COAST Proposal Draft, Fall 2024

Savannah K. Miller

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## Project Description

### Background

Current research shows that there is a complexity of potential futures for marsh ecosystems, in light of expected worldwide sea level rise (Kirwan et al 2016, Callaway 2007). Marsh lands are home to a specific set of species, which are carefully adapted to the unique saline and freshwater influences that characterize a marshland (Dunson and Travis 1994; Fagherazzi, Marani, Blum 2004, pg. 12) . In addition to the unique biodiversity of salt marshes, there have been greater insights on marsh lands roles’ in dampening the impacts of atmospheric rivers and extreme weather events, offering a potential benefit to humankind to protect coastal cities and urban areas (Taylor-Burns 2024, Smolders 2015). Human activity, resource use, and urbanization of these ecosystems has left the remaining marsh ecosystems scarce and vulnerable to the predicted effects in climate when accounting for preserving species and ecosystem function (Gedan 2009). The individual complexity of the tidal, geomorphic, and vegetative makeup of each estuary underline the importance of detailed in-field confirmation of the existing abiotic processes at play on a local scale if more mashes are to be built and restored (Ritter 2008, Thorne 2023, Moffet 2010)

Sediment is the major component in a marsh, transported through waves and tidal action suspended in the water (suspended sediment), and later contributing to surface area and composition of the marsh through sediment particles building up on the salt marsh (deposition), followed by layers of the sediment and organic matter building on top of each other to raise the elevation of the marsh platform over time (accretion) (Ganju 2005, Lacy 2019). To improve and preserve marsh ecosystems, understanding the paths that sediment takes to get to the marsh are pertinent to building and retaining more successful marsh restoration projects (Fagherazzi 2013, Bloemendaal 2021, Vandenbruwaene 2011).

Vegetation also plays an important role along the marsh platform in terms of attenuating sediment to the surface, allowing greater opportunity for the sediment to settle on the marsh and accrete over time (Temmerman 2005). Evidence comes from multiple models and in-field studies that have determined that vegetation is a key factor to control flow and sedimentation patterns in the marsh platform, and even assist in differences in levels of deposition on the marsh platform. Specifically in the San Francisco Estuary, it has been observed that two vegetative species, pickleweed and cordgrass, work together in tandem for both accretion and deposition of sediment, respectively (Lacy 2019). Across studies, the link between vegetation structure, density, and location is complex when taking into account differences in their role in sediment accretion (Boorman 2016).

Therefore, it is crucial for vegetation growth and structure to be monitored in tandem with understanding differences in suspended sediment transport patterns across the marsh platform.

At the forefront of the issues of sea level rise is the marsh edge, where the start of this estuarine ecosystem bares the brunt of tidal cycles, storm influences, and erosional impacts to the sediment bank. The marsh edge is a dynamic area of the marsh that is thought to evolve through different types throughout the lifecycle of the marsh (Moller 2002, Moller 2006). However, more information is needed to understand the dynamics of the marsh edge type in order to understand how to manage the marsh platform in response to critical issues like sea level rise (Shifting Shorelines Beagle et al 2015). Our study will focus on how suspended sediment transport paths differ along different marsh edge types. Vegetation monitoring of Pickleweed (*Salicornia pacifica*) will also be completed near the marsh edge, taking measurements of the structure of the plants to correlate their accretional potential for the sediment bank.

### Graphical user interface Description automatically generatedResearch Objectives

Based on previous literature (Shifting Shorelines Beagle et al 2015), there are thought to be five marsh edge types, which are based on the geomorphological differences: scarp with bayward vegetation (SV), scarp without bayward vegetation (SN), ramp without inflection point (RNI), ramp with inflection point (RI), and beaches or rocky shoreline (B). Within the report, the “scarp without bayward vegetation” had the highest rates of retreating at the time of the report. The location of these marsh edge types can be linked to the riverine-estuary connection of the Gallinas Creek, Sonoma Creek, Petaluma River, and Napa River. These correlations in observations provide a great opportunity to confirm conditions of the adjacent marshlands to understand the variables at play within the action. Considering the key role of vegetation within this finding and past research, we have the following research objectives:

Figure 1. Marsh Edge Types (Beagle 2015)

* To better understand the sediment transport pathways along the scarp without bayward vegetation marsh edge type vs. scarp with bayward vegetation marsh edge types, through measurement of suspended sediment in the water column and accreted and deposited across the marsh over time.
* To understand the role and differences in bayward vegetation across a marsh edge (cordgrass) and within the marsh (pickleweed) in rates of sediment deposition and accretion on a marsh land platform
* To compare the validity and level of detail of in-field measurements against annual sensors for suspended sediment

