QUARTERLY REPORT

April 1, 2019 – June 30, 2019

Date: August 19, 2019

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 Invoiced for Services through June 30, 2019†	Total Amount Remaining
CDFW GGRF Grant Funds	$1,055,827	$580,268	$475,559
Cost Share	$1,306,048	$1,753,775*	<$447,727>
Agreement Totals	$2,361,875	$2,300,517	$475,559‡

† Includes Invoices 38-2019, 39-2019, 40-2019, enclosed.
* See itemized cost share expenditures presented in Attachment 1B.
‡ Cost Share agreements have already been achieved and are therefore not included in this total.

PROGRAM/TECHNICAL REPORT

Project Overview

The Seal Beach National Wildlife Refuge (Refuge or NWR) Thin-Layer Sediment Augmentation Project is the first project of this kind to be implemented on the Pacific Coast. The primary goal of the project is to test the benefits of thin-layer sediment augmentation as a sea-level rise adaptation strategy for ensuring the long-term availability of coastal salt marsh habitat for carbon sequestration, as well as for the conservation of listed and sensitive species that are dependent on coastal salt marsh habitat for their existence. Design and implementation of the project and its associated research components represents a collaborative effort involving public agencies, educational/research institutions, and volunteers. The project team includes the U.S. Fish and Wildlife Service (Service), Naval Weapons Station Seal Beach, U.S. Army Corps of Engineers (ACOE) Engineer Research and Development Center, U.S. Geological Survey (USGS) Western Ecological Research Center, California Department of Fish and Wildlife (CDFW), California State Coastal Conservancy, County of Orange Parks, researchers from the University of California, Los Angeles (UCLA), California State University, Long Beach (CSULB), and Chapman University, and volunteers from the Friends of the Seal Beach NWR.

The application of sediment to approximately 7.9 acres of the designated augmentation site was completed in April 2016. Post-augmentation monitoring began immediately to evaluate the reestablishment of invertebrates, vegetation, and bird use on the site, as well as to observe elevation changes on the site over time. Identical surveys are also conducted on a 2.5-acre control site. Other analysis includes observations of tidal creek formation over time, nutrient analysis of porewater and sediment, and evaluation of nutrient levels and leaf mass area for Pacific cordgrass (*Spartina foliosa*). In April 2019, we completed year three of our post-augmentation monitoring. Pre- and multiple year post-augmentation monitoring plan is essential to the evaluation of the project goal of successfully raising the elevation of the marsh plain to support cordgrass and associated salt marsh species.

The team will also provide a thin-layer sediment augmentation guidance document that describes this "proof-of-concept" project. The guidance will include a description of the procedures and techniques employed to achieve sediment depths and minimize movement of sediment offsite (including the effectiveness of all tested procedures and lessons learned), details about the lessons learned, and data and overall results of the biological and physical monitoring program. This information will be disseminated to interested parties to facilitate future thin-layer sediment augmentation projects along the California coast.

Summary of Activities Performed from April 1, 2019 to June 30, 2019

Monitoring

Monitoring during this quarter included:

- collecting SET and feldspar plot data by USGS;
- conducting 3 years post-sediment application surveys of invertebrates and plants, along with photosynthesis assessments, in April by CSULB;
- surveying existing tidal creeks and sampling feldspar plots in the control site (4 creek crossings and 15 feldspar plots), and conducting 3 years post-sediment application sampling of sediment accretion, feldspar plots, and bulk density plots, and surveying the extent of tidal creek formation at the Augmentation Site (73 sediment stakes, 23 feldspar/bulk density plots, 8 creek crossings) in April by UCLA;
- conducting light-footed Ridgway's rail call count in March; and
- conducting monthly surveys of shorebird presence on the augmentation site in April, May, and June.

Summary of Site Conditions for this Quarter

Staff Site Visit. On June 6, 2019, Refuge Manager Rick Nye and Refuge Planner Vicki Touchstone were joined by Erin Aquino-Carhart, CDFW Environmental Scientist, to evaluate the progress of revegetation on the site.

We observed *Salicornia biglovii*, an annual pickleweed, growing in nearly every location of the augmentation site (Figure 1). This pickleweed was also observed growing at higher densities near the edge of the augmentation site, around areas where the sediment had been disturbed

post augmentation, and where the contents of sandbags used to retain sediment during the augmentation process had been emptied onto the site (Figure 2).

Although *Batis maritima* (saltwort) is primarily growing near the outer edges of the augmentation site, several plants have been observed growing within the interior of the site (Figure 3).

Figure 1. Annual pickleweed density decreases from edge toward middle of the site.

Figure 2. Annual pickleweed growing in areas where sand from emptied sandbags was deposited on the site.

Figure 3. *Batis* growing in an area near the center of the site.

Figure 4 illustrates the density of vegetation that has established near the south end of the project site. However, the overall establishment of *Spartina foliosa* (cordgrass) continues to be slow, with little expansion since the last growing season. Although not necessarily related, Refuge staff has noted that cordgrass presence throughout the marsh complex appears to be declining. For example, several areas within the Refuge where last year the cordgrass was thick enough to provide shelter for a rail nesting platform are now dominated by pickleweed, making them less than ideal sites for encouraging rails to nest. The reason for this transformation from cordgrass to pickleweed is currently unknown.

Figure 4. Cordgrass mixed with annual pickleweed at the southern end of the site.

Site Elevations. USGS continued monitoring the surface elevations at the augmentation site and the control site, with the latest measurements from the surface elevation tables (SETs) taken on April 24, 2019. According to the USGS July 10, 2019 report (Attachment 1), the augmentation site has had a gradual average decrease in elevation of -4.51 mm across all fifteen SETs over this quarterly time period; while the control site also showed a slight decrease of -1.63 mm across its six SETs. The original pre-augmentation SETs (n=4) also showed a similar decrease of -1.69 mm.

The feldspar readings showed a decrease in sediment above the feldspar layer during this quarterly time period for the augmentation site with a decrease of -11.79 mm. However, overall post monitoring since the completion of construction has showed little overall change in depth of the feldspar layer with a small decrease of -30.58 mm averaged across all 15 SETs. Feldspar readings at the control site showed a negligible decrease of -0.28 mm over this quarterly time period, whereas the original SETs feldspar readings showed an average increase of 3.68 mm.

Figure 5. Taken June 6, 2019 following a high tide.

Figure 6. Close up of cordgrass and annual pickleweed on the augmentation site in June 2019.

Figure 7. Cyanobacteria and green algae were still present in June 2019 in some areas of the site.

Bird Surveys. Rick Nye conducted three shorebird surveys during this period, with few birds observed when he was present.

Project Management

A research team conference call was conducted by Rick Nye, Refuge Manager, on June 26, 2019. Major topics included removing the remaining sandbags and geotextiles from the augmentation site, identifying funding for and implementing a monitored revegetation plan for a portion of the augmentation site to examine the benefits of planting cordgrass as a means of accelerating the revegetation process following augmentation. Also discussed were the results of spring monitoring efforts and plans for additional monitoring in September.

Rick Nye replaced the close-up time-lapse camera using the same model as before. The old camera was starting to show some wear due to the accumulation of moisture inside the case. Despite its condition, he was able to download the pictures from the previous period. Unfortunately, some of the images were taken as 5-second videos instead of photographs.

