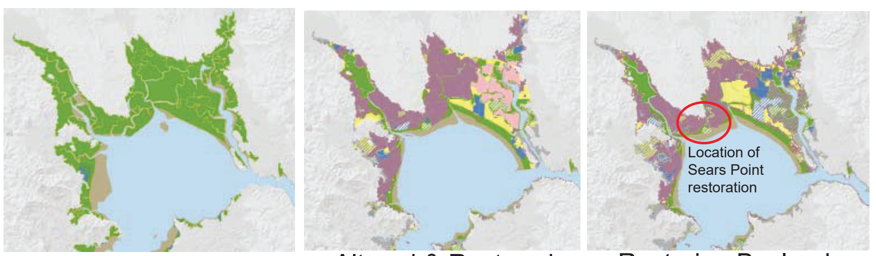
Appendix L. Conference Posters

The Sears Point experience: Early returns on a state-of-the-art tidal wetland restoration project

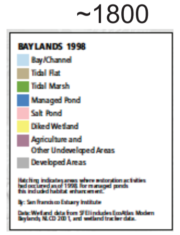
Michael Vasey and Stuart Siegel (SF Bay NERR) & Julian Meisler and Wendy Eliot (Sonoma Land Trust)

The Context



Historic Baylands ~1800 | Altered & Restored Baylands ~ 1998 | Restoring Baylands In 2009

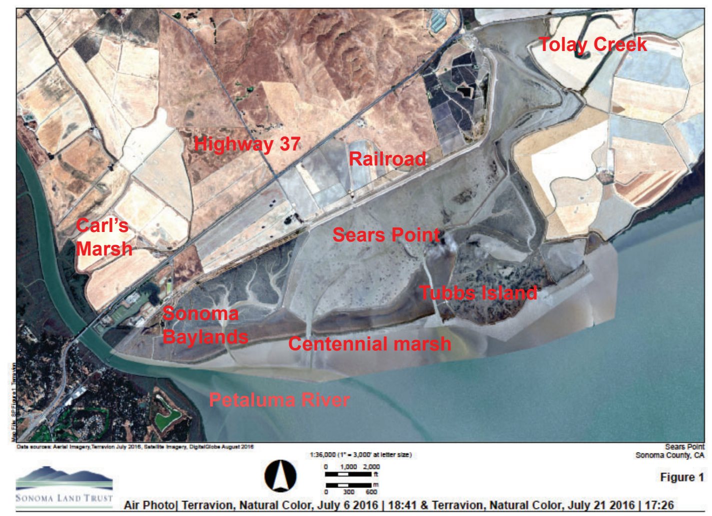
Goals Project. 2015.



Following the loss of 85% of tidal wetlands over the previous hundred plus years, tidal wetland restoration in the SF Estuary heated up in the late 20th Century. Projects progressively moved from small-scale wetland mitigation for loss due to development to large-scale, publicly-funded restoration projects designed for the public good.

The marshes north of San Pablo Bay were particularly impacted by diking for farming, grazing, and salt pond development. Diked baylands suffered various degrees of subsidence. Today, thousands of acres of tidal wetlands are being restored or are planned for restoration. A key consideration is how to gain surface elevation before levee breach. The 1000-acre Sears Point project (red circle) developed a novel, new approach for addressing this problem.

The Vision

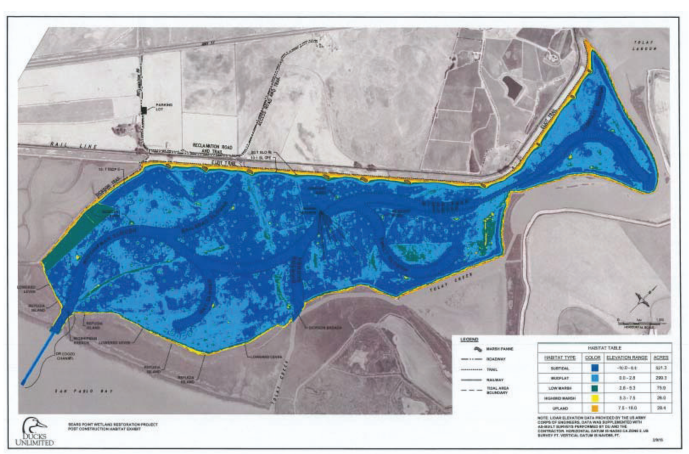


The vision for northern San Pablo Bay is "to restore a broad swath of tidal marsh along the shore as soon as possible, with the widest marshes being in the Napa-Sonoma Marsh" (p. 138, Goals Project 2015). The North Bay region is relatively undeveloped and offers potential for marsh migration in the face of future sea-level rise. Sears Point is a key link to broadening and extending tidal marsh in this region.

The Challenge

While large areas of relatively undeveloped former tidal marsh occur in the North Bay, major constraints include transportation infrastructure, private ownership of these agricultural lands, and subsidence of diked baylands. The Sonoma Land Trust has been very successful at land acquisition for conservation and public recreation, however, railroad right-of-way and Highway 37 are barriers to broadening the "swath" of tidal wetlands needed to accommodate sea-level rise.

