Malibu Living Shoreline Project

Year 1 Annual Report

May 2022

Prepared for:

California Coastal Commission
Los Angeles County Department of Beaches and Harbors
City of Malibu
California State Coastal Conservancy

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Annual Report

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Prepared for:

California Coastal Commission, City of Malibu, Los Angeles County Department of Beaches and Harbors, State Coastal Conservancy

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In addition to the partners listed above, we are also grateful for the many proponents and advocates for this project, including but not limited to: former Malibu Mayor and Councilmember Skylar Peak, former Councilmember Jefferson "Zuma Jay" Wagner, Audubon Society, US Fish and Wildlife Service, United States Geological Survey, University of Southern California Sea Grant Program, Loyola Marymount University's Coastal Research Institute, University of California Santa Barbara, Cooper Ecological Monitoring, Inc., Coastal Restoration Consultants, Inc., Heal the Bay, Tijuana River National Estuarine Research Reserve, US Environmental Protection Agency, Resource Conservation District of Santa Monica Mountains, and local residents and visitors to the site. This support will allow us to explore nature-based adaptation ("living shoreline") protection measures to combat climate change, while bringing back an important coastal habitat to the Los Angeles region.

The contents of this report do not necessarily reflect the views and policies of partner agencies, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Executive Summary

Introduction

This pilot project aims to restore 3.26 acres of coastal habitats located at Zuma Beach and Point Dume Beach in Malibu, CA, by utilizing existing sediments to transform portions of the current beaches into sustainable coastal strand and foredune habitat complexes resilient to sea level rise. Both Zuma Beach and Point Dume Beach reside in the City of Malibu and are managed by the Los Angeles County Department of Beaches and Harbors. As an alternative to traditional hardscaping options, this project will evaluate a living, restored shoreline with a diverse wildlife community as an alternate approach to combat climate change.

Historically, dune systems were a prominent feature of this area; over time with increased development and urbanization, these dune features disappeared. The project site consists of 3.26 total acres of sandy beach and dune habitat. Restoration activities were conducted on 1.02 acres at the Zuma Beach site, adjacent to Zuma Lagoon, and 2.24 acres at the Point Dume Beach site.

Restoration Activities in Year 1

Through habitat restoration and the installation of symbolic pathways and interpretive signage, the site is providing new opportunities to enhance recreational beach experiences, including opportunities to observe native dune plants growing and flowering, bird watching, and to simply enjoy the scenery. Project implementation began on 14 December 2020 and was completed on 12 February 2021. Pre-restoration monitoring occurred prior to implementation, and project implementation was immediately followed by post-restoration site maintenance (i.e., supplemental watering, removal of non-native species, and biomimicry stake / sand fence repair).

Hand seeding occurred in the coastal strand and foredune habitats at Zuma Beach and Point Dume Beach in Winter 2020-21. A mix of container stock and seeding also occurred in the back dunes and dune transition areas at Zuma Beach. Container stock plants were utilized in this area to expedite establishment of the native vegetation community and deter non-native invading plants from returning. In total, over 500 native container stock plants were planted at the Zuma Beach back dune and dune transition area. TBF has a long-term commitment to post-implementation monitoring, maintenance, and adaptive management.

Scientific Monitoring

Accurate and robust scientific monitoring is a vital part of any restoration project. Monitoring for this project includes observations of baseline and post-implementation site conditions to assess plant installation as well as other restoration components (e.g., sand fencing). Monitoring also informs adaptive management actions (e.g., non-native plant cover that may need to be controlled), tracks the project towards meeting success criteria over time, and compares the site to 'control' conditions in adjacent areas that have had no restoration actions. Photos show a substantial reduction in non-native cover, primarily ice plant, from the baseline survey (October 2020) to the post-implementation surveys (June and October/November 2021).

The dune transition area in the most eastern part of the Zuma Beach project site exhibited the most apparent cover transformation, shifting from an area with 1-5% native cover and 75-95% non-native cover in the baseline survey, to an area with 6-15% native cover and 1-5% non-native cover in the Fall 2021 survey. Prior to implementation, this area was dominated by a monoculture of non-native iceplant (*Carpobrotus edulis*), which was removed and planted/seeded with native species as part of project implementation. The baseline surveys from the Point Dume Beach site exhibited small polygons with primarily non-native cover and intermixed low native cover, surrounded by unvegetated sandy beach (predominantly mechanically groomed). Following restoration actions, including post and rope delineation to restrict grooming activities, the site displayed far less unvegetated sandy beach.

Conclusions and Recommendations

The first year of project implementation, monitoring, and maintenance had a number of valuable successes and learning experiences. Even in the first year, the project is already meeting several success criteria, with additional supplemental seeding and planting planned for Winter 2022 to help meet other criteria. Additionally, the project positively engaged the public and has widespread support, created new partnerships and outreach connections, restricted grooming and performed restoration activities in a 3.26-acre area, removed invasive vegetation, allowed native vegetation to grow and the beginning of sand hummocks to form along fence lines and in other areas of the site, provided comprehensive science-based monitoring data to inform nature-based resilience solutions, and is enhancing a rare coastal habitat type in the Malibu region.

Data suggest that the site is performing well and that the restored areas are beginning to diverge from the control areas that did not have restoration activities. As expected, absolute native vegetation cover remains relatively low, although areas that were either covered in invasive iceplant or previously groomed have new dune plants. It is likely that the vegetation community will continue to establish over time, but will probably remain somewhat patchy, as is the trend for natural coastal strand and foredune habitat types.

TBF has a long-term commitment to post-implementation monitoring, maintenance, and adaptive management. Due to the effort required to implement the biomimicry stake plots and the limitations to dune plant growth that they impart, they are unlikely to be used for dune accretion in Year 2, though they will be evaluated in targeted areas for future years. Based on the data results and site visits, supplemental seeding and planting is recommended by the project team to meet additional future vegetation success criteria for the site. Supplemental watering should also be considered if drought years continue. Annual reports will continue to be made available for public download on TBF's website: www.santamonicabay.org.

Introduction

Background

Los Angeles County beaches are some of the most recognizable and popular beaches in the world. They feature expanses of sand, cliffs, tidepools, and marine life; and they hold many recreational opportunities for the millions of people who visit the vast coastline each year. In recent years, over 70 million people have visited beaches in Los Angeles County annually. Although sandy beaches traditionally have been and continue to be managed primarily as recreation areas, they are also important natural ecosystems that link marine and terrestrial environments and are considered a major habitat. The protection of sandy beaches and an understanding of their condition has become increasingly important in their relationship to sea level rise and coastal resilience.

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 such as erosion, interrupted sediment transport, beach replenishment with non-natural sediment, pollution, and loss of natural morphology due to grooming and other maintenance activities, which has led to the extirpation and extinction of many native species and loss of important ecosystem functions (Dugan et al. 2003, Dugan and Hubbard 2010, Hubbard et al. 2013). Dunes and other beach habitats are critical in managing sand transport to create resilient beach morphologies, which naturally adapt to climate change impacts. These systems can also offer a nature-based adaptation approach, or “living shoreline”, form of protection for our coastlines. By restoring natural processes to impacted beach systems, we will improve their ecological and utilitarian functions, and serve as a model for similar projects statewide.

Since the 1960s, many of the beaches in the Los Angeles area have been subjected to the continuous removal of natural features as they begin to develop. Additional impacts have occurred from development such as roads and highways, homes, and other types of infrastructure. However, when beaches are allowed to maintain or create natural features, such as low dunes, they provide a cost-effective buffer to storm surges and other regular, predictable threats, including sea level rise and increased erosion. 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.

In April 2016, Los Angeles County published the LA County Public Beach Sea-Level Rise Vulnerability Assessment, made possible by a grant from the California State Coastal Conservancy. This assessment identified public beach facility assets at Zuma and Point Dume County Beaches, where the Malibu Living Shoreline Project is located. Collectively there are 33 assets, including a concession, multiple lifeguard buildings, a maintenance yard, parking lots, restrooms, and an access road at Zuma and Point Dume County Beaches. These assets comprise the essential components that are needed to support and promote safe public beach recreation opportunities. The study identified that if no protection measures are implemented, assets at Zuma and Point Dume County Beaches will be vulnerable to inundation damage under high sea-level rise projections. Additionally, with no shoreline protection measures implemented, the analysis suggests that Zuma and Point Dume County Beaches could lose up to 50% of beach by 2040, and up to 70% of beach by 2100. The Malibu Living Shoreline Project provides a cost-

effective and low-impact solution to increase the resiliency of the shoreline at Zuma and Point Dume County Beaches.

Historically, large expanses of dunes once covered the coastal zone at both Zuma and Point Dume County Beaches. Due to urbanization, an increase in development, and beach grooming (raking) practices, the majority of these historical dunes have disappeared. The Los Angeles County Department of Beaches and Harbors (LACDBH) built up some sand dunes in recent years to protect coastal infrastructure at Zuma and Point Dume Beaches in Malibu, but they were largely covered by monocultures of non-native, invasive species such as iceplant (Figure 1).

Figure 1. Representative site photographs from Zuma Beach adjacent to the lagoon (above) and Point Dume Beach adjacent to the parking lot (below).

Project Goals

This pilot project aims to restore 3.26 acres of coastal habitats located at Zuma Beach and Point Dume Beach in Malibu, CA by utilizing existing sediments to transform portions of the current beaches into sustainable coastal strand and foredune habitat complexes resilient to sea level rise. As an alternative to traditional hardscaping options, this project will evaluate a living, restored shoreline with a diverse wildlife community as an alternate approach to combat climate change. Three specific goals of the Malibu Living Shorelines Restoration Project (MLSP) include:

1) increasing the resiliency of the shoreline through the restoration of sandy beach and foredune habitat;
2) implementing nature-based adaptation, or 'living shoreline', protection measures against sea level rise and coastal storms; and
3) increasing engagement of the community through enhanced beach experiences, outreach, and education.

Encouraging natural accretion of sand will build topography and increase elevation across the upper shore to store sand over time. This will help alleviate the effects of erosion due to large winter storms and in the long-term, sea level rise. Intact and native dune systems are more resilient to disturbance than degraded systems.

This project aims to enhance the existing dunes by replacing the invasive plants with native dune species as well as enhancing the footprint of ungroomed areas. After seeding and planting vegetation, sandy coastal strand habitats and foredunes would naturally develop, which will then support higher levels of the ecological community (e.g., invertebrates, birds). 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). The ecosystem benefits that living shorelines projects provide are not limited to a narrow time period but continue over time as the shoreline establishes, compared to hard shorelines that require maintenance and often result in the loss of beach.

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" nature-based, low-cost, natural living shoreline protection from sea-level rise and storms while providing public benefits and enhancing natural resource values.

Additionally, this project will help reestablish an appreciation that has been lost in the Los Angeles region of a natural, functioning beach ecosystem and the site will provide educational and recreational opportunities including interpretive signage and pathways for people to interact with the site. In addition to reducing coastal hazards and protecting nesting birds, this project will encourage nature-based tourism and increase community awareness of living shorelines while still allowing all other existing recreational uses of the beach to continue. All of these benefits are expected while having low-to-no impact on existing recreational uses of the beach.

Site Description

Both Zuma Beach and Point Dume Beach reside in the City of Malibu and are managed by the Los Angeles County Department of Beaches and Harbors. Historically, dune systems were a prominent feature of this area; over time with increased development and urbanization, these dune features disappeared. The project site consists of 3.26 total acres of sandy beach and dune habitat (Figure 2). Restoration activities were conducted on 1.02 acres at the Zuma Beach site, adjacent to Zuma Lagoon, and 2.24 acres at the Point Dume Beach site (Figure 3).

Figure 2.Overview map of both restoration areas implemented as part of the Malibu Living Shoreline Project.

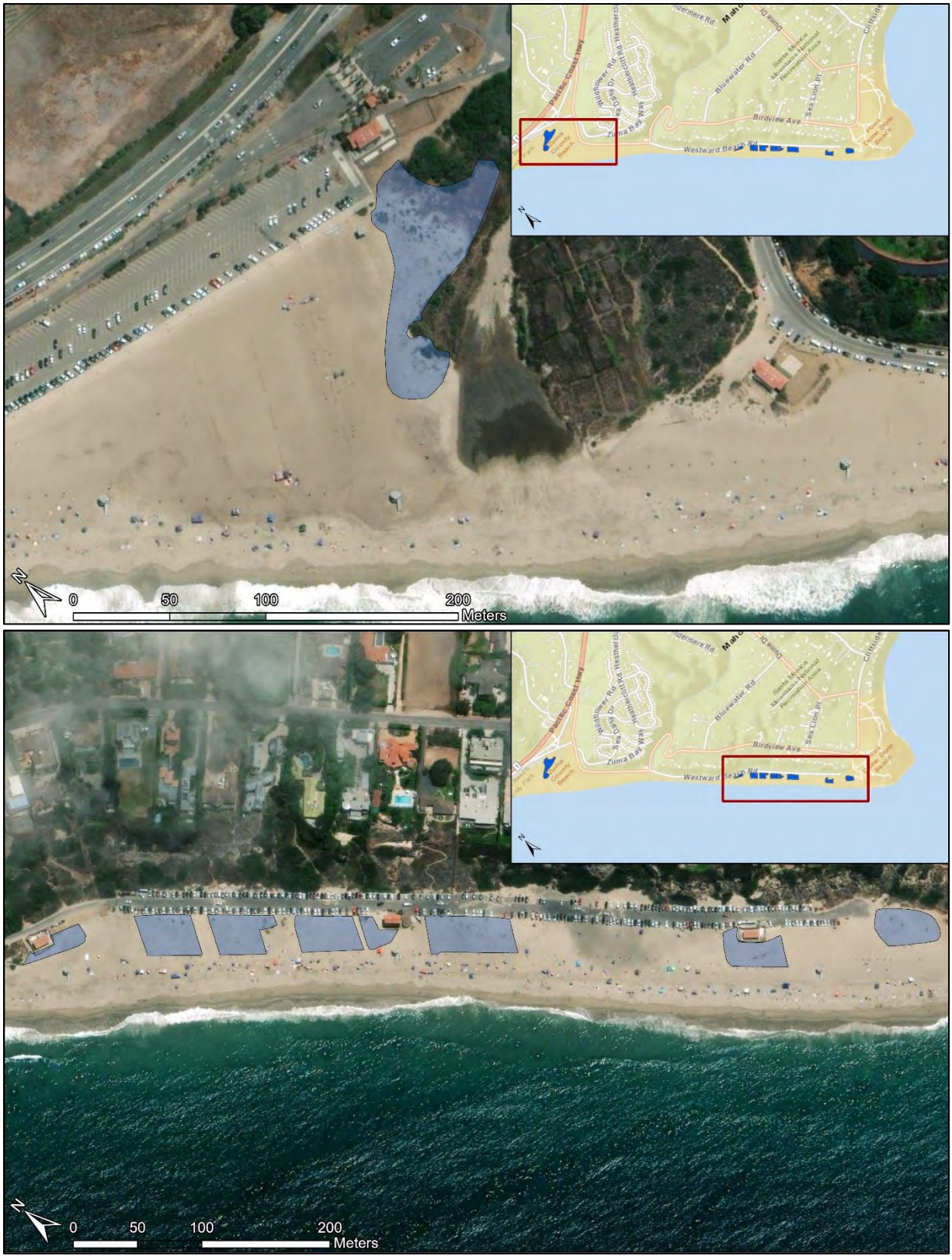


Figure 3. Zuma Beach (top) and Point Dume Beach (bottom) project footprints.

Pre-Restoration Conditions: *Zuma Beach*

Pre-restoration conditions of the dune system present at Zuma Beach adjacent to Zuma Lagoon was largely overrun by invasive vegetation, including large monocultures of invasive iceplant, European sea rocket (*Cakile maritima*), and non-native grasses such as Bermuda grass (*Cynodon dactylon*). Small patches of native beach bur (*Ambrosia chamissonis*) were identified during baseline assessments, but the areas designated for restoration in this system were largely covered by non-native plants. Pre-existing native vegetation was protected during restoration efforts, while non-native plants were targeted for removal. Pre-restoration, the existing native dunes could not expand due to grooming activities, but the new project footprint was configured to allow room for expansion and enhancement of the existing dunes. This site was and remains dynamic over time with strong fluvial, aeolian, and marine processes at work (Rios and CRC 2019).

Major habitats identified during baseline surveys within the restoration area for Zuma Beach included dune transition (including some back dune), back dune, southern foredune, and mechanically groomed beach. Back dunes and dune transition habitats on site occur on sandy soils that are sufficiently stabilized (i.e., little or no blowing sand) due to their position in the lee of foredunes. The lack of sand movement leads to a buildup of nutrients and inclusion of some fine sediments (i.e., silt, clay, or organic components) in the soil. This soil structure allows for the potential to restore a wide range of native forbs and shrub species not found in foredunes or coastal strand areas. In Figure 4, the foreground is a mix of native and non-native species in a more stabilized dune area, with iceplant in the background. In In Figure 5a, the photograph is closer to the transition habitat area and is dominated by iceplant.

Figure 4. Representative pre-restoration photograph of back dune habitat (foreground) and dune transition habitat (background) at Zuma Beach.

Figure 5a. Representative pre-restoration photograph of dune transition habitat at Zuma Beach.

Plant communities identified in the baseline assessment in the dune transition area included large monocultures of invasive iceplant and non-native grasses. Pre-restoration plant communities in the back dune habitat were predominantly iceplant, with interspersed patches of Geraldton carnation weed (*Euphorbia terracina*) and Bermuda grass. There was a few patches of beach bur and beach saltbush (*Atriplex leucophylla*) intermixed that were protected during restoration activities.

Southern foredune habitats occur on fine to coarse sand that is subject to aeolian processes and disturbances. The plant communities identified in baseline surveys in the southern foredunes included some native plants (e.g., beach bur and beach evening primrose, *Camissoniopsis cheiranthifolia*) and non-native plants (e.g., Bermuda grass, sea rocket, iceplant) prior to restoration (Figure 5b). Removal of non-native plants in this habitat allows for native plant germination and expansion. Groomed beach areas had no vegetation prior to restoration activities and were frequently smoothed and raked by mechanical equipment (Figure 5b).

Additional adjacent habitats included riparian areas dominated by arroyo willow (*Salix lasiolepis*), emergent brackish wetland dominated by California tule (*Schoenoplectus californicus*), upland habitat dominated by non-native Ngaio tree (*Myoporum laetum*), and other habitats. Removal of the Ngaio trees in the upland habitat was part of the initial scope of the project; however, following discussions with project partners and input from stakeholders, it was determined it would not be included in this phase of the restoration, though may be considered in a future phase. For additional details on the biological community of the restoration area and surrounding habitats, refer to the supplemental "Baseline Assessment and Site Characterization" (CRC and TBF 2020).

Figure 5b. Representative pre-restoration photo of foredune habitat (top) and mechanically groomed sandy beach adjacent to foredune habitat (bottom) at Zuma Beach.

Pre-Restoration Conditions: *Point Dume Beach*

Prior to restoration actions, the project area at Point Dume was comprised of small, sporadic, and patchy dunes lining the edge of the beach and buffering the parking lot (Figures 6 and 7). The site historically supported foredune, dune, and back dune habitats in front of the bluffs. Almost no native coastal strand or foredune vegetation species were identified during baseline surveys, with several exceptions of small intermixed native plant patches. Those areas that were vegetated were covered with non-native, invasive species such as iceplant and sea rocket (Cal-IPC 2020). The pre-restoration conditions of the dune habitat were poor; thus, restoration actions served to increase ecosystem values, critical habitat, and the ability of the site to build healthy and stable dune ecosystems to protect against sea level rise (Figure 8). Additionally, dunes serve to protect existing beach infrastructure such as parking lots, restrooms, and lifeguard facilities. There was sufficient sand supply and natural wind and wave conditions to restore natural processes that support dunes (Rios and CRC 2019). Both sites border the 16-square mile Point Dume State Marine Protected Area, and US Fish and Wildlife Service has also designated this area as critical habitat for the federally threatened western snowy plover.

Figure 6. Representative pre-restoration photograph from Point Dume Beach (north).

Figure 7. Representative pre-restoration photographs from Point Dume Beach (south).

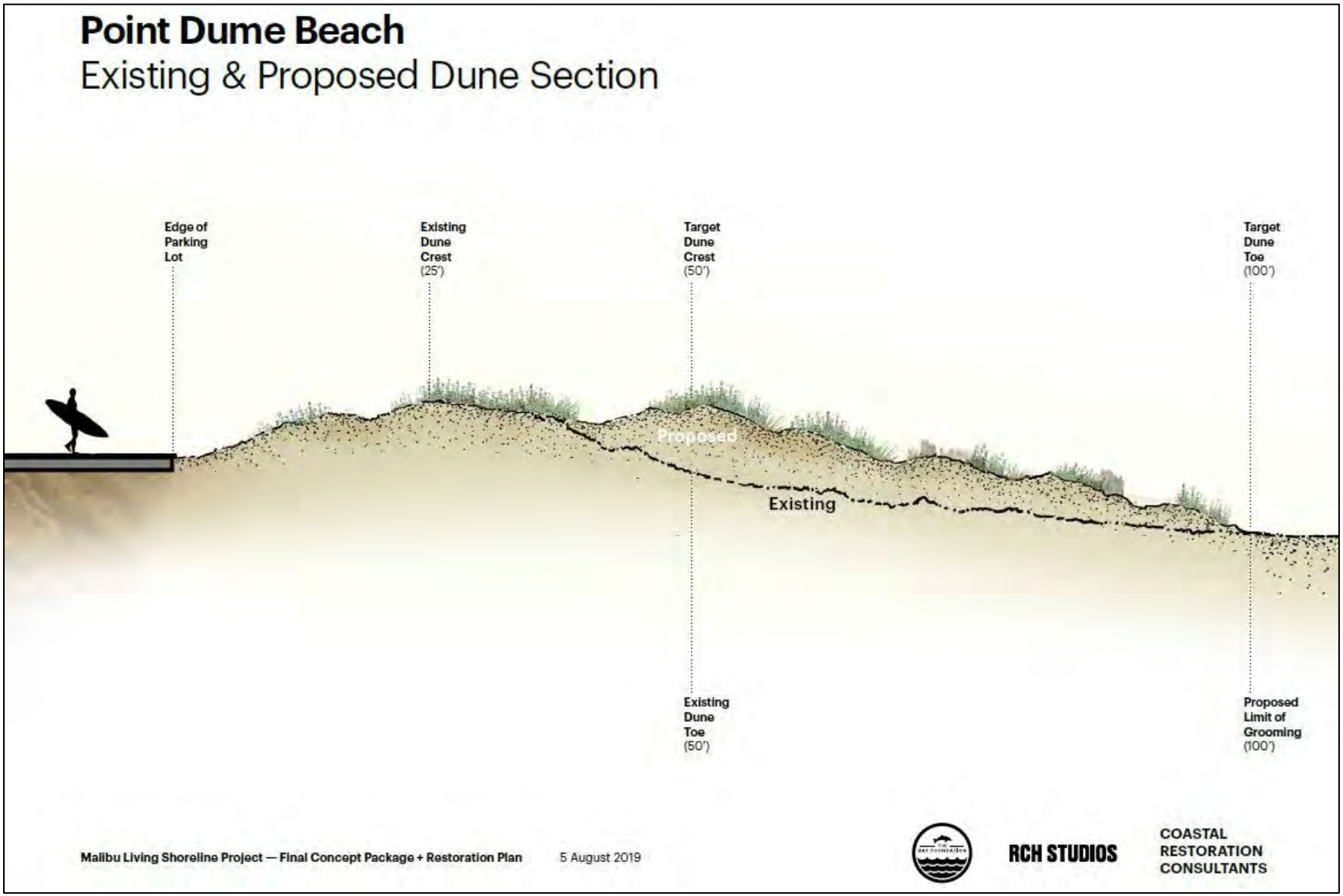


Figure 8. Graphic representation of an existing and proposed dune section at Point Dume Beach (credit: Rios and Coastal Restoration Consultants).

Permitting and Outreach

TBF, in coordination with the City of Malibu and LACDBH, obtained the necessary permits to implement the Malibu Living Shoreline Project. The project was brought before the City Council of the City of Malibu on three occasions prior to permitting issuance, with additional special presentations at an Environmental Subcommittee Meeting, beach walk outreach events, and other public venues. This project fits within City of Malibu's Local Coastal Program (LCP) and was enthusiastically supported by City Councilmembers as a demonstration pilot project for the region. While not a building or construction project, this project did have the potential to affect beach activities and as such required a public process.

TBF prepared and submitted a Coastal Development Permit (CDP) application through the City of Malibu's LCP (in partnership with LACDBH) in Summer 2020. The CDP application package included, but was not limited to a CEQA exemption, the Baseline Assessment and Site Characterization report, and the Implementation and Monitoring Plan. Following approval by the City of Malibu and subsequent appeal period through the California Coastal Commission, the final CDP was issued in December 2020. TFB also obtained a Right of Entry (ROE) permit through LACDBH to conduct monitoring, maintenance, and restoration actions on-site.