Project Outreach/Information Dissemination

A webpage (https://www.fws.gov/refuge/seal_beach/what_we_do/ resource_ management/ Sediment_Pilot_Project.html) for the project is maintained on the Seal Beach NWR website. Information about the sediment augmentation project is posted and progress on the project is updated periodically. Quarterly reports prepared for CDFW are also posted, and photos and links to time lapse photography are provided. The page also acknowledges our funding partners.

Elizabeth Murray, U.S. Army Corps of Engineers, Engineer Research and Development Center, presented a discussion on thin-layer placement, including information about the Seal Beach NWR project, at the Society of Wetland Scientists, held in Baltimore, Maryland on May 28 through 31, 2019. Christine Vanzomere, U.S. Army Corps of Engineers, who visited the site in December, has prepared two videos on sediment augmentation; one addresses iron sulfides and the other addresses the Seal Beach sediment augmentation project. They have not yet been posted for viewing. Finally, the Long Beach Post ran an article (attached) on April 22, 2019 about the project entitled "Nature can soften impact of rising seas – if we let it."

Status of Ongoing Research

UCLA (Sediment Coring)**.** UCLA researchers under the direction of Dr. Glen MacDonald completed their analysis and prepared the final results of their assessment of pre-augmentation net sediment accretion rates, carbon stock, carbon accumulation rates, and historic sea-level rise on the Seal Beach NWR from historic sediment core data. The final report (Brown et al. 2018) was provided with the last annual report for the project.

Chapman University (Greenhouse Gas Flux)**.** Sampling to measure seasonal emissions of CO_2, CH_4, and N_2O and associated abiotic parameters (i.e., water level, porewater salinity, sulfate and nitrate) in the three dominant plant communities at Seal Beach NWR, including the project site pre- and post-augmentation, has been completed. Dr. Jason Keller and his team are preparing their final report.

UCLA (Changes in Marsh Plain Post-Augmentation)**.** Under the direction of Dr. Richard Ambrose, sediment thickness has been sampled at multiple locations distributed across the project area. The two types of sampling stations include consolidated stations including feldspar plots, sediment stakes and bulk density sampling locations, and sediment stake stations. The study of the development of tidal creek formation on the site has also been initiated.

In April 2019, UCLA completed the 36-month field sampling for the project. Data collected at the control site included measuring creek cross-section elevations at four creek crossings and measurements of sediment accretion at 15 feldspar plots. On the augmentation site, sediment accretion data was collected by measuring sediment stakes and feldspar (deep and shallow) plots, involving 73 sediment stakes and 23 feldspar/bulk density plots. Bulk density samples were also collected for lab analysis, and creek cross-section elevation data was collected at eight creek crossings on the augmentation site.

UCLA also completed the laboratory work on the acquired samples from the feldspar/bulk density plots to determine bulk density and percent organic carbon. Grain size analysis was also conducted. Graphs were updated to include data from most recent sampling effort and data organization and management on the UCLA online server (BOX) was also accomplished.

To improve data collection related to tidal creek development, Dr. Ambrose has also been preparing an application to the Navy to obtain permission to use a drone to collect digital elevation data. This will enable better characterization of tidal creek development.

CSU Long Beach (Plant and Invertebrate Studies). In April 2019, Dr. Christine Whitcraft and her students at CSULB completed spring 2019 post-augmentation surveys of invertebrates and plants, and conducted photosynthesis assessments. Data collection included invertebrate samples, plant cover and species, and photosynthetic measurements on *Spartina foliosa.* Additional sediment samples for grain size and organic matter were also collected.

The priority of sorting invertebrates for top 2 cm samples and identifying them has been completed for all samples collected including fall 2018 samples. Processing of spring 2019 samples has started. Invertebrate vouchers are in process for identification to lowest taxonomic level. In addition, sorting of the bottom 4 cm samples for all prior time points continues.

Samples from fall 2018 have also been run to determine grain size. Porewater nutrient samples gathered from Chapman University are being run for nutrients in collaboration with the CSULB Geology Department. Leaf area measurements from *Spartina* leaves are being analyzed on the LiCor Leaf Area Meter.

The results of laboratory analysis of grain size from the sediment samples collected in fall 2018 are provided in Figure 8. This analysis was conducted in areas supporting *Batis maritima* and *Spartina foliosa* at the control site and in areas at the augmentation site supporting *Batis maritima* and *Spartina foliosa*, as well as at the location of a pre-augmentation pond site within the project area. All of the samples collected from the augmentation site continue to include high percentages of sand, with significantly less clay and silt content than the samples taken from the control site.

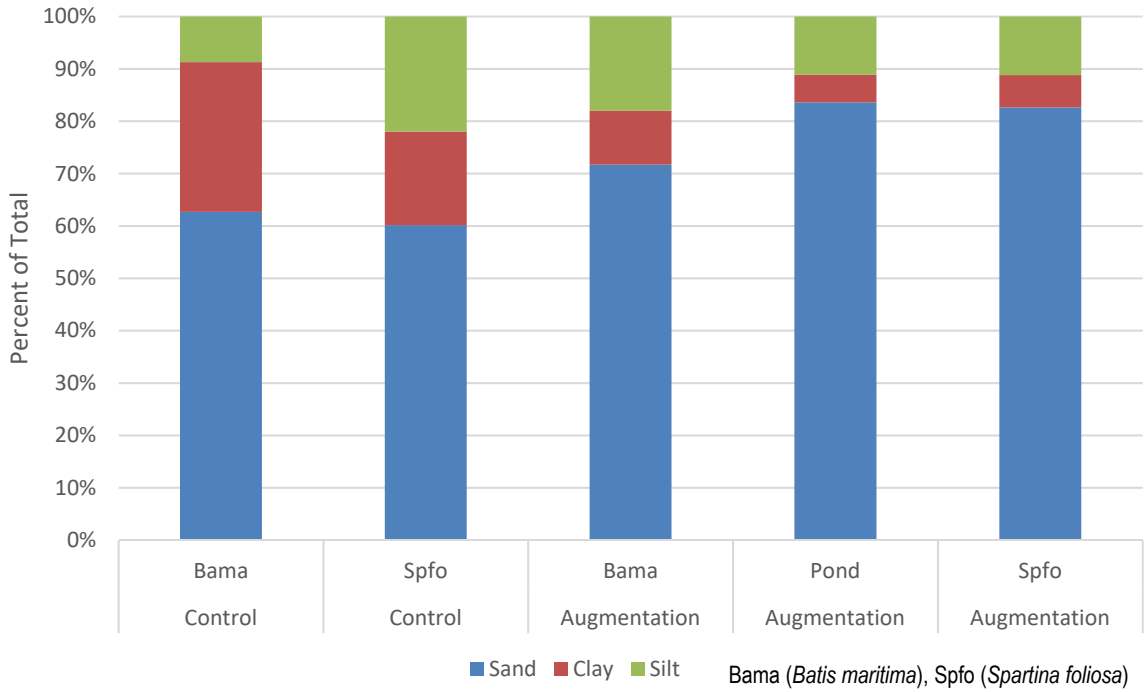


Figure 8. Results of grain size analysis from samples collected in fall 2018.

Invertebrate samples are still being processed for final invertebrate identification, but preliminary data indicate that abundance and species richness are still significantly lower than in the control areas. Community composition also remains significantly different in all three habitats between the control and augmentation sites (Figures 9a, 9b, and 9c).