### Hypotheses

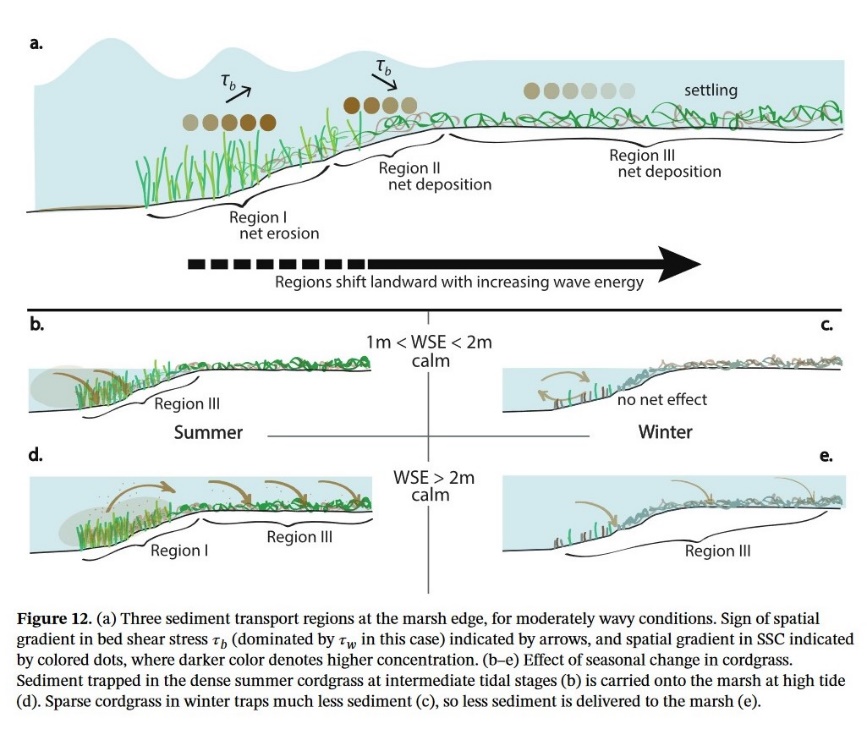
Sites further eastward (due to the influence of tidal action) with higher densities and canopies of pickleweed along marsh edge will accrete at higher rates than those edges further west with increased tidal action, and no bayward vegetation

### Methods

All measurements will be collected over 2 summer seasons, and 2 winter storm seasons  
will help measure the changes and patterns of this marsh over a shorter time scale with  
repeated, detail intensive methods at each site for a more complete picture to accompany  
the broad landscape level models existing for land managers of today.

Summer season measurements will be completed at Mean high high water of field  
collection, and mean low low water of the proceeding day, as those time periods appear to  
have the most potential for sediment transport. Winter season measurements will be  
completed following the summer season protocol, unless there is a storm event predicted  
that can be planned for data collection, which is another event of great potential for  
sediment transport (Thorne 2022).

#### Experimental Design and Procedure



The measurements for data will be taken at the following zones, as outlined and demonstrated through this conceptual diagram (Lacy 2019):

* Region 1: (closest to the mudflats) Characterized by wave-driven resuspension, a  
  landward increase in bed shear stress and SSC, and net erosion.
* Region 2: Vegetation strongly attenuates waves, and bed shear stress and SSC  
  decrease in the landward direction.
* Region 3(within the pickleweed) is also depositional. Bed shear stress is spatially  
  uniform and particle settling is the dominant process.

#### Suspended Sediment Measurements

The following suspended sediment variables will be focused within the five field sites, as  
taken from the methodology of (Lacy 2019 and Thorne 2022)

**Accretion**

*(collected annually)*

* ***Surface Elevation Tables (SETs):*** Quantify net surface elevation change. Will be used to measure accretion rates closer to the marsh edge. Two measurements for two years of data collection.
* ***Feldspar marker horizons (MH):*** Quantify deposition or accretion above a clay  
  feldspar layer applied on the marsh surface. Will be used to measure accretion rates farther from the marsh edge upland. Two measurements for two years of data collection.
* ***Database records of SETs and MH over the years 2015-2024***: To confirm with prediction rates in Shifting Shorelines and to accomplish a complete data set.

**Deposition**

*(collected April-June and collected December-February; twice a month for spring-neap tide)*

* ***Sipper Bottle*** Captures a 24 hour time stamp at a spring tide, when it is known that most of the sediment that later accretes in the upper reaches of the marsh are transported
* ***Short Term Accretion Mats:*** Place on a neap tide scale, and collect again once it has returned to a neap tide (approx.. 7-14 days)

#### Vegetation Measurements

Within the five field sites, pickleweed will be mapped 30-50 meter between the pickleweed zone and the cordgrass zone (Lacy 2019) beyond the point of growth from the marsh edge, with the following measurements collected across 5 transects from each marsh edge site:

* Canopy density using imageJ to map out the amount of the picture is taken up
* Presence of annual vs perrenial pickleweed within the plot in each transect
* Canopy height (in field measurement)
* Branching pattern complexity (random sample from plot of 5-10 plants)

### Data Acquisition and Analysis

The following data points will be plotted across linear regression curves to understand the relationship between variables:

* Short Term Accretion Collection (SETs-Weight measurement-grams)
* Suspended Sediment Collection (Sipper bottles and Marsh Platform Mats-Weight measurement-grams)
* Long Term Accretion Collection (MH-Change in length/height-centimeters)
* Vegetation Structure (% Density of the image, Highest Canopy height-cm, # of  
  Branches of average plant)

## Need for Research

## The marsh edge is the starting point for sediment to be deposited on the marsh platform transported through the aquatic environment. It is complex to understand how one grain of sediment moves from one place to another. Scientists who have focused on the marsh edge have largely depended on static in-situ sensor measurements of suspended sediment and linear models or field collection of sediment accretion. Few studies have paired in-situ sensor measurements and field collections of the same collection of suspended sediment system together to compare the feasibility and accuracy of those measurements. This information not only gives potential insight on the sediment bank across important marshlands of the San Francisco Bay, it also provides comparison that land managers can use to assess the capability and feasibility of their methods to collect different measurements. This work could also offer a new perspective on environmental monitoring of common living (biotic) and nonliving (abiotic) parameters, such as vegetation surveys as a way to measure the functional physical components of an evolving marsh. Once we better understand the typical abiotic processes across the bayward side of the marshlands in terms of sediment transport, it will inform future decisions on managing unprecedented weather events and land use changes and adaptation.

## Relevance to State of California

The geology of California is one of the most unique systems within the world. The river basin within the Central Valley, connecting the mountain fresh water to the salty tidal water of the bays and oceans bordering the western side of the state is a unique formation at which unique plants and animals thrived in great numbers. However, as early as the mid-1800s during the Gold Rush, humans already began to impact the tidal marsh lands of California through the downstream movement of sediment from explosives blasting mountainsides in search for gold (Barnard 2013). Later in European colonization, tidal marshlands were filled in for farming and housing development purposes. The majority of modern Californians have no idea if where they currently live and work sits on what was an existing tidal marsh plane. Currently, more than 90% of California wetlands drained across the state (California Natural Resources Agency 2010).

The importance to understand the existing tidal marshes of California lies in the benefits provided through ecosystem services such as extreme flooding and water filtration services. Studies have found (CITE) that the presence of a tidal marshland nearby an urban flood plain can minimize the probability of a coastal community by (insert statistic here). Tidal marshes are also now widely regarded for their water filtration ability for both the ecosystem and human consumption.

Within California, we have already augmented the sediment bank through human development. What we need to do now to prepare for unforeseen climate change affects is find out how the natural sediment bank works so we can use the benefits to protect ourselves against the inevitable.

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## Budget and Justification

This field-heavy data collection requires extensive driving and bridge tolls.

In addition, conference attendance to share and compare findings is very pertitnent considering how location specific these findings are

| Item/Description | Unit Price | Quantity | Amount to Awardee (via Financial Aid) | Amount to Department |
| --- | --- | --- | --- | --- |
| Bridge toll(s) | $9.25 per bridge trip | 6 months | $1,688.13 | N/A |
| Gas, 2 full tanks per month | $138.30/2 full tanks | 6 months | $829.80 | N/A |
| Conference Attendance | ~$500/trip | 2 trips | $1000.00 | N/A |
| Conference | ~$241/trip | 2 trips | 482.07 | N/A |
| Total: |  |  | $4000.00 |  |

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## Timeline

*May-June 2025:* Collect data at five study sites of interest including short and long term accretion field methods, suspended sediment monitoring, and canopy and density measurements of pickleweed on marsh platform.

*September 2025-November 2025:* Analysis of summer results, planning for winter deployment of field instruments, and plan out tidal cycle timing for field collections

*December 2025-February 2026:* Collect data at five study sites of interest including short and long term accretion field methods, suspended sediment monitoring, and canopy and density measurements of pickleweed on marsh platform.

*March 2026:* Analysis of winter results, planning for summer deployment of field instruments, and plan out tidal cycle timing for field collections. Begin to write up winter results and finalize.

*April-June 2026:* Collect data at five study sites of interest including short and long term accretion field methods, suspended sediment monitoring, and canopy and density measurements of pickleweed on marsh platform.

*September 2026-November 2026:* Analysis of summer results, planning for winter deployment of field instruments, and plan out tidal cycle timing for field collections

*December 2026-February 2027:* Collect data at five study sites of interest including short and long term accretion field methods, suspended sediment monitoring, and canopy and density measurements of pickleweed on marsh platform.

*February 2027-May 2027:* Thesis write-up, prepare for defense