In addition, TBF has conducted substantial public outreach and stakeholder engagement as part of this project through meetings, events, tours, social media, newspaper articles, newsletters, and a project webpage. Table 1 displays various outreach conducted throughout this reporting period (December 2020 - December 2021), as well as outreach conducted prior as part of pre-implementation outreach and stakeholder engagement. Outreach highlights from this reporting period include regular participation and presentations given to the Beach Ecology Coalition, a Press Release from the City of Malibu, and an in-depth story released by the Los Angeles Times. Due to the COVID-19 pandemic, outreach was primarily performed remotely from March 2020 through December 2021. In total, from 2018 through December 2021, it is estimated that TBF reached a total of approximately 1,000 individuals (~250/year on average) through various presentations, stakeholder engagement activities, and other public outreach opportunities (this number excludes estimations for media reach). 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).

Table 1. Various outreach and stakeholder engagement conducted from the beginning of the project through the end of this reporting period (December 2021).

Outreach Event	Date
Beach Ecology Coalition Meting	1/9/2018
Santa Monica Bay Restoration Commission (SMBRC) Governing Board Meeting	3/1/2018
City of Santa Monica – public panel on sea level rise	3/15/2018
International Sandy Beach Symposium in Greece	5/26/2018
SMBRC Governing Board Meeting	6/21/2018
SMBRC Watershed Advisory Council Meeting	6/21/2018
City of Malibu, City Council Meeting	6/26/2018
SMBRC Governing Board Meeting	7/19/2018
Strengthening Coasts for a Resilient Future – conference	7/19/2018
City of Malibu, City Council Meeting	7/23/2018
Management and Technical Advisory Group meeting; NOAA Marshes on the Margins	8/14/2018
City of Manhattan Beach, Sustainability Task Force	9/21/2018
Restore America's Estuaries 9th National Summit on Coastal and Estuarine Restoration and Management	10/1/2018
Los Angeles Marine Protected Area (MPA) Collaborative Honor the Ocean Event	10/20/2018
Beach Ecology Coalition Meeting	1/23/2019
LA County Beaches & Harbors, LA Beach Commission	1/23/2019
Ocean Science Conference; Ocean Institute	2/16/2019
Southern California's Academy of Sciences Annual Conference	5/3/2019
City of Malibu, Malibu Area Conservation Coalition Meeting	6/11/2019
National Estuary Program evaluation meeting with US Environmental Protection Agency – site visit	6/19/2019
California Beach Water Quality Workgroup; CA Water Quality Monitoring Council	8/21/2019
KPCC NPR radio interview	9/30/2019
City of Malibu, Environmental Sustainability Subcommittee	11/14/2019
City of Malibu, City Council Meeting	1/27/2020
Los Angeles Regional Collaborative (LARC) presentation on Living Shorelines at University of Southern California	3/4/2020
SMBRC Governing Board Meeting	4/16/2020
LA Regional Climate Collaborative presentation on Living Shorelines	5/7/2020
AdaptLA Coastal Resiliency Webinar	6/4/2020
Dragonfruit podcast	10/29/2020
American Shore and Beach Podcast	10/30/2020
Malibu Surfside News article	12/14/2020
Malibu Times article	12/15/2020
Santa Monica Daily Press article	12/15/2020

Outreach Event	Date
City of Malibu, News Flash article	1/13/2021
City of Malibu, Press Release	1/13/2021
Beach Ecology Coalition Meeting	1/14/2021
Canyon News	1/17/2021
Regional Snowy Plover Meeting	1/21/2021
Site Visit with LACDBH and LA County Lifeguards	1/25/2021
LMU Seaver News	1/27/2021
ASBPA National Summit Conference – presentation	3/25/2021
National Conference on Ecosystem Restoration – presentation	7/26/2021
LA Times article	8/2/2021
Beach Ecology Coalition Meeting	8/9/2021
Collect Impact Speaker Series (LAGBC)	8/11/2021
Santa Monica Daily Press article	9/20/2021
TBF website re-launch and new project webpage	10/1/2021
2021 Coastal Dunes for Resilience Workshop hosted by the CA Dune Science Network	12/8/2021
Santa Monica Daily Press article	12/28/2021

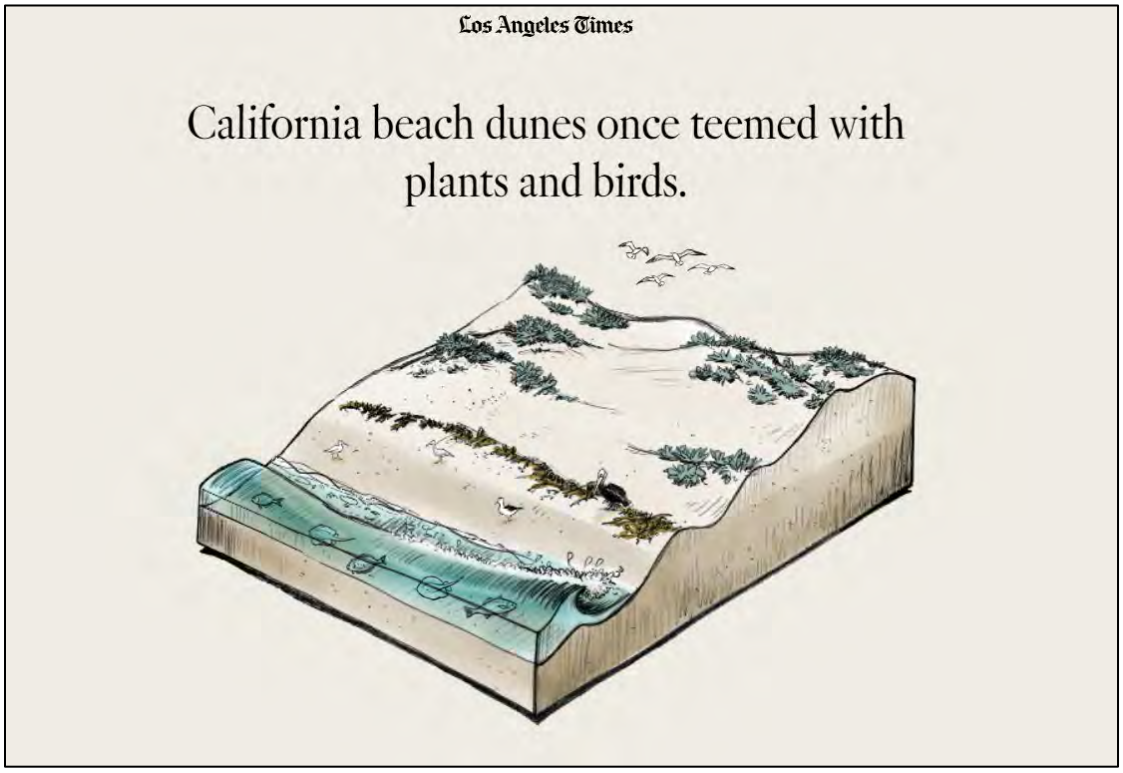


Figure 9. Los Angeles Times Article published 9 August 2021 highlighting Malibu Living Shoreline Project.

Restoration Activities

Through habitat restoration and the installation of symbolic pathways and interpretive signage, the site is providing new opportunities to enhance recreational beach experiences, including opportunities to observe native dune plants growing and flowering, bird watching, and to simply enjoy the scenery. Project implementation components can be found in the Implementation and Monitoring Plan. Narrative details on project implementation strategies, components, specific methods, and vegetation species can be found in the subsections below.

Project implementation began on 14 December 2020 and was completed on 12 February 2021. Pre-restoration monitoring occurred prior to implementation, and the project implementation was immediately followed by post-restoration site maintenance (i.e., supplemental watering, removal of non-native species that re-sprouted, and biomimicry stake/sand fence repair). Monitoring methods and results can be found in the "Scientific Monitoring" section of this report. TBF has a long-term commitment to post-implementation monitoring, maintenance, and adaptive management. Maintenance may include various strategies over time such as removing or replacing fencing and biomimicry stakes, removing non-native vegetation, spot watering, supplemental seeding or planting of native vegetation, and picking up trash. For more information, details, artistic renderings, and links to public documents and photographs, please visit the project webpage and other project documents.

The remainder of this Restoration Activities section of the report details the implementation process and activities. Implementation was conducted in consideration of the following set of goals, informed by project partners and scientists:

1. Increase the resiliency of the shoreline through the restoration of sandy beach and foredune habitat and topography;
2. Implement nature-based living shoreline protection measures against sea level rise and coastal storms; and
3. Increase engagement of the community through enhanced beach experiences, outreach, and education.

Objectives used to meet the goals above included:

1. Reduce cover of non-native plants;
2. Increase cover of native dune plants;
3. Stabilize blowing sand to build dune topography and decrease nuisance sand (e.g., windblown sand in parking lots);
4. Use strategies that allow for potential future phases of implementation if desired;
5. Enhance recreation with wildflowers, wildlife, and pedestrian paths through dunes; and
6. Engage the public through interpretive signage and educational tours.

Restoration Implementation

Restoration activities at Zuma County Beach included restoring approximately one acre of sandy beach, foredune, back dune, and dune transition habitat adjacent to Zuma Lagoon. Restoration activities at

Point Dume County Beach included just over two acres of sandy beach and foredune habitat. On-the-ground implementation was performed by TBF staff and interns along with project partner, the Los Angeles Conservation Corps (LACC). At the time of implementation, TBF was adhering to state and local regulations associated with COVID-19. As a result, TBF was not able to utilize volunteers for restoration activities. In addition, TBF utilized its own daily health screening for staff and TBF interns, as well as a Lion Health check screening for Loyola Marymount University (LMU) Coastal Research Institute (CRI) interns. The following subsections below outline the various restoration components.

Perimeter Fencing and Established Trail Systems

Boundaries were defined and established at both sites using symbolic fencing (Figure 10). Symbolic post and rope fence utilized sustainable materials to the highest extent possible and were installed around most of the perimeter of the project site. This perimeter establishment serves several purposes, including delineating areas to be restricted from mechanical grooming (raking), encouraging safe recreational activities, and minimizing excessive disturbance to the dune areas, especially during initial establishment in the first several years.

Figure 10a. LACC crew members pounding in posts to delineate the Point Dume project boundary (5 February 2021).

Symbolic Pathways and Interpretive Signage

Symbolic post and rope fence was also installed to create several cross-cutting pathways that formally delineate project trails between the parking lots and the open beach (Figure 10). This is an improvement both for recreation purposes as well as native habitat protection as compared to the random and

unmaintained pathways that existed prior to restoration activities and went from the parking lots, meandered through the dunes, towards the ocean.

Figure 10b. Photos of post and rope delineation and pathways at the Zuma Beach site (25 January 2021).

Interpretive signs or exhibits offer stories that are designed to stimulate visitors' interest while challenging their imaginations, and present new perspectives on familiar topics. Four interpretive signs were designed by Rios Clemente Hale Studios. Review and input were provided by The Bay Foundation, LACDBH, City of Malibu, State Coastal Conservancy, external scientists, and others. Interpretive sign graphics can be found in the project's Implementation and Monitoring Plan, and each sign has its own theme and storyline. Interpretive signs will help visitors and beachgoers understand the importance of the dune system for plants and wildlife, but also as buffers to help improve our coastal resiliency to storm erosion and sea level rise. Signs were developed specifically for use in the restoration area to help engage the public with the site and to facilitate a unique opportunity for education and recreation on their way to the beach. Signage was not installed as part of initial restoration actions, but four interpretive signs are anticipated to be installed in Spring 2022, with two at the Zuma Beach site and two at the Point Dume site.

Dune Restoration

One of the primary goals in increasing coastal resilience at the site is to trap more of the blowing sand in the upper beach area and to increase topographic complexity and elevations in key areas. Sand fencing and biomimicry stakes are restoration elements utilized for repairing damaged dunes and increasing resilience to rising sea level by accreting sand and building topographic complexity. These methods were used both individually and in combination, depending on the specific area.

1. Sand fencing. Sand fencing is a proven technique for stabilizing areas with high levels of blowing sand and was determined to be most effective in the coastal strand areas and in strategic locations, particularly in the Point Dume restoration area. Sand fencing can be effectively mixed with re-vegetation techniques to delineate restoration areas, slow sand movement, accrete sand, build topographic complexity, and create areas suitable for plant establishment. Short lengths of sand fencing (approximately 5-10 ft) were installed perpendicular to predominant wind direction to enhance rapid dune establishment, and in strategic locations to reduce potential for erosion (Figures 11-12). Evaluation of sand fencing is ongoing and may be eventually pulled up over time and removed through adaptive management once the dunes are stabilized.

Figure 11. Sand fence segments installed at Zuma Beach (30 March 2021).

Figure 12a. Photos of sand fencing segments installed at Point Dume Beach (top: 11 February 2021; bottom: 12 February 2021).

Figure 12b. Photo of sand accretion from sand fencing installed at Point Dume Beach approximately 9 months after implementation on 9 November 2021.

2. Wooden slats or "Biomimicry Stakes". Recently, restoration practitioners have been using groupings of wooden slats, or biomimicry stakes to build topographic complexity in degraded dunes. This technique is being tested at Cardiff State Beach and at the mouth of the Tijuana River Estuary. The wooden slats are installed perpendicular to the prevailing wind direction and aim to mimic the sand trapping capabilities of native dune plants, to accrete sand and build hummocks. Preliminary results suggest that biomimicry stakes effectively accrete sand, though further assessments and testing of this method are warranted. Groups of wooden slats were installed at the Point Dume location in conjunction with strategic sand fencing to maximize sand retention and encourage plant growth (Figure 14). The wooden slats (~1 foot tall) were installed 18 December 2020 in five 20 by 20 ft plots using two densities in each plot (6 in and 12 in spacing). A subset of the stakes within each plot served as measurement stakes with cm markings to assess the accretion of sand over time. Sand accretion measurements were taken on 4 February 2021, 4 March 2021, and 26 March 2021. After approximately 3.5 months, the lower density plots (12 in spacing) had accumulated an average of 12.8 cm of sand and the higher density plots (6 in spacing) had accumulated an average of 34.1 cm of sand. Figure 14 displays sand accumulating within one treatment plot 7 weeks after initial installation. Wooden

slats are not permanent features and were raised over time as sand accreted and were removed approximately 11 months after installation on 10 November 2021. Biomimicry stakes will be evaluated as a potential future adaptive management action.

Figure 13. Photo of a biomimicry stake plot the day of installation (top; 18 December 2020) and photo of the same plot after accumulating sediment for approximately three months (bottom; 26 March 2021). The plot was located within the Point Dume Beach project area and had the stakes pulled up due to sediment accumulation two additional times (credit: Lexi Neary, LMU Coastal Research Institute).

3. Re-vegetation. Native dune plants are a sustainable long-term choice for building coastal dunes and retaining and stabilizing sand in California and elsewhere. California native dune plants also benefit greatly from protection from driving and trampling, so directing foot and vehicle traffic around vegetated areas is important. The project site was seeded and planted in accordance with the project Implementation and Monitoring Plan (Figure 14). Please see the re-vegetation section below for details.

Figure 14. LACC planting native container stock on 13 January 2021.

Invasive Non-Native Species Control

To successfully expand native plant populations within the project area, certain non-native plants needed to be controlled and/or eradicated. Non-native plants will be managed for a minimum of five years post-restoration, though additional maintenance may be necessary after that time period and will be determined by TBF through systematic scientific surveys upon completion of five years of monitoring.

1. Ice plant (*Carpobrotus edulis*, Cal-IPC Rating: High). Removed by hand with support from Los Angeles Conservation Corps workers and volunteers. A majority of iceplant from the beach and upland shrub habitats was off-hauled in green waste dumpsters and several small patches were turned upside down and left on site along steep faces for erosion control and mulch.

2. Bermuda grass (*Cynodon dactylon*, Cal-IPC Rating: Moderate). Manually removed, with subsequent follow up for regrowth.
3. Sea rocket (*Cakile maritima*, Cal-IPC Rating: Limited). Hand-pulled large plants.
4. Geraldton carnation weed (*Euphorbia terracina*, Cal-IPC Rating: Limited). Hand-pulled before seed production, repeated at 2 or 3 week intervals, was used for small patches, with subsequent follow up for regrowth. We are continuing to hand-pull as it continues to grow in the upland transition area. Gloves are used when handling leafy spurge due to the irritating effects of latex sap.

As part on implementation actions, a total of approximately 25 tons (50,000 lbs) of non-native plants were removed from the project areas at Zuma Beach and Point Dume Beach (Figure 15). The majority of this was comprised of a large iceplant monoculture in the stabilized back dune and dune transition areas at Zuma Beach. Figure 16 displays photos taken before and after iceplant removal in this area. In addition, TBF staff and interns continued site maintenance by removing non-native vegetation that sprouted up since initial restoration efforts. Figure 17 displays photos taken before and after removal of non-native sea rocket that sprouted within the Zuma Beach project area. Due to COVID-19 restriction, volunteers were not able to be utilized for restoration actions or site maintenance the start of project implementation (December 2020) through the end of this reporting period (December 2021); however, planning and coordination for outreach and restoration events along with partners, LACDBH and the City of Malibu, is ongoing. Volunteer events are scheduled to begin in March 2022.

Figure 15. TBF and LACC removing non-native ice plant at Zuma Beach (17 December 2020).

Figure 16. Photos taken before (top) and after (bottom) removal of ice plant monoculture at Zuma Beach (top: 2 October 2020; bottom: 30 December 2020).

Figure 17. Photos taken before (top) and after (bottom) removal of non-native sea rocket during post-restoration site maintenance (14 April 2021).

Re-vegetation Strategies

In sand dune areas, one of the most effective strategies for re-introducing native species is to seed the areas in the late Fall/Winter and to let seed germinate with winter rains. Upland shrub areas also benefit from planting with container stock. Supplemental watering using a water truck, backpack sprayers, or watering cans was also proposed as an adaptive management strategy, especially in the back dune and dune transition areas with upland shrub species.

The following re-vegetation strategies were employed during project implementation/planned for future adaptive management:

1. Sandy beach and dune areas were seeded with primary dune forming plants. Used seeding rates per S&S Seeds. Prepared the sand surface using a rock rake (leave deep grooves). Scattered seeds by hand and buried seeds by raking again with rock rakes. Care was taken to prevent driving and trampling in seeded areas.
2. Most dune plant seeds remain viable for years. Germination rates are low in any given year. If year one performance is poor because of very low rainfall (less than 6 inches), consider re-starting in the second year with the same seed in the ground. Re-seeding is planned for February 2022.
3. Add California poppy (coastal variety) seed and other native annual coastal dune species after primary dune vegetation exceeds 10% cover and sand is relatively stable. This is being considered as a future adaptive management action.

Please see the Implementation and Monitoring Plan for additional re-vegetation planning details, including the plant palettes.

Native Plants: Seeding and Container Stock

Hand seeding occurred in the coastal strand and foredune habitats at Zuma Beach and Point Dume Beach in Winter 2020-21. Seed was sourced from S&S Seeds and Stover Seed Company, who collected seed from local sources when possible. A mix of container stock and seeding also occurred in the back dunes and dune transition areas at Zuma Beach. Container stock plants were utilized in this area to expedite establishment of the native vegetation community and deter non-native invading plants from returning. In total, over 500 native container stock plants were planted at the Zuma Beach back dune and dune transition area (Figures 18 and 19). Container stock plants were sourced from Palos Verdes Peninsula Land Conservancy, Matilija Nursery, and El Nativo Growers. In addition, ecological consulting firm, Tidal Influence, made a generous donation of approximately 13 seacliff buckwheat (*Eriogonum parvifolium*) to the project. No container stock was used in the Point Dume project area due to limited availability of foredune container stock species; however, supplemental planting is scheduled for Year 2 at Point Dume Beach.

In addition to targeted supplemental planting at Point Dume, TBF intends to re-seed both project areas and plant additional container stock in the back dunes and dune transition areas at Zuma Beach in Winter 2022. TBF has already coordinated a contract grow out with both Tree of Life Nursery and Palos Verdes Peninsula Land Conservancy to provide all container stock species for supplemental re-vegetation. Seed for supplemental seeding will be provided by S&S Seeds and Stover Seed Company. All seeding and planting was in accordance with the project Implementation and Monitoring Plan.

Figure 18. Photos taken during planting of container stock in the dune transition area at Zuma Beach.

Figure 19. Photos taken during planting of container stock in the dune transition area at Zuma Beach (12 December 2020).

Supplemental Watering

The dune transition and back dune areas required supplemental irrigation in the first growing season for good initial plant establishment, especially for areas with container stock. In particular, upland habitats in the northwestern portion of the Zuma Beach site required supplemental irrigation, due to not meeting rain event conditions identified in the Implementation and Monitoring Plan. Planted container stock was watered using watering cans and backpack sprayers on 12 and 13 January and 14 and 23 April 2021 (Figure 20). In total, approximately 250 gallons of water were used on site at Zuma Beach only.

Figure 20. Photo of TBF staff watering container stock with a backpack sprayer in the Zuma dune transition area.

Scientific Monitoring

Accurate and robust scientific monitoring is a vital part of any restoration project. Monitoring for this project includes observations of baseline and post-implementation site conditions to assess plant installation as well as other restoration components (e.g., sand fencing). Monitoring also informs adaptive management actions (e.g., non-native plant cover that may need to be controlled), tracks the project towards meeting success criteria over time, and compares the site to 'control' conditions in adjacent areas that have had no restoration actions. Specialist ecological and restoration scientists are partners and advisors for this project, and their expertise was used to advise both the monitoring program and its assessments. Data will be collected for up to five years to evaluate the ecological health of the created dune ecosystem and its potential for long-term adaptation to accelerated rates of sea level rise. In addition, opportunistic research is being conducted in partnership with Loyola Marymount University's Coastal Research Institute and other universities.

Table 2 summarizes the monitoring that occurred from October 2020 through November 2021. It lists eight major parameters, the primary protocol(s) which were implemented for each parameter, and the dates of implementation. Asterisks indicate a baseline survey date. 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.

Table 2. Summary of key parameters, protocols implemented, and survey dates. Asterisk indicates baseline survey.

Parameter	Protocol	Survey Dates
Photo Point	Fixed geospatial and bearing photo locations throughout sites	*2, 9, and 15 October 2020; 10, 11, and 18 June 2021; 9 and 20 October and 9 and 5 November 2021
Wrack Cover	Percent cover, composition by species, average depth	*2, 9, and 15 October 2020; 10, 11, 18 June 2021; 20 October and 5 and 9 November 2021
Vegetation Cover and Seedling Density (if present)	Selective mapping, fixed cover class quadrats along t-sects; fixed quadrat density counts for seedlings	*2, 9, 15 and 17 October 2020; 10, 11, and 25 June 2021; 20 October and 5, 9, and 22 November 2021
Avifauna (+ pollinator presence)	Visual presence / behavior surveys; identified plover nesting will immediately halt activities and USFWS will be notified	Avian species observed were recorded on all field day
Physical Characteristics	Elevation profiles and cross-sections, beach width, beach slope	*2, 9, and 15 October 2020; 10, 11, and 18 June 2021; 20 October and 5, 9, and 22 November 2021
Weather Conditions	Air temperature, precipitation, and tide gauge data (NOAA)	As publicly available data sets are posted online
Sediment Grain Size	Sieve method	Collected on: *2, 9, and 15 October 2020; 20 October and 5, 9, and 22 November 2021

Monitoring transects for vegetation and topographic surveys included 20 total transects, described in Table 3 and shown in Figures 21 and 22 below. The dune habitat restoration transects are located within the project area at Point Dume Beach and Zuma Beach. The groomed sandy beach control transects are located outside, but adjacent to, the project area at Point Dume Beach and Westward Beach, where the beach is groomed regularly. The dune habitat restoration transects were compared to the groomed sandy beach control transects to analyze differences in vegetation and elevation between a restored and ungroomed dune habitat and an unrestored and groomed sandy beach habitat.

The dune transition habitat control transect (ZC1) is located in an established dune transition habitat that has had a stabilized dune system for several decades after initial restoration by CA State Parks. The dune transition restoration transect (Z2) located within the Zuma Beach restoration project area will be compared with ZC1 and considered independently from other dune restoration transects, due to the differences in habitat type (i.e., vegetation cover amount and soil stability).

Lastly, a total of six wrack transect locations were surveyed, consisting of two transects each in the wash zone directly in front of the two restoration sites (four total) and two transects in the wash zone of the control area, located at Westward Beach (Figures 21 and 22). The wash zone is a dynamic area, therefore, exact transect locations varied across surveys.

Table 3. Summary of the transects for vegetation and topographic surveys.

Transect Type	Habitat Type	# of Transects	Transect Names	Location
Restoration	Dune habitat	9	P1, P2, P3, P3L, P4, P5, P5L, P6, P7	Point Dume Beach project area
Restoration	Dune habitat	2	Z1, Z3	Zuma Beach project area
Control	Groomed sandy beach habitat	7	PC1, PC2, PC3, PC3L, PC4, WC1, WC2	Outside, but adjacent to, the project area at Point Dume Beach and at Westward Beach
Restoration	Dune transition habitat	1	Z2	Zuma Beach project area
Control	Dune transition habitat	1	ZC1	Outside, but adjacent to, the project area at Zuma Beach

Figure 21. Dune habitat restoration (P1, P2, P3, P3L, P4, P5, P5L, P6, P7) and control (PC1, PC2, PC3, PC3L, PC4) transects and approximate locations of wrack transects located at Point Dume Beach.