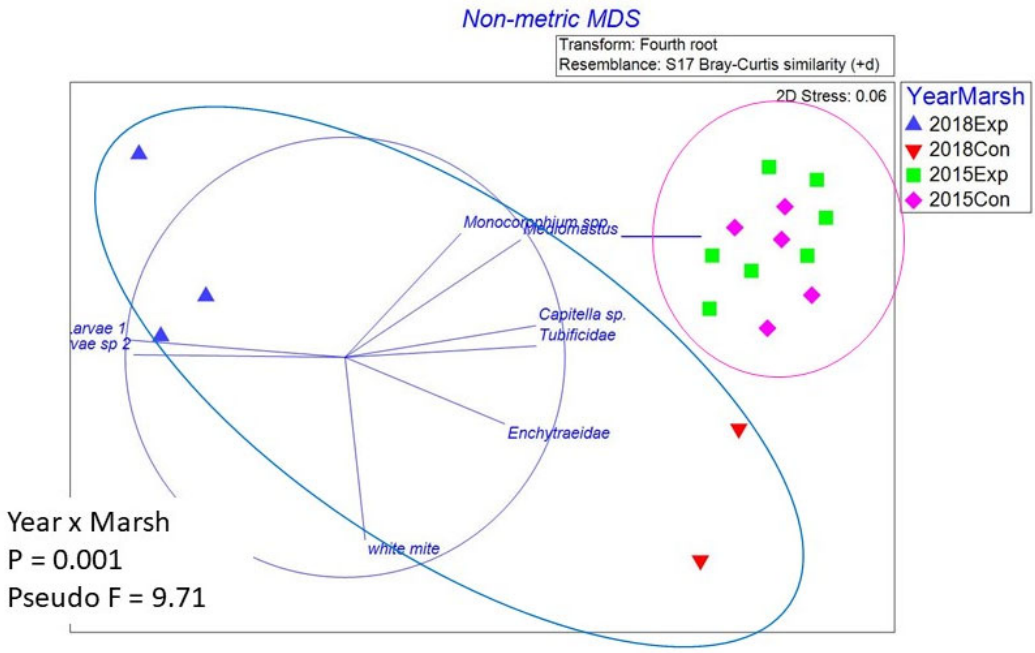


Figure 9a. *Spartina folisa* habitat

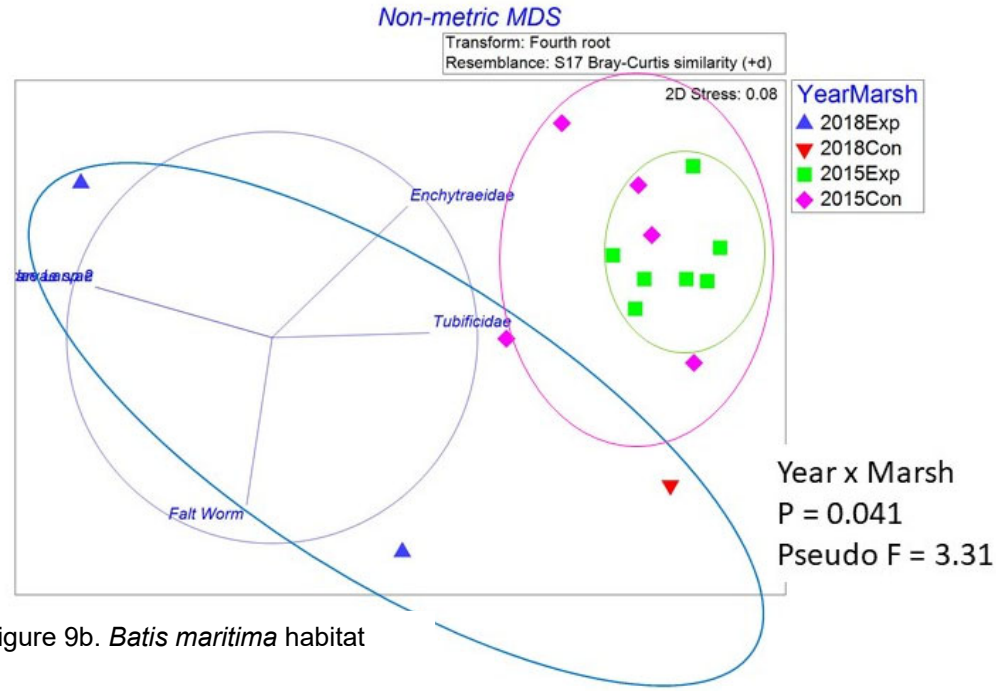


Figure 9b. *Batis maritima* habitat

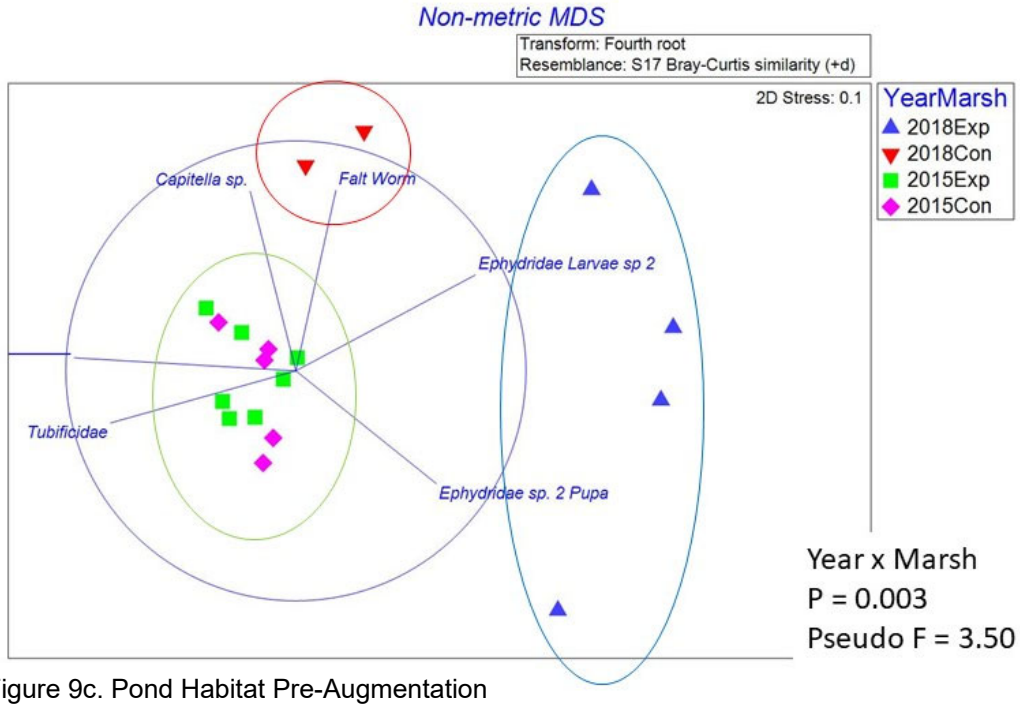


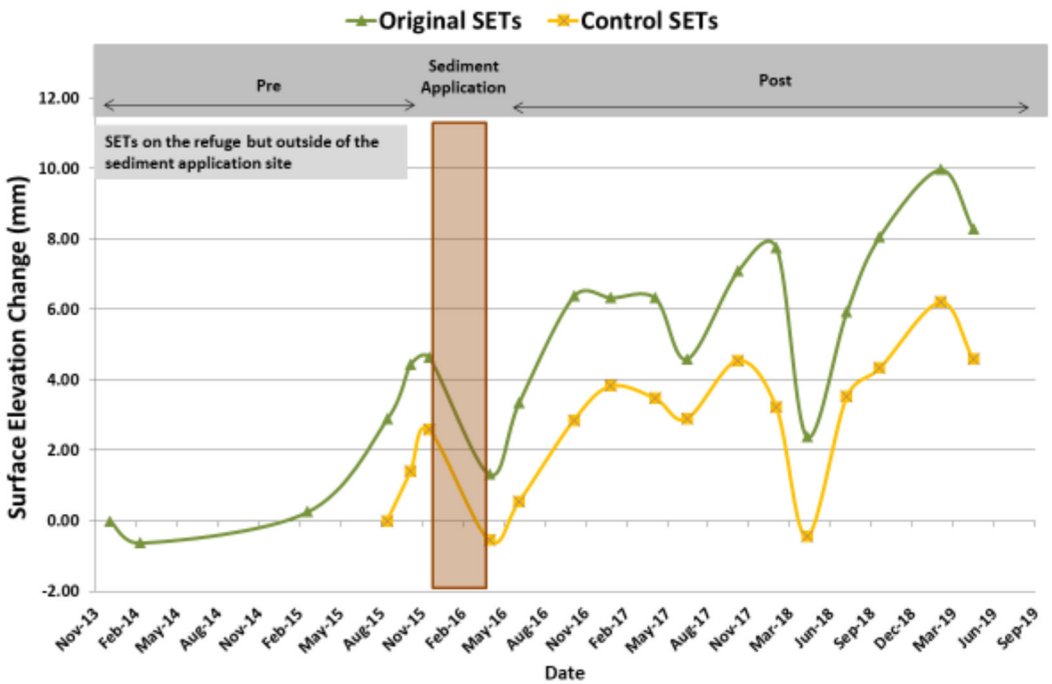
Figure 9c. Pond Habitat Pre-Augmentation

Figures 9 a, b, and c. Preliminary community composition analysis of different vegetative areas within the control and augmentation sites. Circles indicate significant differences among locations.

USGS (Sediment Flux Patterns and Sets). Between winter 2014 through the end of August 2017, USGS maintained two YSI EXO2 multi-parameter sondes (ysi) to monitor turbidity and a Nortek aquadopp current profiler (ADCP) to monitor inundation and flow velocities within tidal channels located in proximity to the augmentation site. A final report has been issued. USGS has also prepared an article entitled: *Thin-layer sediment addition to an existing salt marsh to combat sea-level rise and improve endangered species habitat in California, USA*. This article, provided as Attachment 2, is currently in press and will be published in Ecological Engineering.

