Effect of sea level rise on the coastal protective services of Pacific Northwest salt marshes

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Statement of Work

INTRODUCTION

Coastal vegetated habitats are on a global decline due to climate change, specifically sea level rise (SLR) and increased storminess (IPCC, 2014). These fringing environments connecting land and sea are important mediators of SLR and increased wave action, providing essential ecosystem services such as coastal protection, water purification, and erosion control (Barbier et al., 2011). However, as coastal vegetation declines due to human activity and environmental change, vulnerability of these shorelines to erosion and flooding increases (Gedan et al., 2011). Salt marshes, in particular, are essential for coastal protection as they provide the ecosystem functions through which many negative impacts of SLR can be minimized. Salt marshes dissipate wave energy through tall vegetation, stabilize sediment through root systems, and can increase intertidal elevation and extent through accretion (Barbier et al., 2011). Accretion occurs when sediment-laden water is slowed by vegetation, releasing sediment that is then deposited on the marsh surface. This process results in a change in marsh surface elevation relative to SL, as well as an increase in marsh extent, and is influenced by incoming sediment load and vegetation type. How salt marshes ultimately respond to variable SL will likely depend on species-specific difference in accretion ability, sediment supply, and local effects of SLR (Pethick, 1981).

BACKGROUND

To explore how salt marshes will respond to SLR, I will start by taking advantage of the variability in SLR across four salt marshes in Oregon. The Pacific Northwest (PNW) is tectonically active with the Juan de Fuca and Gorda plates colliding and subducting underneath the North American plate. Thus, the coast is slowly rising, but at varying rates (Komar et al., 2011). This geomorphological factor shapes salt marsh response in the face of climate change because the variable elevation results in potential changes to hydrology and energy regime, two highly influential factors in determining the coastal zonation of plant species (IPCC, 2007). Marshes and their vegetative communities are sensitive to changes in elevation because they are adapted for certain levels of tidal inundation—cyclical periods of wet and dry (Borde et al., 2003). Variable elevation also means variable inundation and salinity both of which impact plant distribution and productivity (Janousek and Mayo, 2013). The physical vertical gradient in salt marsh community structure is reflective of the different tolerances of organisms to the environmental gradient across the marsh (Nelson and Kashima, 1993). Species at different distribution ranges may have varying capacities to accommodate changes in SL. The ability of these species to adapt will influence their subsequent expansion or contraction in the face of climate changes. In the face of SLR, salt marsh communities that cannot accommodate SLR will likely shrink (and migrate landward) or disappear (Kennish, 2001).

Salt marshes influenced by SLR and subsistence are considered “submergent” whereas those experiencing tectonic lift and greater accretion rates are “emergent.” For example, the southern Oregon coast is rising more rapidly than the regional SLR, creating emergent coastal habitats. Central and northern Oregon coasts are rising less relative to SLR, thus creating submergent habitats. I have selected four study sites along the coast that represent the range of marsh elevations to demonstrate how variable SLR will affect the functions and services of marshes. The two southern Oregon sites, Coos Bay and Bandon, are emergent. The two Northern sites, Yaquina Bay and Tillamook Bay, are submergent. Vegetation structure and zonation in salt marshes is likely reflective of these salt marsh types. Low elevation submergent marshes are often dominated by pickleweed *(Salicornia virginica)*, fleshy jaumea (*Jaumea carnosa*), arrowgrass (*Triglochin maritime),* saltgrass (*Distichlis spicata*) and bulrush (*Scirpus spp.*) (Oberrecht; South Slough NERR Site Report, 2011). Higher elevation emergent marshes are often dominated by creeping bentgrass (*Agrostis stolonifera*), tufted hairgrass (*Deschampsia caespitosa*), saltgrass (*Distichlis spicata*), and Pacific silverweed (*Potentilla pacifica*) (Oberrecht; Weinmann et al., 1984). Compared to East Coast salt marshes, those in the Pacific Northwest (specifically Oregon) do not have native marsh grasses that are good at sediment accretion (such as *Spartina*), and thus may be more susceptible to SLR.

RESEARCH QUESTIONS

My goal is to determine how climate change in the form of SLR will impact salt marsh ecosystems and their coastal protective services. To do this I will study multiple coastal salt marshes along the PNW coast that vary in their exposure to SLR and thus their resiliency to flooding and erosion. In particular my objectives are to: **(1)** Determine the relationship between current SL, vegetation, and salt marsh elevation and extent, **(2)** Determine experimentally how SLR will modify the relationship between vegetation and sediment accretion and thus affect salt marsh elevation and extent, and **(3)** Project using models how altered salt marsh elevation and extent will affect coastal vulnerability to flooding.

HYPOTHESES

(1) I predict that marshes experiencing greater SLR will be dominated by plant communities typical of submergent marshes and be lesser in elevation and extent while marshes experiencing less SLR will have vegetation types typical of emergent marshes and be greater in elevation and extent. **(2)** I hypothesize that marshes experiencing lower SLR will have better accretion rates, be better able to counter balance SLR, and grow in elevation and extent, while those experiencing greater SLR will have compromised accretion, be less able to counterbalance SLR, and shrink in elevation and extent. **(3)** I predict that submergent salt marshes will be more vulnerable to erosion and flooding by SLR.

