Santa Monica Beach Restoration Pilot Project

Year 2 Annual Report

August 2018

Prepared for:
- City of Santa Monica
- California Coastal Commission
- Metabolic Studio, Annenberg Foundation
- US Environmental Protection Agency
- California Department of Parks and Recreation

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Prepared by: The Bay Foundation

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City of Santa Monica, California Coastal Commission, Annenberg Foundation, US Environmental Protection Agency, California Department of Parks and Recreation, Environment Now, Patagonia

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Acknowledgements
We would like to thank the US Environmental Protection Agency and the Metabolic Studio (Annenberg Foundation; Grant 15-541) for funding this pilot project, and our partners: City of Santa Monica and California Department of Parks and Recreation. Their support has allowed us to explore soft-scape protection measures to increase coastal resilience, while bringing back an important coastal habitat to the Los Angeles region. We would also like to thank the many students, volunteers, and supporters of this project – without which it would not have happened.

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Executive Summary

This report summarizes activities for the Santa Monica Beach Restoration Pilot Project from December 2015 through July 2018. During this time, the restoration was implemented in two phases over the course of two weeks in December 2016 including the installation of fencing and seeding of native coastal strand vegetation species. For details on the implementation efforts, please reference the Year 1 Report. The 18 months following the pilot project implementation had a number of valuable successes and learning experiences. As the project was meant to be an experimental pilot for the region, no specific, quantifiable success criteria were set; however, the project can be evaluated against its ability to meet the project goals. The project positively engaged the public, created new partnerships and outreach connections, restricted grooming in an approximately 3-acre area, allowed vegetation to grow, encouraged sand hummocks to form along fence lines and within the project area, provided comprehensive science-based monitoring data to inform soft-scape beach restoration solutions, and is bringing back a rare coastal habitat type to the Los Angeles region.

Additionally, the increased functions within the restoration habitat area included benefits to several notable species. Nesting of the federally threatened western snowy plover had not been recorded in the Los Angeles region for almost 70 years, and the first nest for the Los Angeles region was found in April 2017 within the restoration area and contained three eggs. Plovers have been repeatedly identified on bird surveys throughout both survey years. Furthermore, a new native plant species, possibly a rare variant of woolly heads (*Nemacaulis denudata*), was identified as germinating in the project area in 2017. As the seeds of this species are not sold by the seed provider, it is probable that there was either an existing seed bank for this species already along Santa Monica Beach, or that it was transported by wind, waves, birds, or humans. It was not identified in areas adjacent to the project site. Beach sand verbena (*Abronia umbellata*) was also identified on site and was not seeded. Another addition to the restoration project area in 2017 were dune beetles, which provide an increased layer of the food web available to foraging birds and wildlife.

Data suggest that the restoration area is considerably different from both the control sites and from itself over time as compared to the baseline surveys, especially for vegetation and sand morphology, though (as expected) vegetation cover remains fairly low after the second growing season. Additional years will allow an evaluation of the vegetation cover trend over time. It is likely that the vegetation community will continue to establish, but will probably remain somewhat patchy, as is the trend for natural coastal strand habitat types. The variability of the berm over time and the notable changes in elevation along the fenced perimeters, oceanward berm, and throughout the restoration area surrounding patches of vegetation suggest that longer periods of time for scientific evaluation for these parameters will also allow for additional trends to be defined. Future monitoring will continue to inform sand morphology within the restoration site in response to vegetation growth, fence placement, and seasonal changes from storms, king tides, and wave energy. Additionally, elevation profile data will provide information to understand the effects of sand grooming versus the development of natural beach morphology over time.

For more information, details, artistic renderings, and links to public documents, reports, and photographs, please visit the project website.

Introduction

Background

Over 17 million visitors frequent the beaches of Santa Monica every year. Beaches are broadly recognized and highly valued as cultural and economic resources for coastal regions (Dugan et al. 2015). However, their value as ecosystems is often less appreciated. Southern California beach systems and associated wildlife are highly impacted by threats, including native species extirpation and extinction, erosion, non-natural sediment and sand transport through mechanical means, pollution, and loss of natural morphology due to daily vegetation and top soil removal through grooming and other regular maintenance (Dugan et al. 2003). However, these systems also offer essentially the last line of defense in terms of natural "softscape" protection as components of a living shoreline. As a vital part of our coastline, beaches and dunes support and protect our homes, roads, and infrastructure, providing a natural buffer from sea level rise (SLR) as well as from tidal and wave action from the ocean. Beach habitats and dunes are critical in managing sand transport to create resilient beach morphologies, which naturally buffer climate change impacts. By restoring natural processes to impacted beach systems, we improve their ecological and utilitarian functions, and serve as a model for similar projects statewide.

Since the 1960s, beaches in the Los Angeles area have been subjected to the continuous removal of natural features as they begin to develop. Mechanical maintenance of beaches has significant impacts on the physical and biological processes of natural beach and dune ecosystems (Dugan et al. 2003, Dugan and Hubbard 2009, Hubbard et al. 2013). Over much of the state, and in many parts of the country, beaches are not frequently groomed, but are instead allowed to develop natural features, such as low dunes away from active recreation areas. These features not only support native, and in many cases, rare and endemic species of plants and animals, they also provide a cost-effective buffer to storm surges and other regular, predictable threats, including SLR and increased erosion.

In addition to providing habitat for avifauna, including Federally-designated "Critical Habitat" (US Fish and Wildlife Service) for the threatened western snowy plover (*Charadrius nivosus alexandrius*), coastal strand habitats have a varied native vegetation community, including species such as red sand verbena (*Abronia maritima*), dune evening-primrose (*Camissoniopsis cheiranthifolia*), and beach saltbush (*Atriplex leucophylla*), and provide a vital habitat for invertebrate species. Thus, the current condition of groomed and flattened sand with vegetation removed for most of the beaches in Los Angeles and the Santa Monica Bay provides almost no habitat value and removes all of the ecosystem services (Dugan et al. 2003, Hubbard et al. 2013, Gilburn 2012). Without vegetation, erosion is more frequent and there is nothing to trap wind-driven aeolian transport of sand (Nordstrom et al. 2011).

Restored conditions of the beach include no mechanized 'flattening' of the sand and removal of vegetation. After seeding and planting vegetation, sandy coastal strand habitats and plant hummocks are starting to develop, which then support higher levels of the ecological community (e.g. invertebrates, birds). Recent scientific literature highlights the need for ecosystem-level, rather than species-level, beach restoration planning to achieve the greatest ecological benefits (e.g. Schlacher et al. 2008). This project represents one example of that model.

Project Goals

This pilot project restored approximately three acres of sandy coastal strand habitat located on the beaches of Santa Monica by utilizing existing sediments to transform a portion of the current beach into a sustainable coastal strand and foredune habitat complex resilient to sea level rise. As an alternative to traditional hardscaping options, this project will continue to evaluate a living, restored shoreline with a diverse wildlife community as an alternate approach to combat climate change (Figure 1).

Another project goal was to bring back a diverse, endemic-rich, coastal plant and wildlife community which has been almost completely extirpated from the Los Angeles region. Returning broad ecosystem functions will create increased protection for coastal infrastructure and residences from sea level rise and erosion while providing a vital refuge for invertebrates, birds, and rare coastal vegetation species.

This demonstration site will also serve as a model for the region, showing that heavy recreational use of beaches and meaningful habitat restoration are not incompatible goals. It will provide not only a scientific basis to develop guidelines and protocols but an integrated, locally-based program for increasing the usefulness of natural environments in a developed area. It will evaluate "soft" low-cost natural shore protection from sea-level rise and storms while providing public benefits and enhancing natural resource values. All of these benefits are expected to have low-to-no impact on existing recreational uses of the beach.

Additional benefits of healthy beach ecosystems include, but are not limited to:

- Enhancing a developed coastline
- Critical habitat for rare coastal strand vegetation and invertebrate species
- Habitat for birds, possibly including the threatened western snowy plover
- Familiarizing residents, especially children, with a healthy, natural landscape
- Promoting tourism through unique aesthetic and bird watching opportunities
- Educational opportunities including native plants and healthy beach management practices
- Understanding of a 'soft-scape' climate change protection project
- Natural shoreline protection through buffering and absorption of wave energy
- Sea water filtration and food web support
- Detrital processing and nutrient recycling

Figure 1. Photograph from the restoration area of sanderlings in swash zone (8 February 2018; credit: R. Abbott).

Project Description

The pilot project of approximately three acres aims to return a healthy and beautiful ecosystem to Santa Monica State Beach (Figure 2), which in turn, will address climate change issues for both humans and wildlife. This pilot project used low-lying sand fencing and native plant seeds to actively restore approximately two out of three acres of a highly impacted beach system (Figures 3, 4, 5, and 6). The third acre is comprised of the dry and wet sand shore-ward of the project area that will remain ungroomed (passive restoration through not raking the sand), and the area immediately adjacent to the perimeter of the sand fence, which will also remain ungroomed.

Design aspects feature curved, flowing, low-lying fence lines, a path through the restoration area, and an unenclosed perimeter along the water's edge – all components requested by various members of the public during the first few months of outreach about the project. Many of these design components were incorporated to minimize disturbance, and even enhance different forms of interactions and recreation along the beach. The site allows visitors to continue to recreate as well as enjoy the local native flora and fauna that are currently absent along the groomed beaches of the Santa Monica Bay.

Specialized coastal strand and foredune vegetation was seeded and is currently growing, developing, and trapping sand transported by wind. Wind-driven sand bumps into vegetation, falls, and accretes, naturally increasing the elevation of plant hummocks over time to a future estimated height of 1-3 feet. Additional trapping of sand has occurred through the deployment of sand fencing. Because beach dunes have the potential to accrete sediment transported from the ocean they could continue to grow concurrently with rising sea levels. This dynamic process can continue as long as the vegetation community is robust and healthy. This process has repeatedly been demonstrated in the scientific literature as well as in pilot projects in other California counties, such as the Surfer's Point restoration project in Ventura County. Long-term monitoring will define trends at this site.

Project implementation began in November and December 2016, and required approximately 3 weeks, including monitoring. It will be followed by post-restoration monitoring for a time period of no less than five years. For more information, details, artistic renderings, maps, and links to public documents and photographs, please visit the project website: http://www.santamonicabay.org/santa-monica-beach-restoration-pilot/ (Figure 3).

This project would not have been possible without two additional project partners: City of Santa Monica (land managers) and California Department of Parks and Recreation (land owners). We are very grateful for their support and enthusiasm in the implementation of this pilot project. Additionally, we are also grateful for the many proponents and supporters of this project, including but not limited to: Audubon Society – Santa Monica Chapter, Loyola Marymount University, University of California, Santa Barbara, Cooper Ecological Monitoring, Inc., Coastal Restoration Consultants, Inc., California Native Plant Society, Congress Member Ted Lieu, Assembly Member Richard Bloom, Senator Fran Pavley, Los Angeles World Airport Dune Preserve, Friends of Ballona Wetlands, US Fish and Wildlife Service, Heal the Bay, University of Southern California SeaGrant, Santa Monica Bay Restoration Commission, Santa Monica Bay National Estuary Program, US Environmental Protection Agency, Patagonia, Council Member Paul Koretz, Girl Scout Troop 10975, Friends of LAX Dunes, Mia Lehrer and Associates, US Green Building Council – LA, beach managers throughout Southern California, and many local residents!

Figure 2. Photograph of the project site prior to restoration at Santa Monica Beach, Santa Monica, CA.

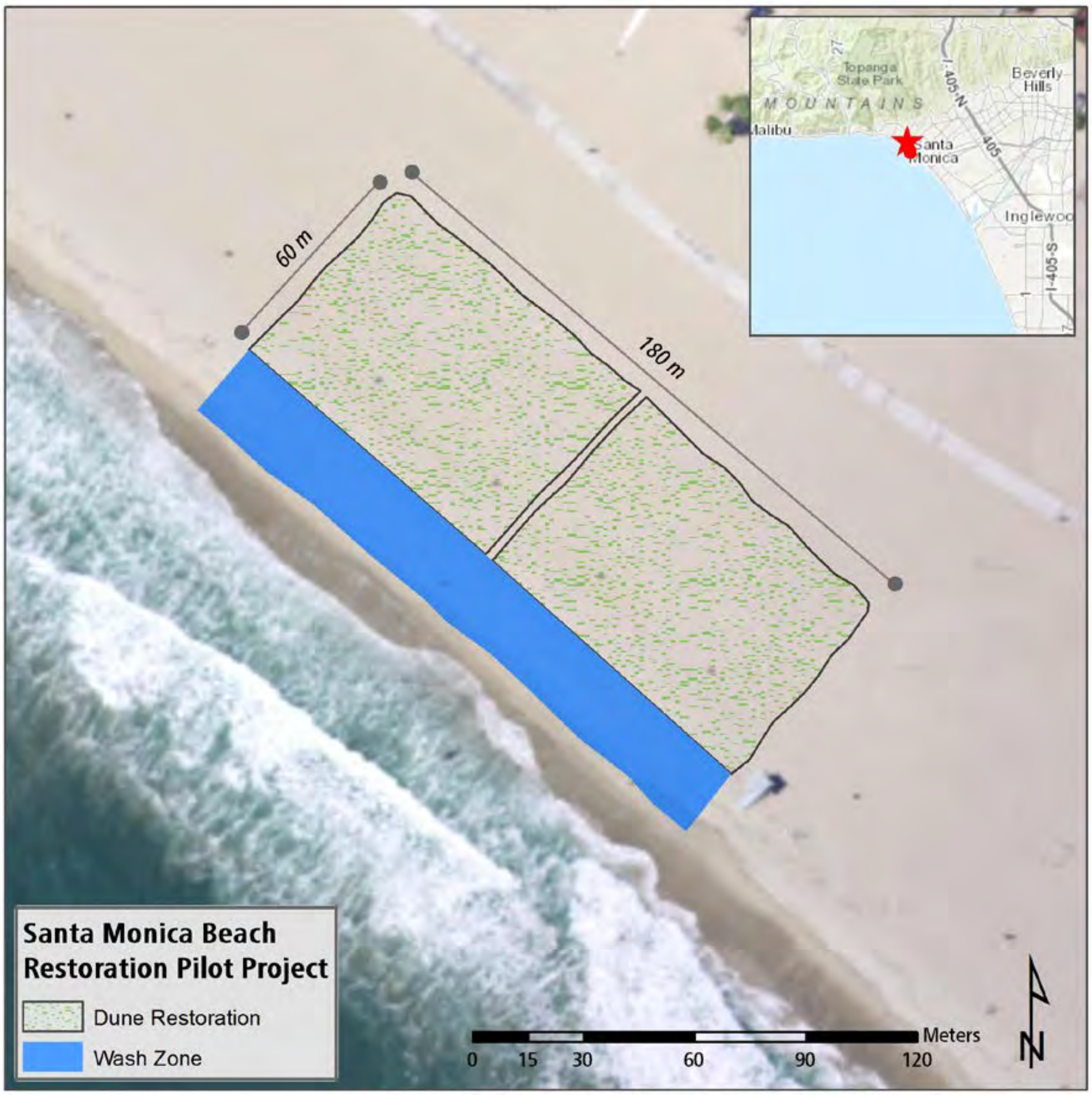


Figure 3. Map of the Santa Monica Beach Restoration Pilot Project location and general vicinity.

Figure 4. Artistic rendering overview of project area, post-establishment of vegetation (rendering credit: Mia Lehrer and Associates).

Figure 5. Photograph of post-restoration project site (25 January 2017).

Figure 6. Photograph of post-restoration project site (13 April 2018).

Restoration Design

The project area is divided into two, roughly 1-acre, treatment plots (T1, or the North plot, and T2, or the South plot; Figure 7). The treatment plots are separated by a curved path, bordered by a symbolic rope fence. The exterior perimeter (except for the ocean-ward side) is surrounded by a low-lying sand fence (approximately 3 feet in height from the original base). Each treatment plot is further subdivided into four quadrants for analysis, though there are no physical barriers within the treatment plots. This subdivision allowed for an experimental treatment design by implementing two different seeding protocols.

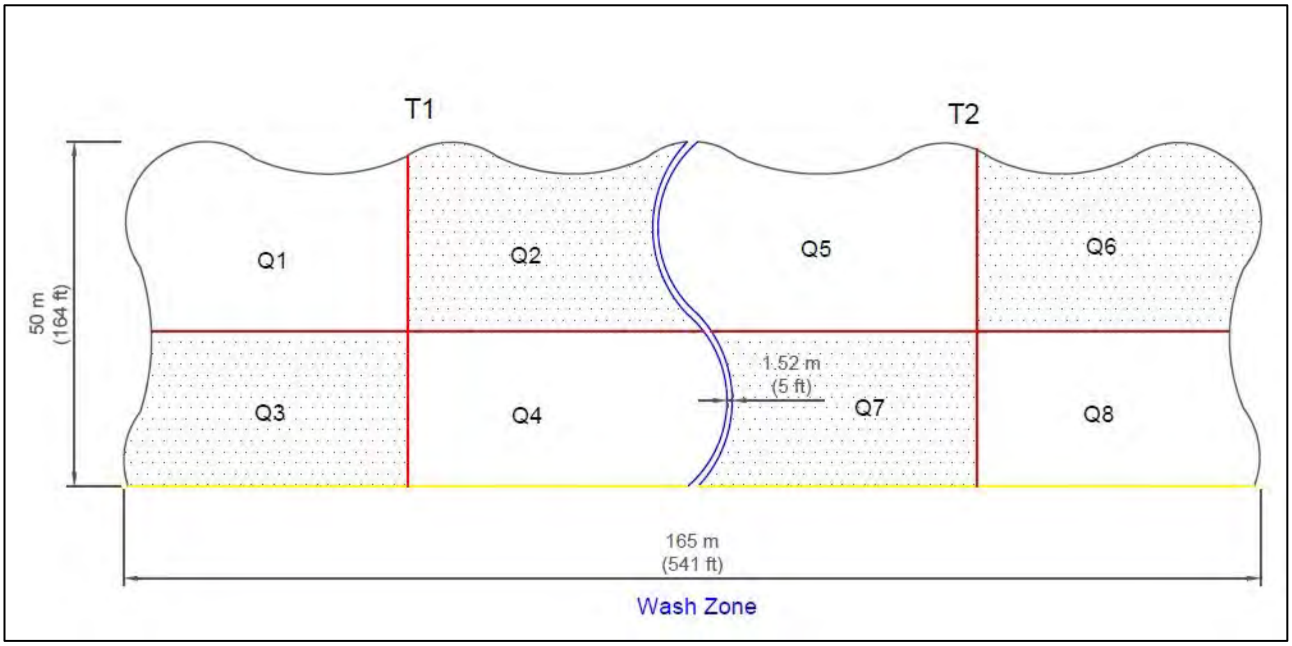


Figure 7. Restoration site graphic design, including two treatment plots (T1 and T2).

