ANNUAL REPORT

October 1, 2016 – September 30, 2017

Date: November 20, 2017

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 as of September 30, 2017	Total Amount Remaining
CDFW GGRF Grant Funds	$1,055,827	$340,877†	$714,950
Cost Share	$1,306,048	$1,612,834*	<$306,786>
Agreement Totals	$2,361,875	$1,953,711	$714,950‡

* See itemized cost share expenditures presented in Attachment 1.
† An additional $15,167 was expended in August and September, but has not yet been invoiced.
‡ Cost Share agreements have already been achieved and are therefore not included in this total.

PROGRAM/TECHNICAL REPORT

Project Overview

This project involves the initiation of a thin-layer sediment augmentation project, along with a five-year post-augmentation monitoring plan, for an area of coastal salt marsh habitat located within the Seal Beach National Wildlife Refuge (NWR). The ultimate goal of this thin-layer sediment augmentation project is to ensure 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. The existing conditions at the Seal Beach NWR present a unique opportunity to proactively develop and refine a sea-level rise adaptation strategy that if successful can then be implemented elsewhere over the next few decades. At the end of the project, a thin-layer sediment augmentation guidance document that describes this “proof-of-concept” project, including 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) and a discussion of the biological and physical monitoring results, will be produced and disseminated to facilitate future thin-layer sediment augmentation projects along the California coast. Project goals and initial results are already being shared with Federal, State, and local agency staff, land managers, and researchers through project team participation in webinars, seminars, workshops, and conferences.

Summary of Activities Performed from October 1, 2016 to September 30, 2017

The primary focus of the project team during the last year has been on monitoring the changing physical and biological conditions occurring on the approximately 7.9-acre augmentation site (Attachment 2 – Location Map), along with the physical and biological conditions on the associated 2.5-acre control site since the augmentation process was completed in April 2016. Bird and eelgrass monitoring also continued. A number of team members also participated in seminars and conferences to present the project to a range of interested parties, including pubic agencies, academia, and land managers.

October 1 to December 31, 2016

Activities and Accomplishments:

- Curtin Maritime, the dredging/sediment augmentation contractor for the project (hired by Orange County Parks) issued their final report describing the sediment application process for the project (report provided with the October 1 – December 2016 Quarterly Report).

- CSU Long Beach researchers sorted invertebrates in cores collected following augmentation, conducted fall sampling (2nd post-restoration time point) of plant and invertebrate community parameters; conducted a colonization study to help determine if the observed changes in the invertebrate community between the augmentation and control sites were due to grain size or elevation differences; continued invertebrate sorting in the laboratory, and continued processing biomass in the long cores collected by UCLA.

- USGS staff continued to monitor turbidity levels in the waters surrounding the augmentation site, and completed the "Thin-Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge: Elevation Change Assessment." This document summarizes the initial elevations on the augmentation site, presents the site's elevations following the sediment application process, and provides an estimate of the volume of sediment applied to the site (report provided with the October 1 – December 2016 Quarterly Report).

- UCLA researchers completed all initial post-augmentation sampling related to feldspar plots, sediment flux, and bulk density/carbon content in the sediment. The process of feldspar coring was difficult due to the amount of sand in the sediment. After testing various techniques in an effort to obtain complete cores, they revised their protocols and used a Russian corer. As a result, all required data was collected. Processing of the data occurred throughout this period.

- Researchers from Chapman University conducted sampling monthly during this quarter. On each sampling trip, they collected gas samples from both the control and augmentation sites and analyzed those samples for carbon dioxide, methane, and nitrous oxide. They also collected surface porewater during each visit and analyzed it for chemical properties. Refinements were made to the sampling technique to address collecting porewater from the sandy sediment on the augmentation site. To address concerns raised about possible acificiation on the augmentation site due to the amount of sand content in the sediment, pH in surface water was also measured in the field and in porewater collected at both sites.

- Refuge staff conducted monthly site visits to document site conditions and low and high tide bird surveys were completed.

- Several presentations addressing various aspects of the project were made during this quarter, as addressed below under public outreach.

- During this period, we also completed our annual report for the State fiscal year that ended June 30, 2016. Team conference calls were also conducted to keep everyone informed of current activities and changes occurring on the site.

January 1 – March 31, 2017

Activities and Accomplishments:

- USGS staff continued to maintain and upload data from YSI and ADCP monitoring equipment (to measure turbidity levels and sediment flux) adjacent to the augmentation site. They also measured elevation changes at the control site and the augmentation site using deep rod Surface Elevation Tables (SETs) and adjacent feldspar plots.

- CSU Long Beach researchers continued invertebrate sorting in the laboratory during this quarter. All fall 2017 (2nd post-augmentation period) invertebrate samples (top 2 cm) were sorted, and will be identified to species. Equipment problems affected photosynthetic measurements, but this is being addressed and measurements will be repeated more frequently as more plants are established on the site. Analysis of below ground biomass in the core samples was coordinated with UCLA researchers.

- Core samples being studied by UCLA were sent to USC for Cesium dating and for radiocarbon dating with UC Irvine.

- UCLA researchers continued analysis of sediment samples for bulk density and carbon content.

- Chapman University researchers continued collecting gas and pore water samples.

- Refuge staff conducted monthly site visits to document site conditions and additional visits when needed to accompany researchers. Low and high tide bird surveys were completed and monitoring of light-footed Ridgway's rail activity in and around the site was conducted in February and March.

April 1 – June 30, 2017

Activities and Accomplishments:

- Researchers at UCLA and CSU Long Beach continued post-augmentation monitoring and/or conducted lab work to analyze data and samples obtained from the augmentation and control sites.

- Analysis associated with cesium and lead dating of long cores continued, and grain size analysis of the top 10 cm of the six cores was nearing completion.

- USGS staff continued to conduct post-construction marsh surface elevation monitoring with SETs and adjacent feldspar plots. Monitoring of turbidity and sediment fluxes occurred at two YSIs and an ADCP in the deep channel site (control) and in the eelgrass site (adjacent to augmentation site).

- Chapman University researchers made two trips to the sites during this quarter to collect gas samples from both the control and augmentation sites and analyzed those samples for carbon dioxide,

methane, and nitrous oxide. Surface porewater was analyzed for chemical properties and pH levels. Redox in surface water was also measured. Also during this quarter, methods to measure porewater collected over the course of this project for sulfate/chloride using ion chromatography was finalized, while exploring methods to quantify nitrate in porewater collected from this project continues.

- Refuge staff visited the site a minimum of once a month to document site conditions and assist researchers.

- Low and high tide bird surveys were conducted and monitoring of light-footed Ridgway's rail activity in and around the site was conducted throughout this period.

- Our required one-year post augmentation eelgrass survey was conducted by MTS. Side-scan sonar and SCUBA surveys of the study area and reference area were conducted on April 26 and May 24.

<u>July 1 – September 30, 2017</u>

Activities and Accomplishments:

- Chapman University researchers collected gas samples from both the control and augmentation sites twice during this period. Samples were analyzed for carbon dioxide, methane, and nitrous oxide. Surface porewater was analyzed for chemical properties and pH levels. Redox in surface water was also measured. Methods for measuring sulfate and chloride ions within porewater were refined and the data collected through August 2017 are being analyzed for patterns.

- Analysis associated with cesium and lead dating of long cores collected by researchers at UCLA is nearing completion, and grain size analysis of the top 10 cm of the six cores has been completed. A final report describing the results of this process is underway.

- CSU Long Beach researchers completed their analysis of the below ground biomass for the long cores being processed by UCLA. In addition, sorting was completed for all pre-augmentation cores taken in fall 2016 and spring 2017. Results showed no significant differences in invertebrate communities between the augmentation site and control site prior to the augmentation process. Plant community monitoring continued. Fall sampling began in late September and will extend into October. A summary of the pre-augmentation monitoring results for the augmentation site and the control site was also prepared and is provided as Attachment 3.

- Researchers from UCLA and the U.S. Army Corps of Engineers visited the site in late August to observe signs of creek formation and plant reestablishment within the augmentation site, and to identify any indications of acidification within the augmentation site.

- Refuge staff visited the site on numerous occasions to document site conditions.

- Low and high tide bird surveys were conducted and monitoring of light-footed Ridgway's rail activity in and around the site was conducted throughout this period.

- USGS removed the two turbidity meters (YSIs) and the Acoustic Doppler Current Profiler (ADCP) from the project site at the end of August 2017. Turbidity and sediment flux monitoring started in November 2014 (pre-construction) and continued through augmentation to approximately 17 months post augmentation.

Summary of Site Conditions – October 1, 2016 to September 31, 2017

The sediment augmentation process was completed on April 4, 2016, since that time, we have conducted a variety of monitoring activities, as summarized above, to document how the site responds to the thin-layer of sediment that was placed on the site. A description of site conditions over time is present below.

Site Elevations: The first SET data post-augmentation was collected on April 15, 2016, 72 days later on June 28; a decrease in elevation was measured at all locations. The change ranged from 1" to 2-3". The lack of evidence of sediment moving off the site and the presence of deposition on the feldspar plots supports the conclusion that this decrease was likely from consolidation of the new sediment or compaction of the sediments below the added material.

Post Augmentation elevation surveys were also conducted by GPSI, who flew a photogrammetry elevation survey on April 18, 2016 and delivered a Digital Terrain Model (DTM) as well as shapefile elevation points for interpolating digital elevation models (DEM) for comparison with the pre-augmentation surveys. The post-augmentation surveys showed a mean elevation for the control site of 1.15 meters, whereas the mean elevation for the augmentation site was 1.45 meters. Within the augmentation site, the area affected by the application of sediment had a mean elevation of 1.63 meters, while the buffer area had a mean elevation of 1.30 meters.

In August 2016, the elevation and accretion changes, as measured with SETs and feldspar plots, varied within and between the augmentation site and the control site. The average elevation change for the augmentation site between pre and post augmentation was +23.4 cm (+9.23 in). The control site showed a decrease in elevation of -0.39 cm (-0.16 in), averaged across all six control SETs. It should be noted that subsidence within the larger marsh complex has been studied periodically since 1968, and most recently by USGS in 2012[1].

Based on monitoring conducted by USGS researches through May 2017, the SETs at the control area have indicated gains and losses of elevation since installation (Figure 1). The SETs in the augmentation site had a mean increase in elevation with sediment application, but the mean elevation has decreased post sediment application. Elevation decreases were most rapid initially after the sediment application period (augmentation) and elevation loss has slowed over the course of monitoring. SETs will continue to be read quarterly over the next few years.

Sediment Flux Patterns: From winter 2014 through the end of August 2017, USGS researchers used autonomous equipment deployed at two channels within Seal Beach NWR to monitor turbidity and sediment flux in adjacent and adjoining tidal channels that support eelgrass beds. Locations of instruments are selected to effectively answer the projects questions and provide robust data to generate a sediment flux budget for the sediment augmentation study area. This equipment included two turbidity meters (YSIs 6920 optical turbidity probes) and one Acoustic Doppler Current Profilers (ADCP) mounted on the channel bed at a key cross-section that drains the majority of the wetland complex.

[1] Takekawa, J. Y., K. M. Thorne, K. J. Buffington, C. M. Freeman, and G. Block. 2013. Evaluation of subterranean subsidence at Seal Beach National Wildlife Refuge. Unpubl. Data Summary Report. U. S. Geological Survey, Western Ecological Research Center, Vallejo, CA. 24pp.

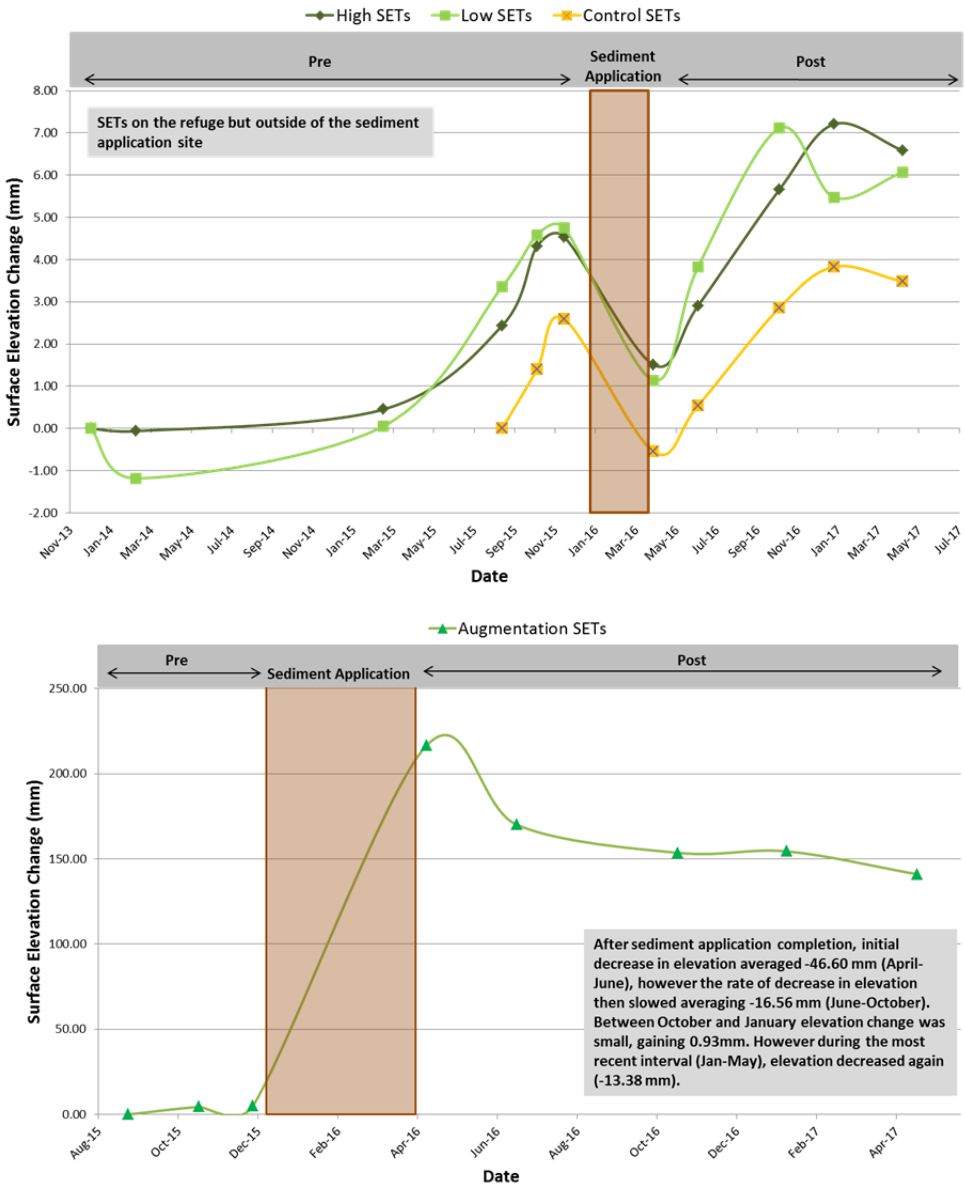

Figure 1. Mean surface elevation change at control site (above) and augmentation site (below). Brown box represented construction time frame[2].

In April 2017, the recalculated post construction mean suspended sediment concentration (SSC) values were 8 mg/L and 6 mg/L for the eelgrass and deep site, with a small export of sediment. Mean post construction SSC is still equal to baseline levels observed in the deep channel, but is now only 2.7 times greater, compared to 4 times greater in the last quarter of 2016, than mean pre-construction SSC at the eelgrass site. The mean SSC was greatest at both the eelgrass site and deep site during a storm on January 22, 2017, which yielded 3.66 inches of rain.

[2] Thorne, K.M., N.K. Ganju, C.M. Freeman, and J.A. Rosencranz. 2017. Annual Report: Thin Layer Sediment Application Pilot Project at Seal Beach National Wildlife Refuge: Sediment flux and turbidity patterns, Surface Elevation Table (SET) monitoring. U. S. Geological Survey, Western Ecological Research Center, Vallejo, CA. June 22, 2017.