Measurements at the Surface Elevation Tables (SETs) were taken on April 24, 2019. Elevation SET pin measurements showed that the augmentation site has had a gradual average decrease in elevation of -4.51 mm across all fifteen SETs since the last quarter, while the control site also showed a slight decrease of -1.63 mm across its six SETs. The original pre-augmentation SETs (n=4) also showed a similar decrease of -1.69 mm (Figure 10).

Control SETs have had gains and losses of elevation since installation but have a mean cumulative increase of 4.58 mm from the date of installation (Figure 11). Augmentation SETs had a mean increase in elevation of 216 mm with sediment application, but had a decrease in elevation of -94.75 mm post sediment application (April 2016-April 2019; Figure 10), and therefore a mean cumulative increase in elevation of 121.91 mm.



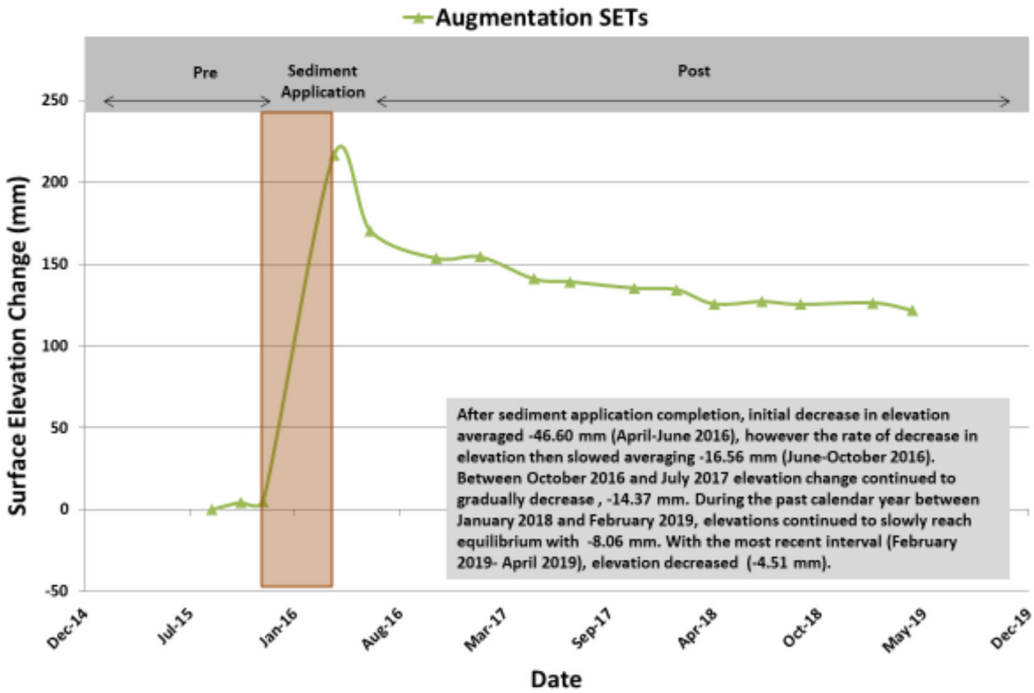


Figure 10. Mean surface elevation change at control site (above) and augmentation site (below).