Sears Point Restoration Concept



In **2004**,an innovative design team (Baye, Leventhal, & Siegel) assisted the Sonoma Land Trust in developing a tidal wetland restoration conceptual plan covering ca. 1,000 acres. Rather than using dredge spoils to gain elevation in the subsided diked bayland, ca. 500 mounds were to be created to protect a transition levee from wind wave erosion and to act as nuclei for future revegetation. The transition levee was structurally engineered to resist erosion and protect the railroad along the north side of the project. Marsh pannes were an added feature along the levee to add heterogeneity and attract special birds, plants, and invertebrates that specialize on this type of habitat. Deep channels and other features were to be constructed on-site with heavy equipment and the spoils used to build a new levee.

Sears Point Implementation

The EIR/EIS was approved in **2012** and Ducks Unlimited was awarded the contract to construct the project. The Google Images to the left show the active construction which took place in 2014. Winter rainwater pooled in the constructed channels making the many mounds visible. Two breaches were accomplished in **October 2015**. No planting was done on the mounds pre-breach. Implementation challenges are detailed in the poster by Ducks Unlimited which describes the construction of the project.

As part of the permitting, extensive monitoring negotiations were conducted with the regulatory agencies (BCDC, Regional Water Quality Control Board, Army Corps of Engineers,USFWS, and CDFW). Sonoma Land Trust retains the responsibility to conduct the monitoring, however, the property has since been transferred into the USFWS San Pablo Bay National Wildlife Refuge.

Sears Point Monitoring

The Sears Point tidal wetland restoration project is, so far, unique in its large size and portfolio of innovative design features. It is a bold approach relying on suspended sediment from the nearby extensive northern San Pablo Bay shoals to raise elevation in conjunction with wave protection by constructed mounds and inter-tidal wetland vegetation recruiting naturally around the periphery of the project on the gradual slopes of the constructed transition levees. Monitoring requirements are geared more for compliance than to provide deep insights into effectiveness, potential for adaptive management, and/or lessons that might be learned from the experimental features of this project that could be transferred to future projects in the region.

The Sonoma Land Trust recognized that simply constructing the project was not enough. Joining with the San Francisco Bay National Estuarine Research Reserve, it is investing in a comprehensive five year monitoring program that involves research and innovative studies that assess how changes at the site are impacting fish, birds, vegetation, sedimentation, erosion, and other features. It is hoped that some of these studies ultimately contribute to a regional tidal wetland monitoring program that is more efficient and less costly overall.

This project is very new (less than two years since breach) and yet the insights gained already are quite dramatic. This poster cluster is intended to provide a snapshot into the changes that have already occurred at this site, to demonstrate insights that can be gained by new technologies, and to show how paying attention at a finer scale can yield important insights that may have deep significance for future tidal wetland restoration projects.

Reference

Goals Project. 2015. The baylands and climate change: What we can do. Baylands Ecosystem Habitat Goals Update 2015. California State Coastal Conservancy, Oakland, CA.

Hydrology, Geomorphic Processes, and Vegetation at the Sears Point Tidal Wetland Restoration Project

Michael Vasey, Stuart Siegel, Matt Ferner, Anna Deck, Alex Wick, Margot Buchbinder, Ryan Anderson, Julian Meisler, Jerry Davis

San Francisco Bay National Estuarine Research Reserve

San Francisco State University

Sonoma Land Trust

Note the "tear drop" shape of this wind-wave eroded mound. As mounds erode, wave energy deposits sediment on protected sides of the mounds.

Julian Meisler, Sonoma Land Trust, and Anna Deck, SF Bay NERR

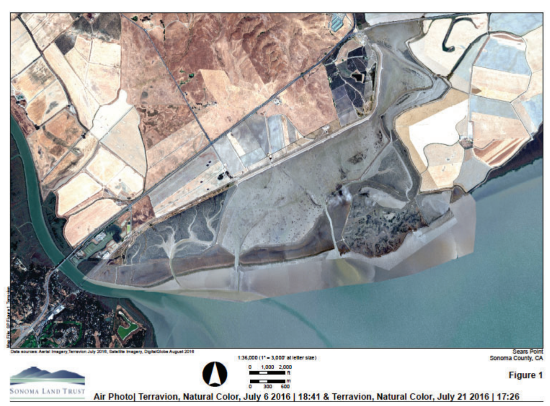
Wind wave erosion scoured the shore of the transition levee leaving a pavement-like surface in March 2017

Photo by Jared Blumenfeld

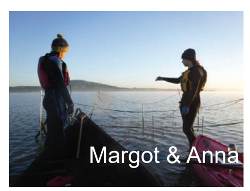
Wind waves erode "potholes" in transition levee, these fill with coarse sediment and provide footholds for intertidal plants.