OBJECTIVES AND METHODS

(1) I will determine the relationship between current SL, vegetation, and salt marsh elevation and extent by conducting plant community surveys (species type, size, and density), collecting data on the physical environmental gradients (salinity, soil characteristics, turbidity, and inundation regime), and obtaining GPS measurements (elevation and extent) at each of the four marshes and across the different elevation zones of the marshes. Plant community surveys will take place in all 4 of the coastal Oregon salt marsh estuaries at three intertidal heights (low, medium, and high) annually starting with preliminary surveys in Summer 2015. Using three permanent transect lines, I will record species present, total length (substrate to tip of main stipe), and estimates of percent cover in five quadrats per transect line. At each intertidal height, surface elevation data will be recorded using an RTK GPS system. In efforts of controlling for elevation variability across sites, all transect lines will be laid at roughly the same surface elevation across sites. Water level loggers will be implemented at each intertidal height to record inundation regime. Baseline environmental conditions including salinity, soil composition, and turbidity will also be recorded for assessing local variability across sites. In field salinity data will be collected using a refractometer while a secchi disk will be used to assess turbidity. Soil samples at each intertidal height will also be collected for laboratory analysis. I will analyze these data and predict their relatedness using permutational multivariate ANOVA.

(2) I will determine the impact of SLR on the ability of marsh vegetation to accrete sediments by conducting (a) field and (b) laboratory experiments. (a) I will manipulate sediment accretion by conducting controlled vegetation removal experiments at the four marshes that vary in SLR. The removal will occur in the low intertidal zone thereby simulating conditions of disturbance that could potentially result under events of increased storminess or SLR. Sediment deposition of the bare patch will be recorded throughout the year using sediment plates. (b) I will conduct sediment accretion experiments under various physical conditions (wave intensity, flooding, and salinity) with three marsh species of interest (those that are most prevalent as measured by total percent cover and presence in all marshes) in wave tanks at the O.H. Hinsdale Wave Laboratory of Oregon State University. Mature species will be transplanted into the tanks where isolated and community studies will ensue.

(3) I will project how salt marshes, altered in elevation and extent by the effect of SLR on vegetation-sediment dynamics, will respond to future coastal flooding using hydrodynamic models currently being created within our lab for each estuary in Oregon (Luettich and Westerink, 1991;Oregon Sea Grant 2014-2016).

What portions of work have already been completed (if any)

TIMELINE

Initial site surveys and feasibility assessments are currently being carried out along the Oregon coast and will continue through Spring 2015. Preliminary data collection will begin in Summer 2015 with data collection resuming through 2018 for a total of three complete field seasons. Analysis of data and manuscript production will follow through 2019 (expected graduation year).

How the study benefits coastal wetlands

This proposed work is both foundational and applied resulting in a use inspired research project that will advance knowledge about PNW coastal salt marsh ecosystems and lay the groundwork for future conservation initiatives in these settings. Oregon coast salt marshes have the potential to be a strong model system in which to evaluate how SLR influences marsh plant accretion and subsequent coastal erosion or maintenance. Given varying SL across the Oregon coast due to elevation gradients, studying how these marshes respond both in terms of resiliency and coastal protection will emulate the effect of variable increases in SL and be an indication of the services they may provide in the future. These research results will aid in identifying which coastal marsh systems are most vulnerable given species presence, accretion ability, elevation, and SLR and help parse out the factors that will potentially improve coastal resilience. This project fills a critical research gap in the PNW, and thus can inform current and future adaptive management plans geared toward coastal protection. As coastal populations and development continue to increase, the need to collect information on PNW salt marshes and understand the ecosystem services they provide, will become ever more important.

How funds would be used

Project funds will be allocated toward purchasing an RTK GPS (1 @ ~$2,000), water level loggers (1 per low tidal height, 4 sites (4 @ $300 = ~$1,200)), a refractometer (1 @ ~$100), a secchi disk (1 @ ~$50), sediment plates/glazed ceramic tiles (3 per low intertidal transect, 4 sites (12 @ ~$5 = ~$60)), and transportation to and from sites. I would also like to enlist the assistance of an undergraduate research technician. The estimated subtotal of these evaluations is between $4,000 and $5,000. The total amount of requested support is $5,000.

Plans or opportunities for sharing research results with a larger audience

I would like to create a framework to be used for the protection of coastal marshes in the PNW developed through research and sustained through community support. Currently, no such framework exists as this research area, particularly in reference to vegetative communities, has been somewhat overlooked. The data collected regarding species specific and community wide plant accretion abilities will be able to inform salt marsh restoration efforts. Using this data, I will work with local organizations to plan and facilitate community wide planting initiatives in vulnerable or disturbed marsh settings.

I will reach a broader audience and encourage further community participation through the creation of "Muddy in the Marsh", a classroom outreach initiative that I will create with Oregon Sea Grant at Oregon State University's Hatfield Marine Science Center. The program will involve field activities that expose students to Oregon salt marshes and the role they play in coastal protection. I will also conduct classroom activities that demonstrate the protective role of marshes using exercises that focus on the role of coastal habitats. In addition to "Muddy in the Marsh" I will provide opportunities for undergraduate students to get field and laboratory experience.

To expand community awareness and engagement, I will create a weekly-updated website linked to an array of social media. The site will cover my research, outreach initiatives, and salt marsh conservation in the PNW. The initiatives will improve coastal literacy and foster connections to the coast. To assist local efforts, I will produce a detailed and accessible assessment of the vegetative surveys and field experiments and present the findings at local and regional meetings. My communication efforts will focus on inspiring public interest and participation by connecting my research to coastal communities.

By implementing these efforts, the link between individuals of all ages and their estuarine systems will be strengthened. These opportunities are geared toward inspiring interest in the next generation of young scientists while expanding the knowledge base of the local community and beyond.

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