Sea Grant California

# Climate change and tidal marsh plant communities in the San Francisco Bay-Delta

Lisa Schile, Delta Science Fellow 2007–2012

## BACKGROUND

Sea levels in California, south of Cape Mendocino, are predicted to rise between 90 and 95 cm between 2000 and 2100, with a range as high as 167 cm and as low as 42 cm, according to a 2012 report by the National Academy of Sciences.

Whatever the ultimate rise in sea level is, it will largely control the fate of tidal marsh habitats in the San Francisco Bay-Delta.

Tidal marshes are wetlands periodically inundated by tidal flows and, unlike mudflats, are vegetated. They provide overwintering and foraging habitat for resident and migratory birds, and are a buffer against floods and storm surge. They also filter and remove pollutants.

Only about 5 to 10 percent of the delta's historic tidal marshes remain. Most fringe an aging collection of levees. Former wetlands – now diked, behind levees and dry – are sinking and below sea level by as much as 20 m in some places.

Plans are underway to restore thousands of acres of tidal marshes. Whether these marshes are sustainable in the long term will be determined by their ability to build elevation or migrate to higher ground.

Each syringe is attached to a tube inserted in the sediment. Pore water is analyzed for salt and sulfide levels to characterize the growing conditions. Credit: L. Shile

## PROJECT

This project examined processes structuring tidal wetland plant communities in the Bay-Delta and then investigated how plant communities and their distributions might respond to sea-level rise.

Field surveys were conducted to map out and otherwise gather information on existing plant communities (species richness and biomass, above ground and below) in relation to elevation, inundation and salinity (water and soil). A transplant experiment was carried out to test responses of two dominant marsh sedges to conditions that might be experienced under future climate change.

In ongoing work, results of these surveys and experiments are being used to develop a "Marsh Equilibrium Model" for predicting what will happen to the region's wetlands in the future. The output will be used to help identify long-term strategies for wetland conservation.

## RESULTS

As expected, marshland habitats are structured by the tides. Specifically, marsh plants were shown to grow within a narrow elevation band, defined by the difference in the twice-daily high tides. At the sites surveyed, the transition from mudflat to marsh occurred slightly below the mean tide line (the average of all tides) and transitioned to upland habitat at about 10 cm above the mean higher high tide line (the average of the day's highest high tide). This high water line also coincided with a local peak in plant productivity (growth) and species richness. Most of the biomass was found between the means of the lower and higher high tide lines.

High salt concentrations, also as expected, impaired marsh plant growth rates. This was observed across the salinity gradient in the delta, and seasonally at individual marshes. The germination and early rapid growth of plants coincided with seasonal surges in river flows, which lower salinity levels. This point is worth mentioning as climate scenarios generally predict shifts in the timing of snowmelt off the Sierras. Reduced freshwater flows, along with continued water diversions, are expected to lead to higher overall salinities in the delta, as well.

The dominant plants in the low-salinity and freshwater marshes of the estuary were *Schoenoplectus acutus* and *S. americanus*. Both are tall, thin, leafless, flowering plants known as sedges. *S. acutus* was found growing along channel edges, while *S. americanus* was dominant on the marsh plain, where the majority of habitat is.

The transplant experiments, conducted with the same sedge species, showed that both are tolerant to inundation, but only for short periods. Prolonged contact with water reduced the biomass of *S. acutus* by about 60 percent and *S. americanus* by about 93 percent. The latter was able to survive the equivalent of a 60-cm rise in sea level (i.e., it was capable of growing 60 cm lower in marshes), while the former was able to survive at least an 80-cm rise, the maximum elevation change simulated in the transplant experiment.

"What this all means is that there will likely be a future reduction in *S. americanus*," explained Lisa Schile, a Delta Science Fellow from 2007 to 2012. "The elevations that *S. americanus* grows at are also the elevations where the most species diversity occurs. So, a reduction in marsh area, due to sea-level rise, will likely result in a reduction in species diversity, too."

In addition to studying individual species' tolerances to sea-level rise, the scientists also conducted "competition" experiments in which *S. acutus* and *S. americanus* were grown together in planters exposed to different tidal heights and salinity. The results of these experiments were surprising. "The species we thought would be competitively dominant, *S. americanus*, wasn't," Schile said. "It appears very vulnerable to climate change."