Waves and tidal currents deposit coarse sediment on wind protected shore providing recruitment sites for intertidal plants

Hydrology



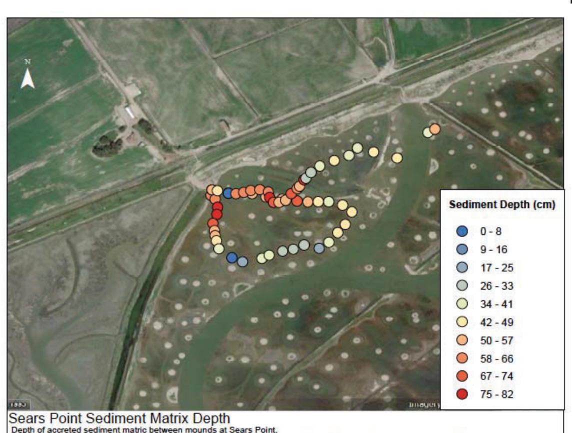
The main breach connects with the Petaluma River channel and there is a robust tidal prism. Wind waves mobilize sediments from nearby mudflat shoals. The result is an excellent supply of suspended sediments.



Margot & Anna

SFSU grad student examines cordgrass planting survivors

One of the sediment pins used to estimate mound erosion.



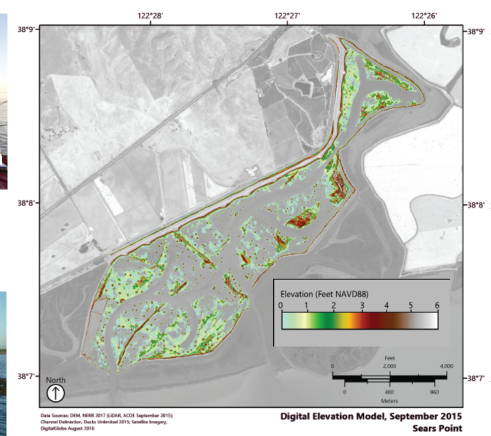
Sears Point Sediment Matrix Depth
Depth of accreted sediment matrix between mounds at Sears Point.
Data collection: 2017 SFSU Wetlands Ecology students. Map preparation: Margot Buchbinder. Imagery: Google Maps

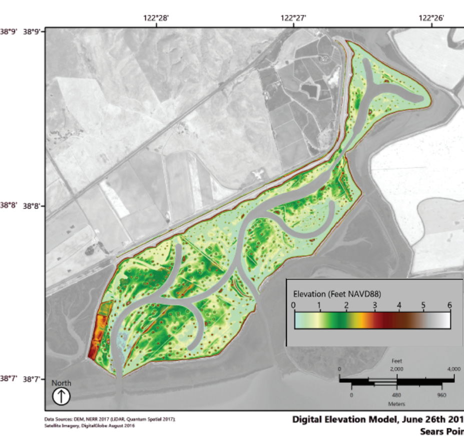
Students in Kathy Boyer's Wetland Ecology class measured sediment accretion in April, 2017 under the guidance of Margot. Note the dramatic amount of sediment accretion in just one and one-half years.

Julian & Ryan

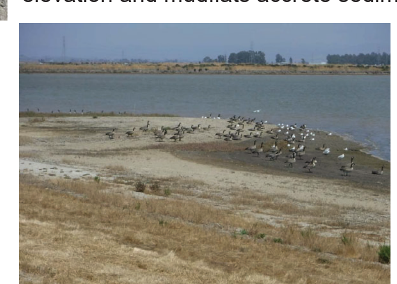
Erosion has severely narrowed the levee that separates Tolay Creek from Sears Point. If it breaches, it could add sediment to the eastern end of the project which appears to have the least sediment transport.

Geomorphology





Comparison of ground LiDAR image taken in September, 2015 by Ducks Unlimited and aerial LiDAR taken during a maximum low tide in June 2017. Shadows impacted the coverage of the ground LiDAR image and high areas were probably affected by remnant vegetation. However, although image analysis is still preliminary, there appears to have been a dramatic rate of sediment accretion since the breach in 2015. Maximum mound erosion (average of 40cm) appears to have taken place in 2016 whereas only an average of 5cm has taken place in 2017 (see Buchbinder poster). Sediment accretion appears to be accelerating and it is now difficult to do field work in the vicinity of the mounds. As mounds decrease in elevation and mudflats accrete sediment, it appears that the system is "leveling off".



Canada geese roost on the edge of a panne in the eastern "whale's tail" section of the restoration. This area is protected from wind and seems to also get less sediment supply, perhaps because it is farthest from the main breach

Coarse sediment deposits, possibly derived from eroded mounds, create ideal habitat for pickleweed recruitment.

Vegetation

K Boyer Wetland Ecology class sampling panne vegetation

Natural recruitment of a diversity of species occurred on several pannes during Spring 2017. Intertidal vegetation was sparse.