Elevated post-construction turbidity at the eelgrass site suggests that there may be lingering impacts from augmentation and heavy storm conditions during winter 2016 and early 2017. USGS speculates 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. However, the post-construction surface elevation and accretion gains from SETs suggest that erosion is not occurring from the marsh surface. This may mean that the increased turbidity levels observed at the eelgrass site during storms is not from runoff of the augmentation site, but possibly resuspension of sediment at the channel bottom and adjacent areas (USGS 2017).

As of the end of August 2017, sediment export out of the Refuge's marsh complex has remained minimal throughout the study period. Turbidity was still elevated at the eelgrass monitoring site, but remains low at the deep channel site near the mouth of the refuge. USGS suspects that the bed of the channel in the vicinity of the eelgrass turbidity sensor has increased in elevation. The elevated turbidity measurements could be a result of fines moving around at the floor of the channel which are now in closer proximity to the sensor than pre-augmentation.

Invertebrates: The fall and spring cores taken from the project site and the control site prior to augmentation have been sorted and no significant differences were observed between the invertebrate communities present on the control site and the project site pre-augmentation. Immediately following augmentation, invertebrate abundances decreased significantly on the augmentation site. Invertebrates were found at nine out of 24 sites with Ephydridae (type of fly) larvae having the highest representation. Samples taken six months after augmentation in fall 2016 showed an increase in the abundance of invertebrates with 18 out of 21 sites having invertebrates present. Although still dominated by Ephydridae larvae, there was an increased representation of oligochaetes and polychaetes. Samples taken from the augmentation site 12 months (Spring 2017) post augmentation showed an increase in the abundance of invertebrates with 21 out of 21 sites having invertebrates present in spring 2017.

A side experiment focusing on invertebrate recruitment indicated that the types of invertebrate species colonizing the site appear to be influenced by the type of sediment (sand versus mud).

Plants: Plant community monitoring is ongoing. Plants within the augmentation area as of September 2017 included annual pickleweed (which is widespread), perennial pickleweed, and cordgrass. The cordgrass is extending into the site from the adjacent 50-foot buffer area and from groups of plants that were not fully buried beneath the added sediment. Annual pickleweed is more prevalent than perennial pickleweed. During a site visit in August 2017, Refuge and CDFW staff observed cordgrass on the site to be producing seeds, however, the viability of Pacific cordgrass seed is considered very low and when viable seeds are present, seedling germination requires decreased soil salinity[3]. As a result, there is a very low potential for recruitment of Pacific cordgrass into the site via seed, which is consistent with long term observations of this and other marshes in Southern California.

Bird Use: Prior to augmentation, species diversity on the project site during monthly high and low tide surveys never exceeded seven species and total abundance ranged from 0 birds to 53 birds (with a total of seven species identified). In the months following augmentation, observed species diversity was low, but species diversity and abundance has increased over the past year. These numbers are not always reflected in the observations made during low and high tide counts, which are presented in Attachment 4.

[3] Ward, K., J.B. Callaway, and J. Zedler. 2003. Episodic colonization of an intertidal mudflat by native cordgrass (*Spartina foliosa*) at Tijuana Estuary. Estuaries and Coasts 26(1):116-130. February, 2003.

During recent visits to the site, researchers and Refuge staff have observed a variety of shorebirds, seabirds, and raptors on the augmentation site. Refuge staff have noted 150 or more least and western sandpipers, as well as numerous long-billed curlews, great blue herons, egrets and other shorebirds on the augmentation site during visits throughout the years which typically occur during high tide.

As reported in our last quarterly report, a western snowy plover nest was discovered on the site, but because the nest would be lost during an upcoming higher high tide, the eggs were collected and incubated at the Wetlands Wildlife Care Center in Huntington Beach. The chicks were banded and released on June 19, 2017.

A peregrine falcon, which represents a potential threat to least tern chicks, was also observed using elevation stakes on the augmentation site for perching. Due to the proximity of these “perches” to the least tern nesting site on NASA Island, stakes are being removed or cut to discourage raptor perching on the project site.

Light-footed Ridgway’s rail monitoring during the 2017 nesting period did not identify any use the nesting rafts located on the same peninsula south of the augmentation site. Rail activity was observed on those rafts that were relocated prior to augmentation to the shore across the west channel from the augmentation site. Overall, 98 rails were observed throughout the Refuge during a high tide count on November 6, 2017. The same count in 2016 documented 119 rails. This slight decrease in the number of rails observed in 2017 is likely because this year’s count occurred at the end of a series of spring tides. Rails are more sensitive to being exposed after a series of spring tides and are better at hiding. Consequently, they are less likely to be observed.

Gas Flux: Gas flux measurements within the control and augmentation sites occur two to three times per quarter. Preliminary data from these measurements indicate that significant CH_4 fluxes were minimal, but there were occasional positive fluxes measured from Pacific cordgrass and pond communities at the control site. Low CH_4 fluxes are common from salt marsh soils. Low N_2O fluxes are common in salt marsh soils without nitrogen pollution. CO_2 fluxes were generally lower from the control site pre-augmentation (possibly due to lower air temperatures during sampling) and were lowest from ponded communities. After the addition of sediment, the augmentation had very low CO_2 fluxes compared to pre-augmentation and the control site.

Site Photos: Photos and videos have been taken of the site to document changing site conditions. These are archived in the project files and are available upon request. A few photos are provided here to illustrate changing conditions on the augmentation site over time and additional photos are provided in Attachment 5.

Photo 1. February 2016 – Ponding on the site following a high tide.

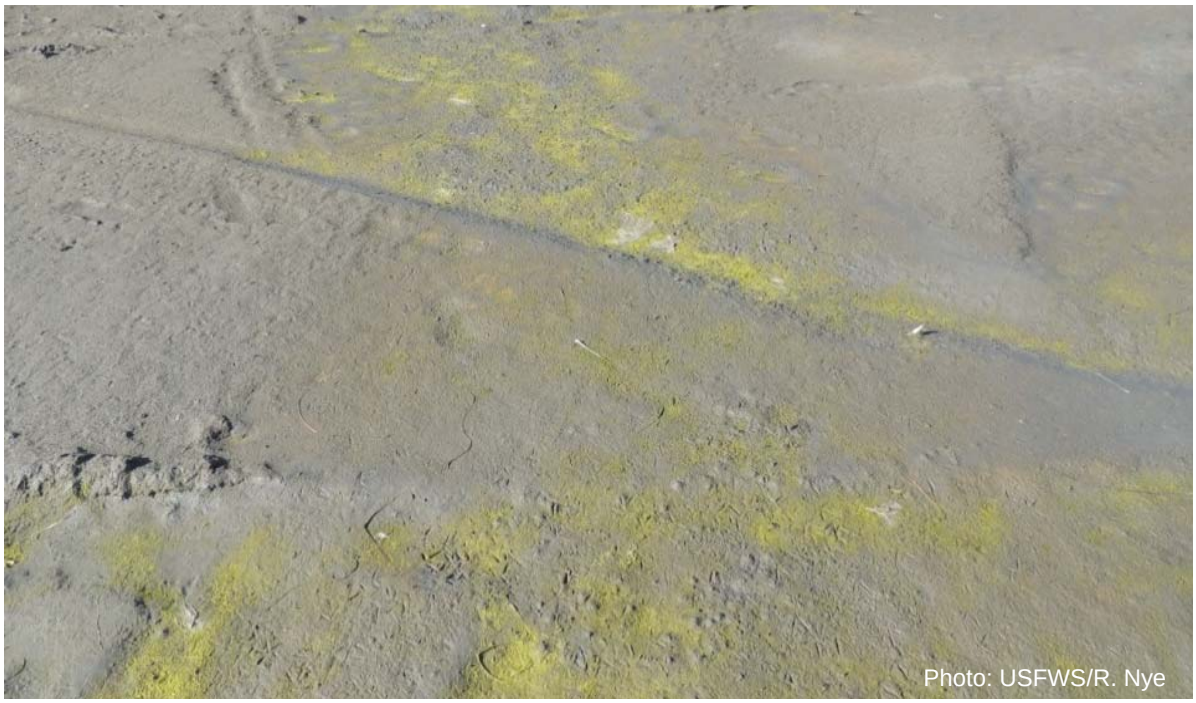

Photo 2. November 2016 – A small creek is forming near the highest point of the augmentation site; algae are also present on the site.

Photo 3. January 2017 – Taken from the northwest corner of the augmentation site looking west: cordgrass is present within the augmented area in the foreground, ponded water and algae can be seen near the top of the photo.

Photo 4. May 2017 - Cordgrass and annual pickleweed are present on the edges of the site. The cordgrass appears to be moving into the site from rhizomes of plants located within the 50-foot buffer area retained around the site.

Photo 5. September 2017 – Taken following a higher tide; note the creeks beginning to form within the site, the presence of algae, pickleweed, and cordgrass, and the use of the site by foraging shorebirds and invertebrates.

Eelgrass Survey: The most recent eelgrass survey (one-year post completion of the sediment augmentation process) was performed by Marine Taxonomic Services, LTD. (MTS) using side-scan sonar and SCUBA surveys of the study area and the reference area on April 26, 2017 and May 24, 2017, respectively. The completed survey report is provided as Attachment 6.

Eelgrass cover was calculated by comparing the area mapped as eelgrass using a side-scan to the total survey area to provide an estimate of percent eelgrass cover. Then the line intercept data provided by the SCUBA survey was used to determine percent eelgrass cover by calculating the transect distance where the eelgrass intercepted the transect lines over the total transect distance. The multiple transects performed within the study and reference survey areas were then used to calculate an estimate of average cover and an associated standard deviation based on the sample data. Eelgrass density was calculated by taking the average of the leaf shoots counted within each of the quadrats sampled within the study and reference survey areas.

The eelgrass maps produced as a result of the side-scan sonar record in spring 2017 identified 72,109 square meters of eelgrass and 146,697 square meters of eelgrass habitat within the 263,168 square meter study area. Eelgrass density (mean $\pm$ 1 standard deviation) at the study area was 74 $\pm$ 76 leaf shoots per square meter and at the reference area it was 190 $\pm$ 125 shoots per square meter. These results show a decline in the overall eelgrass cover within the study area relative to the 2016 post-construction monitoring, which continues a trend of minor declines between the pre- and post-construction surveys. Eelgrass cover within the survey area declined 0.6 percent between the pre- and post-construction survey, and 14.1 percent between the post-construction and year 1 annual post-construction survey. Eelgrass cover within the reference area declined 2 percent between the pre- and post-construction survey and then increased 9.4 percent between the post-construction and year 1 annual post-construction surveys.

Various factors may have contributed to the reduction in eelgrass coverage within the study area, including effects of sediment that may be moving off the augmentation and a large storm event in February 2017. Turbidity data collected by USGS indicates that turbidity levels are still elevated compared to pre-construction conditions at the eelgrass monitoring site. It may be that the bed of the channel has increased in elevation and there are fines moving around. This sediment is not necessarily coming from the augmentation site, as the suspended sediments consist of fine, unconsolidated material, not sand.

Also of note is the condition of the area near the southeast shore of the fill area. Visual inspection of the sonar data showed losses in this region between pre- and post-construction surveys. The current survey results show that while the eelgrass cover has generally declined across the study area, eelgrass cover within the footprint of the impact area has expanded in the past year (Figure 2). Eelgrass cover during the post-construction survey within the impact area was 3,978 square meters, but increased to 6,626 square meters when surveyed one year post construction.

Figure 2. Changes in eelgrass coverage between 2016 and 2017 in the impacted area (MTS 2017).

It is not clear what the reasons are for the decline in the areal extent and density of eelgrass within the study area. Current monitoring of elevations and accretion on the augmentation site do not indicate significant losses of sediment from the site. An additional survey will be conducted two years post augmentation and that monitoring will provide additional information that may provide better insight into what factors are influencing eelgrass density and extent within the vicinity of the project site. For more information and maps of the eelgrass beds, refer to Attachment 6.

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 as necessary. 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.

Many members of the project team have participated in presentations, seminars, conferences, and webinars. A number of these public outreach efforts are listed below.

- Kirk Gilligan gave a presentation at the Natural Areas Conference at UC Davis on October 18, 2016.
- A student of Dr. Keller presented the GHG flux work conducted on the site through November 2016 in poster format at a student research event at Chapman University.
- Evyan Sloane, California Coastal Conservancy and Karen Thorne, USGS, presented various aspects of the project during poster sessions held at the Restore America's Estuaries 2016 Summit, which occurred December 10-15, 2016, in New Orleans.
- On April 13, 2017, Rick Nye, Vicki Touchstone, and Elizabeth Murray attended a Southwest Climate Science Center Workshop which was hosted by Glen MacDonald and Rich Ambrose at UCLA to discuss this project and other climate related research projects.
- Students working with Dr. Keller presented a poster of their findings to date at the annual meeting of the Southern California Academy of Sciences, held on April 28, 2017. The poster was also presented at the Chapman University Student Research Expo in mid-May 2016.
- Team members Evyan Sloane, California Coastal Conservancy, and Elizabeth Murray, U.S. Army Corps of Engineers, attended the Headwaters to Oceans (H_2O) Conference at UC Irvine, May 23-24, 2017 to present various aspects of the thin-layer sediment augmentation process, including how this sea-level rise adaptation process compliments the discussion of living shorelines on the west coast.
- Rick Nye, the Refuge and Project Manager, conducted of site visit for representatives from the U.S. Army Corps of Engineers and the Coastal Conservancy on May 25, 2017. Various topics were addressed including tidal creek reformation.
- Rick Nye also discusses the project with the public during monthly tours of the Refuge.
- Rich Ambrose (UCLA) gave a presentation about his research on this project at the Society of Wetland Scientists' 2017 Annual Meeting held in Puerto Rico in June 2017. Christine Whitcraft and M.S. student Kaelin McAtee (CSULB) also present the results of their work thus far in two posters at this meeting. One poster addressed the overall project and one addressed an invertebrate colonization experiment conducted on the augmentation site.
- On August 18, 2017, Rick Nye conducted a site visit for representatives from the California Department of Fish and Wildlife.

- On August 29, 2017, Rick Nye conducted a site visit with Rich Ambrose for representatives from the U.S. Army Corps of Engineers to discuss creek formation and soil conditions.

- On September 21, 2017, Rick Nye presented this project to Paul Souza, USFWS, Regional Director for the Pacific Southwest Region.

Status of Ongoing Research

UCLA (SEDIMENT CORING): Researchers at UCLA under the direction of Dr. Glen MacDonald are finalizing their report on the results of assessing the pre-augmentation net sediment accretion rates and average carbon accumulation rate (CAR) at Seal Beach NWR and evaluating the long-term storage and temporal scale of carbon storage. A total of 18 cores were collected, six from the control site and 12 from the augmentation site. Cores were GPS located, photographed, and described. Magnetic susceptibility analysis was conducted to 100cm depth on all cores. Cores were halved, with one half stored for analysis at UCLA facilities and the other sent to USCLB for belowground biomass analysis.

Radiocarbon (^{14}C) dating was conducted at the UC Irvine Keck Radiocarbon Lab. A total of 16 samples were dated, including 14 plant macrofossils and 2 marine shells from a single hash layer. In July 2017, radiocesium (^{137}Cs) and radiolead (^{210}Pb) dating was conducted on three control and four augmentation cores at the University of Southern California Lab. Grain size analysis was completed on six cores (three from the control site and three from the augmentation site), at 2 – 5 cm resolution for a total of 280 samples. Analysis also included determining carbon sequestration rates within the marsh pre-augmentation. The result of this work will be included in a final report to be completed by January 2018.

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, will continue to be conducted by Dr. Jason Keller and his team two to three times per quarter for three years post augmentation. The objective of this research is to compare greenhouse gas fluxes from the sediment augmentation project at Seal Beach NWR pre- and post-augmentation and greenhouse gas fluxes post-augmentation to a natural salt marsh within the Refuge (the control site).

UCLA (CHANGES IN MARSH PLAIN POST-AUGMENTATION): Under the direction of Dr. Richard Ambrose, researchers are measuring thickness and bulk density of added sediment in the augmented area over time. Additionally, the morphology of pre-augmentation tidal creeks within the augmented site is being assessed and newly forming tidal creeks are being documented. This data will provide insight into the effects of sediment augmentation on tidal creek characteristics prior to and following augmentation.

Sediment thickness is being sampled at multiple locations distributed across the project area and will continue for five years post-augmentation in an effort to better understand the effectiveness of sediment augmentation as an adaptation measure in addressing sea level rise. Sampling locations have been coordinated with other sampling aspects, particularly the invertebrate and vegetation sampling, to provide the most integrated view of the ecosystem response to sediment augmentation. Two types of sampling stations have been established on the marsh plain: consolidated stations including feldspar plots, sediment stakes and bulk density sampling locations, and sediment stake stations. Consistent with data being obtained from the SETs, UCLA researchers have observed accretion rates on the augmentation site at the feldspar plots of about 2 to 5 mm per month.

Changes in tidal creek morphology are being assessed using various methods including aerial photography and creek cross-section surveys. Aerial photography includes the entire sediment augmentation site and control site, so there are no specific sampling locations. Tidal creek cross-sections were taken prior to sediment augmentation at representative creeks in the sediment augmentation area and the control area.

Since the completion of sediment augmentation on April 4, 2016, 24 new feldspar plots have been established in the augmentation area adjacent to the original plots that are now buried by the sediment. The plots allow researchers to quantify any sediment accretion on the site following augmentation. In addition, 14 feldspar plots in the control area are measured for thickness of sediment over the feldspar layer that was applied prior to augmentation.

Bulk density samples are collected in the sediment augmentation area next to each feldspar plot. Two new PVC stakes were added to delineate the area for taking bulk density measurements to ensure that the sample area is not disturbed. The distance from the top of the stakes of the old feldspar plot to the sediment surface was measured.

CSU LONG BEACH (PLANT AND INVERTEBRATE STUDIES): To evaluate the health and function of the augmentation site prior to and for five years following augmentation, Dr. Christine Whitcraft (CSULB) and her students are monitoring the diversity, abundance, and distribution of the plant and invertebrate communities and associated abiotic parameters (temperature, porewater salinity, redox) of the control and augmentation sites both pre- and post-augmentation. Plant community sampling locations are co-located with the invertebrate sampling locations, and these locations were selected in collaboration with USGS and UCLA so that the sampling locations overlap with placement of sediment monitoring stakes.

These researchers are also assessing the ability of plants and sediment to store carbon by collecting data on the photosynthetic rate of plants, C:N ratios of plants, plant traits (e.g. leaf area), and isotope ratios in sediment. Initial results indicate that the cordgrass present in the augmentation site and control site is photosynthesizing at comparable rates.

Fall plant and invertebrate sampling at the control and augmentation site occurred in late August and early September 2017. The preliminary results of this sampling effort will be in the next quarterly report. Fall and spring monitoring efforts will continue for five years post augmentation.

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. Data was periodically uploaded to calculate sediment fluxes using Matlab 2014a. The data from this monitoring equipment was used to detect changes in turbidity in the eelgrass bed adjacent to the project site due to effects of construction and sediment application and to detect changes in turbidity and sediment fluxes at the deep channel site due to effects of construction and sediment application.

In August 2015, USGS installed and continues to obtain data from 21 deep rod surface elevation tables (SETs) (15 SETs in the sediment augmentation area and 6 SETs in the control area). Data was taken pre- and immediately post- augmentation and will continue to be collected quarterly until the end of the monitoring schedule. The data is used to assess changes in elevation, including accretion and shallow subsidence, before, during, and immediately after sediment application at the sediment augmentation site. Results related to elevation changes at the augmentation site are compared with results at a control site.

Four SETs were also installed elsewhere on the Refuge in 2013 for another research project. These SETs have recorded a couple millimeters of accretion at the Refuge. Specifically, the feldspar plots indicate 6 mm of accretion (probably due to storms); however, the SETs are only showing 2 mm of increased elevation, indicating continuing subsurface subsidence of 4 mm within the larger salt marsh complex. Based on the data collected in August 2017, compaction appears to be slowing on the augmentation site; the average rate since the last reading was about 1.8 mm across the site. The SETs on the control site also found subsidence. USGS will be adding a new leveling device to the SETs on the control site and the augmentation site to improve accuracy.

The SETs on the augmentation site and control site include rods that extend deep into the sites (providing measurements from the point of refusal) and are therefore measuring subsurface changes. With evidence of deep subsidence in the area provided by the original SETs installed on the Refuge in 2013 in locations outside of the current project and from data at the control site, it appears that subsidence on the augmentation site cannot be attributed fully to the weight of the sediment applied to the site. There is clearly something occurring deeper than the point at which the SETs rods are drilled into the rock.

Bird Surveys and Light-footed Ridgway's Rail Monitoring: Bird surveys to assess species diversity and abundance on the augmentation site are ongoing. These surveys are generally conducted twice monthly, during a high tide and a low tide. 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. These surveys will continue for five years post augmentation.

Eelgrass Surveys: As part of our effort to understand the overall physical and ecological responses of the marsh ecosystem, which includes adjacent eelgrass habitat, the project includes requirements for eelgrass surveys. The primary purpose of performing eelgrass surveys is to determine if the addition of a thin-layer of sediment to the marsh plain within the Anaheim Bay salt marsh complex has an impact on eelgrass located in tidal channels to the east and west of the augmentation site. To date, eelgrass surveys have been conducted in the vicinity of the study area and at a reference site prior to the sediment augmentation process, immediately following the completion of sediment augmentation, and most recently, one-year post sediment augmentation. The goals of these surveys are to provide eelgrass maps of the surveyed areas (study areas and reference area), eelgrass cover estimates, and eelgrass density estimates. Both side-scan sonar and SCUBA surveys are conducted. The sonar survey provides a means to create a spatially accurate eelgrass survey map and provide an estimate of eelgrass coverage. The SCUBA survey provides a means to verify the sonar data, provide a separate estimate of eelgrass cover with an estimate of sampling variation, and is the means by which eelgrass density is determined.[4] Another survey is scheduled for two years post completion of the augmentation process.

Percentage of Task Completed as of September 30, 2017

Task 1 – Project Management and Administration	42%
Task 2 – Sediment Augmentation	100%

[4] Marine Taxonomic Services, Ltd. (MTS). 2017. Seal Beach National Wildlife Refuge Sediment Augmentation First Annual Post-Construction Eelgrass Survey. July 20, 2017.

Task 3 – Project Monitoring (overall)		47.5**%**
1) Carbon Storage/Sequestration Benefits	65%	
2) Plant and Invertebrate Monitoring	30%	
3) Pacific Cordgrass Analysis	30%	
4) Site Elevations	30%	
5) Sediment Analysis (compaction, movement, bulk density)	30%	
6) Turbidity Levels	90%	
7) Bird monitoring	30%	
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)		50%
1) Oral/Poster Presentations	65%	
2) Workshops and/or Webinars	35%	
Overall Project		**77%**

Deliverables Completed for Each Task

Task 1 – Project Management and Administration

1) Quarterly Progress Report	9 reports (This annual report also serves as the July 1 – September 30, 2017 quarterly report.)
2) Monthly Invoices	21 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 underway

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 underway
7) Bird Monitoring	pre-augmentation work completed; post augmentation work ongoing
8) Eelgrass	pre-augmentation, post- augmentation and year one 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 2018

Problems/Delays Proposed Resolution

Sediment Augmentation - As indicated in previous reports, we were not able to fully achieve our sediment augmentation site acreage or uniform coverage objectives for the project site. Unexpected outcomes of the sediment augmentation process included: 1) achieving sediment coverage over at total of 7.87 acres rather than 10 acres as originally proposed; 2) achieving a less uniform coverage of sediment than anticipated (overall coverage was closer to 10” ±2”, rather than 10” ±1”); and 3) the sediment delivered to the site contained a much greater percentage of sand than the grain size analysis conducted for the dredge sites had implied. Additionally, due to contractor error, a portion of the site received up to 20” of sediment, rather than the 10” identified in the contract. All of these outcomes will be addressed in a forthcoming lesson learned document.

The effects of the variability in sediment thickness will be determined as post-augmentation monitoring continues. Because the research plots for studying sediment depth and elevation were collocated with plant and invertebrate monitoring sites, the differences in sediment depth access the site are not expected to significantly influence study results.

To better understand the sand to silt ratio of the sediments delivered to the site, we identified additional funding that enabled us to conduct grain size analysis of the dredge material that was applied to various portions of the site. This information will be helpful in understanding the timeframes for and species diversity associated with plant reestablishment and invertebrate recolonization.

Changes in Eelgrass Distribution Pre, Immediately Post, and One-Year Post Augmentation - Post-augmentation surveys indicate 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, and during the one-year post augmentation survey, areas known to be impacted during augmentation are recovering.

The project budget includes funding for an additional survey two years post augmentation. Following the results of that survey, we hope to have additional information that may better inform the cause(s) for the current decline. If the decline continues, it may be necessary to use some remaining funds in the budget for an additional eelgrass survey in 2019.

Nutrient Analysis in the Augmented Site - Although not currently identified as a problem, the research team has discussed the importance of understanding the role of nutrients in the sediment that has been added to the project site, particularly because the original intent was to apply sediment with a higher clay content. The analysis of nutrient content in pre and post-augmentation sediments and in salt marsh plants from the site is not currently included in the budget, but there is some unallocated funding that could be used for this purpose. The results could inform other land managers of the relative importance of sediment grain size and nutrient content in sediments to be considered for use in thin-layer sediment application projects. The team still retains cores in a freezer that could be used to look at pre-augmentation conditions (an inventory is needed to see what samples are still available). Analysis of nitrogen levels in the sediment would be relatively inexpensively, but the cost for student researchers would be more costly. Dr. Whitcraft has also saved plant tissue that could be analyzed for nutrient content. We request that CDFW consider allocating some funds from our original budget for this task. We can prepare a budget and scope of work if this is acceptable to the Department.

Tidal Creek Formation - Also not currently identified as a problem, but a topic to be aware of as we move forward is the importance of tidal creek development in the reestablishment of native plants and invertebrates on the augmentation site. The original tidal creeks were dammed during sediment augmentation to minimize the flow of sediments from the site and into the adjacent tidal channels. Most of the hay bales installed around the perimeter of the site have deteriorated, but many of those used to hold back sediment in existing tidal channels remain. Representatives from the Army Corps of Engineers indicated that other restoration projects have resulted in high marsh plains with poor drainage, and raised concerns that the middle of our project site may not be receiving the benefits of tidal flushing.

Photo 6. Tidal creek (identified as channel J) forming near the site of a tidal creek that was present in the area prior to augmentation. Photo: USFWS/R. Nye (September 2017)

The Refuge Manager, Rick Nye, provided assurance that the site is fully inundated during tides of greater than +5 feet MLLW, but agreed that tidal inundation within the site should be better characterized.

Another concern of inadequate inundation is increases in acidity when sediments with high sand content are used in thin-layer augmentation projects. There is however currently no indication that acidity levels are increasing on the project site.

Photo 7. Another tidal creek forming on the site. Photo: UCLA/R. Ambrose (August 2017)

Rick Nye is currently developing pros and cons for determining which channels should be altered to facilitate tidal flushing on the site. A recommendation for the best three creeks to be notched is forthcoming. Rick will also review the tide charts to determine how many days out of the year the site is fully inundated by the tides. We are also considering seeking funds to establish current elevations on the site, as this information will facilitate the long term monitoring of creek formation on the site. Work on this topic will continue into November and December 2017.

Project Benefits and Results

Thin-Layer Sediment Augmentation. Although it is too early in the project to fully address project benefits and results, 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. The “lessons learned” document related to the initial augmentation process will be completed in early 2018. This document will include the final turbidity monitoring results and describe the outcomes of the long core analyses conducted by UCLA, which will provide a better understanding of carbon sequestration rates in southern California salt marshes.

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}) (Figure 3). 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)[5] provided an average carbon sequestration for salt marsh habitat at the Seal Beach NWR control

[5] 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

Control

Augmentation

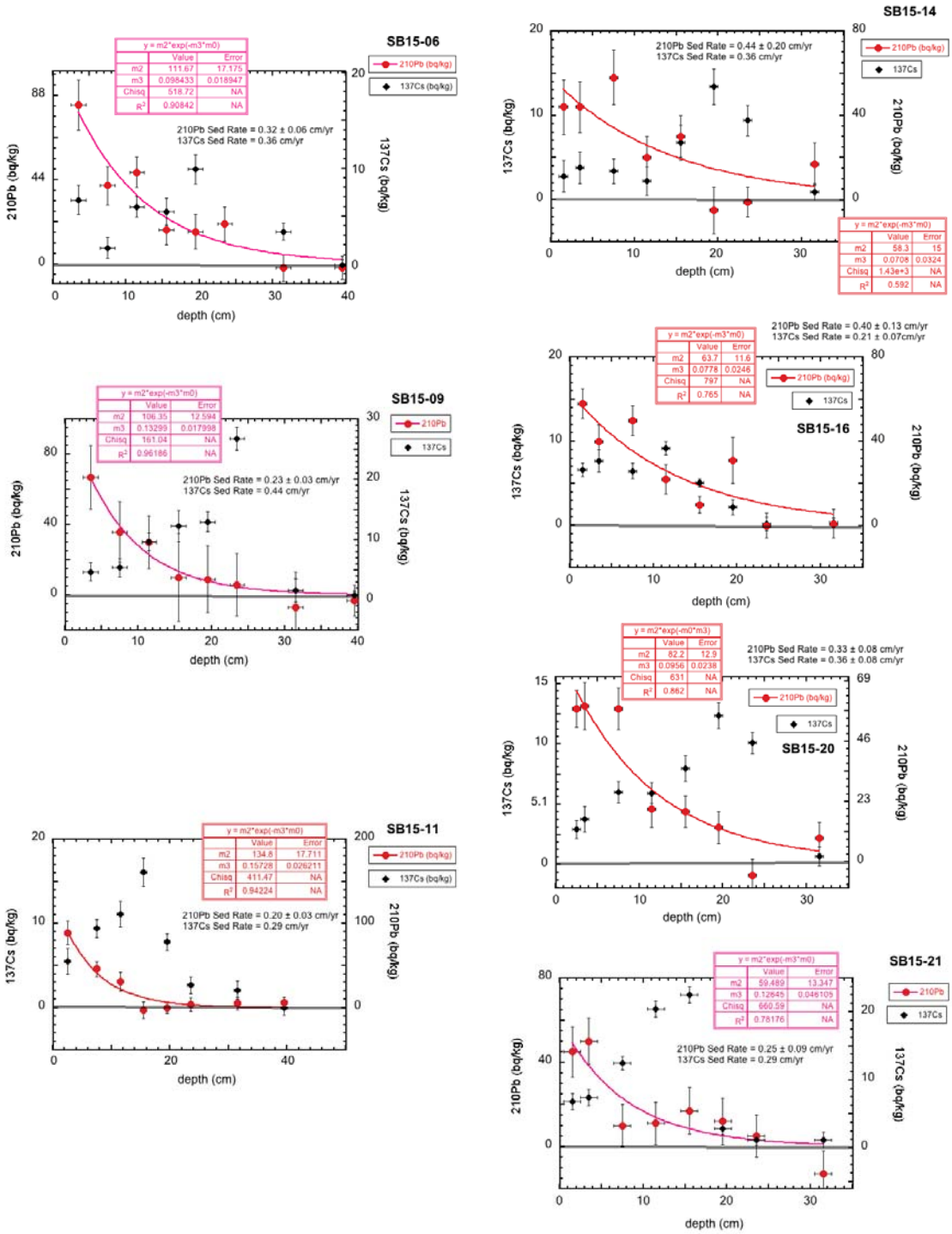

Figure 3. University of Southern California Lab results for radiocesium (^{137}Cs) and radiolead (^{210}Pb) dating of cores taken at the control site and augmentation site.

site and augmentation site to 100 cm depth of 117 g C m^{-2} yr^{-1}, consistent with rates of carbon sequestration around California[6] of ~100 g C m^{-2} yr^{-1} and global[7] 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 the following table.

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)

List of Proposed Activities and Tasks for 2018

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. A “lessons learned” document will be completed. Reports summarizing the final results of pre-augmentation monitoring will be reviewed and provided to CDFW.

Task 2 – Sediment Augmentation
This task is now complete.

Task 3 – Project Monitoring
Post-augmentation monitoring will continue and expand as the augmentation site continues to revegetate.

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

Annual monitoring reports will be prepared.

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

Dr. MacDonald and his team at UCLA will complete their final report in early 2018.

[6] 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

[7] 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

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.

Dr. Whitcraft and her staff will continue to conduct post-augmentation sampling and analysis related to plant and invertebrate diversity and abundance, plant photosynthesis, and biomass. Additional research will be conducted in an effort to determine the origin of plants and invertebrates that appear/colonize on the augmentation site (e.g., growing from existing plants/invertebrates and/or new recruits).

USGS will continue collecting data from the SETs, but no more turbidity data from the adjacent tidal channels will be monitored.

Dr. Keller from Chapman University will continue collecting samples and analyzing porewater ions (e.g., chloride, sulfate), as well as conduct post-augmentation gas flux measurements at the augmentation site and control site.

An eelgrass survey and report will be conducted to evaluate eelgrass conditions two years post augmentation.

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 some more substantial post-augmentation monitoring results, we will identify an appropriate format for presenting this information to interested parties.

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. The eelgrass elevation survey was completed and the final report was issued in November 2016.

Attachments

1. Table of Cost Share Expenditures
2. Location Map
3. Summary of Pre-augmentation Monitoring Results for Plants and Invertebrates (CSU Long Beach)
4. Monthly High and Low Tide Survey Results of Avian Usage at the Sediment Augmentation Site (October 2016 – September 2017)
5. Recent Photos of the Augmentation Site
6. Seal Beach National Wildlife Refuge Sediment Augmentation First Annual Post-Construction Eelgrass Survey, July 20, 2017

Attachment 1
Itemized Cost Share Items and Activities

Cost Share (June 1, 2015 to September 30, 2017)		
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	$170,776
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	**$1,381,545**
Total Cost Share from October 1, 2016 to December 31, 2016		
Post-augmentation monitoring	California State Coastal Conservancy	$45,179
USFWS staff time[2]	USFWS CRI Grant	$10,575
	Subtotal	**$55,754**
Cost Share from January 1 – March 31, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$38,002
USFWS staff time[2]	USFWS CRI Grant and Station Funds	$1,071
	Subtotal	**$39,073**
Cost Share from April 1 – June 30, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$23,885
USFWS staff time[2]	USFWS CRI Grant and Station Funds	$9,201
	Subtotal	**$33,086**
Cost Share from July 1 – July 31, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$21,019
USFWS staff time[2]	USFWS Station Funds	$578
	Subtotal	**$21,597**
Cost Share from August 1 – August 31, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$22,104
USFWS staff time[2]	USFWS CRI Grant[4] and Station Funds	$973
	Subtotal	**$23,077**
Cost Share from September 1 – September 30, 2017		
Post-augmentation monitoring	California State Coastal Conservancy	$58,386
USFWS staff time[2]	USFWS and Station Funds	$316
	Subtotal	**$58,702**
	Total Cost Share to Date	**$1,612,834**

[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.

Attachment 2
Seal Beach National Wildlife Refuge
Thin-Layer Sediment Augmentation Project
Location Map

Attachment 3

Summary of Pre-augmentation Monitoring Results for Plants and Invertebrates (CSU Long Beach)

Initiation of Thin-Layer Sediment Augmentation on the Pacific Coast

Seal Beach National Wildlife Refuge

PRE-RESTORATION MONITORING REPORT
(SPRING 2015 – SPRING 2016)

Date: _August 2017_____

Researcher/Contractor: ____CSULB (Whitcraft, McAtee)_____

Summary Report:

- Few differences in abiotic factors (porewater salinity and temperature) existed between experimental and control sites pre-augmentation (Spring 2015). Most observed differences were related to differences among sampling days.
- Plant and invertebrate parameters (cover, species richness, community composition) were similar between experimental and control sites before augmentation (Spring 2015).
- Few changes in abiotic factors, plant parameters and invertebrate parameters existed in the control site from pre-augmentation (Spring 2015) to post-augmentation (Spring 2016), giving us a background level of environmental variation at the site.
- Significant decreases in the percent cover, abundance, and species richness of plants were found in the experimental site post-augmentation as compared to pre-augmentation. We are expecting plant recruitment or rhizomatous extension from edges by Fall 2016.
- Significant decreases in abundance and species richness of invertebrates existed in the experimental site post-augmentation (Spring 2015) as compared to pre-augmentation (Spring 2016).

Research Objectives

Our research objectives were to assess 1) the plant community 2) associated abiotic parameters (temperature, porewater salinity, redox) and 3) invertebrate community pre- and post-sediment application. In addition, we were assessing the ability of plants and sediment to store carbon by collecting data on the photosynthetic rate of plants, C:N ratios of plants, plant traits (e.g. leaf area) and isotope ratios in sediment

Monitoring purpose:

Assessing the effects of sediment augmentation on plant and invertebrate communities is critical to fully understanding the biological response of wetlands to this kind of disturbance. Plants contribute directly to vertical accretion through organic matter input (Turner et al., 2002). Their above and below ground biomass provides structure and support for sediments and can slow water flow through wetlands leading to an increased deposition of sediment

(Leonard and Luther, 1995). Plant litter and detrital matter on the soil surface can also trap sediment, thus contributing to vertical accretion (Cahoon et al., 2006). Thus, plant species composition can influence the ability of a salt marsh ecosystem to accrete and keep pace with SLR (Kirwan and Megonigal, 2013). Vascular plants are important as they are responsible for many of the services provided by wetlands including habitat structure, nursery habitats, stabilization of the coastline, water filtration and trophic support (Cronk and Fennessy, 2001). Additionally, plants are fundamental to the stability of wetlands as they control the biotic communities that thrive in these habitats and determine the structure of benthic communities and sedimentation rates of the marsh (Whitcraft and Levin, 2007). Marshes with higher vegetation cover have been found to have a higher abundance of macrofaunal invertebrates (invertebrates that live in or on the sediment surface) than less densely vegetated marshes (Talley and Levin, 1999).

An assessment of the effect that augmentation has on invertebrate communities is essential as the abundance, diversity, and community structure of infaunal communities (polychaetes, oligochaetes, amphipods etc.) serve as indicators for marsh health (Anderson et al., 2012), and these communities are the base of the marsh food web (Kwak and Zedler, 1997). The presence or absence of certain infauna (organisms that live in the sediment) or epifauna (organisms that live on the sediment surface) can indicate water quality, anthropogenic or natural stressors, and the health of other trophic levels. The burrowing and decomposition activities of macrofaunal invertebrates also contribute to how marshes accrete or retain sediment and plant material. However, excessive inundation can decrease substrate aeration which results in the deterioration of vascular plants which may in turn affect the invertebrate populations (Slocum et al., 2005).

Monitoring approach

Abiotic Parameters

Porewater soil temperature at a depth of 2 cm was measured at each sampling location using handheld Fisher brand digital thermometer. Salinity of porewater in the sediment was measured at every sampling period in every plot using a refractometer. Top 2 cm of sediment was collected, placed in a syringe with filter, and porewater was extruded onto refractometer for reading of salinity (psu).

Cover Class Transects

This survey method is based on the Daubenmire (1959) cover-class system using a 7-point scale (Table 1). Surveys were conducted using 0.125 m^2 PVC quadrats. Because canopies of different strata (e.g. grasses, shrubs) may overlap and the cover is broken down into classes, these cover estimates can total more than 100% (Ambrose and Diaz 2008). Each species (and whether it is alive or dead) was recorded as a cover class.

Infaunal Invertebrates

Infauna were collected using a 6 cm diameter push corer inserted into the sediment to a depth of 6 cm. These cores were subdivided in the field into 0-2 cm and 2-6 cm depth sections.

Each core covered an area of 18.1 cm^2. These cores were transported to the lab for preservation in formalin and were sieved on a 300 µm sieve. Invertebrates were sorted to lowest possible taxonomic level and vouchered in ethanol.

Plant physiology parameters

Twelve randomly selected salt marsh plants per area (within the application site and in a control site) were chosen for continual physiological monitoring at biweekly intervals prior to and for the first year and quarterly intervals for four years post-augmentation. On each of the measurement dates, leaf-level photosynthesis and conductance were measured (using a Li-Cor LI-6400X portable photosynthesis system) under light-saturating conditions (>900 lmol m) on a single, young but fully expanded leaf on each of these 12 plants. On each date, 12 additional, randomly chosen plants were measured similarly, then harvested and preserved in formalin-acetic acid-alcohol mixture. These sections will be used to determine total leaf thickness, total chlorophyll, total leaf area (LMA) (using LiCor), foliar % N, and percent C, H, and N.
One set of leaves was collected to analyze leaf nitrogen and LMA while a 2nd set of leaves was collected to analyze leaf chlorophyll. LMA will be determined following the protocol reported by Funk (2008). Leaf nitrogen content will be determined by processing samples in an elemental analyzer (Costech 4010, Pioltello, Italy). Leaves will be dried at 60°C and ground to pass a 40-mesh screen using a Wiley mill. Samples will be dried once more before being placed in tin foil boats and sent for analysis at Chapman University (Orange, California). An apple leaf standard with 2.25% nitrogen will be used for a standard in the processing. The leaves collected for chlorophyll analysis will be frozen at -80°C until processed. Leaf chlorophyll content will be determined following the protocol reported by Lichtenthaler (1987). A spectrophotometer will be used to determine absorbance at 646nm and 663nm, following the protocol reported by Bonin and Zedler (2008). Following sample processing, chlorophyll a and b will be calculated as in Lichtenthaler (1987). These analyses will be conducted in the upcoming year.

Monitoring dates and actions

Sampling occurred twice per year in the spring and fall. Pre-augmentation data were gathered in spring 2015 and fall 2016. Sorting of invertebrate samples and sediment cores were ongoing in the laboratory.

Results

Throughout the results, we will refer to habitat type (*Batis maritima*-dominated [BAMA], *Spartina foliosa*-dominated [SPFO], Pond) and treatment type (experimental augmentation, control).

Abiotic Data

There was significantly lower porewater temperatures in the control sites for Spfo ($p<0.001$, $F=23.483$) and Bama ($p<0.001$, $F=21.165$) habitats in fall 2015 as compared to the same habitats in the experimental site (Fig. 1). This was most likely related to warmer air temperatures and sunnier conditions on the days of sampling and not related to actual differences between the sites. Overall, there was no difference in temperature between experimental and control site in spring 2015 (Fig. 1).

Salinity was significantly higher in the control site in spring 2015 as compared to the experimental site for Pond ($p<0.001$, $F=11.736$) and Bama habitats ($p=0.03$, $F=6.04$) (Fig. 1). Again, this is potentially related to differences in sampling time relative to tidal elevation among sampling days. There was no significant difference in salinity between experimental and control sites for fall 2015 before augmentation (Fig. 2).

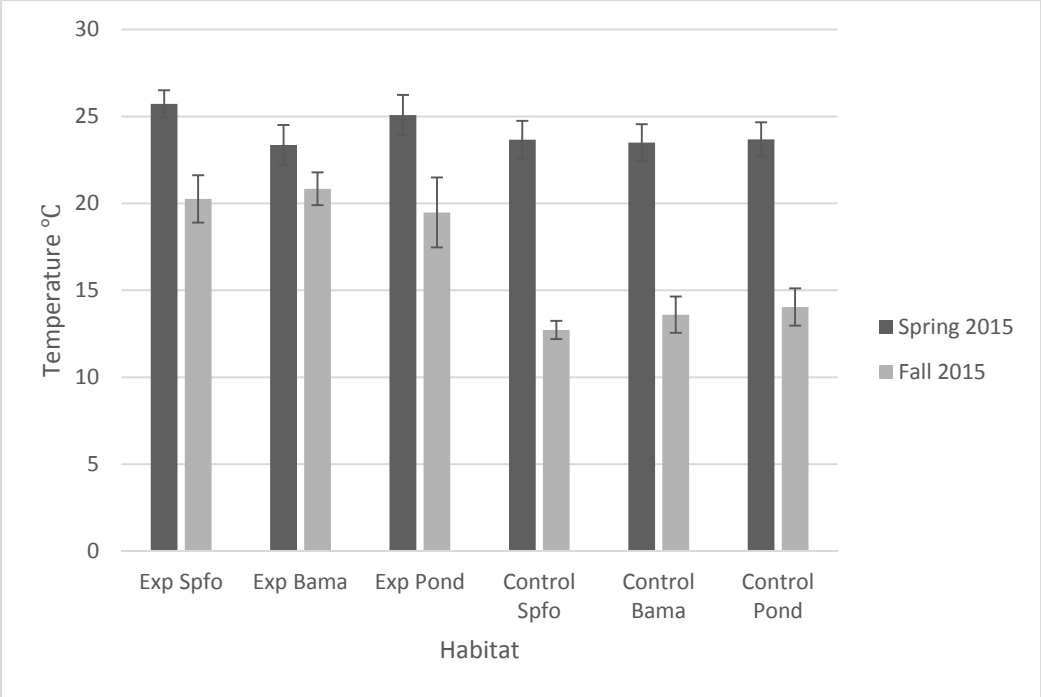

Fig. 1 Temperature data from the control and experimental sites before augmentation

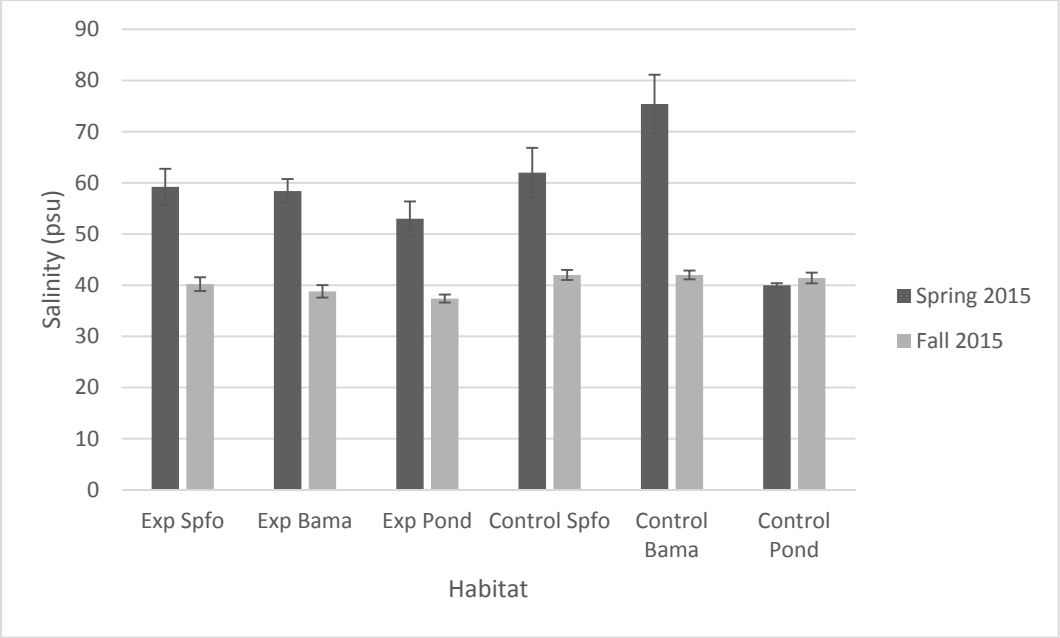

Figure 2. Salinity data from the control and experimental sites before augmentation

Plant community

In the experimental and control sites in Spring and Fall 2015 (pre-augmentation), BAMA areas had the highest initial plant cover, then SPFO areas, then ponds (Figs. 3,4). No differences existed within habitat type between the experimental and control sites in overall percent cover. In both the experimental and control sites in Spring and Fall 2015 (pre-augmentation), BAMA areas had the highest initial plant species richness, followed by Spfo and Pond habitats (Fig. 5). No differences existed between the experimental and control sites in overall species richness within habitat in the pre-augmentation period. In the experimental and control sites in Spring and Fall 2015 (pre-augmentation), each habitat type had distinct plant communities (by definition), but the habitats were similar in composition between control and experimental sites (Figs. 6,7; ANOSIM $p > 0.05$). The control site had higher photosynthetic rates on average than the experimental site in the fall before augmentation, but this difference was not significant (Fig. 8).

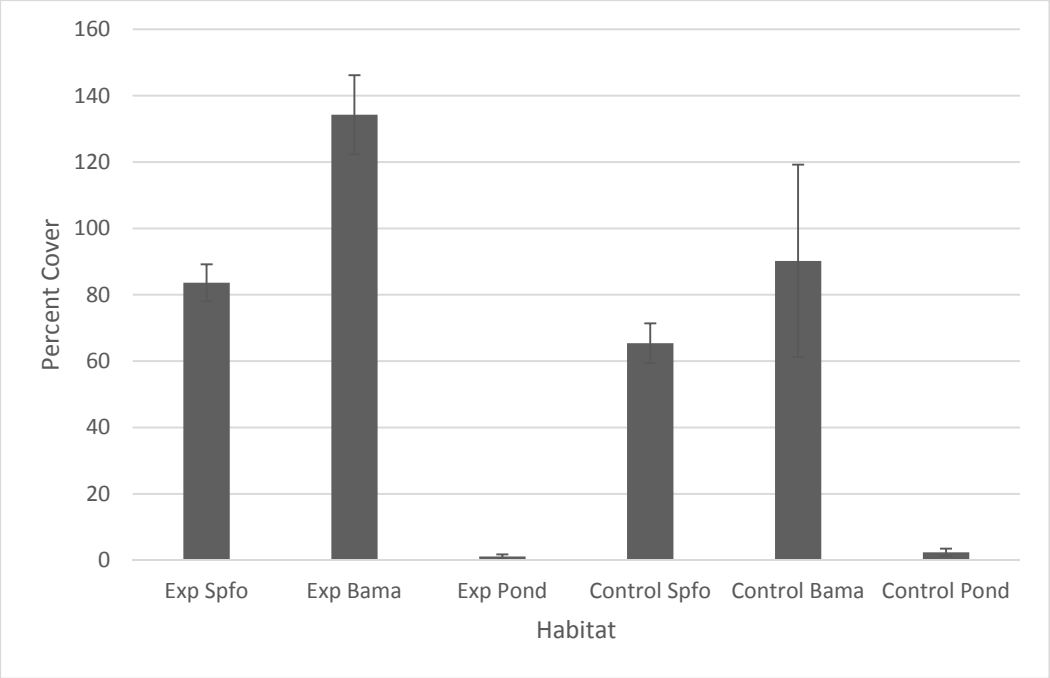

Figure 3. Percent cover of plants in the experimental and control site during spring 2015

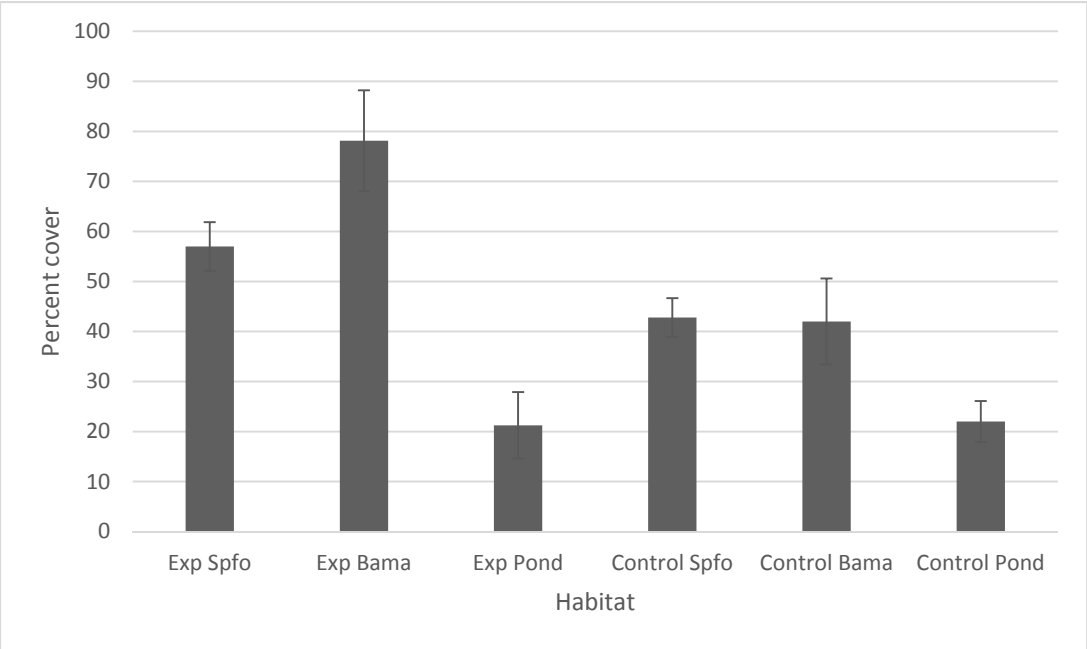

Figure 4. Percent cover of plants in the experimental and control site during fall 2015

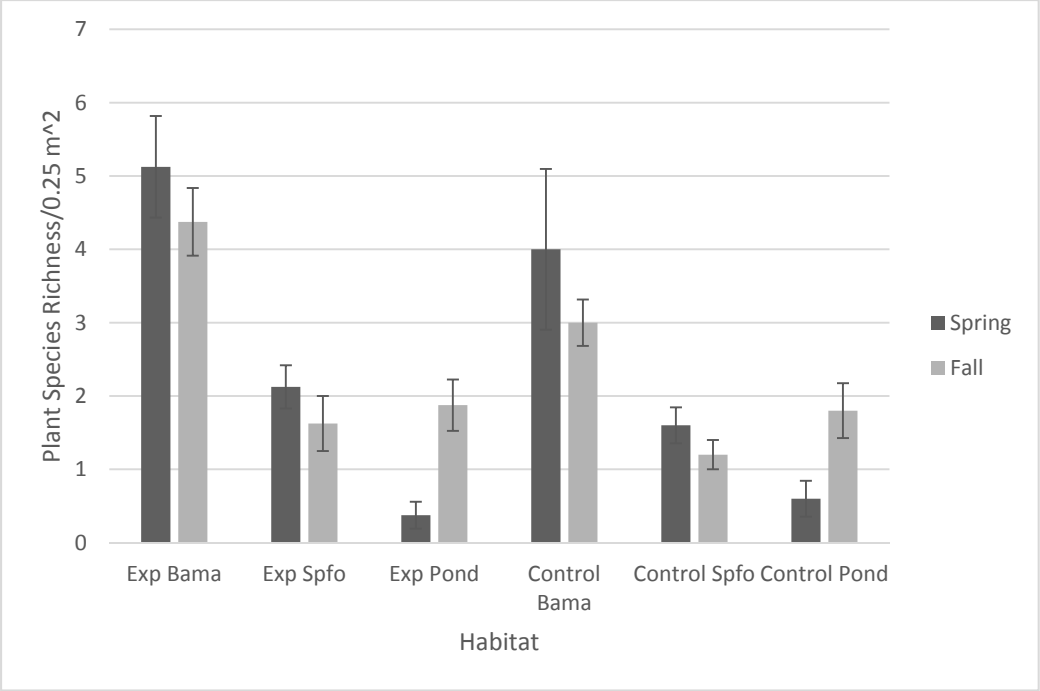

Figure 5. Species richness of plants in the control and augmentation site before sediment augmentation in fall and spring 2015

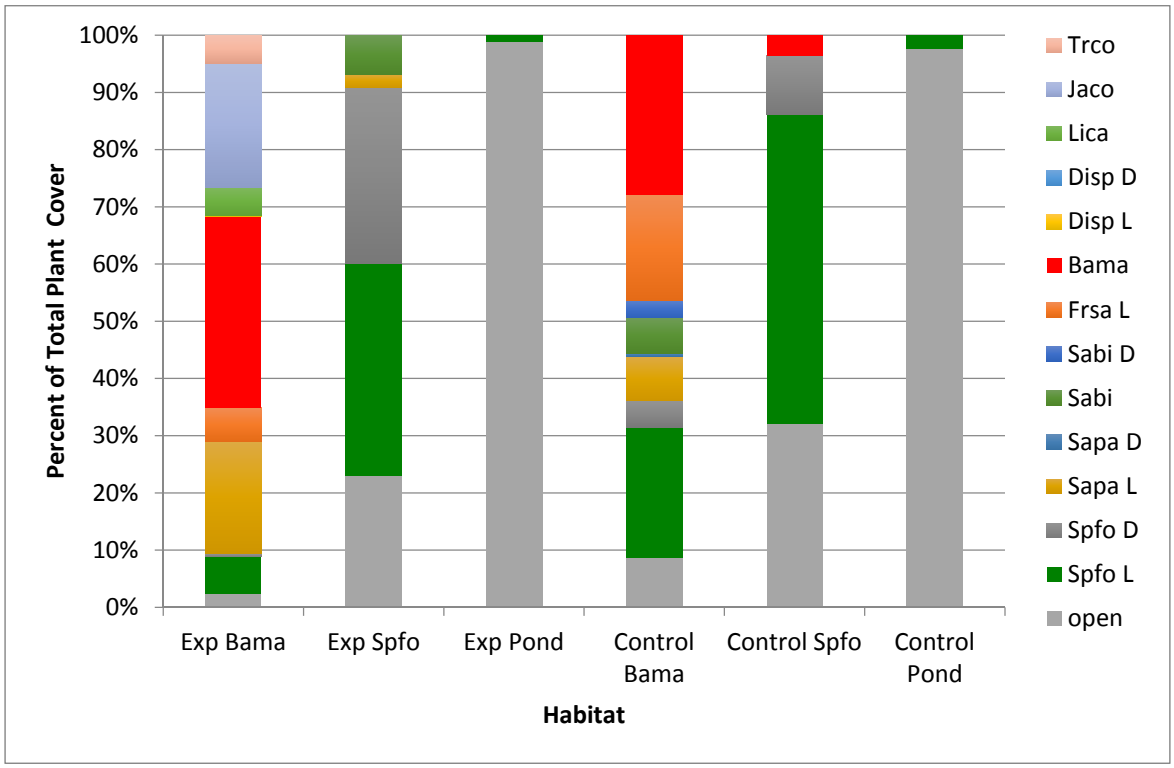

Figure 6. Percent of total plant cover by plant species in the experimental and control sites during Spring 2015 (pre-augmentation)

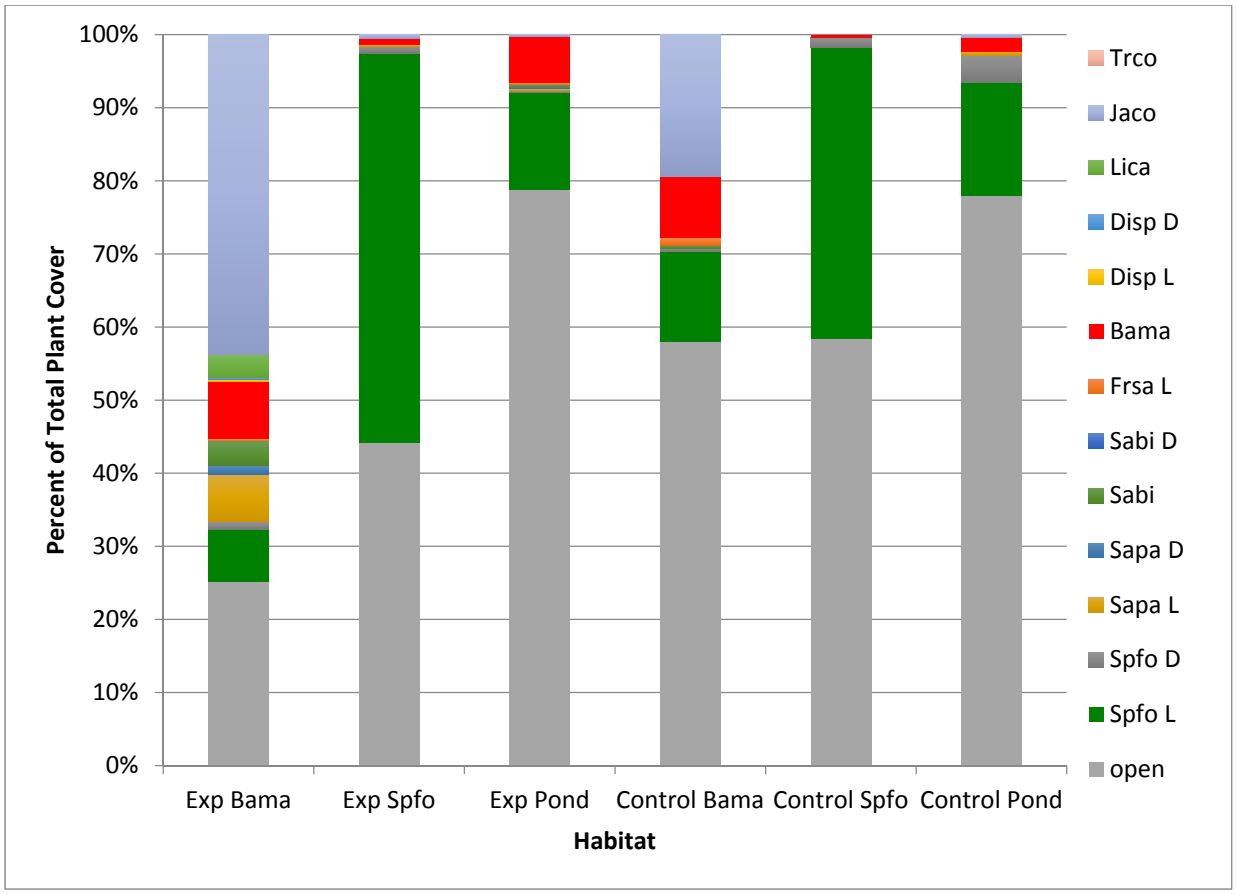

Figure 7. Percent of total plant cover by plant species in the experimental and control sites during fall 2015 (pre-augmentation)

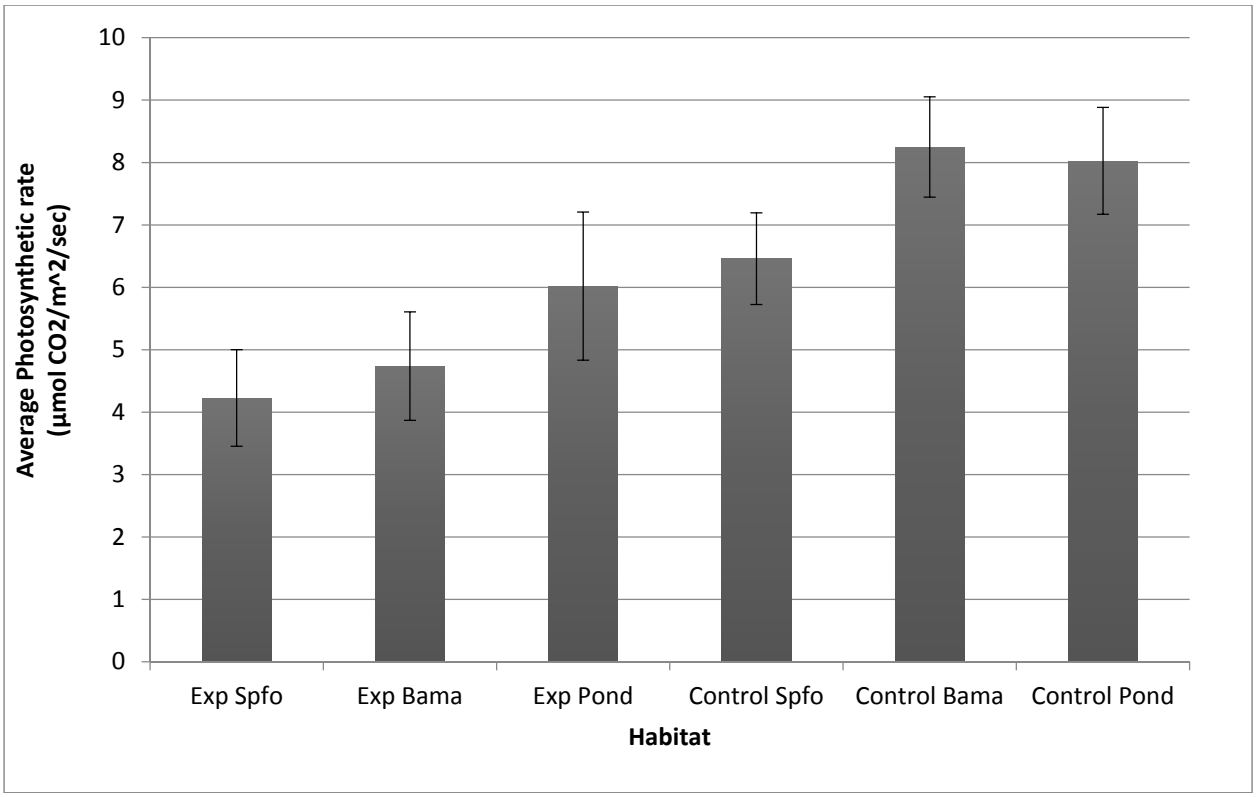

Figure 8. Photosynthetic rate of *Spartina foliosa* during fall 2015 (pre-augmentation)

Invertebrate Data

All results presented for the invertebrate community are for spring 2015 and fall 2015 and for the 0-2 cm samples. Most (78–89%) of the macrofauna in southern California *Spartina foliosa* marshes is found in the top 2 cm of sediment (Levin et al. 1998).

Pre-augmentation, the abundance (N) and species richness (S) of invertebrates in experimental and control sites were similar in both the spring and the fall within habitat. Community composition for the control and experimental site were similar pre-augmentation within season (spring and fall 2015).

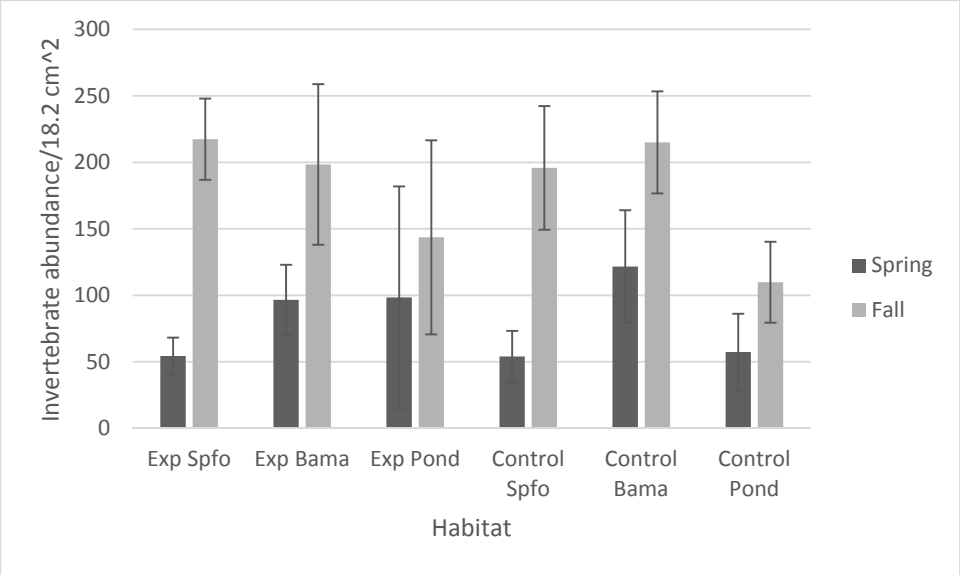

Figure 12. Abundance of invertebrates in each habitat in the experimental and control site

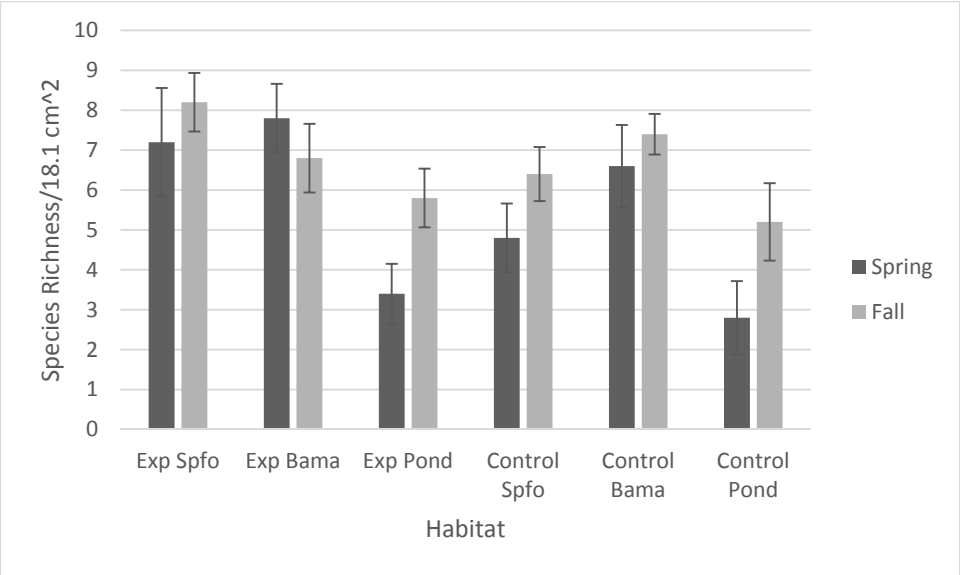

Figure 13. Invertebrate species richness of invertebrates in each habitat in the experimental and control sites

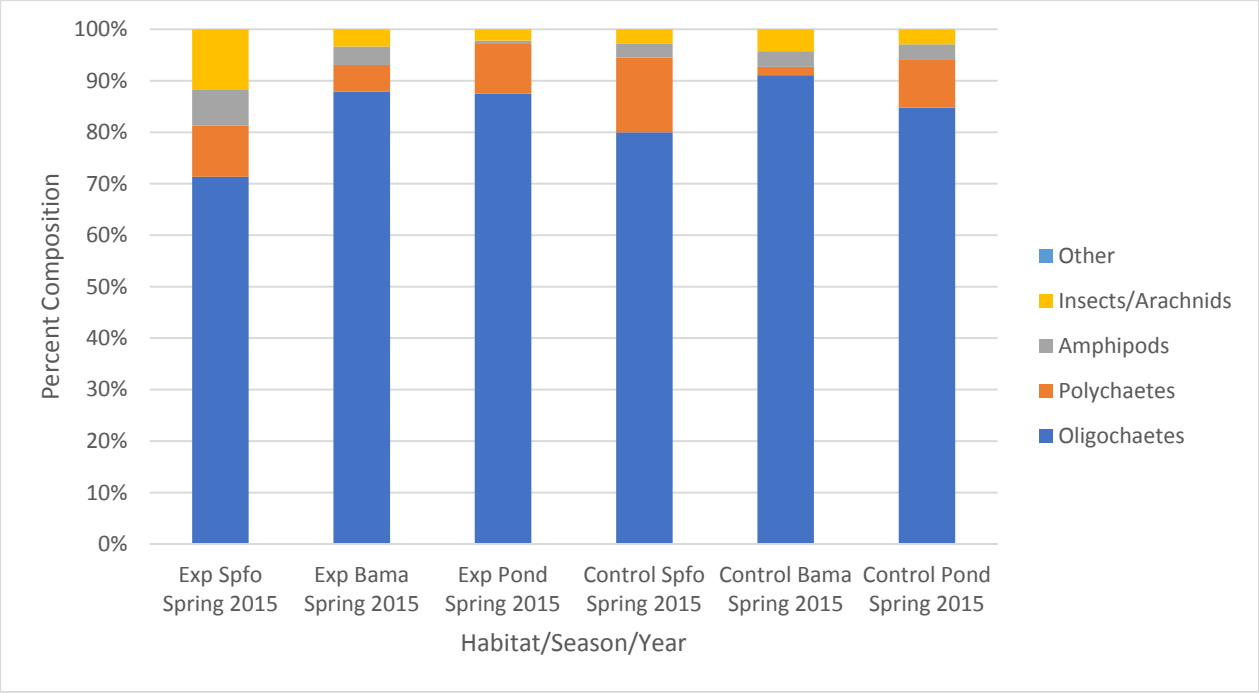

Fig. 14. Invertebrate community composition within major taxonomic divisions in each habitat in the experimental and control sites for spring 2015. The grouping "Other" includes nemerteans and gastropods (because so few were present in each group).

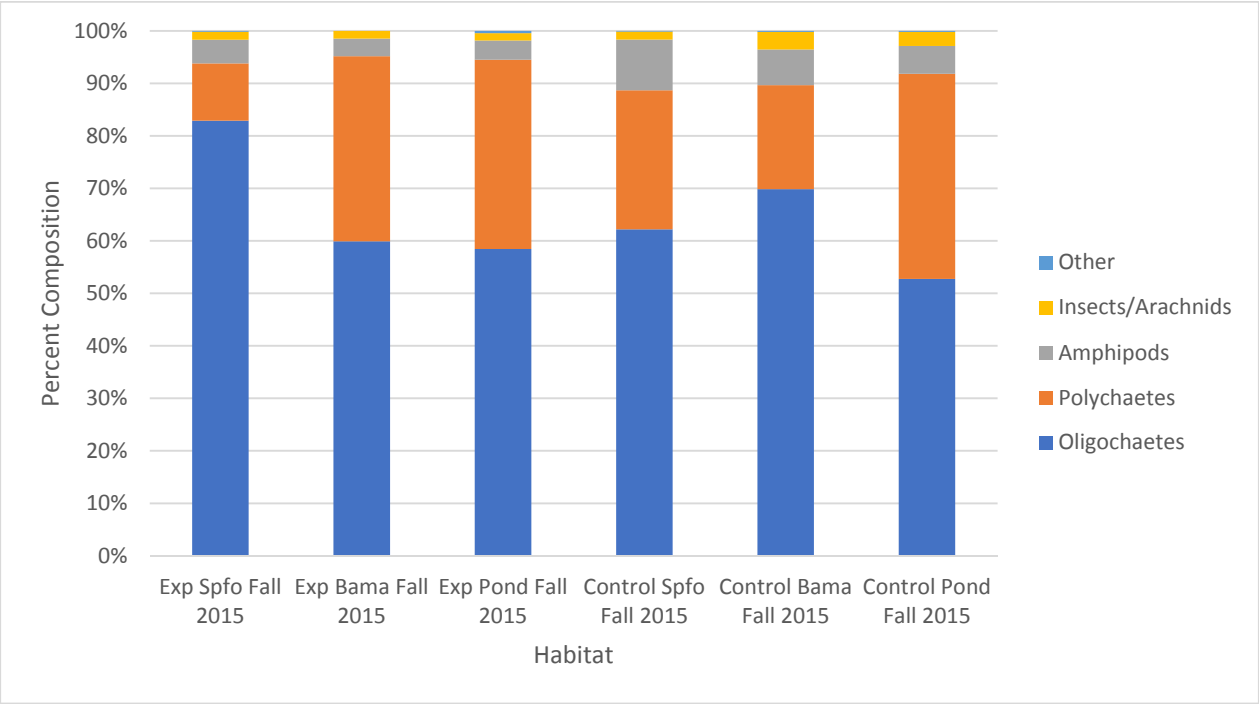

Fig. 15. Invertebrate community composition within major taxonomic divisions in each habitat in the experimental and control sites for fall 2015. The grouping "Other" includes nemerteans and gastropods (because so few were present in each group).

Attachment 4
Monthly High and Low Tide Survey Results
of Avian Usage at the Sediment Augmentation Site
(October 2016 – September 2017)

Species	10/14/16 low tide	10/18/16 high tide	11/14/16 high tide	12/13/16 high tide	01/14/17 high tide	02/24/17 low tide	02/28/17 high tide	03/11/17 high tide	06/30/17 high tide	07/18/17 high tide	08/16/17 high tide	09/20/17 high tide
Great blue heron			1	1								
Great egret		1	1	1	2		1					1
Canada goose								2				
Black Brant									3			
American wigeon			1									
Surf scoter					4							
Red-breasted Merganser			1		19							
Osprey												1
Northern harrier						1						
American coot			2	18								
Black-bellied plovers		34	2								22	125
Killdeer			2									
Willet		1	1						1	30		
Long-billed curlew				12	1			12				
Calidris sp.		45	190	125						30		
Short-billed dowitcher									20			
Ring-billed gull			1									
Western gull	2				1		1	2		1	2	3
Caspian tern												8
Forster's tern												
Total Birds Counted	**2**	**81**	**202**	**157**	**27**	**1**	**2**	**16**	**24**	**61**	**24**	**138**

Dates when no birds were observed: 11/29/2016 (low tide); 12/26/2016 (low tide); 01/24/2017 (low tide); 04/2017 (low/high tides); 05/2017 (low/high tides); 07/30/2017 (low tide); 08/13/2017 (low tide); 09/19/2017 (low tide)

Attachment 5

Seal Beach National Wildlife Refuge Sediment Augmentation

First Annual Post-Construction Eelgrass Survey, July 20, 2017

MARINE TAXONOMIC SERVICES, LTD.

Seal Beach National Wildlife Refuge Sediment Augmentation First Annual Post-Construction Eelgrass Survey

7/20/2017

First Annual Post-Sediment Augmentation Eelgrass Report

Mayda Winter
Southwest Wetlands Interpretive Association
700 Seacoast Drive #108
Imperial Beach, CA 91932

RE: Seal Beach National Wildlife Refuge Sediment Augmentation First Annual Post-Construction Eelgrass Survey

July 20, 2017

Dear Mayda:

Thank you for contracting with Marine Taxonomic Services (MTS) to provide the eelgrass (*Zostera marina*) monitoring surveys in support of the Thin-Layer Salt Marsh Sediment Augmentation Pilot Project (Project). The previous post-sediment augmentation eelgrass survey (post-construction survey) was performed in May 2016 (MTS 2016). This report provides the results of the second post-sediment augmentation eelgrass survey (first annual post-construction survey) and compares the past survey efforts to determine potential long-term impacts to eelgrass from construction. The survey methods and results are provided below. All eelgrass survey components were performed in accordance with guidelines specified within the California Eelgrass Mitigation Policy (CEMP [NOAA Fisheries 2014]).

Introduction

Seal Beach National Wildlife Refuge (Seal Beach NWR) implemented the Project to document the effectiveness of sediment augmentation over 10 acres of low elevation salt marsh habitat within Seal Beach NWR (SBNWR 2015). The Project seeks to evaluate the impacts of subsidence and sea-level rise on the quality and long-term persistence of the salt marsh. A key element of the Project is to determine whether adding a thin layer of sediment will improve habitat quality for the flora and fauna in the salt marsh, with a focus on cordgrass-dominated habitat associated with the federally endangered light-footed Ridgway's rail (*Rallus obsoletus levipes* [formerly light-footed clapper rail (*Rallus longirostris levipes*)].

Sediment augmentation efforts at Seal Beach NWR involved the removal of clean material dredged from the nearby Sunset/Huntington Harbour Maintenance Dredging and Waterline Installation Project. Dredge material was transported to the site and pumped as a slurry over the placement area. Sediment was contained to the placement area using hay bales; this minimized transport of fine material to the water and prevented turbidity. A buffer area was also established between the salt marsh augmentation area and the tidal channels to minimize the movement of sediment into the adjacent tidal channels.

The effectiveness of the Project will ultimately be evaluated on the overall physical and ecological responses of the marsh ecosystem, which includes eelgrass habitat. The main purpose of performing eelgrass surveys is to determine if the addition of sediment impacts

Figure 1. NOAA navigational chart for Seal Beach National Wildlife Refuge showing the location of the Project eelgrass survey area (Study Area) and the Project's eelgrass reference area (Reference Area). This map not intended for navigational uses.

eelgrass habitat. The current survey effort provides the first annual post-construction eelgrass mapping data (one year after the project). These data are evaluated against the pre-construction data and the post-construction data as the basis for determining long-term impacts following construction.

Methods

MTS performed side-scan sonar and SCUBA surveys of the study area and the reference area on April 26, 2017 and May 24, 2017, respectively. The goals of the survey effort were to provide post-sediment augmentation eelgrass maps, eelgrass cover estimates, and eelgrass density estimates of the study area and the reference area. The sonar survey provided a means to create a spatially accurate eelgrass survey map and provide an estimate of eelgrass coverage. The SCUBA survey component provided a means to verify the sonar data, provided a separate estimate of eelgrass cover with an estimate of sampling variation, and was the means by which eelgrass density was determined.

The sonar survey was performed by navigating a series of parallel survey transects through the study and reference areas using a pole-mounted side-scan sonar operating at 450 kHz. The sonar was set to scan 30 meters on both the port and starboard channels for a total scanning swath of 60 meters. Survey transects were navigated such that adjacent sonar swaths overlapped. This provided for complete and redundant bottom coverage within the study and reference areas.

The collected side-scan files were geographically registered using the ship's navigation data collected during the survey. The multiple side-scan files were compiled to create a contiguous view of the seafloor across the entirety of the study and reference survey sites. The compiled survey results were then used to digitize eelgrass by tracing the eelgrass boundaries. Once digitized, the eelgrass boundary was buffered 5 meters in accordance with CEMP mapping guidelines. The CEMP requires the buffer in recognition of the fact that eelgrass beds have benefits that extend beyond their boundaries and the fact that eelgrass can expand as much as 5 meters annually (refer to CEMP and references therein). This buffered area and the eelgrass within constitutes "eelgrass habitat" on the provided figures. The eelgrass habitat buffer was cropped in accordance with the CEMP where depth, substrate, or existing structures are unsuited to supporting eelgrass habitat. The digitized eelgrass and the eelgrass habitat boundaries were plotted on an aerial image of the Seal Beach NWR.

The SCUBA survey was performed by selecting locations for 100-meter sampling transects within the study (n=8) and reference area (n=4) survey boundaries prior to the pre-construction survey (Figure 2 and Figure 3). The same survey transects were established during this post-construction survey as were sampled previously. The 100-meter transects were placed on the seafloor with the aid of a differential GPS.

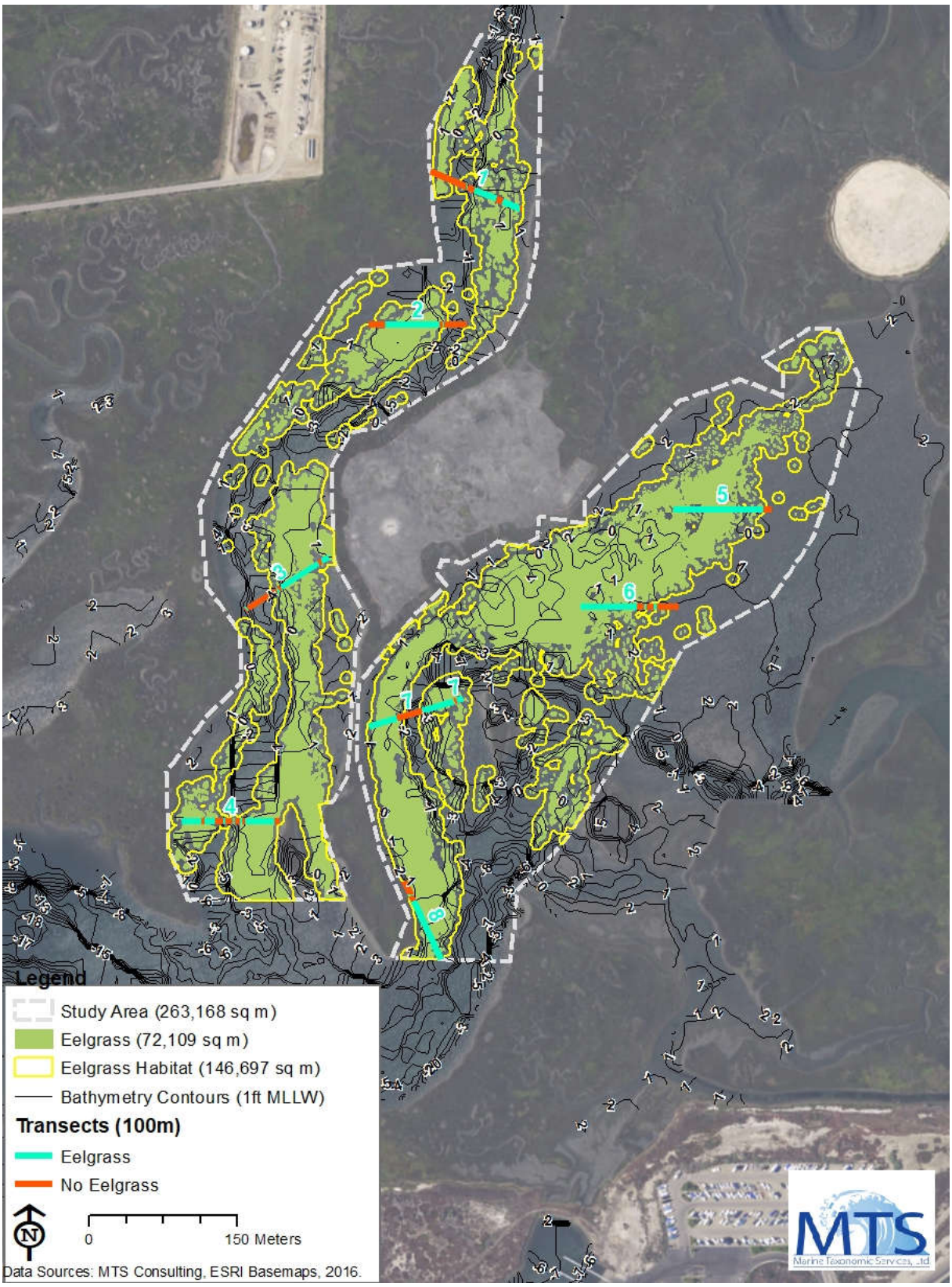

Figure 2. Study area with position of diver transects and post-sediment augmentation mapped eelgrass. Survey dates were April 26, 2017 (side-scan sonar) and May 25, 2017 (transects).

Figure 3. Reference area with position of diver transects and post-sediment augmentation mapped eelgrass. Survey dates were April 26, 2017 (side-scan sonar) and May 25, 2017 (transects).

A diver swam each transect line and measured the distance where each transect line intercepted eelgrass. Additionally, eelgrass densities were estimated by placing a 0.16 square meter quadrat within eelgrass beds during the transect survey. Eelgrass leaf shoots were counted within quadrats randomly-placed every ten meters on each transect within the study and reference areas. A total of 61 and 40 quadrats were sampled within the study and reference areas, respectively.

Eelgrass cover was calculated by two means. First the area mapped as eelgrass using the side-scan sonar record was compared to the total survey area to provide an estimate of percent eelgrass cover. Second, the line intercept data were used to determine percent eelgrass cover by calculating the transect distance where eelgrass intercepted the transect lines over the total transect distance. The multiple transects performed within the study and reference survey areas were used to calculate an estimate of average cover and an associated standard deviation based on the sample data. All estimates of cover and area based on the diver transects are presented as the mean ± 1 standard deviation of the mean.

Eelgrass density was calculated by taking the average of the leaf shoots counted within each of the quadrats sampled within the study and reference survey areas. A quadrat was considered to be part of an eelgrass bed if it was placed within eelgrass or within a gap between eelgrass turions that was less than 1 square meter. If this criterion was not met the placed quadrat was rejected as a suitable randomly selected sample. The calculated averages and associated standard deviations were scaled to present the data as eelgrass density per square meter. All eelgrass densities are presented as the mean number of leaf shoots per square meter ± 1 standard deviation of the mean.

Depth data were provided by Seal Beach NWR. The provided data were a 5 meter grid of depth data where the coordinates were in UTM (Zone 11, meters) and the depths were in meters NAVD. The depth values were converted to feet MLLW and used to generate 1 foot MLLW contours in accordance with the CEMP. Depth data apply to conditions at the time of the depth survey.

Comparisons across monitoring events were made by studying each of the survey data components across monitoring events. The eelgrass cover data were compared numerically and visually. Numerical comparisons were made by examining the amount of eelgrass cover increase or decrease at the study and reference areas. Visual examination of the eelgrass cover was performed to look for areas where eelgrass may have disappeared in association with construction. The transect intercept data were compared across the surveys to determine if the percentage occurrence along transects had changed. Finally, density data were evaluated to determine if there were any meaningful trends with regards to eelgrass density over time.

Results

2017 Findings

The side-scan sonar record was digitized to produce the eelgrass maps of the study and reference areas depicted in Figure 2 and Figure 3. The mapping identified 72,109 square meters of eelgrass and 146,697 square meters of eelgrass habitat within the 263,168 square meter study area. This equates to an eelgrass cover of 27.4% over the entirety of the study survey area. There were 10,353 square meters of eelgrass and 15,555 square meters of eelgrass habitat within the 18,107 square meter reference area. This equates to an eelgrass cover of 57.2% within the reference area.

The diver transect surveys are summarized in Table 1. At the study area, the 8 surveyed transects resulted in 800 meters of total transect sampling. The mean (± 1 sd) percent cover of eelgrass at the study area based on the transect survey was 65 ± 15%. At the reference site, the 4 diver transects resulted in 400 meters of total transect sampling. The mean percent cover of eelgrass at the control site was 92 ± 6%.

Table 1. Transect eelgrass intercept data for diver transects performed at the study and reference areas for the first (top) and second (bottom) post-augmentation surveys. Coordinate labels "E" and "N" refer to easting and northing, respectively.

Diver Eelgrass Monitoring Transects (Year 1 Annual Post-Construction)						
Transects	**Transect End Coordinates (UTM, Z 11, NAD 1983)**					
Study Area	**E1**	**N1**	**E2**	**N2**	**Intercept (m)**	**Intercept (%)**
1	400068	3733739	400160	3733701	44	44%
2	400005	3733584	400105	3733584	57	57%
3	399880	3733296	399964	3733349	56	56%
4	399816	3733080	399916	3733080	66	66%
5	400414	3733397	400314	3733397	96	96%
6	400320	3733299	400220	3733299	62	62%
7	400101	3733205	400005	3733177	71	71%
8	400041	3733020	400078	3732941	67	67%
				Study Area Averages	65 ± 15 m	65 ± 15%
Reference Area						
9	401412	3732946	401312	3732953	100	100%
10	401289	3732918	401389	3732918	86	86%
11	401294	3732901	401394	3732901	93	93%
12	401292	3732849	401392	3732849	88	88%
				Reference Area Averages	92 ± 6 m	92 ± 6%

Eelgrass density (mean ± 1 sd) at the study area was 74 ± 76 leaf shoots per square meter and at the reference area, eelgrass density was 190 ± 125 leaf shoots per square meter. Density was statistically different between the study and reference areas ($t=-5.745_{(\alpha=0.05,\ df=85)}$;$p<0.001$).

Comparisons among Monitoring Events

The results of the sonar mapping show declines in overall eelgrass cover within the study area relative to the 2016 post-construction monitoring (Table 2). These results continue a trend where there were minor declines noted between the pre- and post-construction surveys. Eelgrass cover within the survey area declined 0.6% between the pre- and post-construction surveys. Between the post-construction survey and this year 1 annual post-construction survey, survey area eelgrass cover declined 14.1%. Eelgrass cover within the reference area declined 2.0% between the pre- and post-construction surveys and then increased 9.4% between the post-construction survey and this year 1 annual post-construction survey.

Table 2. Side-scan sonar survey mapping results for eelgrass area following the before and after the Project.

	Study Area			
	Survey Dates (Scan/SCUBA)	**Survey Area (sq m)**	**Eelgrass (sq m)**	**Percent Cover**
Pre-Construction	Oct 2015	263,168	110,892	42.1%
Post-Construction	Apr/May 2016	263,168	109,320	41.5%
Year 1 Post-Construction	May/Apr 2017	263,168	72,109	27.4%
	Reference Area			
	Survey Dates (Scan/SCUBA)	**Survey Area (sq m)**	**Eelgrass (sq m)**	**Percent Cover**
Pre-Construction	Oct 2015	18,107	9,013	49.8%
Post-Construction	Apr/May 2016	18,107	8,663	47.8%
Year 1 Post-Construction	May/Apr 2017	18,107	10,353	57.2%

General trends noted from the three surveys include overall minor contraction of eelgrass beds at both the survey and reference areas followed by continued and increased contraction at the survey area with expansion at the reference area. The differences between the pre- and post-construction survey efforts were generally minor and hard to describe except for one localized area of eelgrass loss near the Project area (MTS 2016). The changes in eelgrass cover between the pre- and post-construction surveys is shown graphically in Figure 4 . The changes between the post-construction survey and the year 1 annual post-construction survey are more readily viewable (Figure 5). The results show eelgrass habitat along the upper limits of large eelgrass patches appears to be the most vulnerable to change at the study survey area. Within the reference area, eelgrass tended to expand into shallower water over the past year; however, most expansion was within an area largely dominated by *Chaetomorpha californica* during past monitoring events.

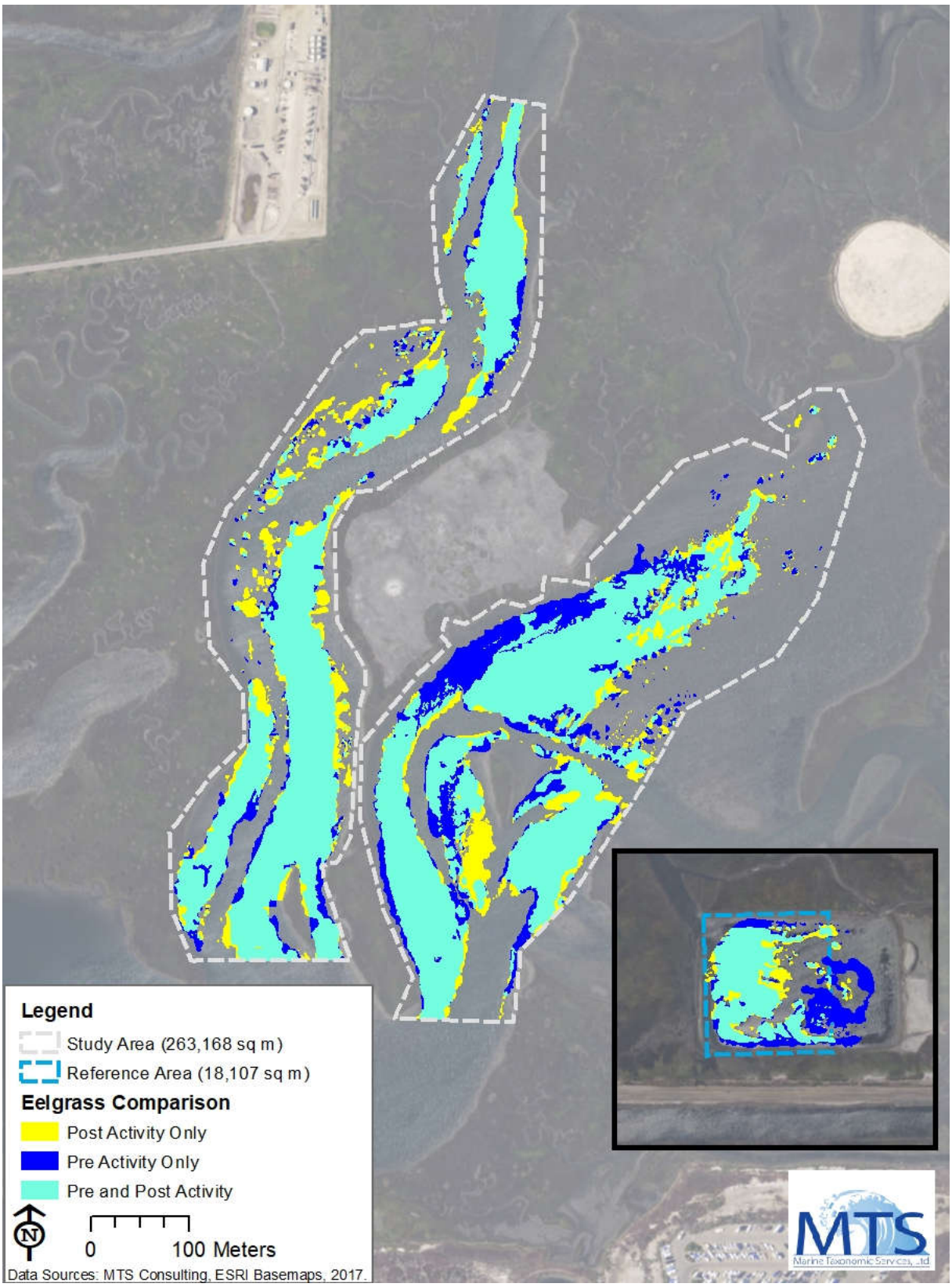

Figure 4. The above figure provides a graphical representation of changes in eelgrass cover between the pre-construction (Oct 2015) and post-construction (Apr 2016) eelgrass surveys. Adapted from MTS (2016).

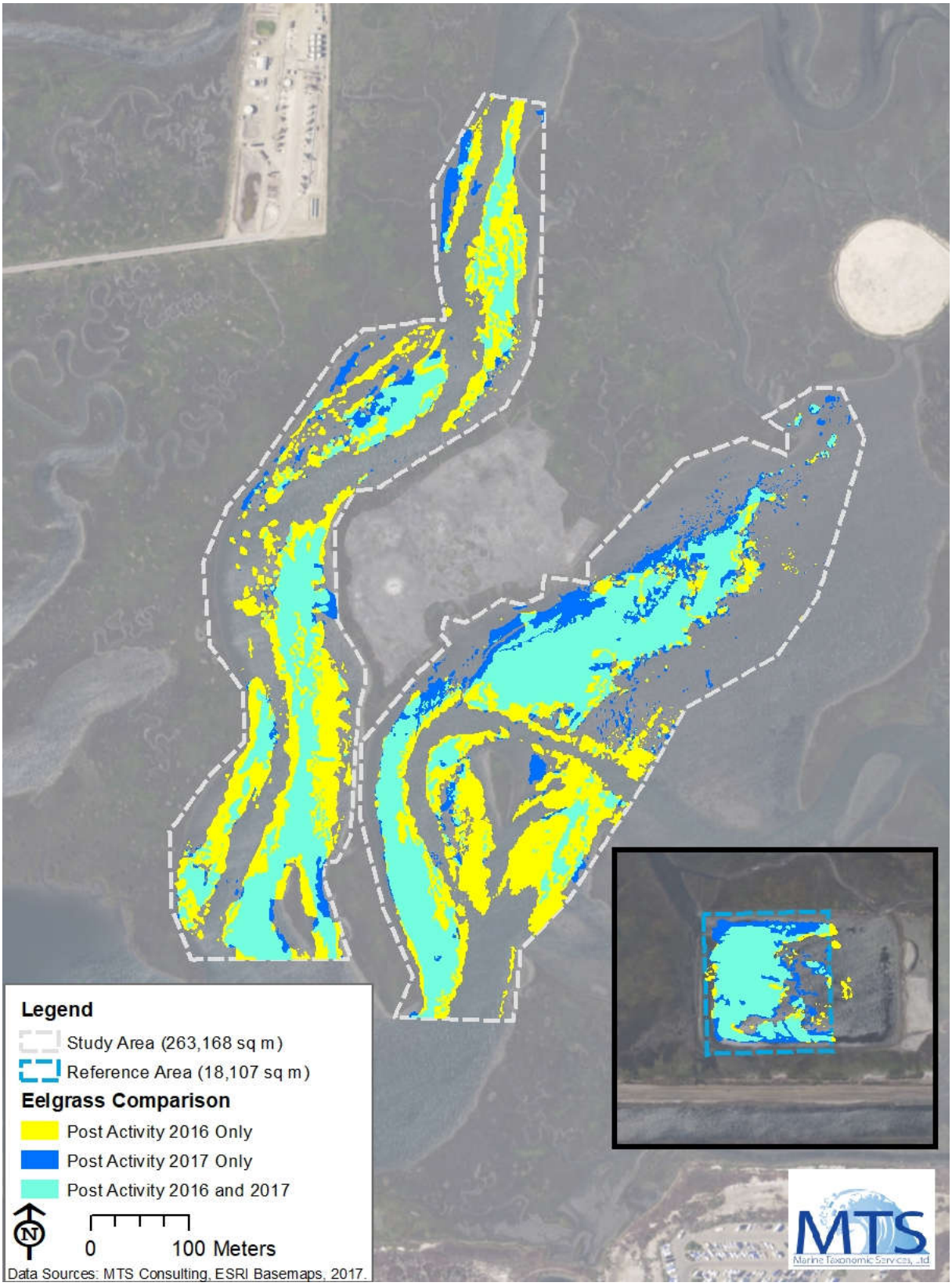

Figure 5. The above figure provides a graphical representation of changes in eelgrass cover between the post-construction (Apr 2016) and year 1 annual post-construction (Apr 2017) eelgrass surveys.

In the 2016 post-construction report, evaluation of impacts focused on a region that was noted to have been impacted by construction. This area was adjacent to the project area near the southeast shore of the fill area (Figure 6). Visual inspection of the sonar data showed losses in this region between the pre- and post-construction surveys. The current survey results show that while eelgrass cover has generally declined across the study area, eelgrass cover within the footprint of the impact area has expanded in the past year. Eelgrass cover during the post-construction survey within the impact area was 3,978 square meters. During this year 1 annual post-construction survey, eelgrass cover in the same area has increased to 6,626 square meters.

Eelgrass percent cover within the study survey area, as measured by the transect sampling, showed a decline between the pre- and post-construction surveys followed by an increase between the post-construction survey and the year 1 annual post-construction survey (Table 3). The pre-construction, post-construction, year 1 annual post-construction transect results found 64 ± 18%, 57 ± 22%, and 65 ± 15% eelgrass cover within the study survey area, respectively. Over the same monitoring periods, the mean percent cover of eelgrass on reference area monitoring transects increased across monitoring periods and was 60 ± 8%, 62 ± 3%, and 92 ± 6%, respectively.

Eelgrass density across surveys has continually declined at the study area. The pre-construction, post-construction and first annual post-construction eelgrass densities at the study survey area were 135, 106, and 74 turions per square meter, respectively. The reference area showed a decline in eelgrass density between the first two surveys followed by an increase. The pre-construction, post-construction and first annual post-construction eelgrass densities at the reference area were 112, 104, and 190, respectively. In all cases the variation among samples was high.

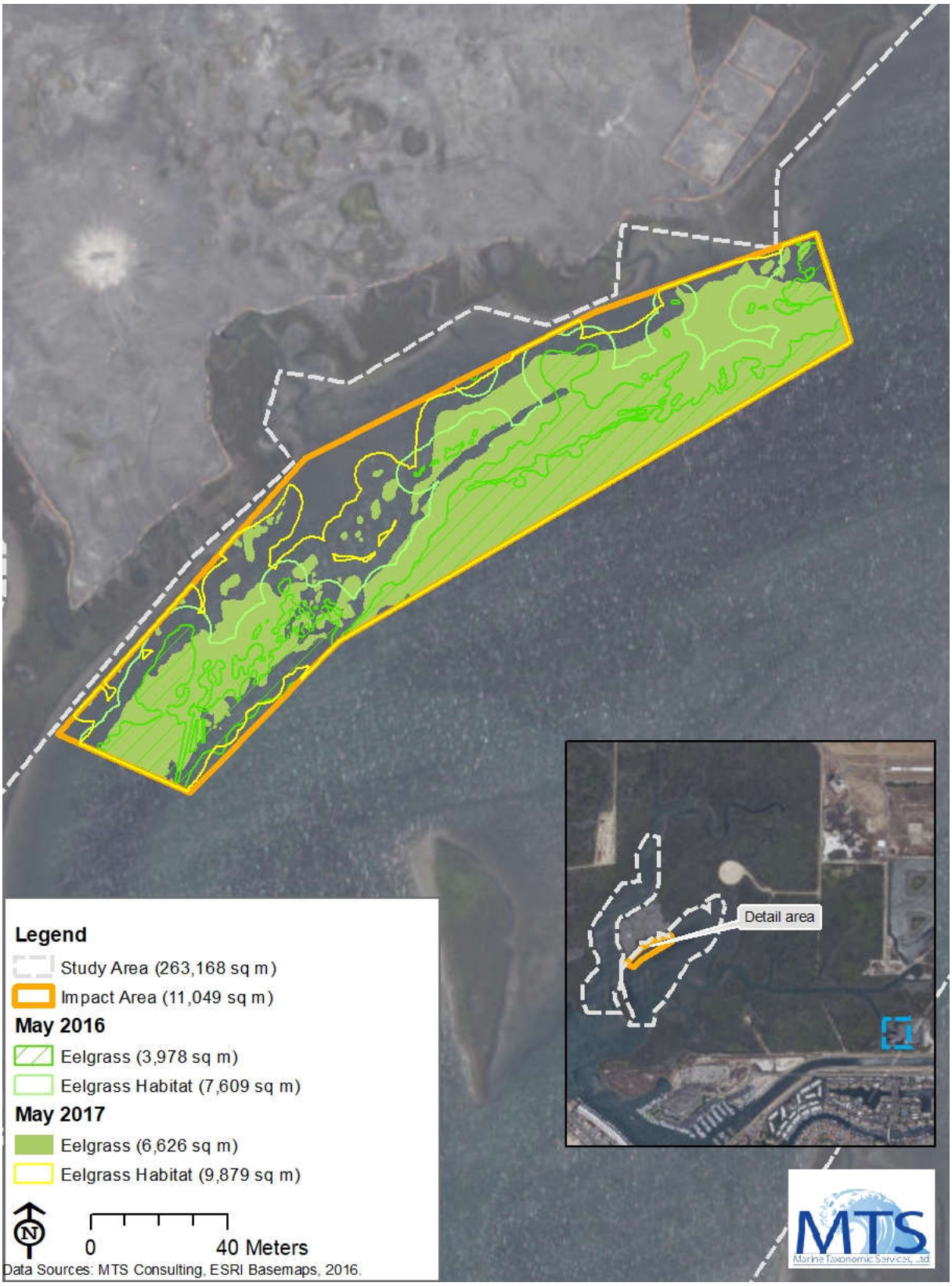

Figure 6. Expanded view of a localized area that appears to have lost eelgrass following implementation of the Project.

Table 3. Diver transect survey results for all survey periods.

Transects	Transect Coordinates (UTM, Z 11, NAD 1983)						
Study Area	**E1**	**N1**	**E2**	**N2**	**Pre**	**Post**	**1st Annual**
1	400068	3733739	400160	3733701	63%	62%	44%
2	400005	3733584	400105	3733584	51%	43%	57%
3	399880	3733296	399964	3733349	52%	52%	56%
4	399816	3733080	399916	3733080	75%	73%	66%
5	400414	3733397	400314	3733397	56%	47%	96%
6	400320	3733299	400220	3733299	44%	29%	62%
7	400101	3733205	400005	3733177	72%	53%	71%
8	400041	3733020	400078	3732941	100%	100%	67%
				Study Area Averages	64 ± 18%	57 ± 22%	65 ± 15%
Reference Area							
9	401412	3732946	401312	3732953	50%	64%	100%
10	401289	3732918	401389	3732918	59%	61%	86%
11	401294	3732901	401394	3732901	65%	59%	93%
12	401292	3732849	401392	3732849	67%	65%	88%
				Reference Area Averages	60 ± 8%	62 ± 3%	92 ± 6%

Table 4. Mean eelgrass density at the study area and reference area during the three monitoring events. Values are mean ± standard deviation.

	Pre-Construction	Post-Construction	First Annual
Study Area	135 ± 48	106 ± 63	74 ± 76
Reference Area	112 ± 67	104 ± 62	190 ± 125

Discussion

This first annual post-construction eelgrass survey was required to monitor the eelgrass resources within the area surrounding the Project construction activities. Determining impacts to eelgrass is not often straightforward as the resource naturally varies in space and time. Thus, to look for potential impacts, one has to be selective in terms of the scale at which impacts are sought and be aware of how eelgrass might change within that landscape over time. The usual way to determine whether or not a given project has impacts to eelgrass is to perform monitoring before and after project implementation and to perform monitoring within the potential area of impact as well as within a suitable reference area. This is similar to a type of experimental design known as BACI (Before After Control Impact). The problem for determination of impacts in the typical eelgrass construction monitoring effort is that there is no replication; this means that expert interpretation of the results is the only way to make recommendations relative to impacts.

Within the current monitoring program, the results of monitoring transects, density, and cover throughout the surveyed areas within the BACI design all lead to a reasonable recommendation that the Project had impacts to eelgrass. Those impacts were attributed to a potential loss of containment of placed sediment that overran eelgrass in a localized area. This area was observed to have lost a disproportionate amount of eelgrass between the pre- and post-construction surveys. This area is now showing strong eelgrass recovery.

The larger overall decline in eelgrass areal extent and reduction in density across the study area indicates that eelgrass is currently dying back within the studied portion of the Seal Beach NWR. However, the results of eelgrass cover on the fixed transects indicates that eelgrass cover is relatively consistent within the study area.

Ultimately, the patterns of eelgrass loss and recovery indicate that processes larger than the Project are structuring the eelgrass beds within the study survey area. While eelgrass has generally appeared to have died back in shallow areas subject to dessication stress at low tides, the impacted area is rapidly recovering. The increased cover and density over time in the reference area could be due to separate structuring forces than the study area. The reference area was observed to contain dense patches of *Chaetomorpha californica* during prior surveys. This green alga was observed to be displacing eelgrass in the reference area. *C. californica* is now much reduced within the reference area. The reduction in this competitor's abundance has likely accounted for much of the observed increase in eelgrass cover and density within the reference area.

Given there is no reasonable explanation for the declines in areal extent and density at the study area relative to the reference area, a possible explanation for increases in the reference area, and recovery in the localized impact area, the observed reductions in the study area are not likely related to the Project. The Project is required to monitor eelgrass again in spring 2018. The 2018 monitoring event will provide additional information that can be used to determine whether or not the observed trends continue and the extent to which the Project may have had long-term impacts to eelgrass.

It has been a pleasure working on this Project. If there is any additional information that I can provide to you, please contact me at (760) 331-7897 or robert@consultmts.com.

Sincerely,

Robert Mooney, Ph.D.
Principal Scientist

References

MTS 2016. Seal Beach National Wildlife Refuge Sediment Augmentation Post-Construction Eelgrass Survey. Marine Taxonomic Services, Ltd.

NOAA Fisheries. 2014. California Eelgrass Mitigation Policy and Implementing Guidelines. Available online at www.westcoast.fisheries.noaa.gov/publications/habitat

Seal Beach National Wildlife Refuge (SBNWR). 2015. Thin-Layer Salt Marsh Sediment Augmentation Pilot Project – Seal Beach National Wildlife Refuge (NWR). Section 7 Biological Evaluation Form.