Figure 22. Dune habitat restoration (Z1 and Z3), dune transition habitat restoration (Z2), dune transition habitat control (ZC1) transects, and approximate location of wrack transects at Zuma Beach; and sandy beach control transects (WC1 and WC2), and approximate location of wrack control transects located at Westward Beach.

Individual Protocols and Results

Each of the following subsections summarizes an individual protocol methods and results implemented as part of the monitoring program (Table 2). 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, publicly available for free download: http://www.santamonicabay.org/california-estuarine-wetlands-monitoring-manual-level-3/ (Johnston et al. 2015). Additionally, some protocols were adopted from Dugan et al. 2015 Final Report: Baseline Characterization of Sandy Beach Ecosystems along the South Coast of CA.

Photo-Point

Photo point monitoring occurred to identify major site changes or 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). Eight permanent photo point locations were established during baseline monitoring and the locations recorded using a high-resolution GPS and included 22 total photographs (June 2021 photos for PP2 and PP4 were removed during the Quality Assurance/Quality Control (QAQC) process and are thus not included in this report). Photographs are used as qualitative assessments of broad-scale changes following restoration activities and dune development over time. Survey dates are listed in Table 2.

Appendix A displays photo point results. Photos showed a substantial reduction in non-native cover, primarily ice plant, from the baseline survey (October 2020) to the post-implementation surveys (June and October/November 2021). This was most apparent in photo points 1, 4, 5, and 7. The series of photos for photo point 5 displayed non-native sea rocket spouting following iceplant removal, which was then subsequently hand-removed through maintenance actions. Photo points from the baseline survey (October 2020) showed areas of groomed beach that were then seeded during implementation (January/February 2021). Seedlings were not readily visible within the October/November 2021 photo points, but germination of seedlings was documented within the previously groomed area. Additional rounds of photo point monitoring are needed to assess potential topographical change and native vegetation establishment over time.

Wrack Cover

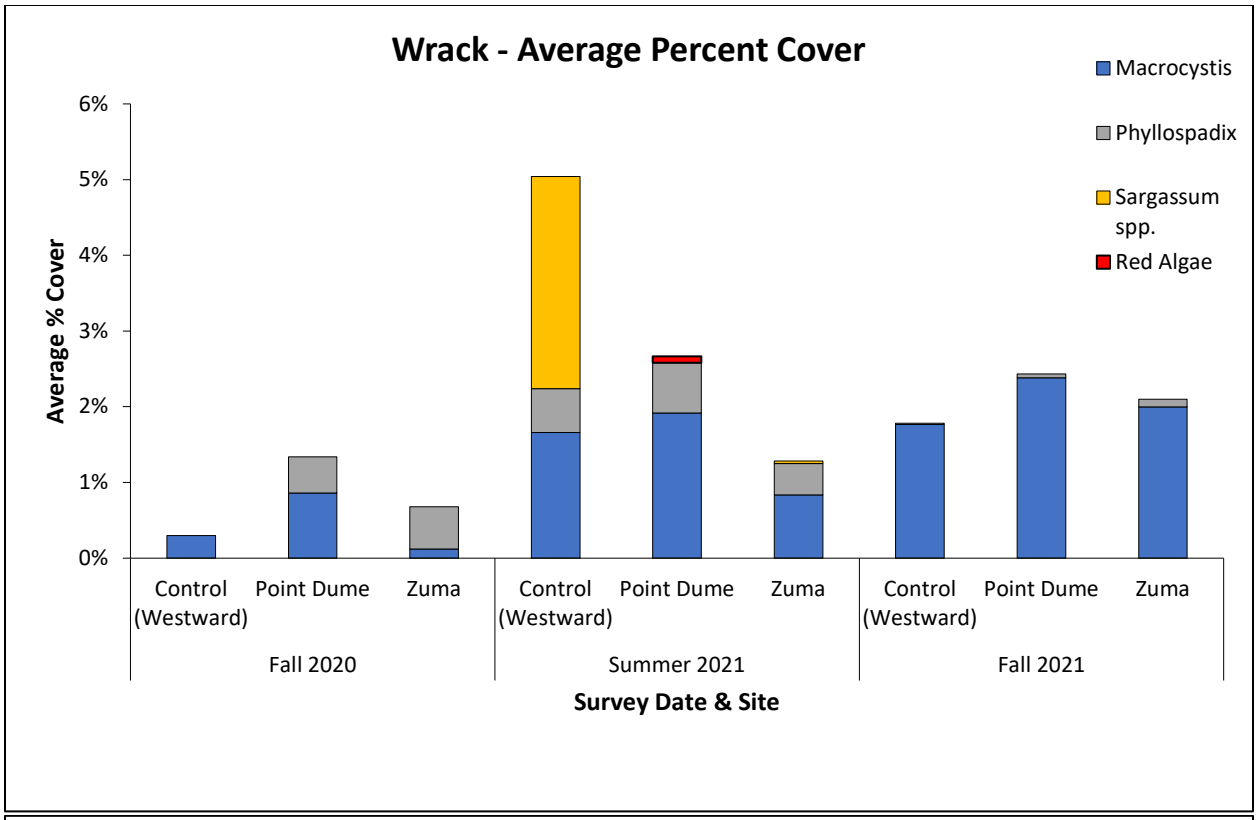
Wrack, or plants and algae that have washed ashore, surveys were conducted to determine the percent cover and composition by species directly in front of the restoration sites (Zuma Beach, Point Dume Beach) and at a control site (Westward Beach). As the project does not extend to the high tide line or swash zone, it is unlikely to have an effect or change on the wrack composition. However, wrack is included as a survey assessment because it is an important component of the beach trophic system and can provide support for invertebrates and foraging birds.

A total of six line-intercept transects were surveyed, consisting of two transects each in the swash zone directly in front of the two restoration sites (four total) and two transects in the swash zone of the control area, located at Westward Beach (Figure 23). These transects also recorded any trash, tar,

driftwood, or other detritus in a similar manner. The swash zone is a dynamic area, therefore, exact transect locations varied over surveys. Survey dates are listed in Table 2.

Figure 23. Photo of wrack control transect at Westward Beach on 10 June 2021.

Across all survey periods, average percent cover of wrack was relatively low, between 0.3% and 5.04%. During the baseline surveys (October 2020: Figure 24, top), both the restoration and control sites had low cover of wrack (all <1.50%), which was comprised of two species: giant kelp (*Macrocystis pyrifera*) and surfgrass (*Phyllospadix torreyi*). A similar pattern was observed in the Fall 2021 survey, approximately eight months post implementation, with wrack cover below 2.5% across all sites and comprised of giant kelp and surfgrass. The highest total cover (5.04%) was found during the Summer 2021 survey, approximately six months post-implementation, at the Westward Beach control site, with giant kelp, surfgrass, and *Sargassum* spp. observed. In addition, an erect red alga was observed at Point Dume in the Summer 2021 survey (Figure 25). Giant kelp was the most frequently observed species, showing up across all survey dates. Trash and terrestrial debris, which includes leaf litter, sticks and twigs, and other natural debris, were not observed during any baseline or post-implementation survey (Figures 24, bottom).



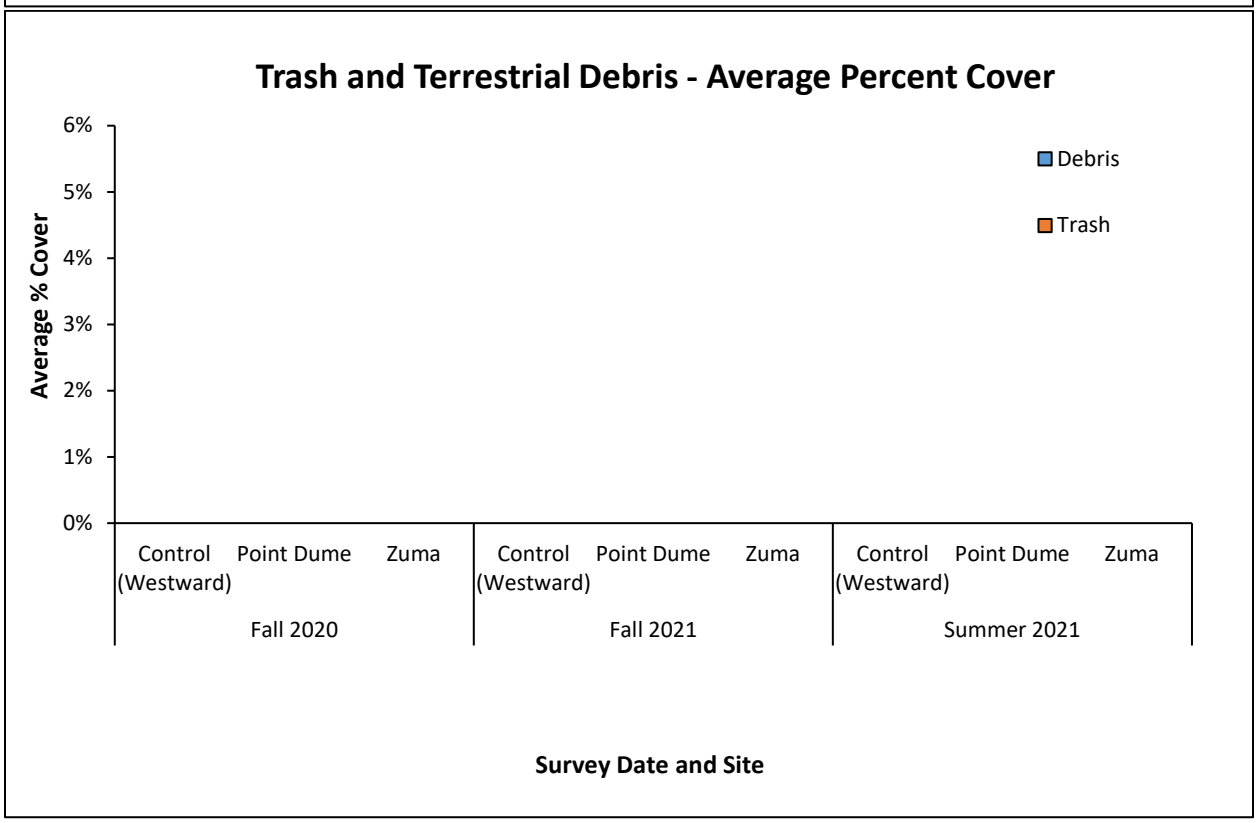


Figure 24. Average percent cover of wrack by species (top) and trash and terrestrial debris (bottom) in the restoration area and control site across all surveys. Note that the bottom graph contains only zeros.

Figure 25. Erect red algae with branching tree-like form observed during post-implementation wrack survey on 18 June 2021.

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 line-intercept and quadrat cover surveys for this project is to assess the approximate cover of native coastal strand vegetation semi-annually over time. Surveyed transects (20 total) include: nine transects located within the project area at Point Dume Beach (dune habitat), three transects located within the project area at Zuma Beach (two dune habitat and one dune transition habitat), seven control transects located outside, but adjacent to, the project area at Point Dume Beach and Westward Beach (sandy groomed beach habitat), and one control transect located east of Zuma lagoon (previously restored dune transition habitat; Figures 21 and 2; Table 3). Survey dates are listed in Table 2.

Figure 26. Photos taken during baseline vegetation cover surveys (9 October 2020).

The transect survey methods are described, along with field data sheets, in SOP 3.2 Vegetation Cover Surveys (TBF 2015b). Line-Intercept transects document species observed directly below the transect tape where the vegetation crosses a minimum of 0.01 m (1 cm). This transect survey method is useful when collecting vegetation cover data in patchy habitats or those with a significant amount of bare ground (or sand). Line-intercept data were summed by species to determine the length of the transect occupied by each species. Species were then classified as native or non-native. The absolute native percent cover was calculated by summing the total transect length occupied by native species and dividing by the total length of the transect. The relative native percent cover was calculated by summing the total transect length occupied by native species and dividing by the total vegetated length of the transect. The same was done to determine non-native (or exotic) absolute and relative percent cover.

The dune transition habitat transect (Z2), and accompanying dune transition habitat control transect at Zuma Beach (ZC1), were evaluated separately from the other dune/sandy beach habitat transects due to the differences in habitat type. The average absolute cover (native and non-native) and average relative cover (native and non-native) were calculated across transects for restoration and control areas by habitat type. Completely unvegetated transects were omitted from the average relative percent cover analysis. Additionally, individual seedlings were counted within fixed selected quadrats as part of the Cover Class Quadrat vegetation cover assessment method. 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 for each habitat type.

Average absolute non-native cover for the dune habitat restoration transects decreased from 2.4% in the baseline survey to 0.7% and 0.1% in the Summer and Fall 2021 surveys, respectively (Figure 27). Average absolute native cover increased from 2.4% in the baseline survey to 4.3% in the first post-implementation survey (Summer 2021) and remained similar in the Fall 2021 survey (4.10%). Average relative cover displayed a similar pattern, with non-native cover decreasing after restoration implementation (baseline: 41.1%; Summer 2021: 31.1%; Fall 2021: 33.92%) and native cover increasing from the baseline (56.0%) to post-implementation surveys (Summer 2021: 68.9%; Fall 2021: 66.1%; Figure 28). Vegetation is likely to continue to increase and become more diverse over time, though naturally occurring coastal strand and dune habitats also usually have a significant portion of bare sand, even after becoming mature vegetation communities.

In the groomed sandy beach control areas, average absolute and relative native and non-native cover were both 0.0% during the baseline and Fall 2021 surveys (Figures 29 and 30). This is due to control transects being located on mechanically groomed sandy beach. During the Fall 2021 survey, two additional control transects (PC3L and PC4) were added to the Point Dume control area, one of which (PC4) intersects with a patch of non-native iceplant located in the ungroomed back dune area (Figure 35). As a result, average absolute non-native cover was 0.2% and relative non-native cover was 100% in the Fall 2021 survey. Average absolute and relative native cover remained 0.0% in the groomed sandy beach control areas. No restoration actions occurred within the control areas.

Absolute percent non-native cover for the dune transition habitat transect located within the project area at Zuma Beach (Z2) was 86.3% during the baseline survey (Figure 31). The non-native cover was primarily comprised of a monoculture of non-native iceplant. Following the removal of the iceplant, as part of project implementation, absolute non-native cover fell to 0.0% in Summer 2021 survey and remained close to zero (0.1%) in the Fall 2021 survey. No iceplant was observed in the dune transition habitat transect (Z2) in Fall 2021. The non-native cover was comprised of European sea rocket that had sprouted following iceplant removal. Absolute native cover was 0.0% in the baseline survey and remained extremely low in subsequent surveys (1.4% and 0.9% in the Summer and Fall 2021 surveys, respectively) (Figure 31). Relative native and non-native cover displayed a similar pattern, with 100% relative non-native cover in the baseline survey, 100% relative native cover in the first post-implementation survey (Summer 2021), and a ratio of 12.5% / 87.5% non-native to native cover in the Fall 2021 survey (Figure 32). The slight return of non-native cover in the most recent survey included non-native annuals which were subsequently pulled during maintenance activities. Non-native annuals will likely need to be maintained (hand pulled) while the native vegetation community establishes.

Absolute native cover for the dune transition habitat control transect (ZC1), located outside of the project area and used for comparison, was highest during the baseline Fall 2020 survey (63.5%) and decreased slightly over the Summer 2021 (57.9%) and Fall 2021 (48.5%) surveys (Figure 33). All surveys within the previously restored dune transition control area (ZC1) had 100% relative native cover, with 0.00% absolute and relative non-native cover (Figures 33 and 34). This stabilized dune area is comprised of a well-established native vegetation community. Since this dune community has been established for many decades (it was a restoration conducted by CA State Parks in the 1990's), it may be many years or several decades before the restoration site achieves similar cover. However, the comparative transect is useful to track and compare the trajectory of the dune transition system within the restoration area.

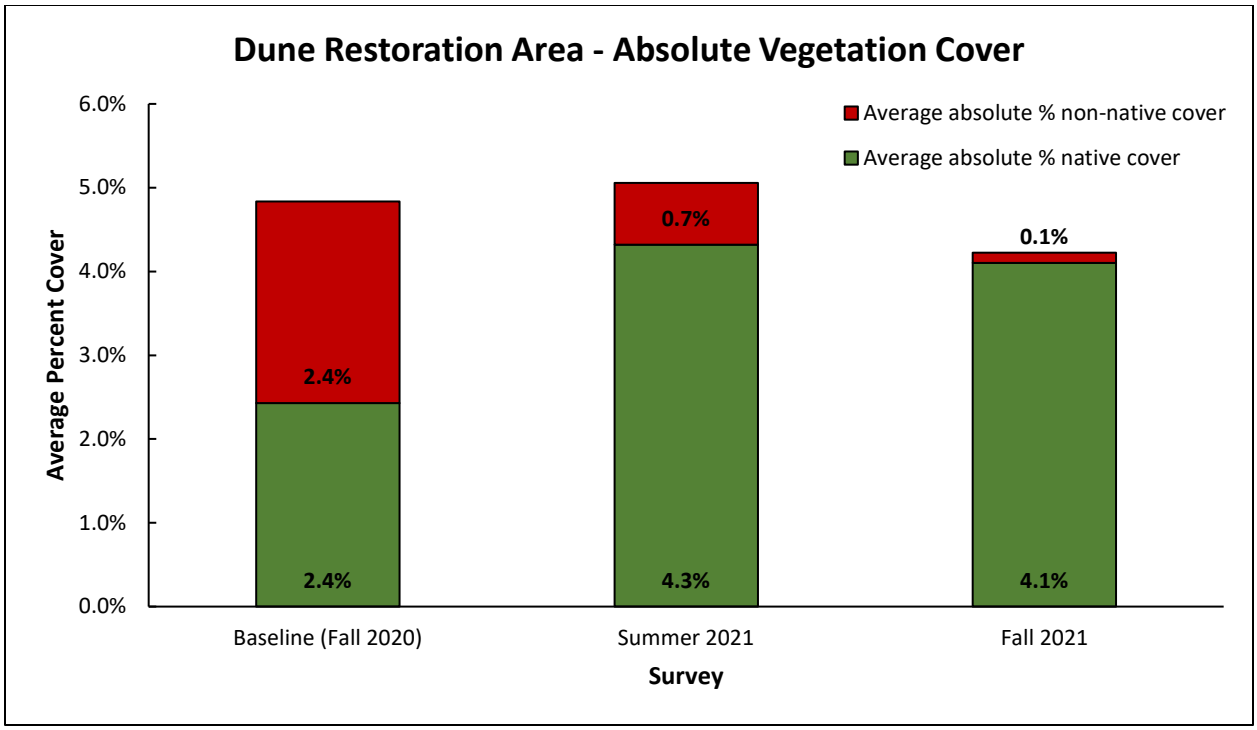


Figure 27. Average absolute percent cover for all dune habitat transects located within the project area at Zuma Beach and Point Dume Beach.

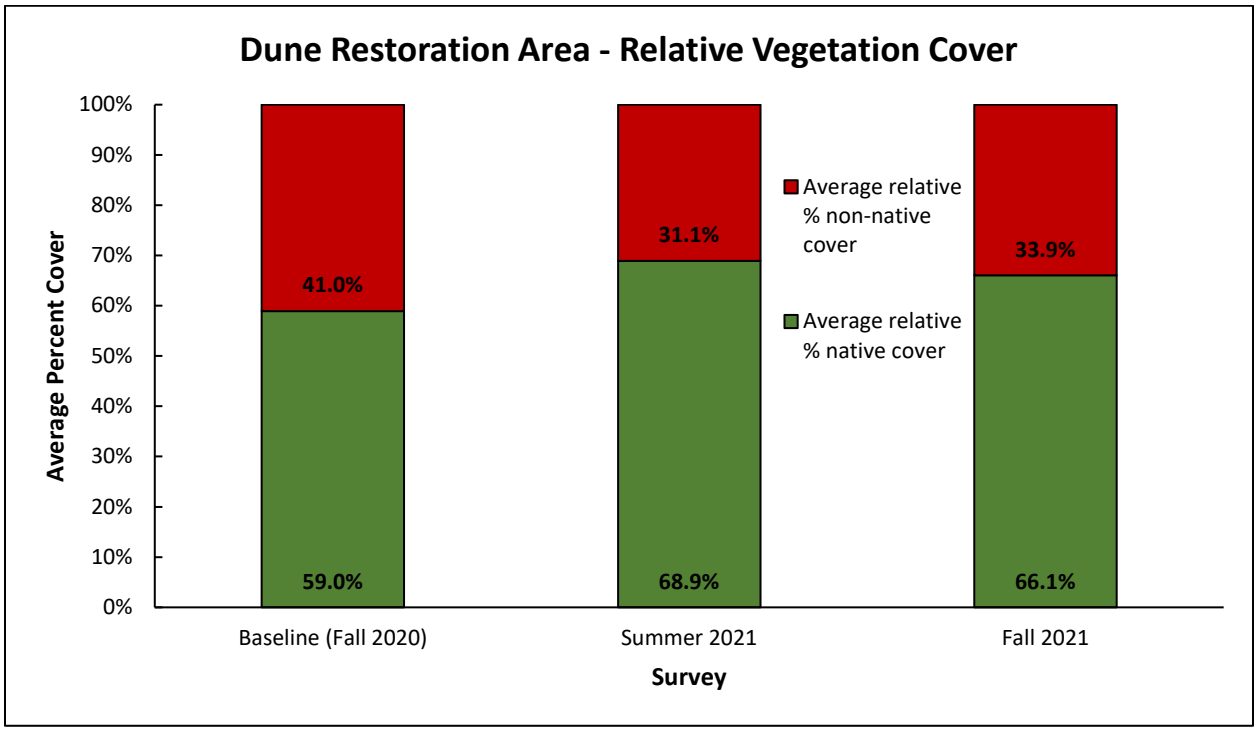


Figure 28. Average relative percent cover for all dune habitat transects located within the project area at Zuma Beach and Point Dume Beach.

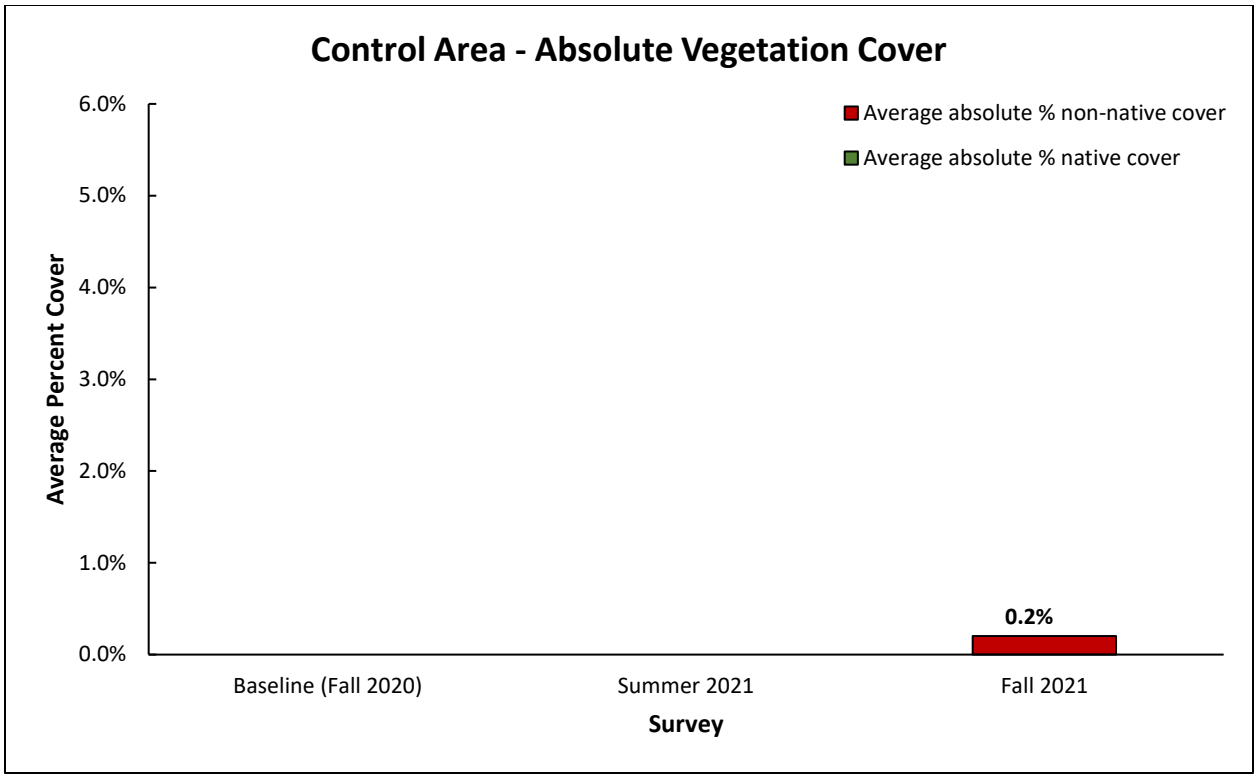


Figure 29. Average absolute percent cover for all dune habitat transects located within the control area at Point Dume Beach and Westward Beach.