During the summer, large stands of pickleweed and other species established in protected areas of the mid-intertidal zone

Margot taking a photo of alkali bulrush recruits

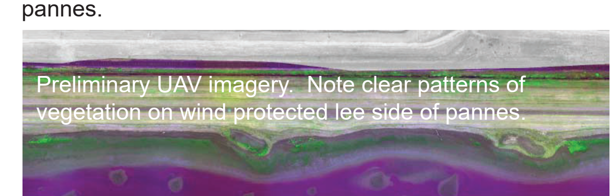
Other than planted mounds, there appears to be limited mound recruitment. Surviving mound plantings of cordgrass have become well established.

Annuals such as *Plagiobothrys bracteatus* can be found on pannes.

Wave scoured shores are still not well vegetated.

Dr. Jerry Davis, Drew Davis, & Dr. Sara Busguskas from SFSU GIS Center

We are investigating use of UAV imagery to monitor transition zone vegetation.



Preliminary UAV imagery. Note clear patterns of vegetation on wind protected lee side of pannes.

Margot & Karen Backe, USGS, with RTK GPs

Testing elevations of cordgrass recruitment. May become site for active restoration of cordgrass by Invasive Spartina.

Summary

Hydrology, geomorphology, and vegetation patterns demonstrate rapid change at the Sears Point tidal wetland restoration project. Apparently, as wind waves erode the mounds, coarse grain sediments are deposited onshore that yield recruitment sites for intertidal vegetation, particularly pickleweed. Rapid accretion is taking place particularly in areas between mounds and nearshore. Pannes provide vegetation diversity and wind protected shore that promotes intertidal plant recruitment. Sears Point appears to be on a positive marsh development trajectory.

Early-Stage Outcomes at the Innovative Sears Point Tidal Marsh Restoration Project

Stuart Siegel[1,2], Michael Vasey[1,2], Julian Meisler[3], Margot Buchbinder[2], Ryan Anderson[2]

[1]San Francisco Bay National Estuarine Research Reserve; [2]Estuary & Ocean Science Center, San Francisco State University; [3]Sonoma Land Trust

I. Introduction

Rebuilding tidal marsh elevations to restore emergent vegetated marsh and its associated ecological functions and ecosystem services and having these restored marshes strive to keep pace with sea level rise is a major question being examined in the San Francisco Estuary. The Sears Point Tidal Marsh Restoration Project of the Sonoma Land Trust is located on the northwest shore of San Pablo Bay, the broad, shallow northern embayment in the Estuary (Figure 1) where tidal currents and wind maintain generally very high suspended sediment loads in the water column.

Restoration design took advantage of this setting to utilize natural sedimentation as the approach to rebuild elevations on the property that had subsided to roughly mean lower low water, and it applied lessons learned from the nearby "Carl's Marsh" restoration project that proved to be very effective. Specifically, the design included multiple breaches (two built) and large channels to bring sediment-laden waters into the site and about 500 "marsh mounds" dispersed throughout the site to promote sedimentation and to serve as nuclei of marsh vegetation establishment. (For a variety of reasons, pre-breach vegetation of the mounds to stabilize them did not occur.)

In this poster we present the early results of sedimentation using two airborne LiDAR topographic monitoring data collection efforts and we illustrate the performance of the marsh mounds including their early erosion and later efforts to stabilize and revegetate them.

Figure 1: Vicinity Map

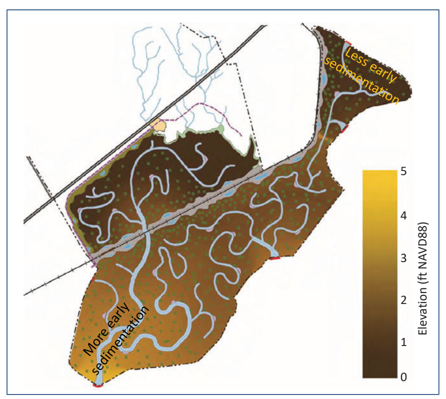


Figure 2: Predicted Early Sedimentation Pattern

The design Report (WWR 2007 Figure 24) predicted early pattern of greater sedimentation near bay (southwest) and lesser sedimentation farthest from bay (northeast). As Figures 3A and 3B show, this pattern has been roughly borne out, with more nuance.

II. Topography and Net Sedimentation Baseline to Year 2.7 (June 2018)

Sears Point has undergone a significant amount of natural sedimentation in its first three years of restoration. Figure 3A shows the as-built topography (comprised of mixture of ground-based LiDAR and engineering design elevations). Figure 3B shows the airborne LiDAR data for 1.7 years after breach, June 2017. Figure 3C shows the airborne LiDAR data for 2.7 years after breach, June 2018. Figures 3D through 3F show the *change* in elevation from baseline to Year 1.7, Year 1.7 to Year 2.7, and baseline to Year 2.7, respectively. To date, we have analyzed the 2017 LiDAR data and elevation change, and Figures 4A and 4B present the total accretion and average annual accretion rates, respectively.