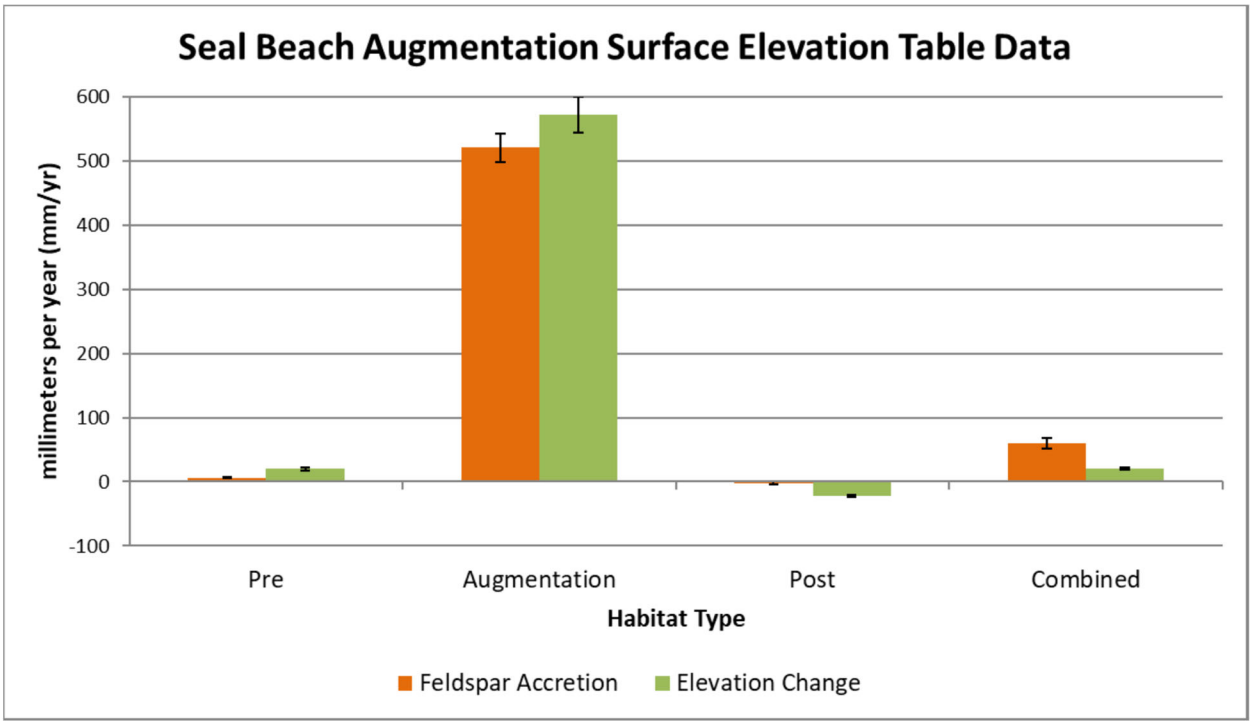


Figure 11. Sediment augmentation site rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion) for different time periods of the augmentation project.

Feldspar readings from the augmentation site showed a decrease in sediment above the feldspar layer during the same time period with a decrease of -11.79 mm. However, overall post monitoring since the completion of construction has showed little overall change in depth of the feldspar layer with a small decrease of -30.58 mm averaged across all 15 SETs. This finding demonstrates 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, while the rest could be due to the compaction, dewatering of the surface, or loss of the applied sediment.

Feldspar readings at the control site showed a negligible decrease of -0.28 mm over this period, whereas the original SETs feldspar readings showed an average increase of 3.68 mm. Taking into account the entire time period for the SET installations, this raw data presents a view of the rate of change over time. Currently, the augmentation marsh has a 20.27 mm/yr rate of change due to sediment application. However, due to subsidence or sediment leaving the marsh, the post augmentation time period has a -22.31 mm/yr rate of change. Whereas, the control site has a 1.27 mm/yr rate of change and the original SETs have a 1.63 mm/yr rate of change over the course of the entire study (Figures 11 - 13). These trends are similar for the feldspar data.

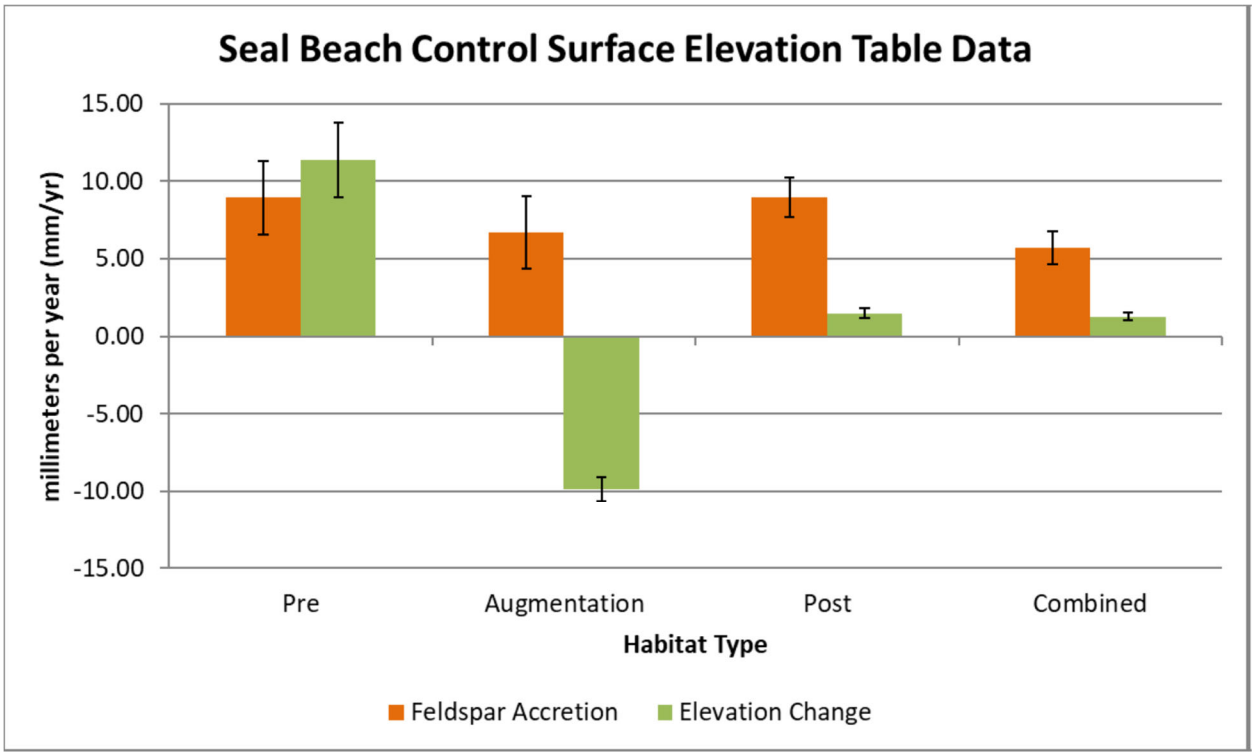


Figure 12**.** Control site rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion) for different time periods of the augmentation project.

