QUARTERLY PROGRESS REPORT
As of March 31, 2018 DRAFT

Date: April 24, 2018 Dates Covered by this Report: January 1, 2018 – March 31, 2018

Agreement No.: P1496011 00 Grant Term: March 1, 2020

Project Title: Initiation of Thin-Layer Sediment Augmentation on the Pacific Coast

Grantee: U.S. Fish and Wildlife Service, San Diego NWRC

FISCAL REPORT

Fund Source	Amount Awarded	Amount Expended as of March 31, 2018	Total Amount Remaining
CDFW GGRF Grant Funds	$1,055,827	$419,833[1]	$635,994
Cost Share	$1,306,048	$1,682,677	<$376,629>
Agreement Totals	$2,361,875	$2,102,510	$635,994[2]

[1] This amount includes invoices through the period 01/31/2018.
[2] Cost share agreements have already been achieved and exceeded; therefore these amounts are not included in this total.

Invoice Submitted this Quarter: ☐ Yes ☒ No (Awaiting billings from our Denver office.)

PROGRAM/TECHNICAL REPORT

Activities Performed from January 1 – March 31, 2018:

Monitoring

- Site visits to evaluate plant growth occurred during this quarter; however, no data collection was conducted. The first quarter of each year involves only limited monitoring of plants and invertebrates, with the majority of the monitoring occurring between April and June and again between October and November of each year.

- During several site visits, UCLA continued their work of documenting the existing characteristics of newly forming tidal creeks on the augmentation site. 100s of pictures were taken of four creeks to create an orthomosaic of each creek to document the current characteristics (e.g., width, depth, configuration) of the creeks.

- USGS staff visited the project site and control site to collect data from the SETs in late January 2018.

- Rick Nye, the Refuge Manager, conducted general site evaluations and volunteers conducted bird surveys. Time lapse photos of the site continue to be collected.

Site Observations

- During visits to the site in early January, researchers and the Refuge Manager noted the presence of large areas of black mold or algae scattered throughout the site. In Figure 1, the organism appears as moldy spots on bread, while in other areas it covers the sediment in a thin (1-3mm) layer (Figure 2). Figure 3 depicts a sample at 5 times magnification.

Figure 1. Dark spots on the sediment, which appear like mold or algae.

Figure 1. Same material as seen in Figure 1, but present in a thin layer.

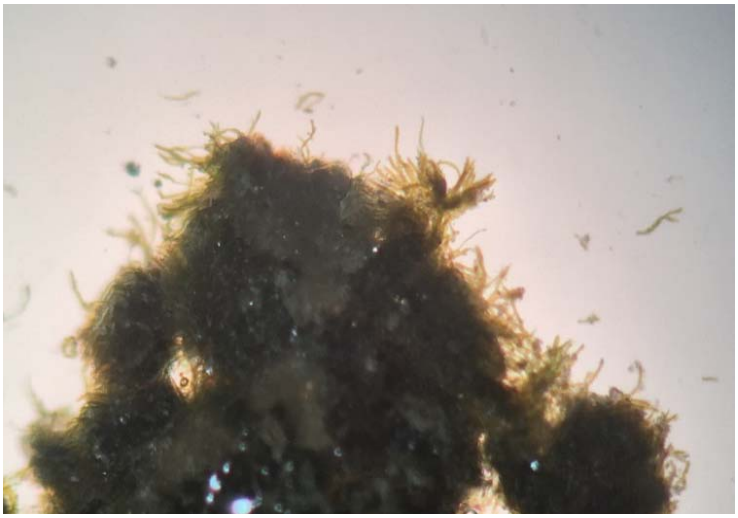

Figure 3. Sample at 5x magnification.

- Samples were provided to the CSULB Wetlands Ecology Lab, who later identified the organisms as cyanobacteria and green algae which normally occur in saltwater marshes.

- In early February, the Refuge Manager observed many new pickleweed seedlings present throughout the site (Figure 4), while cordgrass was generally limited to areas adjacent to the buffer zone and in some low spots on the site where cordgrass was previously present.

- The Refuge Manger located and mapped those areas within the site where cordgrass was growing. The locations were identified by recording GPS points around the outside perimeter of each cordgrass patch and polygons were then created from those files and included on an aerial of the site, as shown in Figure 5. The shape files were provided to USGS for incorporation into the elevation data obtained from each Surface Elevation Table (SET) being monitored on the site. The change in elevation across the site following augmentation is also indicated on Figure 5.

Figure 4. Numerous annual pickleweed seedlings were observed growing in proximity to last season's annual pickleweed plants.

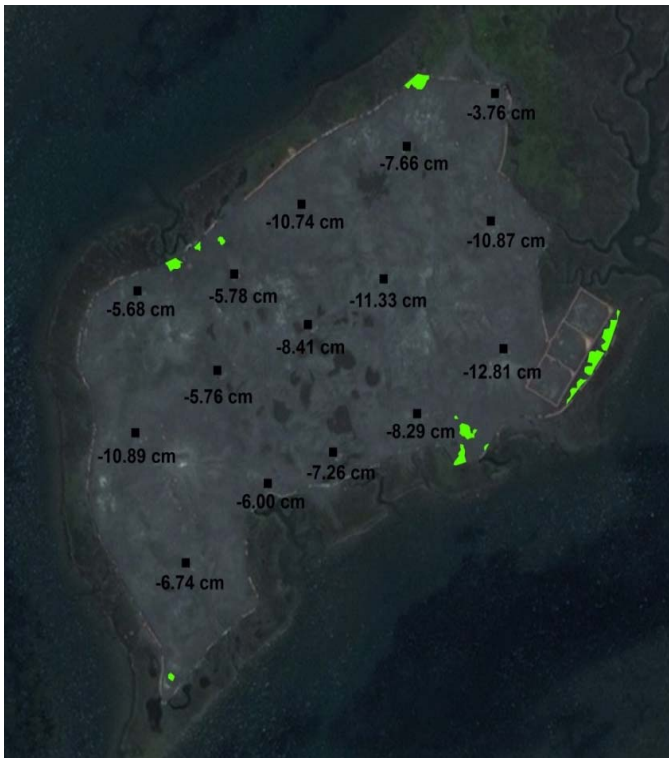

Figure 5. The green areas on this aerial photograph depict the locations where cordgrass is growing on the augmentation site.

- During general site monitoring, pickleweed was observed growing in a depression left by a 5-gallon bucket on the augmented sediment surface (Figure 6), which lead to the question, could cracks or depressions in the augmented sediment be conducive to seedling recruitment.

- Twine from deteriorated hay bales placed on the site to confine applied segment has been observed in the study area, especially around the edges of the 3 test plots. Volunteers will be recruited to help remove the twine from the site, as well as to assist in removing wooden grade stakes and other trash.

- During a site visit on March 21, 2018, the Refuge Manager observed some areas on the site where water is pooling (Figure 7) and not moving off the site as the tide recedes, while in other areas water is draining off towards a tidal creek.

Figure 6. Pickleweed seedlings growing in the impression left by a 5-gallon bucket.

Figure 7. View of pooled and moving waters during a receding tide.

- More than 1,000 shorebirds were observed on the augmentation site during monitoring visits in mid-February (Figure 8). On March 13, approximately 300 western and least sandpipers along with about 400 other shorebirds, and one great blue heron were observed on the site.

Figure 8. Shorebirds foraging in the augmentation site after a high tide.

Project Coordination

- A team conference call was held on January 31, 2018. Discussion topics included:
    - notching the tidal creeks to allow tidal waters to more easily move on and off the site and to reach the higher elevations on the site;
    - work being conducted by UCLA to establish baseline data for the depth, height, and other physical characteristics of the tidal creeks;
    - U.S. Army Corps of Engineers funding for a photogrammetry survey to be conducted in August;
    - a proposal by Lauren Brown (UCLA) to incorporate the results of the belowground biomass analysis conducted by CSULB into her recently completed report on coring for long-term carbon sequestration and environmental change (Brown et al 2018);
    - USGS data collection and analysis of elevational changes at the site;
    - initiation of photosynthesis analysis of cordgrass by CSULB; and
    - grant opportunities for a nutrient study of the augmented sediment, as well as a study of the benefits of planting cordgrass to assist in reestablishment of the species on augmented sites.

- Members of the Project Team held a conference call on February 23, 2018 to discuss applying for a Proposition 84 USC SeaGrant to fund research related to accelerating recovery of Pacific cordgrass on the augmentation site using experimental planting. The pre-proposal was subsequently submitted on March 15. Christine Whitcraft (CSULB) agreed to be the Principal Investigator and primary grant writer for the proposal.

- Refuge staff coordinated with researchers on monitoring visits to the site and quarterly and final reports.

Project Outreach/Information Dissemination

- The Refuge webpage (https://www.fws.gov/refuge/seal_beach/what_we_do/resource_management/Sediment_Pilot_Project.html) was updated to include this quarterly report and new site photos are periodically uploaded to the site.

- Karen Thorne, USGS Western Ecological Research Center, and Evyan Sloane, California State Coastal Conservancy (both members of the project team) presented the lessons learned from the project to date via a widely noticed webinar held on March 15, 2018 as part of the Restoration Webinar Series. This webinar series is a partnership between the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service. The presentation, entitled Testing a Novel Adaptation Strategy in a California Salt Marsh, was initially viewed by 219 people from 23 states plus Canada. The webinar is available for viewing online and the link has been added to our webpage. Link: https://fws.rev.vbrick.com/#/videos/071d7a44-047d-46e7-b437-d849648d393c.

- Richard Ambrose (UCLA), Christine Whitcraft (CSULB), and Karen Thorne (USGS) continue to work on a journal article, and in March a manuscript by Kaelin McAtee and Christine Whitcraft was submitted to Estuaries and Coasts for review.