At Year 1.7, total net accretion was nearly 4 ft maximum, with a median accretion of 1-1.5 ft (Figure 4A), translating to average annual rates of 0.5-1 ft/yr median and 3-3.5 ft/yr maximum. Net accretion reflects elevation change only and combines all processes of deposition, consolidation, and compaction that intertidally deposited sediment undergoes. These rates are anticipated based on earlier findings from nearby Carl's Marsh (Siegel 2002).

Spatial distribution of accretion also followed general predictions of the "prograding delta" concept wherein more deposition occurs near the inlets and along channel banks as flow velocities reduce and less sediment remains in the water column to deposit in the farthest areas from tidal connections (Siegel 2002, WWR 2007). Figure 2 shows the generalized design prediction and Figures 3B and 3C show the site patterns. Actual patterns reflect interaction of flows through the two breaches.

These findings strongly suggest that tidal marsh restoration sites located near locally abundant sediment supplies and well connected to those tidal waters will undergo rapid natural deposition.

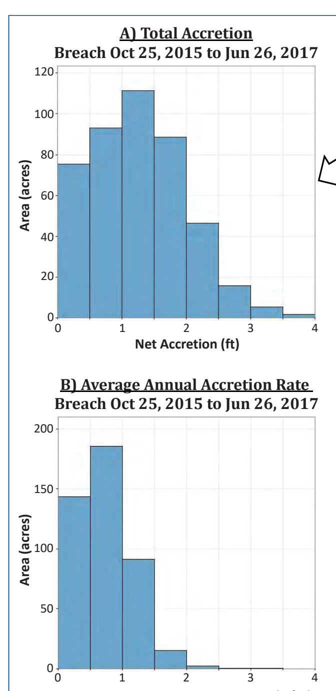


Figure 4: Net Accretion (Total, Average Annual Rate)