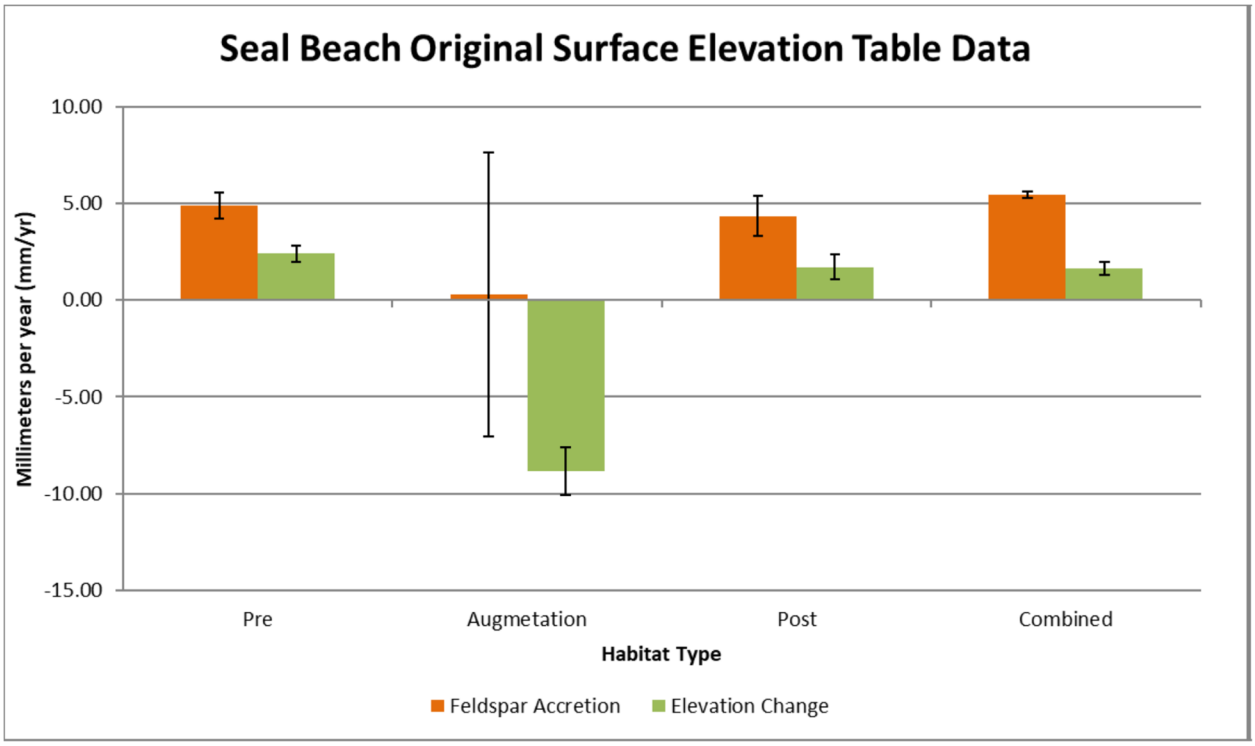


Figure 13. Original Seal Beach SETs rates of change in millimeter per year (mm/yr) calculated from pin measurements (elevation change) and feldspar measurements (feldspar accretion).

Bird Surveys and Light-Footed Ridgway's Rail Monitoring. Bird surveys were initially conducted twice monthly, during a high tide and a low tide, however, due to the timing of the surveys, observations were occurring when the site was either completely submerged or totally exposed. As a result, no birds were being recorded on the site during these surveys. To provide better bird data, the Refuge Manager initiated site-specific surveys for the augmentation site. These surveys are now being conducted during moderate falling and/or rising tides, and will continue throughout the remainder of the monitoring program.

Bird surveys were conducted three times during the last quarter. The number of birds observed was low (Table 1), which coincides with low bird counts throughout the Refuge at this time of year.

Table 1. Bird Surveys Conducted April - June 2019

Survey Date	17 Apr 19	10 May 19	6 Jun 19
Time	10:15 AM	6:15 PM	11:00 AM
Tides	1.33m (4.4-ft), falling	0.98m (3.2-ft), falling	0.78m (2.6-ft), rising
Caspian tern			
Black-necked stilts			
Willet			
Long-billed curlew			9
Whimbrel			
Ruddy turnstone			
Black bellied plover			
Least/western sandpiper			
Other sandpipers (*Calidris sp.)*			

Rail monitoring is conducted as part of a refuge-wide rail monitoring survey. Annual monitoring reports are prepared following the end of the rail nesting season. A high tide count is conducted in fall and a night call survey is conducted just prior to the start of the breeding season. Nesting data is obtained through monthly visits to the nesting rafts.

During the 2018 nesting season, 88 rafts were deployed at the Seal Beach NWR. Rafts and other nesting areas were visited every 3 - 4 weeks during the breeding season (March 26 – July 20). Surveys were conducted by two observers, who accumulated 131 field-hours over six rounds of raft checks. Direct evidence of breeding activity on the Refuge included the observation of 27 clutches of eggs laid on 26 rafts and 15 marsh hatches with subsequent brood nests built on 17 rafts. There were an additional 22 brood nests built on 22 rafts in 2018. Overall nesting success on rafts was 98 percent[1]. The 2018 call count was conducted on 9 March by nine observers when 21 pairs, 2 males, and 1 female were heard.

A total of 60 pairs of rails were reported at the Seal Beach NWR in 2016 and 2017. This was based on combine call count and raft nesting data for those years. In 2018, the total count of 43 pairs was down 28 percent from the past two years and is the lowest count since 2013.

[1] Zembal, R., S.M. Hoffman, J. Konecny, and B. Sabiston. 2018. Light-footed Ridgway's (Clapper) Rail in California, 2018. Report to US Fish and Wildlife Service and California Department of Fish and Wildlife.

Reductions in total pair counts between 2017 and 2018 were also observed at other rail nesting sites, with an overall reduction of 300 fewer breeding pairs, a 31 percent decrease from 2017 data.

During the 2018 nesting season, rail nesting and other activities were noted on 61 of the 88 available rafts. Although most of the estimated 43 pairs in the Refuge nested and brooded on rafts, at least 18 clutches probably hatched in the marsh. The proportion of the population nesting in natural cover may continue to rise if cordgrass vigor increases (Zembal et al. 2018).

Photogrammetry Flight Results. A second photogrammetry flight was conducted Aug 22, 2018. The data from this second flight provides site elevation data two years post-augmentation. Funding for the second flight was provided by the U.S. Army Corps of Engineers, Engineer Research and Development Center (ACOE ERDC). Analysis of this data is expected to occur during the next quarter.

Percentage of Task	
Task 1 – Project Management and Administration	80%
Task 2 – Sediment Augmentation	100%
Task 3 – Project Monitoring (overall)	91%
1) Carbon Storage/Sequestration Benefits	100%
2) Plant and Invertebrate Monitoring	85%
3) Pacific Cordgrass Analysis	85%
4) Site Elevations	90%
5) Sediment Analysis (compaction, movement, bulk density)	85%
6) Turbidity Levels	100%
7) Bird monitoring	85%
8) Eelgrass	100%
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[2]	90%
2) Workshops and/or Webinars	60%
Overall Project	**89%**

[2] This category also includes published technical articles related to the project.

Deliverables Completed for Each Task

Task 1 – Project Management and Administration

1) Quarterly Progress Report	16 reports
2) Monthly Invoices	33 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 completed; long core data processing complete; post-augmentation monitoring underway; long core data final report in preparation
2) Plant and Invertebrate Monitoring	pre-augmentation work completed; post-augmentation work underway
3) Pacific Cordgrass Analysis	pre-augmentation work completed; post-augmentation monitoring continuing
4) Site Elevations	pre-augmentation RTK survey; post-augmentation photogrammetry; SET data downloads continuing; monitoring of feldspar plots continuing
5) Sediment Analysis	initial core samples retrieved; data processing nearing completion; grain size analysis of new sediment nearing completion
6) Turbidity Levels	monitoring completed in August 2017; final report completed; technical paper published
7) Bird Monitoring	pre-augmentation work completed; post-augmentation work ongoing
8) Eelgrass	pre-augmentation, post-augmentation and year one and year two post-augmentation surveys completed

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; primarily results presentation planned for late 2019

Problems/Delays Proposed Resolution

Sediment Augmentation. All of these outcomes will be addressed in a forthcoming lesson learned document. Our goal is to complete this document by the end of the next quarter.

Changes in Eelgrass Distribution. The post-augmentation and one year post-augmentation surveys indicated a declining trend in the areal extent and density of eelgrass in the project study area, while the reference site showed an increase in areal extent and density one-year post-augmentation. There is no definitive evidence at this point that the augmentation process is solely responsible for this decline as eelgrass losses were experienced throughout the range of this species. During the one-year post-augmentation survey, a specific area known to be impacted during the augmentation construction phase was showing signs of recovery. At two years post-augmentation, the affected area is now showing strong eelgrass recovery. It has 7,646 m^2 of eelgrass coverage, which is 86% of the eelgrass coverage it had in that area during the pre-augmentation survey.