Permitting, implementation, and post-restoration maintenance and monitoring is coordinated and conducted by The Bay Foundation (TBF) and consultants.

Public Outreach

Significant public outreach has been conducted as part of this project through meetings, events, tours, social media, newspaper articles, newsletters, and a project webpage. Outreach is ongoing and also occurs on-site to beach visitors who have questions and through local media. The ability for the public to interact with, learn from, and benefit from this project are vital components of the project goals.

Members of the public had multiple opportunities to provide feedback about the project (Figure 8), and suggested changes were incorporated into the project design. Public-requested components include, but are not limited to, the curved sand fence, a 3-foot maximum fence height, several of the flowering plant species (e.g. sand verbena), no fence along the open ocean side of the project, and an extra buffer of open space on the ocean-ward side of the project area to allow for pedestrian traffic and lifeguard vehicle emergency access. Additionally, outreach occurred in advance of the application for permitting from the California Coastal Commission, in accordance with permit conditions for the project. More than 20 public meetings, tours, or media articles occurred for this project prior to its implementation. Since implementation in December 2016, many additional news articles and tours have occurred. Additionally, several television segments have also aired, including on KNBC, KCAL, and KSCI.

Possibly the most significant outreach occurred through the development of a website that highlighted artistic renderings of the project completed by Mia Lehrer and Associates (Figure 9), photographs, and project information and materials. The project website and frequently asked questions can be found here: http://www.santamonicabay.org/explore/beaches-dunes-bluffs/beach-restoration/santa-monica-beach-restoration-pilot/. Selected media links are presented below the outreach photographs. The site is frequently written up in local newspapers, blogs, newsletters, and social media postings.

Lastly, TBF continues to find opportunities to share the project and ongoing monitoring results to beach managers and coastal scientists in the region. During Year 1 following implementation TBF staff presented at a Beach Ecology Coalition Meeting, LA County Beach Commission meeting, and a Southern California Living Shorelines workshop. Year 2 has presented several opportunities for TBF to continue outreach for the project and has included presentations with the NOAA Coastal Resiliency Network (webinar on 12 December 2017) and Beach Ecology Coalition (9 January 2018), as well as serving as a key member of a panel with the City of Santa Monica's LCP and sea level rise event (15 March 2018). Figure 10 highlights an on-site tour given by TBF Staff during the City of Santa Monica's Shrinking Shores event on 3 June 2017 which aimed to engage the community on the impacts of sea level rise. Additional tours occur through the Annenberg Community Beach House, the Santa Monica Bay Audubon Society, and Loyola Marymount University's Coastal Research Institute.

Figure 8. Photograph of community stakeholder meeting held on 30 April 2016.

Figure 9. Artistic rendering of project site several years in the future by Mia Lehrer and Associates.

Figure 10. Onsite tour during the City of Santa Monica's "Shrinking Shores" event on 3 June 2017.

Selected Media Links

- KPCC 89.3 interview with Executive Director Tom Ford on 7 December 2016 (screen capture below).
- Santa Monica Lookout article on 5 December 2016.
- Curbed LA article on 6 December 2016.
- Next City article about the project on 16 March 2017.
- City of Santa Monica press release about the ribbon cutting event on 3 May 2017.
- Ventura County Star article about the project and plovers on 8 May 2017.
- Daily Breeze article about the Western Snowy Plovers nesting on site on 9 May 2017.
- KCET article about the project on 9 May 2017.
- Los Angeles Times article about the project and plovers on 10 May 2017.
- Santa Monica Daily Press article about the Western Snowy Plovers nesting on 11 May 2017.
- The Argonaut article mentioning project in context of sea level rise in LA on 5 July 2017.
- Stormwater Solutions article on 10 August 2017.
- Baywire feature Quarter 3 – 2017. The Baywire provides news and updates from the Santa Monica Bay National Estuary Program.
- Baywire feature Quarter 4 – 2017: Annual Report (Figure 11, below).
- Hakai Magazine (international) article about the pilot project, trash maintenance, and Santa Monica beaches on 31 July 2018.

#CAWildBeach Project Brings Dunes, Plovers & Plants…& Lots of Excitement!

One year ago, TBF and the City of Santa Monica implemented an innovative beach restoration pilot project to create natural habitat and evaluate soft-scape protection measures to increase coastal resiliency. Several early successes, include native plant growth, the formation of small sand dunes, and the discovery of the first documented federally-endangered Snowy Plover nest in LA County in over 69 years! The project provides an important case study as we evaluate the benefits of a wild beach in the context of shoreline protection and sea level rise, and existing recreational use. For more information, please click here.

A native sand verbena plant grows along the fence at the Santa Monica Beach Restoration Pilot Project.

Figure 11. Clipped article from the Baywire, the Santa Monica Bay National Estuary Program newsletter, Q4 2017 Special Edition: Annual Report.

Permitting

TBF, in coordination with the City of Santa Monica (City) and California Department of Parks and Recreation (DPR), obtained the necessary permits to implement the Santa Monica Beach Restoration Pilot Project. Approval from the City at a public City Council meeting in the form of a Memorandum of Understanding (MOU) and restoration site plan stamped and approved by the Planning Department was obtained prior to the submittal of a Coastal Development Permit application to the California Coastal Commission (Commission). Additionally, a CEQA exemption was filed and obtained by the City to implement this project.

In October 2016, the Commission approved permit application No. 5-16-0632 with the following special conditions:

1) An assumption of risk, waiver of liability and indemnity;
2) Limited development authorization period;
3) Dune habitat creation plan;
4) Public access requirements; and
5) Permit compliance.

Permit condition 1 included a waiver signed by the City and DPR. Regarding permit condition 2, CDP (No. 5-16-0632) authorizes the approved beach restoration project for a period of five years from the date of Commission action. After such time, the authorization for continuation and active management of the dune habitat shall cease, unless the applicants submit an amendment to this permit, or new CDP application to the Commission, and that amendment or permit is approved, thereby extending the time period for the project. The dune habitat created pursuant to the permit may remain in place. The third permit condition was met by the Implementation and Monitoring Plan and the Site Plan. Permit conditions 4 and 5 will be met throughout the duration of the project.

Lastly, coordination and communications are ongoing with federal and state agencies with an interest in this project, beach management, and/or wildlife (e.g. US Fish and Wildlife Service). All annual reports for this project will be made publicly available on The Bay Foundation's (TBF) website: www.santamonicabay.org. For details on the implementation of the project in December 2016 and the first year of summary data, please reference the Year 1 Report on TBF's website.

Scientific Monitoring

Accurate and robust scientific monitoring is a vital part of any restoration project. Monitoring is used to assess successful project implementation; for example, in this project, monitoring will allow an assessment of accretion rates of sand and elevation increases to combat sea level rise. TBF is currently implementing a biological, physical, and human use long-term monitoring plan to quantifiably evaluate the project over time. Additional "control" data are collected along the adjacent unrestored beach as part of a before-after-control-impact ecological assessment monitoring program. Specialist scientists such as ornithologists and invertebrate biologists are partners in this project and will use their expertise to advise both the monitoring program and its implementation. Data will be collected for up to ten years to evaluate the ecological health of the created coastal strand ecosystem and its potential for long-term adaptation to accelerated rates of sea level rise.

The development of the monitoring plan was conducted with the input from many scientific advisors throughout southern California (details can be found in the "Implementation and Monitoring Plan" document available on the website). Additionally, data were collected to help inform other projects in southern California evaluating "softscape" methods of shoreline protection.

Pre-restoration baseline monitoring occurred prior to the implementation of the seeding component of the restoration project to allow a comparison of the pre- and post-project conditions of the area. Post-restoration monitoring occurred beginning in January 2017. Table 1 summarizes the monitoring sampling design that occurred from the time period 1 December 2016 through July 2018. It lists nine major parameters, the primary protocol(s) implemented for each parameter, and the frequency of implementation. Additional protocols for management efforts such as trash collection, human use, and invasive vegetation removal are described in the adaptive management section of the report, below.

Individual Protocols and Results

Each of the following subsections summarizes an individual protocol methods and results implemented as part of the monitoring program. For in depth details on objectives, equipment, field preparation, field methods, quality control check procedures, and datasheets, refer to the individual Standard Operating Procedures listed below within the California Estuarine Wetland Monitoring Manual, publically available for free download: http://www.santamonicabay.org/california-estuarine-wetlands-monitoring-manual-level-3/. Additionally, some protocols were adopted from Dugan et al. 2015 Final Report: Baseline Characterization of Sandy Beach Ecosystems along the South Coast of California.

Table 1. Summary of key parameters, protocols implemented, and survey dates.

Parameter	Protocol	Survey Dates
Wrack Cover	Percent cover and composition by species	28 December 2016*, 14 February, 12 March, 21 June 2017, 11 January, 18 March, 24 May 2018
Vegetation Cover and Seedling Density	Transects assessing cover by species; quadrat density counts	13 December 2016*, 24 March, 21 June, 20 September 2017, 11 January, 24 May 2018
Invertebrates	Cores along transects using 1mm mesh bags as sieve	28 December 2016*, 18 July 2017, 8 March 2018
Avifauna	Visual presence and behavior surveys; nesting surveys by USFWS	10 December 2016*, 5 January, 22 February, 18 April, 24 April 2017, 13 July 2018 and additionally throughout quarterly surveys
Grunion and Other Wildlife	Protocols follow www.grunion.org, and use the Walker Scale	17 April, 13 July 2018
Weather Conditions	Wind speed (Kestrel), max wind speed, air temperature, precipitation data (NOAA)	14 and 28 December 2016, 13 and 25 January, 4, 14, and 23 February, 24 March, 12 April, 21 June, 21 August, 13 September 2017, 11 January, 8 March, 13 April, 24 May 2018
Elevation	Elevation profiles and cross-sections; topographic map	13 December 2016*, 24 March, 21 June, 13 September 2018, 13 February, 24 May 2018; April 2017, May/June 2018
Sand Deposition and Sediment Grain Size	MWAC method (Goossens et al 2000); sieve method; Empirical sand transport calculations (Hsu 1981)	13 December 2016*, 24 March, 13 September 2017, 24 May 2018
Photo Point	Georeferenced photograph series from fixed locations	13* and 17 December 2016, 13 and 25 January, 4 February, 24 March, 25 April, 21 August, and 13 September 2017, 11 January, 13 April, and 24 May 2018

** = baseline survey*

For details on the individual protocols and sampling design, refer to the Santa Monica Beach Restoration Pilot Project Implementation and Monitoring Plan.

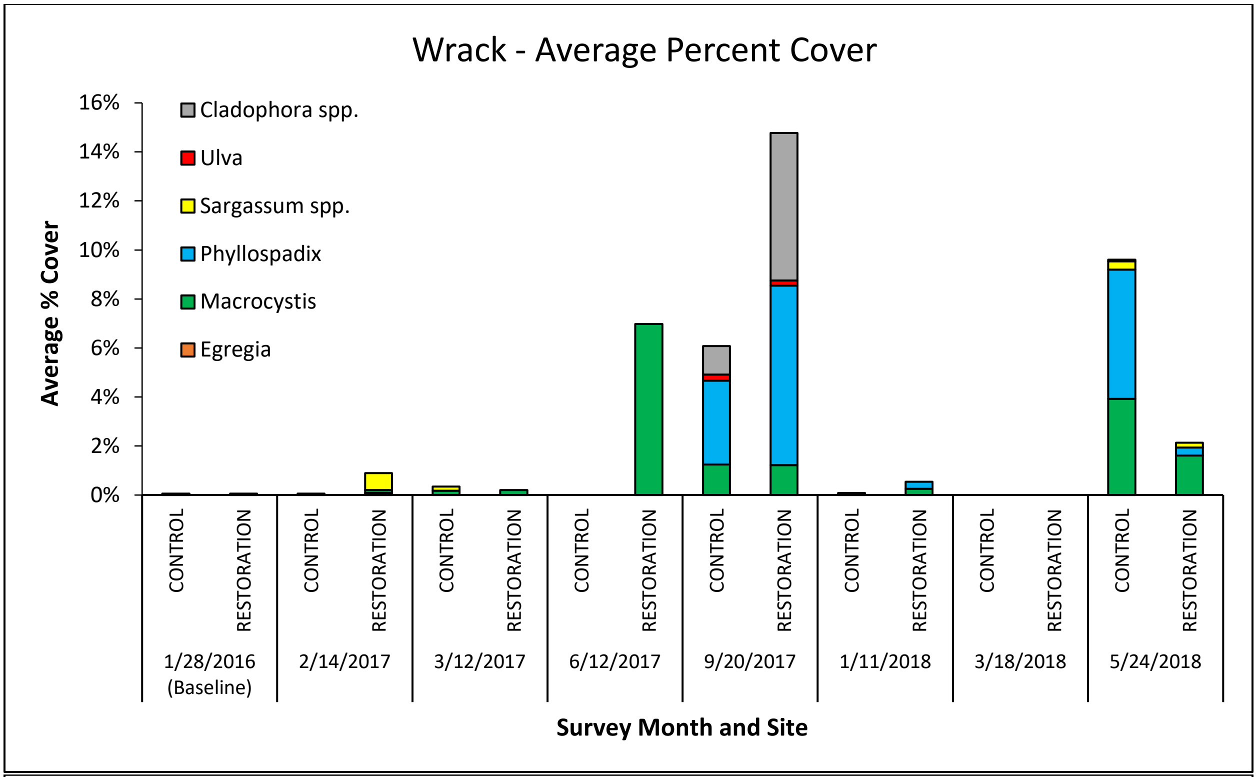
Wrack Cover

Wrack cover surveys were conducted to determine the percent cover, composition by species, and average depth of macrophyte wrack in the wash zone area directly in front of the restoration site and at a control site. A total of four line-intercept transects were surveyed, consisting of two transects in the wash zone directly in front of the restoration site and two transects in the wash zone of the control areas outside the project area (Figure 12, top). Wrack was identified to species when possible [e.g. giant kelp (*Macrocystis pyrifera*)] (Figure 12, middle and bottom). These transects also recorded trash, tar, driftwood, or other detritus in a similar manner. Wrack cover surveys were conducted on 28 December 2016; 14 February, 12 March, 12 June, and 20 September 2017; 11 January, 12 March, and 24 May 2018.

Wrack cover included six species: *Macrocystis pyrifera, Phyllospadix torreyi, Sargassum spp., Egregia menziesii, Ulva spp*., and an unknown *Cladophora spp*. Both the restoration and control sites had the same low cover of wrack during the baseline surveys (December 2016) (Figure 13, top). The first two post restoration surveys (February and March 2017) displayed very little change (Figure 13, top). However, the June and September 2017 surveys displayed an increase in wrack cover, especially within the restoration area. January and March of 2018 displayed low overall cover again, indicating that the pattern may have seasonal fluctuations. In May 2018, the control site displayed a higher cover of wrack than the restoration area. Wrack cover was frequently dominated by surfgrass (*Phyllospadix torreyi*) and giant kelp but was highly variable by survey. Longer-term data will inform this metric of assessment further, though it is possible that it will remain seasonally variable as the surveys are conducted along the high tide line, below most grooming activity (for the control sites).

Terrestrial debris and trash were variable throughout the survey months with the most terrestrial debris (e.g. twigs, leaves, feathers, other natural debris, etc.) seen in January 2018 [Figure 13 (bottom)]. The middle photograph in Figure 12 shows some small sticks and twigs classified as terrestrial debris. Trash was found to be zero percent cover for both the control and restoration sites during the December 2016 baseline and March 2018 surveys, and very low (much less than 1%) on the other surveys along both the restoration area and control area transects. This indicates either a lack of trash in the survey area, or beneficial adaptive management measures such as hand-removal of trash that are shown to be effective at maintaining the restoration and control areas with very low overall trash cover.

Figure 12. Photographs of wrack transect in front of control site (top, 24 May 2018); giant kelp mixed with terrestrial debris and surfgrass (middle), and large clump of giant kelp in front of the restoration area (17 September 2017).



