the distribution and abundance of both native and non-native species. As with data collected at other NERRS sites around the country, data collected as part of the NOAA Sentinel Sites Program in the San Francisco Estuary will be a valuable resource for scientists and managers to evaluate and inform tidal marsh conservation and restoration efforts throughout the region in the context of sea level rise and climate change.

Keywords: sea-level rise, climate change, long-term monitoring, tidal marsh, reference site

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Building a Regionally Coordinated Monitoring Network for Assessing Future Sustainability of Marsh Habitats in the San Francisco Estuary

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Tidal marsh habitats in the SF Bay Estuary are being restored as part of the second largest wetland conservation effort in the Nation. To address challenges for future conservation and management of these wetlands as well as natural marshes within the Estuary, we held a multi-stakeholder workshop in Fall 2011 entitled, “Will They Sink or Swim? A Workshop on Managing, Monitoring, and Modeling of California’s Estuarine Marshes under Sea-level Rise.” It brought together scientists, managers, and consultants from across the region to discuss current management challenges and managers’ needs concerning marsh sustainability under sea level rise, and how marsh accretion models could be used to aid future management of these marsh systems. In a follow-up workshop we refined managers’ questions and found that main concerns relate to how/where marshes will move or transgress, whether/where there is sufficient sediment supply for marsh persistence, the effects of marsh loss on special status species, and the prioritizing of sites for future conservation. As part of a comprehensive managers’ guide for assessing marsh sustainability under sea level rise, we propose a regionally coordinated monitoring network for assessing future sustainability of marsh habitats. This network will be an integral part of the regional wetland monitoring and evaluation framework the San Francisco Bay Joint Venture is currently building. As part of a special session entitled “The Role Of A Comprehensive Monitoring Network In Supporting Adaptive Management Of Marsh Habitats Under Sea Level Rise," we will seek further input and discuss the determination of a coordinated suite of metrics needed to inform marsh sustainability models for natural and restored tidal marshes throughout the Estuary. The information gleaned from our coordinated multi-stakeholder modeling and monitoring approach will provide critical insight for future conservation planning and management in the Bay-Delta region and beyond.

Keywords: Tidal marsh sustainability, sea-level rise, modeling, regionally coordinated monitoring framework

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