Although the eelgrass survey conducted in May 2018 showed improvement in eelgrass coverage throughout the 263,168 m^2 survey area, the current coverage (36.6%) does not yet match pre-project conditions (42.1%). There are various factors that could be affecting coverage, including both project and non-project conditions. Based on discussions with NOAA Fisheries, we will be working with them to compensate for the loss of 500 square meters of eelgrass. We are continuing to work with NOAA on this issue.

Tidal Creek Formation. The project team continues to study the importance of tidal creek development in the reestablishment of native plants and invertebrates on the augmentation site. Initial notching did not result in increases in the rate of tidal creek formation, but it also did not result in increases in the loss of sediment from the site. Therefore, all of the remaining dams created during the augmentation process have been removed. Evaluation of tidal creek formation continues and we are currently working with the Navy to gain approval to fly a drone over the site to obtain additional elevation data.

Reestablishment of Cordgrass. Pacific cordgrass has continued to expand into the site, and now several monitoring plots include cordgrass. CSU Long Beach is working on grant to conduct an experimental planting project on the site. A request is also being prepared by the Refuge to use a portion of the remaining CDFW grant funds to plant cordgrass on approximately 1.2 acres of the augmentation site.

Project Benefits and Results

Thin-Layer Sediment Augmentation. We have already learned quite a bit about the sediment augmentation process and can suggest changes to the process that will benefit future projects. Some of this information has already been addressed at various workshops and seminars, as described above. Ongoing analysis of the effects of higher sand content in the sediment used for augmentation will provide important information for future projects, particularly because sediment with a higher sand content may be more readily available for use in thin-layer projects. Early data from the site suggests that some salt marsh vegetation, including cordgrass, can be

supported at elevations higher than are currently present within the Refuge. This is important information that can be used to design future thin-layer projects. This and other information will continue to be recorded and disseminated to all interested parties.

Greenhouse Gas Assessment. The results of radiocarbon (^{14}C) dating of long cores taken from the Seal Beach NWR by UCLA researchers indicate an average long-term accretion rate at the Refuge of 1.55 ± 0.16 mm yr^{-1}, which is typical for accretion rates obtained from ^{14}C. In addition, radiocesium (^{137}Cs) and radiolead (^{210}Pb) dating results from three control site and four augmentation site cores had an average ^{137}Cs- and ^{210}Pb-measured accretion for all cores of 3.2 ± .21 mm yr^{-1}, with average ^{137}Cs-measurements showing slightly higher accretions rates (3.2 ± .28 mm yr^{-1}) compared to ^{210}Pb-measurments (3.1 ± .33 mm yr^{-1}). Variation in accretion rates between control and augmentation for all methods was consistently < 0.5 mm yr^{-1}, and only significant using ^{210}Pb methods.

Using the chronological control obtained from ^{14}C, ^{137}Cs, and ^{210}Pb results, a CAR based on carbon estimates made from loss-on-ignition (LOI)[3] provided an average carbon sequestration for salt marsh habitat at the Seal Beach NWR control site and augmentation site to 100 cm depth of 117 g C m^{-2} yr^{-1}, consistent with rates of carbon sequestration around California[4] of ~100 g C m^{-2} yr^{-1} and global[5] averages of approximately 220 g C m^{-2} yr^{-1}.

The estimated carbon sequestration benefit from the USFWS Seal Beach NWR thin-layer sediment augmentation project is presented in Table 2.

Table 2 – Estimated Carbon Sequestration

Grantee	Project (Abbrev. Title)	Project Acreage	Project Life as defined in proposal	Carbon Sequestered as Reported in the Application	Conversion Process to Arrive at Reported GHG sequestration value	Value to Report on Project Report (MT CO2-e)
U.S. Fish and Wildlife Service	Seal Beach NWR Sediment Augmentation	10 acres	n/a	Carbon storage estimate of 250 Mg C ha^{-1} of tidal marsh (i.e., 917.5 Mg CO2 ha-1) represents avoided emissions - associated with halting loss of tidal marsh at the SBNWR	250 MT C ha-1 * 3.67 = 917.5 MT CO2 ha-1 917.5 MT CO2 ha-1 * (1 ha/2.471 ac) = 371.3 MT CO2 ac-1 371.3 MT CO_2 ac-1 * 10 ac = 3,713.1 MT CO2	3,713

Summarize Benefits to Disadvantaged Communities (not applicable)

[3] Craft, C. B., Seneca, E., & Broome, S. (1991). Loss on ignition and Kjeldahl digestion for estimating organic carbon and total nitrogen in estuarine marsh soils: calibration with dry combustion. *Estuaries*, *14*(2), 175–179. Retrieved from http://link.springer.com/article/10.2307/1351691

[4] Chmura, G. L., Anisfeld, S. C., Cahoon, D. R., & Lynch, J. C. (2003). Global carbon sequestration in tidal, saline wetland soils. *Global Biogeochemical Cycles*, *17*(4), n/a-n/a. http://doi.org/10.1029/2002GB001917

[5] Ouyang, X., & Lee, S. Y. (2014). Updated estimates of carbon accumulation rates in coastal marsh sediments. *Biogeosciences*, *11*, 5057–5071. http://doi.org/10.5194/bgd-10-19155-2013

List of Proposed Activities and Tasks for July – September 2019

Task 1 – Project Management and Administration
Refuge staff will continue to coordinate individually and through conference calls with researchers and other team members. Invoices and quarterly reports will be prepared. The lessons learned" document will be completed.

Task 2 – Sediment Augmentation
This task is now complete.

Task 3 – Project Monitoring

a) Post-augmentation monitoring will continue as the augmentation site continues to revegetate.

b) USFWS staff will continue to work with the researchers to ensure that no impacts to listed or sensitive species occur during post-augmentation monitoring.

c) Monthly bird surveys and annual monitoring of the light-footed Ridgway's rail will continue.

d) Dr. MacDonald and his team at UCLA have completed their final report.

e) Dr. Ambrose and his team at UCLA will continue to analyze core samples from feldspar plots to measure the thickness of sediment over the feldspar. Laboratory analyses of bulk density, grain size, and carbon content (LOI) will also be conducted on core samples taken from the site. Analysis of tidal creek formation will continue hopefully with the help of drones to obtain more precise elevation data.

f) Dr. Whitcraft and her staff will conduct post-augmentation sampling and analysis related to plant and invertebrate diversity and abundance and biomass in September 2019. In addition, sediment samples for grain size and organic matter will be taken, and they will continue invertebrate identification and community analysis in the laboratory on the contract samples. Also during the next quarter, photosynthetic measurements of cordgrass leaves will be conducted.

g) USGS will collect data from the SETs again in September 2019. All collection of turbidity data from the adjacent tidal channels has been completed. Final report on elevation changes on the augmentation site and the control site will be delivered before December 2019.

h) Dr. Keller from Chapman University is preparing his final report related to greenhouse gas flux at the augmentation site and control site.

i) Time-lapse videos will be continually updated and posted to the Refuge website.

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

Task 5 – Public Participation/Presentations
We will continue to update the project webpage and participate in conferences and webinars as opportunities arise. Once the "lessons learned" documentation is completed for the sediment augmentation process and we have the results from the spring 2019 monitoring surveys, we will initiate additional avenues for disseminating project results.

Description of Amendments and Modifications to Grant

We made a minor modification to the existing grant by redirecting $4,950 of unallocated research funds to additional eelgrass survey work. The reallocation of funds was approved by CDFW on June 10, 2016.