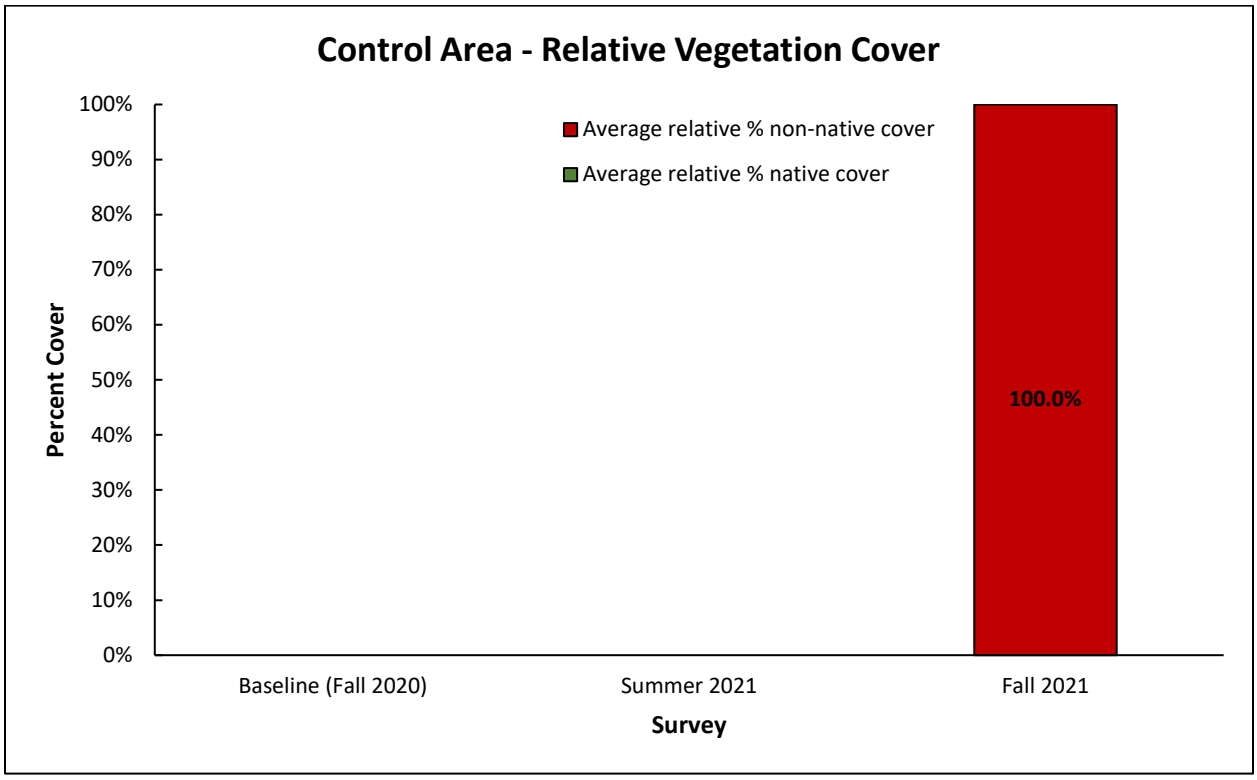


Figure 30. Average relative percent cover for all dune habitat transects located within the control area at Point Dume Beach and Westward Beach.

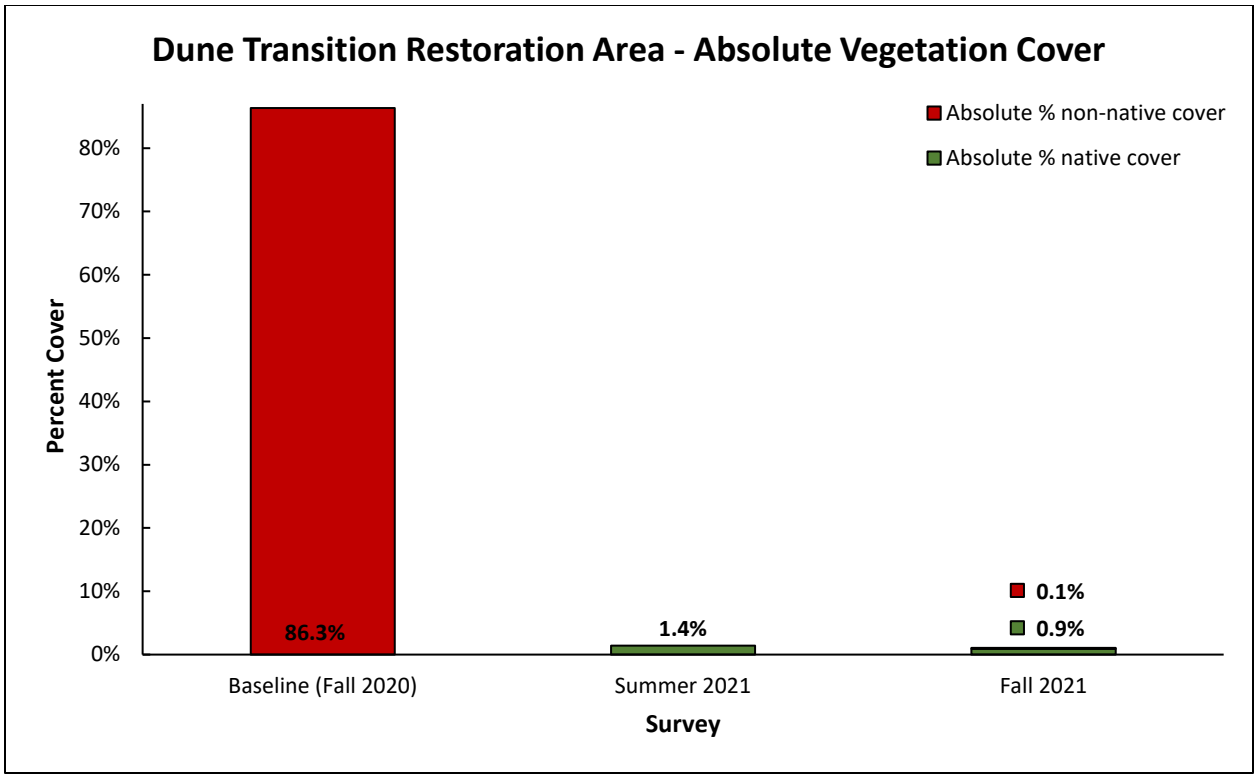


Figure 31. Absolute percent cover for the dune transition habitat transect located within the project area at Zuma Beach.

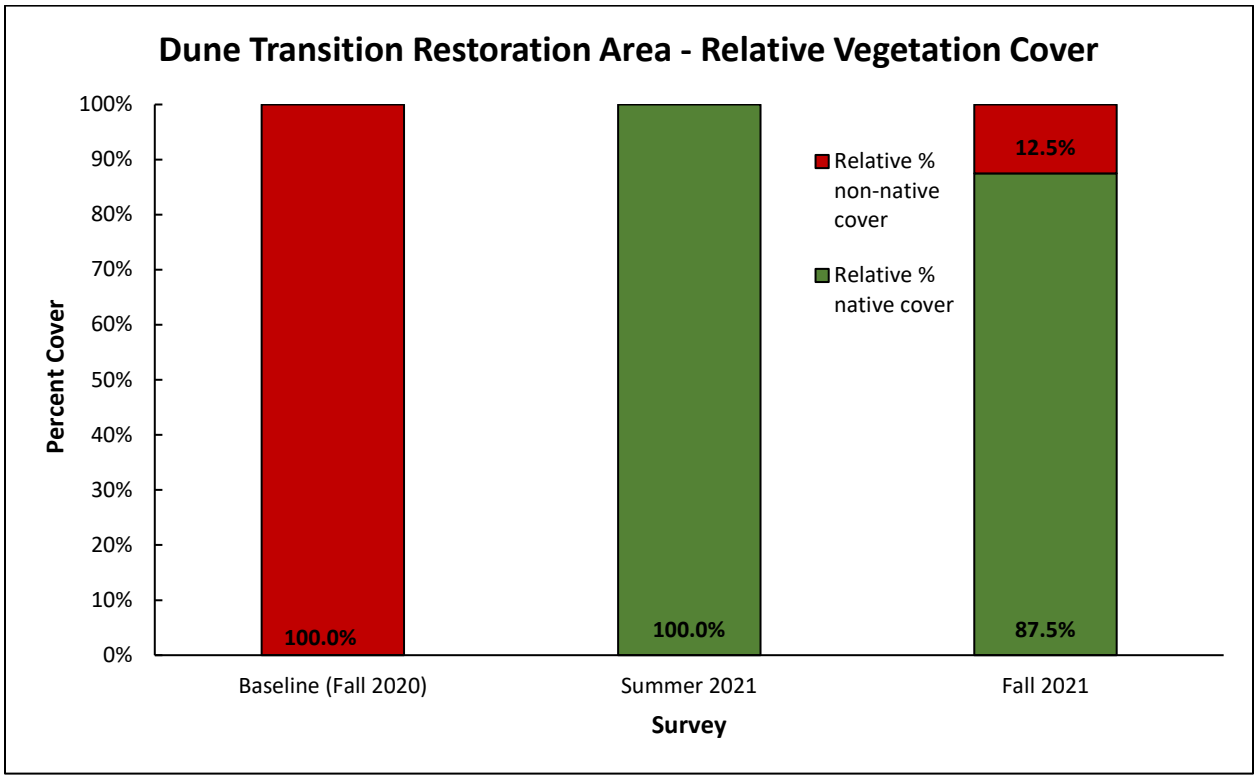


Figure 32. Relative percent cover for the dune transition habitat transect located within the project area at Zuma Beach.

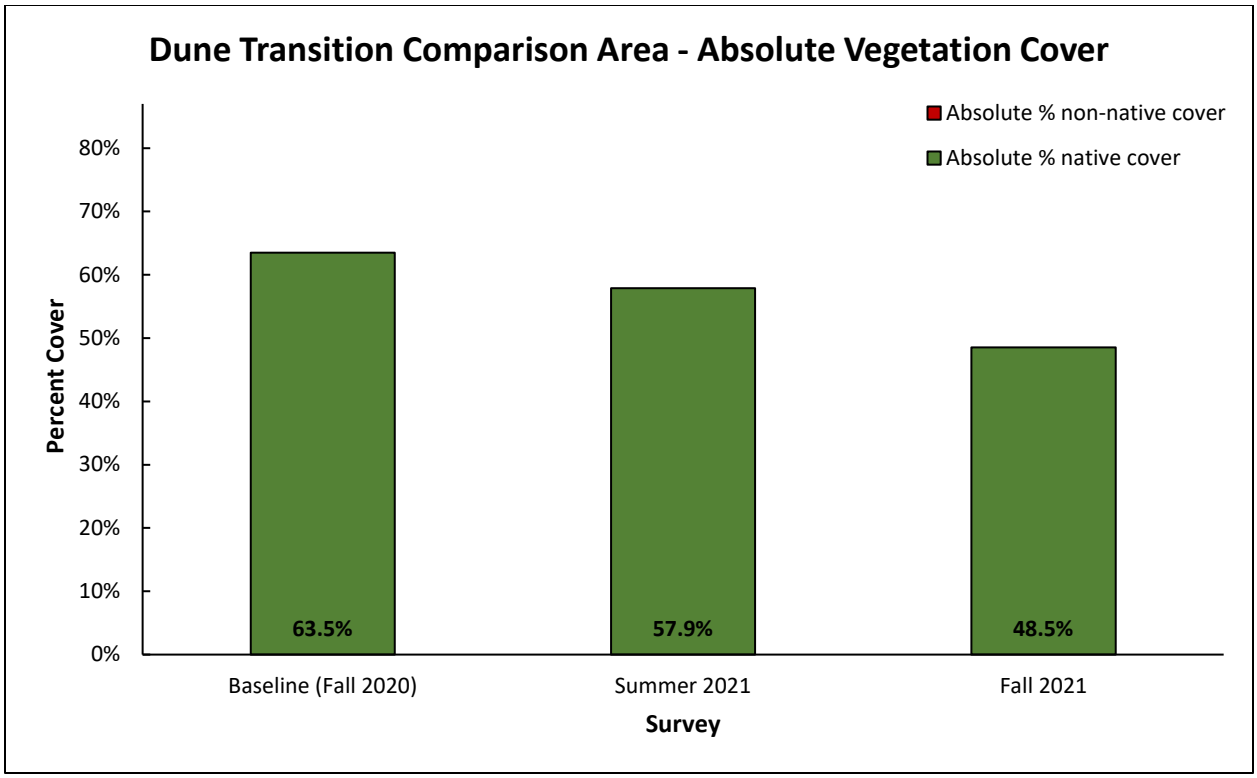


Figure 33. Absolute percent cover for the dune transition habitat control transect located adjacent to the project area at Zuma Beach.

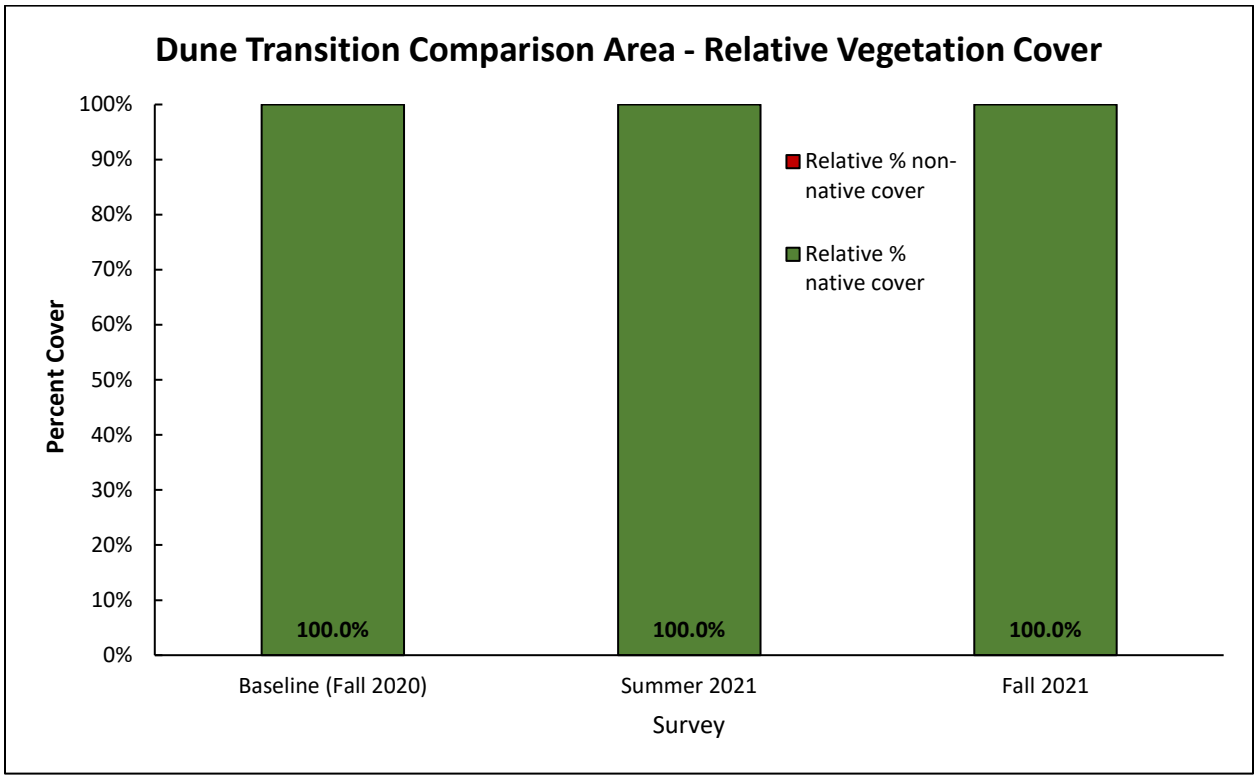


Figure 34. Relative percent cover for the dune transition habitat control transect located adjacent to the project area at Zuma Beach.

Figure 35. Representative photo of non-native iceplant within the ungroomed back dune area of control transect PC4 at Point Dume. This transect was added during the Fall 2021 survey (9 November 2021).

All surveys (baseline, Fall, and Summer 2021) recorded no seedlings across all restoration and control transects, thus no data are displayed; however, seedlings were frequently observed within the restoration area outside of the transect survey boundaries during post-implementation surveys and other on-site activities. Native seedlings were often observed directly adjacent to the sand fence segments. Native seedlings observed on-site include red sand verbena (*Abronia maritima*), pink sand verbena (*Abronia umbellata*), beach bur, and beach evening-primrose (Figure 36). Non-native seedlings observed within the restoration area consisted of sea rocket (Figure 36).

Figure 36. Photos of various seedlings. Top left: native pink sand verbena (*Abronia umbellata*); top right: native red sand verbena (*Abronia maritima*); middle: native beach bur (*Ambrosia chamissonis*); bottom left: native beach evening-primrose (*Camissoniopsis cheiranthifolia*); bottom right: non-native sea rocket (*Cakile maritima*).

Vegetation Mapping

Vegetation mapping uses a combination of aerial imagery, high-resolution Trimble GPS, and in-situ observations to delineate polygons depicting species composition. Vegetation mapping protocols are described in more detail in SOP 3.5 Vegetation Mapping (TBF 2015c). Survey dates are listed in Table 2.

Figures 37 displays the absolute native cover within the Zuma Beach restoration area for the baseline (Fall 2020) survey and for the Fall 2021 survey. Figure 38 shows the absolute exotic cover within the Zuma Beach restoration area for the baseline (Fall 2020) survey and for the Fall 2021 survey. Note "unvegetated" denotes the polygon contained no vegetation, while "0%" cover signifies that the polygon did contain vegetation, just not of the cover type (i.e., native or non-native) that is being displayed. The dune transition area (most eastern part of project site) exhibited the most apparent cover transformation, shifting from an area with 1-5% native cover and 75-95% non-native cover in the baseline survey, to an area with 6-15% native cover and 1-5% non-native cover in the Fall 2021 survey (Figure 37 and 38). Prior to implementation, this area was dominated by a monoculture of non-native iceplant, which was removed and planted/seeded with native species as part of project implementation. Native cover increased or remained similar throughout the Zuma project area following implementation, whereas non-native cover was reduced throughout. Remaining non-native cover in the Fall 2021 survey was primarily composed of annual species that had sprouted since initial restoration actions and were subsequently removed. In addition, the southwestern toe of the dune area, which was once mechanically groomed sandy beach, shifted to an area with low intermixed native and non-native cover.

Figures 39 and Figure 40 shows absolute native cover and absolute non-native cover, respectively, for the Point Dume project area for the baseline survey and Fall 2021 survey. The baseline surveys exhibit small polygons with primarily non-native cover and intermixed low native cover, surrounded by unvegetated sandy beach (predominantly mechanically groomed; Figure 39 and 40). Following restoration actions, including post and rope delineation to restrict grooming activities, the site displays far less unvegetated sandy beach (Figure 39 and 40). While non-native cover appears to slightly increase in surface area across the site from the baseline to Fall 2021, it also decreases considerably in density (Figure 40). The low non-native cover in the Fall 2021 survey consisted almost entirely of sea rocket, which had sprouted up since initial restoration actions and was subsequently removed during maintenance activities. Native cover increased from the baseline to Fall 2021 survey (Figure 39). Native cover identified in the Fall 2021 survey consisted of several polygons with pre-existing native dune vegetation and larger areas of low cover, made up of scattered seedlings and small juvenile plants.

Lastly, Table 4a displays all native and non-native species identified through various vegetation cover and vegetation mapping surveys in each monitoring round (baseline, Summer 2021, Fall 2021). Native species richness increased from seven in the baseline survey to eleven in both the Summer and Fall 2021 surveys. Non-native species richness decreased from nine in the baseline survey to four in the Summer 2021 survey and then continued to stay lower than the baseline at six species in the Fall survey.

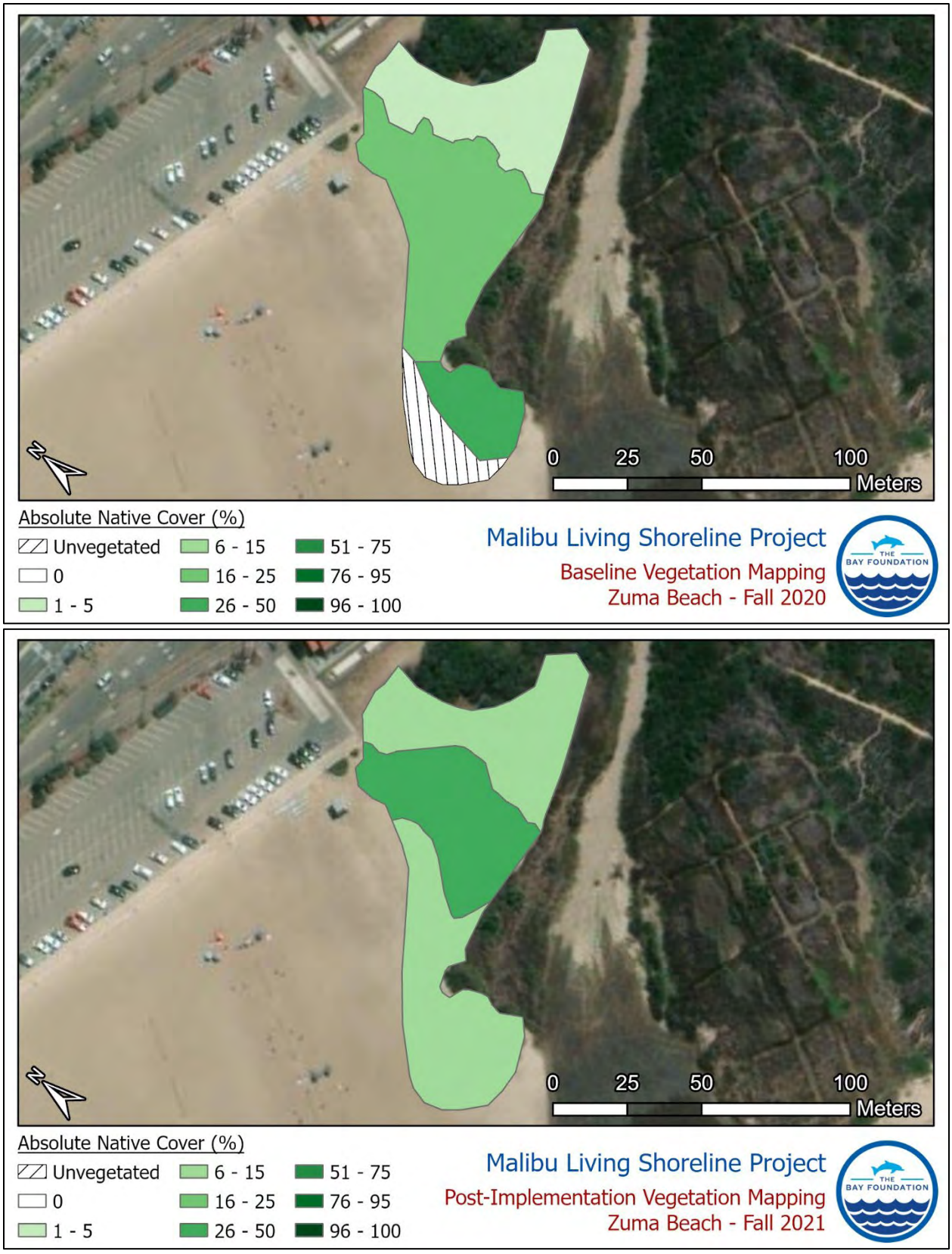


Figure 37. Absolute native vegetation cover within the Zuma Beach restoration area for the baseline (Fall 2020) survey (top) and for the Fall 2021 survey (bottom).

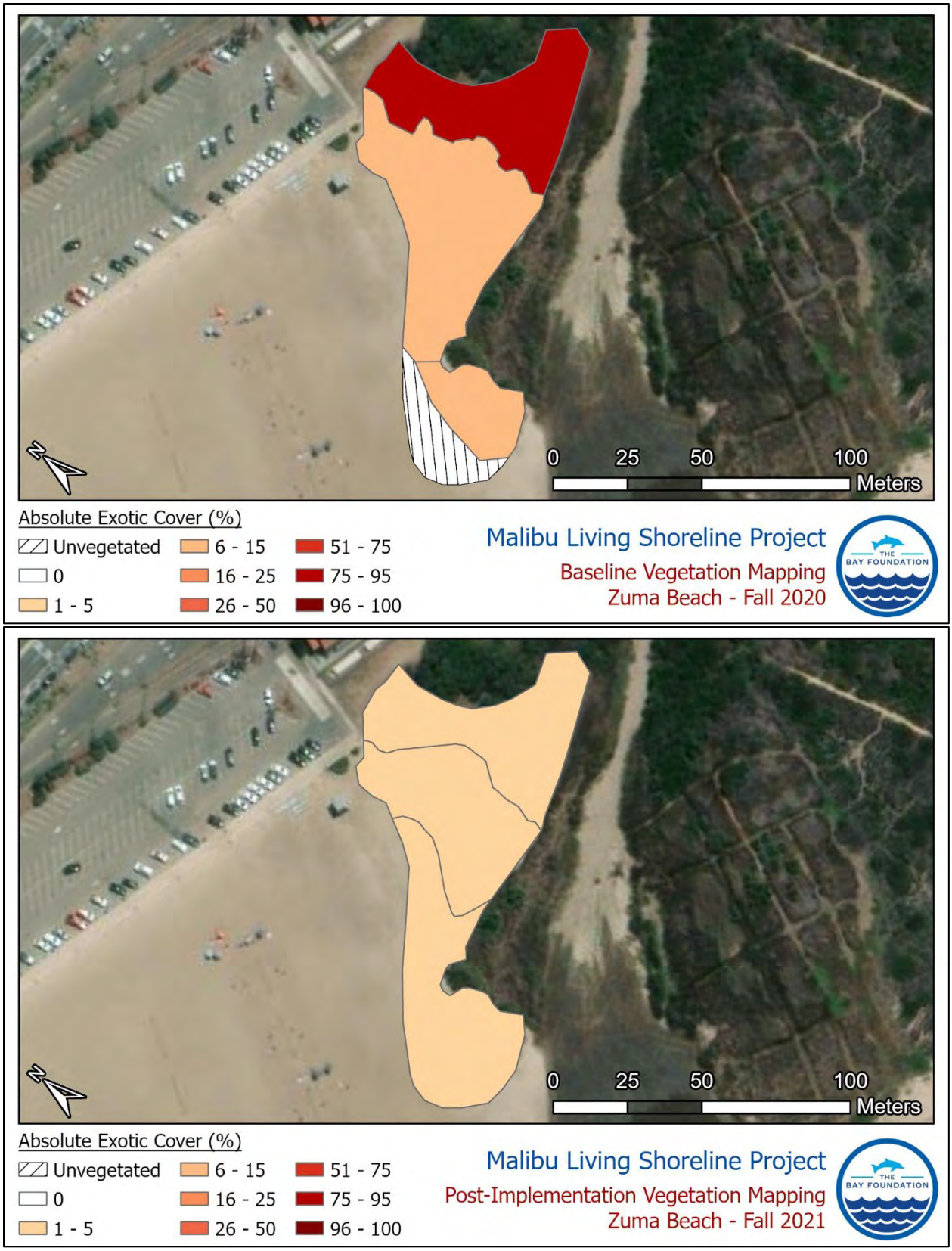


Figure 38. Absolute exotic vegetation cover within the Zuma Beach restoration area for the baseline (Fall 2020) survey (top) and for the Fall 2021 survey (bottom).

Figure 39. Absolute native vegetation cover within the Point Dume Beach restoration area for the baseline (Fall 2020) survey (top) and for the Fall 2021 survey (bottom).

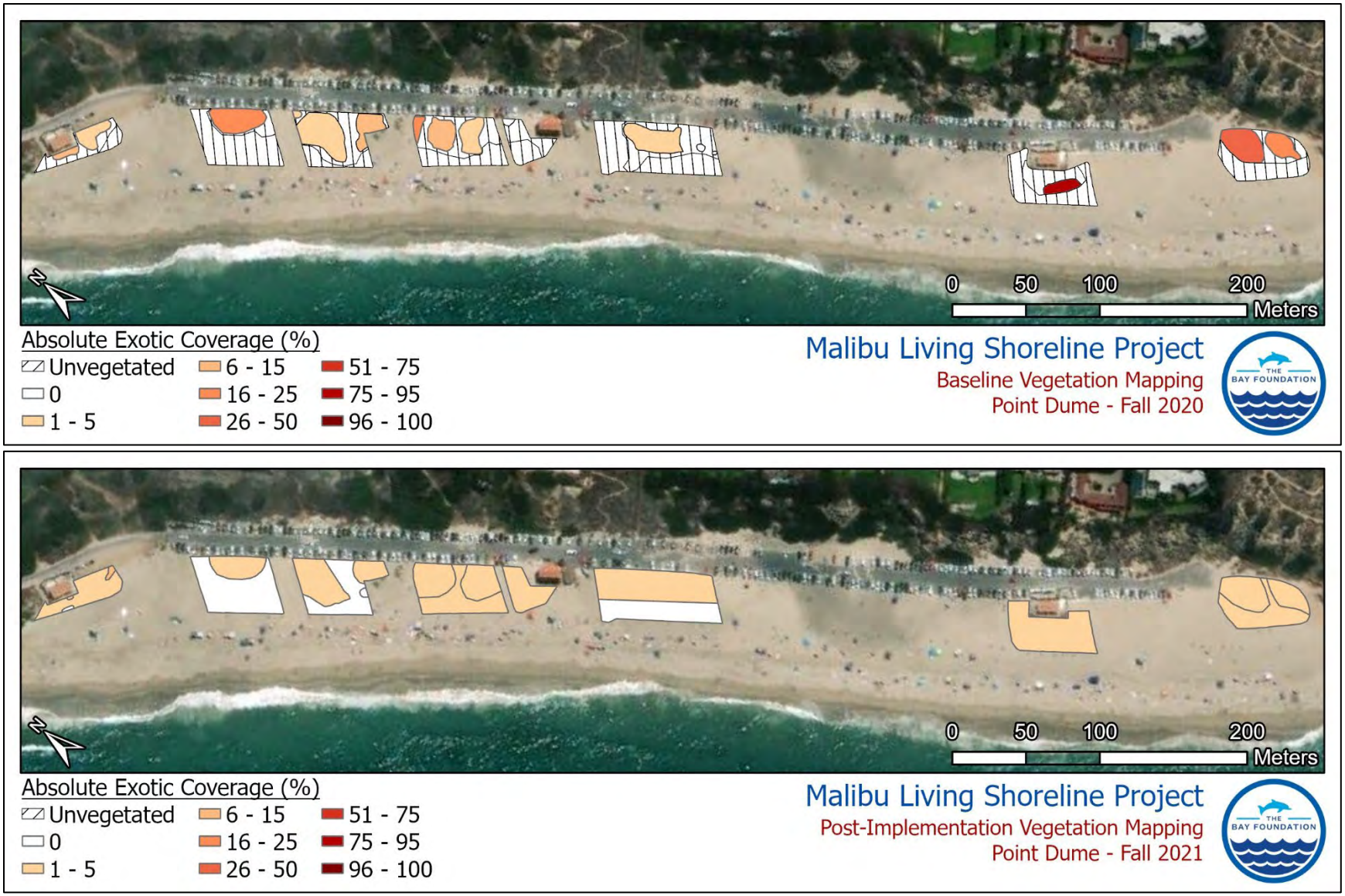


Figure 40. Absolute non-native vegetation cover within the Point Dume Beach restoration area for the baseline (Fall 2020) survey (top) and for the Fall 2021 survey (bottom).

Table 4a. Native and non-native species identified in vegetation cover and mapping surveys for various monitoring rounds.

Common Name	Species	Baseline (Fall 2020)	Summer 2021	Fall 2021
Native Species				
Red sand verbena	*Abronia maritima*	X	X	X
Pink sand verbena	*Abronia umbellata*	X	X	X
Beach bur	*Ambrosia chamissonis*	X	X	X
California sagebrush	*Artemisia californica*		X	X
Big saltbush	*Atriplex lentiformis*		X	
Beach evening-primrose	*Camissoniopsis cheiranthifolia*	X	X	X
California croton	*Croton californicus*			X
Seacliff buckwheat	*Eriogonum parvifolium*	X	X	X
California poppy	*Eschscholzia californica*		X	X
Telegraph weed	*Heterotheca grandiflora*	X	X	X
Goldenbush	*Isocoma menziesii*	X		
Giant coreopsis	*Leptosyne gigantea*		X	X
Lemonade berry	*Rhus integrifolia*		X	X
	Total	**7**	**11**	**11**
Non-Native Species				
Black mustard	*Brassica nigra*	X		
Iceplant	*Carpobrotus edulis*	X	X	X
Sea rocket	*Cakile maritima*	X	X	X
Bermuda grass	*Cynodon dactylon*	X	X	X
Geraldton carnation weed	*Euphorbia terracina*	X		X
Hairy cats ear	*Hypochaeris radicata*		X	
Crown daisy	*Glebionis coronaria*	X		
Castorbean	*Ricinus communis*	X		X
Russianthistle	*Salsola tragus*	X		X
Sow thistle	*Sonchus oleraceus*	X		
	Total	**9**	**4**	**6**

Avifauna and Other Wildlife

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 information is useful to characterize representative avian assemblages and spatial distributions within a particular area. Bird presence, species, number, behavior, and proximity to site were recorded opportunistically on all monitoring days and some site maintenance days. The primary purpose of avifauna surveys for this project was to provide a general understanding of the bird community and activity in the restoration area. It is not intended to provide statistical results; rather, its goal is to generally characterize bird species utilizing the site.

Bird surveys were conducted pre-restoration and semi-annually and include observational species presence and activity/behavior. Additionally, breeding or nesting activity of birds will be recorded if

observed but has not been identified to date. LA Audubon Society also provided supplemental plover survey data. Lastly, presence of other wildlife, including species of pollinators such as butterflies or bees, were also recorded as part of these surveys. Survey dates are listed in Table 2.

A total of 28 avian species were observed within or adjacent to the restoration area over all surveys combined (Table 4b). Frequently observed species include gulls (*Larinae spp.*), various shorebirds (e.g., sanderling, *Calidris alba*), and urban species (e.g., American crow, *Corvus brachyrhynchos* and red-tailed hawk, *Buteo jamaicensis*; Figure 41). Western snowy plovers (*Charadrius nivosus nivosus*) were also observed in a pre-restoration survey adjacent to the restoration area. Western snowy plovers were not observed within or adjacent to the project site during surveys conducted by TBF throughout restoration implementation, but were observed within the roosting site northeast of the Zuma site in surveys conducted by LA Audubon and Ryan Ecological Consulting (Table 6). In addition, Table 5 displays other wildlife, including pollinator species observed during surveys. Frequently observed species include western fence lizards found within the restoration areas (*Sceloporus occidentalis*), and offshore dolphins (*Delphinidae spp.*) visually identified off coast from the restoration area.

Table 4b. 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/ Wading Bird	Black-bellied Plover	*Pluvialis squatarola*	X	
	Great Egret	*Ardea alba*	X	
	Marbled Godwit	*Limosa fedoa*	X	
	Sanderling	*Calidris alba*	X	
	Sandpipers	*Scolopacidae spp.*	X	
	Snowy Egret	*Egretta thula*	X	
	Western Snowy Plover *	*Charadrius nivosus nivosus*		X
	Whimbrel	*Numenius phaeopus*	X	
	Willet	*Tringa semipalmata*	X	
Open Water	Brandt's Cormorant	*Phalacrocorax penicillatus*		X
	CA Brown Pelican **	*Pelecanus occidentalis californicus*		X
	Cormorants	*Phalacrocorax spp.*		X
Gull/Tern	California Gull	*Larus californicus*	X	
	Elegant Tern	*Thalasseus elegans*	X	
	Gulls	*Larinae spp.*	X	
	Heermann's Gull	*Larus heermanni*	X	
	Royal Tern	*Thalasseus maximus*	X	
	Western Gull	*Larus occidentalis*	X	
Urban	American Crow	*Corvus brachyrhynchos*	X	
	Anna's Hummingbird	*Calypte anna*	X	
	Black Phoebe	*Sayornis nigricans*	X	
	California Towhee	*Melozone crissalis*	X	

Category	Common Name	Scientific Name	Restoration	Adjacent
	Geese	*Anserini spp.*	X	
	House Finch	*Haemorhous mexicanus*	X	
	Peregrine Falcon	*Falco peregrinus*	X	
	Red-tailed Hawk	*Buteo jamaicensis*	X	
	Rock Pigeon (Feral Pigeon)	*Columba livia*	X	
	White-crowned Sparrow	*Zonotrichia leucophrys*	X	

** = rare species listed as threatened by USFWS*

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

Figure 41. Species observed during avian surveys. Top left: Sanderling (*Calidris alba*), top right: Western gull (*Larus occidentalis*), bottom left: red-tailed hawk (*Buteo jamaicensis*), bottom right: elegant tern (*Thalasseus elegans*).

Table 5. Other wildlife 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
Mammal	Dolphins	*Delphinidae spp.*		X
	Harbor Seal	*Phoca vitulina*		X
	Seals	*Phocidae spp.*		X
Herpetofauna	Southern Alligator Lizard	*Elgaria multicarinata*	X	
	Western Fence Lizard	*Sceloporus occidentalis*	X	
Insect	California Bumble Bee	*Bombus californicus*	X	
	Darkling Beetles	*Tenebrionidae spp.*	X	
	Grass Skippers	*Hesperiinae spp.*	X	
	Lady Beetles	*Coccinellidae spp.*	X	
	Malachite Beetles	*Malachiinae spp.*	X	
	Salt Marsh Moth	*Estigmene acrea*	X	
	Scarabs	*Scarabaeidae spp.*	X	
	Water Scavenger Beetles	*Hydrophilidae spp.*	X	

Western Snowy Plovers

Western snowy plovers, a federally threatened species of bird, are known to inhabit roosting sites on northern Zuma Beach. Individuals show high site fidelity and have been observed returning to Los Angeles County to the same beach for as many as six years (Ryan and Vigallon 2010). Beach grooming is one of the key impacts to plovers both directly through mortality and indirectly through habitat restrictions (Ryan et al. 2017). Roost population counts are generally highest between August and March. This beach and the roosting area are within Western Snowy Plover Critical Habitat Subunit CA-43 (USFWS 2012). “Physical or biological features” essential to the conservation of the species are identified (in part) as dune-backed beaches, sparsely vegetated dunes, and beaches at creek and river mouths (USFWS 2012). However, the Zuma Beach plover roost site is northwest from the restoration area by approximately 1,300 meters and restoration activities during implementation did not directly affect the Zuma Beach population. The project has the potential to provide future indirect benefits for the plovers, and it will be carefully monitored over time for any changes or movements in the roosting plover populations.

Los Angeles Audubon Society and Ryan Ecological Consulting produce monthly reports of snowy plover counts in Los Angeles and Orange County (Ryan and Vigallon, September 2020 through December 2021). Reports are based on surveys conducted by staff and volunteers. Table 6 displays monthly plover counts for Zuma Beach from September 2020 through December 2021. Plover counts ranged from zero (May, June, July, August 2021) to 59 (January 2021). Note that the plover survey area is outside of the restoration area.

Table 6. Number of Snowy Plovers Observed at Zuma Beach plover roost site. Data from monthly plover reports by Tom Ryan (Ryan Ecological Consulting) and Stacey Vigallon (LA Audubon Society).

Survey Month	Plover Count
Sep-20	29
Oct-20	34
Nov-20	54
Dec-20	45
Jan-21	59
Feb-21	51
Mar-21	48
Apr-21	6
May-21	0
Jun-21	0
Jul-21	0
Aug-21	0
Sep-21	10
Oct-21	47
Nov-21	26
Dec-21	44

Physical Characteristics

Physical characteristics were collected using techniques described in detail in Dugan et al. 2015. To physically characterize the project area and surrounding beach, elevation profiles were taken using a combination of elevation poles and a high-resolution GPS Trimble (Figure 42). These measurements were collected along all transects (excluding wrack transects) displayed in Figures 21 and 22. Restoration and control transects at Point Dume Beach, and control transects at Westward were primarily oriented perpendicular to the ocean. For these transects, elevation measurements were collected from the start of the transect at the back beach all the way past the berm, to the water line, to capture the full beach profile. For the Zuma Beach transects and the Point Dume Beach lateral transects, elevation data were only collected for the length of the transect (30 m) due to their varying orientations. One control transect (PC3L) was added during the first post-implementation survey (June 2021) and an additional control transect (PC4) was added in the subsequent survey (October/November 2021); therefore, data from earlier rounds are not displayed for these transects. In addition, baseline surveys (October 2020) for the control transects at Westward Beach (WC1 and WC2) and for P6 at Point Dume Beach were removed during the QAQC process. Survey dates are listed in Table 2.

Overall, there were minor physical differences across sites and little variation in elevation profiles from Fall 2020 to Fall 2021 (Figures 46-55; please note the varying x-axis). Beach elevation profiles within the restoration area at Point Dume Beach (P1-P7) display a large pre-existing dune mound in the back beach area, which then steadily declines towards the berm and subsequent water line (Figures 43-47, top). Post implementation surveys (June and October/November 2021) showed similar profiles to baseline surveys (October 2020), with minor exceptions, such as a small hummock, which appears to have developed at the approximately 20-meter mark on transect P5 (Figure 45, bottom). The variability observed in the lateral restoration transect (P5L) over time does not reflect site conditions but is likely a result of an error in the transect start point combined with reduced Trimble precision due to satellite connectivity issues. Continued monitoring is needed to understand trends in elevation over time. Some of the Point Dume beach transects were shorter in the Fall 2021 survey period; variability in the length of the elevation transects over time may be expected, as transects are measured to the waterline in all surveys. Additional monitoring is necessary to determine if this is due to seasonal and tide variation. The lateral transects within the Point Dume restoration area (PL3 and PL5) exhibited minor variability across all surveys (Figure 44, bottom and Figure 46, top). The dune habitat transects (Z1 and Z3), and dune transition habitat transect (Z2) within the Zuma Beach restoration also remained very similar across all surveys (Figure 47, bottom and Figures 48). Additional rounds of monitoring are necessary to better assess the accretion of sand within the restoration areas.

Transects within the Point Dume control area (PC1-PC4) displayed a fairly steady decrease from the back beach to the water line (Figures 49-51, top). These profiles lack the apparent back beach dune that the transects within the Point Dume restoration area display. The flat profile of the lateral control transect (PC3L) also appears very consistent across survey periods (Figure 50, bottom). The Westward Beach control transects (WC1 and WC2) exhibited an even flatter profile across all surveys with a drop-off at the berm (Figure 51, bottom, Figure 52, top, and Figure 53). The considerable variability observed in the Westward Beach elevation profiles (WC1 and WC2) does not reflect site conditions but may be attributed to an error in the transect start point combined with reduced Trimble precision due to satellite connectivity issues. Continued monitoring is needed to better characterize the elevation profile

at the Westward Beach control site. The dune transition habitat control transect (ZC1) also displayed a consistently flat profile across all surveys (Figure 52, bottom).

Figure 42. Photos of TBF staff and interns performing elevation surveys using a GPS Trimble and elevation poles.

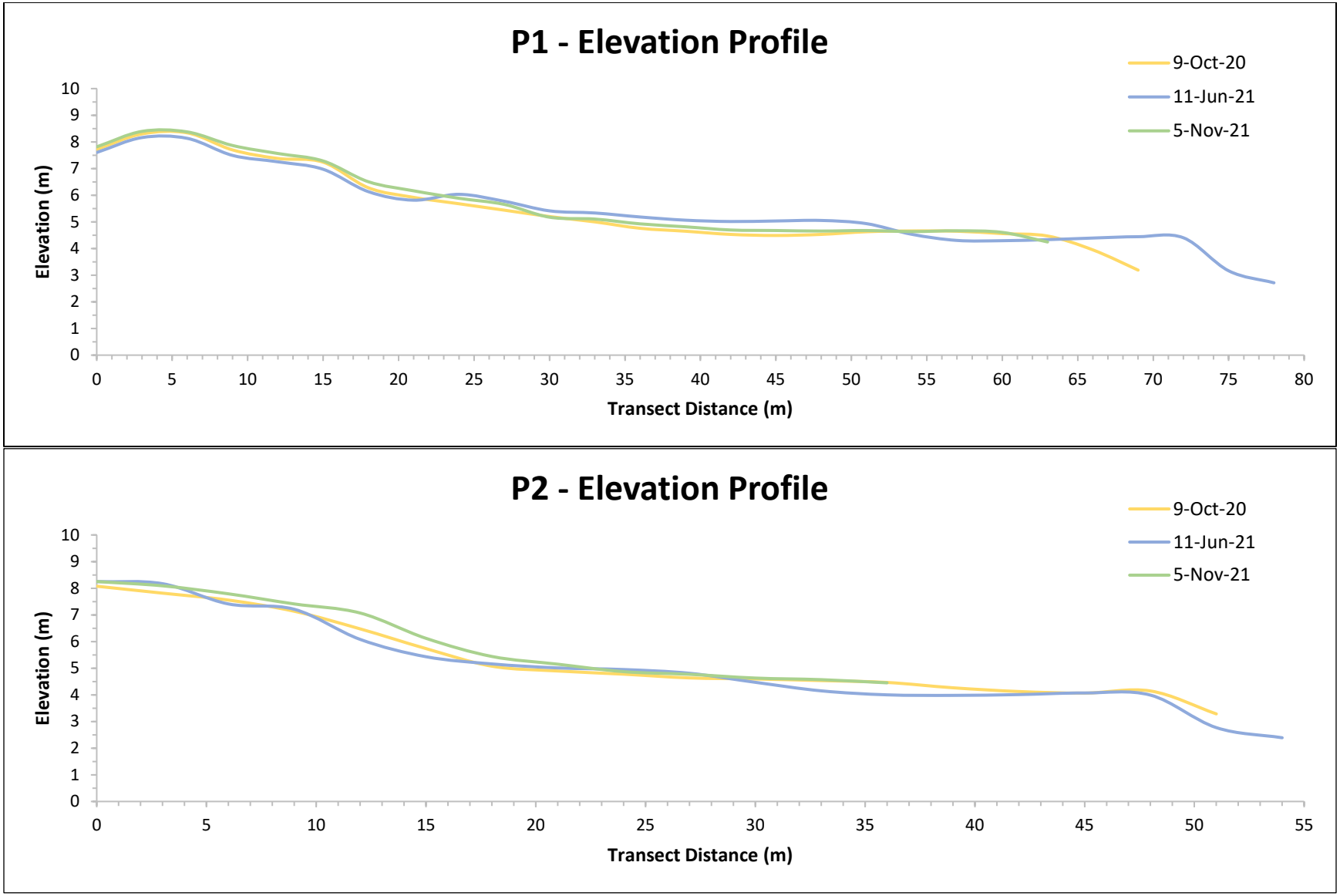


Figure 43. Restoration transect P1 (top) and P2 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys.

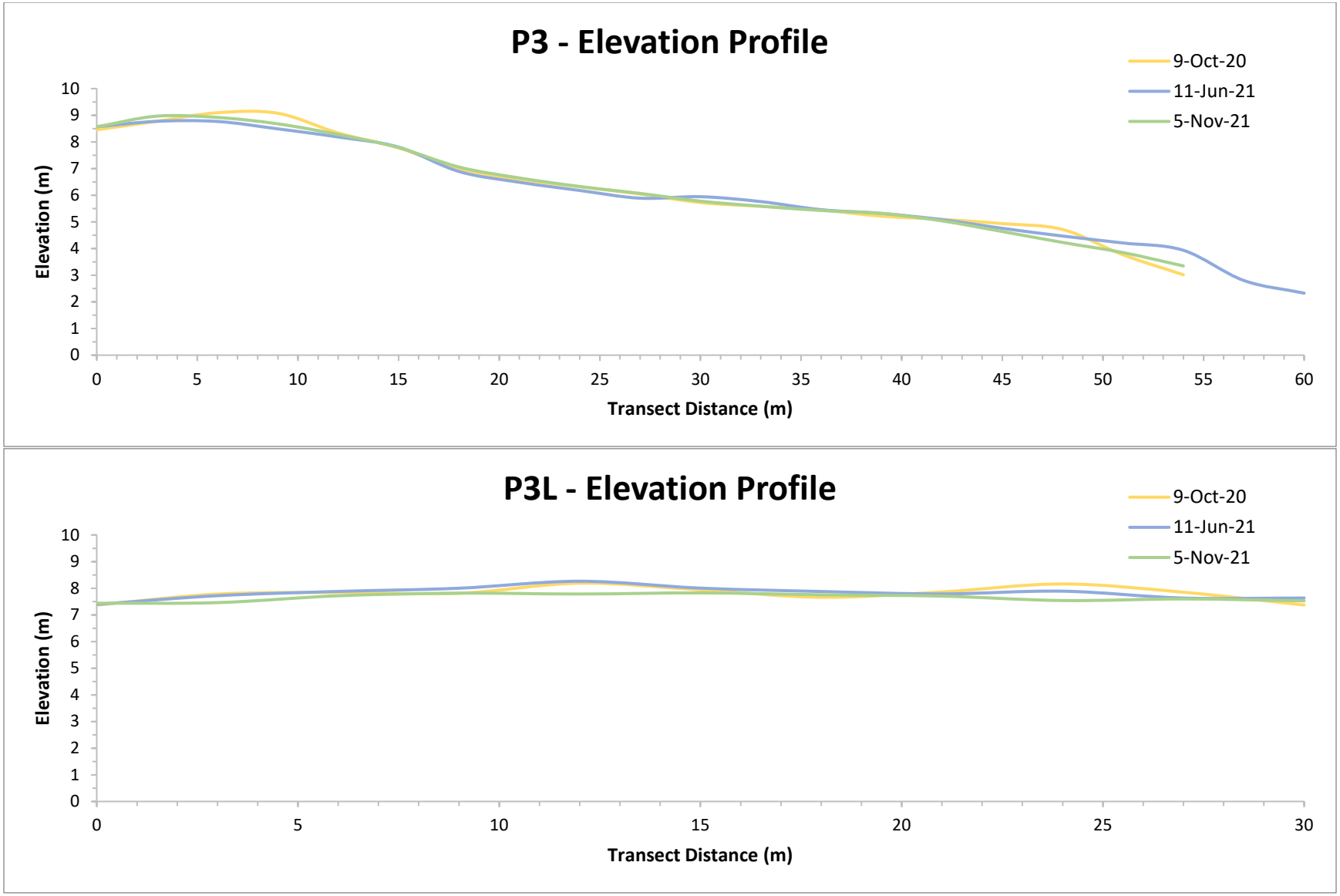


Figure 44. Restoration transect P3 (top) and P3L (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys. Note: this is a lateral transect that runs parallel to the ocean.

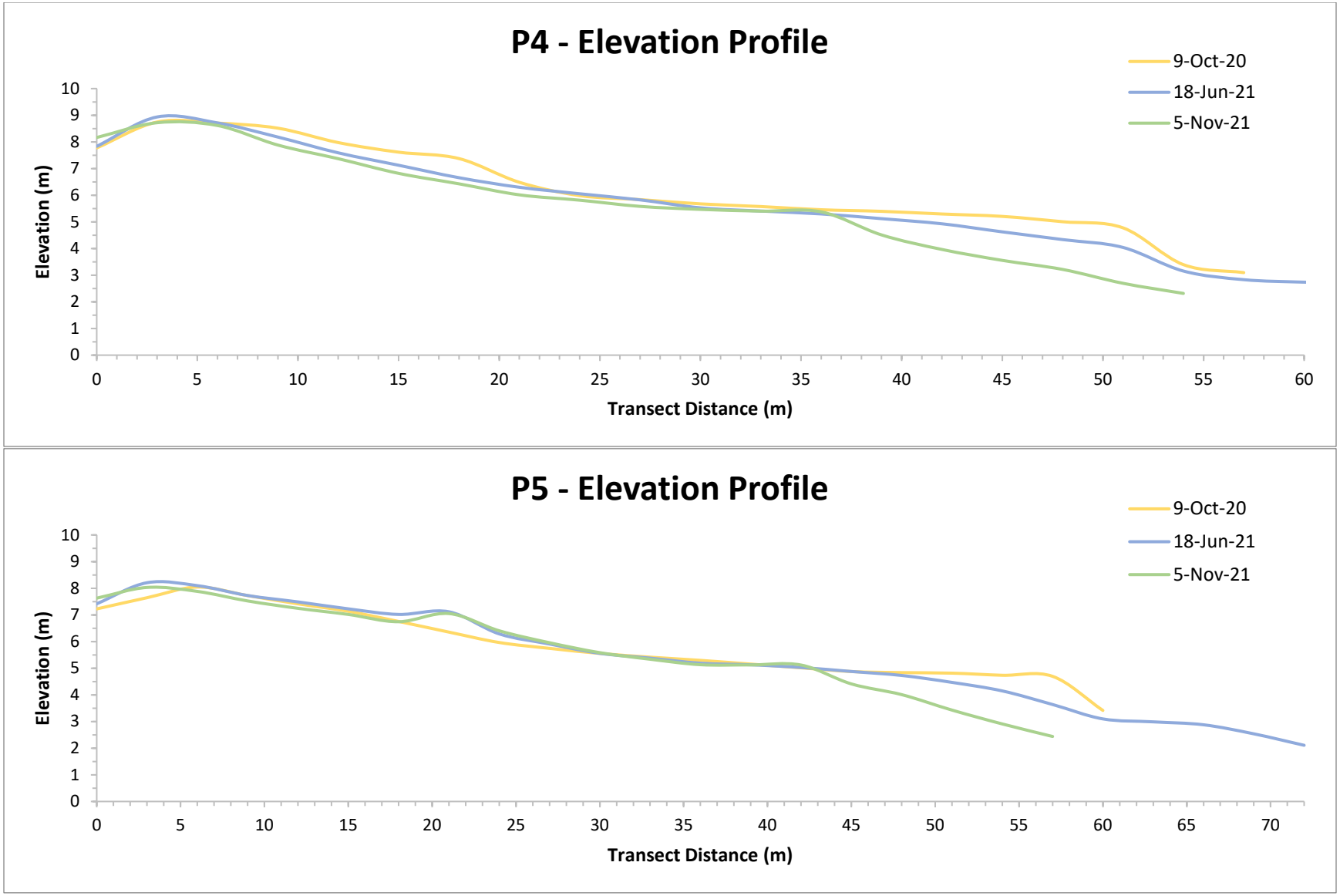


Figure 45. Restoration transect P4 (top) and P5 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys.

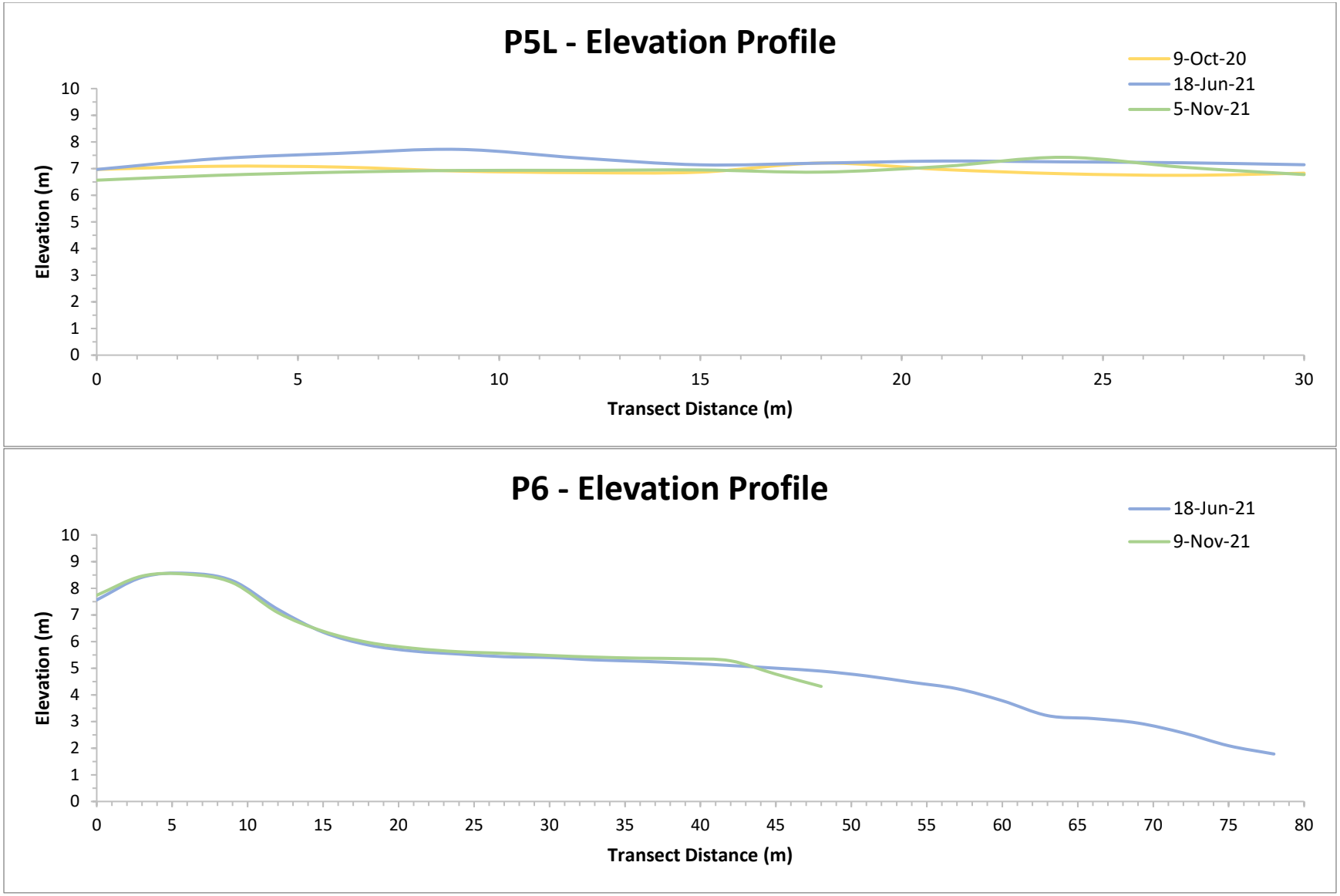


Figure 46. Restoration transect P5L (top) and P36 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys. *Note: P5L is a lateral transect that runs parallel to the ocean. Baseline data for P6 were removed during the QAQC process.*

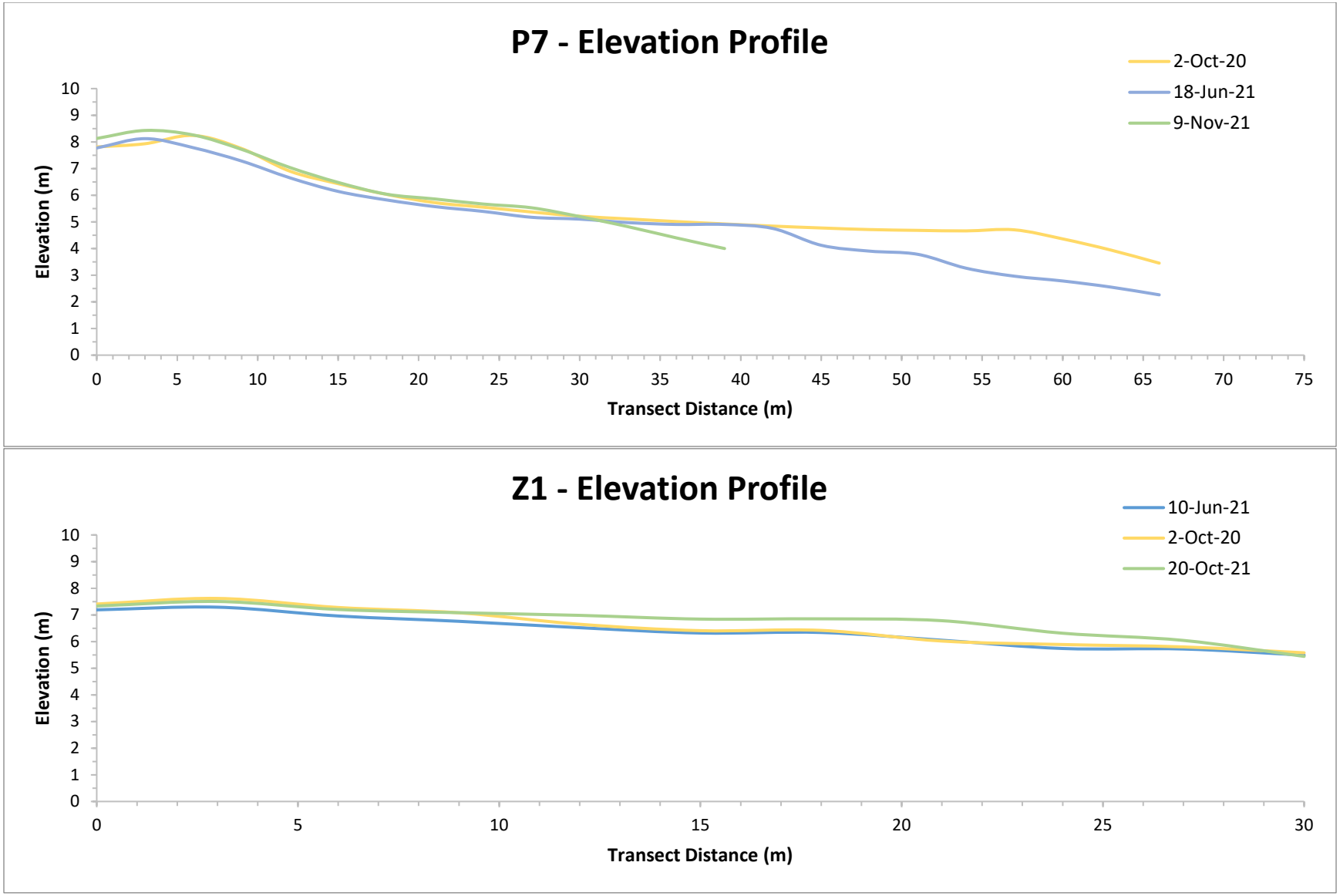


Figure 47. Restoration transect P7 (top) and Z1 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (October/November 2021) surveys.

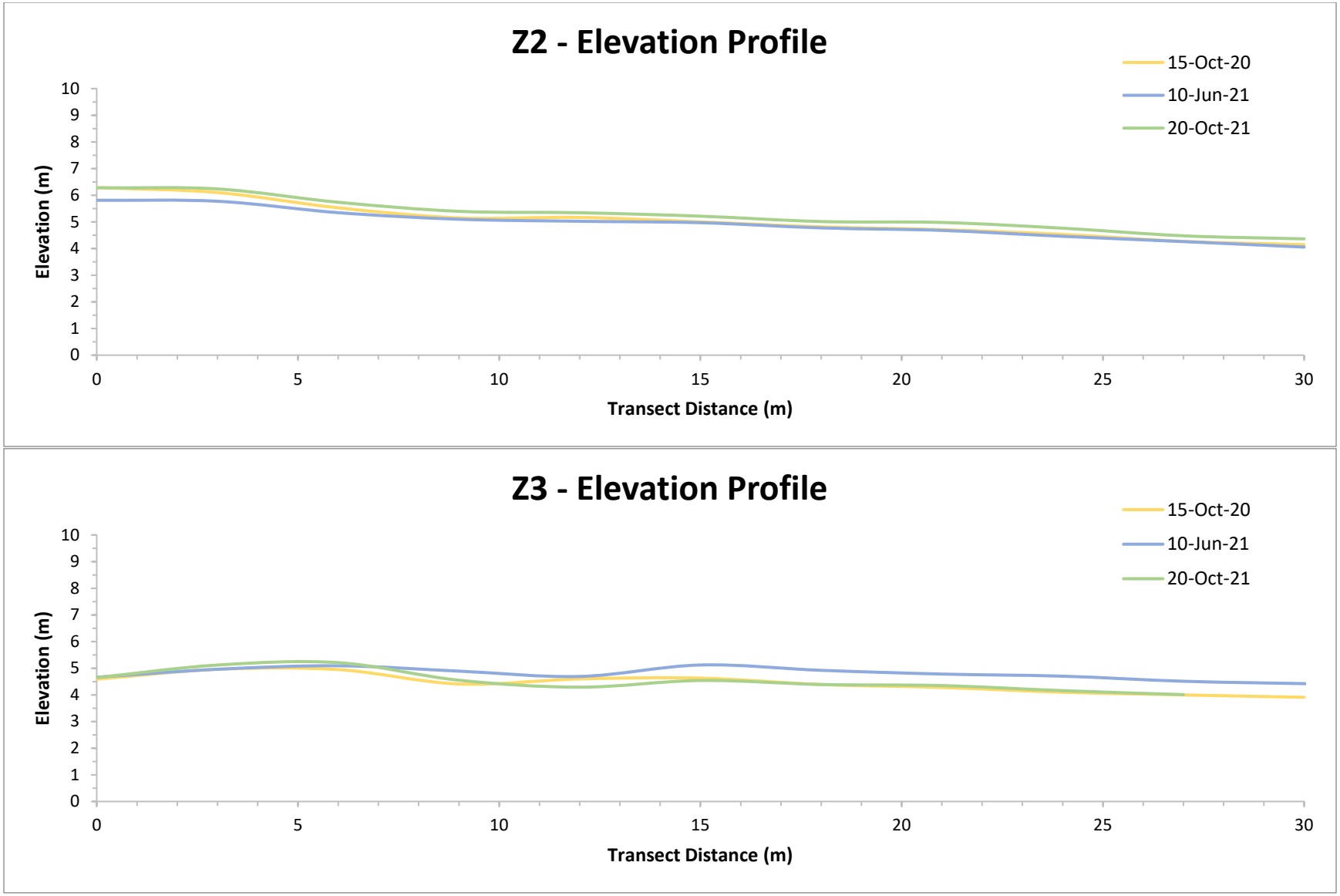


Figure 48. Restoration transect Z2 (top) and Z3 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (October 2021) surveys.

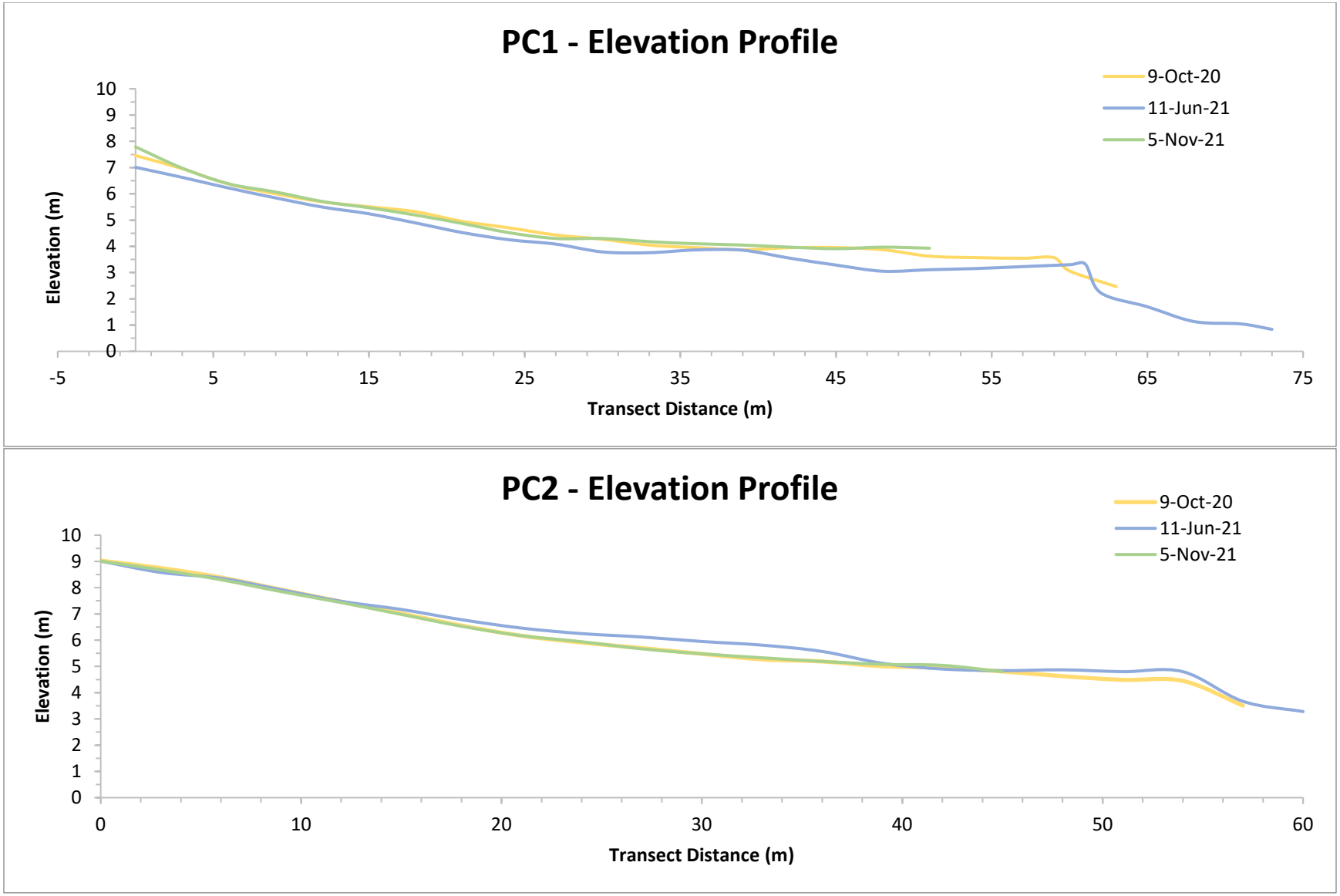


Figure 49. Control transect PC1 (top) and PC2 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys.

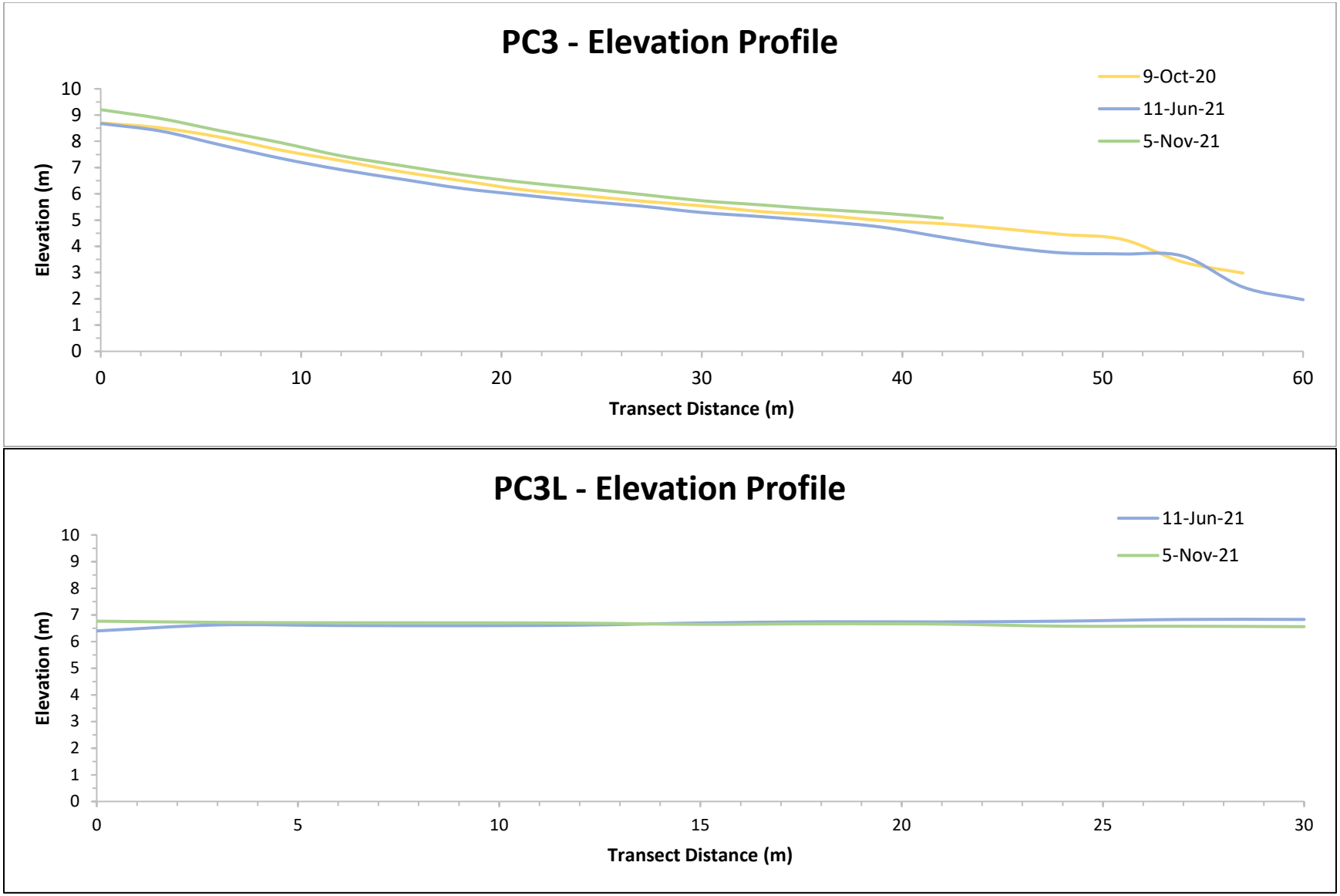
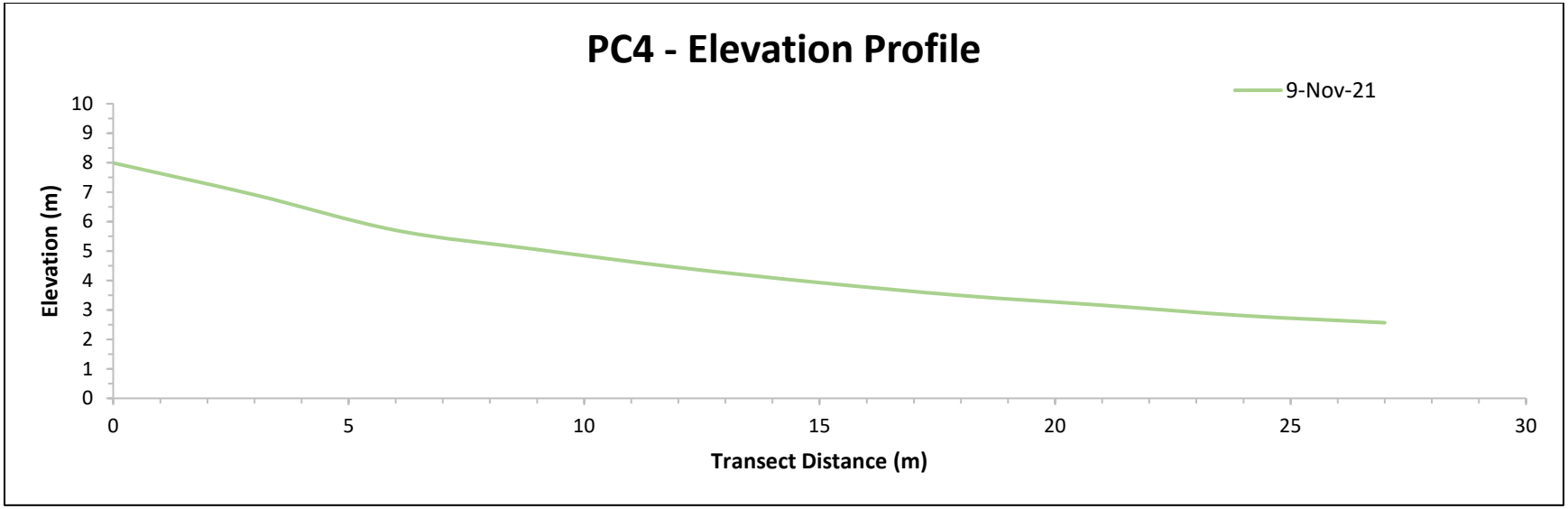