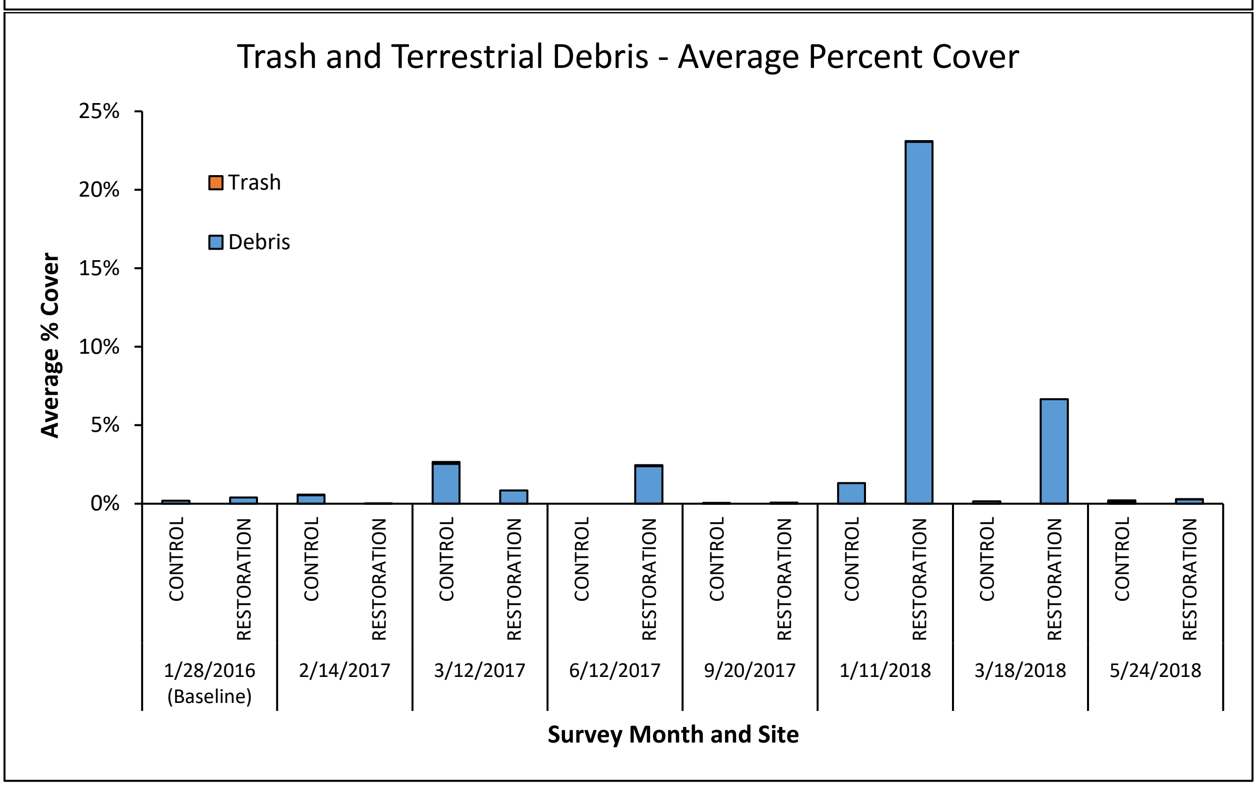


Figure 13. Average percent cover of wrack by species (top) and trash and terrestrial debris (bottom) in the restoration area and control site across the four surveys. Note variable y-axis for each graph.

Vegetation Cover and Seedling Density

Vegetation cover surveys can be used to provide a wide range of information and data, including: summarizing the prevalence of native and non-native plant cover, determining species cover, relative species richness and diversity, and assessing canopy height. The primary objective of the transect- and quadrat-level cover surveys for this project was to assess the approximate cover of native coastal strand vegetation over time. The line-intercept transect and cover class quadrat survey methods are described, along with example field data sheets, in SOP 3.2 Vegetation Cover Surveys (TBF 2015b). Data were evaluated as percent cover by species. Additionally, individual seedlings were counted within randomly selected quadrats as part of the Cover Class Quadrat vegetation cover assessment method semi-annually. Data are presented as germinated seedlings per square meter categorized by species and nativity, following assessment procedures described in SOP 3.4 Seed Bank Germination (TBF 2015c), and seedling data are also extrapolated up to the whole restoration area at approximately 6,900 m^2. Four vegetation transects were surveyed within the restoration area, and compared to two control transects surveyed outside the restoration area (approximately 100 m south of the restoration area). Vegetation cover surveys were conducted on 13 December 2016; 24 March, 21 June, and 20 September 2017; 11 January, and 24 May 2018.

All four of the seeded vegetation species germinated within and immediately adjacent to the restoration area (i.e. beach evening primrose, sand verbena, beach bur sage, and beach salt bush) (Figure 14). Additionally, three other vegetation species germinated within the project area, two native and one non-native. The two natives were woolly heads (annual native herb, *Nemacaulis denudata*) (Figure 15) and beach sand verbena (*Abronia umbellata*); sea rocket (*Cakile maritima*) (Figure 16) was the non-native that germinated within the project site and immediately adjacent. Neither woolly heads, a native and possibly rare species variant, nor beach sand verbena (a different species than *A. maritima*) were in the seed mix as confirmed by the seed provider; thus, it is probable that there was either an existing seed bank for these species' already along Santa Monica Beach, or that they were transported by wind, waves, birds, or humans. Combining all transects surveyed, the highest proportion of cover was found to be beach evening primrose, followed by beach bur sage, in the most recent survey (May 2018, Figure 14). Sea rocket had the least cover of all vegetation species and was periodically removed by hand from within the restoration area as an adaptive management activity.

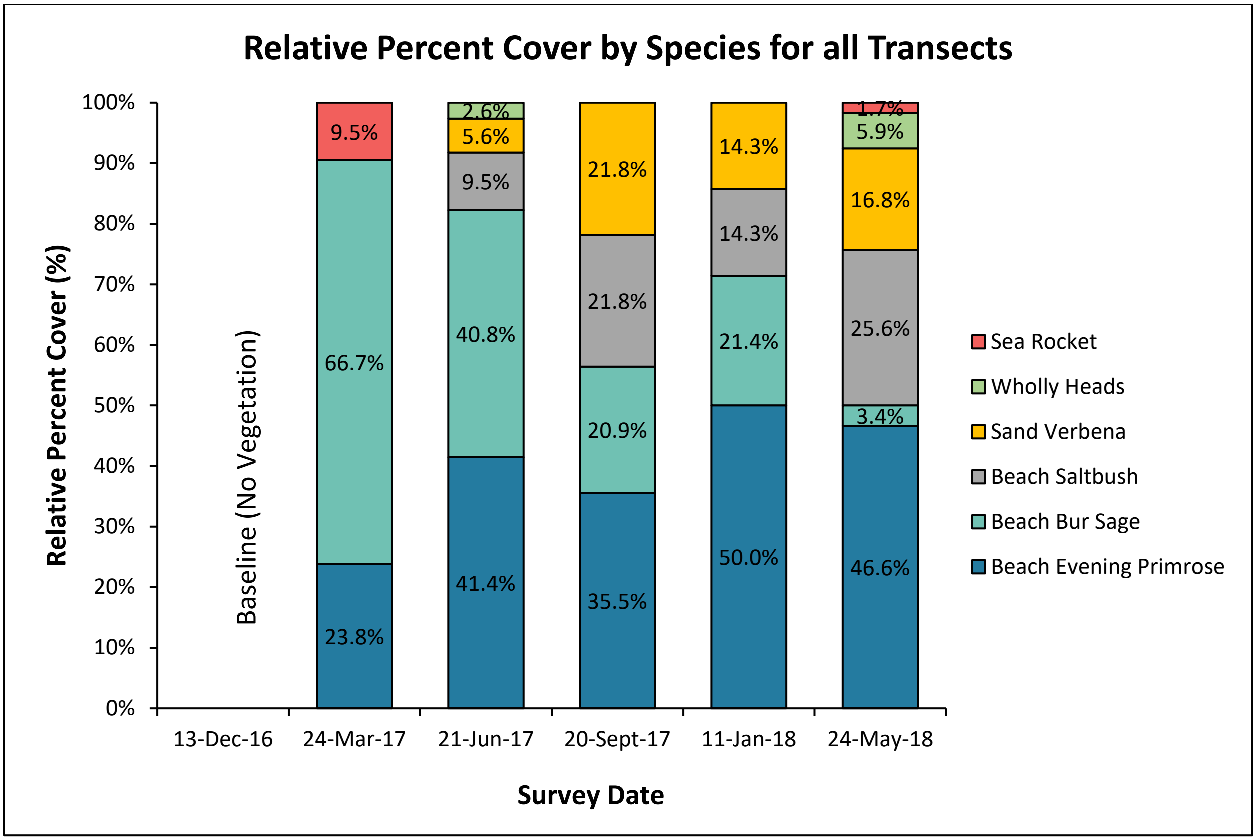


Figure 14. Relative percent cover by species for all transects (live vegetation only, 13-Dec-16 was baseline survey with no vegetation identified).

Figure 15. Photograph of woolly head (native *Nemacaulis denudata*) in the restoration area (24 May 2018).

Figure 16. Photograph of sea rocket (non-native, *Cakile maritima*) outside the project area (14 February 2017).

Vegetation cover assessed during the baseline (December 2016) surveys within both the restoration area and control site was zero and remained zero at the control site throughout all survey times (Figure 17, bottom). Native vegetation cover was much higher than non-native cover (sea rocket) during all surveys, with zero non-native vegetation in the two most recent surveys (11 January and 24 May 2018; Figure 17, top). The native cover increased over time, with the exception of the September 2017 survey. At this time, native vegetation fell slightly, from 1.3% to 0.6% average cover, likely due to the timing of the survey at the end of summer. On the most recent survey, May 2018, native vegetation reached a maximum cover of 3.4%, more than double that of any previous survey (Figures 17 and 18). Vegetation cover was highest on the three fenced perimeters of the restoration area with patches of vegetation cover up to 25% within a single quadrat, becoming sparser towards the interior of the restoration area and towards the water line (Figure 18). Vegetation is likely to continue to increase and become more complex over time, though naturally-occurring coastal strand habitats also usually have a significant portion of bare sand, even after becoming mature vegetation communities.

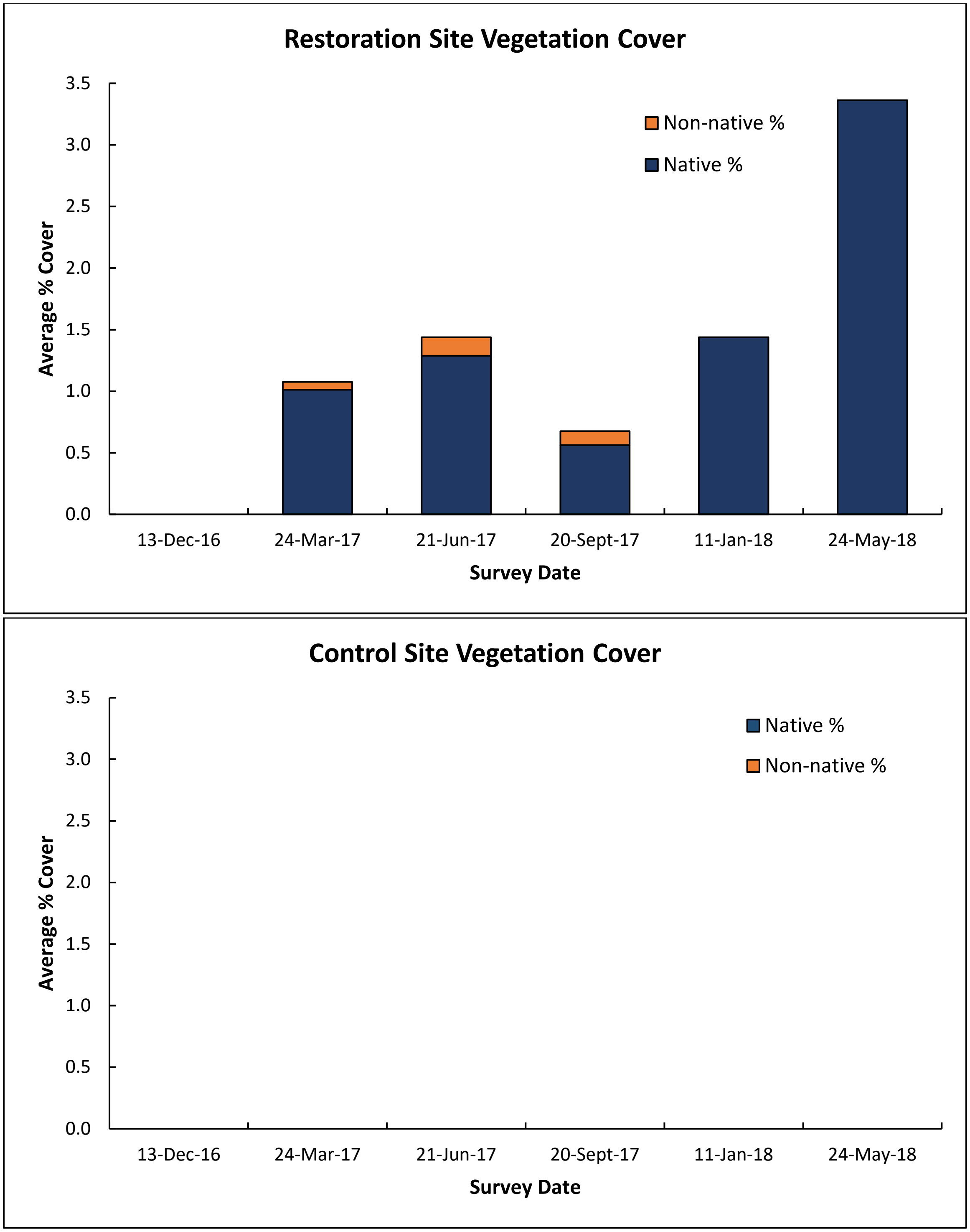


Figure 17. Average native and non-native vegetation cover during all surveys within the restoration area (top) and at the control site (bottom).

Figure 18. Photograph of various native vegetation facing the northern fence line (top) and along the northern fence line (13 April 2018).

Both the baseline survey and each of the control surveys found zero seedlings on all transects. By the time of the June 2017 surveys, seedlings were identified much more prominently as vegetation cover, thus, instead of "seedling counts", flowering species were identified. Table 2 displays the results of the seedling counts from the 24 March 2017 and 11 January 2018 surveys and extrapolates the results up to the total project area (approximately 6,900 m²) by species. Note that the extrapolated data are based on averages and are thus not likely to represent an exact numerical count for the area but are considered estimates (rounded down to the closest thousand). The March 2017 survey found more seedlings within the restoration area than the January 2018 survey, since it closely followed the initial vegetation seeding in December 2016. The January 2018 vegetation data are better represented as flowering plants. The total estimated number of seedlings in March across the entire project area was 158,000, weighted heavily by beach bur sage as the most frequently identified germinated seedling (Table 2). Woolly head seedlings and beach sand verbena (*A. umbellata*) were not found within the surveyed quadrats and are thus underrepresented as zero data points, though present on site within the restoration area. Figure 19 represents a photo series over time of a variety of vegetation species. The presence of germinated seedlings in 2018 (second year) indicates the presence of a viable seed bank still within the restoration project area.

Table 2. Seedling data results by species for 24 March 2017 and 11 January 2018 reported as counts, number / m², and extrapolated counts for the entire restoration area (last row). Asterisk indicates non-native species.

		Beach bur sage	Beach saltbush	Sand verbena	Beach sand verbena	Beach evening primrose	Woolly heads	Sea rocket *
March 2017	Total Number of Seedlings	337	35	9	0	71	0	9
	Average Seedling Count / m²	16.85	1.75	0.45	0	3.55	0.00	0.45
	Total Estimated for Restoration Area	**116,000**	**12,000**	**3,000**	**0**	**24,000**	**0**	**3,000**
January 2018	Total Number of Seedlings	36	16	2	0	56	0	0
	Average Seedling Count / m²	1.80	0.80	0.10	0	2.80	0.00	0.00
	Total Estimated for Restoration Area	**12,000**	**6,000**	**1,000**	**0**	**20,000**	**0**	**0**

Figure 19. Photographic series of various seedling species over time (top: January 2017, middle: April 2017, bottom: May 2018).

Invertebrates

Invertebrate data were collected using techniques described in detail in Dugan et al. 2015 and led by researchers from Coastal Restoration Consultants, Inc., and the University of California, Santa Barbara. Common examples of macroinvertebrate indicator taxa in southern California include talitrid amphipods such as *Megalorchestia*, and the common sand crab, *Emerita analoga*. Invertebrates were surveyed on 28 December 2016, 18 July 2017, and 8 March 2018 and led by University of California, Santa Barbara scientist, David Hubbard and Dr. Jenifer Dugan. Six within-restoration transects were surveyed and compared to data from six control transects located several hundred meters south of the restoration area (Figure 20). Additional sieving of sand adjacent to vegetation patches to assess dune beetle presence occurred on the 8 March 2018 survey (Figure 21). For additional method details, refer to the Santa Monica Beach Restoration Pilot Project Implementation and Monitoring Plan (October 2016).

Figure 20. Photograph of researchers conducting invertebrate core surveys (8 March 2018).

Figure 21. Beach ecologist, Dr. Jenifer Dugan, and UCSB staff collecting invertebrate data (8 March 2018).

The December baseline surveys indicated low background levels of upper beach invertebrates (e.g. beach hoppers, *Megalorchestia californiana*) at between 300-400 individuals / m², with approximately the same number at both the restoration site and the control site. These data are indicative of the frequent beach grooming prior to restoration. Preliminary analyses of the December 2016 and July 2017 data indicate similar results for both surveys. Data from the March 2018 survey were not available at the time of publication of this report but are currently being processed in the laboratory. Further surveys will help identify the invertebrate trends on site over time. Dune beetles were visually present during the July surveys and all subsequent surveys; since they were not present during the baseline (December) surveys, these data indicate a new colonization of dune beetles post-restoration, likely attributed to the new vegetation (Figure 22).

Figure 22. Dune beetle identified on vegetation within the restoration area (8 March 2018; R. Abbott, TBF).