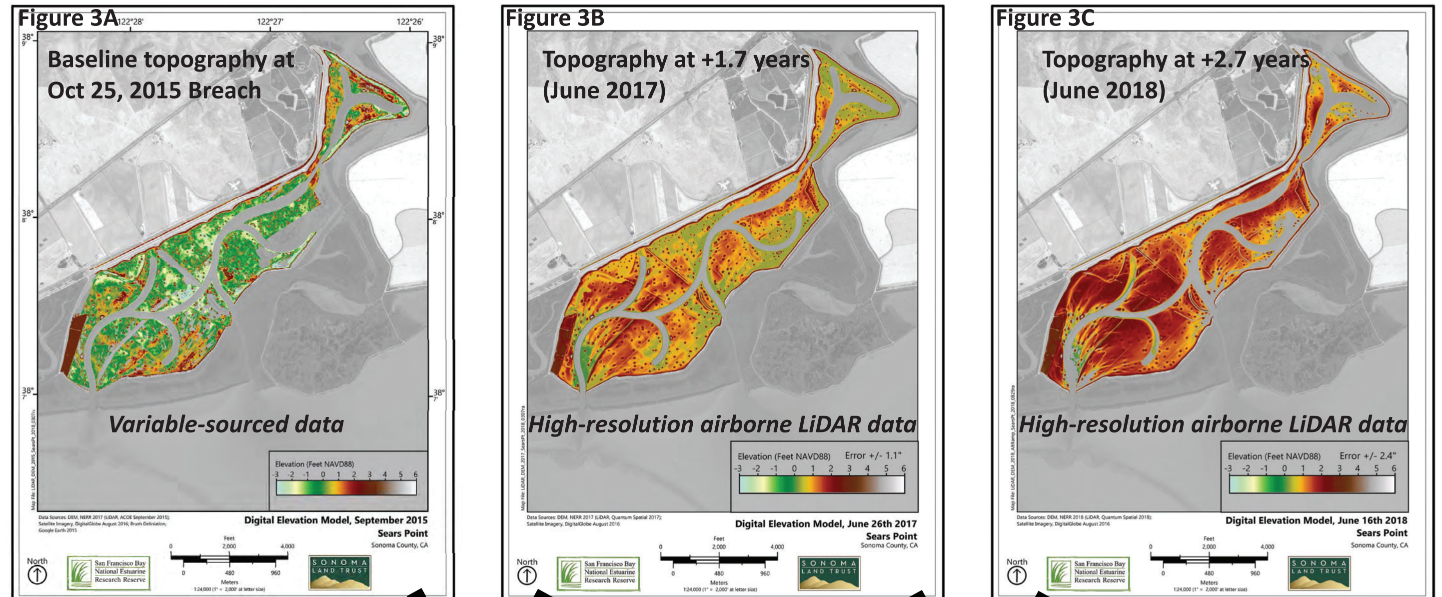
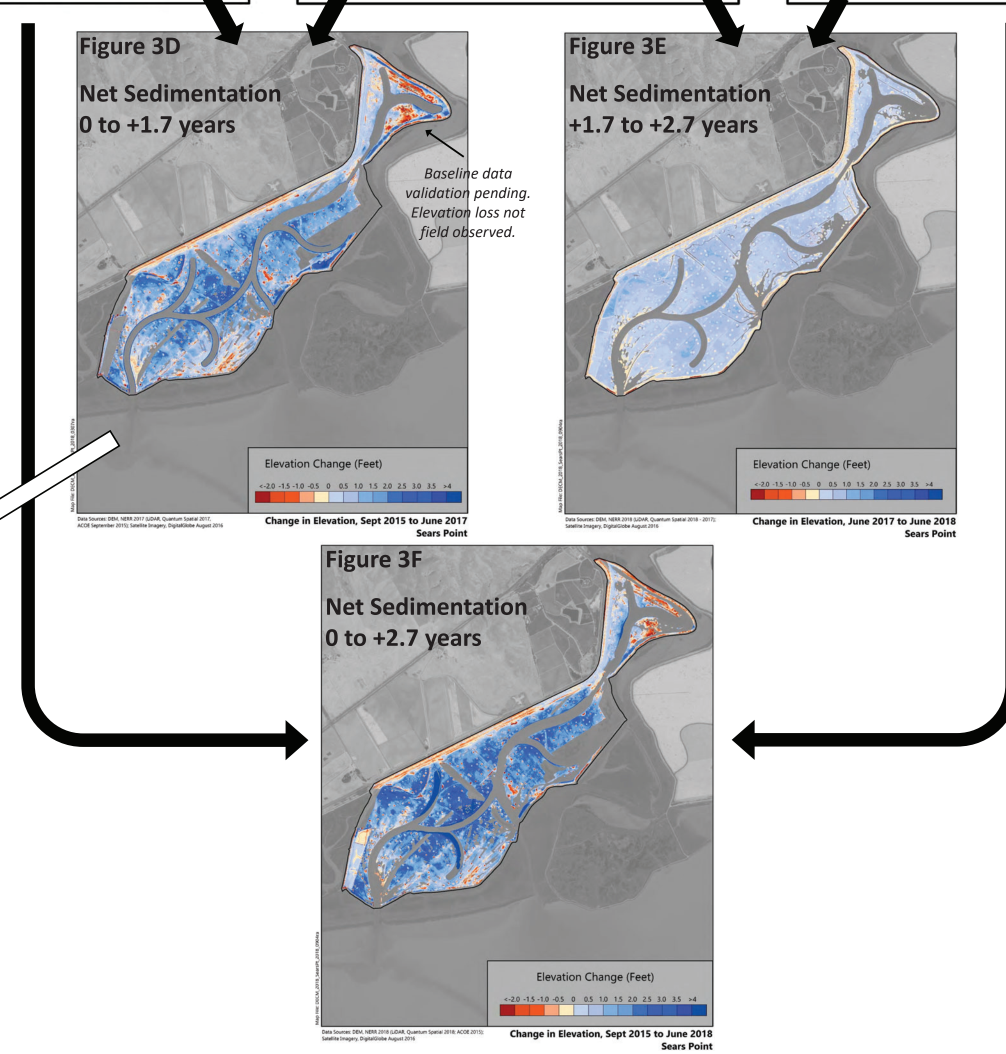



Figure 3: Topography and Net Sedimentation, Baseline to June 2018

III. "Marsh Mounds" – Promote Deposition, Reduce Erosion, and Provide Marsh Vegetation Nuclei

About 500 "marsh mounds" – essentially, piles of on-site soil with top elevations around mean higher high water – were included in the restoration design to promote sediment deposition, reduce erosion of the new perimeter tidal flood control levee, and provide disbursed points of marsh vegetation establishment "nuclei" throughout the restoration site (Figure 5). These ideas originated from lessons learned at nearby Carl's Marsh (Siegel 2002) and observations of the design team (Siegel, Baye, Leventhal, Toms). For a variety of reasons, mounds were not vegetated before breaching and consequently were subjected to significant erosion after breaching (Figure 7). An EOS graduate student (Buchbinder) started field experiments immediately before breach in October 2015 and continued through 2018, surveying mounds for erosion, testing erosion control with coir logs, planting native cordgrass (Figure 6A), and measuring vegetation and other physical and biological responses. That work identified the value of additional native cordgrass plantings, which the Invasive Spartina Project then carried out in March 2018 at more than 30 mounds (Figure 6B). The recent August 2018 site visit found very successful native cordgrass plantings (Figure 6C). Future monitoring will establish both vegetation spread as well as whether sedimentation rates are increased within vegetated areas.