Figure 50. Control transect PC3 (top) and PC3L (lateral transect) (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (November 2021) surveys. *Note: PC3L was added during Summer 2021, thus no baseline data are displayed.*



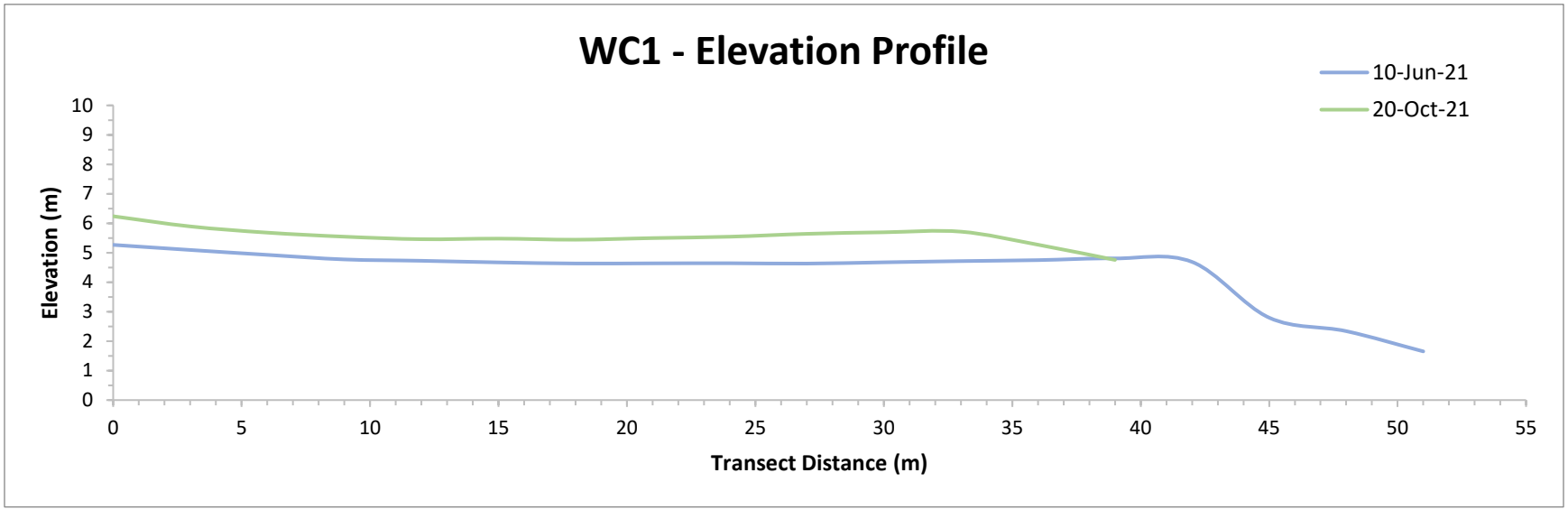


Figure 51. Control transect PC4 (top) and WC1 (bottom) elevation profiles during, Summer 2021 (June 2021), and Fall 2021 (October/November 2021) surveys. *Note 1: PC4 was added during Fall 2021, thus no previous surveys are displayed. Note 2: baseline data for WC1 were removed during the QAQC process.*

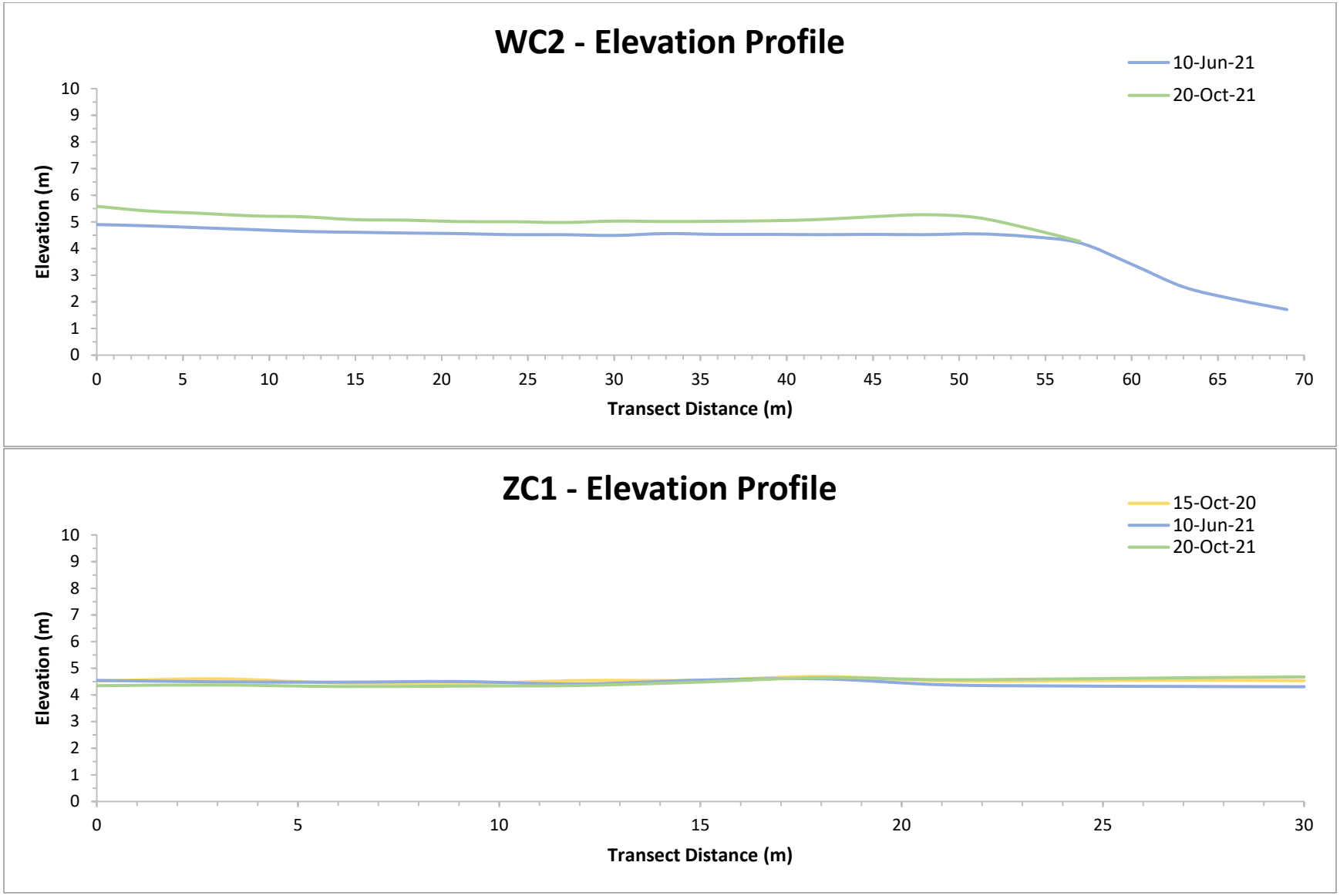


Figure 52. Control transect WC2 (top) and ZC1 (bottom) elevation profiles during Fall 2020 (October 2020; baseline), Summer 2021 (June 2021), and Fall 2021 (October 2021) surveys. Note: baseline data for WC2 were removed during the QAQC process.

Figure 53. Photo showing steep berm drop-off at Westward Beach control site, outside the restoration area on 10 June 2021.

Weather Conditions

Average air temperature and precipitation data were downloaded for the project area from NOAA: Climate Data Online (Tables 7 and 8). The project sites are located centrally between the Santa Monica Municipal Airport and Point Mugu NF weather stations, thus data were downloaded for both sites. In addition, tide/water level data were downloaded from NOAA: Tides and Currents for the Santa Monica Station (closest station; Table 9). Weather patterns and climate data collected from external sources were meant to be representative, not indicative of specifics within the restoration area at any given moment in time.

In Year 1 (December 2020 through December 2021) The Santa Monica (SM) station recorded a total of 20.43 cm (8.04 in) and the Point Mugu (PM) station recorded a total of 16.21 cm (6.38 in; Table 7). The month with the highest recorded rainfall amount for both stations was in December 2021 (SM: 7.8 cm; PM: 9.7 cm). At the SM station, the temperature ranged from an average maximum of 24.4˚ C (August 2021) to an average minimum of 8.3˚ C (December 2020 and 2021; Table 8). At the PM station, the temperature ranged from an average maximum of 23.3˚ C (August 2021) to an average minimum of 6.1˚ C (December 2020). In addition, Table 9 displays tide water level data. According to the SM station, the water level ranged from a high of 7.34 ft (June 2021) to a low of -1.79 ft (December 2020)

Table 7. Precipitation data downloaded for the Santa Monica Municipal Airport and Point Mugu NF weather stations from NOAA: Climate Data Online (downloaded on 3 January 2022).

Year	Month	Total Precipitation (cm)	
		Santa Monica	Point Mugu
2020	December	3.28	3.45
2021	January	4.47	2.11
	February	0.00	0.08
	March	2.90	0.38
	April	0.00	0.00
	May	0.00	0.00
	June	0.00	0.00
	July	0.25	0.05
	August	0.05	0.08
	September	0.00	0.00
	October	1.68	0.33
	November	0.00	0.03
	December	7.80	9.70
Total		**20.43**	**16.21**

Table 8. Air Temperature data downloaded for the Santa Monica Municipal Airport and Point Mugu NF weather stations from NOAA: Climate Data Online (downloaded on 3 January 2022).

Year	Month	Temperature (˚C)			
		Santa Monica		Point Mugu	
		Average Maximum	Average Minimum	Average Maximum	Average Minimum
2020	December	20.6	8.3	20.6	6.1
2021	January	19.4	8.9	20.6	7.2
	February	19.4	9.4	18.3	6.7
	March	18.3	8.9	17.8	5.6
	April	20.0	11.7	20.0	8.3
	May	20.0	13.9	19.4	11.1
	June	21.7	16.1	21.1	13.9
	July	23.9	17.8	22.8	16.1
	August	24.4	17.2	23.3	15.0
	September	23.3	16.1	22.2	13.9
	October	22.8	12.8	22.2	10.6
	November	21.1	11.7	21.1	9.4
	December	16.7	8.3	16.1	7.2

Table 9. Tide/water level data downloaded for the Santa Monica station from NOAA: Tides and Currents (downloaded on 30 December 2021).

Year	Month	Water Levels							
		Highest (ft)	MHHW (ft)	MHW (ft)	MSL (ft)	MTL (ft)	MLW (ft)	MLLW (ft)	Lowest (ft)
2020	December	7.15	5.68	4.70	2.84	2.88	1.08	-0.18	-1.79
2021	January	6.90	5.73	4.76	2.88	2.90	1.04	-0.13	-1.73
	February	6.49	5.33	4.58	2.67	2.70	0.82	-0.11	-1.37
	March	5.96	5.11	4.63	2.57	2.58	0.54	-0.12	-0.99
	April	6.68	5.33	4.79	2.76	2.77	0.76	-0.05	-1.31
	May	7.06	5.55	4.80	2.87	2.91	1.02	-0.09	-1.77
	June	7.34	5.79	4.90	3.04	3.07	1.24	0.04	-1.53
	July	7.02	5.79	4.87	3.10	3.12	1.37	0.31	-1.39
	August	6.96	5.76	4.94	3.15	3.16	1.37	0.49	-0.84
	September	6.22	5.52	4.97	3.07	3.08	1.18	0.42	-0.55
	October	6.42	5.42	4.97	3.02	3.05	1.12	0.31	-0.28
	November	6.93	5.45	4.76	2.83	2.86	0.97	-0.04	-1.23

**MHHW: Mean Higher High Water; MHW: Mean High Water; MSL: Mean Sea Level; MTL: Mean Tide Level; MLW: Mean Low Water; MLLW: Mean Lowest Low Water.*

Sediment Grain Size

Sediment grain size is collected annually to detect long-term shifts in grain size composition using techniques described in detail in Dugan et al. 2015. Average sediment grain size is determined from sand samples collected at randomly generated meter marks along each restoration and control transect. Samples are dried to constant weight and then shaken through a series of sieves with a variety of screen aperture size (in microns) to determine the relative abundance and proportion of sand in each size class (phi). Survey dates are listed in Table 2.

Due to COVID-19 regulations and guidelines, TBF did not have access to the lab on LMU's campus to complete sediment analyses for the majority of the survey period. As a result, no grain size analyses have yet been completed. However, campus restrictions have since lifted and TBF has begun sorting and prioritizing collected samples for analysis. Analyses will be included in future reports.

Success Criteria Evaluation

Setting appropriate performance criteria for restoration projects, and assuring those criteria are met, helps assure that the ecological benefits of the project are realized. Performance criteria focus on measuring the extent to which appropriate physical and biological ecosystem processes have been restored in the short-term and how they might be expected to be self-sustaining in the long-term. Additionally, performance criteria are intended to assess whether the project goals have been achieved. Performance criteria are quantitative and measurable and were determined in the Implementation and Monitoring Plan and approved as part of the permit process.

Restoration success criteria are intended to support the project goals and assist in information sharing throughout California and beyond for living shoreline projects. Additionally, criteria inform the need for adaptive management of the site. The following table summarizes the restoration success criteria associated with this project over time and the progress towards meeting those targets for the first evaluation year (Table 10).

Table 10. Success criteria for the Malibu Living Shoreline Project.

Criteria Parameter	Quantifiable Metric	5-Year Target	Year 1 Assessment
Non-native vegetation	Absolute cover as assessed along transects within the restoration areas and compared to the controls	Reduced (or absent) non-native cover within restoration area compared to baseline and controls (<15% absolute cover non-natives; <5% absolute cover of highly invasive non-natives as determined by CalIPC)	Met criteria during Year 1
Native vegetation	Absolute cover as assessed along transects within the restoration areas and compared to the controls; species richness	Increase in native cover and native species richness (total) within restoration areas compared to baseline and controls; minimum absolute native cover of 15% (coastal strand and foredune), 20% (back dune), 30% (dune transition)	Native species richness increased compared to the baseline; native cover criteria not met yet
Native / Non-native ratio	Relative cover as assessed along transects within the restoration areas	Minimum of 85/15% ratio of native to non-native relative plant cover	Year 1 did not meet the relative ratio yet in one area of the site
Topography change	Change in elevation profiles and dune heights along restoration transects	Stable dune system over time without long-term erosion (incorporating seasonal change); shift in berm crest towards ocean compared to baseline and accretion over time	System has been stable in the face of disturbance events; no berm crest shift to date
Community participation	Number of volunteers (and hours worked) annually during restoration events, outreach events, tours, and public meeting participation	Minimum of 50 people directly or virtually engaged annually for five years (> 250 total)	Exceeded criteria prior to and during Year 1

Adaptive Management, Maintenance, and Site Use

Adaptive management is a tool for achieving success where there is uncertainty as to what actions will be needed to accomplish specific goals. As systems like Zuma Lagoon and Point Dume Beach are inherently dynamic, with high levels of visitation and changing management strategies, an adaptive management approach leads to better outcomes in the long-term. Adaptive management is implemented based on the success of the project as interpreted by TBF, beach managers, LACDBH, and the City of Malibu. The monitoring components and resulting data are integral in determining the success of the project both from a socio-economic and ecological perspective. Scientific monitoring serves to inform progress towards restoration objectives and success criteria. TBF is resolutely committed to the long-term ecological and physical health of the site.

TBF is undertaking a hands-on maintenance strategy without the use of mechanized equipment, including trash removal and invasive species removal during the implementation of the project and for a duration of no less than five years afterwards. While volunteers were not able to be utilized during this reporting period (Year 1), TBF's future maintenance approach will be strongly supported by volunteers and interns, as well as LACDBH, City of Malibu, or other partners and project supporters. TBF and partners have already begun coordination for the first community-based restoration events in 2022.

Site visits were regularly conducted to visually assess the restoration progress and evaluate the need for maintenance activities. The overall condition of the restoration areas was 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 also occurred. If non-native invasive vegetation was found in a restored area, adaptive management steps such as weed removal by hand was performed.

In Year 1, European sea rocket (annual non-native) was the primary species that sprouted post-implementation and required hand removal during site maintenance days (Figures 17 and 54). Areas of the restoration site that were previously groomed beach had the most European sea rocket. Several years of hand removal will likely be necessary to deplete the seed bank. Other non-native species that required hand removal during maintenance days included but were not limited to Bermuda grass, Geraldton carnation weed, castor bean, Russian thistle, and iceplant.

In addition to removing non-natives, recently planted native species required supplemental irrigation to promote establishment. Please see the Supplemental Watering section for more details. Supplemental planting and seeding of both the Zuma Beach and Point Dume Beach project areas is scheduled for Winter 2022.

Figure 54. TBF staff pulling non-native sea rocket on 14 April 2021.

Trash identified within the project area was also removed during maintenance days (Figure 55). Minimal trash was found within the Point Dume Beach site. Slightly more trash was seen within and adjacent to the Zuma Beach site, particularly within the non-native Ngaio trees neighboring the site, where several houseless individuals had tents set up. Trash removed during maintenance days consisted of chips bags, food wrappers, bottles, plastic bags, Styrofoam, and small pieces of plastic.

Figure 55. TBF interns removing trash from the project site on 3 August 2021.

There have been minor challenges associated with some of the houseless individuals around the Zuma Beach project area. In addition to some of the accumulation of trash, there was one instance (18 June 2021) where several tents were observed within the restored project area (Figure 56). TBF notified project partners, who had the individuals remove the tents from the project site.

Figure 56. Two tents observed within the Zuma Beach project area on 18 June 2021.

In addition, the sand fencing, biomimicry stakes, and post and rope fencing required regular maintenance. Sand fencing segments were occasionally knocked over or had missing or broken fence slats (Figure 57, top). Fencing segments were re-propped up and repaired as needed. The biomimicry stakes plots were also very frequently disturbed through trampling or other means (Figure 57, bottom). While appearing to be an effective means of sand accumulation, maintenance was found to be very time intensive. Plots were removed on 9 November 2021 after just under a year of deployment. Lastly, the posts for the post and rope fencing required occasional repairs or replacement. The only substantial repairs necessary occurred on the Point Dume site in November 2021, when a contractor who was working on an adjacent restroom disturbed a portion of the site by removing of a segment of post and rope fencing, knocking over construction fencing onto the site, and leaving scattered debris within and adjacent to the site (Figure 59). TBF coordinated with LACDBH to repair the site damage.

Figure 57. Fallen sand fence (26 April 2021).

Figure 58. Fallen and disturbed biomimicry stake plot (9 November 2021).

Figure 59. Disturbance of the Point Dume project area caused by a contractor who was working on the adjacent restroom (10 November 2021).

Lastly, an important goal of the restoration project is to evaluate whether heavy recreational use of beaches in Los Angeles and natural habitats to benefit birds and wildlife can coexist. The project area includes post and rope delineated pathways to help guide visitors through the site while also minimizing trampling of native vegetation particularly in the early years of establishment. Visitors were frequently seen utilizing the delineated pathways and seldom observed within the restored portion of the project area (Figure 60, top). In addition to using the pathways, visitors were also observed walking and running adjacent to the site or laying out their towels nearby to simply enjoy a day at the beach (Figure 60, bottom). While performing on-site activities, TBF staff were also frequently approached by visitors and members of the community who were eager to learn more about the project. Interpretive signage is anticipated to be installed in Spring 2022 and will serve to further enhance the beach experience for

visitors while cultivating stewardship through teaching about natural dune systems and coastal resilience.

Figure 60. Beach visitors walking through the pathway at the Zuma Beach project site (top; 5 August 2021) and setting up their towels and umbrellas adjacent to the Point Dume project site (bottom; 29 June 2021).

Conclusions and Recommendations

The first year of project implementation, monitoring, and maintenance had a number of valuable successes and learning experiences. Even in the first year, the project is already meeting several success criteria, with supplemental seeding and planting planned for Winter 2022 to help meet additional success criteria. Additionally, the project positively engaged the public and has garnered widespread support, created new partnerships and outreach connections, restricted grooming and performed restoration activities in a 3.26-acre area, removed invasive vegetation, allowed growth of native vegetation and formation of sand hummocks along fence lines and in other areas of the site, provided comprehensive science-based monitoring data to inform nature-based resilience solutions, and is enhancing a rare coastal habitat type in the Malibu region.

Data suggest that the site is performing well and that the restored areas are beginning to diverge from the control areas that did not have restoration activities. As expected, absolute native vegetation cover remains relatively low, although areas that were either covered in invasive iceplant or previously groomed have new dune plants. 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 and foredune habitat types. Future monitoring will continue to inform changes in 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 variations in the development of natural beach morphology over time.

One suggestion for future projects with a similar set of existing uses is to have a strong public outreach component that directly engages local stakeholder groups, similar to the suite of public outreach strategies utilized prior to the initiation of this project. 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 input to beach management in the area. This effort went far beyond requirements for the permits and included hosting virtual stakeholder meetings to answer questions, incorporating feedback on project planning from the public, and working with the City of Malibu 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.

TBF has a long-term commitment to post-implementation monitoring, maintenance, and adaptive management. Due to the effort required to implement the biomimicry stake plots and the limitations to dune plant growth that they impart, they are unlikely to be used for dune accretion in Year 2, though they will be evaluated in targeted areas for future years. Based on the data results and site visits, supplemental seeding and planting is recommended by the project team to meet additional future vegetation success criteria for the site. Supplemental watering should also be considered if drought years continue. Annual reports will continue to be made available for public download on TBF's website: www.santamonicabay.org.

Literature Cited

(Cal-IPC) California Invasive Plant Inventory. 2009. California Invasive Plant Council (Cal-IPC), www.cal-ipc.org. Website referenced April 2020.

Calflora. Information on California plants for education, research and conservation, with data contributed by public and private institutions and individuals, including the Consortium of California Herbaria. 2020. Berkeley, California: The Calflora Database. Available: https://www.calflora.org/ (Accessed: April 2020).

Conway, C. 2008. "Standardized North American Marsh Bird Monitoring Protocols." Arizona Cooperative Fish and Wildlife Research Unit, Wildlife Research Report 01.

(CRC and TBF) Coastal Restoration Consultants, Inc., and The Bay Foundation. 2020. Malibu Living Shoreline Project: Baseline Assessment and Site Characterization. Report produced for California Coastal Commission, City of Malibu, LA County Department of Beaches and Harbors, and California Coastal Conservancy. 33 pp.

Dagit, R., and Resource Conservation District of Santa Monica Mountains. 2018. Summary of Tidewater Goby Activities, Santa Monica Bay, Los Angeles County. Technical Report prepared for Permit TE-811188 for Ventura, CA, US Fish and Wildlife Service. 23 pp.

Dugan, J.E., D.M. Hubbard, and G. E. Davis. 1990. Sand Beach and Coastal Lagoon Monitoring Handbook. Channel Islands National Park California. Prepared for the National Park Service, Ventura, California. 50 pp.

Dugan, J.E., D.M. Hubbard, M. McCrary, M. Pierson. 2003. "The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California." Estuarine, Coastal and Shelf Science 58S: 25-40.

Dugan, J.E., Hubbard, D.M., Rodil, I.F., Revell, D.L., and Schroeter, S. 2008. Ecological effects of coastal armoring on sandy beaches. 2008. Marine Ecology. 29(1): 160-170

Dugan, J.E., D.M. Hubbard. 2010. "Loss of coastal strand habitat in southern California: the role of beach grooming." Estuaries and Coasts, 33(1): 67-77.

Dugan, J.E., D.M. Hubbard, K.J. Nielsen, J. Altstatt, and J. Bursek. 2015. Final Report: Baseline Characterization of Sandy Beach Ecosystems along the South Coast of California. Prepared for the South Coast Marine Protected Area Baseline Program. 134 pp.

Gilburn, A.S. 2012. "Mechanical grooming and beach award status are associated with low strandline biodiversity in Scotland." Estuarine, Coastal and Shelf Science. 107:81-88

Grifman, P.M., J.F. Hart, J. Ladwig, A.G. Newton Mann, M. Schulhof. 2013. "Sea Level Rise Vulnerability Study for the City of Los Angeles." USCSG-TR-05-2013.

Griggs, G. and K. Patsch. 2018. Natural changes and human impacts on the sand budgets and beach widths of the Zuma and Santa Monica littoral cells, Southern California. Shore and Beach 86(1): 1-14.

Goossens, D. Z. Offer, and G. London. 2000. Wind tunnel and field calibration of five aeolian sand traps. Geomorphology 35: 233-252.

Hubbard, D.M., J.E. Dugan, N.K. Schooler, S.M. Viola. 2013. Local extirpations and regional declines of endemic upper beach invertebrates in southern California. http://dx.doi.org/10.1016/j.ecss.2013.06.017

Johnston, K.K., Medel, I.D., Anderson, S., Stein, E., Whitcraft, C., and Crooks, J. 2015b. California Estuarine Wetland Monitoring Manual (Level 3). Prepared by The Bay Foundation for the United States Environmental Protection Agency. pp 297.

(LACDBH) Los Angeles County Department of Beaches and Harbors. 2016. Final Report: Los Angeles County Public Beach Facilities Sea-Level Rise Vulnerability Assessment. Prepared by Noble Consultants-G.E.C., Inc. 117 pp.

National Oceanic and Atmospheric Administration Coastal Services Center, 2012. Incorporating Sea Level Change Scenarios at the Local Level, a companion report for Technical Considerations for Use of Geospatial Data in Sea Level Change Mapping and Assessment.

Nordstrom, K.F., Jackson, N.L., and Korotky, K.H. 2011. "Aeolian transport across beach wrack." Journal of Coastal Research. 1(59):211-217

Nordstrom, K.F., Jackson, N.L., Korotky, K.H., and Puleo, J. 2011. "Aeolian transport rates across raked and unraked beaches on a developed coast." Earth Surfaces, Processes, and Landforms. 36:779-789

Nordstrom, K.F., Jackson, N.L., Freestone, A.L., Korotky, K.H., and Puleo, J. 2012. "Effects of beach raking and sand fences on dune dimensions and morphology." Geomorphology. 179:106-115

Orme, A.R., G.B. Griggs, D.L. Revell, J.G. Zoulas, C.C. Grandy, and J. Koo, 2011. Beach changes along the southern California coast during the twentieth century: A comparison of natural and human forcing factors. Shore & Beach, 79(4): 38-50.

Rios Clemente Hale Studios and Coastal Restoration Consultants. August 2019. Draft Restoration Plan for Zuma Lagoon and Point Dume Beach in Malibu, CA. Final Concept Package and Restoration Plans for Malibu Living Shoreline Project.

Schlacher, T.A, Dugan, J., Schoeman, D.S., Lastra, M., Jones, A., Scapini, F., McLachlan, A., and Defeo, O. 2007. "Sandy beaches on the brink." Diversity and Distributions. 13:556-560

TBF. 2015a. Level 2 Photo Point Standard Operating Procedures (SOP 7.2). Unpublished protocols. The Bay Foundation, Los Angeles, CA. 30 June 2015.

TBF. 2015b. Vegetation Cover Surveys Standard Operating Procedures (SOP 3.2). Unpublished protocols. The Bay Foundation, Los Angeles, CA. 30 June 2015.

TBF. 2015c. Vegetation Seed Bank Standard Operating Procedures (SOP 3.4). Unpublished protocols. The Bay Foundation, Los Angeles, CA. 30 June 2015.

TBF. 2015d. Bird Abundance and Activity Standard Operating Procedures (SOP 5.1). Unpublished protocols. The Bay Foundation, Los Angeles, CA. 30 June 2015.

United States Fish and Wildlife Service (USFWS). 2007. "Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*)." In 2 volumes. Sacramento, California. xiv + 751 pages.

United States Fish and Wildlife Service (USFWS). 2012. Department of the Interior. Federal Register / Vol. 77, No. 118. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Pacific Coast Population of the Western Snowy Plover.

United States Fish and Wildlife Service (USFWS). 2013. Department of the Interior. Federal Register / Vol. 78, No. 25. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Tidewater Goby.

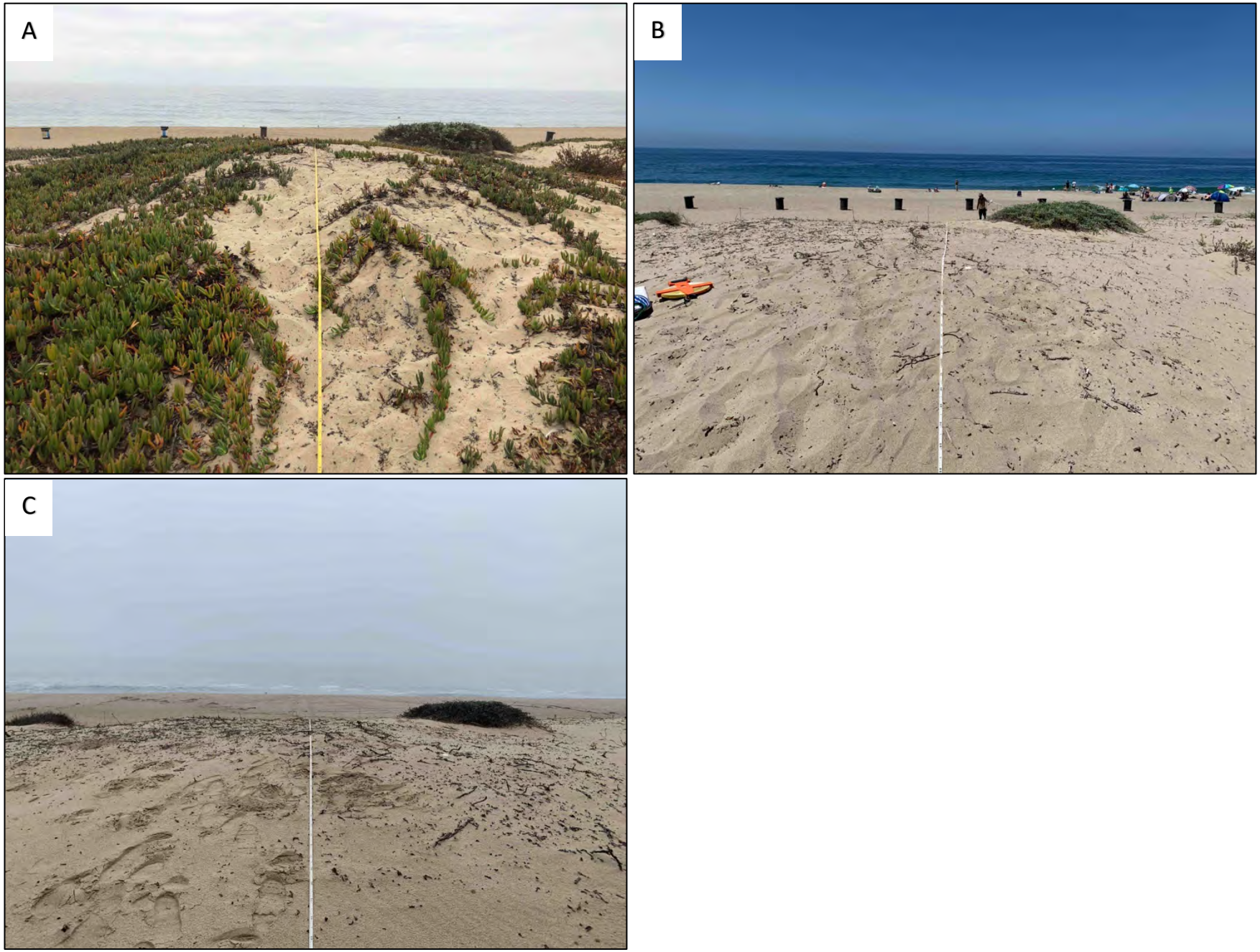


Figure A-1. Photo Point 1 on (A) 09 October 2020; (B); 11 June 2021; (C) 05 November 2021.

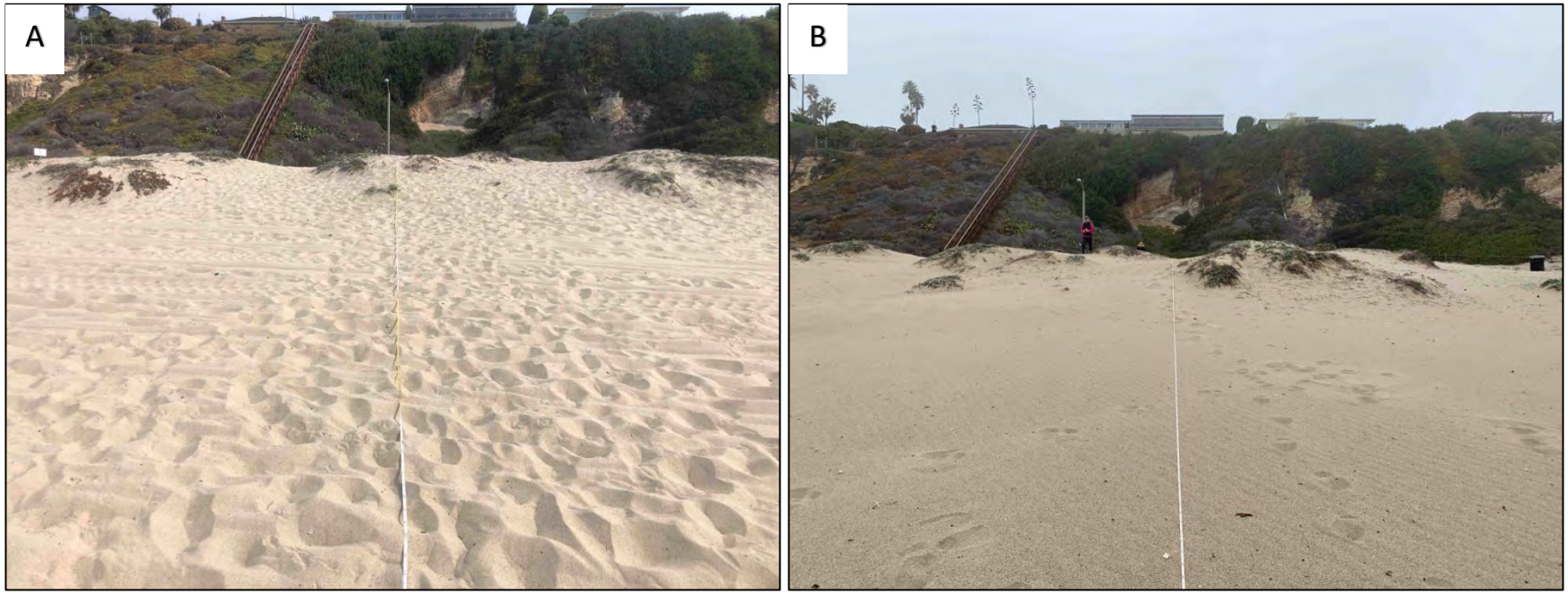


Figure A-2. Photo Point 2 on (A) 09 October 2020 and (B) 05 November 2021.

Figure A-3. Photo Point 3 on (A) 09 October 2020; (B); 18 June 2021; (C) 05 November 2021.

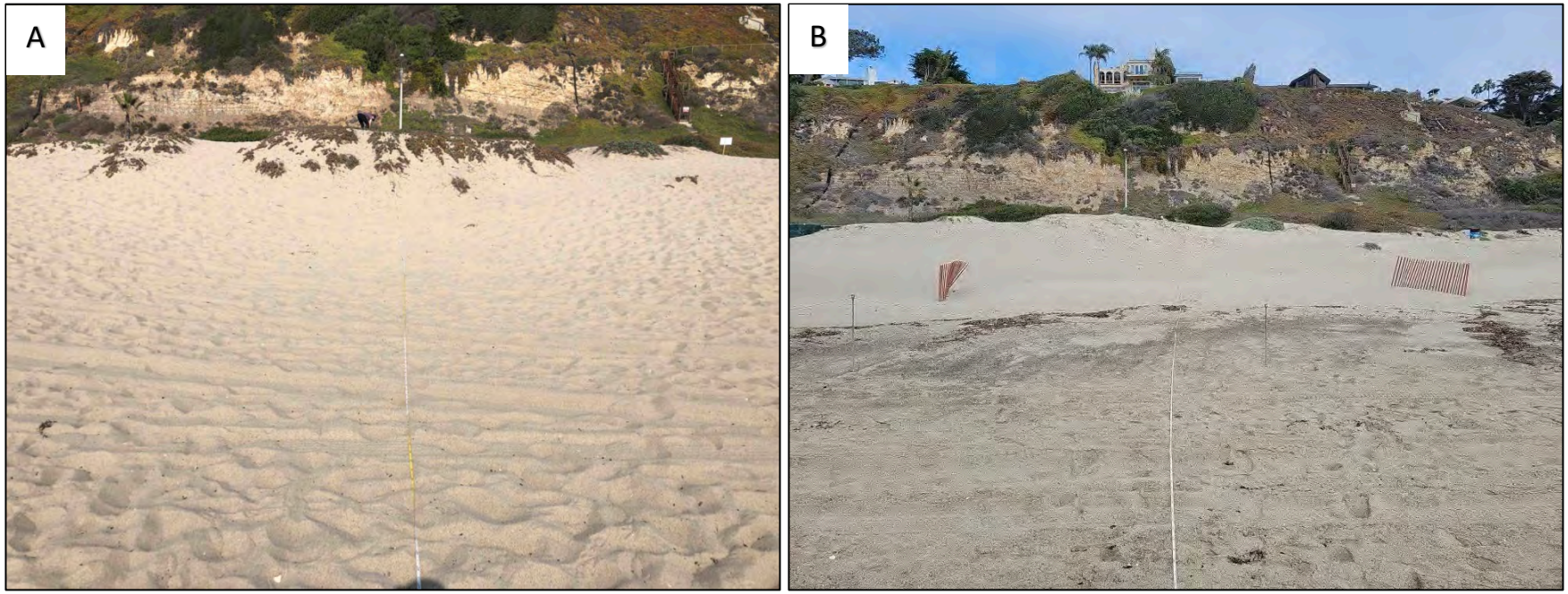


Figure A-4. Photo Point 4 on (A) 02 October 2020 and (B) 09 November 2021.

Figure A-5. Photo Point 5 on (A) 09 October 2020; (B); 18 June 2021; (C) 09 November 2021.

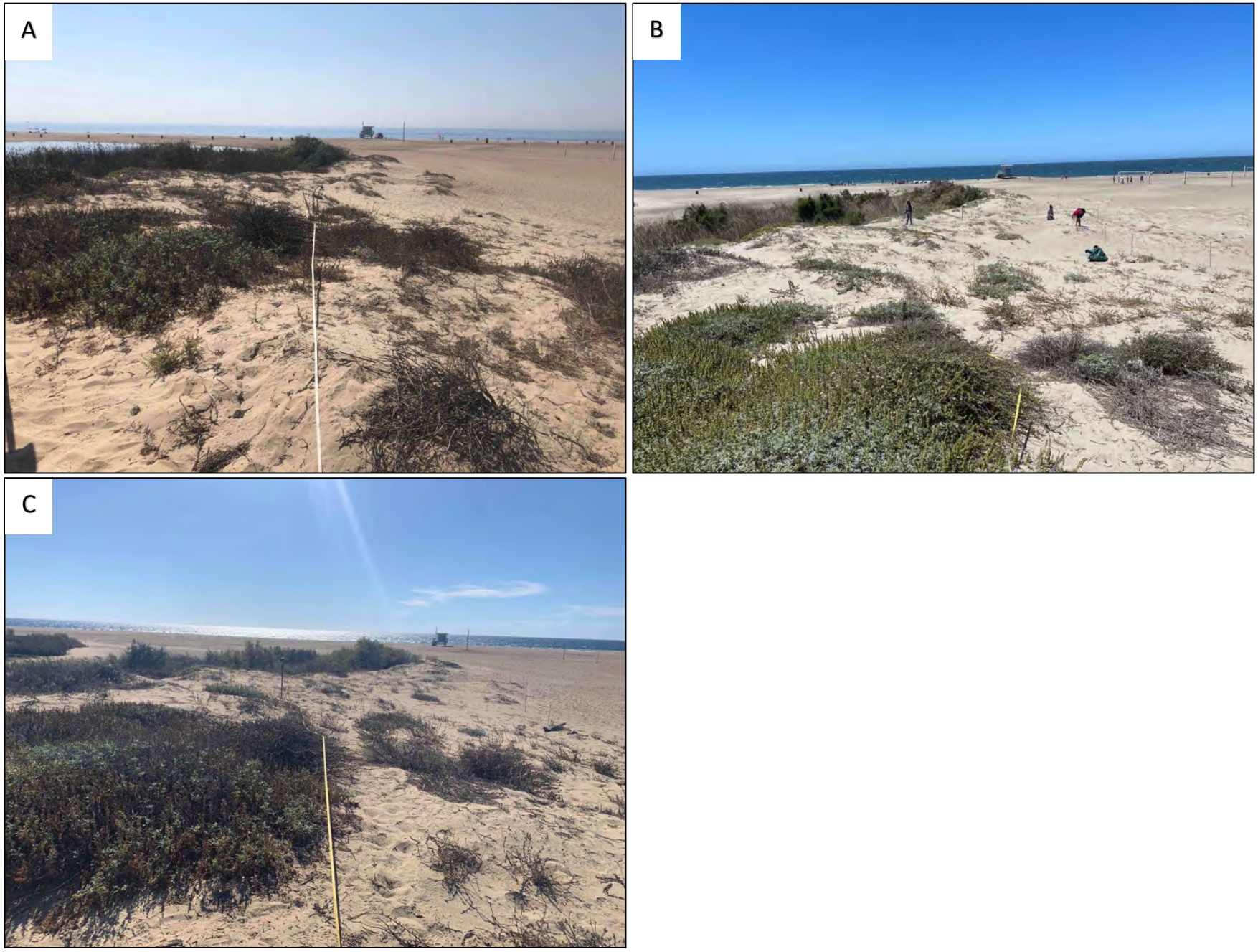


Figure A-6. Photo Point 6 on (A) 02 October 2020; (B); 10 June 2021; (C) 20 October 2021.

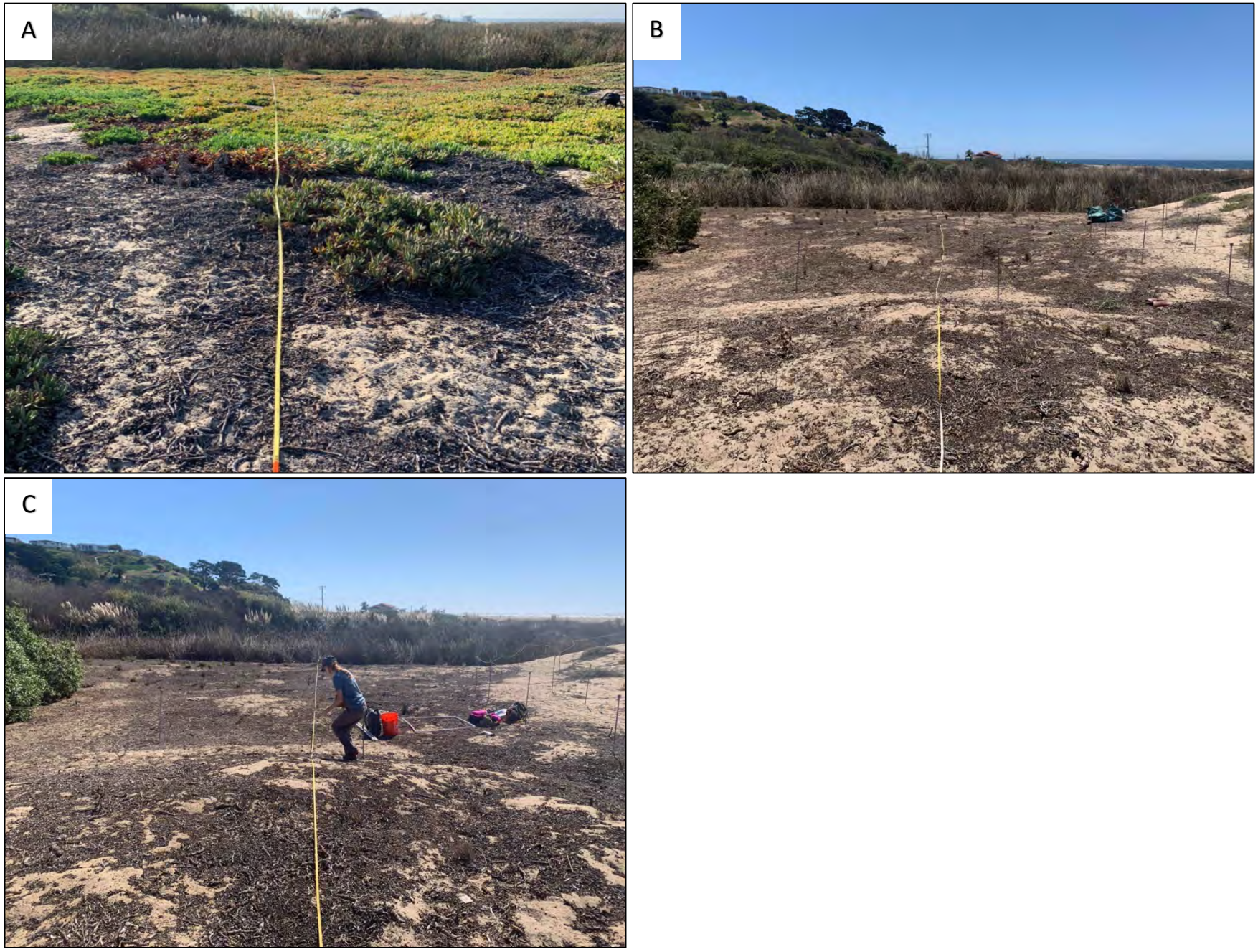


Figure A-7. Photo Point 7 on (A) 15 October 2020; (B); 10 June 2021; (C) 20 October 2021.

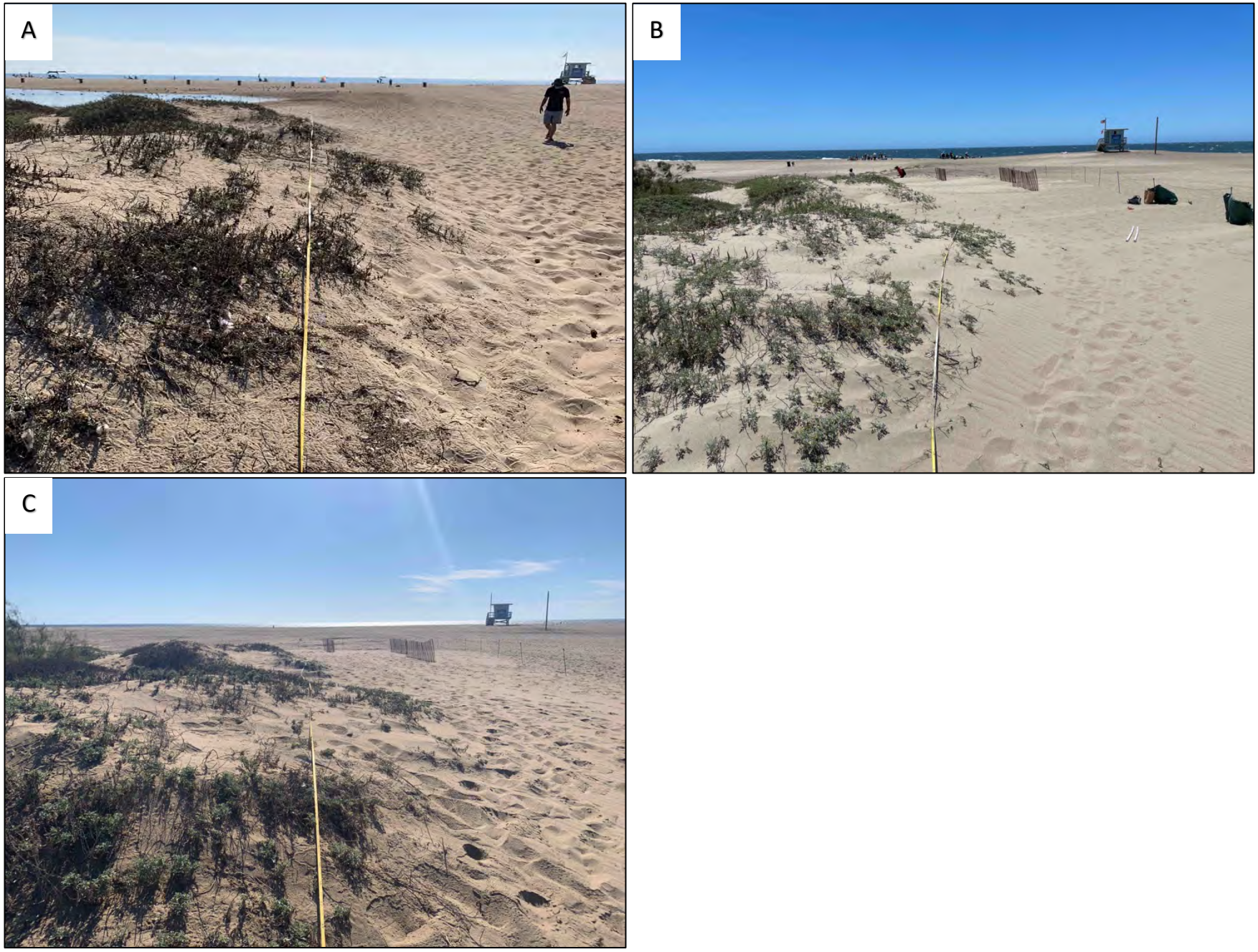


Figure A-8. Photo Point 8 on (A) 15 October 2020; (B); 10 June 2021; (C) 20 October 2021.