Avifauna

The presence and distribution of avifauna within an ecosystem is often used as an index of habitat quality due to their diet and vulnerability to environmental conditions (Conway 2008). Avifauna data are useful to characterize representative avian assemblages and spatial distributions within a particular area. Bird survey methods are described in detail, along with field data sheets, in SOP 5.1 Bird Abundance-Activity (TBF 2015d). The primary purpose of avifauna surveys for this project was to provide a general understanding of the bird community and corresponding behavior in the restoration area before and after restoration. Bird surveys were conducted by an ornithologist on 10 December 2016 (baseline, pre-restoration survey), and on 5 January, 22 February, 18 April, and 24 April 2017, and 13 July 2018. Additionally, birds were recorded as part of other surveys such as vegetation or elevation, and as part of two student projects through Loyola Marymount University. All bird data results are combined and reported below, comparing birds found within the restoration area and immediately adjacent to those found several hundred meters away or flying over the area.

Frequently identified species on surveys included gulls and several shorebirds (e.g. willet, *Tringa semipalmata*) (Table 3). Shorebirds were observed both roosting (e.g. whimbrel) and foraging (e.g. willet) within the restoration area. Additionally, there were several shorebird species that were identified exclusively within the restoration area, including marbled godwit (*Limosa fedoa*) and, notably, the federally threatened western snowy plover (*Charadrius alexandrinus nivosus*), which produced the first egg-bearing nest in the Los Angeles region in almost 70 years within the restoration area (discussed further below) in 2017. In May 2018, a killdeer (*Charadrius vociferous*) nested within the restoration site (Figure 32). Several species of gull were also frequently identified in and around the restoration area, flying overhead, and in the adjacent 'control' sites. Urban species such as the rock pigeon (*Columba livia*) were identified primarily in adjacent areas, but not within the restoration site. During the July 2018 survey, an adult and juvenile peregrine falcon (*Falco peregrinus*) were observed circling low over the sand inland of the restoration site. Additional avifauna surveys will continue to inform the identified species present and activities within and adjacent to the restoration area.

Table 3. Avifauna species identified as present in the restoration area and in the surrounding area adjacent to the restoration. Data for all surveys were combined.

Category	Common Name	Scientific Name	Restoration	Adjacent
Shorebird	Western Snowy Plover *	*Charadrius alexandrinus nivosus*	X	
	Whimbrel	*Numenius phaeopus*	X	X
	Willet	*Tringa semipalmata*	X	X
	Sanderling	*Calidris alba*	X	X
	Marbled Godwit	*Limosa fedoa*	X	
Open Water	Surf Scoter	*Melanitta perspicillata*		X
	CA Brown Pelican **	*Pelecanus occidentalis californicus*	X	X
Gull	California Gull	*Larus californicus*	X	X
	Ring-billed Gull	*Larus delawarensis*	X	X
	Western Gull	*Larus occidentalis*	X	X
	Heermann's Gull	*Larus heermanni*		X
Urban	Canada Goose	*Branta canadensis*		X
	American Crow	*Corvus brachyrhynchos*	X	X
	Rock Pigeon (Feral Pigeon)	*Columba livia*		X
	Peregrine Falcon	*Falco peregrinus*		X
	Killdeer	*Charadrius vociferous*	X	X

** = rare species listed as threatened by USFWS*

*** = previously listed species, but delisted in 2008*

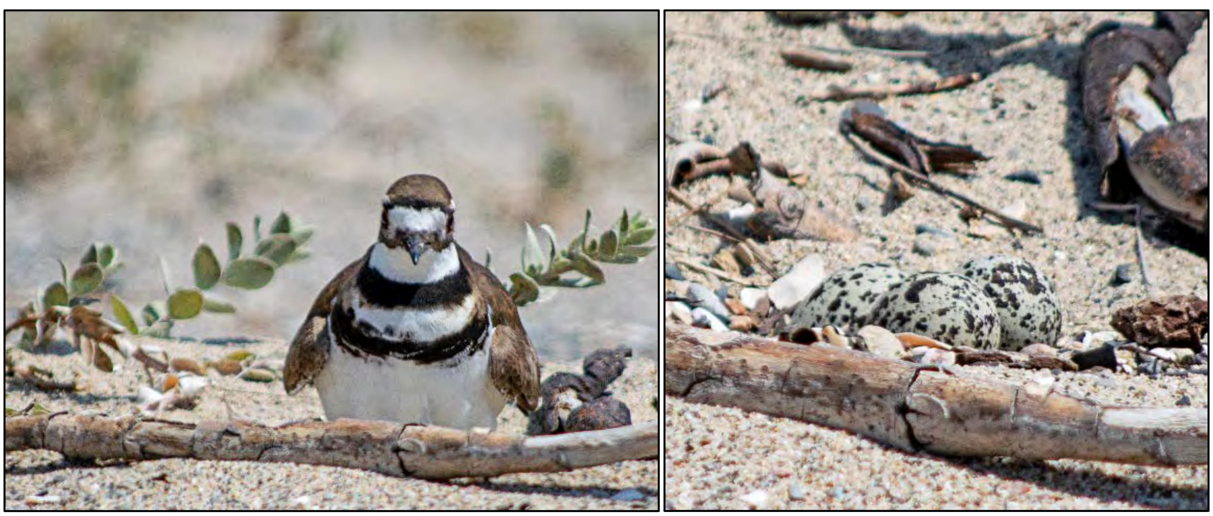


Figure 23. Photograph of nesting killdeer and eggs inside restoration area (29 April 2018, credit: R. Abbott, TBF).

Western Snowy Plover

The first four western snowy plovers identified within the restoration area were found roosting during a TBF bird survey on 23 February 2017, two months after the installation of the project. Plovers are known to overwinter in the vicinity (within an enclosure approximately 500 m south of the restoration area) but had not previously been identified using the specific restoration area of the beach. Care was taken to avoid disturbance to the birds, and an ornithologist was notified. The restoration area falls within approximately the middle of the Santa Monica Beach critical habitat area for plovers (Subunit 45A, Figure 25), southwest of San Vicente Boulevard. As migrant plovers may start trying to identify breeding locations as early as March, the plovers were carefully monitored for several months moving in and out of the restoration area.

Dan Cooper, an ornithologist, detected a nesting plover within the restoration area on 18 April 2017 and confirmed the presence of one egg in a nest scrape containing bits of shells and adjacent debris. This confirmed nest was the first one in the Los Angeles region in almost 70 years. Local, state, and federal agencies were all immediately notified along with the Santa Monica Audubon Society, an important local stakeholder group who have conducted bird surveys in Los Angeles for many decades and who maintain the plover enclosure on the southern portion of Santa Monica Beach. On 24 April 2017, US Fish and Wildlife Service (USFWS), who have jurisdiction over federally threatened species, several ornithologists, and TBF installed a mini-enclosure over the nest and confirmed the presence of three eggs. After the mini-enclosure was installed, the male plover immediately returned to the nest (Figures 26 and 27). Unfortunately, extremely high winds buried the nest, which was subsequently abandoned. While plovers remained in the restoration area in the breeding season in both 2017 and 2018, no subsequent nesting attempts were made. Signs were posted around the perimeter of the site notifying the public of possible nesting (Figure 24). Additional nests were made by plovers at Malibu Lagoon and Dockweiler State Beach during both years, the first fledged plover chicks in the Los Angeles region in decades.

Figure 24. Signs indicating possible snowy plover nesting area posted onsite (13 April 2018).

Figure 25. Map of WSP critical habitat (Subunit CA 45A) and restoration area boundary (Data source: USFWS ECOS 2018).

Figure 26. Photograph of nesting western snowy plover (credit: Tom Ryan 24 April 2017).

Figure 27. Group photograph of installation team for the mini-enclosure including several ornithologists and USFWS (24 April 2017).

Grunion and Other Wildlife

California grunion are a species of marine fish found only along the coast of southern California and northern Baja California. They exhibit unique spawning behavior, laying and fertilizing eggs completely out of the water, on high spring tides along sandy beaches (Martin 2006). Grunion spawn between March and August, with peak events between April and June.

While no grunion were seen spawning within the restoration project area, at least one grunion "run" (spawning event) was identified in the Santa Monica Bay region during the season. Grunion surveys will be conducted multiple times in 2019 to confirm presence or absence of spawning events in or adjacent to the restoration area.

Two grunion surveys were conducted during the 2018 season on 17 April 2018 and 13 July 2018. Surveys were conducted at night, during peak high tide events and following a full or new moon. The Grunion Greeter Observation Form was completed during each survey and subsequently entered onto the regional web database at www.grunion.org. The Walker Scale was used as a monitoring metric, which ranges from W-0 to W-5 as shown in Table 4. During both survey events, no grunion were observed and a Walker Scale of W-0 was recorded.

Table 4. Walker scale for monitoring California grunion runs.

Walker Scale	Description
W-0	No fish, or 1 or 2 scouts, no spawning
W-1	10-100 fish spawning at different times in one or several locations
W-2	100-500 fish spawning at different times, in one or several locations
W-3	Hundreds of fish spawning in several locations or over a broad area of the beach
W-4	Thousands of fish together, little sand visible between them over relatively small area for less than one hour
W-5	Fish covering beach, not possible to walk through the run without stepping on fish, run lasts for an hour or more over large area

In addition to birds frequently seen in and around the restoration area and human uses, wildlife using the area included dolphins frequently seen offshore foraging in the surf zone, jumping fish, small clams, and one sea lion also seen in the surf zone offshore.

Physical Characteristics

Physical characteristics help to characterize the beach in comparison to other locations (e.g. elevation profiles; Dugan et al. 2015). Additionally, site checks were performed at least quarterly to assess the condition of the fence, collect trash, etc. Specific data for physical characteristics collected and summarized in this report include precipitation, wind, temperature, climate data, elevation profiles, sand deposition, and sand grain size. Supplemental weather data were downloaded from Los Angeles County Department of Public Works Electric Avenue precipitation gage and National Oceanic and Atmospheric Administration's (NOAA) Climate Data Online. Weather patterns and climate data collected from external sources are meant to be representative, not indicative of specifics within the restoration area at any given moment in time.

Overall, the restoration site exhibited physical differences as compared to control locations and itself over time primarily through the accretion of sand along the fence line and wrack line. Elevation profiles and high-resolution topographical mapping provide

Precipitation

The total rainfall for the water year (from the beginning of October to end of July the following year) was 16.83 inches during Year 1 and 5.66 inches during Year 2, as measured at the Los Angeles County Department of Public Works Electric Avenue precipitation gage (closest gage to the restoration area). The highest rainfall month since the project was implemented was 6.77 inches in January 2017 and Year 2 had significantly lower rainfall amounts in the winter months compared to Year 1 (Figure 28).

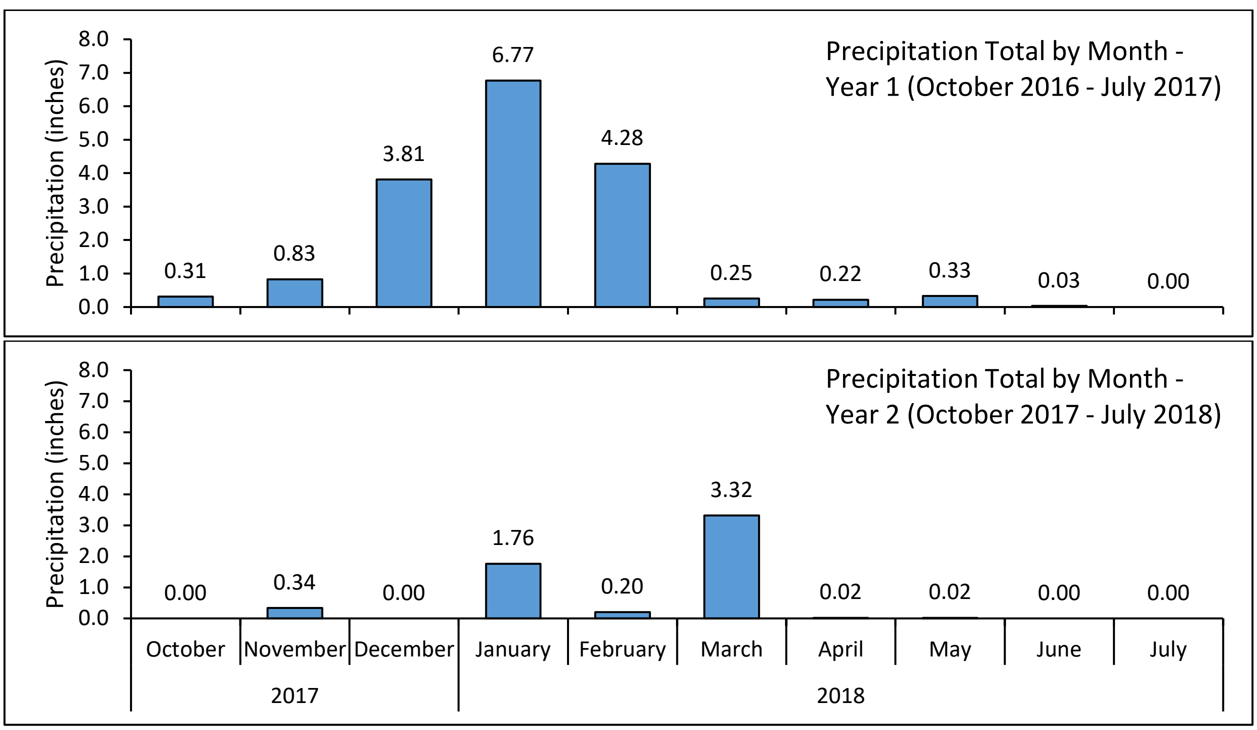


Figure 28. Precipitation total (inches) by month for the water year (top: 1 Oct 2016 - 31 July 2017; bottom: 1 Oct 2017 - 31 July 2018). Data were downloaded from Los Angeles County Department of Public Works Electric Avenue precipitation gage on 30 July 2018.

Wind and Temperature

Average sand temperature, wind speed, and maximum wind speed (over three minutes) were recorded in each of the two treatment plots using a small, hand-held weather meter (Kestrel®) and a Fluke Mini IR Thermometer®. Data were collected on 14 and 28 December 2016, 13 and 25 January, 4, 14, and 23 February, 24 March, 12 April, 21 June, 21 August, and 13 September 2017, and 11 January, 8 March, 13 April, and 24 May 2018. These data are reported as collected from within the restoration area, specifically. NOAA climate data follow below.

Air temperature, sand temperature, and wind speeds were all highly variable depending on the specific conditions of the survey days. Sunnier days and summer months had higher temperatures up to 36.5 °C recorded as the sand temperature (Table 5). The wind speed on average ranged from approximately 1.7 to 5.7 m/s with gusts of up to 7.1 m/s at 1.5 m in height, with the average wind speed recorded along the ground ranging lower at approximately 1.0 to 4.2 m/s with gusts of up to 5.0 recorded during surveys (Table 5).

Table 5. Summary data for temperature and wind speed collected on site during surveys.

Date		Temperatures (°C)		Wind Speed (m/s)			
Year	Month	Air	Sand	Maximum (1.5 m)	Average (1.5 m)	Maximum (ground)	Average (ground)
2016	December	18.7	18.8	2.1	1.7	1.6	1.0
2017	January	14.2	19.9	2.9	2.4	2.3	1.7
	February	14.5	26.7	7.1	5.7	5.0	4.2
	March	17.2	22.4	2.5	2.1	2.1	1.6
	April	----	----	3.0	2.7	2.4	2.0
	June	18.8	36.5	2.5	2.1	2.1	1.8
	August	24.4	29.3	4.0	3.2	2.6	2.0
	September	23.9	40.8	6.1	3.9	4.3	3.0
2018	January	21.5	25.7	3.9	3.2	2.5	1.9
	March	15.1	24.0	1.9	1.4	1.3	1.0
	April	21.0	46.6	2.1	1.7	2.8	2.2
	May	17.1	30.1	2.4	1.9	2.3	1.8

NOAA Climate Data

National Oceanic and Atmospheric Administration's (NOAA) Climate Data Online were downloaded for the Santa Monica Municipal Airport Station on 1 August 2018 for the time period 1 October 2016 through 28 July 2018. The data results are summarized in Tables 6 and 7. Precipitation totals during the 2017-2018 winter were notably less than precipitation following initial restoration implementation in 2016-2017; however, the site continued to show native plant growth despite less rain. Wind gust observations remain high (31-40 mph) during the months of December to April (Table 7).

Table 6. Table displaying NOAA temperature and humidity monthly data for the Santa Monica Municipal Airport Station (downloaded on 30 July 2018).

Year	Month	Temperature (°C)			Humidity
		Average	Maximum	Minimum	Average
2016	October	18.9	34.4	12.8	74.4
	November	17.0	34.4	7.8	60.8
	December	14.0	27.2	5.6	67.5
2017	January	12.7	23.9	4.4	79.0
	February	13.5	21.1	5	88.6
	March	15.0	25.6	7.2	73.0
	April	16.7	28.3	10	67.9
	May	16.2	29.4	8.9	77.1
	June	18.1	27.8	13.9	83.5
	July	20.9	31.1	16.1	81.5
	August	21.0	31.7	17.2	81.7
	September	20.9	36.1	13.3	76.8
	October	20.2	38.3	13.9	66.4
	November	17.0	33.3	9.4	72.3
	December	14.7	27.8	6.1	51.9
2018	January	15.2	30.6	6.7	67.7
	February	13.4	26.1	5.0	62.1
	March	13.6	26.7	5.6	77.9
	April	15.0	28.3	9.4	72.0
	May	15.7	24.4	11.1	77.4
	June	17.8	23.9	13.3	77.3
	July	21.8	36.7	16.1	76.6

Table 7. Table displaying NOAA wind speed and precipitation monthly data for the Santa Monica Municipal Airport Station (downloaded on 30 July 2018).

