Malibu Living Shoreline Project
Annual Report

August 2023


Photo: A Tower

Prepared by:

Alexandra Tower, Jordan Arney and Mai Griffith and K Plouffe and M. Jazmín Rios of The Bay Foundation

Prepared for:

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

Suggested Citation:

Tower, JA, MJ Rios, K Plouffe, J Arney and M Griffith. 2023. Malibu Living Shoreline Project Years 2 and 3 Annual Report. Technical report prepared by The Bay Foundation for the California Coastal Commission, City of Malibu, Los Angeles County Department of Beaches and Harbors, and California Coastal Conservancy. 26 pages.

Acknowledgements:
We would like to thank the California State Coastal Conservancy for funding this coastal dune restoration project, and our partners: Los Angeles County Department of Beaches and Harbors and the City of Malibu. Additionally, significant credit goes to Rios Clementi Hale Studios and Coastal Restoration Consultants, Inc., for providing many of the baseline assessments for this report. We are grateful to Tom Ford, other scientists and the LA Conservation Corps who contributed to the planning and implementation efforts. Research, monitoring and maintenance were accomplished with the help of student-interns, including from Loyola Marymount University's Coastal Research Institute, Marymount High School, and Santa Monica High School. Additionally, we recognize and acknowledge that the restoration sites are on the ancestral homeland of the Chumash and Micqanaqa'n peoples. We pay respects to their elders past and present, and we hold in the highest regard their strength, perseverance, and resilience. Sections of this document are revised from the Malibu Living Shoreline Project Implementation and Monitoring Plan; please see that document for additional restoration planning details (Rios Clemente, 2019).

In addition to the partners listed above, we are also grateful for the many advocates of this project, including but not limited to: the California Coastal Commission, 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 continued support allows us to continue to explore nature-based adaptation ("living shoreline") to defend shorelines in the face of sea level rise induced by climate change, while bringing back an important coastal ecosystem 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.

Table of Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

Introduction

The purpose of this project is to transform 3.26 acres of coastal habitat on Zuma, Westward and Point Dume Beaches in Malibu, CA, into a non-contiguous California native plant, coastal dune system that not only beautifies the Malibu coast, but also provides a nature-based defense in the face of impending sea level rise due to the climate crisis. Historically, dune systems were a prominent feature of the Malibu area; over time with increased development and urbanization, these dune features disappeared. More recently, this area is managed by the Los Angeles County Department of Beaches and Harbors. This restored shoreline project was implemented as an alternative to traditional hardscaping practices for defending the coastline against the effects of storm surge and rising sea level.

Pre-restoration monitoring was completed prior to December 2020. Initial restoration activities were conducted December 2020 through February 2021 on 1.02 acres at the Zuma Beach site, adjacent to the Zuma Lagoon, and 2.24 acres at the Point Dume Beach sites. Hand seeding occurred in the coastal strand and foredune, back dunes and dune transition habitats at Zuma Beach and Point Dume Beach in Winter 2020-21. More than 500 individual CA native plants in container stock were introduced to expedite native vegetation establishment at the Zuma site. Post-restoration adaptive management (i.e., supplemental watering, removal of non-native species, and biomimicry stake / sand fence repair) has continued throughout 2021, 2022 and 2023. The intense weather conditions of the 2022-2023 winter made site management mostly impossible, until we were able to return to the site in March 2023.

Post-implementation

The eastern-most part of the Zuma Beach was initially transformed from only 1-5% native cover and 75-95% non-native cover (dominated by iceplant (*Carpobrotus edulis, Aizoaceae*) to 6-15% native cover and 1-5% non-native cover in the Fall 2021, and 34% native cover in 2023. A similar trend was recorded at the Pt Dume restoration sites, starting with zero percent native plant cover in 2020, due to consistent mechanical grooming, followed by 4.3 percent cover in 2021 and increasing to 7.8 percent cover in 2023. Dune stability seems to be enhanced by the presence of the restoration areas, as do beach width and upper berm accretion. The public is generally supportive of this project. It is both beautiful and a helpful approach to defending the Malibu coastline.

Scientific Monitoring

TBF staff recommend long-term monitoring of this project with quantifiable success criteria to assess long-term effects of the project, as well as to inform adaptive management decisions. Currently, TBF staff suggest repeated seeding with native plant species to increase plant cover and plant diversity, which will, in turn, improve ecosystem stability and habitability by avifauna and other wildlife.

Conclusions and Recommendations

Since the first year of implementation, the project immediately met several success criteria. To continue, supplemental seeding and planting were done in winter 2022. Because maturation of sand dune ecosystems takes time, we anticipate the need for continued adaptive management for several

more years. Additionally, the project positively engaged the public and has widespread support, created new partnerships and outreach connections, restricted grooming and performed restoration activities. The first few years of monitoring data suggest that the site is performing well and that the restored areas are divergent from the unrestored comparison areas. Areas in Pt Dume that were once covered by invasive iceplant, or previously groomed, have native dune plants, but as expected, absolute native plant cover remains relatively low. We anticipate that the native plant community will continue to establish and mature over time, but will probably remain somewhat patchy, as is the norm for natural coastal strand and foredune habitats.

TBF staff are strongly committed to post-implementation monitoring, maintenance, and adaptive management for ensuring successful restoration efforts. Further, given that sea level continues to rise and storms are expected to intensify, TBF staff strongly recommend expanding upon dune restoration projects such as this along as much shoreline as possible.

Annual reports will continue to be made available for public download on TBF's website: www.santamonicabay.org.

Introduction

Background

Revegetation of coastal sand dunes with native plants has become increasingly important for improving biodiversity and wildlife habitat, and for creating a first line of defense against climate change-induced sea level rise and intensified wave action on the coast. In recent decades, sandy beaches have been managed as primarily recreation areas. Lately though, an attitude shift from municipalities and other agencies has begun, as they come to realize that sandy beaches serve as the interface between the marine and terrestrial environments. With climate change, Southern California beach systems and associated wildlife are under pressure 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 historically damaging maintenance activities. Such threats have led to the local extinction of many native species and loss of important ecosystem functions (Dugan et al. 2003, Schlacher et al. 2008, Dugan and Hubbard 2010, Hubbard et al. 2013). By restoring natural processes provided by healthy coastal ecosystems, we will improve their ecological and utilitarian functions, and serve as a model for similar projects statewide.

Beaches are broadly recognized and highly valued as cultural and economic resources for coastal regions (Dugan et al. 2015), and Los Angeles County beaches are some of the most recognizable and popular beaches in the world with upwards of 70 million visitors annually (LACDBH 2016). Since the 1960s, most of the beaches in the Los Angeles area have been subjected to the continuous removal of natural features as they begin to develop. In April 2016, Los Angeles County published the LA County Public Beach Sea-Level Rise Vulnerability Assessment, which identified areas most at risk. The assessment suggested that Malibu could lose up to 50% of beachfront by 2040, and up to 70% by 2100. Similar findings have been reported statewide.

The Malibu Living Shoreline Project provides a cost-effective and low-impact solution to increase the resilience of the shoreline at Zuma, Westward and Point Dume County Beaches. The purpose of this project is to restore 3.26 acres of coastal habitats located at Zuma Beach and Point Dume Beach in Malibu, CA by introducing CA native plant species to transform portions of the current beaches into coastal strand and foredune habitat that could help defend the shoreline, making it more resilient to sea level rise (Appendix A). Coastal dunes can provide a cost-effective buffer system against threats like storm surges, sea level rise, and increased erosion. Further, as a vital part of the coastline, beaches and dunes support and protect coastal homes, roads, and infrastructure. Historically, large expanses of dunes once covered the coastal zone at both Zuma and Point Dume County Beaches. This project is an initial step toward the restoration and revegetation of Malibu beaches.

Project Goals

As a possible alternative to traditional hardscaping options, this project has established a living, restored shoreline with a diverse wildlife community. We continue to evaluate the full extent of the functional role of these restored dunes. Three specific goals of the Malibu Living Shorelines Restoration Project (MLSP) include:

1. increase shoreline resilience through the restoration of sandy beach and foredune habitat;
2. implement nature-based defense features, or 'living shoreline', against sea level rise and intensifying storms; and
3. increase community engagement through outreach, volunteer events and education.

Figure 1. Westward Beach with *Carpobrotus edulis* (Aizoaceae), a non-native, prior to restoration implementation.

Scientific Monitoring

The five-year monitoring plan for this project includes quantitative assessment of baseline and post-implementation site conditions to inform adaptive management actions (e.g., non-native plant removal and re-seeding) and assess progress toward success criteria. Expert ecological and restoration scientists have been consulted for both the design and implementation of the monitoring aspect of this restoration project. In addition, opportunistic research is being conducted in partnership with scientists from Loyola Marymount University's Coastal Research Institute and other universities.

The following is a summary of the protocols (table 1) and current results. For in-depth details on objectives and methodologies, refer to the Standard Operating Procedures in the California Estuarine Wetland Monitoring Manual (Johnston et al. 2015) and to Dugan et al. (2015).

Table 1. Summary of key parameters, protocols implemented, and survey dates, including the baseline survey. *This task is no longer being done.

<table>
<tr><th>Parameter</th><th>Protocol</th><th>Baseline Survey (2020)</th><th>Survey Dates Year 1 (2021)</th><th>Survey Dates Year 2 (2022)</th><th>Survey Dates Year 3 (2023)</th></tr>
<tr><td>Photo Point</td><td>Fixed photo locations</td><td rowspan="5">October</td><td rowspan="3">June
October
November</td><td rowspan="3">June</td><td rowspan="2">Aug</td></tr>
<tr><td>Vegetation Cover & Seedling Density</td><td>Quadrats along transects</td></tr>
<tr><td>Physical Characteristics</td><td>Elevation profiles; beach width</td></tr>
<tr><td>Wrack Cover</td><td>Percent cover</td><td rowspan="2">NA*</td></tr>
<tr><td>Sediment Grain Size</td><td>Sieve method</td><td>October
November</td><td>NA*</td></tr>
<tr><td>Avifauna & Pollinator</td><td>Presence and behavior</td><td colspan="4">Avian species observed were recorded on all field days</td></tr>
<tr><td>Weather & Sea Level</td><td>Archived NOAA Data</td><td colspan="4">As data sets are posted online</td></tr>
</table>

A total of 20 transects are monitored for vegetation and elevation profiles (Table 2; Appendix B). The restoration transect data were compared to those from the groomed sandy beach for differences in vegetation and elevation. The Zuma Creek habitat control transect (ZC1) is an established dune transition habitat in a stabilized dune system following restoration by CA State Parks several decades ago. Due to the differences in habitat type (i.e., vegetation cover amount and soil stability), the dune transition Zuma Beach restoration transect (Z2) is compared with ZC1 and considered independently from the Pt Dume restoration sites.