Status of Ongoing Research:

Tidal Creek Formation

Establishing Baseline Data for Tidal Creeks. UCLA, under the direction of Richard Ambrose, completed the process of photographing four tidal creeks within the augmentation site prior to any dam notching. Hundreds of photos were taken of each creek using a camera on a pole. The photographs were then processed using the Pix4D Mapper program to create an orthomosaic of the augmentation site tidal creeks. The orthomosaic will document the pre-notching baseline conditions for the creeks. We found that using the camera on a pole process has significant limitations. The use of a drone would be optimal, but to date, we have not obtained permission to fly a drone on the Naval Station. Also, per USFWS policy the operator needs to be FAA certified. In August 2018, the condition of the tidal creeks will be documented again, this time using photogrammetry. Funding for the survey has been provided by the U.S. Army Corps of Engineers. The ground control points for the survey will be reestablished on the site prior to the flight. The photogrammetry survey will provide updated elevational data for the site, including for the four previously photographed tidal creeks. Changes to the tidal creeks following notching will be evident and will be compared to pre-notching conditions.

Notch Hay Bale/Sandbag Dams. As addressed in previous quarterly reports, tidal creek formation on the augmented site was determined to be hindered by hay bale/sandbag dams installed prior to applying sediment to the site. The dams were put in place to assist in retaining sediment on the augmentation site during application. After discussing the potential problems associated with restricted tidal flow to portions of the site (e.g., inadequate tidal flows to support the plant growth, the potential for sediment acidification should the sediment dry out), the project team determined that several of the dams should be notched

to facilitate better tidal flow across the site. The location and condition of the creeks and dams on the site were documented in September 2017.

As illustrated in Figure 9, 34 creeks and 10 dams were located on the site. Based on discussions with the project team, the Refuge Manager determined three of the existing hay bale/sandbag dams (identified as E, G, and I) should be notched to allow tidal waters to move more freely on and off the site and to ensure that the entire site is inundated during a normal high tide.

Notching, which was initiated by the Refuge Manager in February 2018, entailed removing some sandbags from the area where water was flowing over or through each dam. One or two layers sandbags were also removed from the top of the dams. Prior to taking this action, UCLA imaged and characterized four channels to facilitate monitoring of changes on the site through the end of the research phase. The team is particularly interested in identifying those changes that occur one year post notching.

Dam E was notched on February 13, 2018. 19 sandbags were removed from the obstructed creek opening and two layers (19 sandbags) were removed from the top of the remainder of the dam which made the top of the dam even with the adjacent sediment layer. Remnants of the hay bales were still present, so all hay bale twine that was found was cut and extracted from the dam and existing landscaping fabric was cut from the notched area. Dam G was notched on February 13 and 15, with all nine sandbags, landscape fabric, and sediment removed from the dam. There were no hay bales in this area. Dam I was notched on February 21, with 15 sand bags and fabric removed from an area where the tidal creek was flowing through the dam. Additionally, 32 sand bags and fabric was removed from the top two to three layers. Dam I was at least twice as deep as Dam E, which accounts for the large number of sand bags removed from Dam I. Figure 10 provides depicts of each dam prior to and after notching.

Sediment Flux and Turbidity Patterns

USGS provided their final report on sediment flux and turbidity patterns pre, during, and post augmentation. The full report (USGS 2017) is provided as Attachment A; a summary of the report's findings is provided below.

- Turbidity and sediment fluxes were monitored using two high-quality water sensing instruments (YSIs) and an acoustic Doppler current profiler (ADCP) in the deep channel site (control) and in the eelgrass site (adjacent to augmentation site) from November 17, 2014 to August 23, 2017.

- Mobilization of equipment and installation of the hay bale barrier began on January 4, 2016. Sediment application occurred between January 18, 2016 and April 4, 2016. Demobilization activities continued through April 7, 2016. Testing of sediment application began on January 18, 2016, with the first significant sediment application occurring on January 22, 2016.

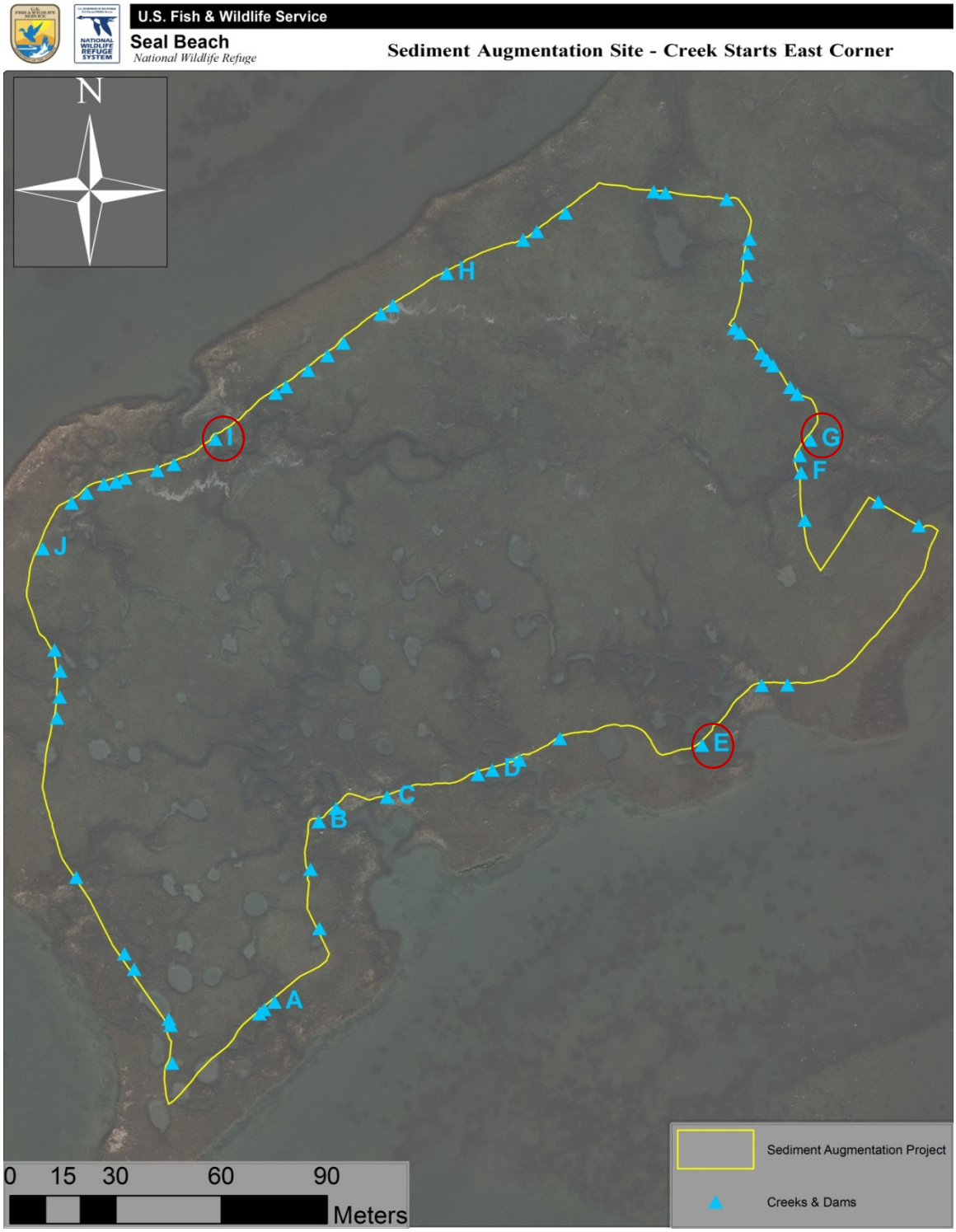

Figure 9. Location of tidal creeks and dams on the augmentation site in September 2017. Note: The dams indicated with red circles (Dams E, G, I) were notched in February 2018, and the underlying aerial photograph represents the site prior to augmentation.

Dam E notching before (left) and after (right). The tide was going out so the sandbags which were present in the notched area before are slightly visible. The two layers from the rest of the dam are clearly gone.

Dam G notching before (left) and after (right), each when the tide was going out.

Dam I before notching (left) and after notching (right).

Figure 10. Views of Dams E, G, and I before and after notching.

- The contractors placed 55 percent of the dredge material during the last 24 percent of the project timeline due to the switch between an 8” and 12” diameter pipe. USGS calculated an average elevation increase of 8.66 inches across the augmentation site immediately following augmentation.

- Mean SSC at the deep YSI site was 6 and 7 mg/L before and after construction, while post-construction mean SSC at the eelgrass site was 2.4 times greater than pre-construction levels. This is likely due to the resuspension of material mobilized during construction activities as well as the closer proximity of the eelgrass site to the augmentation study site.

- Mean flux measured in the deep channel after demobilization was -0.04 g/m2/s, suggesting that little sediment is flowing out of the marsh complex after sediment application was complete.

- Mean SSC was greatest at both the eelgrass site (16 mg/L) and deep site (33 mg/L) during a storm on Jan 22, 2017, which yielded 9.3 cm (3.7 in) of rain.

- Switching from the 8” to 12” pipe increased sediment application rate, but also increased sediment runoff and local turbidity at the eelgrass site adjacent to the augmentation site.

- Sediment application impacts on water quality was only measured locally, and decreased with distance from application location.

- Monitoring of turbidity and sediment fluxes before, during, and after construction showed that the turbidity impacts were localized, relatively small and short lasting after one year of post demobilization monitoring, while the restored marsh surface seems to have stabilized as well during this same time period.

- Switching from an 8” pipe to a 12” pipe increased the rate of sediment application, causing an increase in sediment runoff. This is believed to be responsible for sediment covering nearly a hectare of eelgrass adjacent to the augmentation site.

Surface Elevation Monitoring

USGS continues to monitor surface elevations on the augmentation and control sites. Their full quarterly report is provided as Attachment B. The Surface Elevation Tables (SETs) on both sites were measured on January 29, 2018. The measurements showed that the augmentation site continued a gradual decrease in elevation dropping on average -0.94 mm across all fifteen SETs; while the control site also showed a small decrease of -1.34 mm across its six SETs. Control SETs have had gains and losses of elevation since installation, but have a mean cumulative increase of 3.22 mm since installation. Augmentation SETs had a mean increase in elevation of 216 mm with sediment application, but had a decrease in elevation of -82.19 mm post sediment application (April 2016 - January 2018; Figure 11).

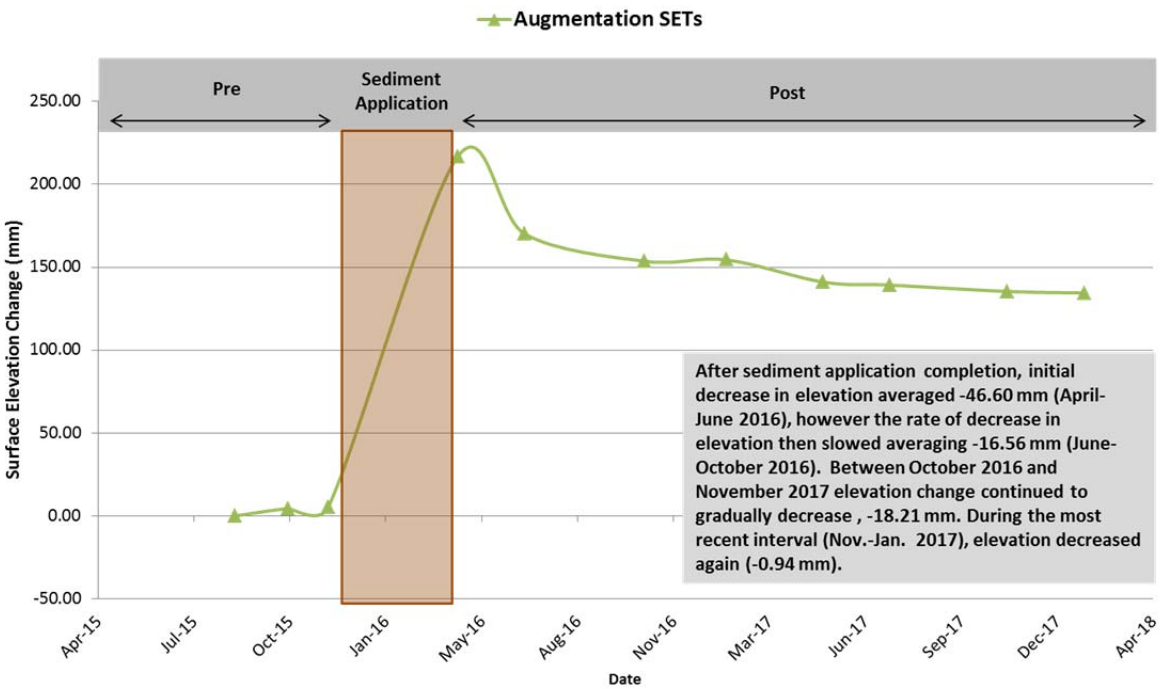

Figure 11. Mean surface elevation change at augmentation site.

The feldspar readings showed an increase in sediment above the feldspar layer during this time period for the augmentation site with an increase of 8.61 mm. mm post sediment application (April 2016-January 2018). However, overall post monitoring has showed little overall change in depth of the feldspar layer with a small decrease of -1.92 mm averaged across all 15 SETs. This finding shows that the majority of elevation decreases shown in the elevation pin measurements is most likely due to the original marsh surface compacting below the feldspar marker horizon.

Plant and Invertebrate Studies

Plant cover continues to slowly increase, but the primary species present on the site continues to be annual pickleweed (*Salicornia biglovii*). The community composition of invertebrates shifted from a dominance of oligochaetes and polychaetes before augmentation to insects and insect larvae for several months after augmentation. At eighteen months following augmentation (the last time collection occurred), CSULB has observed an increase in oligochaetes on the augmentation site; however these organisms are not yet present at pre-augmentation levels. No collection of plants or invertebrates was conducted during this quarter. Invertebrate vouchers are in process for identification to lowest taxonomic level and sorting of the bottom 4 cm samples for all prior time points continues.

Cordgrass Elevation Comparison

A comparison of cordgrass elevations pre- and post-augmentation was conducted to better understand how cordgrass may ultimately revegetate the site. Cordgrass is currently re-growing in areas on the augmentation site that are slightly higher than previously found during the pre-

augmentation 2011 survey. The mean is 0.13 meters higher while the maximum present is only 0.03 meters higher showing that cordgrass may have hit its highest possible elevation at 1.51 meters NAVD88. These results are based on a limited number of cordgrass specimens, and those specimens are extending into the site from rhizomes of existing plants located in the adjacent buffer area. Additional analysis will be conducted when cordgrass is more abundant on the site.

Gas Flux

Jason Keller (Chapman University) and his team conducted sampling in February 2018. Gas samples were collected from both the control and augmentation sites and analyzed for carbon dioxide, methane, and nitrous oxide. Surface porewater was also collected and redox in surface water was measured in the field.

Bird Surveys

As described above, numerous birds were sighted by the Refuge Manager on the augmentation site when the tide was rising or receding; however, no birds were identified on the site during the monthly high and low tide surveys. This is likely due to the timing of the surveys which are occurring when the site is completely submerged or totally exposed. The survey schedule will be evaluated and changes will be made to ensure the documentation of more accurate avian use patterns on the site during the twice monthly surveys.

The monitoring season for the light-footed Ridgway's rail (*Rallus obsoletus levipes*) began at the end of the quarter (late March 2018). Initial monitoring results show that there are 11 nest starts between the 81 nesting platforms that have been checked so far. This is similar to last year when the refuge had 13 nests on 89 nesting platforms.

Population and nesting information related to the Seal Beach NWR for the 2017 nesting season was made available in early 2018 in the 2017 statewide report (Zembal et al. 2017). Nest searching and monitoring was conducted at Seal Beach NWR from March into August 2017, and nesting rafts were visited every three to four weeks during the breeding season into July. In all, two observers accumulated 103 field-hours over six rounds of raft checks, generally over two to three dates each March 26 through July 20. These observers documented 56 clutches of eggs laid on 40 rafts. In addition, 17 brood nests were built on 17 rafts and at least 11 clutches hatched off rafts. The overall nesting success on the rafts was 96 percent. The number of pairs present in 2017 was 60, the same number observed in 2016. So far, rails have not used nesting platforms south of the augmentation site, but they do use nesting platforms located across the channel west of the augmentation site.

<u>Percentage of Task Completed as of March 31, 2018</u>:

Task 1 – Project Management and Administration	58%
Task 2 – Sediment Augmentation	100%
Task 3 – Project Monitoring (overall)	69**%**

1) Carbon Storage/Sequestration Benefits	90%	
2) Plant and Invertebrate Monitoring	58%	
3) Pacific Cordgrass Analysis	58%	
4) Site Elevations	58%	
5) Sediment Analysis (compaction, movement, bulk density)	58%	
6) Turbidity Levels	100%	
7) Bird monitoring	58%	
8) Eelgrass	75%	
Task 4 – Engineering Design/Environmental Documentation (overall)		100%
1) Engineering Plans for Sediment Augmentation Site		100%
2) Environmental Documentation*		100%
*CEQA/NEPA has been completed by SCC/USFWS		
Task 5 – Public Participation/Presentations (overall)		75%
1) Oral/Poster Presentations	65%	
2) Workshops and/or Webinars	85%	
Overall Project		**86%**

Deliverables Completed for Each Task:

Task 1 – Project Management and Administration

1) Quarterly Progress Report	11 reports
2) Monthly Invoices	23 monthly invoices
3) Subcontractor Selection	Orange County Parks & SWIA selected
4) Data Management	preliminary data for monitoring locations
5) Acknowledgement of Credit	ongoing

Task 2 – Sediment Augmentation

1) Sediment Application	completed
2) Adaptive Management	on going
3) Reporting Results/Lessons Learned	in process

Task 3 – Project Monitoring

1) Carbon Storage/Sequestration Benefits	pre-augmentation monitoring complete; long core data processing complete; long core data final report complete, but to be updated to include belowground biomass data analysis; post-augmentation monitoring of carbon storage/sequestration continues
2) Plant and Invertebrate Monitoring	pre-augmentation work completed; post augmentation monitoring underway

3) Pacific Cordgrass Analysis	pre-augmentation work completed; post augmentation monitoring underway
4) Site Elevations	pre-augmentation RTK survey conducted; initial post-augmentation photogrammetry conducted; SETs data downloads continuing; monitoring of feldspar plots continuing; USACOE has provided funding for another photogrammetry survey to be conducted in August 2017
5) Sediment Analysis	initial core samples retrieved; data processing completed; grain size analysis of new sediment nearing completion
6) Turbidity Levels	monitoring completed in August 2017; final report completed 2017 (Attachment
7) Bird Monitoring	pre-augmentation work completed; post augmentation monitoring ongoing
8) Eelgrass	pre-augmentation, post- augmentation and year one post-augmentation surveys completed, year two post-augmentation survey scheduled for May 14 and 15, 2018

Task 4 – Engineering Design/Environmental Documentation

1) Engineering Plans for Augmentation Site	100% engineering plans completed
2) Environmental Documentation*	CEQA/NEPA documents final; ND recorded *for USFWS and Coastal Conservancy

Task 5 – Public Participation/Presentations

1) Oral/Poster Presentations	Presentations ongoing
2) Workshops and/or Webinars	Participated in USACOE webinar; Thorne/Sloane presented the lessons learned in a webinar on March 15, 2018, part of the Restoration Webinar Series

<u>Problems/Delays Proposed Resolution</u>:

No delays have been identified for post-augmentation monitoring. We continue to monitor eelgrass recovery, which is occurring, adjacent to the site. Another eelgrass survey is scheduled for May 2018.

Revegetation of the site by Pacific cordgrass continues to be slow, but growth of annual pickleweed is expanding. We continue to consult with other wetland ecologists in the region who

have experience with Pacific cordgrass restoration projects. In addition, researchers on the project team have prepared a USC Sea Grant pre-proposal through the California Ocean Protection Council, Proposition 84 Competitive Grants Program that addresses accelerating recovery of Pacific cordgrass on the augmentation site using experimental planting. The objective of the proposal is to determine which planting regime will best facilitate colonization of the site with Pacific cordgrass: polycultures with Pacific cordgrass included, polycultures where other plants will facilitate conditions for eventual Pacific cordgrass colonization, or just Pacific cordgrass plantings. The purpose is to experimentally test the best planting strategy (polycultures versus monocultures) to restore Pacific cordgrass over the long term while also monitoring non-planted passive recovery at the augmentation site. If funded, the results of this research would benefit this and other augmentation and coastal wetland restoration projects in California.

Project Benefits and Results:

Although we have not yet achieved our primary project goals, we have compiled a considerable amount of information regarding the sediment augmentation process and pre- and post-monitoring protocols. This information is being disseminated via conference presentations, poster sessions, and most recently a very well attended webinar. There is considerable interest about the project and the project team willingly provides background and details that have benefited other land managers who are considering similar actions both on the east and west coasts of the U.S. Information related to long-term carbon sequestration at Seal Beach will also benefit other land managers and those interested in carbon storage and total value of the carbon stock in southern California's coastal salt marshes.

Summarize Benefits to Disadvantaged Communities (if applicable):

Not applicable to this project.

List of Proposed Activities and Tasks for the Next Quarter:

Task 1 – Project Management and Administration
Tasks include coordination of final pre-project monitoring reports; completion of the "lessons learned" document; assisting researchers with site access; preparing invoices and the next quarterly report; providing other agencies with information about the project, and all other responsibilities needed to successfully complete the project.

Task 2 – Sediment Augmentation
The sediment augmentation process has been completed.

Task 3 – Project Monitoring
Refuge staff will continue photographing and recording the locations (GPS) of cordgrass regrowth within the augmentation site. The research team will continue to evaluate the progress of cordgrass reestablishment on the site. Photo documentation of changes on the augmentation site over time will also continue.

In May, volunteers will be recruited to help remove twine (left from deteriorated hay bales) from the site, as well as to assist in removing wooden grade stakes and other trash.

USGS will continue collecting data from the SETs and feldspar plots.

Richard Ambrose and his team at UCLA will be conducting full field sampling during the next quarter. This will include sediment cores, sampling sediment heights at sediment stakes, and tidal creek cross sections. They will continue taking pictures of the tidal creeks now that the dams have been notched in an effort to identify the initial changes in creek dimensions and locations as a result of improved tidal flows.

Christine Whitcraft and her team at CSULB will begin their two years post augmentation field work (LiCor, invertebrate samples) on April 21 - 23, 2018. They will continue invertebrate identification and community analysis in the laboratory on the contract samples. In addition, they will continue surveying the site one to two times during the quarter to determine how plants are recovering and if there are enough for additional photosynthetic measurements. Now that all belowground biomass cores are sorted, Christine's team has initiated discussions with UCLA about additional uses for these data in their continuing analysis of long-term carbon sequestration and environmental change.

Dr. Keller and his team will continue to measure greenhouse gas fluxes from the control and augmentation sites in April and June. Chemical analysis of surface porewater will continue and pH levels and redox will be measured in surface water. Seasonal patterns in fluxes and their relationship to porewater chemistry will continue to be explored as the dataset expands.

MTS will be conducting the second-year post augmentation eelgrass survey on May 14 and 15, 2018 and will prepare a formal report detailing the results of the survey.

Task 4 – Engineering Design/Environmental Documentation
This task has been completed.

Task 5 – Public Participation/Presentations
Several research papers are currently underway by members of the research team.
The Refuge webpage will continue to be updated, and we will participate in conferences and webinars as opportunities arise.

Description of Amendments and Modifications to Grant:

No amendments or modifications were made this quarter. We previously made a minor modification to the existing grant by redirecting $4,950 of unallocated research funds to additional eelgrass survey work, which was approved by CDFW on June 10, 2016.

Attachments:

A. Sediment Flux and Turbidity Patterns (USGS 2017)
B. USGS Quarterly Report (April 2018)
C. Itemized In-Kind Cost Share Accounting

References:

Brown, Lauren N., S. Avnaim-Katav, and G. MacDonald. 2018. Seal Beach National Wildlife Refuge Sediment Coring for Long-Term Carbon Sequestration and Environmental Change. UCLA Department of Geography, Los Angeles, CA 90095. January 10, 2018.

USGS. 2018. Thin-Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge: Dec 31- April 10, 2018 Quarterly Progress Report. Principle: Dr. Karen M. Thorne, Team: Chase Freeman, Karen Backe, Tesia Forstner. USGS, Western Ecological Research Center, Vallejo, CA. April 10, 2018.

USGS. 2017. Final Report: Thin-Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge, Sediment flux and turbidity patterns. Principle: Dr. Karen M. Thorne[1]; Team: Dr. Neil K. Ganju[2], Chase Freeman[1], and Dr. Jordan A. Rosencranz[1] ([1]USGS, Western Ecological Research Center, Vallejo, CA; [2]USGS, Coastal and Marine Geology, Woods Hole, MA).

Zembal, R., S.M. Hoffman, and John Konecny. 2017. Light-footed Ridgway's (Clapper) Rail in California, 2017. Report to US Fish and Wildlife Service and California Department of Fish and Wildlife.

Final Report: Thin-Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge

Sediment flux and turbidity patterns

October 12, 2017

Principle Contact: Dr. Karen M. Thorne[1], 916-502-2996, kthorne@usgs.gov

Team: Dr. Neil K. Ganju[2], Chase Freeman[1], and Dr. Jordan A. Rosencranz[1]

[1]USGS, Western Ecological Research Center, 505 Azuar Dr. Vallejo, CA, 94592
[2] USGS, Coastal and Marine Geology, 384 Woods Hole Road, Woods Hole, MA 02543-1598

Executive Summary

- The augmentation activities including dredging, construction and sediment application were conducted by Orange county public works and construction. Installation of a sediment barrier around the augmentation site was initiated the week of January 4, 2016, with placement being coordinated by USFWS refuge staff.
- Testing of sediment application began January 18th, 2016 with the first significant sediment application occurring on January 22nd , 2016.
- The contractors placed 55% of the dredge material during the last 24% of the project timeline due to the switch between an 8" and 12" diameter pipe. We calculated an average elevation increase of 8.66 inches across the augmentation study site.
- Turbidity and sediment fluxes were monitored using two high-quality water sensing instruments (YSIs) and an acoustic Doppler current profiler (ADCP) in the deep channel site (control) and in the eelgrass site (adjacent to augmentation site) from 11/17/2014 to 8/23/2017.
- Mean SSC at the deep site was 6 and 7 mg/L before and after construction, while post-construction mean SSC at the eelgrass site was 2.4 times greater than pre-construction levels. This is likely due to the resuspension of material mobilized during construction activities as well as the closer proximity of the eelgrass site to the augmentation study site.

- Mean flux measured in the deep channel after demobilization was -0.04 g/m2/s, suggesting that little sediment is flowing out of the marsh complex after sediment application was complete.
- Mean SSC was greatest at both the eelgrass site (16 mg/L) and deep site (33 mg/L) during a storm on Jan 22, 2017, which yielded 9.3 cm (3.7 in) of rain.
- Augmentation resulted in a reduced depth and less frequent inundation regime, whereas the control site experienced a greater percentage of time under water.

Lessons Learned:

- Biofouling resulted in loss of data at the end of some deployment periods. We encourage more frequent maintenance, especially during summer months when the water is warmer and biofouling is increased.
- More water samples are needed during storm periods, high tide events, and construction related erosion events to ensure collection during high suspended sediment concentration time periods that will result in a more robust calibration curves.
- After testing sediment application, straw waddles, sand bags, and geotextile fabric were used to minimize loss of sediment from these areas throughout the augmentation site. Monitoring of erosion from tidal creed is important.
- Switching from the 8" to 12" pipe increased sediment application rate, but also increased sediment runoff and local turbidity at the eelgrass site adjacent to the augmentation site.
- Sediment application impacts on water quality was only measured locally, and decreased with distance from application location.

Objectives

Our research objectives were to: 1) detect changes in turbidity in the eelgrass bed (adjacent to augmentation site) to asses effects of construction and sediment application; 2) detect changes in turbidity and sediment fluxes at the deep channel site (control) to assess any effects of construction and sediment application; and 3) monitor any post-construction impacts to in-channel turbidity at the eelgrass bed and deep channel site.

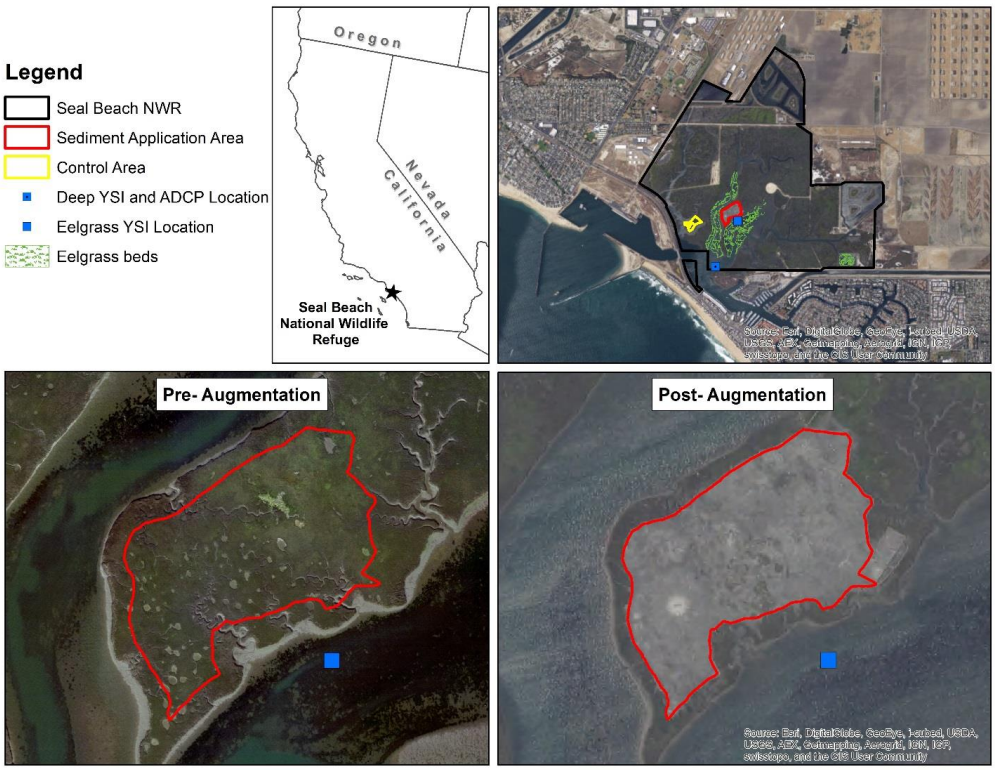

Figure 1. Sediment augmentation and control study areas shown in relation to turbidity monitoring instrumentation and eelgrass habitat within the Seal Beach National Wildlife Refuge. Aerial imagery showing photographic changes of sediment application; Bottom-right: pre-augmentation, Bottom Left: post-augmentation.

Methods

Sediment fluxes and turbidity

Figure 2. A YSI was deployed in an eelgrass bed adjacent to the sediment application site.

Turbidity was measured with YSI multi-parameter sondes at the eelgrass bed and deep channel sites (Figure 1**Figure** and Figure 2). Prior to deployment, sondes were calibrated to a standard turbidity solution. During two deployments between January 2017 and March 2017, a poor turbidity standard was used due to a manufactured error, and turbidity data were corrected with new information. Sondes were recovered, cleaned, and re-deployed approximately every 1-3 months for continuous monitoring. Turbidity data were carefully scrutinized, so that periods characterized by biological fouling and short-term interference were omitted for further analysis. Data processing, time series analysis of turbidity data, and other summary statistics were completed in Matlab 2014a.

After sondes were deployed, water samples were collected opportunistically from a boat with van dorn samplers. Samples were taken adjacent to sensors during a predicted turbidity measurement (i.e., every 15 minutes). Suspended sediment and loss on ignition data from each 1 L sample were analyzed at the U.S. Geological Survey California Water Science Center, Santa Cruz, California. Turbidity data were calibrated to suspended sediment via linear regression in Matlab 2014a.

Relative inundation and flow velocities were measured with Nortek aquadopp current profiler (ADCP, Figure 3). Combined with the instantaneous turbidity values, which were calibrated to collected suspended sediment data, the flow parameters were used to calculate sediment fluxes in Matlab 2014a. Concurrently, absolute inundation data were collected at the eelgrass and deep channel with additional water level loggers, measuring levels in North American Vertical Datum of 1988 (NAVD88). Relative water level data were calibrated to absolute water levels via linear regression in Matlab 2014a. This data set allowed us to calculate the percent of time that the augmentation and control sites were inundated.

Figure 3. ADCP were downloaded and calibrated with water samples.

Results

Water samples, turbidity, and sediment fluxes

Turbidity was calibrated to SSC (Figure 4) according to the following equation:

$$SSC = 2 * (NTU) - 0.42 \quad (1)$$

Mean flux measured in the deep channel after demobilization was -0.04 g/m2/s, suggesting that sediment from the augmentation site has not been flowing out of the marsh complex (Figure 5-7 and Table 1). Mean SSC at the deep site was 6

and 7 mg/L before and after construction, while post-construction mean SSC at the eelgrass site was 2.4 times greater than pre-construction levels (Pre=4 mg/L; Post= 10 mg/L). Storms, which can lead to elevated SSC and sediment fluxes, were common during the post-construction period. Mean SSC was greatest at both the eelgrass site (16 mg/L) and deep site (33 mg/L) during a storm on Jan 22, 2017, which yielded 9.3 cm (3.7 in) of rain (Table 2**Error! Reference source not found.**). During that extreme storm, the sediment import rate was 0.3 g/m2/s (Table 2). After construction the control site experienced the same inundation regime, whereas the augmentation site was inundated less compared to both pre construction conditions and the control site. The highest parts of the augmentation site were almost never inundated after construction (Table 3).

Conclusions

Monitoring of turbidity and sediment fluxes before, during, and after construction showed that the turbidity impacts were localized, relatively small and short lasting after one year of post demobilization monitoring, while the restored marsh surface seems to have stabilized as well during this same time period. During augmentation the switch from an 8” pipe to a 12” pipe to increase the rate of sediment application caused an increase in sediment runoff and is believed to be responsible for sediment covering nearly a hectare of eelgrass adjacent to the augmentation site. Comparing pre and post construction turbidity levels at the deep YSI site, as well as pre-construction turbidity levels at the eelgrass site, elevated post-construction turbidity at the eelgrass site suggest that there may be lingering

impacts from augmentation. We speculate that this elevated turbidity, which is still low relative to other regional salt marsh sites during other periods, may be related to an increased sediment supply in the eelgrass bed from construction and/or continued, chronic export of sediment to the eelgrass site from tidal creeks in the augmentation site. Although the post-construction surface elevation and accretion data from Surface Elevation Tables (SETs) suggest that subsidence may be the main factor in elevation loss of the marsh surface, erosion on the marsh surface and from tidal channel formation could also be accounting for some of the elevation loss as well as the elevated suspended sediment concentrations from post construction monitoring. Further research in the tidal channels within the augmentation site (i.e., not just adjacent to the site) could provide direct evidence on how much, if any, sediment is leaving the augmentation site. Another area needing further research is the elevation of the adjacent mudflats and subtidal areas and the changes in elevation over time. The pre-elevation survey of the adjacent subtidal areas was five years before the augmentation occurred and unfortunately cannot provide an accurate elevation change model showing the impact of the augmentation from the post augmentation elevation surveys. More post elevation surveys could provide insight into how the elevation of these subtidal areas is changing and the corresponding changes in suspended sediment concentrations. We believe there is a lot of added sediment to the mudflat and subtidal areas adjacent to the augmentation site and better pre and post evaluation of these areas will be important in future augmentation projects.

Tables

Table 1. Instantaneous SSC and sediment fluxes averaged across date range of activities.

Activity/Period	Start	End	Mean SSC (mg/L) at Eel Site	Mean SSC (mg/L) at Deep Site	Mean Flux (g/m2/s) at Deep Site
Pre-Construction	11/17/2014	1/3/2016	4	6	-0.38
Hay Bale Install	1/4/2016	3/22/2016	11	7	-0.28
Spray with 8in Pipe	1/22/2016	3/13/2016	10	7	-0.30
Add 33,238.10 ft2	1/22/2016	2/19/2016	9	6	-0.17
Add 116.946.91 ft2	2/20/2016	3/17/2016	14	7	-0.43
Spray with 12in Pipe	3/14/2016	4/4/2016	33	7	0.01
Add 184,512.00 ft2	3/18/2016	4/4/2016	36	7	0.05
Silt Fence Install	3/21/2016	3/22/2016	40	10	0.14
Demobilization	4/5/2016	4/7/2016	36	5	0.26
Post-Construction	4/8/2016	8/23/2017	10	7	-0.04

*negative flux values indicate export

Table 2. Instantaneous SSC and sediment fluxes averaged across date range of storms after demobilization.

Date of First Storm	Precip (in/day) from CIMIS #174	Mean SSC (mg/L) at Eel Site	Mean SSC (mg/L) at Deep Site	Mean Flux ($g/m^2/s$) at Deep Site
11/21/16	0.6	2	6	-0.3
12/16/16	0.6	5	8	-1.1
12/21/16	0.6/0.8/1.1	1	7	-0.3
01/05/17	0.5	1	2	-0.1
01/09/17	0.6	3	3	-0.3
01/12/17	0.7	5	5	-0.7
01/19/17	0.7/1.2	5	13	-0.1
01/22/17	3.7	16	33	0.3
02/06/17	1.1	6	6	-0.2
02/17/17	2.3	7	6	0.2

*negative flux values indicate export

**Storm was defined as one or more consecutive days of rain with at least 0.5in/day of precipitation

Table 3. Changes in salt marsh inundation time across sites, as well as before and after construction periods.

Site (Period)	Inundated Above Min Elevation (%)	Inundated Above Max Elevation (%)	Inundated Above Mean (%)
Control (Pre-construction)	27.2	3.0	7.9
Augmentation (Pre-construction)	16.0	3.1	5.2
Control (Post-construction)	37.6	3.2	9.2
Augmentation (Post-construction)	13.2	0.1	2.3

Figures

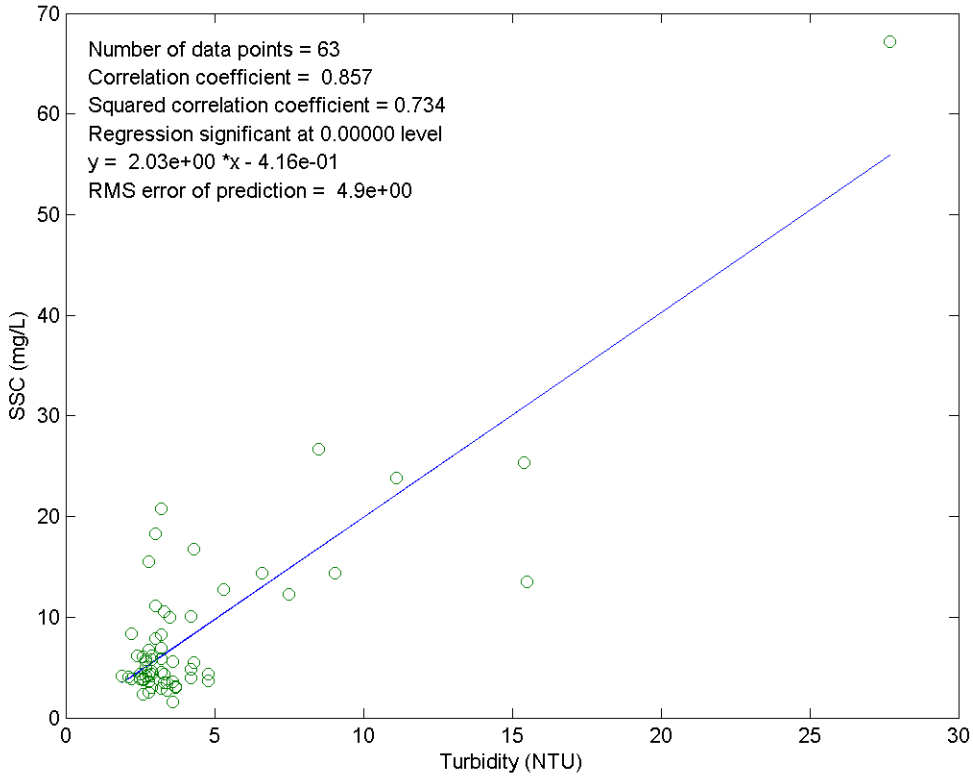

Figure 4. Relationship of suspended sediment concentration (SSC) to turbidity (NTU).

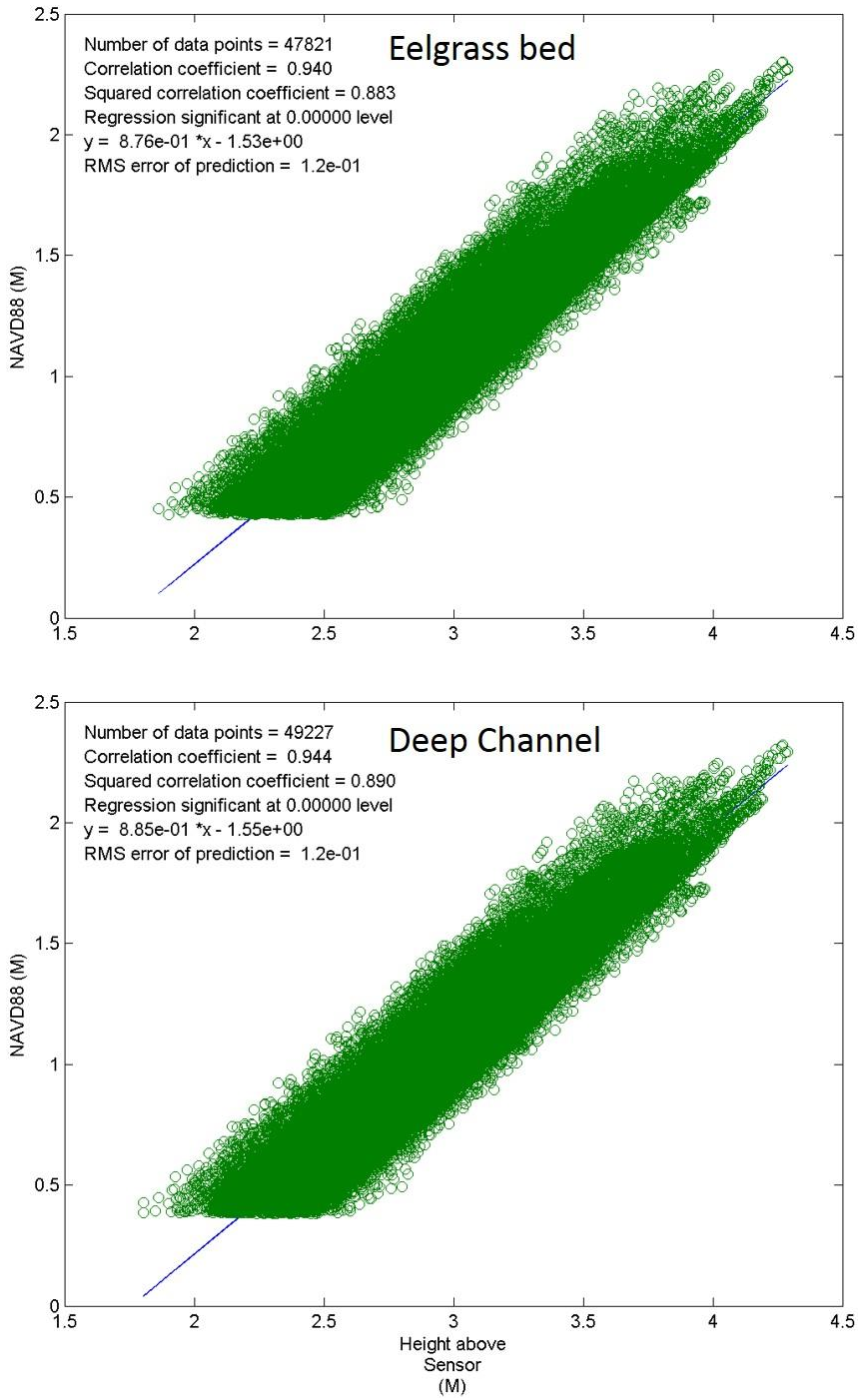

Figure 5. Relationship between water levels measured at the eelgrass bed and deep channel (NAVD88 (m)) to the relative water levels measured at the ADCP in the deep channel.

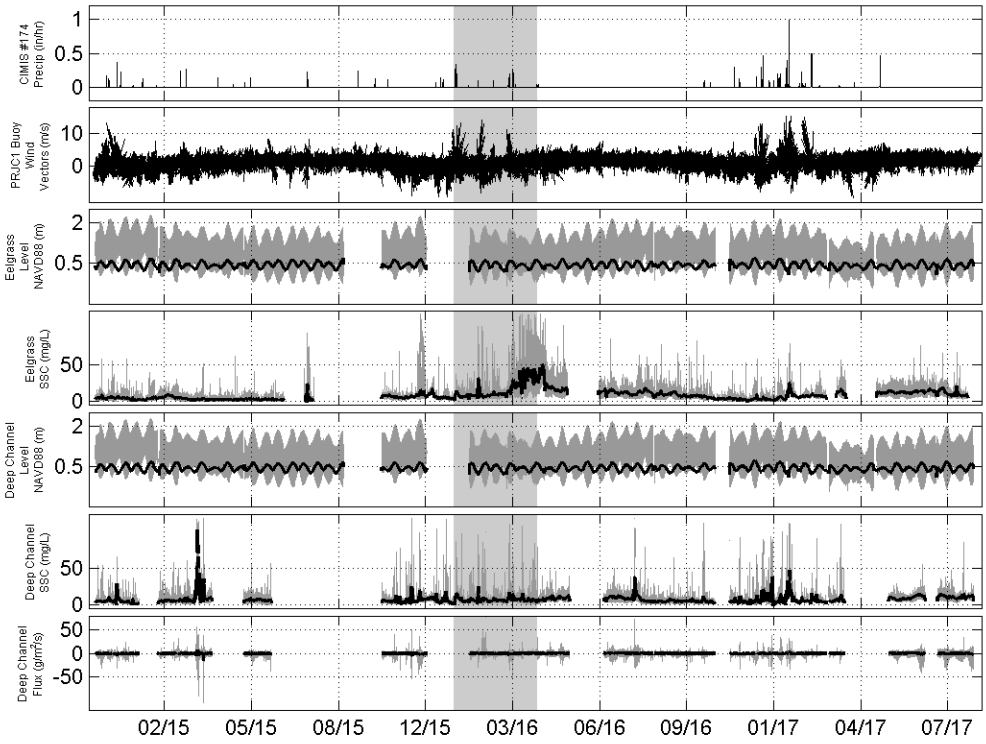

Figure 6. Time series plots showing precipitation, wind speed and direction, water levels, suspended sediment, and sediment flux. Black lines for water levels indicate the root-mean-squared value for water levels, while black lines for suspended sediment concentrations and sediment fluxes indicate the low-pass-filtered values. Gray patch indicates period extending from the beginning and end of thin-layer application activities.