Year	Month	Wind Speed (mph)				Precipitation (cm)
		Average	Maximum	Minimum	Maximum Gust	Total
2016	October	4.0	16.0	0.0	24.0	0.76
	November	4.2	17.0	0.0	33.0	1.80
	December	4.4	21.0	0.0	31.0	8.21
2017	January	4.9	22.0	0.0	32.0	15.71
	February	4.1	26.0	0.0	40.0	7.38
	March	4.6	20.0	0.0	36.0	0.38
	April	5.6	23.0	0.0	37.0	0.22
	May	5.2	17.0	0.0	31.0	0.11
	June	4.7	15.0	0.0	23.0	0

Year	Month	Wind Speed (mph)				Precipitation (cm)
		Average	Maximum	Minimum	Maximum Gust	Total
	July	4.9	14.0	0.0	21.0	0
	August	4.7	14.0	0.0	20.0	0
	September	4.5	15.0	0.0	23.0	0
	October	3.8	13.0	0.0	22.0	0
	November	3.4	13.0	0.0	20.0	0.14
	December	4.0	18.0	0.0	36.0	0
2018	January	3.9	20.0	0.0	31.0	3.04
	February	4.4	22.0	0.0	31.0	0.26
	March	4.6	16.0	0.0	29.0	8.1
	April	5.0	21.0	0.0	37.0	0.06
	May	4.8	16.0	0.0	25.0	0.18
	June	5.0	17.0	0.0	21.0	0
	July	5.1	14.0	0.0	22.0	0

Elevation Profiles

Elevation profile data were collected via four transects within the restoration area and two control transects outside the restoration area (approximately 100 m south of the restoration area) (Figure 29). Elevation profiles provide a method to measure topographical changes within the seeded fenced area and beach face over time. Elevation profile data was collected on 13 December 2016 (baseline), 24 March and 13 September 2017, and 13 February, 24 May, and 29 May 2018. Elevation profiles taken over the two years post-project implementation show notable changes from both the baseline and control transects (Figures 30 – 35). Berm topology shows differences over time between the restoration site and control site, particularly in the northern section of the site where the berm has increased nearly 0.5 meters in height. All elevation profiles, except one, within the restoration area show an overall increase in elevation, indicating the deposition and retention of sand within the site. Sand build up is greatest along the berm, nearest the beach face and ocean, and along the northern and southern fence perimeter. The southeast corner of the restoration area continues to show the buildup of sediment, which can be explained by the predominant wind pattern moving sand in that direction. Survey data show that control sites have shown only slight variability over time, with seasonal changes in the berm and beach face, and a generally flat and even beach profile, likely due to maintenance by grooming. Future surveys will allow for a more thorough assessment of sediment movement over a period of years to support the evaluation of the restoration area as a possible buffer from climate change impacts such as sea level rise and wave erosion, though seasonal changes may also be captured.

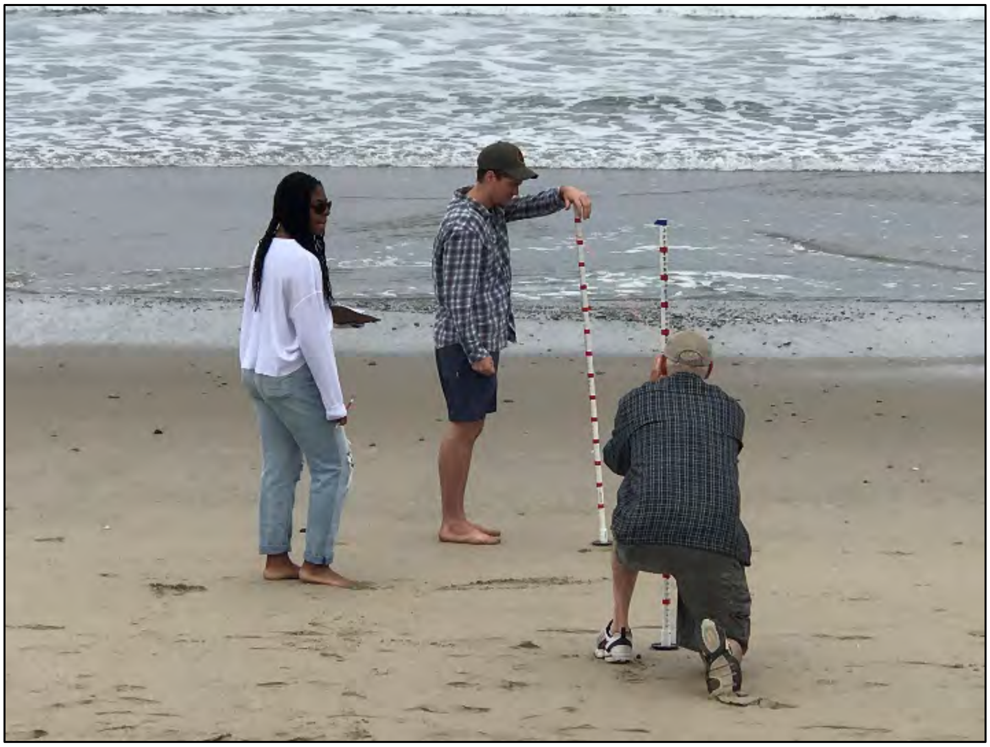


Figure 29. TBF staff and affiliates from LMU's Coastal Research Institute conduct an elevation profile survey (24 May 2018).

A high-resolution elevation survey using a Trimble Geo7x GPS was conducted on 12 April 2017, and again during Year 2 on 24 and 29 May and 27 June 2018. It was necessary to conduct Year 2 elevation surveys on multiple days due to the discovery of a nesting killdeer bird in the northern restoration area. Elevation surveys were paused in May 2018 and continued in June 2018 following the nesting period. Elevation points were downloaded, QAQC'd, and analyzed in a geographic information system (GIS) to create a topographic surface of the restoration site. Figure 36 displays the topographic map results from the GPS elevation survey in May 2017 and May/June 2018. The topographic data supplement the elevation profile transects and indicate a buildup of sand along the berm and fence perimeter. Additionally, the micro-topography of the restoration site appears more complex in the May/June 2018 map compared to the May 2017 map, which supports visual observations of the formation of small dune hummocks around vegetation and wrack within the restoration site. Figure 37 shows buildup of sand along the northern fence perimeter in May 2017 and again in March 2018, where an increase of vegetation, especially sand verbena is present. Berm changes have also been observed in photographic documentation and monitoring data. Figure 38 shows a time-series of the berm changes observed post-restoration. Additional surveys will continue to tract the berm fluctuations over time. The continued rise in elevation of the berm in multiple elevation profiles and supporting topographical surveys indicate promising results that the site may be becoming more resilient to coastal flooding than other sections of the beach that retain a low, flat, profile. Future surveys will continue to inform changes in the restoration site and berm morphology over time. Additional data may also provide the opportunity to begin modelling sea level rise scenarios under new restoration conditions compared to control sites.

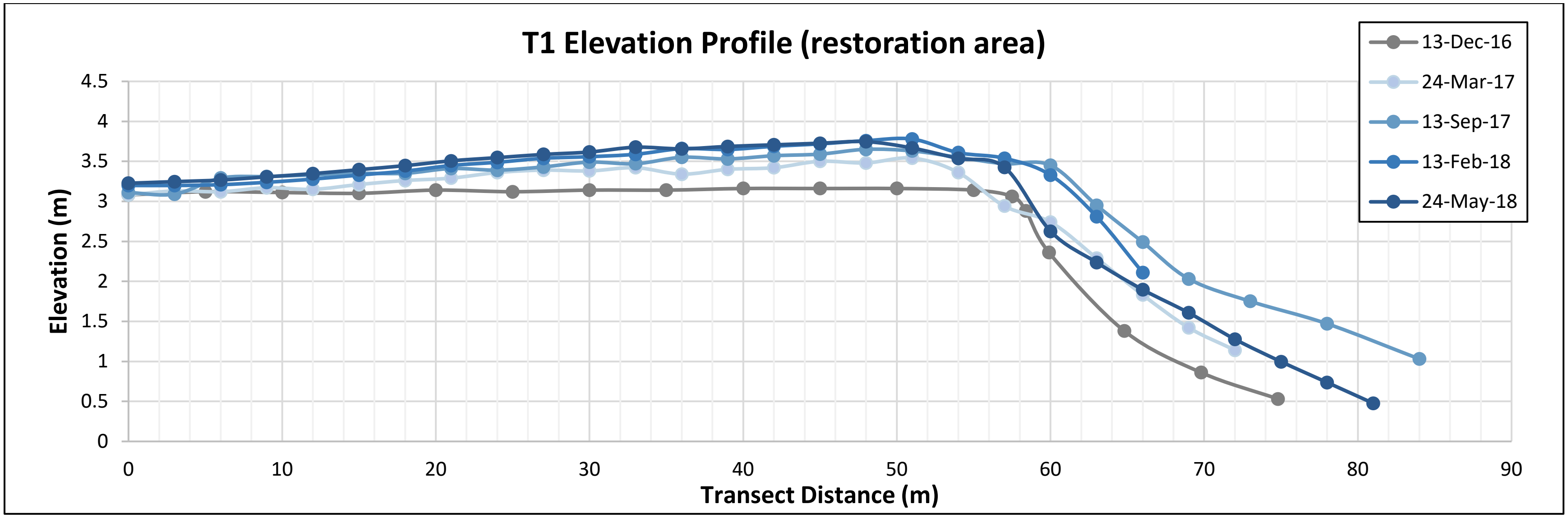


Figure 30. Transect 1 (T1) elevation profile surveys in restoration area (Elevation in NAVD88).

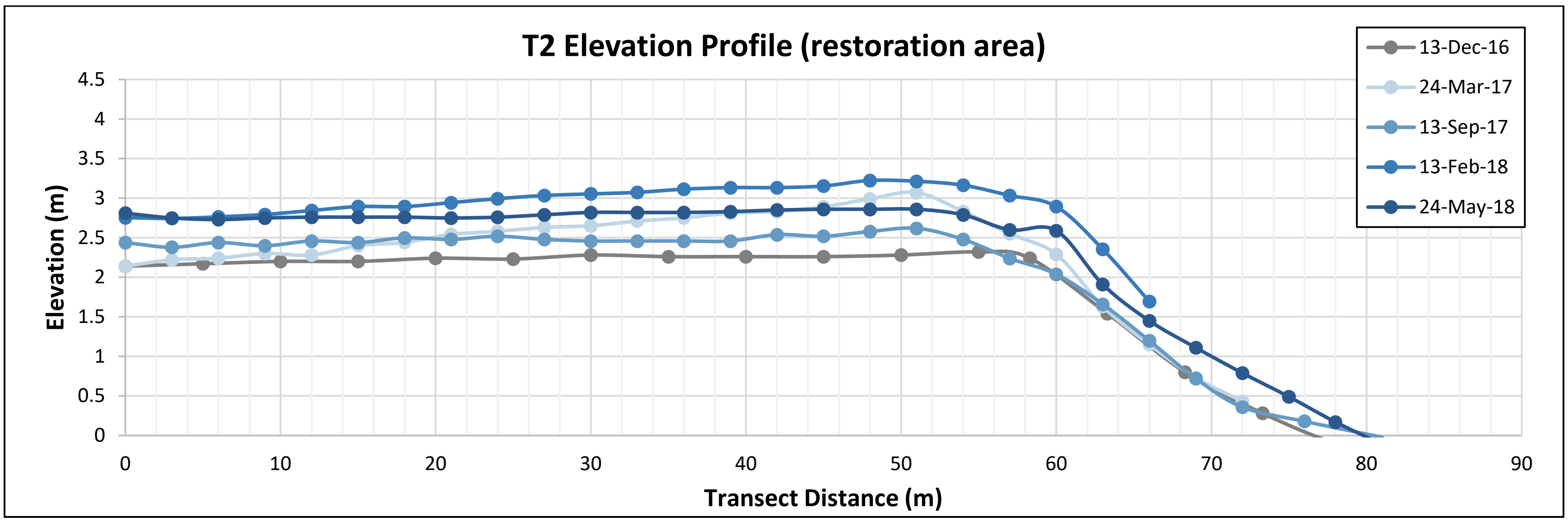


Figure 31. Transect 2 (T2) elevation profile surveys in restoration area (Elevation in NAVD88).

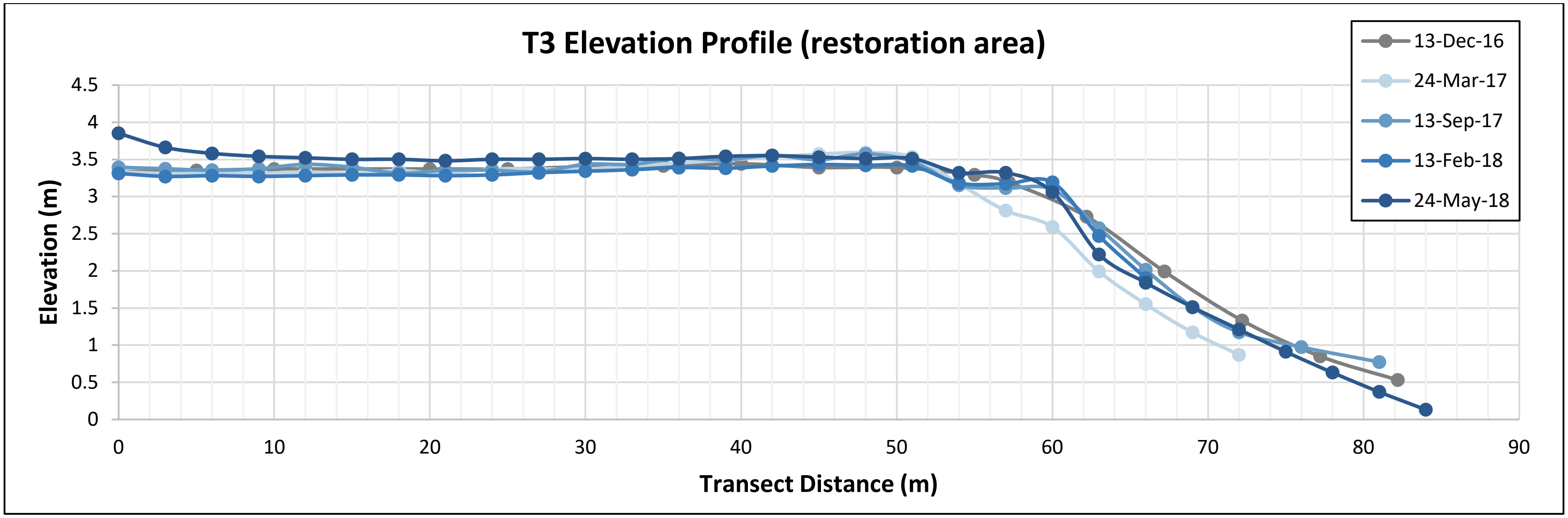


Figure 32. Transect 3 (T3) elevation profile surveys in restoration area (Elevation in NAVD88).

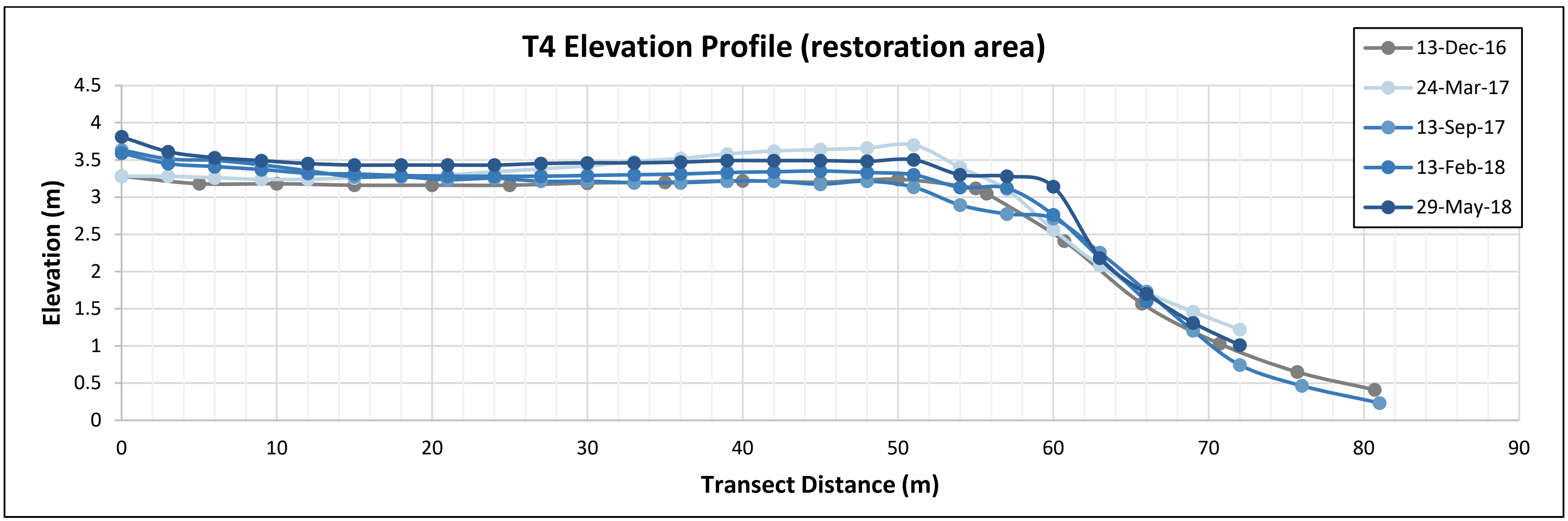


Figure 33. Transect 4 (T4) elevation profile surveys in restoration area (Elevation in NAVD88).