Table 2. Summary of the transects for vegetation and topographic surveys. *Transect areas lost to storm action and subsequent remediation efforts by Beaches and Harbors during winter 2023.

Location	Habitat Type	# transects		Transect names
		Restoration	Control	
Zuma Creek	Dune & Dune transition	1	1	ZC1
Westward	Groomed sandy beach	0	2	WC1, WC2
Pt Dume	Dune	9	5	PC1-4* & P1-7*, P3L & P5L

Individual Protocols and Results

Photo-Point

We used a high-resolution GPS to locate the eight permanent locations and established compass headings for photo point monitoring. The 2022 and 2023 photos showed a substantial reduction in non-native plants since the project began, primarily with invasive iceplant (*Carporbrotus edulis, Aizoaceae*) where it was a monodominant stand (Appendix C). Native plants have established well in many of the

restoration areas since implementation (ex: photo point 1, Appendix C1). The winter of 2023 was a great season for plant growth, but was also destructive to beach morphology. High tides coupled with intensified storm action washed away much of the sand, particularly in front of the area of transects P7 and PC4 (example: Appendix C2). These areas have been fortified with sand taken from other parts of Pt Dume Beach and rip-rap by LA County Beaches and Harbors (Fig. 4). Additional rounds of photo point monitoring are needed to assess potential topographical change in other parts of the restoration area.

Figure 4. Photo of 2023 after heavy winter storms and mitigation with rip-rap. Photo courtesy of LA County Beaches and Harbors.

Wrack Cover

Six line-intercept transects were surveyed in 2020 and 2021 for percent wrack cover, four of which are directly in front of the restoration sites and the other two in a control area at Westward Beach (Appendix B). We have observed no notable differences, regardless of positioning in front of restoration areas. Overwhelmingly, bare ground was the predominant observation, with *Macrocystis pyrifera* a distant second at 0.5-2.5% cover. Because the project does not extend to the high tide line or swash zone, it is no surprise that there is no effect on the wrack composition. For these reasons, this task is being abandoned.

Vegetation Cover

Absolute percent vegetation cover estimates are used to assess native and non-native vegetation. Species richness and diversity are assessed, using 1m^2 fixed quadrats every 5m along 25m transects (Fig. 5). Species were classified as native or non-native. The average absolute percent cover of native and non-native plants in restored and unrestored areas were calculated as described in SOP 3.2 Vegetation Cover Surveys (TBF 2015b).

Figure 5. Image of quadrat used for percent cover surveys.

In Zuma, the native species in the restored area have responded remarkably since implementation, with 0.9% absolute native plant cover in 2021, 10.9% in 2022, and up to 34.5% in 2023. This is accompanied by minimal non-native absolute cover (0.1%, 0.2% and 3.3%, respectively; Fig. 6). The unrestored comparison area was already a mature plant community, with 63.5% absolute native plant cover as the baseline in 2020. Although native plant cover in the comparison area declined during years 1 and 2 (48.5% & 36.2%, respectively), the native plant absolute cover rose to 84% in year 3, attributed to the exceptional 2023 rainfall season. The comparison area is a well-established native vegetation community, resulting from a restoration effort conducted by CA State Parks in the 1990's. The current project will likely take years for the restoration site to accumulate similar native plant cover.

Absolute cover of native species in the Pt. Dume restoration area has steadily increased since implementation in 2020 to 7.8% (Fig. 6, below). Average absolute native cover increased from 2.4% in the baseline survey to 4.3% in year 1 (2021), declined slightly to 3.4% in 2022 and increased greatly to 7.8% in year 3 (2023). Meanwhile, average absolute non-native cover remained at or near zero until year 2 (2022), when it increased to 4.9%, but in year 3 the non-native absolute cover declined to 0.5% (Fig. 6, below). With the help of some intermittent weeding in Pt Dume, the unrestored areas continue to have little plant growth, with *C. edulis* and *C. maritima* being the only species observed. While species richness and diversity in the Pt Dume restoration areas remain low, we expect both to continue increasing over time, but that bare sand cover will be a major component of these areas, even as the communities mature. The modest non-native cover observed during the 2023 survey were subsequently pulled during maintenance days by TBF staff. The removal of non-native species will likely need to continue while the native vegetation gets better established.

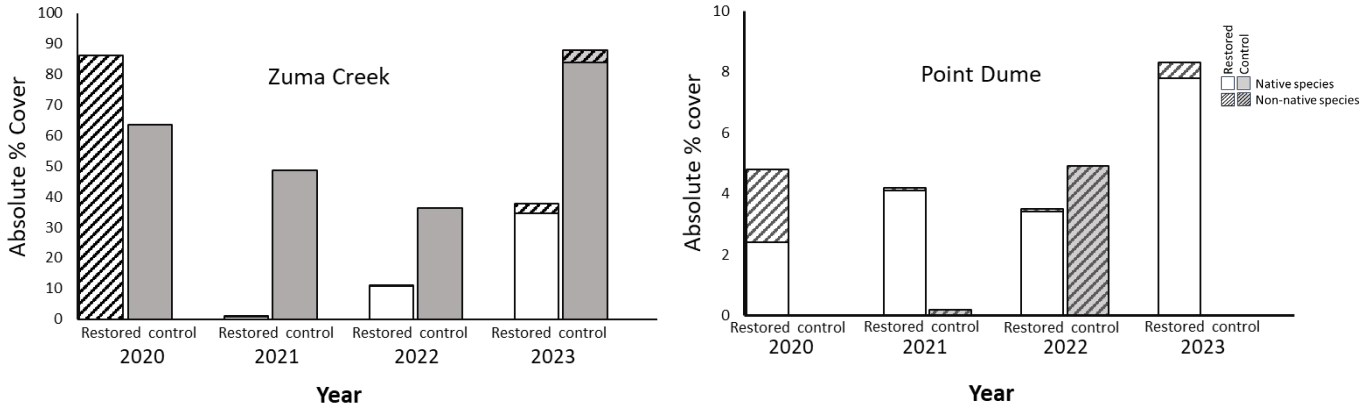


Figure 6. Average percent cover of native (solid bars) and non-native (hashed bars) species in restored and unrestored areas of from Zuma (left) and Pt Dume Beach (right) the baseline surveys (2020) through Summer 2023. Note the difference in scale between the two panels.

Figure 7. Seedling of CA native Beach Evening Primrose (*Camissoniopsis cheiranthifolia*, Onagraceae), which was the most common species observed in the seedling census of 2023.

Seedling Densities

Seedling recruitment was largely unsuccessful in both restoration areas in 2022, with only one individual of Beach Bur, (*Ambrosia chamissonis*, Asteraceae) observed in Pt Dume (in then transect P4). In contrast, many more seedlings recruited in 2023. All seedlings observed in Pt Dume were CA natives located in the restoration polygons, 21 of which were Beach Evening Primrose (*Camissoniopsis cheiranthifolia*, Onagraceae). A single seedling of *A. chamissonis* was also observed in Pt Dume. In contrast, slightly greater seedling recruitment was observed in the Zuma restoration area, coupled with 2 seedlings also observed in the comparison area (transect ZC1; table 3).

Table 3. Seedling recruitment transect observations from the Zuma Creek area (August 2023). *This species is listed in the California Code of Regulations Section 4500 list of California State Noxious Weeds.

Species identification	Native?	# observed	Zuma Area
Encelia Californica (Asteraceae)	Yes	2	Control
Camissoniopsis cheiranthifolia (Onagraceae)	Yes	22	Restored
Ambrosia chamissonis (Asteraceae)	Yes	13	Restored
Salsola tragus (Chenopodiaceae)	No*	3	Restored

Vegetation Mapping

Vegetation mapping uses a combination of aerial imagery, high-resolution Trimble GPS, with emphasis on in-situ observations to delineate species composition in the study areas. Vegetation mapping protocols are described in more detail in SOP 3.5 Vegetation Mapping (TBF 2015c). Maps for 2023 focus on the location of and relative area occupied by each species within the study areas (Appendix D). While species richness of native species was on the rise, a lower species richness was observed in 2023 (table 4).

Table 4. Native and non-native species identified in vegetation surveys.

Common Name	Species	Fall			
		2020	2021	2022	2023
Red sand verbena	*Abronia maritima*	X	X	X	
Pink sand verbena	*Abronia umbellata*	X	X	X	
Beach bur	*Ambrosia chamissonis*	X	X	X	X
California sagebrush	*Artemisia californica*		X	X	
Big saltbush	*Atriplex lentiformis*			X	
Beach saltbush	*Atriplex leucophylla*			X	
Coyote Bush	*Baccharis pilularis*			X	X
Beach evening-primrose	*Camissoniopsis cheiranthifolia*	X	X	X	X
California croton	*Croton californicus*		X		
California brittlebush	*Encelia californica*			X	X
Seacliff buckwheat	*Eriogonum parvifolium*	X	X	X	X
California poppy	*Eschscholzia californica*		X	X	
Telegraph weed	*Heterotheca grandiflora*	X	X		
Goldenbush	*Isocoma menziesii*	X		X	
Giant coreopsis	*Leptosyne gigantea*		X		
Lemonade berry	*Rhus integrifolia*		X	X	
	Total number of CA natives	**7**	**11**	**13**	**5**
Black mustard	*Brassica nigra*	X			X
Iceplant	*Carpobrotus edulis*	X	X	X	X
Sea rocket	*Cakile maritima*	X	X	X	X
Bermuda grass	*Cynodon dactylon*	X	X	X	
Geraldton carnation weed	*Euphorbia terracina*	X	X		
Hairy cats ear	*Hypochaeris radicata*				
Crown daisy	*Glebionis coronaria*	X			
Crystalline ice plant	*Mesembryanthemum crystallinum*			X	
Castor bean	*Ricinus communis*	X	X		
Russian thistle	*Salsola tragus*	X	X	X	X
Sow thistle	*Sonchus oleraceus*	X			
	Total # of non-natives	**9**	**6**	**5**	**4**

It is important to note that just outside the restoration area at Zuma Creek, there are three non-native species that should be removed. The first is a large stand of mousehole tree, (*Myoporum laetum*, Myoporaceae), which is a fast-growing tree that seems to have attained its supposed max height (~10m), and easily spreads. This stand is currently home to a community of unhoused people. The second is a rapidly growing thicket of saltcedar (*Tamarix ramosissima*, Tamaricaceae) growing along both banks of Zuma Creek, which has a California Invasive Plant Council (Cal-IPC) rating of "high", which means that this species has severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. The reproductive biology and other life history attributes are conducive to high rates of dispersal and establishment (URL: Cal-ipc.org). The third species of concern is Pampas grass (*Cortadeira selloana*, Poaceae), which is currently isolated to the south side of Zuma Creek, but it has a Cal-IPC rating of "high" and will surely recruit to the restoration area if not removed. Each of these species is of great concern to us, and we have alerted the City of Malibu, State Parks and LA County Beaches and Harbors.