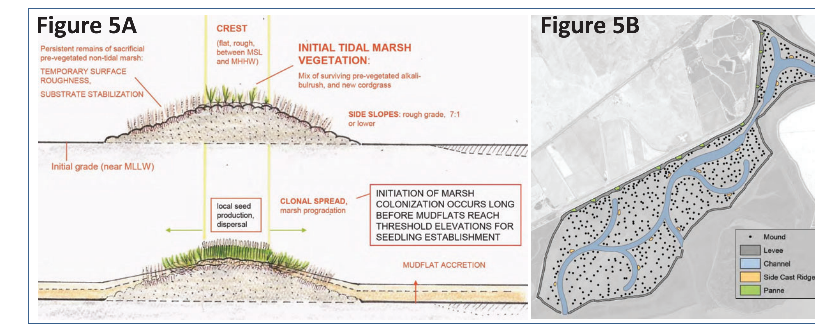


Figure 5: Marsh Mound Design (A) and Constructed Locations (B)

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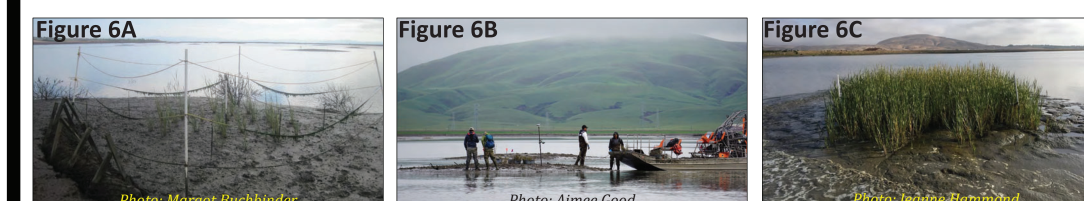

Figure 6: Marsh Mound Experimental Plantings 2016 (A), Plantings by Invasive Spartina Project March 2018 (B), and Resulting Early Vegetation Establishment August 2018 (C)

Planting and erosion control experiments conducted by Margot Buchbinder (SFSU EOS Center graduate student) in 2016 to test mound stabilization approaches with native cordgrass (Spartina foliosa) and coir rolls (Figure 6A). Planting of native cordgrass by the Invasive Spartina Project on ~30 mounds in March 2018 (Figure 6B). Extent of newly establishing native cordgrass on planted mounds as of August 2018 (Figure 6C).

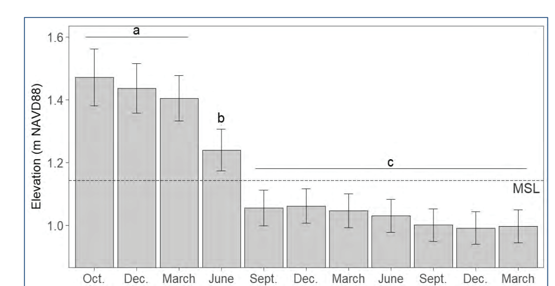

Figure 7: Marsh Mound Early Erosion

Prior to planting experiments and ISP mound planting, many mounds lost about 0.5 m to erosion, indicating the consequence of no pre-breach stabilization planting as designed (see Figure 5A).

References

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Partners in Design and Construction

THE VALUE OF WORKING TOGETHER

Partners and contributors in purchasing and restoring Sears Point include:

Early-Stage Outcomes at the Innovative Sears Point Tidal Marsh Restoration Project

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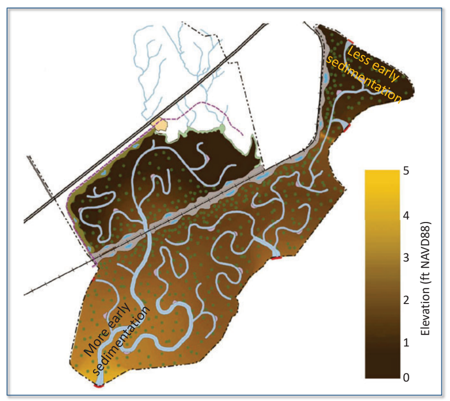

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At Year 2.7, total net accretion averaged around 2 ft, with maximum accretion 6 ft. Net accretion reflects elevation change only and combines all processes of deposition, consolidation, and compaction that intertidally deposited sediment undergoes. These rates are anticipated based on earlier findings from nearby Carl's Marsh (Siegel 2002).

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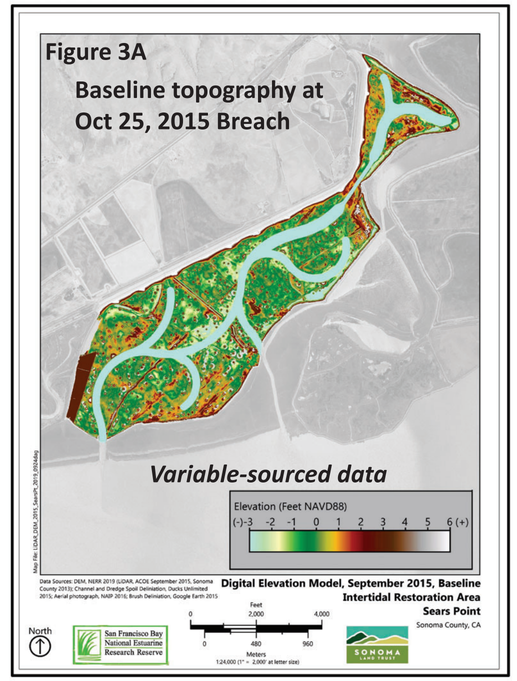