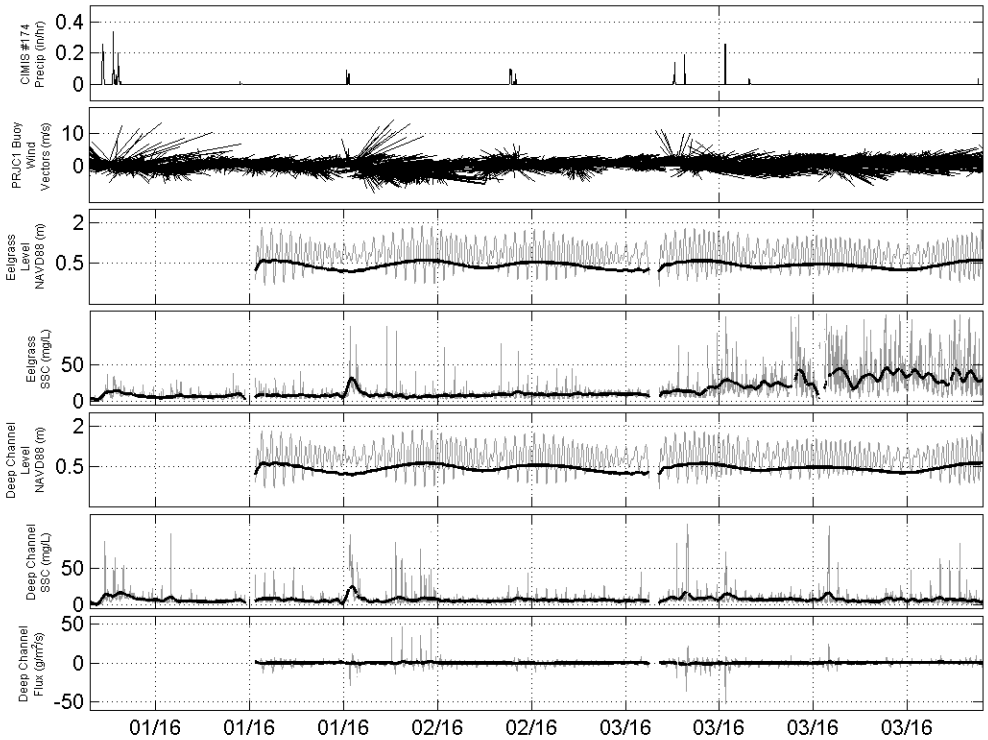

Figure 7. Time series plots for the sediment application period (January 2016 through March 2016) showing precipitation, wind speed and direction, water levels, suspended sediment, and sediment flux. Black lines for water levels indicate the root-mean-squared value for water levels, while black lines for suspended sediment concentrations and sediment fluxes indicate the low-pass-filtered values. Gray patch indicates period extending from the beginning and end of thin-layer application activities.

Thin-Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge: Dec 31- April 10, 2018

QUARTERLY PROGRESS REPORT

April 10, 2018

Principle Contact: Dr. Karen M. Thorne, 916-502-2996, kthorne@usgs.gov

Team: Chase Freeman, Karen Backe, Tesia Forstner

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Pickleweed growing into the SET SBA1 plot Area

Summary

- Monitoring of surface elevations continued at the augmentation site and the control site, while monitoring of sediment fluxes was ended in August of 2017 at both the sites, adjacent to the control site (deep channel site) and near the augmentation site (eelgrass site).
- Using Surface Elevation Tables (SETs) an initial surface elevation loss has been documented at the Augmentation SETs, presumably from a combination of compaction of the marsh platform and sediment being suspended during high tides and leaving the marsh.
- Surface elevation tables were measured during a January 29th 2018 site visit for this quarterly report time period.
- Elevation pin measurements showed that the augmentation site continued a gradual decrease in elevation dropping on average -0.94 mm across all fifteen SETs; while the control site also showed a small decrease of -1.34 mm across its six SETs. The original SETs (n=4) however showed an increase of 0.67 mm (Figure 1).
- Control SETs have had gains and losses of elevation since installation, but have a mean cumulative increase of 3.22 mm from the date of installation (Figure 2). Augmentation SETs had a mean increase in elevation of 216 mm with sediment application, but had a decrease in elevation of -82.19 mm post sediment application (April 2016-January 2018; Figure 1).
- The feldspar readings showed an increase in sediment above the feldspar layer during this time period for the augmentation site with an increase of 8.61 mm.

However, overall post monitoring has showed little overall change in depth of the feldspar layer with a small decrease of -1.92 mm averaged across all 15 SETs. This finding shows that the majority of elevation decreases shown in the elevation pin measurements is most likely due to the original marsh surface compacting below the feldspar marker horizon.

- Feldspar readings at the control site showed a small increase of 2.33 mm, whereas the original SETs showed an average decrease of -7.08 mm.
- Taking into account the time period we can look at this raw data as a rate of change over time to better see the trends in the data. Currently the augmentation marsh has 50.61 mm/yr rate of change due to the sediment application. However, due to subsidence or sediment leaving the marsh the post augmentation time period has a -36.78 mm/yr rate of change. Whereas, the control site has a 1.70 mm/yr rate of change and the original SETs have a 1.94 mm/yr rate of change (Figures 2-4). These trends are similar for the feldspar data.

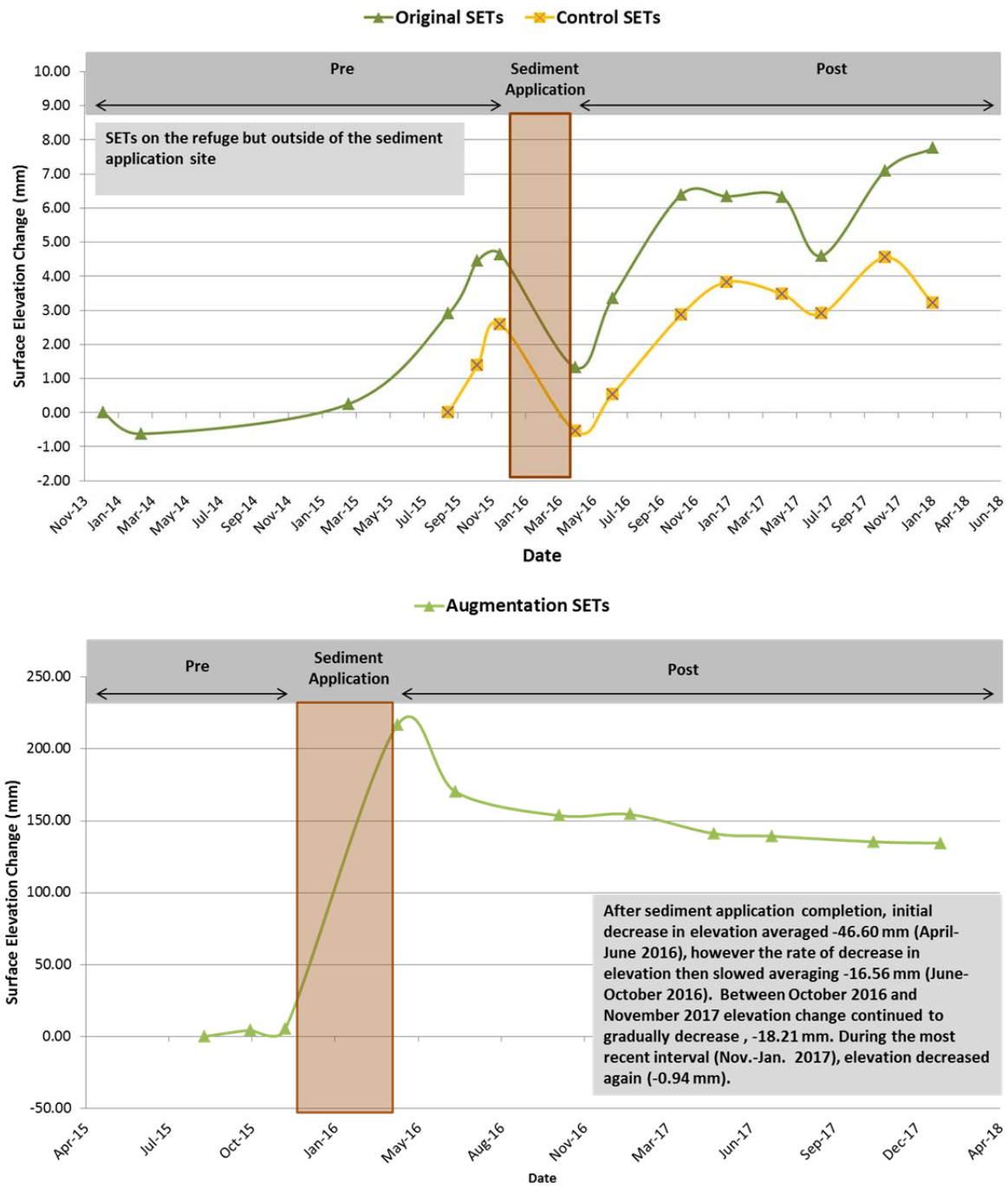

Figure 1. Mean surface elevation change at control site (above) and augmentation site (below).

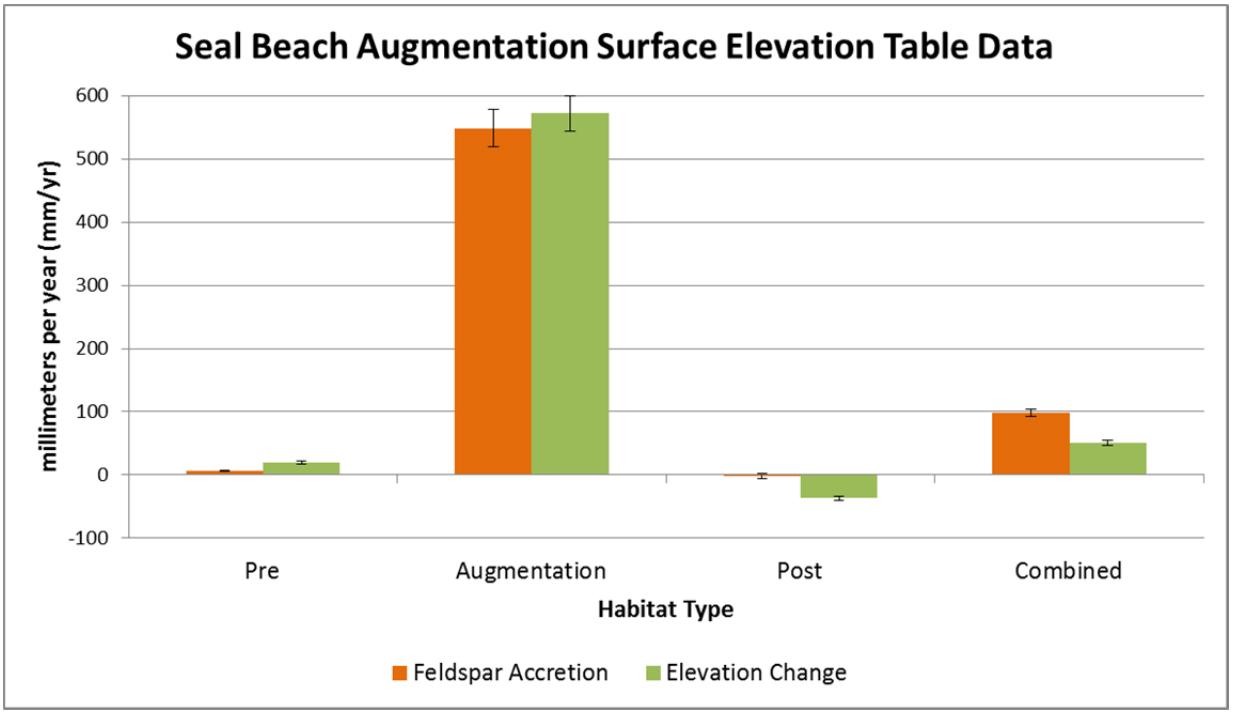

Figure 2. Sediment augmentation site rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion) for different time periods of the augmentation project.