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). Bird presence, species, number, behavior, and proximity to site were recorded opportunistically on all monitoring days to characterize bird species utilizing the site. Frequently observed species include gulls (*Larinae spp.*), and land-based species (e.g., American crow, *Corvus brachyrhynchos* and red-tailed hawk, *Buteo jamaicensis*; Figure 8).

Figure 8. Select species observed during avian surveys. Western gull (Larus occidentalis; left), and red-tailed hawk (Buteo jamaicensis; right).

Western snowy plovers (*Charadrius nivosus nivosus*), a federally threatened species of bird, were also observed in a pre-restoration survey adjacent to the restoration area, and again in the roosting site 1,300m northeast of the Zuma site in surveys conducted by LA Audubon and Ryan Ecological Consulting (Table 5). 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. According to LA Audubon reports, *C. nivosus nivosus* populations were down in the Malibu area in 2023. However, the project has the potential to provide future indirect benefits for the plovers, and it will be monitored for future status updates.

Table 5. Avifauna species identified as present in or above the restoration areas.

Category	Common Name	Scientific Name	Restoration
Gull/Tern	California Gull	*Larus californicus*	X
	Gulls	*Larinae spp.*	X
	Western Gull	*Larus occidentalis*	X
inland	American Crow	*Corvus brachyrhynchos*	X
	Anna's Hummingbird	*Calypte anna*	X
	Black Phoebe	*Sayornis nigricans*	X
	California Towhee	*Melozone crissalis*	X
	House Finch	*Haemorhous mexicanus*	X
	Red-tailed Hawk	*Buteo jamaicensis*	X
	White-crowned Sparrow	*Zonotrichia leucophrys*	X

Additional Associated Wildlife

Other wildlife, including species of pollinators such as butterflies or bees, were also recorded as part of these surveys (table 6). During observations, there were no species of concern recorded.

Table 6. 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
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

Physical Characteristics

Beach width and Elevation profiles were recorded using transect tape, elevation poles and the Nikon AP-8 Automatic Level viewfinder. Between 2020-2022, sections of Pt Dume beach associated with restored areas were slightly wider, relative to unrestored areas along the same stretch of beach and Westward Beach (Fig. 9). Beach width along all study areas sharply contracted during the winter storms of 2023 (Fig. 10). The restored areas seem to have been more stable with much less variation than the unrestored areas (Fig. 9). This contraction was so severe in the transition area between Westward and Pt Dume beaches that LA County Beaches and Harbors reinforced that section of coastline with rip-rap (Fig. 11).

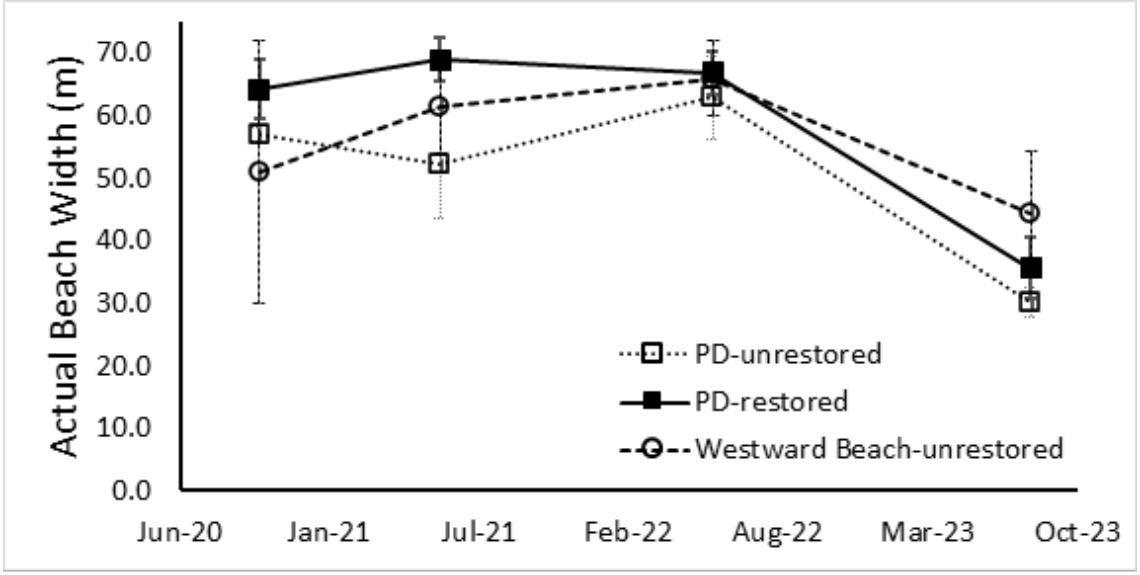


Figure 9. Mean beach width (m) as a function of time at Pt Dume (squares) and Westward Beach (circles). Restored areas (closed squares) at Pt Dume are distinguished from unrestored areas (open symbols). Error bars indicate the standard error of the mean.

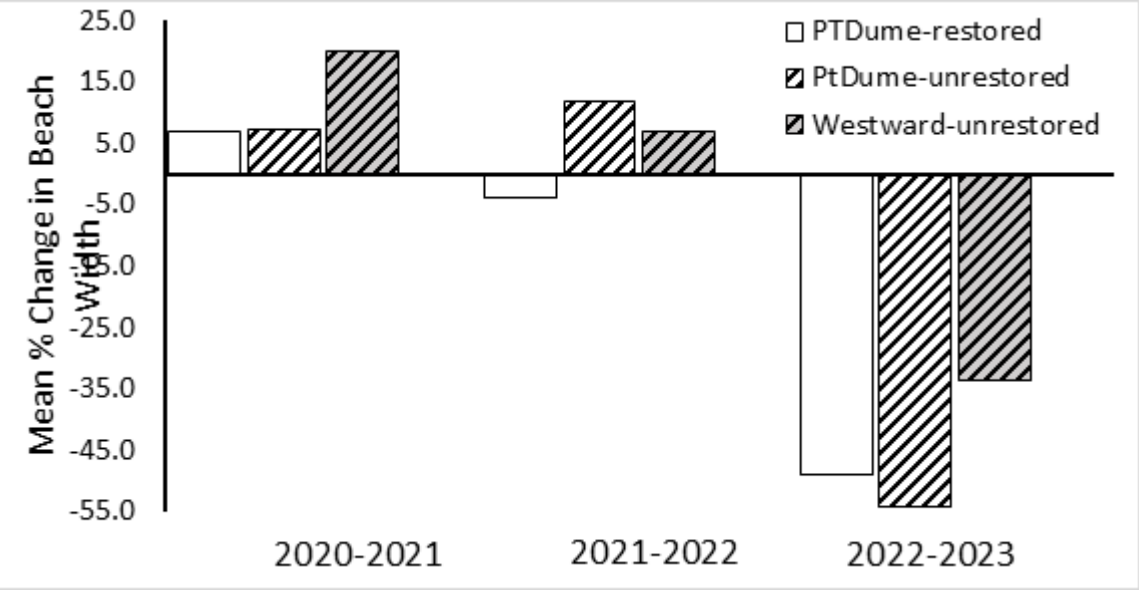


Figure 10. Mean percent change in beach width from year to year in restored areas (open bars) and unrestored areas (hashed bars) in Pt Dume Westward Beach (gray hashed bars).

Although there were minor physical differences across sites and little variation in elevation profiles from Fall 2020 to Fall 2021, there were big changes in beach elevation profiles from 2021 to 2022, and again from 2022 to 2023 (Appendix E). The restored areas seem to have lost less sand than the unrestored areas. It remains to be seen if the beaches will recover during subsequent seasonal replenishment, but these results suggest that dune restoration has the potential to defend sandy coastlines from intensified

storm action. Unfortunately, the point between Westward and Pt Dume beaches (where the north toilets are located) will likely not see any replenishment with the newly installed rip-rap (Fig 11).

Figure 11. Photo of the transition area between Westward and Pt Dume Beaches, showing the narrow beach and newly installed rip-rap after the 2023 Winter storm damage.

Weather, Tides and Sea Level

Because there is no reliable weather station in the Malibu area, and this site is equidistant from the Pt Mugu and Santa Monica weather stations, data from both are included here (Appendix F). The highest high tide, monthly precipitation and mean sea level were downloaded from the NOAA online database and summarized (NOAA: Climate Data Online). At Pt Mugu, total annual rainfall ranged from 12.76mm in 2021 to 44.02mm in 2022 and 38.34mm in 2023. The annual rainfall in Santa Monica was slightly higher than in Pt Mugu in 2021 (17.15mm), but it was dramatically higher than Pt Mugu in 2022 and 2023 (135.1mm and 639.83mm, respectively). Please note at the writing of this report, there are still three months left in 2023, and it is possible that both sites will receive more rainfall before year end. Rainfall is not only higher in 2023, but it falls during more intense storms. When these intense storms drop considerable amounts of rain and bring with them large surf, the coastline gets battered, particularly if these storms coincide with the occasional high-high tides. It is encouraging that after the winter of 2023, the beaches in front of the restored areas have done as well as they have.

Success Criteria Evaluation

Restoration success criteria support the project's objectives and facilitate information dissemination within and beyond California, specifically for living shoreline projects. These criteria are used to evaluate if, and when, the project goals have been met to quantify the short-term effectiveness and long-term sustainability of restored physical and biological ecosystem processes.

These criteria serve to inform planning for adaptive site management. For this specific project, the restoration success criteria evaluate the recovery levels of dune and riparian transition vegetation., as detailed in Table 6.

Table 7. Success criteria, percent absolute cover, species richness, native-to-non-native ratios, beach elevation profiles and community engagement for the Malibu Living Shoreline Project.