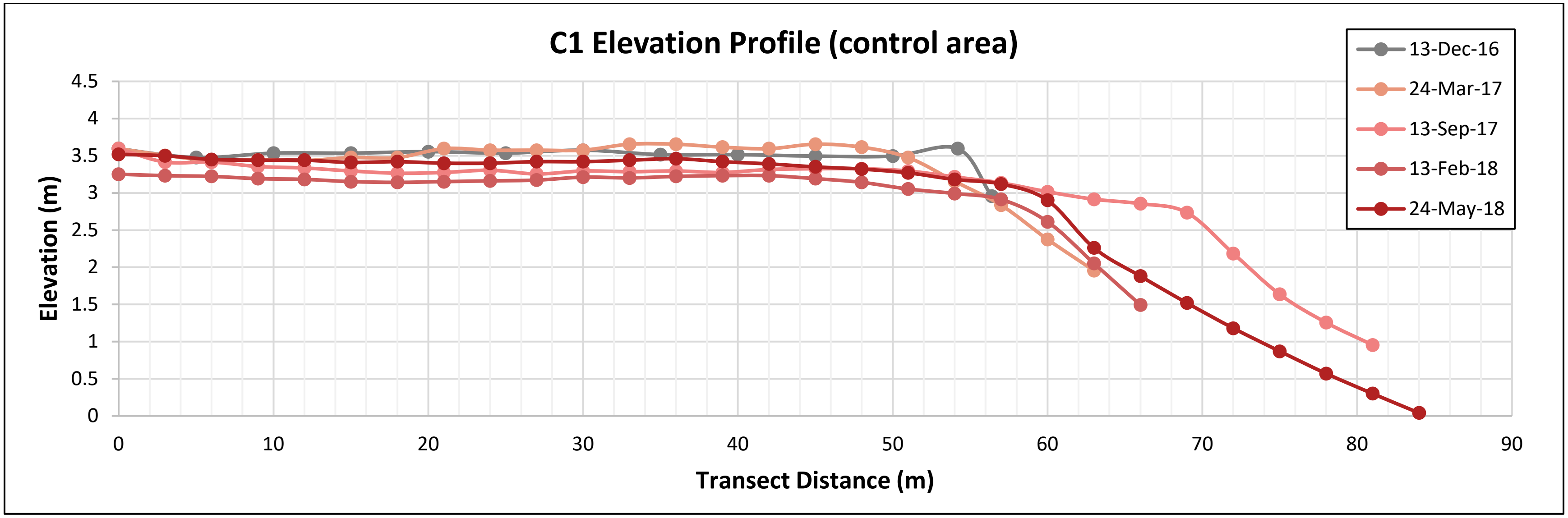


Figure 34. Control transect 1 (C1) elevation profile surveys in non-restored area (Elevation in NAVD88).

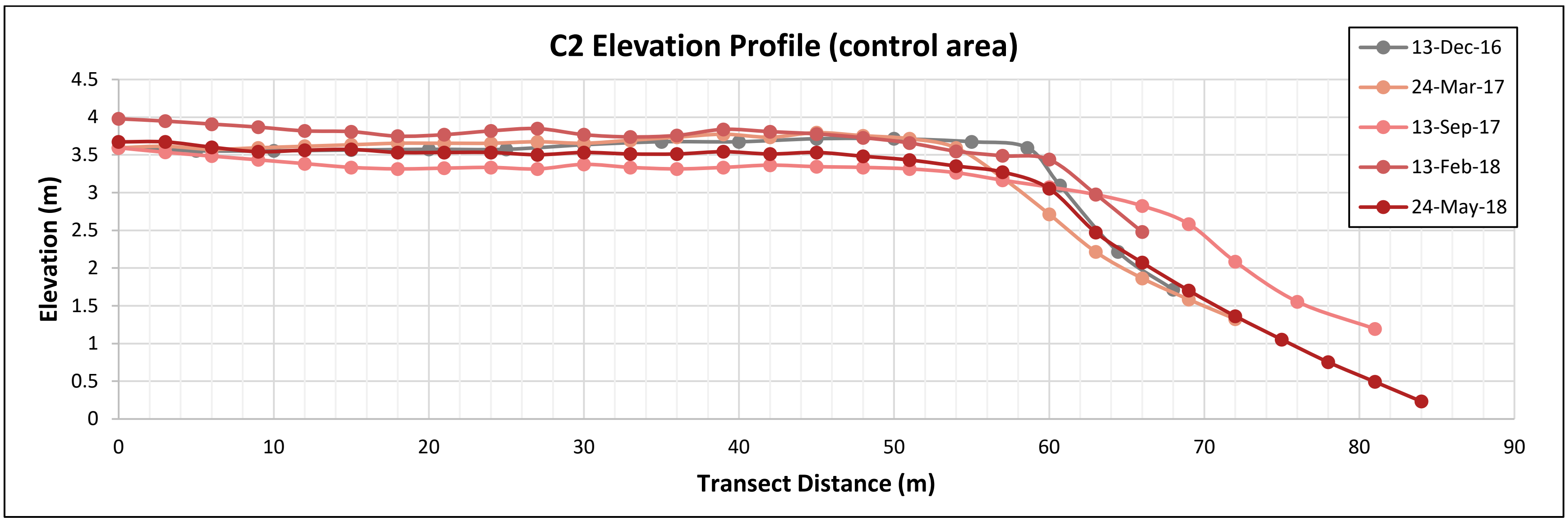


Figure 35. Control transect 2 (C2) elevation profile surveys in non-restored area (Elevation in NAVD88).

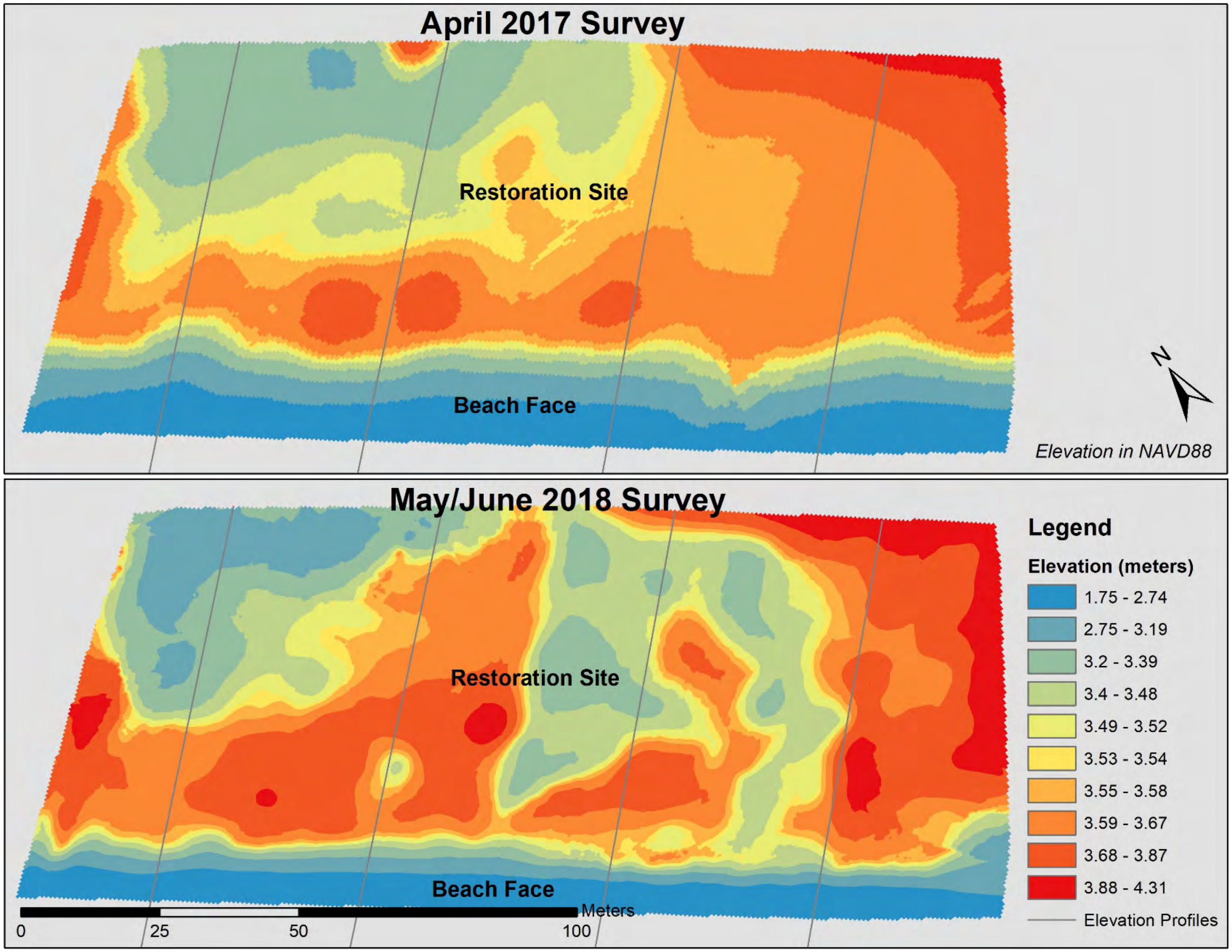


Figure 36. Year 1 and Year 2 topographic map of restoration site.

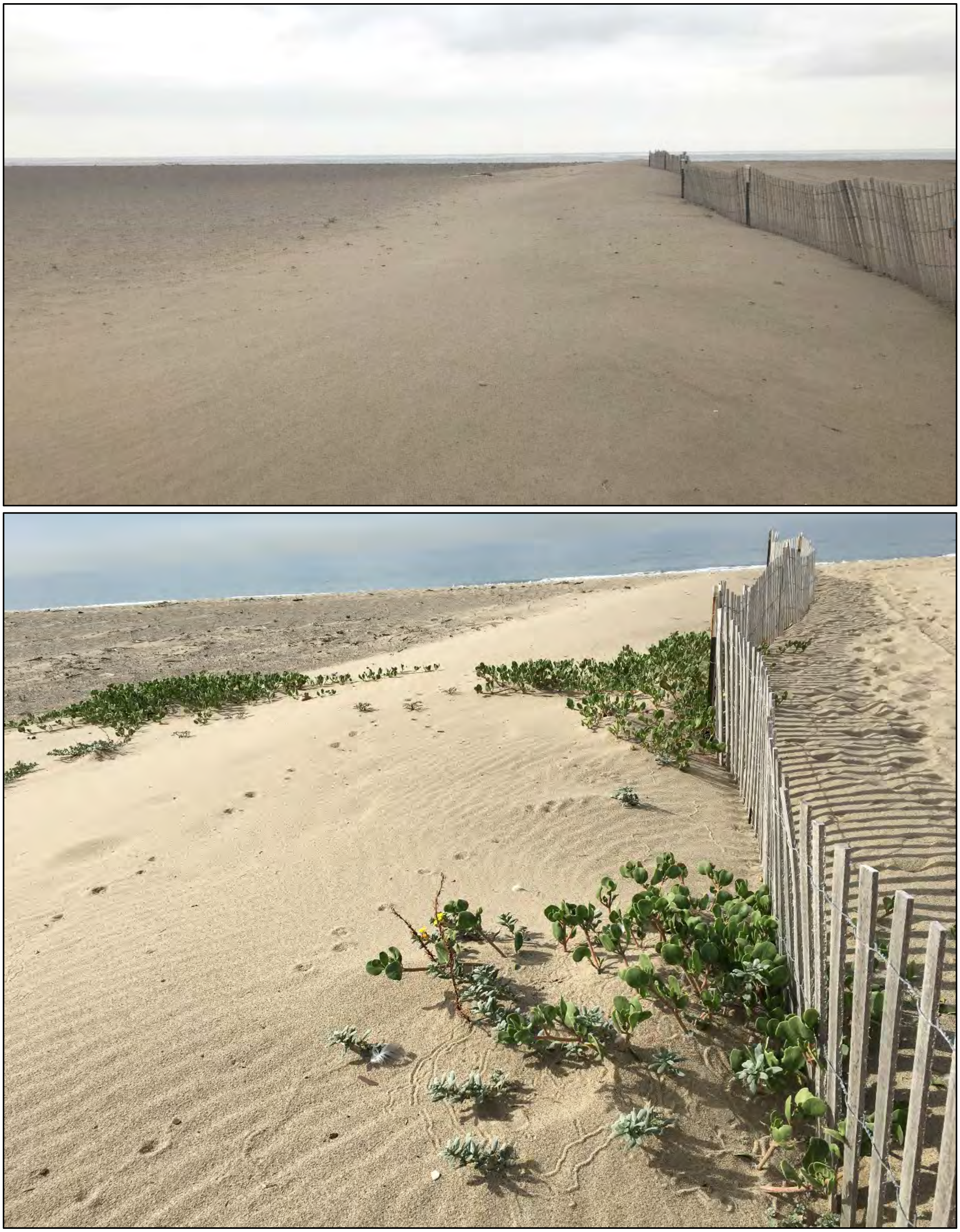


Figure 37. Photograph of sand build-up along the northern fence line in the restoration area (Top: 9 May 2017 and Bottom: 8 March 2018).

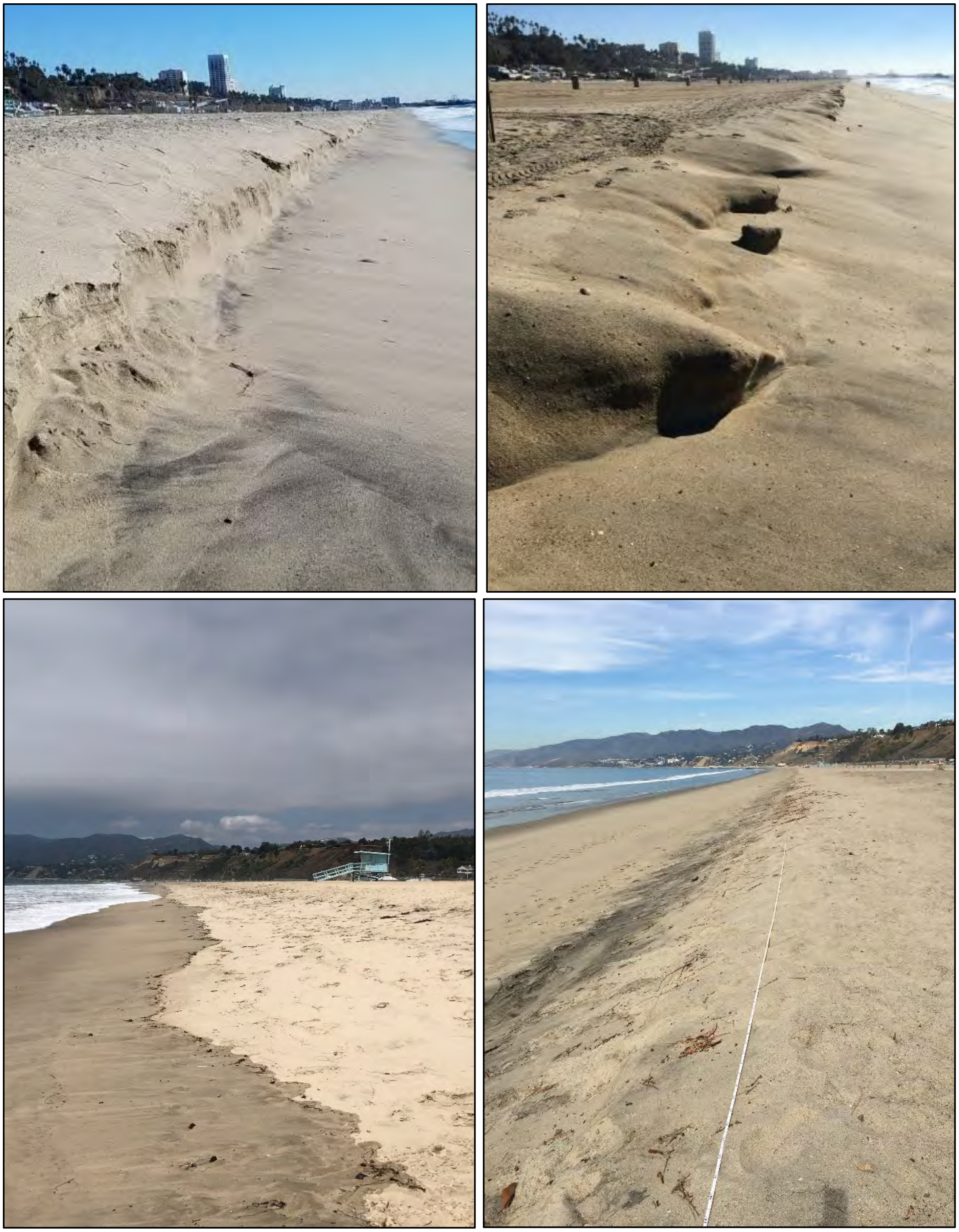
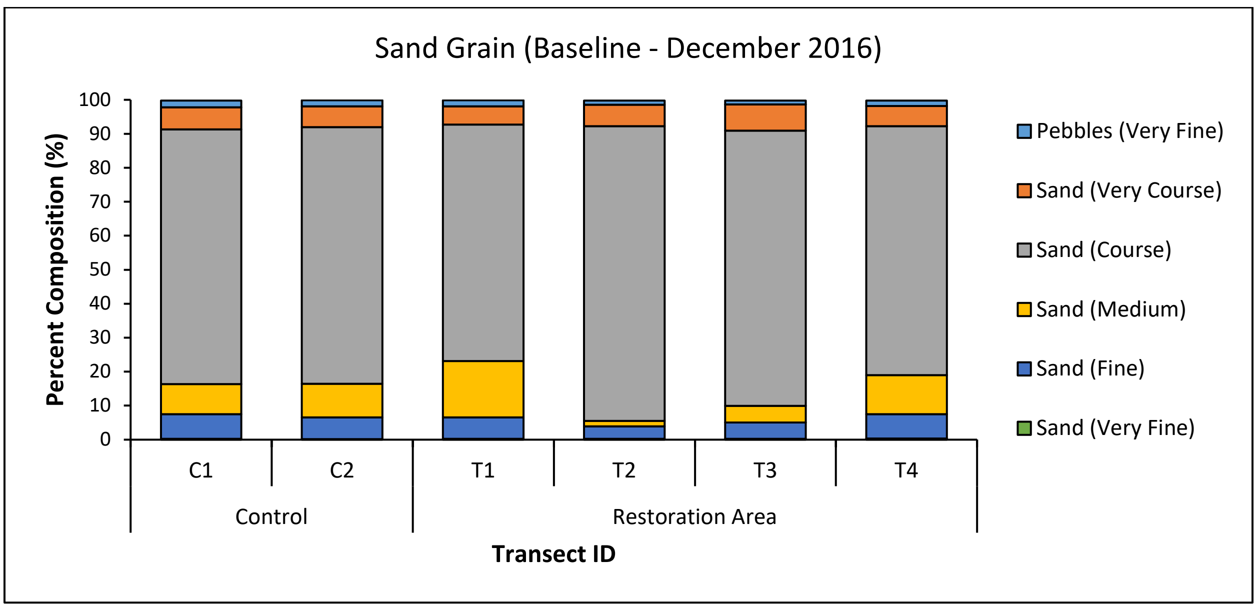