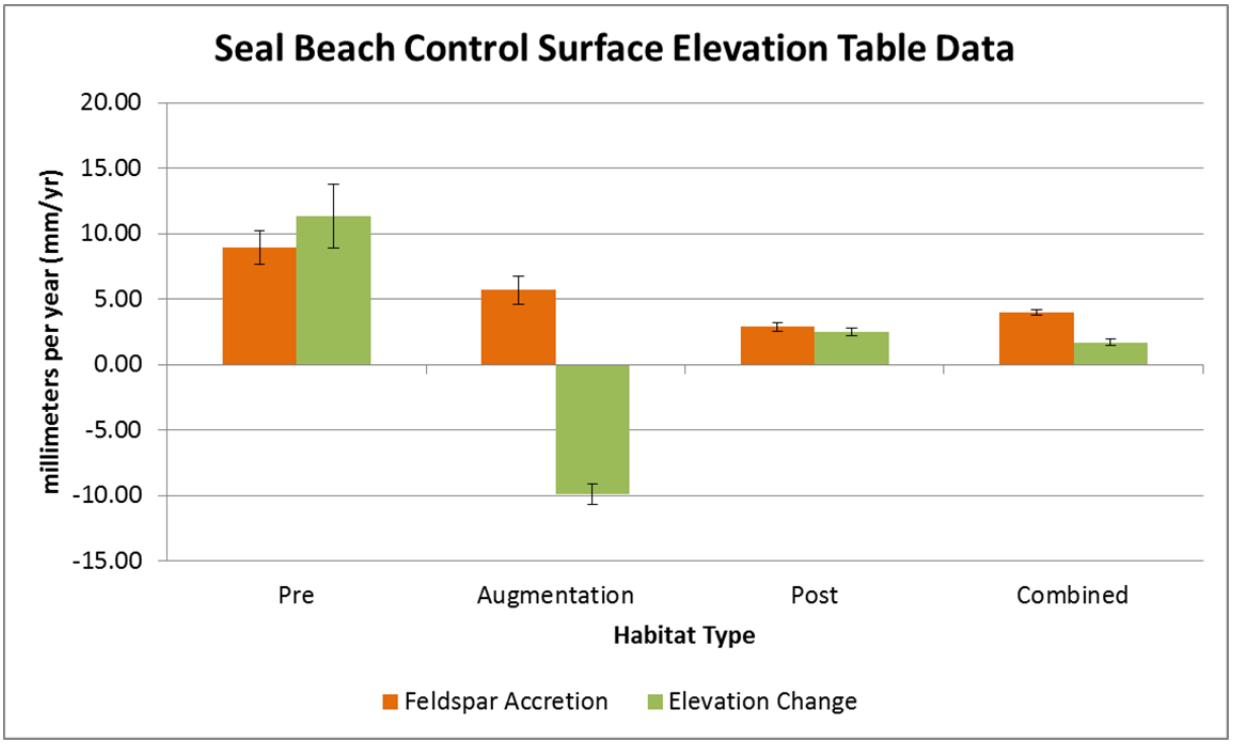

Figure 3. Control site rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion) for different time periods of the augmentation project.

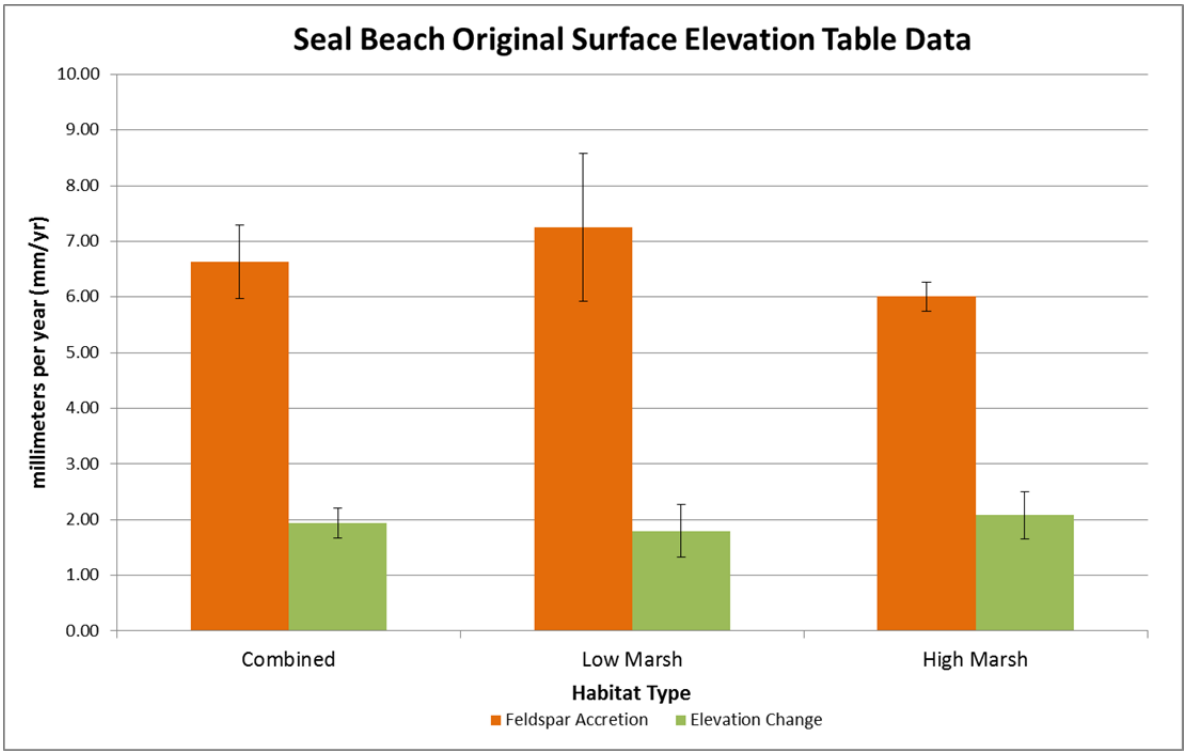

Figure 4. Original Seal Beach SETs rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion).

Attachment 1
Itemized Cost Share Accounting

Cost Share (June 1, 2015 to March 31, 2018)		
Activity or Item[1]	Funding Source	Expenditure
Total Cost Share from June 1, 2015 to September 30, 2016		
Pre and Post-augmentation monitoring[1]	California State Coastal Conservancy	$177,070
Purchase boat to access site	USFWS CRI Grant	$2,425
RTK elevation survey	US Army Corps of Engineers	$50,252
USFWS staff time[2]	USFWS CRI Grant	$137,592
Sediment augmentation[3]	Orange County Parks	$670,500
Sediment augmentation	USFWS CRI Grant	$350,000
	Subtotal	**$1,387,839**
Total Cost Share from October 1, 2016 to December 31, 2016		
Post-augmentation monitoring	California State Coastal Conservancy	$50,198
USFWS staff time[2]	USFWS CRI Grant	$10,575
	Subtotal	**$60,773**
Cost Share from January 1 – March 31, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$42,225
USFWS staff time[2]	USFWS CRI Grant and Station Funds	$1,071
	Subtotal	**$43,296**
Cost Share from April 1 – June 30, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$26,539
USFWS staff time[2]	USFWS CRI Grant and Station Funds	$9,201
	Subtotal	**$35,740**
Cost Share from July 1 – September 30, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$112,790
USFWS staff time[2]	USFWS CRI Grant[4] and Station Funds	$1,867
	Subtotal	**$114,657**
Cost Share from October 1 – December 31, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$38,702
USFWS staff time[2]	USFWS Station Funds	$500
	Subtotal	**$39,202**
Cost Share From January 1 – March 31, 2018		
Post-augmentation monitoring	California State Coastal Conservancy[5]	$1,170
USFWS staff time[2]	USFWS Station Funds	0
		Subtotal $1,170
	Total Cost Share to Date	**$1,682,677**

[1] Costs associated with bird surveys and light-footed Ridgway's rail monitoring are not included.
[2] This does not include staff time accounted for on monthly invoices.
[3] The bids for sediment augmentation came is much higher than estimated by the project engineer, therefore, some of the cost for sediment augmentation was covered by the Orange County Parks.
[4] As of September 30, 2017, all USFWS CRI Grant funds have been expended and the grant is closed.
[5] All Coastal Conservancy costs were revised in March, 2018 to reflect the full amount expended rather the showing the cost less the 10% held by the Conservancy during each billing (this will avoid confusion in the future).