Criteria	Metric	5-Year Target	Year 1	Year 2	Year 3
Non-natives	Absolute cover	< 15% (invasives < 5%)	✓	✓	✓
Natives		PD ≥15%	×	×	PD ×
		ZC ≥30%			ZC ✓+
Native : Non-native	Ratio	≥ 5.6 : 1	×	PD ×	✓
				ZC ✓+	
Elevation Profiles	Relative elevation	sand accretion	×	+	+
Community Volunteers	Annual Numbers & hours	> 50 per year	✓+	✓+	×

× = Not Met, + = Improved, ✓= Criterion Met, ✓+ = Criterion Exceeded

Adaptive Management, Maintenance, and Site Use

Adaptive management is an important component of biological restoration work, and in this case, is implemented based on interpretations of the monitoring results by TBF, beach managers, LACDBH, and the City of Malibu. Particularly in dynamic areas such as Zuma Lagoon and Point Dume Beach, where high levels of visitation and changing management strategies, this approach will lead to better outcomes. Although the COVID-19 Pandemic made it impossible to involve the public as much as we had hoped, future maintenance should be strongly supported by volunteers and interns, as well as LACDBH, City of Malibu, or other partners and project supporters. Public events should include the removal of both trash and non-native species.

In Years 1 and 2, *C. cakile* and *C. edulis* were the primary species targets for hand removal during site maintenance days. We anticipate that the need for hand removal of such weeds will continue for several years while the native vegetation matures and the non-native seed bank is depleted. To encourage further establishment of native species, we suggest the addition of more seed stock at least once more. Other non-native species that will continue to require hand removal include Bermuda grass, Geraldton carnation weed, castor bean and Russian thistle. The invasive weeds along Zuma Lagoon require mechanized removal, and we hope to work with partners to determine the least destructive path toward accomplishing it as soon as possible.

There have been minor challenges associated with some of the unhoused individuals around the Zuma Beach project area. In addition to some of the accumulation of trash, project perimeter ropes and posts have been vandalized and used for personal purposes. There is an encampment in the *Myoporum* stand adjacent the Zuma Beach access road, and partners have been notified. Moving forward, it will be important to find a solution to this ongoing violation of property.

Although interpretive signage was installed in Spring 2022, it will be important to continue to engage the public in creative ways to not only enhance the beach experience for visitors but also cultivate stewardship through education about the importance of natural dune systems and coastal resilience.

Conclusions and Recommendations

Since the first year after project implementation, the formation of sand hummocks and increased diversity and cover of CA native species has steadily increased in the restoration sites located in both Zuma Creek and Pt Dume Beaches. We expect the native vegetation to continue spreading to ultimately reflect the maturity and stability of a fully developed coastal strand and foredune habitat. The elevation profiles in the restored areas are widening at the upper berm and are expected to continue to widen shoreward. Early public support and new partnerships continue as the project not only enhances the resilience of the beach but also beautifies it while educating the public about its importance.

TBF is committed to working closely with LA County Beaches and Harbors to mitigate the storm damage that will ultimately play a role in the long-term defense of the Malibu coast. Supplemental seeding and more volunteer events are recommended to further meet success criteria. TBF is committed to science-based dune creation and restoration, followed by thorough and reproduceable monitoring and adaptive management for the purposes of increasing coastal biodiversity and expanding nature-based coastal resilience to sea level rise and intensified wave action. We are encouraged by the increased native plant cover and diversity, by the slight retention of beach width in restored areas, as well as the accumulation of sand in the widening berm of restored areas. Though these results are still early in the establishment of these coastal dunes, we are buoyed by the trend toward a nature-based solution to the very real threat of coastline erosion.

With more than 17 million visitors a year, and countless recreational opportunities, not to mention the $1.5 billion economy associated with the southern California coast, it is imperative that we work together to defend it. With rising sea level and intensifying storms and waves, our best option for retaining sandy beaches is to create and restore coastal dune ecosystems. It is the most cost-effective approach, and once established and mature, these ecosystems are not only beautiful, but also effective.

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.

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.

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.

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. http://www.santamonicabay.org/california-estuarine-wetlands-monitoring-manual-level-3/

(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.

NCEI, N. C. for E. I. (2021). Observational data map of daily weather stations networks from around the world. https://gis.ncdc.noaa.gov/maps/ncei/cdo/daily

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.

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.

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.

Appendices

Appendix A: Site Description

Both Zuma Beach and Point Dume Beach are 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, 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 A1. Overview map of both restoration areas implemented as part of the Malibu Living Shoreline Project.

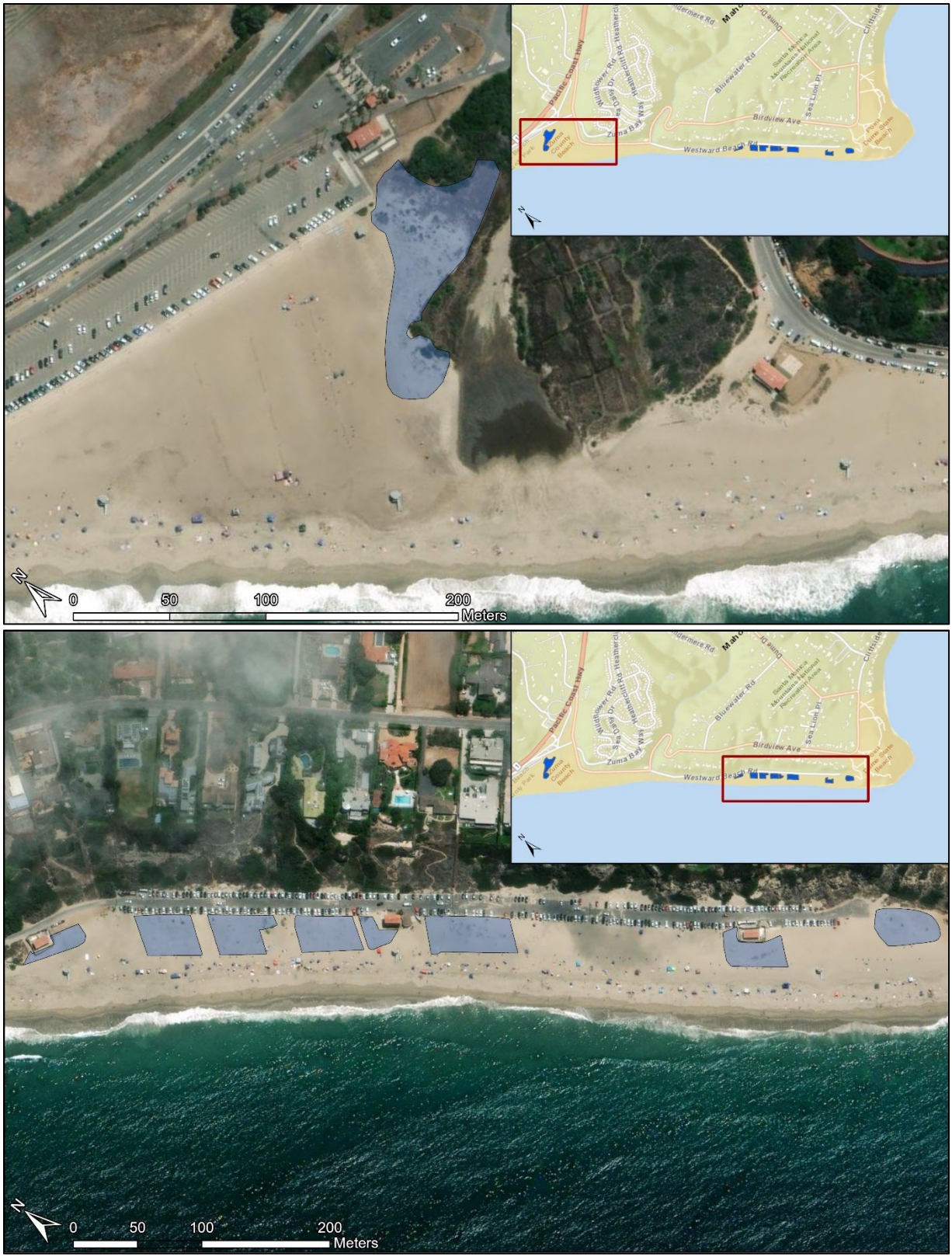


Figure A2. Zuma Beach (top) and Point Dume Beach (bottom) project footprints.

Appendix B: Transect Location Maps

Figure B1. Transect locations for Point Dume Beach (above), including those for restoration (P), control (PC) and wrack (PC-Wrack); and for Zuma and Westward Beach (below), including transects for restoration (Z), dune transition habitat restoration (Z2), dune transition habitat control (ZC1), wrack (Z-Wrack) and sandy beach control transects (WC) and wrack control (WC-Wrack). Map data @2020 Google.

Appendix C: Photo-points

Photo point survey images from 2020 – 2023 (left to right). Survey methods are described in detail in SOP 7.2 Level 2 Photo Point (TBF 2015a). All photo-point locations are recorded using a GPS. Photos for P2 in 2022 and 2023 unavailable.