We are currently preparing a request to redirect unallocated remaining grant funds for two purposes: 1) to fund additional site elevation analysis, and 2) to conduct experimental planting of cordgrass on the augmentation site.

The first request would allocate funding to analyze the data from the second photogrammetry flight of the project site that was funded by the U.S. Army Corps of Engineers. In addition, USGS would conduct RTK surveys of the proposed planting area to identify more precisely the changes in elevation within the planting site. This information would inform monitoring results.

The second request would involve using available funds to plant and monitor cordgrass on a portion of the site followed by an evaluation of the effectiveness of planting cordgrass in augmentation sites to accelerate the reestablishment of marsh vegetation following augmentation. If possible, we are also interested in extending the life of grant for an additional year to enable us to conduct one year of monitoring of the cordgrass revegetation areas using funds currently remaining in the grant.

This request would not involve a budget increase, as the funding required to implement and monitor the experimental planting project would come out of funds already allocated to the Southwest Wetlands Interpretive Association (SWIA) in the approved budget. Our formal request is expected to be submitted the week of August 19, 2019.

Attachments

1. Cost Share Expenditures Table
2. Article: *Thin-layer sediment addition to an existing salt marsh to combat sea-level rise and improve endangered species habitat in California, USA*, by Karen M. Thorne, Chase M. Freeman, Jordan A. Rosencranz, Neil K. Ganju, Glenn R. Guntenspergen, in press.
3. Internet Download of "Nature can soften impact of rising seas – if we let it"

Invoice 34-2019 with attachments is provided under separate cover.

Attachment 1
Itemized Cost Share Accounting

Cost Share (June 1, 2015 to June 30, 2019)		
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 *(revised 6/2018 to exclude funding provided prior to 6/2015; changing expenditure from $177,070 to $173,120)*	$173,120
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	**$1,383,916**
Total Cost Share from October 1, 2016 to September 30, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$231,753
USFWS staff time[2]	USFWS CRI Grant	$22,714
	Subtotal	**$254,466**
Total Cost Share From October 1, 2017 to September 30, 2018		
Post-augmentation monitoring	California State Coastal Conservancy	$58,384
USFWS staff time[2]	USFWS Station Funds	$1,294
	Subtotal	**$59,680**
Cost Share from October 1, 2018 to December 31, 2018		
Post-augmentation monitoring	California State Coastal Conservancy	$52,185
USFWS staff time[2]	USFWS Station Funds	$0
	Subtotal	**$52,185**
Cost Share from January 1, 2019 to March 31, 2019		
Post-augmentation monitoring	California State Coastal Conservancy	$1,280
USFWS staff time[2]	USFWS Station Funds	$0
Cost Share from April 1, 2019 to June 30, 2019		
Post-augmentation monitoring	California State Coastal Conservancy	$2,248
USFWS staff time[2]	USFWS Station Funds	$0
	Total Cost Share to Date	**$1,753,775**

[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).

LONG BEACH POST

An oil field where the California Coastal Commission will decide to return it to the Los Cerritos wetlands restored to a prettier, healthier wetlands area in Long Beach December 7, 2018. Photo by Thomas R. Cordova

WETLANDS

April 22, 2019

Nature can soften impacts of rising seas—if we let it

by **Jason Ruiz** *in* **Climate Change**

75

This story is part of a Long Beach Post multi-part series, "Close to Home: How climate change is shaping the future of Long Beach." For the full series, click here.

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By the end of the century, rising seas will force Long Beach to find ways to protect homes and businesses—or see some of them swallowed by the sea.

While seawalls, breakwaters and other barriers are already deployed up and down portions East Coast and West Coast, not all solutions are made of concrete and stone.

Some say the future of protecting California's coasts, and the developments behind them, will include more natural solutions like restoring wetlands and other habitats so they can help slow storm surges and combat other effects of sea level rise.

"Habitats or ecosystems serve many many benefits, including physical protections in many cases," said Evyan Sloane, a project manager for the State Coastal Conservancy.

"When you're building a wetland or a dune or a beach on the coast you can provide a habitat for different species including endangered species, you can sometimes sequester (carbon dioxide), further fighting against what's causing climate change, and you can sometimes protect against erosion."

Sloane worked on a project in Seal Beach in which sediment was dredged and then transported to two sites where it was layered on top of existing salt marshes. The project was located within the Seal Beach National Wildlife Refuge just south of the Long Beach border.

> CSULB researchers help rebuild Seal Beach wetlands threatened by rising sea levels

It raised the level of the salt marsh by about 8.5 inches above grade, something that researchers said could not only improve the ecosystem, but also make it more resilient to rising seas.

The project was part of a series of case studies performed by Coastal Resiliency, a group that advocates for natural

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National Oceanic and Atmospheric Administration and the California Resources Agency.

Some of these solutions included building a living shoreline in the San Francisco Bay to reduce wave energy through the creation of oyster reefs and eelgrass beds. The project resulted in a 30 percent reduction in wave energy.

One project involved a form of managed retreat in which the coastal city of Ventura restored dunes in front of a parking lot that was being damaged by wave activity. The parking lot was also moved back, resulting in the beach being widened by about 60 feet.

Sloane is hopeful that these types of projects will be recognized more often in the future for their win-win potential.

“We could have a coastline that’s all seawalls and ocean and no habitat and no recreation and all the other benefits, or we can have wetlands that you can kayak in and see birds and go to the beach and lay your towel down on the sand,” Sloane said.

By the year 2100 sea levels are projected to rise by up to 6 feet.

Christine Whitcraft, director of Cal State Long Beach’s Environmental Science and Policy program, said that wetlands serve a vital role in combating rising seas.

They help clean and filter water as it runs from rivers and streams into the ocean and retain nutrients and soil that helps support plant and animal life. But they also have another unique quality when it comes to combating sea level rise.

“Wetlands, if we weren’t here surrounding them, actually have the ability to keep pace with sea level rise and they do that in two ways,” Whitcraft said. “One is by having mud be spread over them from the watershed which helps them get taller, or accrete. And the other way is to transition backward, to transition inland as the water rises.”

If they become completely submerged, Whitcraft said wetlands could lose some of their cleansing qualities when it comes to water and the air.

She says she’s an environmentalist but also a pragmatist and recognizes that the future of protecting the California coast will probably require a mixture of both human-made and natural solutions. But she added that natural formations have the ability to respond to sea level rise in ways that walls do not.

“When you have storms moving onto the coast or even just flooding, having vegetation, plants and soil that can absorb water

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Wetland sediment project

Alison Spindler, a planner with the city's Development Services department, said that the city is "putting everything on the table" when it comes to combating climate change and will focus its efforts regarding sea level rise where flooding is expected to hit first and most dramatically.

The city's draft report on possible climate adaptation actions include options to expand sea walls but it also mentions more natural solutions.

The city could undertake a beach nourishment study to look at sand volumes needed to keep pace with sea level rise and to identify potential sources of sand to transplant onto the city's coast.

It could also pursue building a living shoreline or transforming seasonal sand dunes to permanent ones with vegetation being installed to stabilize the sand against erosion.

"This is just a starting point," Spindler said.

Jason Ruiz covers City Hall and politics for the Long Beach Post. Reach him at jason@lbpost.com or @JasonRuiz__LB on Twitter.

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