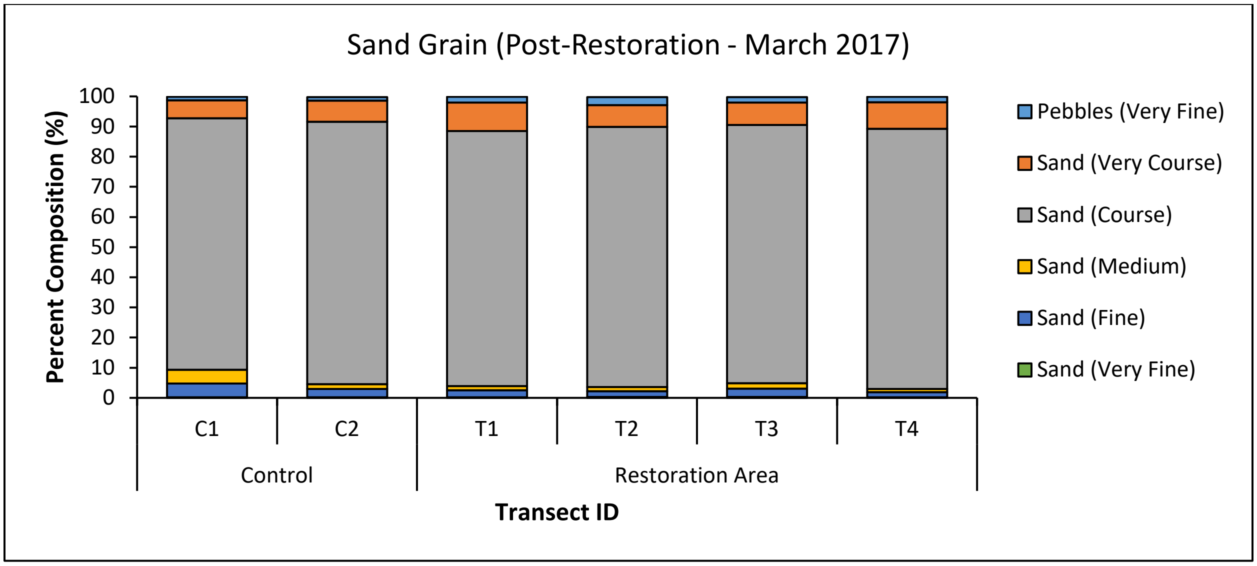
Figure 38. Berm topography (top left: 17 December 2016, top right: 25 January 2017, bottom left: 13 September 2017, and bottom right: 8 March 2018).

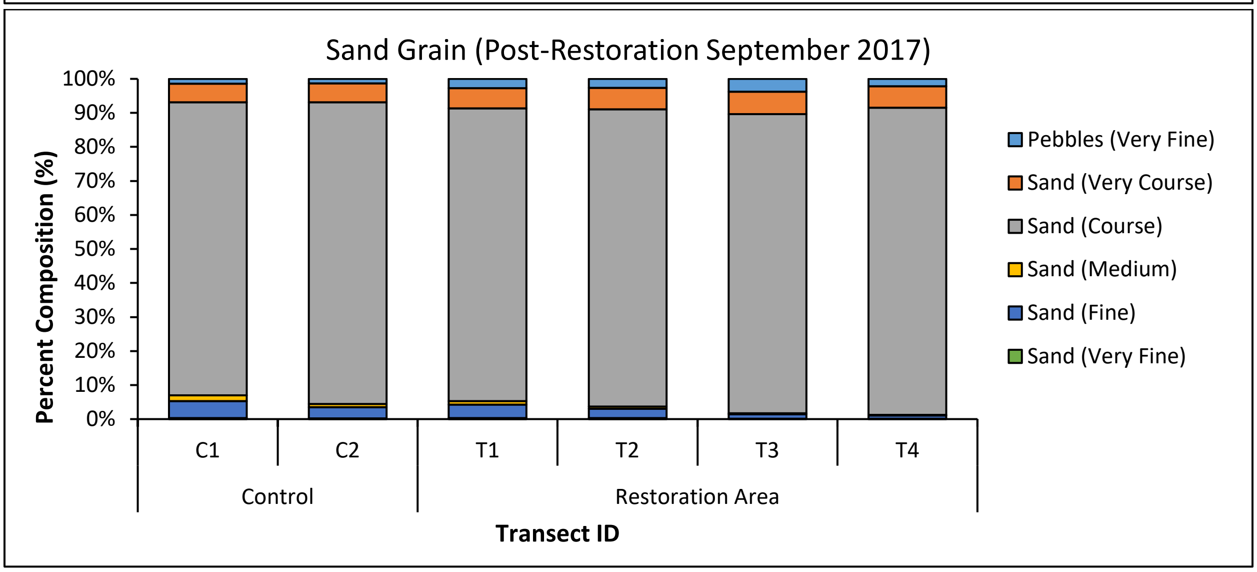
Sand Deposition, Grain Size, and Organics

A set of baseline and post-restoration sand samples were collected from two control transects and four transects on 13 December 2016 (baseline), 24 March and 13 September 2017, and 24 May 2018. Three samples were collected from each transect (approximately 3 meters south of the transect line to avoid footprints), including two dry samples off the 15m and 30m transect meter mark, and a wet sample near the waterline on the beach face. Samples were weighed before and after drying to measure moisture content, then each sample was sorted using a set of sieves measuring from 2mm (very fine pebbles) to 0.06mm (very fine sand). A portion of each sample was also used to analyze organics based on the loss on ignition (LOI) method.

In general, dry sand within the restoration site (averaged for 15m and 30m) saw a shift in grain size from medium and fine sand to course sand (Figure 39). Additionally, all post-restoration samples within the restoration site had a small increase in very fine pebbles, whereas control sites did not. The latest survey in May 2018 shows that course sand continues to dominate the grain size type and that very course sand and pebble percent composition has slowly been increasing. Additional data over multiple survey years are necessary to confirm trends.







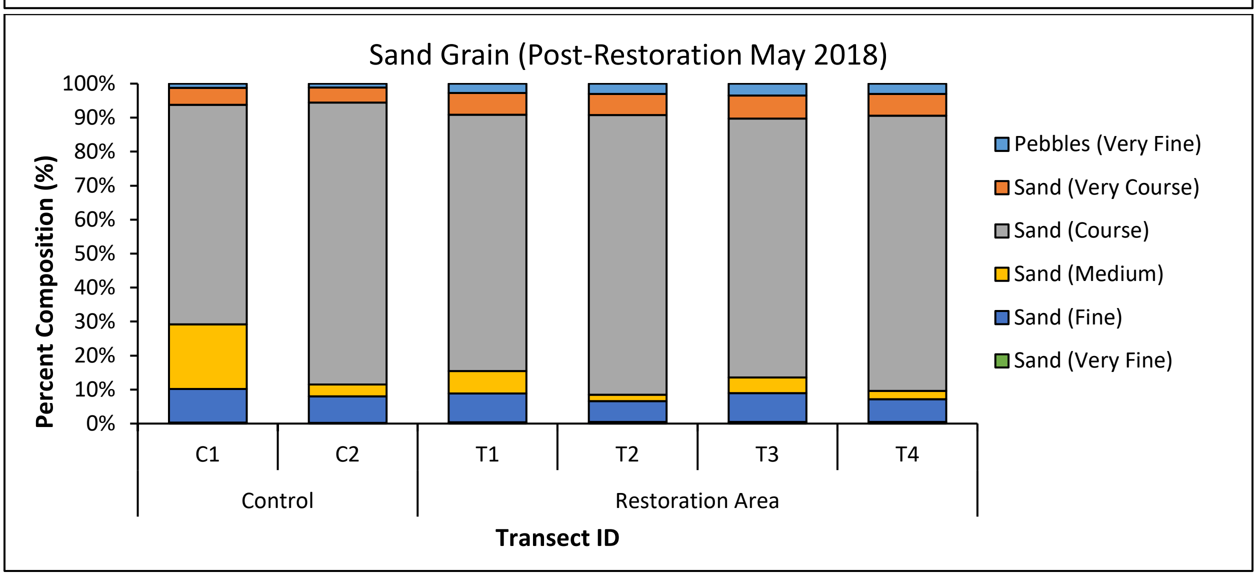


Figure 39. Baseline (top) followed by post-restoration sand grain results for all transects (dry sample averages).

Wet sand results were reported separately (Table 8). Results from the wet sand samples were variable between the baseline survey and the post-restoration survey but displayed relatively similar results at both the control transects and the restoration transects. As the wet sand is outside of the area actively maintained for the restoration, the similarity between the control and restoration results for the wet sand was expected. Similarly, the variability between the baseline and post-restoration surveys is likely due in part to the collection of the samples in two different wet sand locations based on the seasonal movement of the berm and wave erosion. Baseline sand composition, taken December 2016, was dominated by course and medium sand grains, and the data indicate an oscillation between medium grains during summer to course sand grains in winter season (Table 8). This shift in grain sizes is likely consistent with winter storms eroding the beach face followed by deposition of sand in the calmer spring and summer months (Figures 40 and 41).

Figure 40. Photographic time series of beach face at restoration site on 19 February 2017 (left), 13 September 2017 (center), and 8 March 2018 (right).

Table 8. Grain size results from December 2016 (baseline) and post-restoration (March 2017, September 2017, and May 2018).

		Control Transects		Restoration Area Transects			
	Grain Size	C1	C2	T1	T2	T3	T4
Baseline – wet (Dec 2016)	Pebbles (Very Fine)	0.07%	0.00%	1.05%	0.88%	0.23%	0.33%
	Sand (Very Course)	0.38%	0.00%	0.68%	1.02%	1.57%	1.01%
	Sand (Course)	78.52%	58.34%	8.01%	5.11%	93.44%	38.61%
	Sand (Medium)	10.84%	33.34%	32.22%	17.19%	0.66%	32.12%
	Sand (Fine)	10.12%	8.28%	57.01%	74.40%	4.00%	27.64%
	Sand (Very Fine)	0.06%	0.05%	1.01%	1.35%	0.09%	0.27%
Post-Rest –wet (Mar 2017)	Pebbles (Very Fine)	0.21%	2.01%	7.91%	0.06%	0.69%	0.82%
	Sand (Very Course)	4.13%	9.22%	3.77%	2.91%	3.58%	5.82%
	Sand (Course)	81.82%	78.78%	75.52%	95.89%	86.74%	88.43%
	Sand (Medium)	6.01%	5.69%	4.77%	0.67%	1.75%	1.36%
	Sand (Fine)	7.72%	4.24%	7.91%	0.42%	2.06%	3.37%
	Sand (Very Fine)	0.09%	0.05%	0.11%	0.04%	5.19%	0.16%
Post-Rest –wet (Sep 2017)	Pebbles (Very Fine)	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%
	Sand (Very Course)	0.53%	1.17%	0.69%	0.00%	0.41%	0.40%
	Sand (Course)	13.37%	4.69%	2.48%	2.33%	2.45%	2.38%
	Sand (Medium)	64.53%	70.77%	51.31%	66.62%	62.40%	69.31%
	Sand (Fine)	21.16%	22.89%	44.98%	30.51%	34.33%	27.5%
	Sand (Very Fine)	0.32%	0.47%	0.55%	0.55%	0.41%	0.40%
Post-Rest –wet (May 2018)	Pebbles (Very Fine)	0.10%	0.25%	0.13%	0.00%	0.00%	0.00%
	Sand (Very Course)	0.52%	0.74%	0.13%	0.30%	0.41%	0.42%
	Sand (Course)	84.04%	72.65%	89.62%	86.21%	88.16%	80.21%
	Sand (Medium)	1.55%	5.82%	1.14%	1.35%	1.09%	1.88%
	Sand (Fine)	13.47%	20.42%	8.73%	11.99%	10.20%	17.29%
	Sand (Very Fine)	0.31%	0.12%	0.25%	0.15%	0.14%	0.21%

Figure 41. Sand grain examples in restoration site [left: pebbles (very fine); middle: course sand; right: fine to very fine sand].

Sand transport measurement protocols involved using Modified Wilson and Cooke (MWAC) samplers to determine actual in-field sand transport rates (Figure 42). MWAC samplers were deployed for 30 minutes to one hour on multiple field surveys and failed to collect sand. This protocol will continue to be attempted during future surveys, targeting high wind conditions to maximize sand collection success. Additionally, data collected in the field combined with sand grain analyses was used in an empirical model to calculate wind-blown sand transport (Hsu 1981). Hsu's calculations will provide a future method to cross-validate predictive wind-driven sand transport as compared to MWAC samplers for direct measurement. Continued monitoring will inform trends in sand transport within the restoration and control site. Observationally, a shift in courser sand and cobble was seen in the restoration site towards the ocean, where high king tides over washed portions of the site during the winter (Figure 43).

Additionally, sand transport and deposition has been occurring along fence lines and around larger vegetation patches and wrack. High resolution elevation surveys confirm an increase in sand deposition along the fences and behind the berm (Figure 44).

Figure 42. MWAC samplers deployed at restoration site.

Figure 43. Cobble present in site after high king tide events (25 January 2017).

Figure 44. Sand accretion along fence in restoration site (24 May 2018).

A portion of each sediment sample was analyzed for organic matter and carbonate content using the loss on ignition (LOI) method (Figure 45). Samples were placed in weighted crucibles and weight loss was measured after heating the samples in a high-temperature furnace to remove organic matter. Figure 46 compares the average percent organics in dry sediments from the control site and restoration site by survey date. The restoration site shows a slightly higher overall percent organics composition in samples compared to the control site on each survey; however, there are only slight differences from the baseline (pre-restoration, December 2016). Sediments are an important site for organic matter decomposition and nutrient regeneration in coastal marine environments, and continued data collection may inform the effects the beach restoration project has on carbon cycling and transformations.

Figure 45. Organics (loss on ignition) analysis on sand samples (18 July 2018).

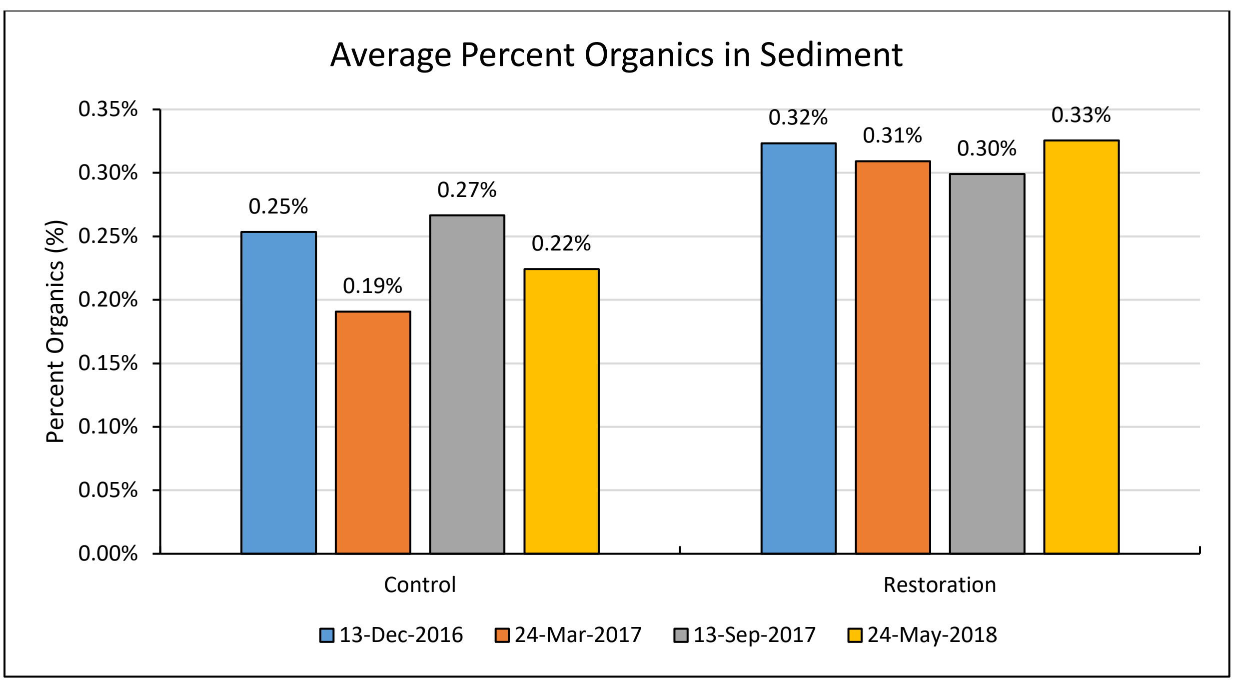


Figure 46. Average percent organics in sediment samples by survey date (dry samples only).