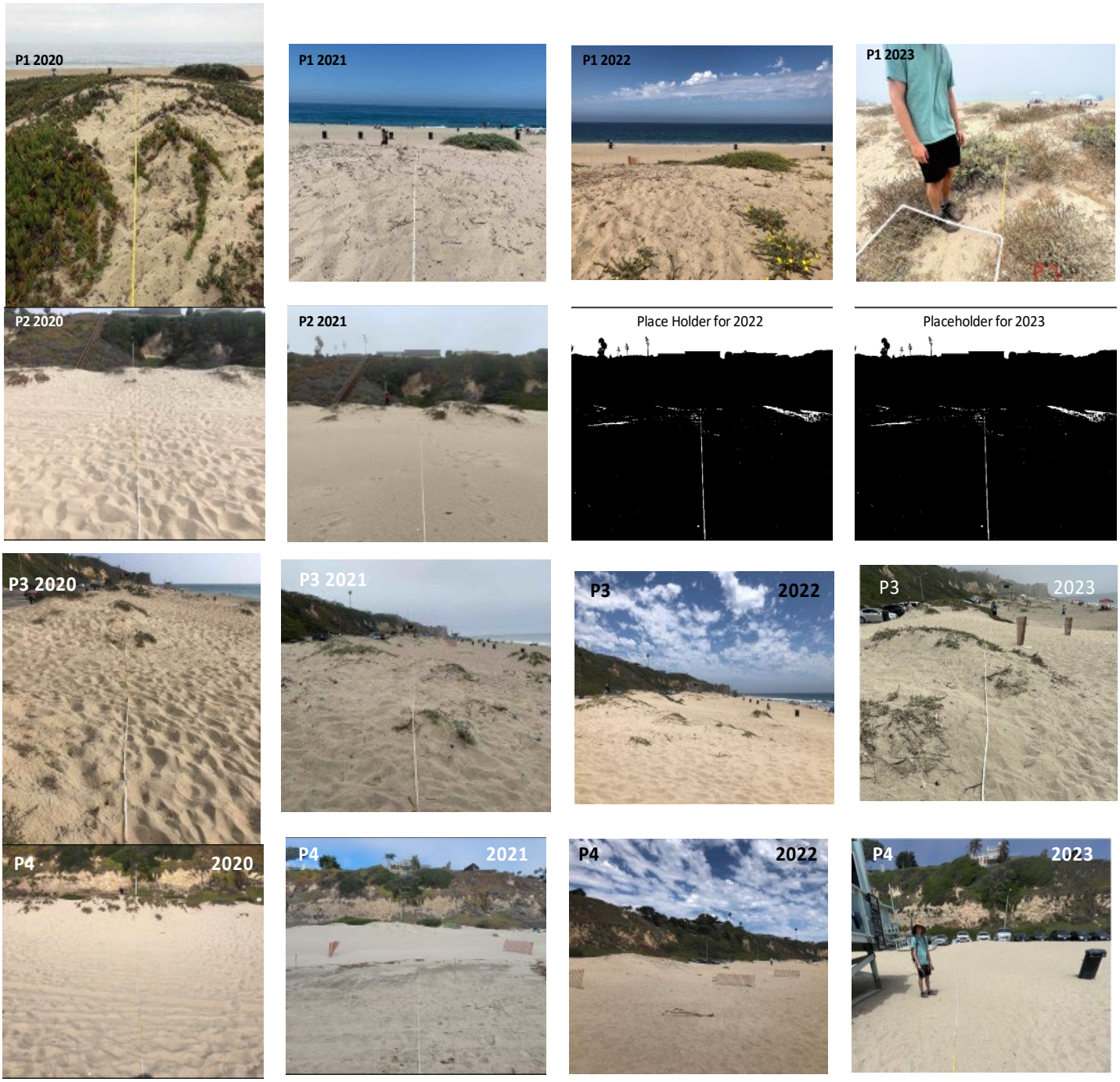


Figure C1. Photo Points 1 – 4 (top to bottom). Photos for P2 in 2022 and 2023 unavailable.

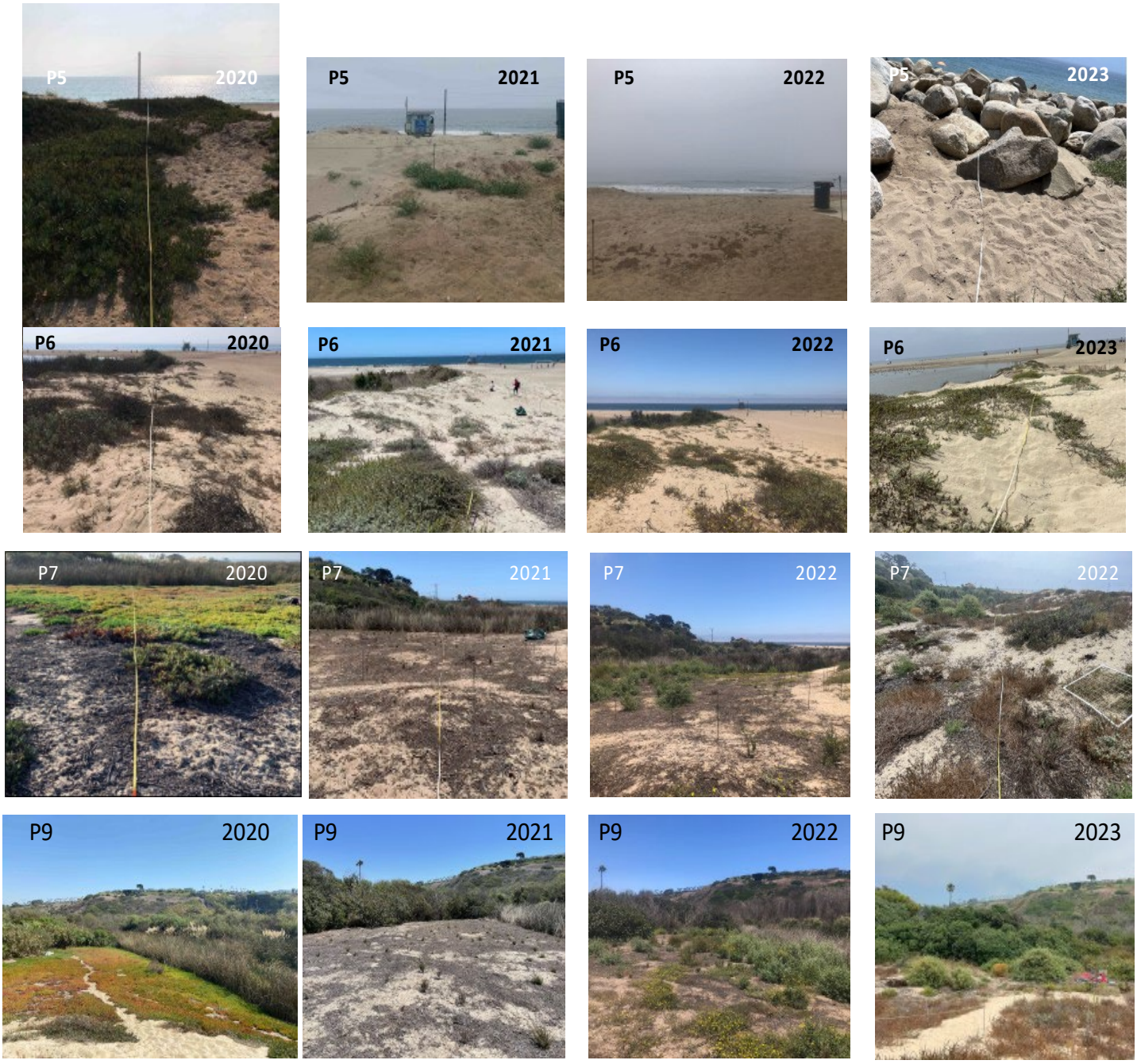


Figure C2. Photo Points 5 - 7 & 9 (top to bottom).

Appendix D: Vegetation Mapping

Maps were created by identifying species locations, mapping them in GIS, followed by visual ground truthing with GPS. Area map (D1) illustrates in red hashed polygons where the rip-rap revetment was done (area 7) and the source of sand for the revetment (area 6), thus razing both restoration areas after Winter 2023. Individual polygon maps show resolution of species with native (solid fill) and non-native (hashed fill) species. Note that native species far outnumber non-natives at all but one area.

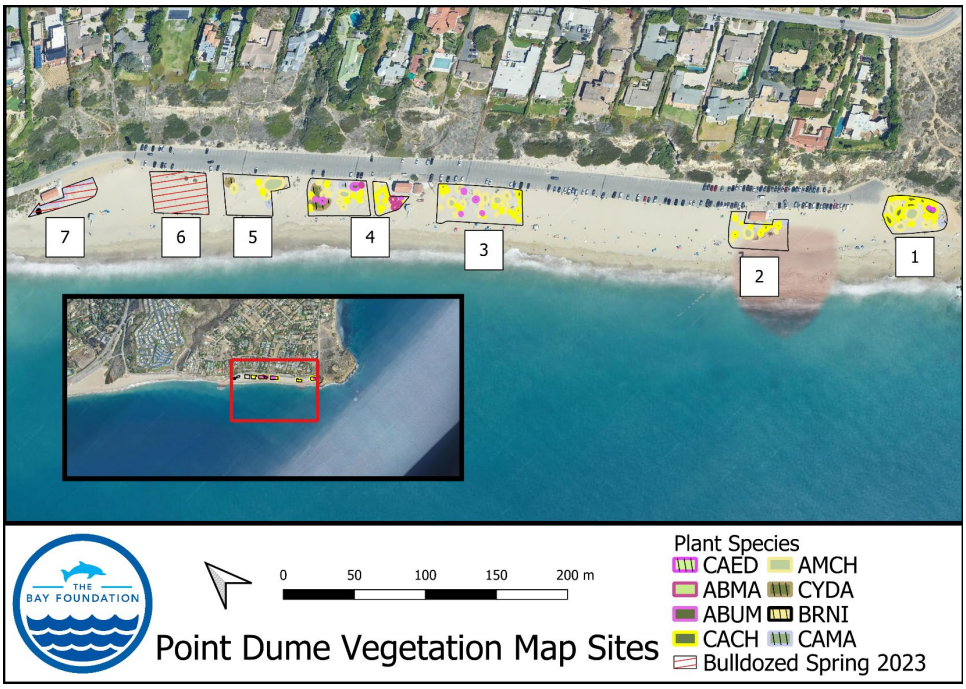


Figure D1. Map for 2023 focus area and occupied by each species within the study areas. Map data @2023 Google.

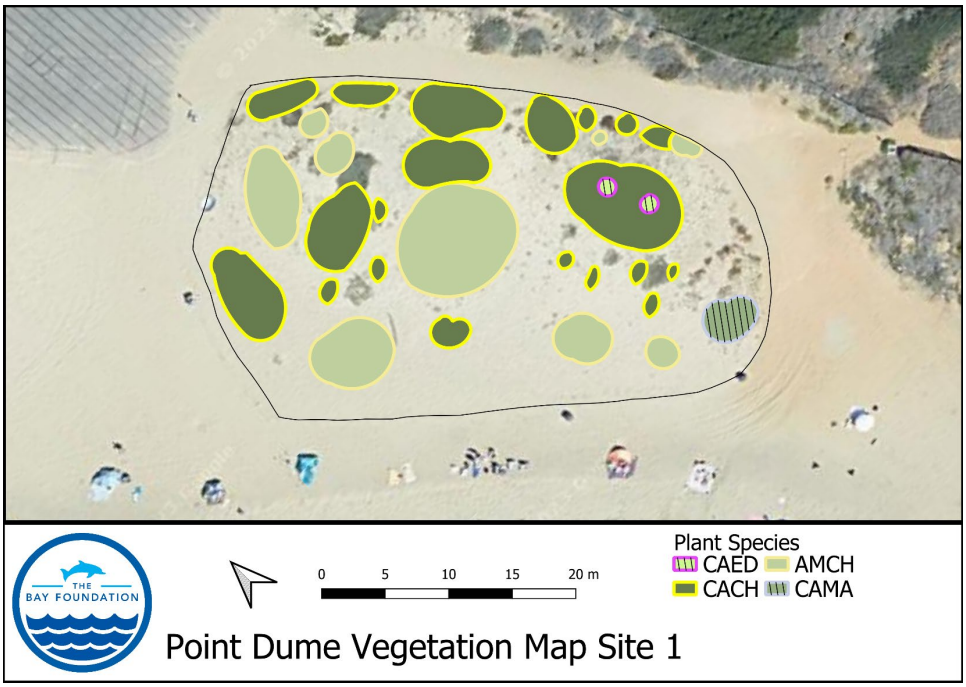


Figure D2. Map of Pt Dume Vegetation Map Site 1. Map data @2023 Google.