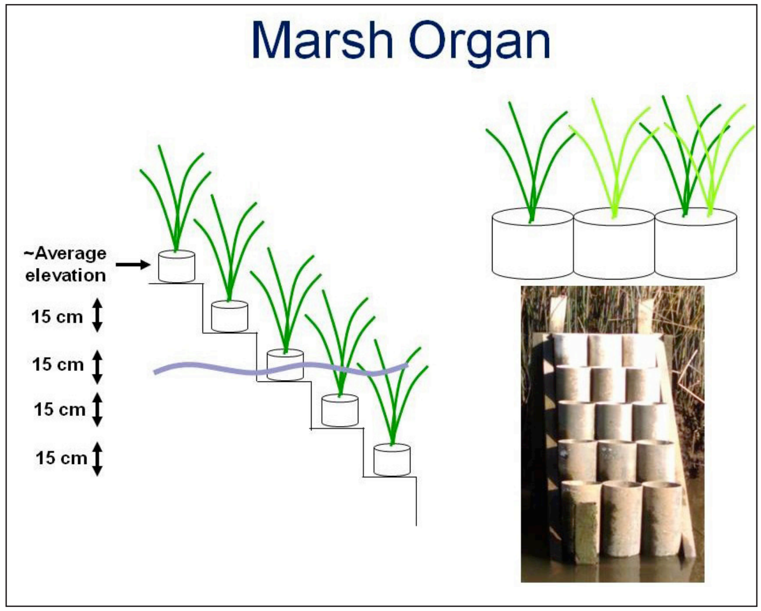
## MANAGEMENT

Vegetation plays a critical role in determining the character of marsh habitats and their responses to rising sea levels. Different species of plants, for example, may be more or less effective at trapping sediments or producing organic matter that can also help build elevation. Ultimately, whether a marsh at a particular location survives sea-level rise is determined by its ability to build elevation or migrate to higher ground.

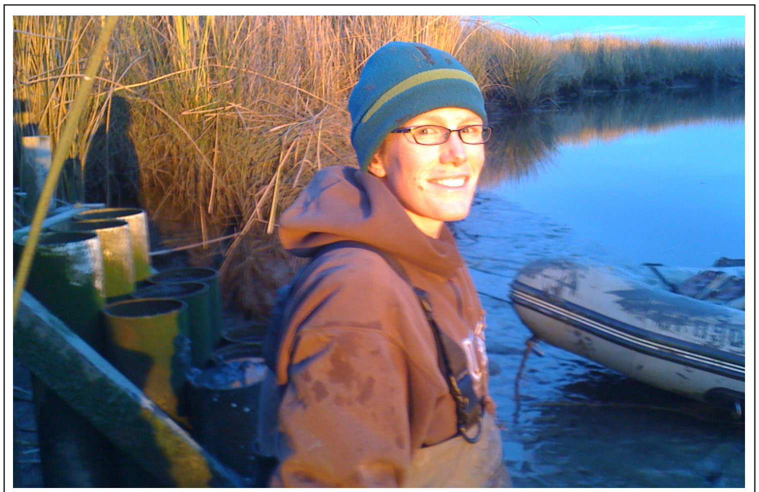
In Northern California and Oregon, tectonic uplift will help mitigate rising sea levels. In the Bay-Delta, though, factors are conspiring to accelerate higher seas. Much of the sediment in rivers that would normally be delivered to the estuary is trapped behind dams and accumulating in reservoirs. Sediment input is thus believed to be declining.

Wetlands can migrate to higher ground; however, this process is only possible when the landward margin of the marsh is unobstructed – rare in the delta. Schile is currently working with colleagues to identify land behind levees that is adjacent to wetlands. The idea is to identify sites where levee removal might allow for upland migration. They are also looking at sites that could be artificially elevated with dredged sediments.

Modeling efforts with colleagues at PRBO Conservation Science have suggested that predictions of tidal marsh survival are highly sensitive to the particular assumed rates of sediment delivery, organic accumulation and sea-level rise. Scientists are currently testing the Marsh Equilibrium Model (developed for the Atlantic Coast) with data gathered in this project – marsh biomass production, suspended sediment concentrations, and species' tolerances to inundation and salinity – to improve its applicability to the Pacific Coast. The output will be used to identify marsh habitats in the delta that are more or less likely to survive climate change impacts.




The setup for a transplant experiment, designed to test plants' tolerances to inundation. The plants on the bottom tier are experiencing a 60-centimeter rise in sea level. Competition experiments involved planting both sedge species in the same container. Credit: L. Shile



Lisa Schile at Browns Island setting up a transplant experiment. Credit: T. Halwachs

## RESEARCH MENTOR

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## COMMUNITY MENTOR

Mark Herzog, co-director of the Informatics Division at PRBO Conservation Science

## PUBLICATIONS

Stralberg, D., M. Brennan, J. Callaway, J. Wood, L. Schile, et al. (2011) Evaluating tidal marsh sustainability in the face of sea-level rise: a hybrid modeling approach applied to San Francisco Bay. PLoS ONE.

Parker, V.T., J.C. Callaway, L. Schile, M.Vasey and E. Herbert. (2011) Climate Change and San Francisco Bay-Delta Tidal Wetlands. San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis.

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