Photo Point

Photo point monitoring helps to identify seasonal site changes and project-level changes as a result of the restoration activities (e.g. native vegetation growth, plant hummock formation). Survey methods are described in detail in SOP 7.2 Level 2 Photo Point (TBF 2015a). Photographs can be used as qualitative assessments of broad-scale changes following restoration activities and plant hummock development over time. Seventeen photographs were taken at nine stations on eight survey days. Two locations were chosen to present in this report as the best representative photographs taken on 13 and 17 December 2016; 13 and 25 January, 4 February, 24 March, 25 April, 21 August, and 13 September 2017; 11 January, 13 April, and 24 May 2018 (Figures 47 and 48). While the vegetation cover is still difficult to see within the restoration area, small individual plants are visible starting in the spring months, with a notable increase in plants seen along the fence lines in the 24 May 2018 survey. Also notable are the changes in sand grain size over time, visible footprints indicating use of the site, and the changes in sand deposition towards the fence lines on three sides of the restoration area (ocean ward side is not fenced to allow for movement in and out of the restoration area).

Photo Point 1A

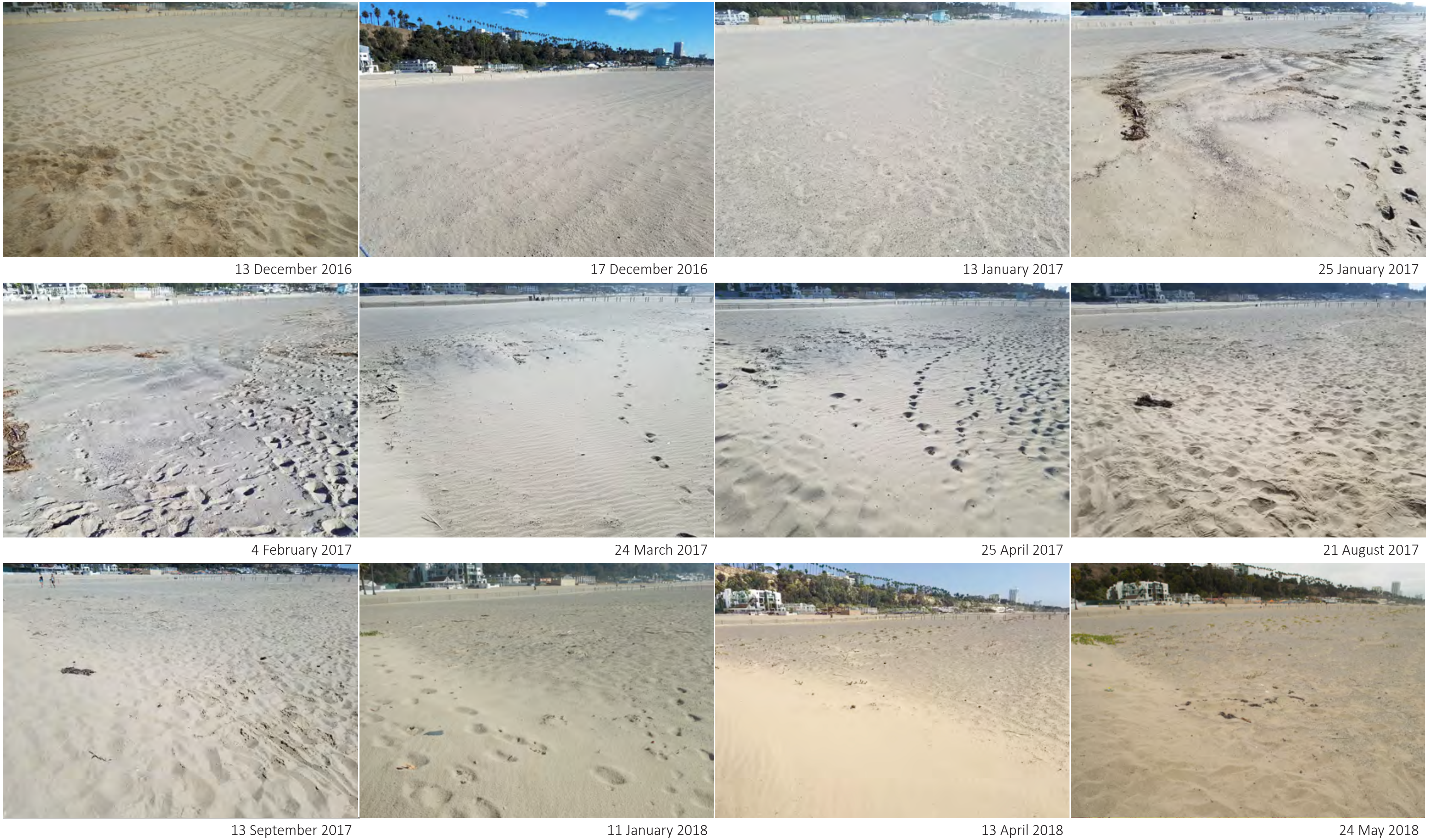


Figure 47. Photo Point Series (bearing 88°)

Photo Point 2A

13 December 2016

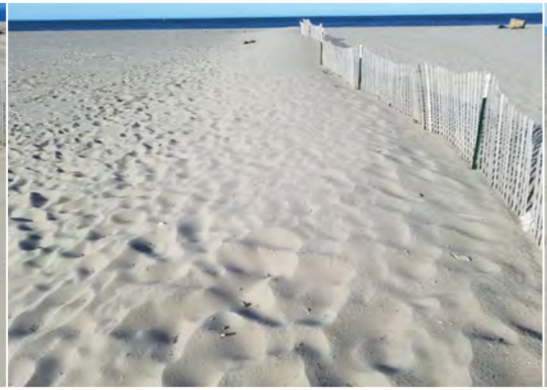
17 December 2016

13 January 2017

25 January 2017

4 February 2017

24 March 2017



25 April 2017

21 August 2017

13 September 2017

11 January 2018

13 April 2018

24 May 2018

Figure 48. Photo Point Series (bearing 210°)

Adaptive Management, Maintenance, and Site Use

Adaptive management is implemented based on the success of the project as interpreted by TBF, the beach managers, the City of Santa Monica, and an advisory group of scientists. The monitoring components and resulting data have been integral to evaluate the project. TBF, with the help of our volunteer internship program and several dedicated students from LMU, have undertaken a hands-on, community-level maintenance strategy without the use of mechanized equipment, including trash removal and invasive species removal. Site checks, invasive plant removal, and trash collection have occurred at least monthly (semi-monthly for the first few months), since the project was implemented. These efforts will continue (possibly at a reduced rate, if feasible) for a duration of no less than five years after the project began in 2016. Evaluation of the project will continue to occur annually via an annual report, including a summary of monitoring data results, and will be provided to the City, DPR, and the Commission and made publicly available on TBF's website (www.santamonicabay.org).

Site visits will continue to be conducted quarterly to visually assess the restoration progress and evaluate the need for maintenance activities. The overall condition of the restoration areas will continue to be noted, along with detailed observations including presence of invasive species re-growth or environmental stressors (e.g. prolonged dry periods). Photographic documentation of any observations of concern will occur. If invasive vegetation is found, adaptive management steps such as weed removal by hand or with hand tools will continue to be taken. Similarly, litter or trash collection and removal from site will continue to be conducted at least bi-monthly.

Thus far, one non-native species, sea rocket, has invaded the project area to a very minimal extent. The areas where it is present do not appear to be directly negatively affecting the native vegetation; however, it continues to be thoroughly monitored and removed periodically from within the restoration area. It is likely to continue sprouting, at least until the native vegetation becomes fully established, because there are source seed populations along the bike path and back dune areas adjacent to the project site, and an assumed pre-existing seed bank in the sand of the project area (Figure 49).

Figure 49. Non-native sea rocket within the project area (21 August 2017).

Trash continues to be very low within the restoration area. Interestingly, there is often more trash that is picked up in the sand immediately adjacent to the restoration plot, in beach areas that are frequently groomed. It is likely that the large grooming rakes either miss or bury some of the smaller tiny bits of plastic and polystyrene foam that are frequently found adjacent to and within the project area. Frequently seen trash items include cigarette butts, small bits of plastic, plastic straws, polystyrene foam, candy wrappers, and bits of coffee cups (Figure 50). Infrequently seen items include things like flip-flops, Frisbees, and tennis balls (Figure 50).

Figure 50. Trash collected after a storm event from within and adjacent to the project area (25 January 2017).

Following a site visit, a section of the northern fence was found damaged, likely by a vehicle, and TBF staff repaired the fence on 3 October 2017 (Figure 51).

Figure 51. Fence repair before (left) and after (right) on 3 October 2017.

Site Use

An important goal of the pilot restoration project is to evaluate whether heavy recreational use of beaches in Los Angeles and natural habitats to benefit birds and wildlife can coexist. Human use data from this project may serve to inform other similar efforts in southern California. One goal of the project was to encourage another, less frequently seen, use of Los Angeles beaches, which is to allow people and families the chance to interact with natural habitats along the beach. As such, the restoration area is not fenced off completely from the public (the shoreward side is left fully open), and recreating inside the project area was only discouraged at the request of USFWS once the plovers (a federally threatened species) began nesting inside the restoration area. However, the sightings of this rare species also brought birdwatchers and other tours to the area. Monitoring was conducted by the Santa Monica Audubon Society and several local ornithologists and followed protocols form USFWS.

Human use data from the site visits suggest that both locals and visitors are interacting positively with the site through everything from jogging through it along the symbolic pathway, surfing next to it, and birdwatching along the perimeter. Frequent human uses of the area include walking, jogging, biking along the adjacent bike path, sun bathing, walking dogs, surfing, paddle boarding, and skim boarding (Figure 52). Additional uses include birdwatching and fishing. Many people have questions as they interact with TBF staff collecting data for surveys such as: “Why is the vegetation here?” “Is this better for birds?” “Will there be flowers?” All of these questions and many more are answered by staff, and all interactions have thus far been positive. It seems that both locals and visitors alike are responding encouragingly to the restoration area, which bodes well for the future of the site and its ability to answer other goals such as whether or not it can increase coastal resilience against climate change stressors like wave erosion and sea level rise. It is heartening when most people suggest expanding into a larger area. The site has also provided many opportunities to teach students about beach ecology. Several LMU students have conducted research and many more have visited the site since implementation. On 4 March 2017, a class of over 50 UCLA students in a geomorphology course visited the site to learn hands-on about applied physical surveys and beach ecology.

Figure 52. Human use of the restoration site [top: TBF-led tour with US EPA staff (15 February 2017); middle: stand up paddle boarders using the symbolic pathway through the middle of the restoration area (17 December 2016); bottom: beach running event in front of fenced restoration area (24 August 2017)].

Conclusions and Recommendations

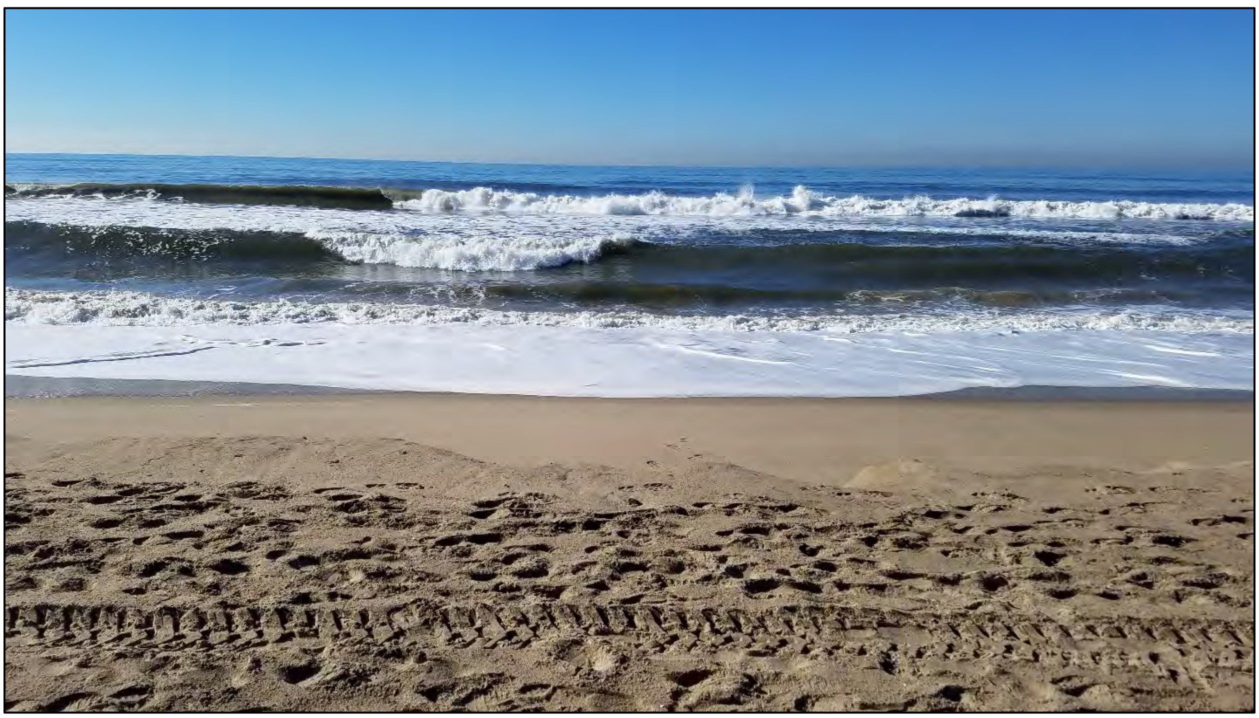
The first approximately nineteen months following the pilot project implementation had a number of valuable successes and learning experiences. As the project was meant to be an experimental pilot for the region, no specific, quantifiable success criteria were set; however, the project can be evaluated against its ability to meet the project goals. The project positively engaged the public, created new partnerships and outreach connections, restricted grooming in an approximately 3-acre area, allowed vegetation to grow and sand hummocks to form along fence lines, provided comprehensive science-based monitoring data to inform soft-scape beach restoration solutions, supported wildlife, and is bringing back a rare coastal habitat type to the Los Angeles region.

Additionally, the increased functions within the restoration habitat area included benefits to several notable species. Nesting of the federally threatened western snowy plover had not been recorded in the Los Angeles region for almost 70 years, and the first nest for the Los Angeles region was found within the restoration area and contained three eggs. Plovers were repeatedly identified on bird surveys throughout both survey years. The presence of plovers throughout breeding and wintering seasons on site suggests that the possibility of future nests by plovers in the area is likely. Furthermore, two native plant species that were not seeded, woolly heads and beach sand verbena, were identified as germinating in the project area. It is possible that there was either an existing seed bank for these species already along Santa Monica Beach, or that they were transported by wind, waves, birds, or humans. Neither species was identified in areas adjacent to the project site. Another new addition to the restoration project area was dune beetles, which provide an increased layer of the food web available to foraging birds and wildlife. Dune beetles were confirmed using a sieving technique by UCSB researchers, monitoring partners of TBF. Specimens were not collected for species-level identification but may potentially be collected in the future.

Data suggest that the restoration area is considerably different from both the control sites and from itself over time as compared to the baseline surveys, especially for vegetation and sand morphology, though (as expected) vegetation cover remains fairly low after the second growing season. Additional years will allow an evaluation of the vegetation cover trend over time. It is likely that the vegetation community will continue to establish, but will probably remain somewhat patchy, as is the trend for natural coastal strand habitat types. The variability of the berm over time and the notable changes in elevation along the fenced perimeters, oceanward berm, and throughout the restoration area surrounding patches of vegetation suggest that longer periods of time for scientific evaluation for these parameters will also allow for additional trends to be defined. Future monitoring will continue to inform sand morphology within the restoration site in response to vegetation growth, fence placement, and seasonal changes from storms, king tides, and wave energy. Additionally, elevation profile data will provide information to understand the effects of sand grooming versus the development of natural beach morphology over time.

One suggestion for future projects with a similar set of existing uses is to have a similar set of strong public outreach components prior to the initiation of the project and to directly engage local stakeholder groups. A significant effort was made to reach out to local residents, stakeholder groups, interested parties, beachgoers, and all of the agencies and organizations who provide some input to beach management in the area. This effort went far beyond requirements for the permits and included setting up stakeholder meetings to answer questions, incorporating feedback on project planning from the public, and working with the City of Santa Monica to announce the project in public meetings and to all of the user groups such as lifeguards, police, maintenance workers, and other City and County groups. Additionally, much of the credit to the aforementioned results also goes to the City of Santa Monica for their efforts to engage the public, take a leadership role on permitting, and for their ongoing support and vision.

Another suggestion for future projects along beaches is to incorporate many of the same or similar monitoring methods that will allow for comparisons between-projects. This will allow for an evaluation across multiple scales and in different areas with different levels of sand accretion or erosion, wave patterns, weather patterns, and vegetation growth over time. Other, more passive restoration projects could also be evaluated, such as restricting grooming to other areas of the beach. Annual reports will continue to be made available for public download on TBF's website: www.santamonicabay.org.



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