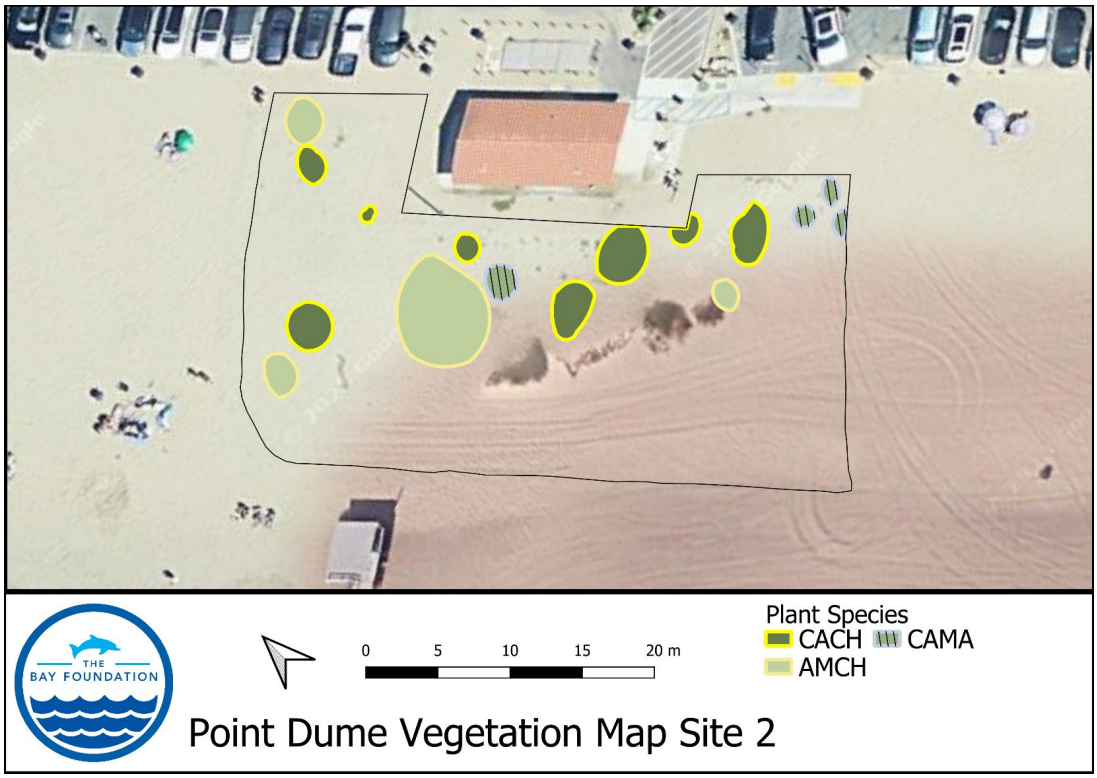


Figure D3. Map of Pt Dume Vegetation Map Site 2. Map data @2023 Google.

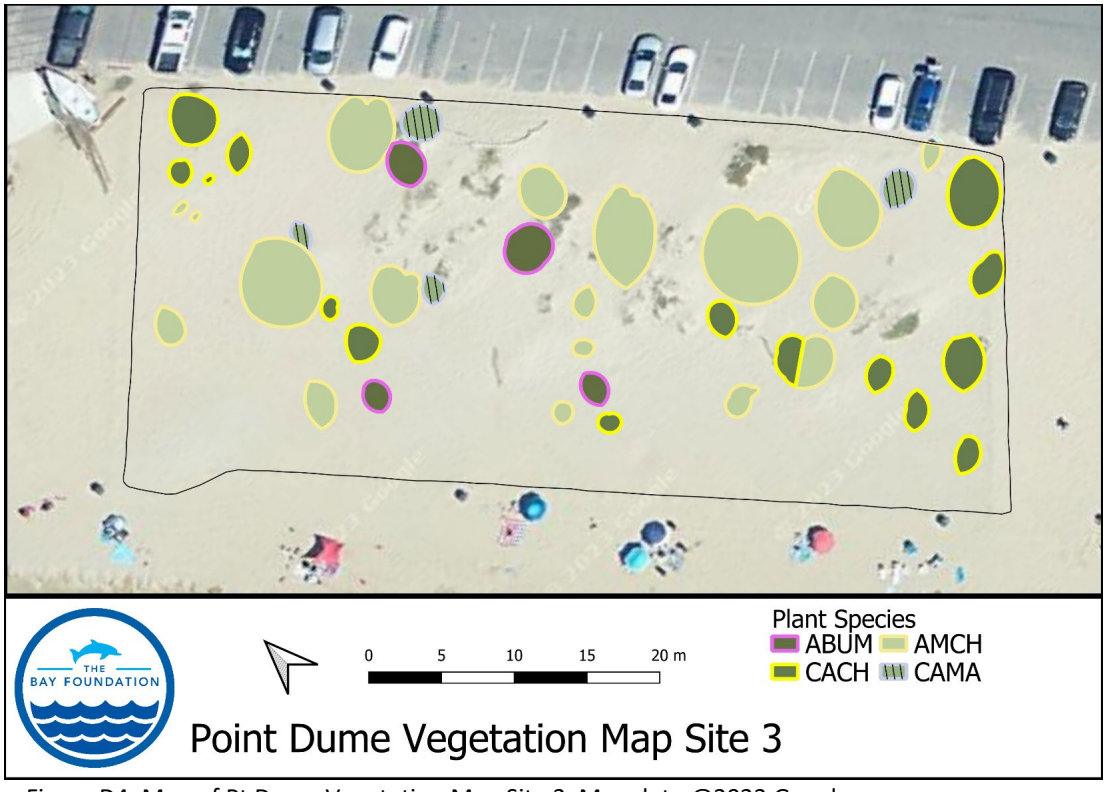


Figure D4. Map of Pt Dume Vegetation Map Site 3. Map data @2023 Google.

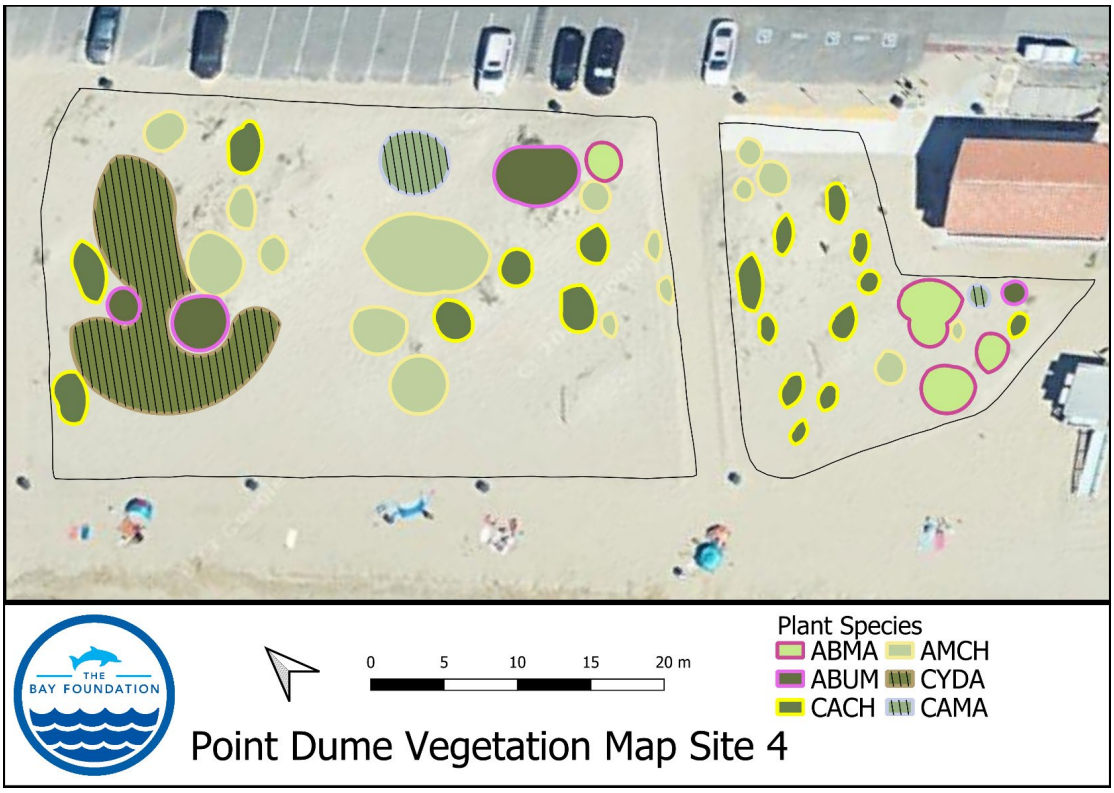


Figure D5. Map of Pt Dume Vegetation Map Site 4. Map data @2023 Google.

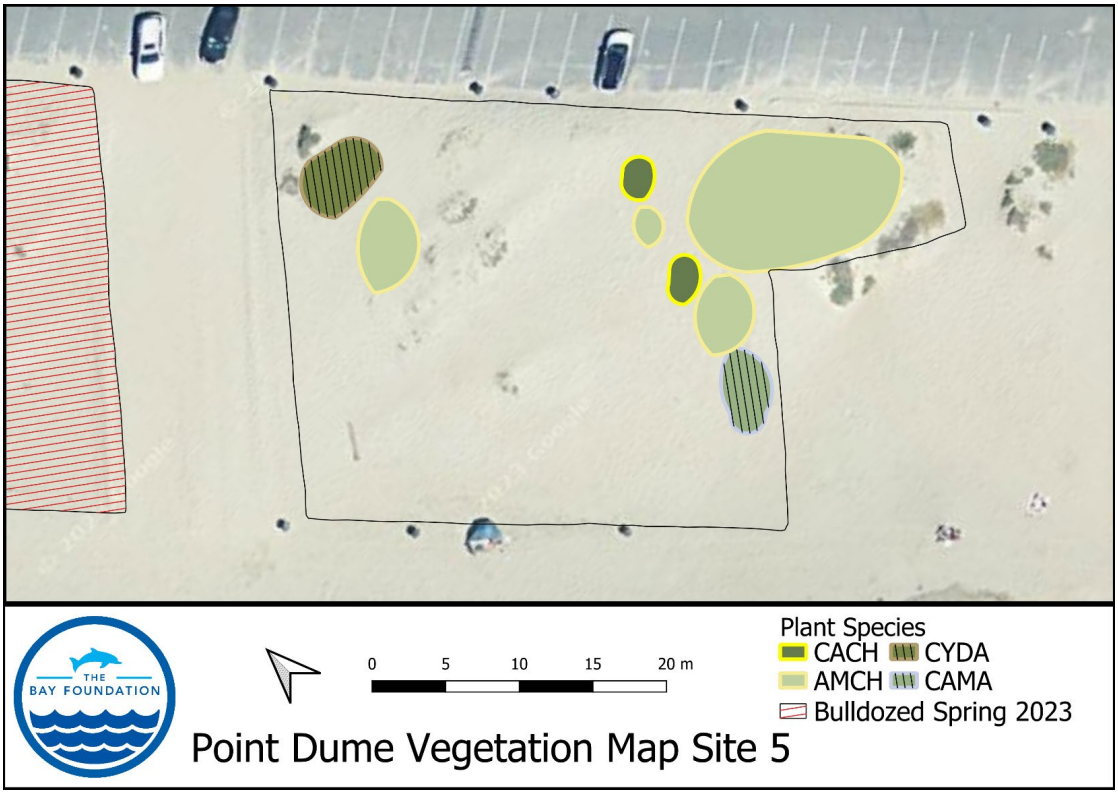
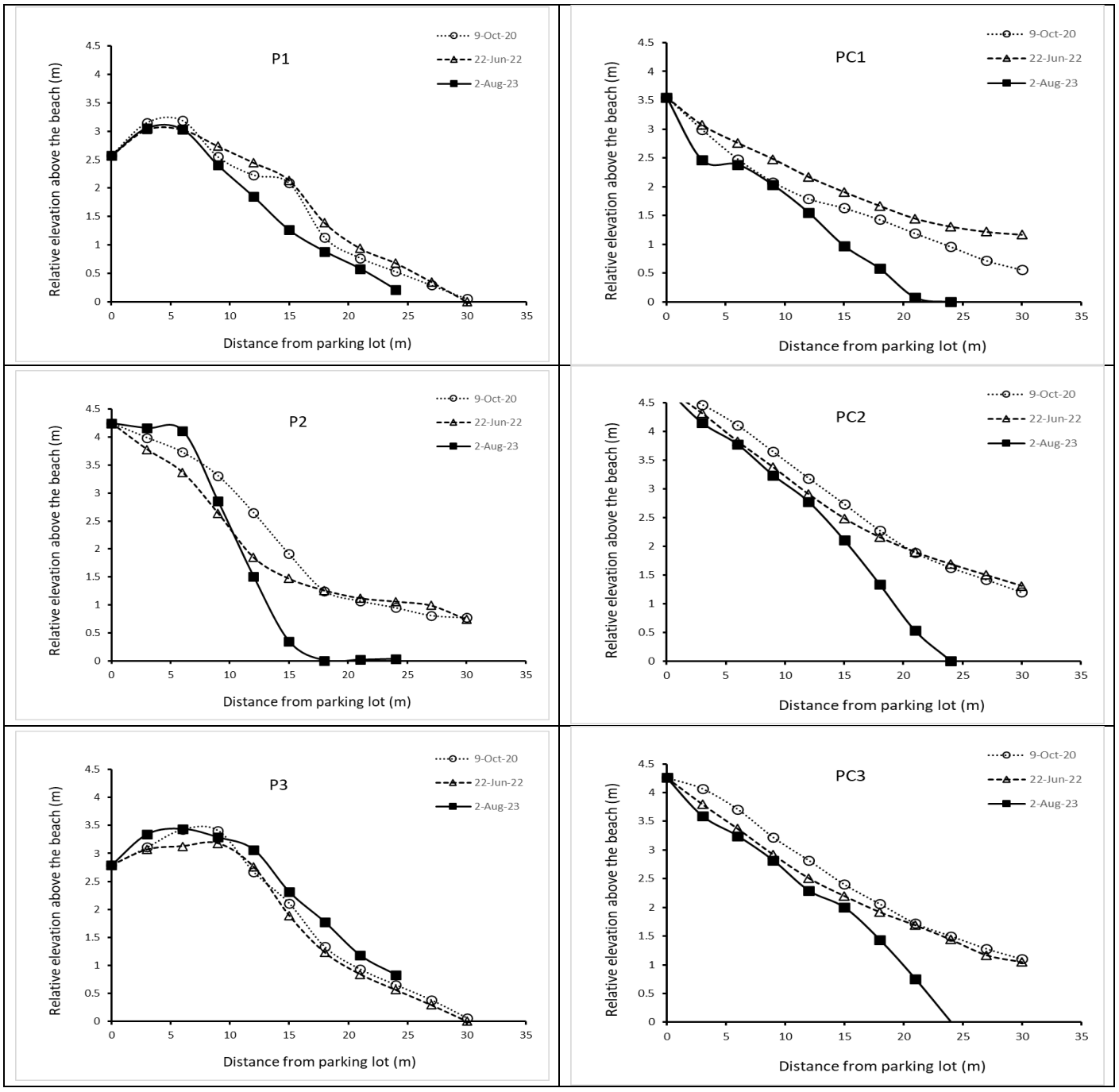


Figure D6. Map of Pt Dume Vegetation Map Site 5. Map data @2023 Google.

Appendix E: Beach Profiles

Beach profile summaries representative of a fixed transect from restored and unrestored sections of Pt Dume Beach. Data are reported from the baseline in October 2020 (open circles, dotted line), year 2 in June 2022 (open triangles, dashed line) and from the current year, year 3, 2023 (closed squares, solid line).



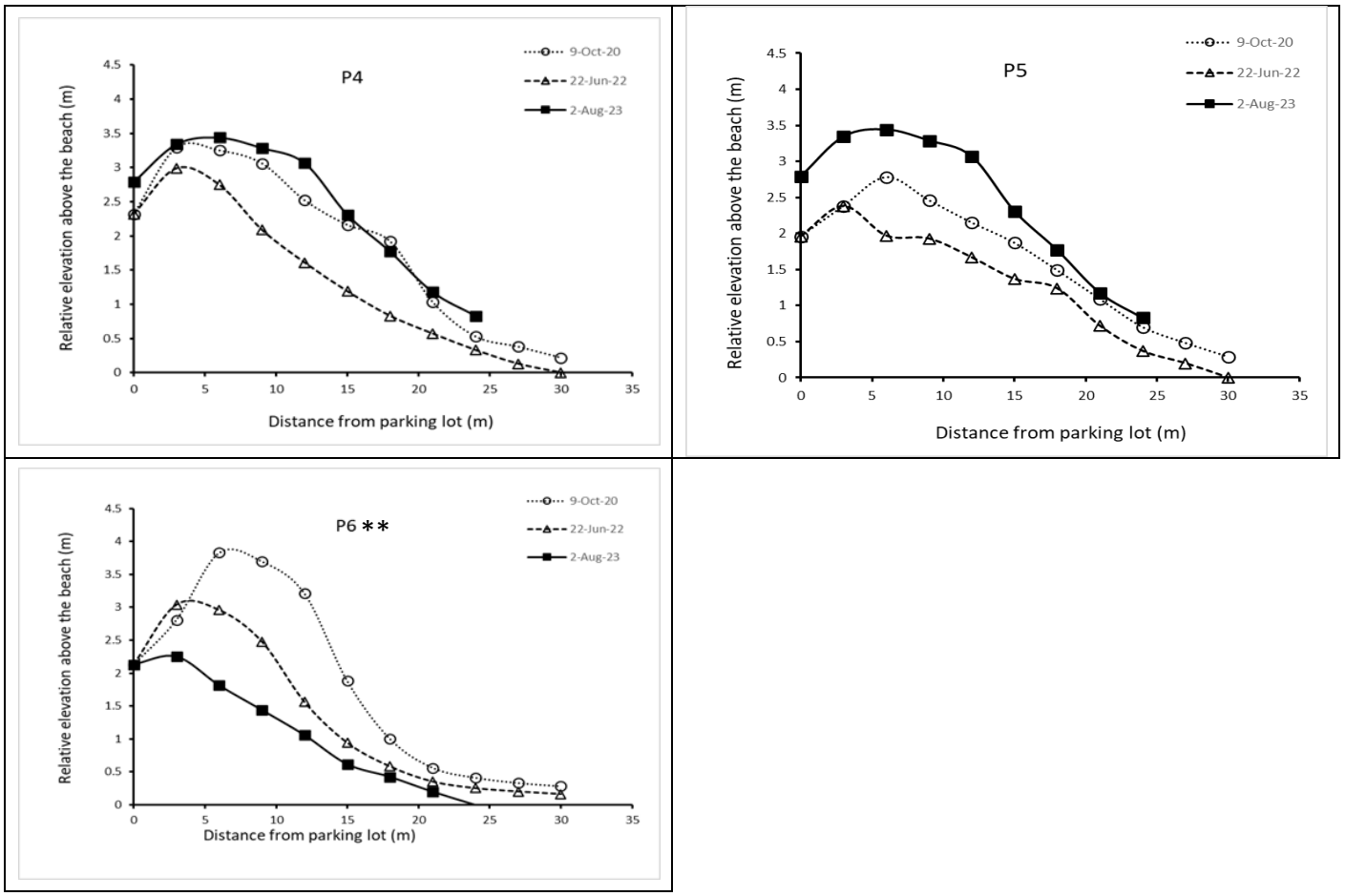


Figure E1. Panels P1 – P3 (left) are paired with an unrestored, adjacent area (PC1 – PC3, right). Panels P4 – P6 do not have direct comparison areas. **Please note: panel P6 (bottom) is a profile of the area that was utilized as a sand source for the rip-rap revetment mentioned in the Photo Point section (p6, Fig 4), which explains the dramatic reduction in elevation profile for that site. Current profiles for p7 were not possible after the revetment mentioned above.

Appendix F: Weather, Tides and Sea Level

Monthly precipitation, mean sea level and the highest high tide were downloaded from the NOAA online database.

Precipitation

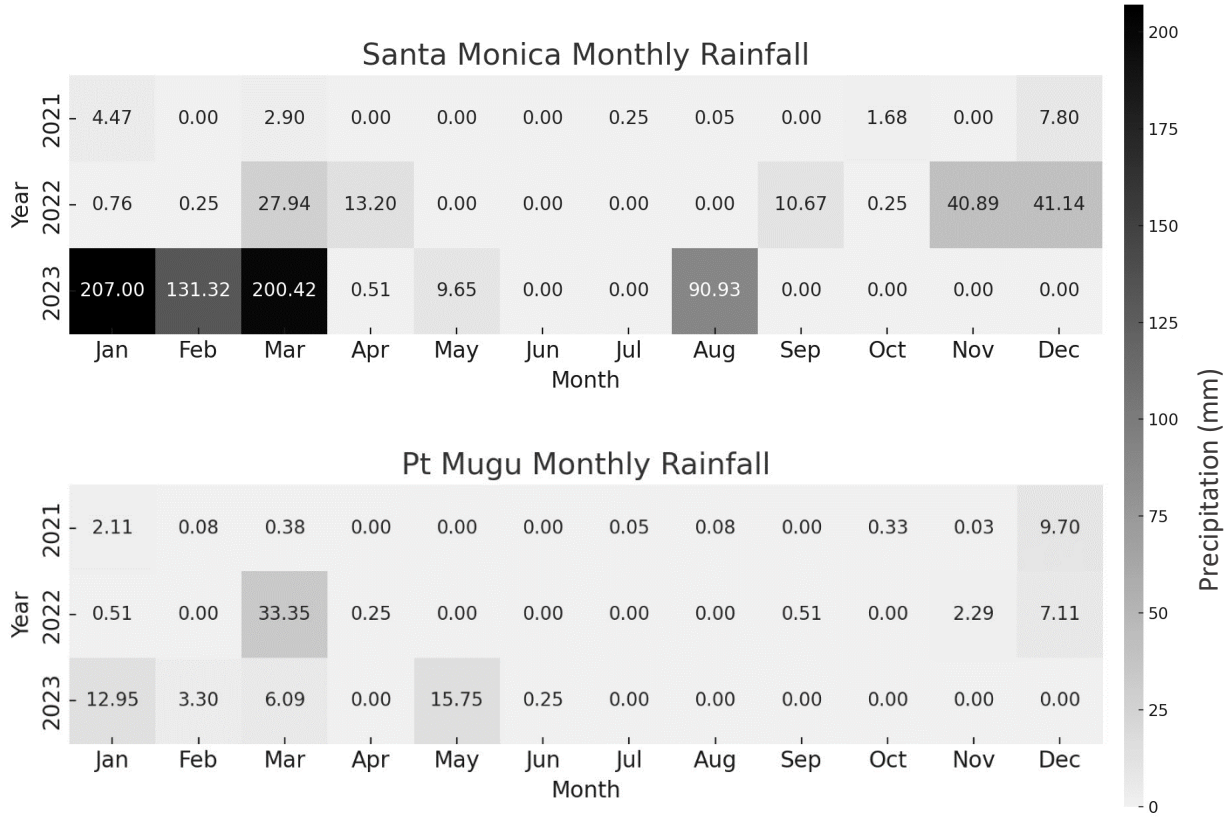


Figure F1. Heatmap of Santa Monica and Pt Mugu monthly precipitation (mm) from 2021-2023. At Pt Mugu, total annual rainfall ranged from 12.76mm in 2021 to 44.02mm in 2022 and 38.34mm in 2023. The annual rainfall in Santa Monica was slightly higher than in Pt Mugu in 2021 (17.15mm), but it was dramatically higher than Pt Mugu in 2022 and 2023 (135.1mm and 639.83mm, respectively). Data from NOAA online database.

Sea Level and High Tide

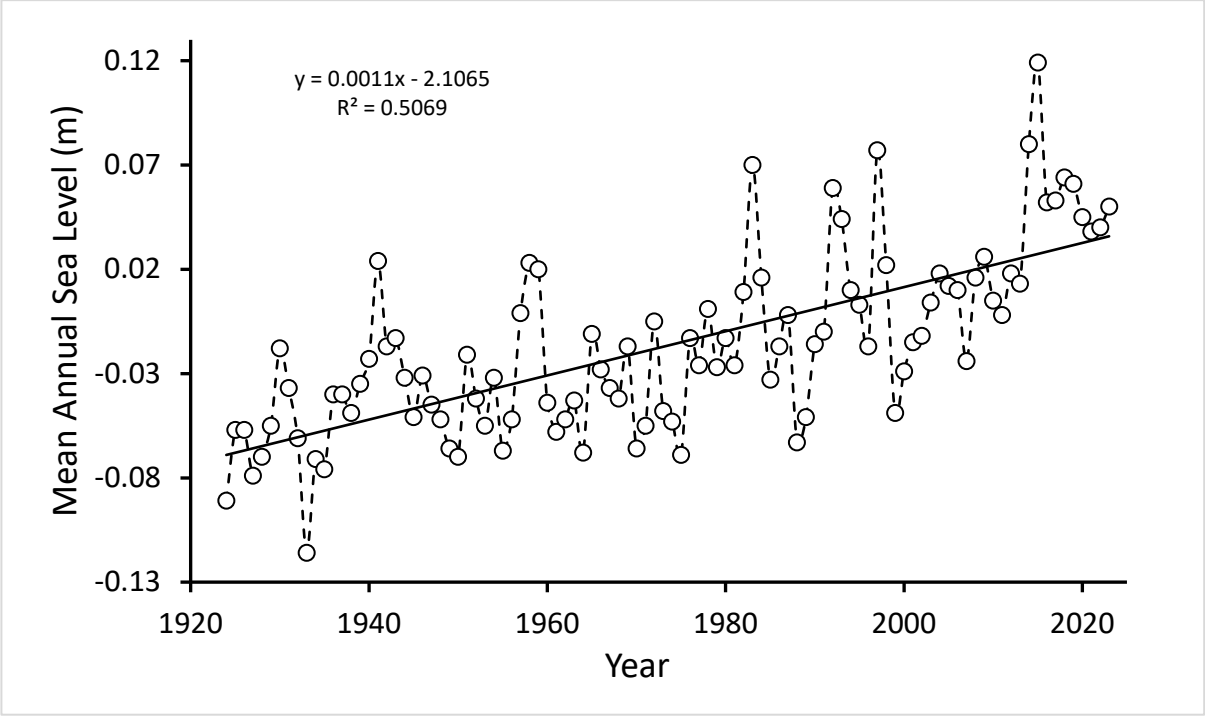


Figure F2. Mean Annual Sea Level (m) per year from 1920-2020. Data from NOAA online database.

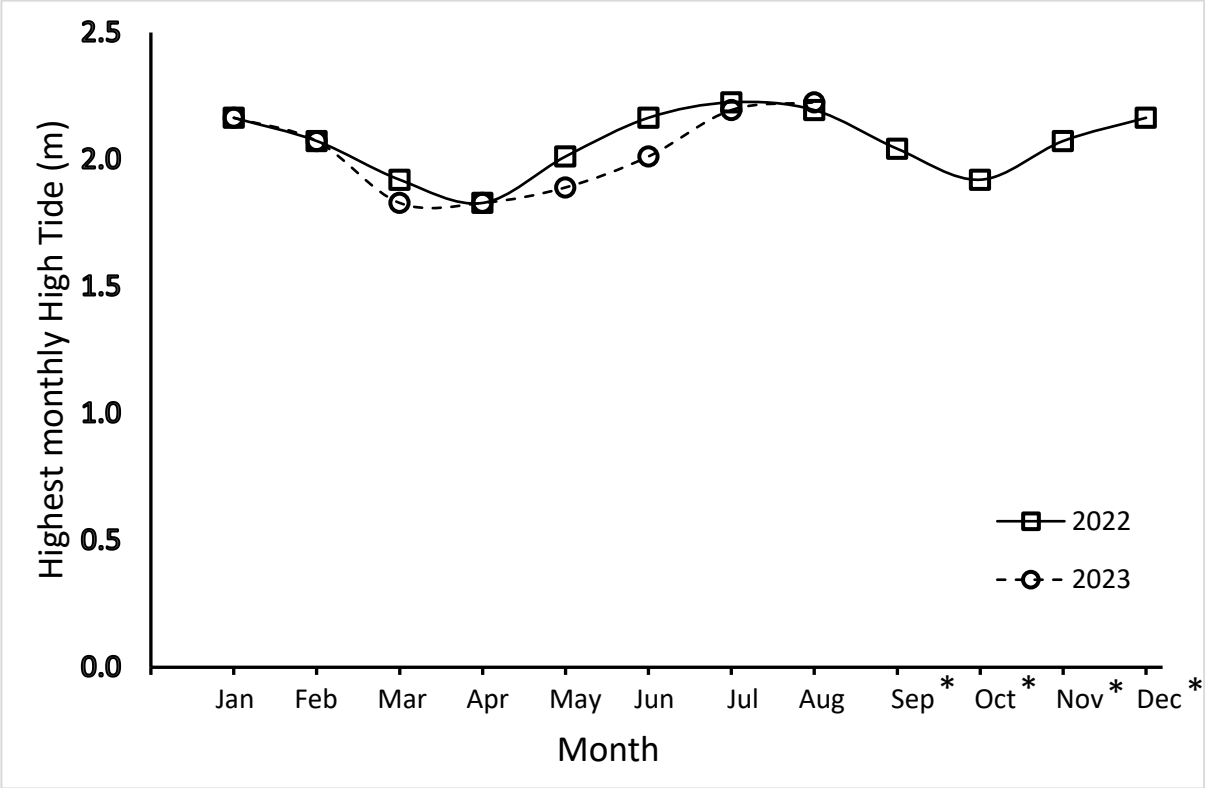


Figure F3. Highest monthly High tide (m) per month in year 2022 and 2023. Data from NOAA online database.