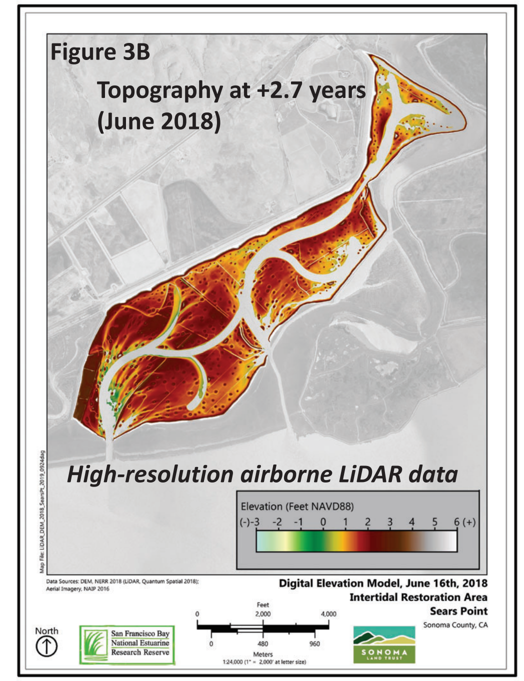

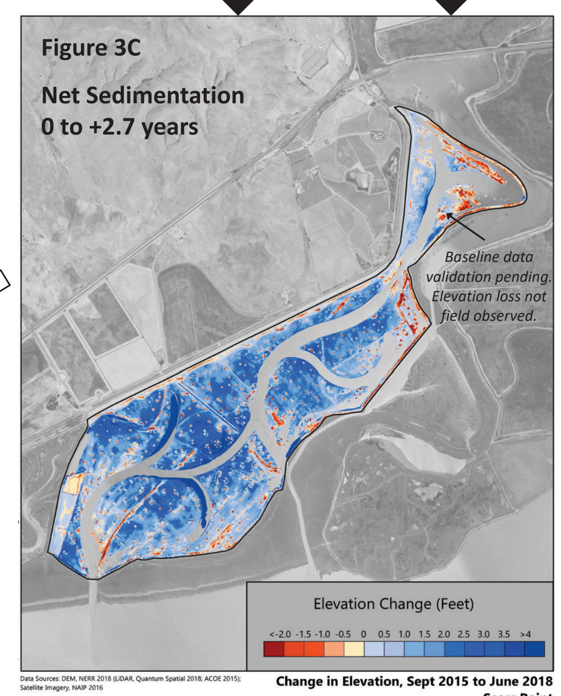

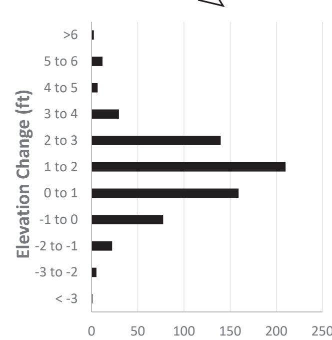

Figure 4: Net Accretion

Figure 3: Topography and Net Sedimentation, Baseline to June 2018

Total accretion volume breach to June 2018 (2.7 yr) ~2 million cubic yards

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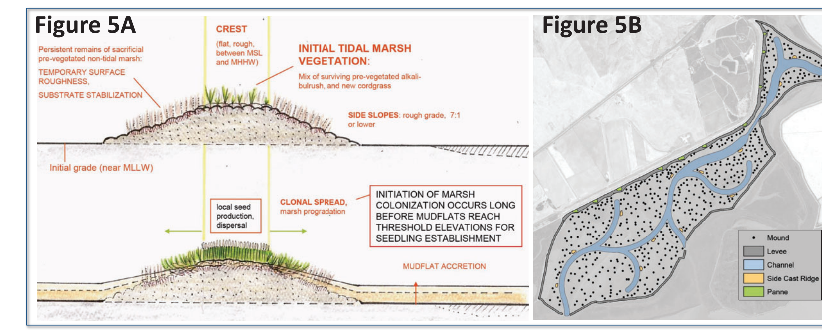

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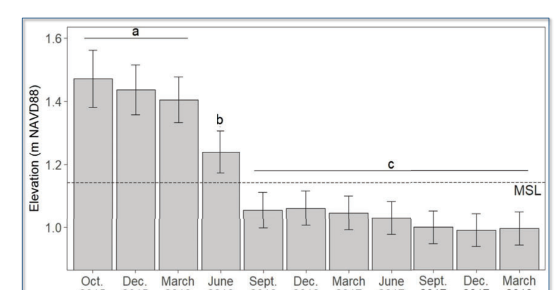

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THE VALUE OF WORKING TOGETHER

Partners and contributors in purchasing and restoring Sears Point include: