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California State Parks San Diego Coast District Coastal Hazards Vulnerability Assessment and Adaptation Pathways

Moonlight State Beach

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1. Introduction

The California Department of Parks and Recreation (State Parks) provides public coastal access and recreational opportunities at 128 coastal park units that are some of the most valued landscapes and coastal destinations within the State. In addition to supporting more than 50 million visitors each year while protecting cultural and natural resources, State Parks must also address the challenge of sea level rise (SLR) at coastal park units. With the growing concerns about the effects of climate change on coastal hazards (e.g., accelerated flooding and erosion), State Parks released a SLR Strategy to better integrate SLR considerations into the department's planning and project development processes (California State Parks Sea Level Rise Adaptation Strategy 2021). Completion of coastal hazards vulnerability assessments and adaptation plans for coastal park units is a critical first step towards understanding potential change and susceptibilities of park units to the changing climate and to create a roadmap that will help State Parks adapt in the coming decades.

The San Diego Coast District (SDCD), located in San Diego County, California, encompasses eleven[1] coastal park units from Carlsbad State Beach to the extreme southwest corner of the continental U.S. at Border Field State Park. SLR and its associated impacts (e.g., erosion, flooding, groundwater intrusion) are already affecting these coastal parks and the communities that use them. On average, sea levels in San Diego are 8 inches higher than they were 100 years ago and as sea level continues to rise at an increasing rate, rising waters will cause changes to coastlines and beaches. According to Vitousek et al. (2017), U.S. Geological Survey model projections (using CoSMoS-COAST) depict that 31% and 67% of Southern California beaches could be lost by 2100 with 3 ft and 6 ft of projected SLR, respectively. The model projections show that current beach nourishment efforts in the region may not keep pace with rising sea levels and erosion rates. Given these potential losses, State Parks decided to pilot the process of preparing vulnerability assessments and adaptation plans in the SDCD.

1.1 About this Report

This report synthesizes the key findings from a coastal hazards vulnerability assessment of Moonlight State Beach (SB) and proposes adaptation pathways to address these vulnerabilities. It also summarizes the results of two rounds of outreach (Appendix A).

Results from the vulnerability assessment will help State Parks understand how existing park assets, resources, and shoreline types in this park unit could be affected by SLR. Based on the vulnerability assessment, an adaptation plan comprised of adaptation pathways was developed for Moonlight SB. An adaptation pathway, defined as a "strategic approach to adaptation over time," is an increasingly common way to account for the uncertainty of (SLR) projections by using a phasing of strategies (Deltares, Zandvoort et al. 2017, Bloemen et al. 2017). Adaptation pathways include information about potential management options and establishes trigger points to support decision making.

[1] There are 11 coastal park units in the SDCD of the State Park System. However, for the purposes of this study, some park units have been combined for evaluation purposes. The park units that have been combined are Torrey Pines State Beach with Torrey Pines State Natural Reserve, as well as Tijuana River Natural Estuarine Research Reserve with Border Field State Park

Use of adaptation pathways maintains flexibility by allowing managers to select strategies with changing conditions over time based on real-time changes occurring at a particular site. This approach is useful given the uncertainty of timing and extent of future sea levels. The phased adaptation approach summarizes:

- which SLR projection and timeframe a given strategy may be effective for;
- when implementation of a complementary strategy should begin; and
- how much planning is needed prior to strategy implementation, through use of a phasing diagram and decision tree that illustrate and articulate potential strategy options over time.

This report is part of a series of nine coastal hazard vulnerability assessments and adaptation pathways that identify highly vulnerable park assets and adaptation strategies at the individual park unit level. In addition to the unit-level reports, a district-wide summary report will describe anticipated effects of SLR at a regional scale.

1.2 Park Unit Characteristics and Setting

Moonlight SB is located on the west end of B and C Street, in Encinitas, CA, and is operated by the City of Encinitas. Moonlight SB is a wide, sandy beach along a narrow shoreline that was formed at the mouth of Cottonwood Creek. Park amenities include a paved path, picnic tables and benches, volleyball courts, equipment rentals, snack bar, fire rings, lifeguard tower, ADA access, playground, outdoor showers, and restrooms.

Much of the land that supports Moonlight SB has been altered by development; however, several areas continue to support native vegetation with abundant wildlife. Cottonwood Creek flows through the park and supports several patches of wetland vegetation (including *Salix lasiolepis* Alliance). The slopes support native shrublands (*Artemisia californica-Eriogonum fasciculatum* vegetation alliance) and degraded habitat (*Carpobrotus edulis* or Other Ice Plants Semi-Natural Stands). Native plant species that occur in the Park may include arroyo willow (*Salix lasiolepis*), yerba mansa (*Anemopsis californica*), spiny rush (*Juncus acutus*), coyote bush (*Baccharis pilularis*), California encelia (*Encelia californica*), cliff buckwheat (*Eriogonum parvifolium*), and Shaw's agave (*Agave shawii*). Wildlife species observed at Moonlight SB include western fence lizard (*Sceloperis occidentalis*), snowy egret (*Egretta thula*), Cassin's kingbird (*Tyrannus vociferans*), green heron (*Butorides virescens*), Nuttall's woodpecker (*Dryobates nuttallii*), and others. Beach habitat supports forage and resting for a variety of shorebirds and habit for a wide variety of beach invertebrates. California grunion also use beach habitat for breeding habitat.

According to the San Diego Coast District Visitation Study (2022), Moonlight SB was near the median in terms of vehicle arrivals out of the 11 SDCD park units between 2018 and 2021, which slightly decreased over the years of the study. Most visitors to the park in 2020 and 2021 were white (approximately 77% and 78%), followed by Hispanic (approximately 17% and 17%)[2], though a wide range of races are represented in the visitation data.

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[2] Since analysis of park visitor demographics spanned the years 2018-2021, all demographic data was derived from the 2010 U.S. Census (Streetlight 2021), and thus some double counting is occurring due to the nature of how "race" was handled in the 2010 Census.

Cultural Resources

Cultural resources found within Moonlight SB include a hearth and midden site. Archaeological research in San Diego County's coastal zone reveals that humans were present here at least by the terminal Pleistocene, around 10,500 years ago (Gallegos 2013). Archaeological complexes represented at these early sites include the San Dieguito complex, which appears to have been related to the early hunting adaptations of interior North America (Warren and True 1961), and the La Jolla complex, a local manifestation of Warren's (1968) widespread Encinitas Tradition (Sutton and Gardner 2010; Warren 1968). Subsequent adaptations in coastal San Diego County during the Holocene were strongly influenced by the dynamics of post-glacial marine transgression, which after about 8500 years before present (B.P.) had created a complex mosaic of productive lagoon and estuary habitats at many locations (Masters and Aiello 2007; Masters and Gallegos 1997). By the mid-Holocene (5,000 years ago), these coastal habitats supported a significant coastal population, as indicated by numerous shell middens concentrated along the former margins of lagoons and estuaries (Gallegos 1992; Moratto 1984). During the late Holocene (after ca. 1500 B.P.), however, regional population increases as well as changes in coastal ecosystems appear to have stimulated more intensive use of a wider variety of coastal and inland settings (Byrd and Raab 2007; Byrd and Reddy 2002; Masters and Gallegos 1987).

At historic contact, most of the study area was occupied by the Kumeyaay, who inhabited portions of coastal San Diego County south of Agua Hedionda, as well as portions of the Imperial Valley and northern Baja California. To the north were the Takic-speaking Luiseño, who occupied northern San Diego and southwestern Riverside counties, including the watersheds of the San Luis Rey and Santa Margarita Rivers. Traditionally, both the Kumeyaay and Luiseño were seasonally mobile but primarily were concentrated in permanent and semi-permanent villages that were connected by economic, kinship, and marriage ties (Bean and Shipek 1978; Carrico 2017; Luomala 1978). These Tribes still inhabit the land today and were involved in the development of the vulnerability assessments (see Section 5).

Regional Adaptation

Addressing beach loss has been a regional priority for several decades. In 2009, the San Diego Association of Governments (SANDAG) developed the San Diego Coastal Region Sediment Management Plan to inform understanding of ongoing sand deficits within the region and possible solutions for future management. To monitor the shoreline, the Scripps Institution of Oceanography has established a comprehensive observation system using in-situ instruments, LiDAR, and drones. SANDAG uses this information to inform its shoreline management and beach nourishment projects such as an effort initiated in 2021 to pump 63,000 cubic yards of sand (19 Olympic-sized swimming pools) from San Elijo Lagoon onto Cardiff SB.[3]

Monitoring and subsequent analysis found that nearly all beaches in the SDCD have had decreasing beach widths over the past three years (Scripps 2023), likely due to a lack of sufficient sediment and inadequate time for the beach to replenish between winters with strong waves. Historically, beach loss in the SDCD and throughout California has occurred during El Niño winters when high winter waves wash away sediment. Beach replenishment and widening typically occur between El Niño events. The rate of accretion is also determined

[3] SANDAG. "Beach Replenishment." Accessed December 14, 2023. https://www.sandag.org/projects-and-programs/environment/shoreline-management/beach-sand-management/beach-sand-replenishment

by the sediment supply in the area. As sea levels rise, shorelines and assets will have to migrate landward to maintain current beach widths. This will require significant accretion that may not be able to keep pace with El Niño events, which accelerate erosion and beach loss. Compounding beach loss from El Niño, stronger atmospheric river events are expected to increase in frequency and severity with climate change as warmer air holds more moisture, leading to larger waves and more beach loss (Huang et al. 2020). In the winter of 2023, which was not an El Niño winter, there was above average beach loss due to atmospheric river events in California (Scripps 2023).

Adapting to SLR and climate change has become a regional priority in recent years. Regional sea level rise planning efforts include:

- In 2021, the San Diego City Council adopted *Climate Resilient San Diego*, the city's first climate adaptation plan. The plan includes a vulnerability assessment, a set of adaptation and resilience goals, policies and objectives, and a set of feasible implementation measures that meet requirements specified in California Senate Bill 1035. The vulnerability assessment identifies sea level rise and increased storm frequency as primary hazards because they will amplify cliff and beach erosion, threatening infrastructure and assets near the coast.
- SANDAG developed the Regional Transportation Infrastructure Sea Level Rise Assessment and Adaptation Guidance in partnership with Caltrans in 2020. The report evaluates potential sea level rise impacts to regional transportation infrastructure, provides an overview of best planning practices, and presents adaptation pathways focused on addressing sea level rise impacts to regional transportation infrastructure.
- The San Diego Region Coastal Resilience Roadmap, developed in 2023 as part of a partnership between the San Diego Regional Climate Collaborative, Resilient Cities Catalyst, and CivicWell, aims to facilitate accelerated action for coastal resilience projects that benefit underserved communities.
- Multiple entities have completed vulnerability assessments, including Caltrans District 11, the Port of San Diego, San Diego County Regional Airport Authority, and the cities of Carlsbad, Imperial Beach, and Coronado.

1.2.1 Shoreline Types

Four shoreline types have been identified in Moonlight SB. Table 1 summarizes the shoreline types and includes definitions of each shoreline type based on both foreshore and backshore conditions. Figure 1 depicts the Moonlight SB shoreline, delineated by shoreline types.

Table 1. Shoreline Types in Moonlight SB

Shoreline Type	Description
Sandy Beach Backed by Hard Natural Bluff	A coastal bluff of hard material, frequently cliff-forming, and typically takes such geological forms as well-cemented sandstones and siltstones, igneous basaltic rock, or other rock formation types, with a sandy beach located at the base of the bluff that extends seaward.

Shoreline Type	Description
Sandy Beach Backed by Soft Natural Bluff	A coastal bluff of soft material, taking the form of more gradual slopes and embankments compared to the cliff-forming hard materials, typically comprised of poorly cemented or recently deposited sands, gravels, rubble, and/or low-strength, heavily weathered, or highly eroded sandstones and mudstones, with a sandy beach located at the base of the bluff that extends seaward.
Sandy Beach Backed by Armor	A sandy beach backed by an engineered revetment (typically rubble mound), or randomly placed riprap or engineered seawall utilized to protect inland features.
Sandy Beach Backed by Road, Parking Lot, or Other Infrastructure	A sandy beach backed by infrastructure, such as an asphalt or concrete parking lot, a highway, or railroad, without protection (armor or seawall) between

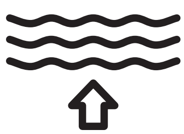
Figure 1. Shoreline Type Delineation for Moonlight SB

1.3 Coastal Hazards Assessed

Coastal parks are continuously evolving due to a combination of oceanic and atmospheric forces such as tides, waves, and storms interacting with the erodible backshore landscape. Although these natural processes have shaped the existing park units and their current recreational opportunities, they are responsive to changes in the climate, which can exacerbate the magnitude of their effects. While many areas of SDCD park units remain natural and unarmored, allowing dynamic coastal processes to occur, the park units also feature fixed infrastructure to support operations and recreational opportunities. As these natural processes begin to affect the park visitor experience, ecosystems, and assets, they transform into coastal hazards that are associated with a range of impacts.

As sea level continues to rise, four major coastal hazards will increasingly affect Moonlight SB (Table 2): tidal inundation, 100-year coastal storm flooding, rising groundwater, and shoreline change. Each of these hazards will affect park facilities and resources in different ways. Major events, such as the 100-year coastal storm, are an episodic hazard, posing immediate, yet short-term effects for coastal features. As sea level continues to rise, tidal inundation, rising groundwater, and shoreline change are expected to become chronic hazards that will cause long-term changes to the park unit. For the vulnerability assessment, the 100-year coastal storm was evaluated as a temporary hazard due to the episodic nature of these events. However, despite their short duration, these “temporary” events can cause long-term effects to park infrastructure and features that may require months or years of recovery time. Tidal inundation, rising groundwater, and shoreline change were evaluated as permanent hazards.

Table 2. Four Major Coastal Hazards

Coastal Hazard	Definition
 **Tidal Inundation**	Tidal inundation is a permanent hazard that occurs when daily high tide levels exceed low-lying areas of the coast. The inland extent of tidal inundation for the coastal hazard vulnerability assessment is represented by the Mean Higher High Water (average height of the highest daily tides).
 **100-year Coastal Storm**	The 100-year coastal storm is a temporary hazard with a one percent chance of occurring in any given year. The inland extent of coastal storm flooding is due to a combined effect of high tides, storm surge, and wave setup. Rising sea levels will exacerbate the frequency and extent of coastal storm effects by allowing wave energy and elevated storm water level to reach further inland.
	Rising groundwater is a permanent hazard occurring as subsurface water tables get pushed closer to the surface in response to sea level rise. The coastal hazard vulnerability assessment considers areas of the park that are exposed to both shallow (less than one meter below ground) and emergent (above land surface) groundwater flooding.

Coastal Hazard	Definition
Rising Groundwater	
 **Shoreline Change**	Shoreline change is a permanent hazard that characterizes the change in shape and position of the park's shoreline geomorphologic features, including beaches and cliffs. Changes in sea level are a primary driver of long-term patterns of shoreline erosion, and sometimes accretion, in the case of beaches.

2. Vulnerability Assessment

2.1 Assessment Conceptual Framework

This coastal hazards vulnerability assessment was designed to evaluate how SLR may affect access, facilities, recreation, cultural resources, natural resources, and shoreline types. It provides information about the potential timing, extent, and consequences of coastal hazards that may affect these assets and resources. This information can be used to prioritize adaptation efforts and to inform the development of targeted strategies and pathways to integrate adaptation into park planning, design, and interpretation and education.

An inventory of park-owned and managed assets, resources, and shorelines was developed to identify and organize park unit features that will be evaluated for their vulnerability to coastal hazards. The inventory was organized around the following park categories:

- Access – park access roads and trails, parking areas
- Facilities – structures, buildings, armoring, and utilities
- Recreational – sport courts, campgrounds piers, and recreational sites (e.g., surfing, birding)
- Cultural Resources – archeological sites and features, historic buildings/ structures
- Natural Resources – land cover types and vegetation alliances
- Shoreline Types – foreshore and backshore geomorphologic features

For the purposes of this report, facilities, access, and recreation assets have been combined into an overarching category – Physical Assets.

For all assets, resources, and shoreline types, vulnerability is expressed in terms of exposure and sensitivity[4]:

[4] SLR vulnerability is typically expressed in terms of exposure, sensitivity, and adaptive capacity. For this assessment, adaptive capacity is considered at a later stage through the development of adaptation pathways.

Vulnerability = Exposure x Sensitivity

- **Exposure** - the nature and degree to which an asset or feature is introduced to the hazard
- **Sensitivity** – the degree to which the physical conditions and functionality of an asset or feature is affected by hazard exposure

Although exposure serves as an indicator of the likelihood an asset or feature will be introduced to hazards, evaluating sensitivity provides valuable information on the degree to which the asset or feature would be impaired once exposed. Assets or features are considered more vulnerable if they are exposed to multiple hazards and are highly sensitive. Details about exposure and sensitivity are included in Appendix D and information about specific assets included within each category are described in Appendix C.

Using this approach, a vulnerability score ranging from 0 (not vulnerable) to 12 (most vulnerable) was calculated to evaluate the relative vulnerability of each asset or feature within the park unit. Details of the approach used to calculate vulnerability scores for assets and features are discussed in Section 2.3. The approach used to calculate vulnerability scores for park shoreline types is discussed in Section 2.4.

First order (e.g., direct changes to capital, operation, maintenance, recreational opportunity, and coastal access) and second order (indirect changes to society and the economy) consequences were identified for each asset category and potential asset damage and loss of functionality were described. Natural resources may experience change caused by vulnerability to coastal hazards and were also evaluated for first order (e.g., habitat shifts, etc.) and second order (e.g., changes in ecological function, etc.) consequences of those potential changes.

2.2 Coastal Hazard Mapping

Coastal hazard maps were developed for Moonlight SB to display the extent of tidal inundation, 100-year coastal storm flooding, emergent groundwater flooding, and sandy beach shoreline change for the planning time horizons of 2035 (1.6 feet of SLR) and 2050 (3.5 feet of SLR), as shown respectively in Figure 2 and Figure 3 (note: Ocean Protection Council's [OPC] 2018 State of California Sea-Level Rise Guidance[5] provides additional information on the likelihood of the adopted projections being met or exceeded at these time horizons). For visualization purposes, the coastal hazard maps do not depict the extent of shallow groundwater or cliff retreat, however, exposure to all coastal hazards was included in the vulnerability assessment. Coastal hazard mapping layers considered in the exposure analysis were sourced from US Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS). Additional details regarding the coastal hazard mapping layers and evaluated SLR scenarios can be found in Appendix E.

[5] https://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

Figure 2. Coastal Hazards Map for 1.6 ft of SLR

Figure 3. Coastal Hazards Map for 3.5 ft of SLR

A Note on Figure 2 and 3.
These reports use higher SLR estimates based on the Ocean Protection Council's 2018 State of California Sea-Level Rise Guidance to assess a high risk-aversion level of vulnerability. The Ocean Protection Council released a Sea Level Rise Action Plan in 2022 that supports planning around these higher levels of SLR for larger scale projects, but addresses that smaller projects likely have locally focused models than can provide better predictions of SLR particularly for complex regions. The OPC is currently updating their SLR guidance based on the newest science and estimates. The draft updated Sea Level Rise Guidance will be released in January 2024 and will be presented to the Ocean Protection Council for adoption in June 2024.

2.2.1 Assessment Limitations

This section discusses the various limitations of the vulnerability assessment data and methods.

This assessment is not intended to give guidance on direct actions that need to occur for specific assets, but to inform future efforts, priorities, and studies by State Parks and help the SDCD understand the vulnerability of their assets to sea level rise. Future work may include feasibility studies to assess the viability of taking specific adaptation actions, collaborations with neighboring partners to further assess and address vulnerability of resources, and more in-depth assessments for specific assets such as natural resource assets, which may require more complex modeling prior to implementing site specific actions.

Coastal Hazard Data Limitations

Coastal hazard mapping layers considered in the exposure analysis were sourced from USGS CoSMoS v3.0 (Barnard et al. 2018). CoSMoS modeling projects coastal flooding, shoreline change, and groundwater change in response to SLR and storm surge. Limitations with CoSMoS data include:

- **Data resolution.** Due to the regional scale of the CoSMoS modeling, it was not possible to capture or ground-truth the presence of small-scale local topography or narrow flood protection features smaller than the LiDAR dataset (~1 meter), such as seawalls. As a result, CoSMoS may over-predict flooding as these fine-scale flood mitigation features are not captured or assumed to fail during a flood event. It is possible to manually modify the flood extents of CoSMoS flood layers to better capture the feature, but this involves expert judgment and a comparison of structure crest elevations and future water level conditions.
- **CoSMoS modeling is based solely on future climate projections and current topography.** CoSMoS simulates future storms based on global climate model projections of wind, pressure, and sea surface temperature. The data has not been validated with on-the-ground observations of how SLR and coastal erosion are already affecting the SDCD. Additionally, assignment of a shoreline typology implies a level of stationarity to the shoreline, and thus results do not fully capture the dynamics of the shoreline system.
- **Changes to shorelines and assets made after data processing and publishing.** Park improvement projects, particularly those affecting the shoreline elevation or grade of

park assets, completed after creation of CoSMoS hazard data layers may not be accurately represented in the model results.[6]

- **CoSMoS data does not directly align with SLR projections**. CoSMoS provides a suite of future SLR scenarios (0 to 2 meters) at 0.25-meter increments and one high-range five meter "extreme" scenario to meet a broad range of possible planning time horizons. While this format provides a consistent and flexible dataset to use in planning and design, the scenarios do not directly align with California State Guidance for SLR projections, and likely do not align with other projections. However, State-recommended SLR values are not static and will be regularly reviewed and updated (approximately every five years) to reflect the latest climate science. Therefore, CoSMoS SLR mapping layers should be selected with the goal of aligning as closely as possible with the latest State-recommended SLR projections.
- **Modeling is based on historic rates of sedimentation.** The shoreline change model is based on historical shoreline behavior (for additional details see CoSMoS technical documentation[7]). As such, CoSMoS does not account for changes in sedimentation, habitat, or landcover that may result from changes in precipitation or other climate and human induced impacts. CoSMoS flood modeling shows coastal areas that will be impacted by SLR, but does not include a hydrodynamic model that explores sediment deposition in response to increased tidal prisms, wetland and estuary system changes, or habitat migration in response to erosion and vegetation change.

Despite these limitations, CoSMoS is currently viewed as the best available regional dataset that provides the most consistency across different portions of the state in terms of the modeling framework, data products available, and SLR scenarios considered. Additional details regarding the coastal hazard mapping layers, parameters used, and evaluated SLR scenarios can be found in the *Final Coastal Hazards Memo.*

Cultural Resources Data and Data Limitations

The archaeological data available for the current study was provided by the State Parks Southern Service Center. The cultural resource dataset focuses on archeological resources, defined for this study as prehistoric and historic locations or sites where human actions have resulted in detectable changes to the area. The cultural resources data does not include historical buildings and structures if they were not recorded as archeological resources.

The inventory of cultural resources was developed by the State Parks Southern Service Center by combining data from several sources, namely: a SLR study conducted as part of the Society for California Archaeology's Climate Change and California Archaeology Studies from 2014-2017 and updated from 2021-2022, a recent record search from the South Coastal Information Center (2016), digitized data from previous archaeological work, and global positioning system (GPS) data that has been collected within the SDCD since the mid-1990s.

There are several caveats associated with cultural resources data, including:

[6] CoSMoS modeling is based on a combination of efforts completed through 2010, including LiDAR derived mean high water shorelines from the USGS National Assessment of Shoreline Change (2009, 2006), Scripps LiDAR surveys (2002-2009), and USGS GPS surveys (2009).
[7] https://www.sciencebase.gov/catalog/item/57f1d4f3e4b0bc0ebfee139

- This cultural resources data inventory is archaeological in nature. It does not include historical built environment/standing buildings/structures/objects or tribal cultural resources that are not also recorded as archaeological resources.
- Areas that were already underwater, including marshes, wetlands, lagoons, estuaries, active wave zones of the beaches, and the underwater portions of Silver Strand SB, San Elijo SB, and Cardiff SB were excluded from the data inventory because these underwater areas have not been systematically surveyed.
- This cultural resources data inventory does not include any determination of site significance or eligibility to the National Register of Historic Places or the California Register of Historical Resources.
- Nearly all of the land within the SDCD coastal zone was surveyed for archaeological resources, but additional sites may exist within unexamined, inaccessible (due to dense vegetation, slope, dangerous conditions, etc.), or buried areas of the coastal zone.

To maintain confidentiality of site locations, a ‘buffer area’ was developed around documented site boundaries. This was created in a geographic information system (GIS) by generating a buffer around documented archaeological site boundaries, site points, and site lines, then merging resulting buffers together where they overlapped, and smoothing and generalizing the resulting polygons to avoid making specific site locations obvious and to maintain their confidentiality. Since the buffer area was used in the exposure analysis, cultural resources that fall in the buffer area are marked as exposed, even if the resources themselves do not intersect the coastal hazard data.

Additional Limitations

In addition to limitations within CoSMoS data, several assumptions were made to determine exposure, sensitivity, and vulnerability.

SLR Projections

The SLR projections chosen for this analysis (1.6 ft and 3.5 ft) represent a high, worst-case scenario. Using the most conservative approach captures the highest extent of flooding, but it may not capture more nuanced trends that may arise, particularly on gently sloping beaches where SLR will occur gradually.

Sensitivity Scores

Sensitivity analysis is, by nature, a subjective process meant to characterize how different assets, resources, and shorelines respond to the same level of exposure. Although sensitivity ratings are applied at the asset type and shoreline type level, individual assets within these groups may be affected by different factors, including age, composition, or the materials and vegetation surrounding them.

Overall Vulnerability Ranking

Overall vulnerability rankings assigned to assets and resources are relative and should be used as a screening tool to identify assets and resources that are vulnerable to multiple hazards. Assets ranked with low overall vulnerability may still have some degree of vulnerability but are considered less vulnerable than other assets or resources in the study.

For example, the South McCoy Trail in Border Field State Park is exposed to, and highly sensitive to, only one hazard, groundwater, thus scoring a 'low' in overall vulnerability. However, exposure to groundwater would still degrade or flood the trail, potentially rendering it inoperable. By contrast, the Beach Route Trail in the same park unit is exposed to all four coastal hazards, scoring a 'high' in overall vulnerability. Although the impacts to both trails are likely similar, the relative ranking shows a higher level of vulnerability for the Beach Route Trail due to multi-hazard exposure. The overall vulnerability score can be used to identify priority assets or resources for adaptation.

The study methodology is a generalization that is useful to characterize broad, potential change across large areas within the SDCD. In addition to the limitations discussed above, it is important to recognize that each park unit has a unique combination of assets, resources, and shorelines, as well as varying levels of public use. For this reason, each park unit will have a different set of adaptation strategies and thresholds at which those strategies should be applied. For site-specific management and decision-making, the uniqueness of the site and existing natural processes should first be evaluated and understood.

Visitation Study Data

These reports also include visitor demographics data from a Visitation Study conducted by Coastal Quest, Utah State University, and State Parks in 2021 using generalized cell phone data. This study looked at trends in visitors across 2021 by segmenting the cell phone data to specific geographic areas that include the parks. This report, while robust, found some conclusions that differed from the on-the-ground visitor studies conducted by State Parks, including increased visitor usage of the parks in winter.

2.3 Evaluating Vulnerability of Physical Assets Resources

This section describes the vulnerability assessment process and results for Moonlight SB. It details the assignment of exposure (Section 2.3.1) and sensitivity (Section 2.3.2) ratings and how they were combined to develop an overall vulnerability matrix (Section 2.3.3).

2.3.1 Exposure Assessment

An exposure assessment estimates the timing and extent of each asset or resource's potential introduction to a coastal hazard. To complete the exposure assessment, coastal hazards mapping layers were overlaid on the locations of inventoried park assets and resources using GIS. This process was completed separately for two SLR projections – 1.6 ft and 3.5 ft – resulting in a set of exposure scores for all Moonlight SB asset categories corresponding with the approximate years 2035 and 2050, respectively. Asset scores were evaluated for exposure to each coastal hazard on a binary basis (0 or 1). For example, assets overlapping with the tidal inundation layer receive a score of 1 and assets outside of an inundation hazard extent receive a score of 0. Documentation of the exposure of natural resources also included the acreage of each land cover or vegetation type affected by the evaluated coastal hazard.

Binary score assignments were added together to calculate an exposure score for permanent exposure (tidal inundation, shoreline change, and groundwater) and temporary exposure (100-year coastal storm flooding). Exposure scores ranged from 0 to 3 for permanent coastal hazards (tidal inundation, shoreline change, and groundwater) and 0 to 1 for temporary coastal hazards (100-year coastal storm flooding). Table 3 provides an example of the methods used to develop exposure scores for assets that were exposed to temporary and permanent coastal hazards.

Table 3. Exposure Score Example

Category	Asset	Tidal Inundation	100-year Coastal Storm Flooding	Shore-line Change	Ground-water	Temporary Exposure Score (0 to 1)	Permanent Exposure Score (0 to 3)
Access	CA Coastal Trail (2)	1	1	1	0	1	2

Table 4 and Table 5 summarize the exposure matrix for assets and resources in Moonlight SB based on 2035 and 2050 projections, respectively. A checkmark indicates that an asset or asset type is projected to be exposed to the coastal hazard and a dash indicates that the asset or asset type is not exposed. When appropriate, the number (or acreage for natural resources) of features projected to be exposed to each coastal hazard is listed in parentheses. The full summary of exposed assets can be found in Appendix C.

Table 4. Coastal Hazard Exposure Summary Matrix for 1.6 ft SLR (~2035)

Category	Asset	Tidal Inundation	100-year Coastal Storm Flooding	Shoreline Change	Groundwater
Access	CA Coastal Trail (2)	-	✓ (2)	✓ (2)	-
Access	CA Coastal Trail (1)	✓ (1)	✓ (1)	-	-
Access	CA Coastal Trail (2)	✓ (2)	✓ (2)	✓ (2)	-
Access	CA Coastal Trail (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)
Access	Collector Roads (1)	-	✓ (1)	-	✓ (1)
Access	Collector Roads (1)	-	✓ (1)	✓ (1)	-
Access	Mobi Mat (1)	-	✓ (1)	-	-
Access	Stairs (1)	-	✓ (1)	-	-

Category	Asset	Tidal Inundation	100-year Coastal Storm Flooding	Shoreline Change	Groundwater
Facilities/ Infrastructure	Building Footprints (1)	-	✓ (1)	-	-
Facilities/ Infrastructure	Discharge Points (1)	-	✓ (1)	-	-
Facilities/ Infrastructure	Lifeguard Towers (1)	✓ (1)	✓ (1)	-	-
Facilities/ Infrastructure	Signage (3)	-	✓ (3)	-	-
Recreation	Surf Breaks (2)	✓ (2)	✓ (2)	-	-
Land Cover	Beach (1)	✓ (0.2)	✓ (1.1)	✓ (3.6)	✓ (0.1)
Note: A checkmark indicates that an asset or asset type is exposed to the coastal hazard and a dash indicates that the asset or asset type is not exposed.					

Table 5. Coastal Hazard Exposure Summary Matrix for 3.5 ft SLR (~ 2050)

Category	Asset	Tidal Inundation	100-year Coastal Storm Flooding	Shoreline Change	Groundwater
Access	CA Coastal Trail Segments (1)	✓ (1)	✓ (1)	-	-
Access	CA Coastal Trail Segments (1)	-	✓ (1)	✓ (1)	✓ (1)
Access	CA Coastal Trail Segments (3)	✓ (3)	✓ (3)	✓ (3)	-
Access	CA Coastal Trail Segments (2)	✓ (2)	✓ (2)	✓ (2)	✓ (2)
Access	Collector Roads (1)	-	✓ (1)	✓ (1)	-
Access	Collector Roads (1)	-	✓ (1)	-	-
Access	Mobi Mat (1)	✓ (1)	✓ (1)	-	-
Access	Stairs (1)	-	✓ (1)	✓ (1)	-

Category	Asset	Tidal Inundation	100-year Coastal Storm Flooding	Shoreline Change	Groundwater
Facilities/ Infrastructure	Building Footprints (1)	✓ (1)	✓ (1)	-	-
Facilities/ Infrastructure	Discharge Points (1)	-	-	✓ (1)	-
Facilities/ Infrastructure	Discharge Points (1)	-	✓ (1)	-	-
Facilities/ Infrastructure	Discharge Points (1)	✓ (1)	✓ (1)	-	-
Facilities/ Infrastructure	Lifeguard Towers (1)	✓ (1)	✓ (1)	-	-
Facilities/ Infrastructure	Lifeguard Towers (1)	-	✓ (1)	-	-
Facilities/ Infrastructure	Signage (2)	-	✓ (2)	-	-
Facilities/ Infrastructure	Signage (1)	✓ (1)	✓ (1)	-	-
Recreation	Surf Breaks (2)	✓ (2)	✓ (2)	-	-
Land Cover	Beach (1)	✓ (0.8)	✓ (1.0)	✓ (2.7)	✓ (0.1)
Note: A checkmark indicates that an asset or asset type is exposed to the coastal hazard and a dash indicates that the asset or asset type is not exposed.					

2.3.2 Sensitivity Assessment

Park assets and resources that are projected to be exposed to coastal hazards were analyzed for sensitivity to SLR, which is characterized as the degree to which an asset or resource could be physically damaged and or/result in loss of function if exposed to each hazard. Table 6 summarizes the qualitative criteria and sensitivity scores, ranging from 0 (not sensitive) to 3 (highly sensitive) were assigned to each asset or resource. Separate sensitivity scores were populated for temporary and permanent hazards to characterize the influence of each hazard on asset or resource sensitivity.

Table 6. Sensitivity Scores Crosswalk for Physical Assets and Resources

Sensitivity Rating	Description	Sensitivity Score
Not Sensitive	No change to asset or resource function	0
Low (L)	Short-term, minor, or reversible change to asset/resource or function.	1

Sensitivity Rating	Description	Sensitivity Score
Moderate (M)	Substantial but reversible change to asset/resource or function	2
High (H)	Irreversible change to asset/resource and permanent loss of function	3

Table 7 provides an example of developing sensitivity scores for assets and resources that are projected to be exposed to temporary and permanent coastal hazards. The full summary of sensitivity results for evaluated assets and resources, which includes assigned sensitivity scores is presented in Appendix D.

Table 7. Sensitivity Score Example

Category	Temporary Sensitivity Rating	Temporary Sensitivity Score	Permanent Sensitivity Rating	Permanent Sensitivity Score
Example Asset 1	Moderate	2	High	3

Appendix D summarizes sensitivity ratings for each asset type and resource type in Moonlight SB that is projected to experience exposure to coastal hazards, with rationale explaining the ratings.

2.3.3 Vulnerability Matrix

After evaluating park assets for exposure and sensitivity, the assigned scores were combined to develop an overall vulnerability score for each asset and natural resource. Vulnerability scores were calculated separately for temporary and permanent coastal hazards by multiplying the respective exposure and sensitivity scores for each hazard type. Individual scores for temporary and permanent hazards were added for an overall vulnerability score ranging from 0 (not vulnerable) to 12 (most vulnerable).

Permanent Exposure x Permanent Sensitivity = Permanent Vulnerability

Temporary Exposure x Temporary Sensitivity = Temporary Vulnerability

Permanent Vulnerability + Temporary Vulnerability = Overall Vulnerability

The vulnerability scores were then used to rank assets to determine which were considered to have the highest vulnerability. Overall vulnerability scores were binned and categorized as Low for scores ranging from 1 to 3, Moderate for scores ranging from 4 to 6, and High for scores ranging from 7 to 12. Table 8 provides an example of developing a total vulnerability score. In general, assets ranking as Low are projected to be exposed to one coastal hazard, assets ranking as Moderate are exposed to two coastal hazards, and assets ranking as High are exposed to more than two coastal hazards.

The full summary of results for evaluated assets is presented in Appendix C.

Table 8. Total Vulnerability Score Example

Category	Temporary Exposure Score (0-1)	Temporary Sensitivity Rating (0-3)	Temporary Vulnerability Score (0-3)	Permanent Exposure Score (0-3)	Permanent Sensitivity Score (0-3)	Permanent Vulnerability Score (0-9)	Total Score (0-12)
Example Asset 1	1	2	**2**	2	3	**6**	8 High
Example Asset 2	1	3	**3**	1	3	**3**	6 Moderate

A summary of ranked vulnerable assets at Moonlight SB for 1.6 ft (~2035) and 3.5 ft (~2050) projections is presented in Table 9 and Table 10. Figure 4 depicts assets with a high vulnerability ranking. The full summary of results for evaluated assets is presented in Appendix C.

Table 9. Vulnerability Summary of Results for 1.6 ft of SLR (~2035) for Physical Assets and Resources

Type	Asset or Natural Resource (if applicable)	Combined Vulnerability Ranking
Access	4 CA Coastal Trail Segments	High
Land Cover	1 Beach	High

Type	Asset or Natural Resource (if applicable)	Combined Vulnerability Ranking
Access	3 CA Coastal Trail Segments	Moderate
Access	2 Collector Roads	Moderate
Recreation	2 Surf Breaks	Moderate
Access	1 Mobi Mat	Low
Access	1 Stairs	Low
Facilities/ Infrastructure	1 Building Footprints	Low
Facilities/ Infrastructure	1 Discharge Points	Low
Facilities/ Infrastructure	1 Lifeguard Tower	Low
Facilities/ Infrastructure	3 Signs	Low

Table 10. Combined Vulnerability Summary Results for 3.5 ft SLR (~2050) for Physical Assets and Resources

Asset Type	Asset (if applicable)	Combined Vulnerability Ranking
Access	6 CA Coastal Trail Segments	High
Land Cover	1 Beach	High
Access	1 Mobi Mat	Moderate
Access	1 CA Coastal Trail Segment	Moderate
Access	1 Stairs	Moderate
Access	1 Collector Road	Moderate
Facilities/ Infrastructure	1 Building Footprints	Moderate
Facilities/ Infrastructure	1 Discharge Points	Moderate
Facilities/ Infrastructure	1 Lifeguard Tower	Moderate
Facilities/ Infrastructure	1 Sign	Moderate
Access	1 Collector Road	Low
Facilities/ Infrastructure	1 Discharge Points	Low

Asset Type	Asset (if applicable)	Combined Vulnerability Ranking
Facilities/ Infrastructure	1 Discharge Point	Low
Facilities/ Infrastructure	1 Lifeguard Tower	Low
Facilities/ Infrastructure	2 Signs	Low

Figure 4. Assets and resources with High Combined Vulnerability Ranking

Key for Figure 4

Category	Asset Name	High Vulnerability 1.6 FT	High Vulnerability 3.5 FT	Map Key #
Access	Trail to Moonlight State Beach 4	1	1	1
Access	Moonlight State Beach Trail	1	1	2
Access	Trail to Moonlight State Beach 2	1	1	3
Access	Trail to Moonlight State Beach 4	1	1	4
Access	Trail to Moonlight State Beach 3	0	1	5
Access	Stairs to Moonlight State Beach from D Street	0	1	6

2.4 Evaluating Vulnerability of Shoreline Typologies

Shorelines are typically designated based on their landform, substrate, and nearby structures that inhibit natural processes. As explained by State Parks' Department Operations Manual,[8] shorelines are naturally dynamic aspects of the landscape that are sculpted by coastal processes over time. These same natural coastal processes will cause accelerated change to shorelines as sea levels continue to rise. In this report, vulnerability of shoreline typologies refers to the susceptibility of existing shorelines to experience a change in shoreline type due to coastal hazards related to SLR (e.g., type change from sandy beach backed by armoring to an armored shoreline without a beach).

This section describes the vulnerability assessment process and results for shoreline typologies in Moonlight SB. It details the assignment of exposure (Section 2.4.1) and sensitivity (Section 2.4.2) scores, described in Appendix C, and how they were combined to develop an overall vulnerability matrix (Section 2.4.3) to understand what areas of the park shoreline may most likely experience shoreline change.

It is important to note that the assignment of a shoreline typology implies a level of stationarity to the shoreline, and thus results in a reduction to the complexity of the resource in the analysis (i.e., does not fully capture the dynamics of the system). Thus, this methodology is a generalization that is useful to characterize broad, potential change across large areas within the park unit, but it does have limitations. For site-specific management and decision-making, the uniqueness of the site and existing natural processes should first be evaluated and understood.

2.4.1 Exposure Assessment

Shoreline typologies were evaluated for projected exposure to shoreline change. The exposure assessment was based on the shoreline change index (SCI) calculated for equally spaced transects along the Moonlight SB shoreline, as described in Appendix E.

[8] State Parks Department Operations Manual, Natural Resources 0307.3.2 Coastlines and Coastal Erosion and 0307.3.2.1 Coastal Development Siting Policy

The SCI characterizes the degree of accretion or erosion that is occurring along each transect relative to a baseline beach width (it indicates the degree a shoreline is shrinking or decreasing). SCI scores can be interpreted as follows: if SCI values are greater than 0, beach width is increasing. If SCI values are less than 0, beach width is decreasing. Exposure scores ranging from 1 (less than 10 percent beach retreat) to 4 (fully eroded beach) were assigned to correspond with the SCI values shown in Table 11. This process was completed for 1.6 ft SLR (~2035) and 3.5 ft SLR (~2050) projections.

Table 11. Exposure Score Crosswalk for Shoreline Segments

SCI	Exposure Score
>0 to -0.1	1
-0.1 to -0.5	2
-0.5 to -1	3
< -1	4

The full summary of shoreline typology exposure scores for 1.6 ft SLR (~2035) and 3.5 ft SLR (~2050) projections are presented in the Vulnerability Matrix (2.4.3).

2.4.2 Sensitivity

State Park shoreline typologies were assigned a sensitivity score to characterize the ability of the beach to migrate landward. Table 12 provides qualitative sensitivity ratings and rationale for each shoreline type in Moonlight SB. Sensitivity scores, ranging from 0 (not sensitive) to 3 (highly sensitive), were assigned based on alignment with the qualitative sensitivity ratings provided in Table 12. A crosswalk between the assigned sensitivity ratings and corresponding sensitivity scores is provided in Table 13. Although exposure is evaluated for each shoreline segment, a single sensitivity rating was applied for each delineated shoreline typology. The full summary of shoreline type sensitivity ratings can be found in Appendix D.

Table 12. Moonlight SB Shoreline Type Sensitivity Ratings

Shoreline Type	Sensitivity to Shoreline Change	Rationale
Sandy Beach Backed by Hard Natural Bluff	High	Hard backshore features do not allow the beach to migrate landward, resulting in permanent loss of beach.
Sandy Beach Backed by Soft Natural Bluff	Moderate	Soft backshore bluffs may erode and contribute to accretion of the sandy beach (depending on bluff composition), although the beach may erode at a higher rate than the backing bluff, resulting in some reduction in beach width.

Shoreline Type	Sensitivity to Shoreline Change	Rationale
Sandy Beach Backed by Armor	High	Hard backshore features do not allow the beach to migrate landward, resulting in permanent loss of beach.
Sandy Beach Backed by Road, Parking Lot, or Other	High	Hard backshore features do not allow the beach to migrate landward, resulting in permanent loss of beach.

Table 13. Example Sensitivity Score for Shoreline types

Shoreline Type	Sensitivity Rating	Sensitivity Score
Example Shoreline type 1	High	3
Example Shoreline type 2	Moderate	2
Example Shoreline type 3	Low	1

2.4.3 Vulnerability Matrix

After evaluating shoreline typologies at Moonlight SB for exposure and sensitivity, the assigned scores were combined to develop an overall vulnerability score for each shoreline segment. The purpose of the overall vulnerability score is to rank areas of the park unit coastline considered to have the highest susceptibility to experience shoreline change. Vulnerability scores range from 0 (not vulnerable) to 12 (most vulnerable).

Shoreline Change Exposure x Sensitivity = Vulnerability

Vulnerability scores were binned and categorized as Low for scores ranging from 1 to 3, Moderate for scores ranging from 4 to 8, High for scores ranging from 9 to 11, and Very High for a score of 12. Shoreline segments with Very High vulnerability ranking have highly sensitive shoreline types (including sandy beach backed by hard natural bluff, sandy beached backed by armor, and sandy beach backed by parking lot) and typically experience complete beach loss. Table 14 provides an example of developing the vulnerability score and ranking. Vulnerability rankings were translated onto a shoreline map (Figure 5) to show how vulnerability varies geographically along the shoreline for each SLR projection. Shoreline typologies categorized as inlets (i.e., Armored Inlet Backed by Estuary/Lagoon and Natural Inlet Backed by Estuary/Lagoon) were not included in the full vulnerability analysis because these stretches of the park are characterized by open water and are not applicable for the applied exposure analysis methodology. However, sensitivity of inlets to shoreline change is documented in Appendix D to capture susceptibility of these features to shoreline change processes. The full summary of shoreline vulnerability ratings can be found in Appendix C.

Table 14. Example Total Vulnerability Scores for Shoreline Typologies

Transect	Exposure Score	Sensitivity Score	Vulnerability Score
Example Transect 1	4	3	12 (Very High)
Example Transect 1	3	3	9 (High)
Example Transect 2	3	2	6 (Moderate)
Example Transect 3	1	2	2 (Low)

Figure 5. Shoreline Vulnerability

3. Vulnerability Assessment Discussion

3.1 Key Findings

Moonlight SB's greatest vulnerabilities to coastal hazards are a product of its dynamic coastal setting and the inherent sensitivities of its shoreline types. Much of the park is characterized as sandy beach backed by soft natural bluff, with sections characterized as sandy beach backed by parking lot, armor, or hard natural bluff.

Historical shoreline change rates are expected to accelerate due to SLR, which may affect the park unit's existing recreational amenities. With 1.6 ft of SLR, beach width loss occurs along the entire beach, with a slight increase in loss as SLR reaches 3.5 feet. At both SLR projections, complete beach loss is expected along the stretches of beach backed by hard natural bluff and coastal armoring.

Park access trails and a staircase located at low elevations on the beach are most vulnerable to near-term changes from coastal hazards. These assets located on the beach are anticipated to experience multi-hazard exposure from tidal inundation, 100-year coastal storm flooding, elevated groundwater levels, and shoreline change with 1.6 ft of SLR.

In addition to affecting visitor beach access and a narrowing and landward transition of beach habitats, the loss of beach width also removes natural wave attenuation benefits provided by the beach to the bluffs. Accelerated erosion rates of the beach and the bluffs due to SLR and loss of fronting beaches represent a key vulnerability to existing park operations because their retreat diminishes the park area as a whole and could lead to fragmentation of the park itself.

The following sections provide a more detailed discussion about vulnerabilities identified for park asset, resources, and shoreline types found within Moonlight SB. The discussions in each section focus on high vulnerability park assets, resources, and shoreline types associated with a high to very high vulnerability (Figure 4 and Figure 5).

3.2 Physical Assets

The following discussion is a summary of the key vulnerability findings for physical assets located within Moonlight SB to coastal hazards projected to impact the region at 1.6 ft and 3.5 ft of SLR. This category includes access, facilities, and recreational features.

3.2.1 Access

- Four segments of the California Coastal Trail have high vulnerability to coastal hazards with 1.6 ft of SLR. The Trail to Moonlight State Beach (segments 1 and 2) is exposed to tidal inundation, 100-year coastal flooding, and shoreline change. The Trail to Moonlight Beach (segment 4) and the Moonlight State Beach Trail are exposed to all coastal hazards. Six segments (including the stairs to the beach) have high vulnerability with 3.5 ft of SLR. Two trail segments, the Moonlight State Beach Trail and the Trail to Moonlight State Beach (segment 2), are exposed to all four of the coastal hazards, and the Trail to Moonlight State Beach (segments 1, 3 and 4) are exposed to tidal inundation, 100-year coastal storm flooding, and shoreline change. Trails have moderate sensitivity to temporary exposure and high sensitivity to permanent exposure. With temporary exposure, trails may require short-term closures and cleanup of minor debris. However, with permanent exposure, trails may erode or wash out. These impacts are likely to limit coastal access for visitors and result in fragmentation of trail networks.

- The stairs to Moonlight State Beach from D Street are vulnerable with 3.5 ft of SLR and are exposed to 100-year coastal storm flooding, shoreline change, and groundwater. Staircases have medium sensitivity to temporary inundation because temporary flooding may require short-term closure and clean-up of debris, but access can be resumed after floodwaters subside. Structural integrity of wood stairways may be compromised by high velocity storm surges. Staircases have high sensitivity to permanent inundation because permanently inundated staircases will become inoperable. Erosion of stairway foundations may affect their structural integrity or access.

3.2.2 Facilities

- No facilities/infrastructure are highly vulnerable.

3.2.3 Recreational Features

- Major water-based recreational uses of Moonlight SP include surfing and swimming, which will likely be impacted to some extent by both 1.6 and 3.5 feet of SLR, with the severity of sensitivity and exposure varying by activity and location.
- Rising sea levels can also affect the quality of the existing surf break location. Increases in water depth at surf breaks can cause the wave to break further inshore, change the shape of the wave, or reduce the ability of the wave to break at all.

3.2.4 Summary of Direct and Indirect Consequences to Physical Assets

Potential parkwide direct consequences to physical assets caused by projected 1.6 and 3.5 ft of SLR coastal hazards include:

- Reduced access to and throughout the park for visitors, park employees, and emergency vehicles due to projected vulnerability of trails, Mobi Mat, and collector roads
- Increased maintenance/replacement costs as physical assets experience direct damage caused by flooding, inundation, and/or erosion
- Disruptions to public access during damage clean-up and construction activities
- Disruptions to interpretive and educational opportunities, such as junior lifeguard training activities (e.g., training, lectures, gathering locations, etc.) due to reduced access and narrowing of beaches
- Reduction of popular recreational activities such as birding, surfing, swimming, fishing, and picnicking caused by decreased access to recreation areas, and narrowing of beaches

Potential indirect consequences of physical asset vulnerabilities caused by 1.6 and 3.5 ft of SLR include:

- Changes to park visitation rates due to decreases in recreational opportunities, which may impact revenue streams
- Reduced availability of low-cost recreational opportunities such as picnicking, walking, jogging, etc. for park visitors
- Loss of health and well-being for the public due to inability to access the park unit during temporary or permanent closures
- Reduced ability to respond to park maintenance needs due to reduced motor vehicle access and damaged equipment
- Potential disruptions to local economy due to reduced visitation if access and recreational areas of the park experience closures

3.3 Natural Resources

The following discussion is a summary of key findings and direct and indirect consequences for the vulnerability of natural resources within Moonlight SB.

- The beach land cover type is highly vulnerable with 1.6 ft of SLR and is exposed to all coastal hazards. Approximately 5.2 and 7.9 acres of beach land cover type are projected to be exposed and highly vulnerable with 1.6 ft and 3.5 ft of SLR, respectively. Beach land cover type has low to moderate sensitivity for temporary hazards and moderate to high sensitivity to permanent hazards. Beach loss due to permanent hazards may cause habitat fragmentation and degradation and may reduce available nesting, foraging, and haul-out opportunities for sensitive coastal and marine species, and potentially introduce spatial competition amongst species that have been displaced (Dugan et al. 2008; Feagin et al. 2005; Largier et al. 2010).

Potential parkwide direct consequences of land cover types/vegetation alliance vulnerabilities from 1.6 and 3.5 ft of SLR:

- Changes in local sediment transport, such as increased rates of sand loss and erosion/accretion rates, as beaches become inundated
- Changes in local sediment transport as coastal lagoon channels erode, deepen, and widen
- Shifts in habitat for highly adapted and endemic wildlife species

Potential indirect consequences of landcover/vegetation alliance vulnerabilities from 1.6 and 3.5 ft of SLR include:

- Decreased flood and erosion protection for coastal habitats and park assets due to the reduction of beach ecosystems
- Changed aesthetics within the park unit due to loss of natural land cover types and vegetation assemblages, such as changes in sense of place, viewsheds, and soundscapes
- Changes in the interpretive and educational experiences for park visitors

3.4 Cultural Resources

This section summarizes key vulnerability findings for cultural resources with 1.6 and 3.5 ft of SLR, followed by a discussion of the potential consequences SLR may have on cultural resources.

- No known cultural resources were identified at Moonlight SB. However, SLR may uncover cultural resources that are currently buried. There also may have been cultural resources present in the past that were inundated at the time of the cultural resources survey or that have been washed away.

Potential consequences of SLR impacts to cultural resources include:

- Reduction in information that may be acquired from cultural resources as they are exposed to coastal hazards. Flooding may move the resource away from its original location, destroying its provenience. Permanent inundation and increased flooding events may result in physical damage to an artifact or site due to increased erosion, changes in pH, and saturation of the site from below.

- Significant loss in access and availability to Tribal archaeological resources for indigenous communities, such as flooding of ceremonial and event locations. Reduced access may result in the loss of knowledge or other traditional values.

- Changes in the interpretive and educational experiences for both Tribal communities and park visitors.

Ensuring archaeological sites are protected will be critical to maintain these important resources. This can be done by nourishing beaches or preventing erosion by building protective barriers. If construction is approved, a cultural resource monitoring program should be implemented to ensure that sites that are buried or otherwise not identified are identified and subject to appropriate treatment. A site's resilience could be improved by physical measures to withstand inundation or constructing a cap over a site. As a last resort, cultural resource sites can be relocated to a safer location. If a cultural resource site cannot be protected or relocated, mitigative measures such as archaeological data recovery or additional documentation should be implemented in consultation with project stakeholders (Smith, N. F., and ICLEI Canada 2020). This can be done through archaeological excavation, photo documentation, and photogrammetry. In the long term, practices to protect cultural resources from SLR impacts could be integrated into standard stewardship practices.

Tribal Outreach Summary

Cogstone conducted Tribal outreach from November to December 2022, which included letters, online surveys, emails, and site visits, but overall Tribal engagement was low due to extenuating circumstances. Appendix B includes details of Tribal outreach. Important takeaways from the outreach process include the need for Tribal collaboration over consultation, protecting submerged archaeological sites, considering all beaches for adaptation measures, developing relationships with non-State Parks entities who control Tribal cultural sites, identifying and setting aside land for future reburials, and using public art or events to raise awareness. The primary recommendations from this process were for State Parks to create a permanent collaborative process with the Tribal Nations to further assess adaptation options, extend the feedback period, present the study results to specific Tribal groups, and hold additional site visits.

3.5 Shoreline Typologies

The following discussion is a summary of the key findings of the vulnerability assessment that were used to evaluate the effects of coastal hazards on shoreline typologies for Moonlight SB.

- With 3.5 ft of SLR, sections of beach backed by armor or hard natural bluff are highly vulnerable due to the inability of the beach to migrate landward in response to coastal hazards.

Potential direct consequences of coastal hazard impacts on shoreline typologies include:

- Loss of beach width, which may limit public beach and water access and recreational opportunities at the park
- Erosion and loss of beach in front of structures and other park assets could leave the assets more vulnerable and potentially lead to damage or loss.

Potential indirect consequences of coastal hazard impacts on shoreline typologies include:

- Increased maintenance cost of park amenities, such as roads, trails, buildings, access routes, etc. as the coastal hazard buffering capabilities of the beach is reduced
- Decrease in park revenue due to lowered visitation rates if beach access is reduced or park amenities changed
- Negative visitor experience due to limited recreational opportunities, change in park amenities or potential safety hazards.

4. Integrating Community Values

4.1 Overview

State Parks' SDCD serves a complex geography with diverse communities. Community outreach and engagement targeted the broad general public, including disadvantaged communities (DACs) and severely disadvantaged communities (SDACs)[9], as well as key stakeholders and partners, such as local governments, California Tribes, and civil and community organizations. The overall purpose of outreach and engagement activities was to gather public input that would inform the SLR Vulnerability Assessments and Adaptation Pathways Reports for coastal park units in the SDCD. More specifically, the goals of the engagement process were to:

- Raise awareness regarding the purpose, goals, anticipated outcomes, and benefits of the project
- Educate the public on SLR, coastal adaptation, project and planning processes, and State Parks' SLR Strategy - including the cross-cutting, integrative nature of State Parks' approach

[9] The State of California defines DACs as households with an annual income ranging from roughly $43,000 to $57,000 and SDACs as those with household incomes less than $43,000.

- Share key vulnerability findings and engage and solicit broad and diverse community perspectives, insight, and feedback on valued places and uses, and SLR adaptation priorities
- Reduce barriers to participation through inclusive engagement strategies identified throughout the outreach and engagement process
- Emphasize equity and inclusion in all outreach and engagement planning and execution, including development of targeted engagement strategies for California Tribes, DACs, and SDACs

There were two rounds of engagement events and activities carried out in summer and fall 2022 with the overall goals of understanding how park visitors and local communities value and use SDCD park units and to gather input on adaptation strategies, respectively. Results of these outreach and engagement effort are summarized in subsequent sections. For a more complete understanding of the engagement approach, and the engagement activities and the breadth and depth of associated input, see Appendix A.

4.1.1 Round 1 Community Input: Values and Use

Round 1 events and activities focused on understanding community values and preferred uses of SDCD coastal park units. Engagement participants were asked about their favorite activities at coastal parks, important places and uses within coastal parks and/or within specific State Parks, and SLR impacts observed at coastal parks. Input was sought through online and in-person activities. An online mapping activity was provided for participants to identify places and features of coastal state parks that are most important to them by dropping markers on virtual maps. Participants also had the option of providing general comment through an online comment form. Input was sought at in-person pop-up events and community events where participants could view and comment on maps of the coastal state parks. All activities took place from August 29 to October 25, 2022, and are summarized in Table 15.

Table 15. Round 1 Engagement Events Overview

Event	Date	Location	Approximate Number of Participants
Online Mapping Activity	August 29 – October 25, 2022	Online	600 unique users[10] 37 map comments 14 questionnaire responses
Pop-Up Event	September 3, 2022	South Carlsbad State Beach, Carlsbad	44
	September 8, 2022	San Diego Natural History Museum, Balboa Park	61
	September 9, 2022	Silver Strand State Beach North, Coronado	51

[10] The total number of unique people who viewed the Social Pinpoint site during Round 1 (determined by browser tracking through Google Analytics).

	September 17, 2022	Torrey Pines State Beach and Torrey Pines State Natural Reserve, La Jolla	83
Community Event	August 30, 2022	Joe and Mary Mottino Family YMCA, Oceanside	22
	September 1, 2022	Copley-Price YMCA, San Diego	90
	September 7, 2022	Border View YMCA, San Diego/Chula Vista	15
	September 16, 2022	John A. Davis Family YMCA, La Mesa	23
Presentation to San Diego Regional Climate Collaborative	September 13, 2022		60
		TOTAL	1,049 participants

4.1.1.1 Round 1 Engagement Results

Engagement participants had varying levels of interest in commenting on specific park units, and most participants instead preferred to share what they generally like to do when visiting parks and beaches on the coast. Responses highlighted key types of assets that were important to participants, such as access, facilities and infrastructure, and recreational features. Key district-wide themes that emerged are summarized in Table 16 and themes specific to Moonlight SB are summarized in Table 17.

Table 16. District-wide Key Themes

Asset Category	Key Community Input Themes
Overarching	▪ Appreciation of state beaches was expressed by many participants ▪ Beach, sand, and ocean experiences were identified as important priorities for many participants ▪ Many participants identified active and passive recreation activities as the primary reason for visiting beaches
Access	▪ Beach Access: Americans with Disabilities Act (ADA) accessibility and mobility concerns were frequently noted as a barrier to accessing some state beaches and, in particular, the beach areas ▪ Parking: Participants shared mixed opinions on the value of parking. Some commenters generally favored continued access to parking facilities; while others noted a desire for parking areas to be shifted to other uses ▪ Paths and Trails: Many participants indicated that a key reason for visiting state beaches was to use biking, walking, and hiking paths and trails for both active and passive recreation
Cultural Resources	▪ General: Participants identified the importance of cultural resources associated with California Tribes, and the U.S.-Mexico

Asset Category	Key Community Input Themes
	border area, specifically at Border Field and Torrey Pines State Beaches
Facilities and Infrastructure	▪ Infrastructure and Visitor Facilities: Many participants noted appreciation for features such as bathrooms, showers, lifeguard towers and surf-related infrastructure, including breaks. ▪ Bathrooms and showers were often highlighted as important by families with children and beachgoers who indicated extended visits to the beach ▪ Some participants reported deteriorating infrastructure leading to the loss of related access points, recreational assets, and other resources
Interpretation and Education	▪ General: Some participants noted the appreciation for the availability of interpretive and educational features at state beaches
Natural Resources	▪ General: Natural areas were identified as some participants' favorite places for passive and active recreation; some participants also noted concern for the loss of these areas ▪ Land Cover: Many participants shared their preference for finer sand and vegetated land covers in comparison to rockier land cover ▪ Water: Many participants shared their appreciation for the water, citing its ecological importance, and the ability to recreate in and around it ▪ Wildlife Habitats: Some participants highlighted recent changes in wildlife habitats, attributing these observations to climate change
Recreation	▪ Gathering Areas: Many participants noted getting together with friends and family as a primary activity at the beach, noting appreciation for gathering areas such as barbecues, bonfire pits, and picnic areas ▪ Active Recreation: The most frequently noted activities were related to active recreation, including walking, hiking, running, and watersports, such as boogie boarding, surfing, and swimming ▪ Passive Recreation: Participants expressed strong appreciation for passive recreation, such as gathering with family and friends, relaxing, building sandcastles, and searching for shells ▪ Pet-friendly Areas: Many participants indicated appreciation for dog parks and on-leash areas within beaches ▪ Play Areas: Participants with children noted appreciation for designated youth playground areas ▪ Wildlife and Natural Area Viewing: Enjoying the beaches’ natural areas and wildlife were identified as favorite activities by many participants

Table 17 summarizes key themes from engagement Round 1 that were specific to Moonlight SB. Where there was not sufficient participant input to generate a key theme, this is indicated by “n/a “.

Table 17. Moonlight State Beach Key Themes – Round 1

Asset Category	Key Community Input Themes
Access	n/a
Cultural Resources	n/a
Facilities and Infrastructure	n/a
Interpretation and Education	n/a
Natural Resources	A few participants shared appreciation for wetland and coastal bluff habitats
Recreation	A couple participants shared appreciation for recreation activities such as volleyball and playing in the sand

4.1.2 Round 2 Community Input: Adaptation

The second round of outreach and engagement focused on generating awareness about the SLR vulnerability of SDCD park units and potential adaptation options. Input was sought through online and in-person activities. An online questionnaire allowed users to provide feedback on adaptation options to minimize risk associated with SLR. An interactive online mapping activity was also available for those participants that wanted to weigh in on SLR options for a specific coastal state park. Engagement activities at in-person events, divided between pop-up events and community events, involved gathering feedback on potential future adaptation approaches. All these activities took place from October 25 to November 18, 2022, and are summarized in Table 18.

Table 18. Round 2 Engagement Events Overview

Event	Date	Location	Approximate Number of Participants
Online Mapping Activity	October 25 – November 18, 2022	Online	372 unique users[11] 2 map comments 45 questionnaire responses
Pop-Up Event	October 28, 2022	Silver Strand State Beach North, Coronado	7
	October 29, 2022	San Diego Natural History Museum, Balboa Park	36
	October 29, 2022	South Carlsbad State Beach, Carlsbad	12

[11] The total number of unique people who viewed the Social Pinpoint site during Round 2 (determined by browser tracking through Google Analytics)

	October 30, 2022	Torrey Pines State Beach and Torrey Pines State Natural Reserve, La Jolla	27
Community Event	October 28, 2022	South Bay Family YMCA, Chula Vista	35
	October 29, 2022	Dan McKinney Family YMCA, La Jolla	42
	November 2, 2022	Copley-Price Family YMCA, City Heights/Kensington	15
	November 3, 2022	Toby Wells YMCA, Kearney Mesa	13
Presentation to San Diego Regional Climate Collaborative	November 15, 2022		60
		TOTAL	619 participants[12]

4.1.2.1 Round 2 Engagement Results

Due the technical nature of SLR adaptation, engagement input related to adaptation options focused on options and preferences rather than suggesting innovative strategies. Participants considered and provided general input on five potential adaptation options: retreat or phased closure, enhancing natural habitats, sediment management, infrastructure, and elevation or updating features.

District-wide, a vast majority of participants were supportive of the enhancing natural habitats option, as shown in Figure 6. Sediment management was the second most popular option, followed by retreat or phased closure, infrastructure, and lastly raise or update features. It is important to highlight that, out of these possibilities, retreat or phased closure faced the greatest opposition by participants, followed by the implementation of new infrastructure and the elevating or updating of features. Sediment management, increasing or modernizing features, and adding infrastructure are options that had the highest uncertainty.

During Round 2 Engagement, enhancing natural habitats, such as living shorelines, was mentioned as a key theme for adaptation options for Moonlight State Beach.

[12] It should be noted that public health conditions during Round 2 of engagement may have impacted levels of participation. At the time, the County of San Diego advised that increased incidences of influenza, respiratory syncytial virus (RSV), and COVID-19 were anticipated, and increased cases were already being reported during the engagement window.

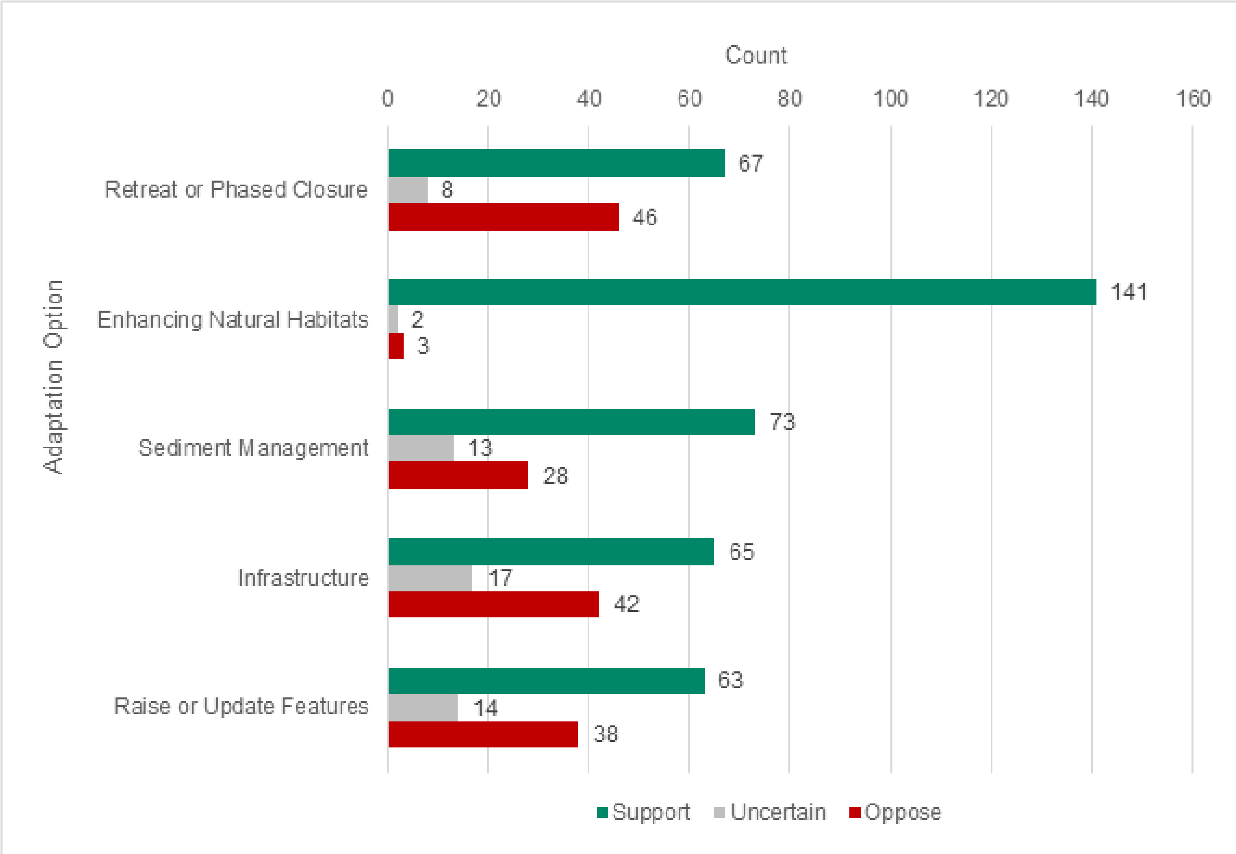


Figure 6. Summary of District-wide Input on Potential Adaptation Options

5. Tribal Outreach and Engagement

The purpose of the Tribal outreach and engagement was to inform San Diego County's Tribal Nations and greater Tribal community members about the SDCD SLR study and to collaboratively assess the risks posed by SLR, identify potential impacts to park units used by the Tribal community, and discuss potential adaptation responses to ensure that the SDCD continue to be available to Tribal partners. This effort was not an official Tribal consultation, but initial contact to provide the Tribes with information about the study. Appendix B includes details of Tribal outreach.

Cogstone conducted Tribal outreach from November to December 2022 which included two site visits with Kumeyaay and Luiseño Tribal representatives, 20 letters to Luiseño and Kumeyaay Tribal Nations via certified US Mail, an online survey, social media posting, and direct emails to Tribal organizations and Tribal community members. Overall, Tribal engagement was low due to prior commitments, holidays, and ceremonies. Tribal representatives from three Tribal Nations (one Kumeyaay and two Luiseño) participated in the site visits. Three Tribal community responses were received via the online survey and no comments were received through the social media postings.

Important themes and takeaways from the Tribal outreach and engagement include the following:

- All beaches are important and Tribal Nations and community members wanted to provide input for all State Park units.
- State Parks should inventory and protect submerged archaeological sites.
- State Parks should identify and set aside land at each State Park unit for future reburials of Ancestors and their items should they be exposed.
- Events or public art can be used to raise public awareness.
- State Parks should consider developing relationships with entities who control other Tribal cultural sites outside State Parks' purview that may be impacted by State Parks' adaption strategies.
- Representatives needed more time to review the information with other Tribal representatives and community members that could not participate.
- Consultation is not enough - all risk assessments, planned responses, policies created, and adaption options should be closely evaluated, planned, implemented, and maintained in collaboration with Tribal Nations.

This feedback was synthesized to produce the following recommendations for State Parks:

- Create a permanent collaborative process with the Tribal Nations to further assess impacts, analyze adaption options, implement adaptation options, and assess effectiveness of adaptation options.
- Send follow-up letters to Tribal Nations stating that State Parks want to continue to collaborate with Tribes and leave the online surveys open for longer durations for additional feedback.
- Present to the Kumeyaay Heritage Preservation Council, the Kumeyaay Diegueno Land Conservancy, the Kumeyaay Cultural Repatriation Committee, and the Southern California Tribal Chairmen's Association to obtain additional feedback.
- Plan additional site visits with Tribal representatives in Spring when the weather is better.

6. Adaptation Vision and Goals

Adaptation and goals were developed in collaboration between AECOM, Coastal Quest, and the PMT. The PMT identified several factors relevant to Moonlight State Beach that guided the development of the adaptation vision and goals including unit-specific key considerations, such as known upcoming projects; key assets or resources; known areas that experience flooding and/or erosion; and community input received during Round 1 and Round 2 of engagement activities. Additionally several guidance documents were reviewed including: California State Parks Sea Level Rise Adaptation Strategy (2021), Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action (2020), California Natural Resources Agency's Outdoor Access for All Initiative (2020), Classification of the park unit (PRC 5019.56), and Moonlight State Beach General Plan (1983).

Based on these factors, AECOM developed draft goals that were then refined through a series of meetings with the PMT and Coastal Quest. Below are the adaptation vision and goals for Moonlight State Beach:

- Maintain public access points, including D Street staircase
- Maintain recreational features, including sand volleyball courts and surf breaks
- Reduce or prevent beach width loss through sediment management and/or nourishment
- Coordinate with other projects and stakeholders to prioritize state park goals and protect backshore infrastructure
- Explore opportunities to record and evaluate archaeological resources as they emerge due to coastal processes

7. Adaptation Strategies and Pathways

The following sections includes a menu of adaptation strategies that consist of natural and nature-based solutions, engineered flood and erosion protection strategies, and other actions such as phased closure and managed retreat. Strategies are combined to create one potential adaptation pathway that can be used as a starting point for discussion with stakeholders and adjacent property owners. The strategies align with State Parks goals and management considerations, and input from the community and other partners obtained through a series of engagement events and activities undertaken in summer and fall 2022.

7.1 Approaches to Adaptation

Given the range of coastal hazards that could affect Moonlight State Beach, especially with increasing severity as a result of SLR, a range of adaptation strategies will need to be implemented to effectively address these impacts. There are many types of strategies that could be applied to minimize the risk posed over time, but they can generally be categorized by one of the following approaches:

- Retreat – This approach is focused on allowing park shorelines to naturally adjust to sea level changes through the removal of assets, landward relocation, habitat transitions, and providing new public access opportunities.
- Physical Interventions – This approach is focused on maintaining or enhancing the performance of existing park facilities through natural and gray design approaches (see section 7.2). It may include larger scale shoreline stabilization approaches, such as beach nourishment, or the modification of individual park assets, such as elevating or changing the construction materials of park facilities.
- Supporting Initiatives – This approach includes non-structural initiatives that may be necessary to implement or support physical interventions. Supporting initiatives may include permitting, conducting studies to address information gaps, educational opportunities, collaboration with regional stakeholders, or identifying funding sources for strategy implementation.

Although the strategies in later sections are described and mapped individually, they are often most effective when implemented using a combination of multiple strategies. Applying a combination of several approaches can be particularly useful when planning for adaptation at a park unit scale or when considering a phased approach to adaptation that is able to evolve as park conditions and needs change. For example, some site- or asset- specific strategies could be implemented in the near-term to address immediate risks to individual facilities, while the planning for longer-term strategies that address a larger area of the park unit are being undertaken.

7.2 Types of Physical Intervention Strategies

Physical intervention strategies are typically characterized as nature-based or gray infrastructure:

- Nature-based – physical modifications to shoreline typologies and physical park assets that are intended to restore or mimic characteristics of natural park features while providing improving coastal resilience (including managed retreat and phased closure)
- Gray infrastructure – physical modifications to shoreline typologies and physical park assets using conventional engineering materials, such as concrete, rock, or metals

Nature-based strategies are increasingly valued for their role in reducing risks caused by coastal hazards, because they offer co-benefits to the surrounding environment and adjacent communities. If provided adequate space and suitable conditions, nature-based strategies can also be dynamic and able to adapt in response to changing conditions (e.g., SLR) with less human intervention. Nature-based approaches to SLR adaptation are also being increasingly promoted and prioritized by numerous State of California policy and guidance documents, including the California Ocean Protection Council (OPC) Sea Level Rise Guidance (2018), California Natural Resources Agency's Safeguarding California Plan (2018), and the California State Parks Sea Level Rise Adaptation Strategy (2021).

While effective in offsetting risks to coastal hazards in some situations, there may be instances where nature-based strategies cannot as effectively reduce coastal hazard risk as traditional gray infrastructure. For example, the performance of nature-based strategies is more sensitive to rapid changes in environmental conditions (e.g., salinity levels, water temperature, flood depths), which can affect their long-term effectiveness. Nature-based strategies also generally require more space to provide the same level of coastal hazard protection as gray infrastructure.

In many cases, physical intervention strategies are designed using elements from both nature-based and gray infrastructure strategies. For example, the Cardiff Living Shoreline project at Cardiff State Beach in the SDCD includes a buried revetment under vegetated sand dunes, with the revetment serving as a last line of protection for the landward roadway. Using this hybrid approach, individual strategies can be combined and/or phased to reduce risk while also mitigating potential negative ecological impacts associated with gray infrastructure strategies.

The broad range of potential physical intervention strategies applicable to California State Parks is summarized in Figure 7. Selection of appropriate strategies, or combinations of strategies, for Moonlight State Beach will depend upon considerations, such as:

- Park unit vision and goals
- Site suitability for existing and planned park facilities
- Adjacent properties land uses
- Implementation costs
- Monitoring and maintenance needs

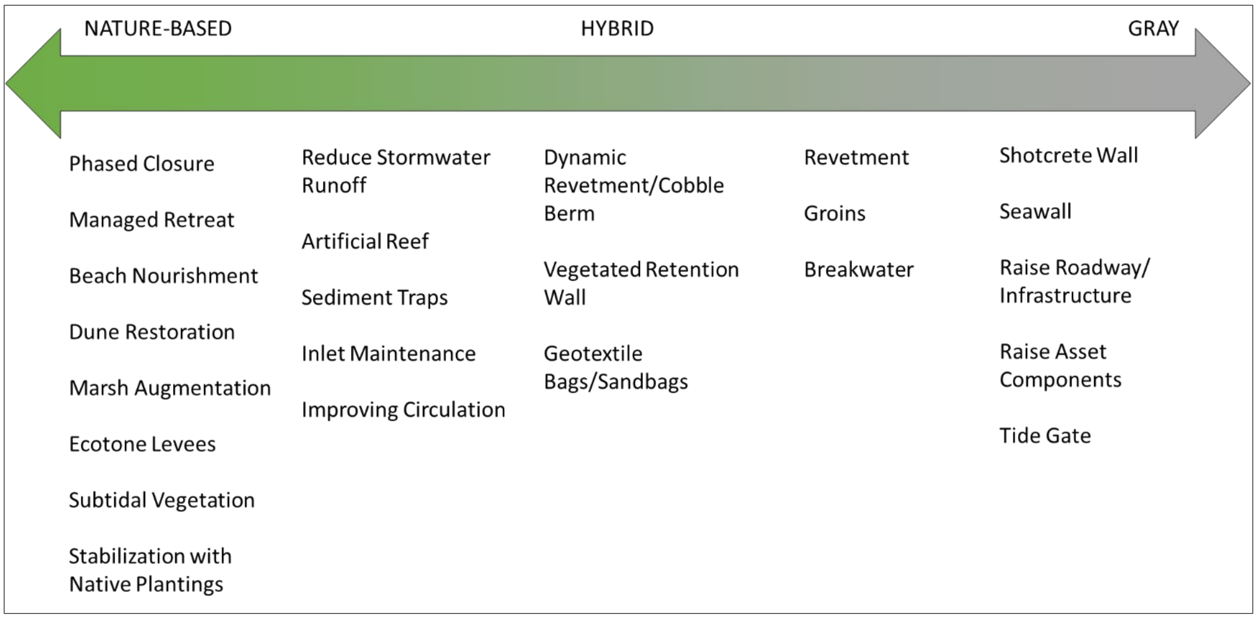


Figure 7. Example Range of Physical Intervention Strategies

Table F-1 in Appendix F includes a menu of potential strategies that could be implemented for each shoreline typology in Moonlight State Beach, and visual examples of what many nature-based or gray infrastructure solutions will look like.. Description of shoreline typologies can be found in the Typologies Memo. These strategies are not necessarily to be used in isolation from one another; often a preferred management decision may involve a subset and/or mix of strategies, potentially overlapping or at the same point in time (and in the same or nearby/overlapping locations within the park unit).

7.3 Adaptation Pathways

Adaptation pathway diagrams provide a roadmap or decision tree that helps planners understand the timing of initial adaptation strategy implementation and options for phasing strategy implementation over time. Pathways begin with a ‘No Action’ scenario and then diverge into different strategies that can be implemented.

Although OPC provides guidance for SLR planning, which informed the Coastal Hazards Vulnerability Assessment component of this project, the exact timing of SLR amounts and associated potential impacts is unknown. Adaptation pathways, which merge the functionality of a phasing diagram and a decision tree, provide a flexible means to transition between individual strategies depending on how the future unfolds (e.g., accelerated SLR). This flexibility facilitates better-informed decision making about major investments at coastal park units and improve park management over time.

Adaptation pathways includes the following elements:

- **Timing of potential SLR**: To assist with park planning, three planning time horizons were included to illustrate the range of OPC's risk aversion scenarios. The timing of adaptation strategies is initially aligned to the low risk aversion scenario. However, the timing of strategies can be shifted horizontally to align with the medium-high or extreme risk aversion scenarios if necessary due to accelerated SLR rates.
- **Vulnerability assessment planning time horizons**: Yellow stars indicate the SLR amounts (1.6 and 3.5 feet) that were used to assess park assets and shoreline typologies for potential coastal hazards.
- **Strategy opportunities**: Each strategy opportunity is depicted by a solid horizontal line. The color of the line indicates the type of action: nature-based (green), stormwater (purple), retreat/relocation (blue), and gray infrastructure (pink).
- **Trigger point and lead time**: Trigger points are depicted by a light gray circle (●), followed by a dashed line preceding the implementation of each strategy. Trigger points are pre-determined thresholds when the conditions for a planned strategy no longer meet their objectives of providing protection from coastal hazards. Trigger points are typically defined based on changes in the environment that prompt decision-making and initiate an adaptation response. Refer to Box 1 for example trigger points to consider for SLR adaptation planning. The associated lead time represents the time frame when project planning activities, such as permitting and design, must occur before proceeding with strategy implementation. Longer dashed lines indicate that the strategy opportunity has a longer lead time. For physical intervention strategies, the lead time includes funding, planning, design, permitting, and construction.
- **Implementation**: Implementation points are depicted by a black circle (●) at the beginning of each strategy solid line and marks the point where the strategy could be implemented and fully functional.
- **Transfer point**: Transfer points are depicted by a hollow circle (○) on the horizontal solid strategy lines. Transfer points represent an opportunity to switch to a different adaptation strategy if the existing strategy approach is no longer providing protection from coastal hazards. Transfer to the alternative strategy is represented by vertical gray lines, indicating the transition.

All the options included in the pathways diagram are based on the low risk aversion scenario, however, the precise timing of strategy implementation may differ based on the rate of SLR and associated coastal hazards. Including trigger points as part of an adaptive management plan will prompt proactive decision-making and adaptation response by promoting the monitoring of implemented strategies. Strategy implementation timelines may also be driven by other, non-coastal hazard factors such as the required duration for project design, permitting, allocating project funding, or timing of maintenance/retrofit schedules that can provide an opportunity for strategy placement.

Box 1. Trigger Points to Consider for Adaptation Planning for State Parks

Understanding trigger points and lead times necessary for the strategy opportunities will help identify the timing of when strategy implementation should be initiated. These conditions can be defined by 1) physical trigger points when the existing adaptation pathway is no longer effective in providing protection for park facilities from coastal hazards or 2) non-physical trigger points when opportunities become available that allow for the transition to strategies that offer greater or longer-term coastal hazard protection for park assets and resources.

Example physical trigger points may include:

- Amount of SLR, or mean high water level, over time. For example, tide gauges show that levels exceed a pre-determined height, such as 2.6 feet higher than today.
- Flooding frequency, or how often an asset or resource experiences flooding. For example, assets such as campgrounds can withstand periodic flooding, but flood events can disrupt and limit campground functions. An example trigger point could be if the campground floods twice per year. Once flooding frequency exceeds that trigger, then park managers should begin transferring to a new adaptation strategy. Establishing a monitoring program of flood impacts to park assets can be a useful way to track the flood frequency trigger.
- Extent of the coastal hazard or the distance of asset from the hazard boundary. This can be a simple trigger to monitor over time but can benefit from having an established monitoring program to track long-term changes in conditions. For example, if the bluff edge erodes to within 100 feet of seaside camp sites, it may no longer be a safe distance and an alternative strategy should be considered.
- Damage to park asset or resource also represents an opportunity to transition to another adaptation strategy. Although trigger points are ideally established with enough warning and lead time to avoid direct damages to park assets and resources, damages can also represent an opportunity to transition to another strategy due to the required intervention to re-establish the resource or repair the asset to its functional condition. Examples may include emergency actions post-flood or repair following erosion damage to buildings or habitat areas.

Example non-physical triggers or opportunities may include:

- Cost of maintenance. Chronic impacts from coastal hazards can increase the cost of long-term maintenance for park assets. Once the cost of maintenance starts to exceed a pre-determined maintenance budget trigger, then park managers should begin transferring to a new adaptation strategy.
- Funding opportunities that are identified to pursue the planning or implementation of prioritized strategies.
- Political will evolves to favor the implementation of more effective or larger-scale strategies.
- Partnership opportunities become available and planning or implementation of strategies becomes feasible.

8. Moonlight State Beach Adaptation Strategies and Pathways

A set of three strategies were identified that, if implemented, would reduce risk from coastal hazards at Moonlight State Beach (Figure 8). These subsets of strategies were selected from the menu of potential strategies (Table F-1 in Appendix F) and were identified in collaboration with the PMT based on factors such as vulnerability, ability of the strategy to achieve park unit goals, applicable shoreline typologies, and stakeholder input.

Potential strategies, illustrated in Figure 8, include a range of strategy types, focusing on nature-based and relocation/realignment strategies that address unit-wide risks. Table F-2 in Appendix F further summarizes the selected potential strategy types.

This list of interventions represents possible strategy opportunities that State Parks can assess for feasibility and discuss with adjacent stakeholders to identify the strategies that best meet regional coastal hazard reduction goals.

Generally, strategies fall into two categories that can be applied at different scales within the park units:

- **Shoreline strategies** represent large-scale interventions implemented at a park unit level to provide coastal hazard protection for multiple park assets or resources. Examples may include beach nourishment, dune restoration, or inlet maintenance.
- **Asset strategies** focus on providing protection for a single park asset or resource. Examples may include raising infrastructure or asset components.

Strategies mapped onto an adaptation pathway diagram for Moonlight State Beach are illustrated in Figure 9. The adaptation pathway begins on the No Action line with 0 feet of SLR. Shoreline Strategies, above the No Action line, represent strategies that address hazards identified across large areas within the park unit and Asset Strategies, below the No Action line, represent strategies that address potential hazards for individual park assets or resources. Each pathway meets the same objectives over the entire time horizon but come with different costs, benefits, and co-benefits, which will be necessary to evaluate with adjacent and regional stakeholders to decide the pathway that is most preferred for the park unit.

Table 19 describes which assets at Moonlight SB are addressed by each strategy.

The sections below include descriptions of the physical strategies, their co-benefits, relationships to other strategies, and additional details about which highly vulnerable or high priority assets they address.

Figure 8. Moonlight SB Potential Adaptation Strategies Diagram

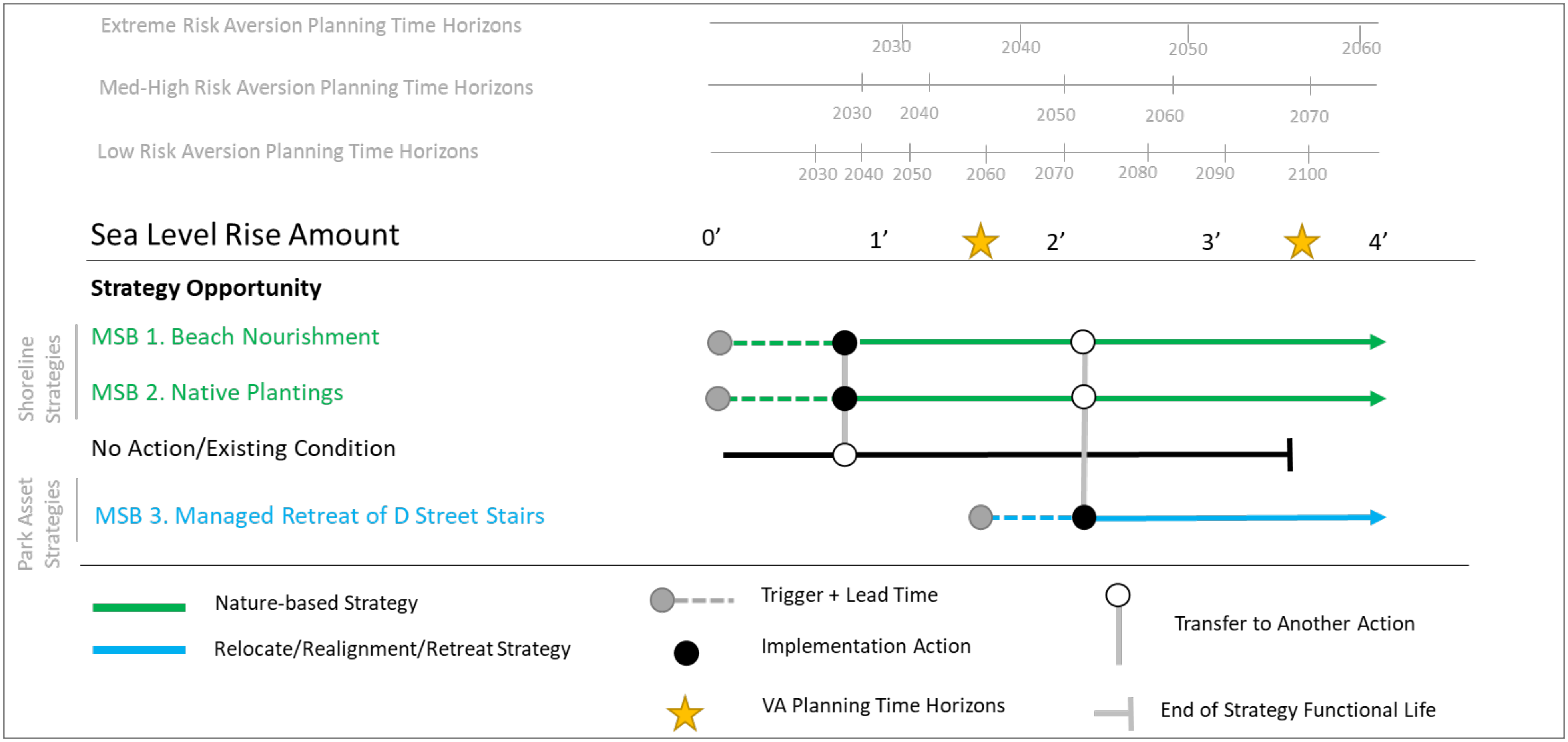


Figure 9. Moonlight State Beach Adaptation Pathways

Box 2. How to Interpret an Adaptation Pathway
MSB 1 recommends nourishing the beach through the placement of sand along the extent of the unit to reduce erosion and flooding impacts on assets and resources. This strategy may be implemented alongside MSB 2 (Natural Plantings) to provide additional protection from coastal erosion. The nourishment and plantings may require some permitting and preparation, so the process should be initiated with adequate lead time to allow the strategies to be implemented before SLR reaches a critical level. It is required to actively monitor trigger points to ensure the effectiveness of the strategy and decide if additional strategies should be implemented earlier than the proposed timeline. If, at some point, the beach nourishment and native planting strategies are not sufficient to protect the D Street Stairs, then MSB 3 (Managed Retreat of D Street Stairs) may become necessary to maintain beach access.

Table 19. Moonlight SB Potential Adaptation Strategies and Assets they Address

Strategy	Strategy Description	Assets addressed (both directly and indirectly):
Shoreline Strategies - Indirectly address all asset types		
MSB1	**Beach Nourishment**	Beach habitat, bluffs, D Street Stairs
MSB2	**Native Plantings**	Bluffs, coastal scrub, and dunes grass/herb
Park Asset Strategies		
MSB3	**Managed Retreat of D Street Stairs**	D Street Stairs

8.1 No Action

The simplest pathway consists of taking no action until 3.5 feet of SLR, which corresponds with the year 2100 based on the low risk-aversion scenario. The results of the park unit vulnerability assessment show the landward extent of coastal erosion and SLR inundation associated with 3.5 feet of SLR could represent the end of the park's useful life. The No Action pathway provides the benefit of not requiring the park or adjacent landowners to retreat or implement physical interventions. However, remaining on this pathway will likely result in damaged or loss of park assets and resources, as well as high costs associated with repair and maintenance of park infrastructure that is exposed to coastal hazards over time.

8.2 Shoreline Strategies

All shoreline strategy pathways start with a trigger and lead time at 0 feet of SLR, indicating that much of the park is already experiencing the effects of SLR and immediate action is required to maintain the park's shoreline. Several strategy options are proposed for implementation around the year 2030, including nature-based strategies (e.g., such as planting native vegetation and nourishing beaches) and park asset strategies (e.g., managed retreat of stairs). These strategies represent opportunities for large-scale and long-term reduction in the risks of coastal hazards facing the park unit. They bolster the natural defense capabilities of the shoreline features to provide a buffer for park assets and resources from coastal hazards.

Over time, shoreline strategies will require monitoring and possible maintenance to preserve their functionality as a coastal hazard defense. As sea levels continue to rise through the coming decades, their ability to provide coastal hazard protection may be diminished or become too costly to maintain. At this point, State Parks may transition to managed retreat of the park shoreline and backshore park facilities.

MSB 1 – Beach Nourishment

- Nature-based strategy that enhances the beach through strategic placement of sand in a manner that attenuates waves in front of assets, resources, or bluffs. Addresses tidal inundation, shoreline change, and 100-year coastal storm. Co-benefits include enhanced habitats, improved coastal landscape, and maintained recreational assets.
- This strategy provides a first line of defense against shoreline change to minimize beach width loss and limit bluff erosion and associated impacts to bluff top assets and highly vulnerable shoreline types within the park including Sandy Beach Backed by Hard Natural Bluff, Sandy Beach Backed by Road, Parking Lot, or Other Infrastructure, Sandy Beach Backed by Soft Natural Bluff.
- Addresses multiple assets, including high priority and highly vulnerable assets, such as the D Street Stairs.
- Should be implemented until no longer feasible to do so.

MSB 2 – Native Plantings

- Nature-based strategy that uses native plantings to stabilize eroding shorelines or slow bluff retreat. Co-benefits include enhanced habitats and increased aesthetic appeal.
- If implemented in conjunction with MSB 1 (Beach Nourishment), this strategy helps reduce shoreline change, specifically beach width loss (see Figure 2 and Figure 3) and addresses a highly vulnerable shoreline typology (Sandy Beach Backed by Hard Natural Bluff) (see Figure 5).
- Addresses high priority and highly vulnerable land cover types such as coastal scrub (*Artemisia californica-Eriogonum fasciculatum),* and dunes grass/herb *(Abronia latifolia-Ambrosia chamissonis)* (see Section 2.3.3).

8.3 Park Asset Strategies

Park asset strategies were identified for park assets and facilities that may require near-term or redundant protection from coastal hazards. In general, they were identified for site-specific application and the timing of implementation was selected to align with the asset's functional life span identified in collaboration with the PMT. Although strategy application reduces the immediate risk of damage to the asset, the strategy will need to be monitored over time to promote its long-term effectiveness and/or inform the potential transition to another strategy.

MSB 3 – Managed Retreat of D Street Stairs

- Retreat strategy that addresses a highly vulnerable access point by relocating the D Street Stairs landward, allowing space for natural shoreline retreat
- This strategy creates space for shoreline to naturally transition landward, and addresses tidal inundation, 100-year coastal storm flooding, and shoreline change. Co-benefits include facilitated natural coastal processes and maintained recreational and habitat interface with ocean.
- Should be implemented after MSB 1 (Beach Nourishment) and MSB 2 (Native Plantings) no longer protect the staircase from coastal hazards.

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Appendix A : Outreach and Engagement Summary

AECOM

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Project name:
California State Parks
San Diego Coast District Sea Level Rise
Adaptation Pathways Report and Statewide Toolkit

To:
Tegan Churcher Hoffmann, PhD
Executive Director
Coastal Quest

CC:
Project Management Team

From:
Jessica Sisco and Paola Pena

Date:
March 22, 2023

California State Parks San Diego District Sea Level Rise Vulnerability Assessments and Adaptation Pathways: Outreach and Engagement Summary

1. Integrating Community Priorities

1.1 Overview

The overall purpose of outreach and engagement activities was to inform Sea Level Rise Vulnerability Assessments and Adaptation Pathways Reports for coastal park units in the San Diego Coast District ("SDCD") of California State Parks ("State Parks"). Sections 1.2 and 1.3 provide a summary of the two rounds of engagement events and activities that were carried out in summer and fall 2022. For a more complete understanding of the engagement approach, and the engagement activities and the breadth and depth of associated input, please see Attachment A: Engagement Approach and Materials; Attachment B: Round 1 Board Input and Online Input; and Attachment C: Round 2 Board Input and Online Input.

In addition, Section 1.4 provides an overview of engagement activities intended to engage California Tribes. Attachment D provides the methodology, materials, and feedback associated with the engagement activities that were conducted with California Tribes; and Attachment E provides all responses from the Outreach and Engagement Evaluation Questionnaire.

Table 20. Round 1 Engagement Events Overview

Event	Date	Location	Approximate Number of Participants
Online Mapping Activity	August 29 – October 25, 2022	Online	600 Unique users[13] 37 Map comments 14 Questionnaire responses
Pop-Up Event	September 3, 2022	South Carlsbad State Beach, Carlsbad	44
	September 8, 2022	San Diego Natural History Museum, Balboa Park	61
	September 9, 2022	Silver Strand State Beach North, Coronado	51
	September 17, 2022	Torrey Pines State Beach and Torrey Pines State Natural Reserve, La Jolla	83
Community Event	August 30, 2022	Joe and Mary Mottino Family YMCA, Oceanside	22
	September 1, 2022	Copley-Price YMCA, San Diego	90
	September 7, 2022	Border View YMCA, San Diego/Chula Vista	15
	September 16, 2022	John A. Davis Family YMCA, La Mesa	23
Presentation to San Diego Regional Climate Collaborative	September 13, 2022		60
		TOTAL	1,049 participants

[13] The total number of unique people who viewed the Social Pinpoint site during Round 1 (determined by browser tracking through Google Analytics).

Table 21. Round 2 Engagement Events Overview

Event	Date	Location	Approximate Number of Participants
Online Mapping Activity	October 25 – November 18, 2022	Online	372 Unique users[14] 2 Map comments 45 Questionnaire responses
Pop-Up Event	October 28, 2022	Silver Strand State Beach North, Coronado	7
	October 29, 2022	San Diego Natural History Museum, Balboa Park	36
	October 29, 2022	South Carlsbad State Beach, Carlsbad	12
	October 30, 2022	Torrey Pines State Beach and Torrey Pines State Natural Reserve, La Jolla	27
Community Event	October 28, 2022	South Bay Family YMCA, Chula Vista	35
	October 29, 2022	Dan McKinney Family YMCA, La Jolla	42
	November 2, 2022	Copley-Price Family YMCA, City Heights/Kensington	15
	November 3, 2022	Toby Wells YMCA, Kearney Mesa	13
Presentation to San Diego Regional Climate Collaborative	November 15, 2022		60
		TOTAL	619 participants[15]

[14] The total number of unique people who viewed the Social Pinpoint site during Round 2 (determined by browser tracking through Google Analytics)
[15] It should be noted that public health conditions during Round 2 of engagement may have impacted levels of participation. At the time, the County of San Diego was advising that increased incidences of influenza, respiratory syncytial virus (RSV), and COVID-19 were anticipated this fall, and increases were already being reported during the engagement window.

Table A-3. Tribal Engagement Events Overview

Event	Date	Location	Approximate Number of Engagements
Letters, Emails, and Phone Calls to Tribal Nations	November 22 – November 30, 2022	Mail, Online, and Phone	20 Luiseño and Kumeyaay Tribal Nations
Outreach to Native American Organizations and Tribal Community Members	November 23 – December 7, 2022	Online (Email) and Phone	8 organizations
Online Survey	November 17, 2022 – Ongoing through Spring 2023	Online	4 responses
Tribal Site Visits	December 1 - December 2, 2022	In-person	2 site visits

1.1.1 Engagement Goals

The goals of the engagement process were to:

- Raise awareness regarding the purpose, goals, anticipated outcomes, and benefits of the project
- Educate the public on sea level rise (SLR), SLR adaptation, project and planning processes, and State Parks' SLR Strategy - including the cross-cutting, integrative nature of State Parks' approach
- Share key vulnerability findings and engage and solicit broad and diverse community perspectives, insight, and feedback on valued places and uses, and SLR adaptation priorities
- Reduce barriers to participation through inclusive engagement strategies identified throughout the outreach and engagement process
- Emphasize equity and inclusion in all outreach and engagement planning and execution, including development of targeted engagement strategies for California Tribes, Disadvantaged Communities (DACs), and Severely Disadvantaged Communities (SDACs)

1.1.2 Engagement Methodology

Attachment A.1 provides an overview of the methodology/approach used to engage participants and collect feedback during Round 1 and Round 2 engagement activities.


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EVA DURAN


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1.2 Round 1 Community Input: Values and Use

Round 1 engagement activities occurred from August 29 to October 25, 2022. The Round 1 events and activities focused on eliciting the following from participants:

- Favorite activities at coastal parks
- Important places and uses within coastal parks and/or within specific State Parks
- Sea level rise impacts observed at coastal parks

1.2.1 District-Wide Themes

This section provides an overview of district-wide community input themes raised during Round 1 engagement activities. It should be noted that there were varying levels of interest in commenting on specific park units, and most participants preferred to share what they generally like to do when they go to parks and beaches on the coast, rather than comment on what they like to do at a specific park unit. Refer to Attachment B to review the entirety of comments provided through the online mapping activity and in-person events.

Table A-4. Key Community Input Themes

Asset Category	Key Community Input Themes
Overarching	Appreciation of state beaches was expressed by many participants Beach, sand, and water experiences were identified as important priorities for many participants Many participants identified active and passive recreation activities as the primary reason for visiting beaches
Access	Beach Access: Americans with Disabilities Act (ADA) accessibility and mobility concerns were frequently noted as a barrier to accessing some state beaches and, in particular, the beach areas Parking: Participants shared mixed opinions on the value of parking. Some commenters generally favored continued access to parking facilities; while others noted a desire for parking areas to be shifted to other uses Paths and Trails: Many participants indicated that a key reason for visiting state beaches was to use biking, walking, and hiking paths and trails for both active and passive recreation
Cultural Resources	General: Participants identified the importance of cultural resources associated with California tribes, and the U.S.-Mexico border area, specifically at Border Field and Torrey Pines State Beaches
Facilities and Infrastructure	

	Infrastructure and Visitor Facilities: Many participants noted appreciation for features such as bathrooms, showers, life guard towers and surf-related infrastructure, including breaks. Bathrooms and showers were often highlighted as important by families with children and beachgoers who indicated extended visits to the beach Some participants reported deteriorating infrastructure leading to the loss of related access points, recreational assets, and other resources
Interpretation and Education	General: Some participants noted the appreciation for the availability of interpretive and educational features at state beaches
Natural Resources	General: Natural areas were identified as some participants' favorite places for passive and active recreation; some participants also noted concern for the loss of these areas Land Cover: Many participants shared their preference for finer sand and vegetated land covers in comparison to rockier land cover Water: Many participants shared their appreciation for the water, citing its ecological importance, and the ability to recreate in and around it Wildlife Habitats: Some participants highlighted recent changes in wildlife habitats, attributing these observations to climate change
Recreation	Gathering Areas: Many participants noted getting together with friends and family as a primary activity at the beach, noting appreciation for gathering areas such as barbecue and bonfire pits, and picnic areas Active Recreation: The most frequently noted activities were related to active recreation, including but not limited to walking, hiking, running, and watersports, such as boogie boarding, surfing, and swimming Passive Recreation: Participants expressed a variety of reasons for strong appreciation of state beaches, including passive recreation, gathering with family and friends, relaxing, building sandcastles, and searching for shells

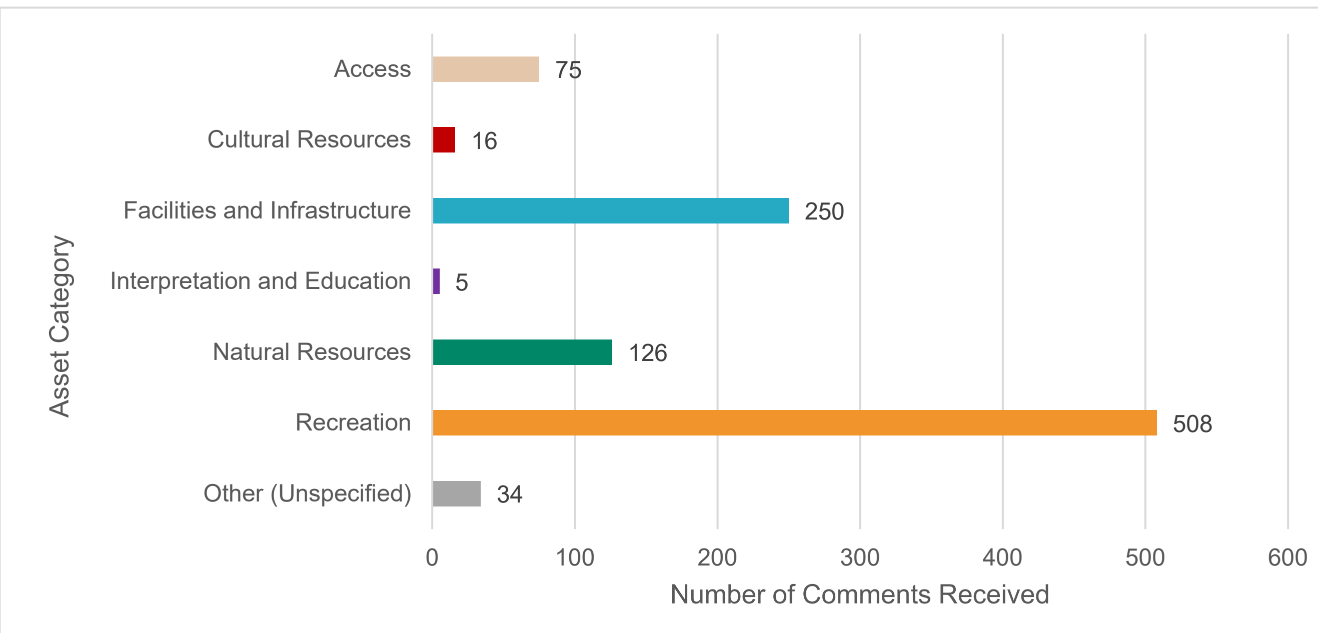
Pet-friendly Areas: Many participants indicated appreciation for dog parks and on-leash areas within beaches

Play Areas: Participants with children noted appreciation for designated youth playground areas

Wildlife and Natural Area Viewing: Enjoying the beaches' natural areas and wildlife were identified as favorite activities by many participants

Figure A-1 provides an overview of the approximate number of comments associated with various uses and features, roughly organized by asset category[16]. This figure is intended to give the reader a general understanding of the types of features and uses that were identified as important most frequently. The overwhelming majority of comments were associated with the recreation experience, followed by comments on facilities, natural resources, access, cultural resources, and interpretation and education.

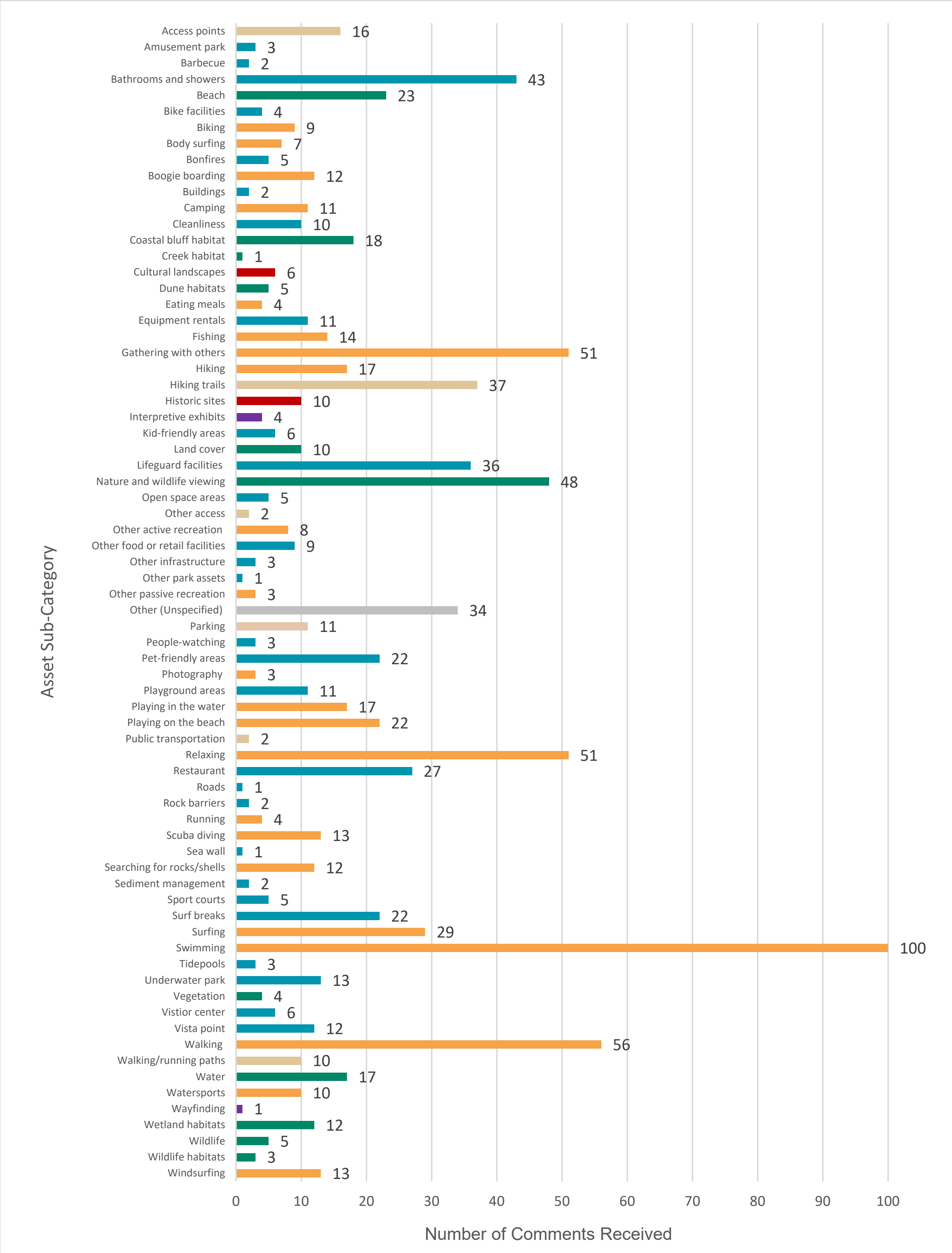
Figure A-1. Comments about Valued Uses and Features by Asset Category



[16] Some feedback provided by participants did not neatly fall within the Asset Typology documented in the Typologies Memo. In addition, some features could logically be assigned to more than one asset category (e.g. gathering areas and picnic areas could be considered "park assets" and therefore, part of the Facilities and Infrastructure category or they could be considered "other" within the Recreation category). For a more detailed understanding of feedback on various features and uses, please see disaggregated data in Figure 2,

Figure A-2 provides an overview of the number of comments received associated with various uses and features. Please see Attachment B for an understanding of the breadth and depth of these comments.

Figure A-2. Comments about Valued Uses and Features



1.2.2 Park-Specific Comments

This section summarizes key themes raised relative to a specific park unit, where applicable. For a comprehensive listing of direct participant feedback regarding specific park units see Attachments B and C.

As mentioned above, it should be noted that there were varying levels of interest in commenting on specific park units, and most participants preferred to share what they generally like to do when they go to parks and beaches on the coast, rather than comment on what they like to do at a specific park unit. Where there was not sufficient participant input on a specific park unit to generate a key theme, this is indicated by “n/a“ in the table.

Table A-5. Park-Specific Key Themes

Park Unit	Asset Category	Key Theme
Carlsbad State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	n/a
	Interpretation and Education	n/a
	Natural Resources	Some participants shared negative opinion of rockier land cover for the beach, citing difficulties walking and running on it
	Recreation	n/a
South Carlsbad State Beach	Access	n/a
	Cultural Resources	A few participants noted the cultural importance of the waves at South Carlsbad State Beach
	Facilities and Infrastructure	Many participants noted the importance of having bathrooms and shower facilities; some shared appreciation for beach equipment rental facilities
	Interpretation and Education	n/a
	Natural Resources	n/a
	Recreation	Many participants shared appreciation for recreational opportunities such as boogie boarding, collecting shells, surfing, swimming, and walking
Leucadia State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	Many participants shared appreciation for the gathering areas and equipment rentals
	Interpretation and Education	n/a
	Natural Resources	n/a
	Recreation	Many participants shared appreciation for recreation opportunities such as fishing, scuba diving, surfing, and swimming
Moonlight State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	n/a
	Interpretation and Education	n/a
	Natural Resources	A few participants shared appreciation for wetland and coastal bluff habitats
	Recreation	A couple participants shared appreciation for recreation activities such as volleyball and playing in the sand
San Elijo State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	Several participants shared appreciation for the restaurant facilities and visitor center
	Interpretation and Education	n/a
	Natural Resources	n/a
	Recreation	Some participants shared appreciation for their ability to camp on-site
Cardiff State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	n/a
	Interpretation and Education	n/a
	Natural Resources	Some participants shared appreciation of the quality of sand on the beach
	Recreation	Many participants shared appreciation for the dog walking beach and the underwater park facilities
Torrey Pines State Beach and Torrey Pines State Natural Reserve	Access	n/a
	Cultural Resources	Some participants shared appreciation for the National Register Historic Buildings
	Facilities and Infrastructure	Some participants shared appreciation for some of the facilities such as the portable lifeguard facilities, vista points, and hiking trails
	Interpretation and Education	n/a
	Natural Resources	Many participants shared appreciation for nature and wildlife viewing opportunities; Many others shared appreciation for active recreation activities such as walking, hiking, scuba diving, and windsurfing
	Recreation	n/a
Silver Strand State Beach	Access	n/a
	Cultural Resources	n/a
	Facilities and Infrastructure	A few participants shared appreciation for the bike path that connects Silver Strand to Coronado along the 75 Highway
	Interpretation and Education	n/a
	Natural Resources	n/a
	Recreation	Many participants shared appreciation for active recreation opportunities at such as boogie boarding and spikeball
Border Field State Park and Tijuana River National Estuarine Research Reserve	Access	n/a
	Cultural Resources	Several participants shared appreciation for Border Field State Park's connection to the U.S.-Mexico Border Some participants shared appreciation for the historic and cultural sites
	Facilities and Infrastructure	n/a
	Interpretation and Education	n/a
	Natural Resources	Several participants shared appreciation for the wildlife viewing areas
	Recreation	Some participants shared appreciation for the picnic areas

1.2.3 Sea Level Rise Impacts Observed at Coastal Parks

Participants identified the following in response to the board prompt asking, "What types of impacts have you seen at coastal parks?":

- Cliff erosion and impacted wildlife, citing climate change as a reason
- Seeing less birds and wildlife at coastal parks
- Loss of native plants and trees
- Beach erosion, higher high tides, and loss of wildlife
- Waves causing birds to be behind schedule on their typical migratory patterns
- Desirable living areas narrowing due to the encroachment of the coast related to sea level rise, and the elevated risk of extreme heat and related hazards (including wildfires, poor air quality) for inland areas
- Sandstone erosion at coastal parks
- Impacts to houses situated on/near cliffs (sliding)

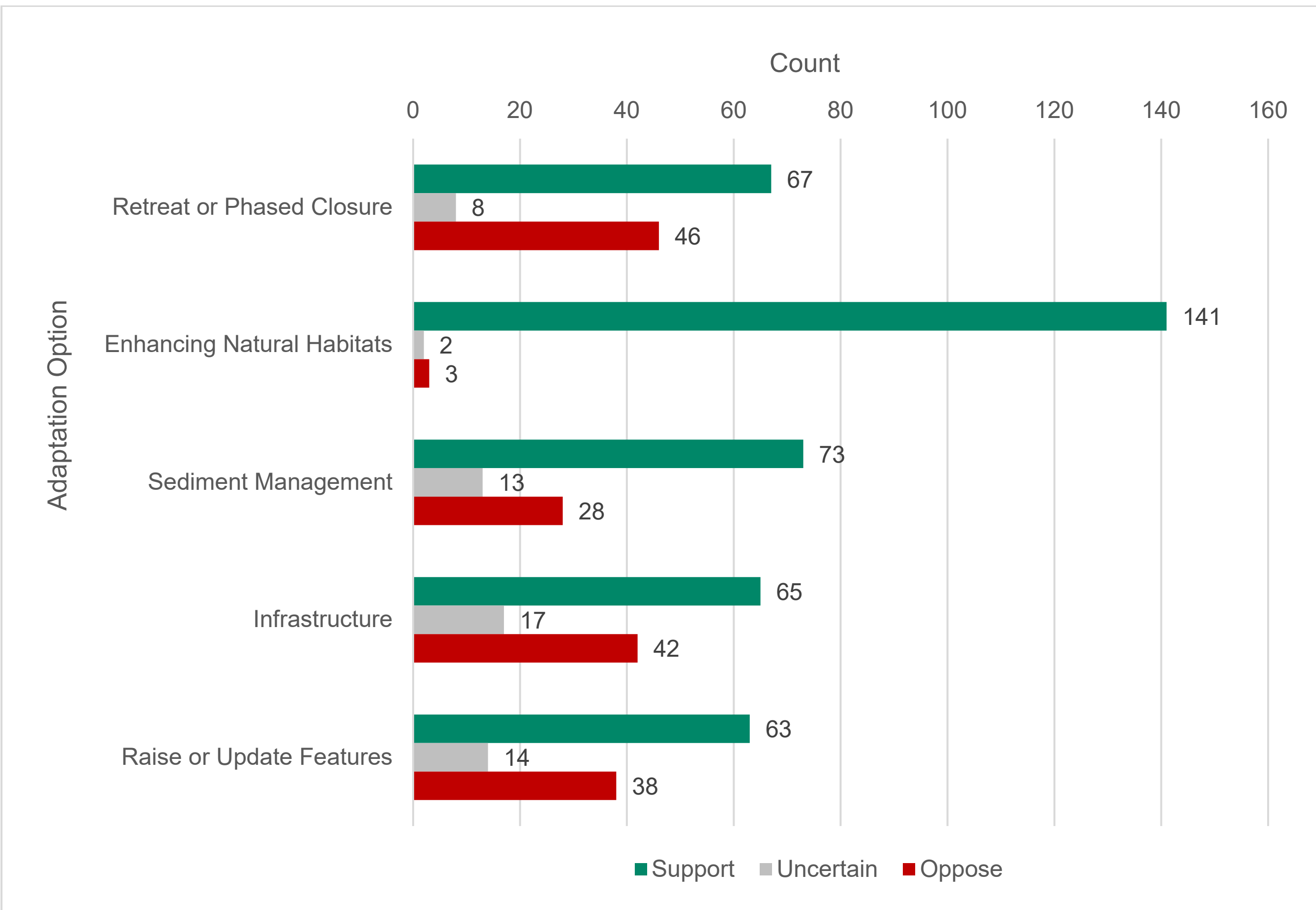

ROBOTICS
CAMP
Preparing for sea level rise at San Diego County coastal state parks

1.3 Round 2 Community Input: Adaptation

1.3.1 District-Wide Themes

This section summarizes community input regarding potential sea level rise adaptation options. Figure A-3 identifies key community input themes related to broad types of adaptation options across all the park units. Table A-6 summarizes park-specific input on adaptation (where this type of input was received), as well as other feedback provided on adaptation.

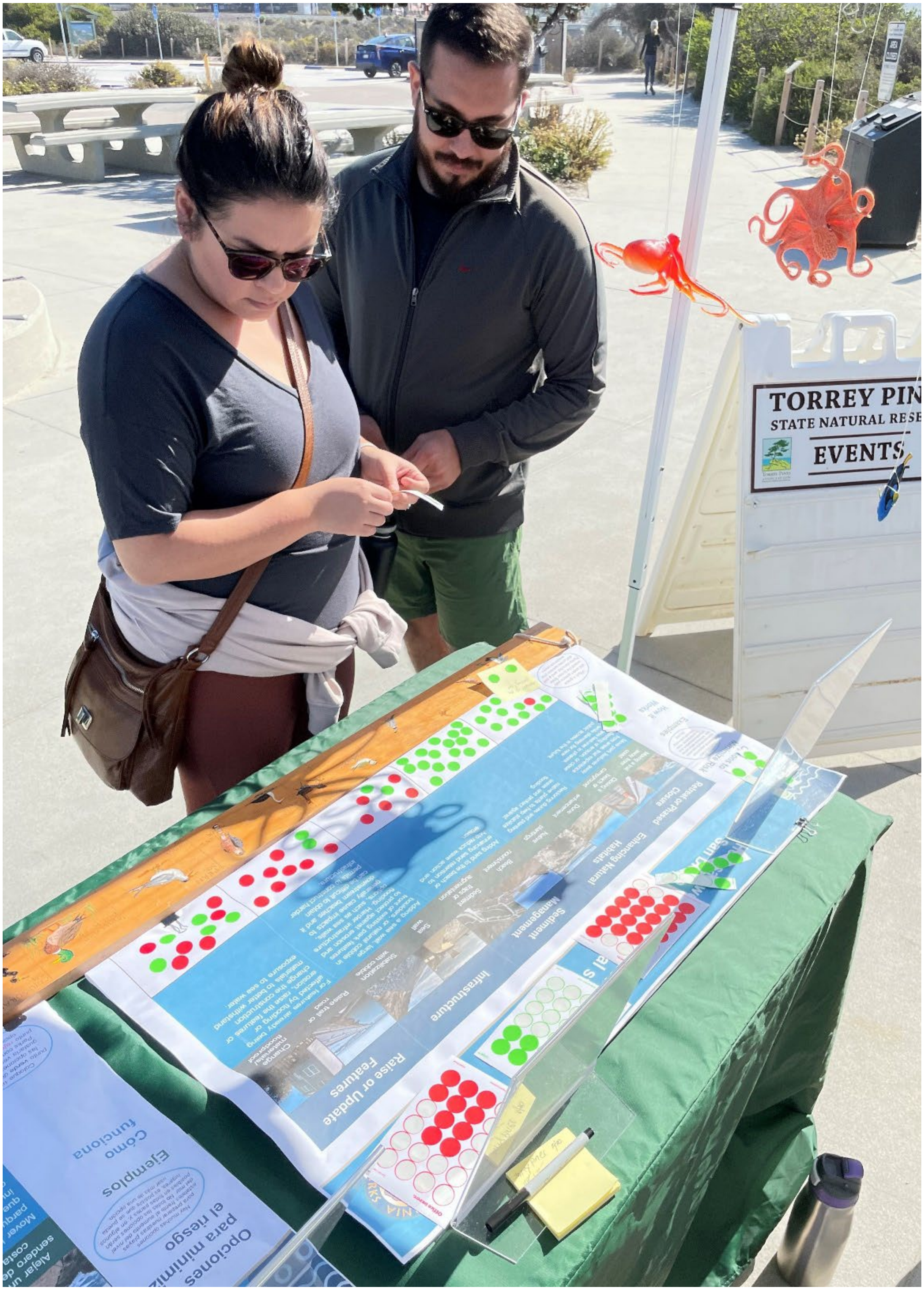
Figure A-3. Summary of Input on Potential Adaptation Options



1.3.2 Park-Specific Comments

Table A-6. Park-Specific Input on Adaptation and Other Comments Related to Adaptation

Park Unit(s)	Adaptation Option	Comment
Moonlight State Beach Silver Strand State Beach Tijuana River National Estuarine Research Reserve/Border Field State Park	Enhancing Natural Habitats	*“In response to your request for public input on State Parks Sea Level Rise Vulnerability Assessment and Adaptation Planning Study I would like to share that I think that CA State Parks and various partners have several terrific opportunities to implement Living Shoreline Projects as a sea level rise adaptation strategy at Moonlight State Beach in Encinitas, Border Field State Park / Tijuana Estuary, and possibly Silver Strand. Similarly, CA State Parks' South Coast Operations Center in Liberty Station could work with the City of San Diego and advocate for a Living Shoreline Project in Liberty Station along the shipping channel which is currently underutilized and could offer blue carbon sequestration. fisheries enhancement, and other environmental, educational, and community benefits.”*
Carlsbad State Beach	Retreat or Phased Closure	*“Currently there is no plan to realign/save the campground, this would be a sad asset to lose as there is very limited affordable overnight access along our coast.”*
Silver Strand State Beach		*“Approve of sea wall but not cobble armor”*
Tijuana River National Estuarine Research Reserve/Border Field State Park	Sediment Management	*“Border Field could be a State leader in sediment management activities to address outdated policy and regulatory guidance and implement new adaptation measures to beneficially reuse local sediment for habitat and shoreline protection.”*


TORREY PIN
STATE NATURAL RESE
EVENTS

1.4 Focused Engagement with California Tribes

The purpose of the Tribal outreach and engagement was to inform San Diego County's Tribal Nations and greater Tribal community members about the Sea Level Rise Vulnerability Assessments and Adaptation Pathways Study for coastal park units in the SDCD of State Parks. Further, the goal was to work with Tribal Nations and the Tribal community to assess the risks posed by sea level rise, identify potential impacts to coastal state parks used by the Tribal community, and suggest potential future responses to ensure that state parks continue to be available to Tribal partners. Attachment D describes the methods used to obtain Tribal input, summarizes results of those efforts, and provides recommendations for further engagement.

1.5 Adaptation Vision and Goals Influenced by Community Input

This section will summarize key SDCD park district-wide community input themes raised during Round 1 and Round 2 outreach and engagement activities that informed development of the draft adaptation vision and goal concepts. This section will be completed following the finalization of the adaptation vision and goals.

2. Participant Evaluation of Outreach and Engagement Process

2.1 Overview

Coastal Quest made an outreach and engagement evaluation questionnaire available in December 2022. Four participants shared in-depth comments about the engagement process, including items they thought worked well and suggestions for engaging more community members in the future.

All participants shared that Social Pinpoint, the online platform that hosted the interactive map and questionnaire, was at least somewhat effective. Two of the four participants noted that they learned at a small amount of new information through this engagement process; while one of the participants noted they learned a large amount of new information. Two participants, however, noted that the online mapping feature was a little tricky to use and would have preferred a simple list of sites to provide feedback. Attachment E includes the participants' full responses to the questionnaire.

Additionally, while participants were engaged in activities at the in-person Pop-Ups, some provided feedback related to the engagement process. Some participants noted appreciation for the availability of both English and Spanish materials but desired additional detail and nuance for the options provided on the boards. Some participants also shared that they felt they needed to be more informed or educated about the topics to provide meaningful feedback, stopping them from participating in the activity.

Appendix B : Summary of Tribal Engagement for the California State Parks San Diego Coast District Sea Level Rise Vulnerability Assessments and Adaptation Pathways

[Appendix B provided in separate PDF]

Appendix C : Moonlight State Beach Vulnerability Results

Table C-1. Vulnerability Results for 1.6 FT of SLR for Physical Assets, Natural Resources, Facilities and Infrastructure, Recreation, and Cultural Resources

Asset	Description	Tidal Inundation	100-year Coastal	Shoreline Change	Groundwater	Permanent Exposure Score	Temporary Exposure Score	Permanent Sensitivity	Temporary Sensitivity	Permanent Vulnerability	Temporary Vulnerability (0-3)	Total Vulnerability (0-12)
Access												
CA Coastal Trail (2)	stairs to Moonlight State Beach from D Street (D * to Moonlight State Beach 3	0	1	1	0	**1**	**1**	**3**	**2**	**3**	**2**	**5**
CA Coastal Trail (1)	Encinitas City Beach (Swamis Beach)	1	1	0	0	**1**	**1**	**3**	**2**	**3**	**2**	**5**
CA Coastal Trail (2)	to Moonlight State Beach 1 to Moonlight State Beach 2	1	1	1	0	**2**	**1**	**3**	**2**	**6**	**2**	**8**
CA Coastal Trail (2)	to Moonlight State Beach 4 Moonlight State Beach	1	1	1	1	**3**	**1**	**3**	**2**	**9**	**2**	**11**
Collector Roads (1)	A ST	0	1	0	1	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Collector Roads (1)	W D ST	0	1	1	0	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Mobi Mat (1)	Moonlight Mobi Mat	0	1	0	0	**0**	**1**	**3**	**3**	**0**	**3**	**3**
Stairs (1)	D St Viewpoint Park	0	1	0	0	**0**	**1**	**3**	**2**	**0**	**2**	**2**
Facilities and Infrastructure												
Building Footprints (1)	Moonlight - Unnamed Building #1	0	1	0	0	**0**	**1**	**3**	**3**	**0**	**3**	**3**
Discharge Points (1)	Moonlight - Discharge Point #1 Moonlight - Discharge Point #2	0	1	0	0	**0**	**1**	**3**	**3**	**0**	**3**	**3**
Lifeguard Towers (1)	Lifeguard Tower - Unnumbered 1	1	1	0	0	**1**	**1**	**3**	**2**	**0**	**2**	**2**

Asset	Description	Tidal Inundation	100-year Coastal	Shoreline Change	Groundwater	Permanent Exposure Score	Temporary Exposure Score	Permanent Sensitivity	Temporary Sensitivity	Permanent Vulnerability	Temporary Vulnerability (0-3)	Total Vulnerability (0-12)
Signage (3)	Moonlight - Sign 1 Moonlight - Sign 2 Moonlight - Sign 3	0	1	0	0	**0**	**1**	**3**	**1**	**0**	**1**	**1**
Recreation												
Surf Breaks (2)	D Street Moonlight Beach	1	1	0	0	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Natural Resources												
Land Cover (1)	Beach	0.2	1.1	3.6	0.1	**3**	**1**	**3**	**2**	**9**	**2**	**11**

Table C-2. Vulnerability Results for 3.5 FT of SLR for Physical Assets, Natural Resources, Facilities and Infrastructure, Recreation, and Cultural Resources

Asset	Description	Tidal Inundat	100-year	Shoreline	Groundwater	Permanent Exposu	Temporary Exposu	Permanent	Temporary	Permanent	Temporary	Total Vulnera
Access												
CA Coastal Trail (1)	Encinitas City Beach (Swamis Beach)	1	1	0	0	**1**	**1**	**3**	**2**	**3**	**2**	**5**
CA Coastal Trail (1)	stairs to Moonlight State Beach from D Street (D *	0	1	1	1	**2**	**1**	**3**	**2**	**6**	**2**	**8**
CA Coastal Trail (3)	to Moonlight State Beach 4 to Moonlight State Beach 1 to Moonlight State Beach 3	1	1	1	0	**2**	**1**	**3**	**2**	**6**	**2**	**8**
CA Coastal Trail (2)	Moonlight State Beach to Moonlight State Beach 2	1	1	1	1	**3**	**1**	**3**	**2**	**9**	**2**	**11**

Asset	Description	Tidal Inundat	100-year	Shoreline	Groundwater	Permanent Exposu	Temporary Exposu	Permanent	Temporary	Permanent	Temporary	Total Vulnera
Collector Roads (1)	W D ST	0	1	1	0	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Collector Roads (1)	A ST	0	1	0	0	**0**	**1**	**3**	**1**	**0**	**1**	**1**
Mobi Mat (1)	Mobi Mat	1	1	0	0	**1**	**1**	**3**	**3**	**3**	**3**	**6**
Stairs (1)	D St Viewpoint Park	0	1	1	0	**1**	**1**	**3**	**2**	**3**	**2**	**5**
Facilities and Infrastructure												
Building Footprints (1)	Moonlight - Unnamed Building #1	1	1	0	0	**1**	**1**	**3**	**3**	**3**	**3**	**6**
Discharge Points (1)	Moonlight - Discharge Point #3	0	0	1	0	**1**	**0**	**3**	**3**	**3**	**0**	**3**
Discharge Points (1)	Moonlight - Discharge Point #1	0	1	0	0	**0**	**1**	**3**	**3**	**0**	**3**	**3**
Discharge Points (1)	Moonlight - Discharge Point #2	1	1	0	0	**1**	**1**	**3**	**3**	**3**	**3**	**6**
Lifeguard Towers (1)	Lifeguard Tower - Unnumbered 1	1	1	0	0	**1**	**1**	**3**	**2**	**3**	**2**	**5**
Lifeguard Towers (1)	Lifeguard Tower - Unnumbered 2	0	1	0	0	**0**	**1**	**3**	**2**	**0**	**2**	**2**
Signage (2)	Moonlight - Sign 3 Moonlight - Sign 1	0	1	0	0	**0**	**1**	**3**	**1**	**0**	**1**	**1**
Signage (1)	Moonlight - Sign 2	1	1	0	0	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Recreation												
Surf Breaks (2)	D Street Moonlight Beach	1	1	0	0	**1**	**1**	**3**	**1**	**3**	**1**	**4**
Natural Resources												
Land Cover (1)	Beach	0.8	1.0	2.7	0.1	**3**	**1**	**3**	**2**	**9**	**2**	**11**

Table C-3. Shoreline Vulnerability

Transect	Shoreline Types	Exposure 1.6 FT (1-4)	Exposure 3.5 FT (1-4)	Sensitivity (1-3)	Vulnerability 1.6 FT (1-12)	Vulnerability 3.5 FT (1-12)	Vulnerability Score 1.6 FT	Vulnerability Score 3.5 FT
718	Sandy Beach Backed by Hard Natural Bluff	1	4	3	3	12	Low	Very High
719	Sandy Beach Backed by Soft Natural Bluff	1	4	2	2	8	Low	High
720	Sandy Beach Backed by Soft Natural Bluff	1	3	2	2	6	Low	Moderate
721	Sandy Beach Backed by Armor	1	4	3	3	12	Low	Very High
722	Sandy Beach Backed by Soft Natural Bluff	1	4	2	2	8	Low	Moderate
723	Sandy Beach Backed by Road, Parking Lot, or Other	1	2	3	3	6	Low	Moderate
724	Sandy Beach Backed by Armor	1	4	3	3	12	Low	Very High

Appendix D : Sensitivity Ratings for Exposed Physical Assets, Cultural Resources, and Natural Resources at Moonlight SB

Table D-1. Sensitivity Ratings for Exposed Physical Assets, Cultural Resources, and Natural Resources at Torrey Pines SB/SNR

Asset Type	Sensitivity to Temporary Exposure	Rationale	Sensitivity to Permanent Exposure	Rationale
Pedestrian Trails and Bike Routes (Unpaved)	Moderate	Temporary flooding may require short-term closure and cleanup of minor debris after floodwaters recede. Frequent or major flooding may completely erode or wash out trails, prohibiting future use until repairs are made.	High	Permanent inundation will make unpaved trails unusable. Long-term shoreline erosion may degrade or completely erode trail.
Pedestrian Trails and Bike Routes (Paved)	Low	Temporary flooding may require short-term closure and cleanup of minor debris after floodwaters recede. Paved pedestrian trails and bike routes are hardened structures and may have low sensitivity to erosion during over wash events. Frequent or major flooding may completely erode or wash out trails, prohibiting future use until repairs are made.	High	Permanent inundation will make pedestrian trails and bike routes inoperable. Long-term shoreline erosion may degrade or completely erode trail.
Unpaved Roads (State Parks Roads, Secondary Roads)	Moderate	Temporary flooding may require short-term closure and cleanup of minor debris after floodwaters recede. Frequent or major flooding may completely erode or wash out	High	Permanently inundated roadways will become inoperable. Long-term erosion may degrade roadway foundation.

Asset Type	Sensitivity to Temporary Exposure	Rationale	Sensitivity to Permanent Exposure	Rationale
		roads, prohibiting future use until repairs are made.		
Mobi Mats	High	Beach sand access walkways may experience structural damage if exposed to temporary flooding or erosion. The extent and degree of damage is dependent on flood depths and duration. Flooding will also temporarily limit walkway access.	High	Beach sand access walkways may experience structural damage if exposed to temporary flooding or erosion. The extent and degree of damage is dependent on flood depths and duration. Flooding will also temporarily limit walkway access.
Stairways (wood)	Medium	Temporary flooding may require short-term closure of stairways and clean-up of debris, but access can be resumed after floodwaters subside. Structural integrity of wood stairways may be compromised by high velocity storm surges.	High	Permanently inundated park structures will become inoperable. Erosion of stairway foundations may affect their structural integrity or access.
Contact Station /Kiosk, Concessions, Staff Housing, Administration, Campfire Centers, Maintenance, Visitor's Centers	High	Buildings may experience structural damage if exposed to temporary flooding or erosion. The extent and degree of damage is dependent on flood depths, duration, conformity of structure with modern building codes, and degree of floodproofing and site drainage. Buildings also often have electrical components that could experience damage and require replacement with even temporary flood exposure. Flooding will also temporarily limit building access.	High	Buildings may experience significant damage and loss of access if exposed to permanent inundation. Erosion of building foundation may cause structural damage.

Asset Type	Sensitivity to Temporary Exposure	Rationale	Sensitivity to Permanent Exposure	Rationale
Wastewater /Stormwater Outfall	High	Although outfalls are not structurally susceptible to flood damage, their functionality is highly sensitive. They are the lowest point of discharge, and their function is limited when receiving waterbody levels are higher than the outfall elevation.	High	Although outfalls are not structurally susceptible to inundation, their functionality is highly sensitive. They are the lowest point of discharge, and their function is limited when receiving waterbody levels are higher than the outfall elevation. Long-term erosion may also remove supporting sediment from beneath the outfall pipeline and cause structural damage.
Lifeguard Tower	Moderate	Structure is elevated but may be structurally sensitive to changes in water levels, particularly during storm events when large waves may reach higher elevations of the structure.	High	Permanently inundated structures will become inoperable.
Signage	Low	Depending on the robustness of signage base support, temporary flooding may dislodge sign from existing location.	High	Asset may experience an increased rate of material degradation and loss of access due to long-term inundation. Sign may become dislodged by erosion.
Surf Breaks	Low	Days associated with temporarily elevated water levels due to coastal storm conditions may cause short-term loss of use of an existing shore break, but access can resume during post-storm conditions.	High	The quality and consistency of existing surf breaks may be affected by permanent SLR.
Beach	Low - Moderate	Beaches experience daily high tides in this region of the state, and even	Moderate - High	SLR is likely to increase erosion rates and permanently inundate

Asset Type	Sensitivity to Temporary Exposure	Rationale	Sensitivity to Permanent Exposure	Rationale
		higher king tides throughout the year. Level of inundation depends on the local processes including slope of the beach, sedimentation, freshwater input, and wave action. Beaches backed by cliffs may experience less impacts from temporary flood impacts as they erode and increase sediment supply to keep pace with SLR.		low-elevation and low-sloped beaches, depending on factors such as elevation, sediment supply, and adjacent land use. Sensitivity is unique to each beach, and if given the opportunity to migrate, beaches can be very resilient systems. In southern California, infrastructure and urbanization generally limit this possibility. The extent of migration capabilities depending on unique shoreline typologies and extents can be found in Table 9. Increased fragmentation (pocket beaches), narrower and steeper beaches will likely result with permanent SLR.

Appendix E : Coastal Hazards Memo

AECOM

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Project name:
California State Parks
San Diego Coast District Sea Level Rise Adaptation Pathways Report and Statewide Toolkit

To:
Tegan Churcher Hoffmann, PhD
Executive Director
Coastal Quest

CC:
Project Management Team

From:
Jessica Sisco, Diana Edwards, and Justin Vandever

Date:
February 25, 2022
Revised April 12, 2022

Subject: Task 2.2.3. Coastal Hazards Memo

Introduction

This Coastal Hazards Memo addresses several items that are prerequisites for the vulnerability assessment phase of the project. Each of the items in this memo will feed into either the San Diego Coast District (SDCD) Vulnerability Assessment Report or the Statewide Vulnerability Assessments and Adaptation Pathways Guide.

Coastal Hazards Maps for each park unit display exposure to tidal inundation, 100-year coastal storm flooding, emergent groundwater flooding, and shoreline change for three sea level rise (SLR) scenarios (1.6 feet [ft] SLR, 3.5 ft SLR, and 7 ft SLR). The Coastal Hazards Maps will help the Project Management Team (PMT) determine which two of the three scenarios will be used for the vulnerability assessments for each park unit and data depicted in the maps will be used for the asset-based exposure analyses. The Coastal Hazards Maps section of this memo provides information necessary to interpret the maps, which are included in a separate PDF.

Projected Shoreline Change describes the methodology and data used to characterize projected shoreline change at defined segments of the shoreline that span each of the park unit's defined shore types. Classification and delineation of park shore types is described in the Shoreline Typology memo.

Guidance for Selection of Sea Level Rise Scenarios provides a process and rationale for determining which sea level rise projections and estimated time horizons to use for a particular project, park unit, or district. This guidance will be included in the

Statewide Methodology Report and guide the PMT's use of the Coastal Hazards Maps to select scenarios to be used in the SDCD vulnerability assessments.

Guidance for Supplementing CoSMoS Data provides guidance on the uses and limitations of United States Geological Survey (USGS) Coastal Storm Modeling System 3.0 (CoSMoS) data, as well as how to supplement it with additional data sources or custom inundation modeling. This guidance will be included in the Statewide Methodology Report.

Coastal Hazards Maps

The Coastal Hazards Maps (included in a separate PDF) display exposure to tidal inundation, 100-year coastal storm flooding (due to the combined effect of high tides, storm surge, and wave setup at the shoreline), emergent groundwater flooding, and sandy beach shoreline change for each park unit for three different sea level rise scenarios. Table E-1 summarizes the sea level rise scenarios and the associated time horizons adopted for this study (note: Ocean Protection Council's (OPC's) 2018 State of California Sea-Level Rise Guidance[17] provides additional information on the likelihood of the adopted projections being met or exceeded at these time horizons). These projections were selected based on instruction from Coastal Quest, OPC staff, and in consultation with the PMT as a conservative approach for sea level rise planning. NOAA has since released updated sea level rise projections that reflect additional data observations and advancements in climate change modeling. The updated NOAA sea level rise projections indicate overall lower sea level rise amounts, particularly in the near-term decades due to a better understanding of ice sheet dynamics that indicate their contribution to sea level rise will be slower than previously projected (Sweet, 2022).

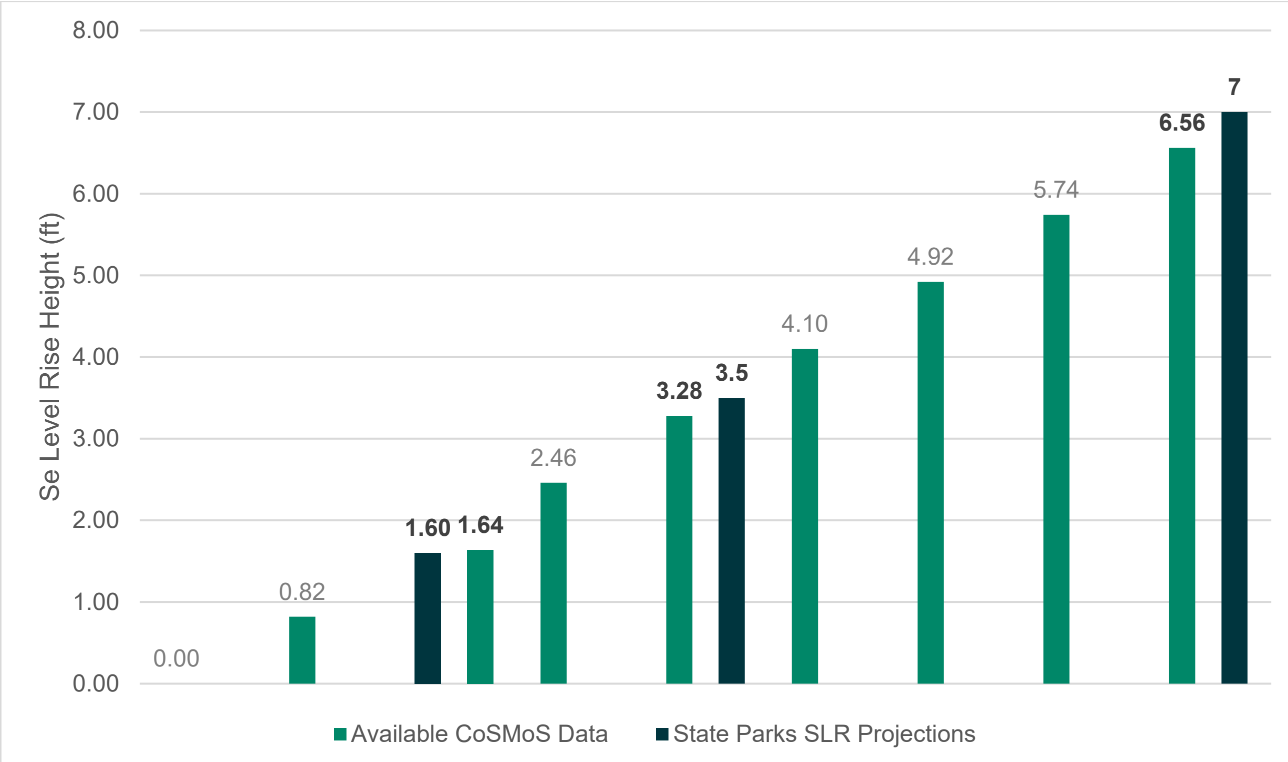
Climate hazards data are sourced from the USGS CoSMoS data. CoSMoS data is available for specific sea level rise heights (25 centimeters (cm) increments up to 200 cm and then 500 cm). Figure E-1 compares the sea level rise projections available in CoSMoS to the sea level rise projections selected for this project. For each scenario, data from the closest CoSMoS sea level rise projections are used in the Coastal Hazard Maps and will be used in the vulnerability assessments. This approach is common practice for sea level rise vulnerability assessments in California since the CoSMoS sea level rise scenarios do not align exactly with State guidance.

Table E-1. Sea Level Rise Scenarios

Year	Sea Level Rise Projection	Closest CoSMoS Sea Level Rise Projection
2035	1.6 ft	1.6 ft / 50 cm
2050	3.5 ft	3.3 ft / 100 cm
2100	7.0 ft	6.6 ft / 200 cm

[17] https://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

Figure E-1. Available CoSMoS Projections vs. Selected Sea Level Rise Projections



The Coastal Hazards Maps depict four different types of coastal hazards. Table E-2 includes a definition of each coastal hazard and the corresponding CoSMoS data layers that will be used to represent them.

Table E-2. Coastal Hazards Definitions and Data Sources

Coastal Hazard	Definition	CoSMoS Data Source
Tidal Inundation	Area that is projected to be exposed to inundation by Mean Higher High Water (average height of the highest daily tides).	CoSMoS 3.0 Phase 2 flood hazard projections: average conditions in San Diego County
100-year Coastal Storm Flooding	Area beyond the area projected to be exposed to permeant inundation that is exposed to coastal flooding due to the combined effect of high tides, storm surge, and wave setup during a 100-year storm.	CoSMoS 3.0 Phase 2 flood hazard projections: 100-year storm in San Diego County

Coastal Hazard	Definition	CoSMoS Data Source
Groundwater	Area that is projected to be exposed to shallow (less than one meter below ground) and emergent (above land surface) groundwater flooding.[18]	Projected responses of the coastal water table for California using present-day and future sea-level rise scenarios
Shoreline Change	Loss or gain in sandy beach width compared to the baseline shoreline location (defined as the present day Mean High Water line).	CoSMoS Southern California v3.0 Phase 2 projections of shoreline change

The following sources include more detailed information on the underlying CoSMoS model, methods, and data:

- About the Coastal Storm Modeling System (Point Blue Conservation Science, 2021)
- CoSMoS Summary of Methods (sea level rise inundation, storm surge, and shoreline change) (Erikson et al. 2017)
- Groundwater model methods (Befus et al. 2020)

The sections below provide additional information on the use of CoSMoS data for groundwater and shoreline change in the Coastal Hazards Maps.

Groundwater Scenario Selection

The CoSMoS Groundwater Model produced a series of output datasets for each sea level rise height that are based on different model parameters. Table E-3 summarizes the model parameters, options within each, the selected option (bold green text), and a rationale for the decision.

Table E-3. Summary of Groundwater Model Parameters

Parameter	Available/Selected Options	Rationale
Horizontal Hydraulic Conductivity	0.1 meter/day **1 meter/day** 10 meter/day	It was determined that the moderate option of 1 m/day would be most appropriate based on guidance provided on the Our Coast Our Future (OCOF) website (Point Blue Conservation Science 2021). The OCOF website suggests use of the moderate option to represent fine to medium-grained sand and is the default option when little is known about the local subsurface geology or current groundwater depths.

[18] For symbology purposes the Coastal Hazards Maps depict emergent groundwater flooding only due to the high degree of overlap between permanent inundation zones and shallow groundwater zones. However, both exposure to shallow and emergent groundwater will be included in the vulnerability assessments for each park unit.

Parameter	Available/Selected Options	Rationale
Marine Boundary Condition	Local Mean Sea Level (LMSL) **Mean Higher High Water (MHHW)**	MHHW was selected over LMSL because MHHW is higher and represents a more conservative assumption.
Model Version	Natural drainage simulated **Natural drainage not simulated**	Natural drainage is simulated in the model by removing all groundwater reaching the land surface. This assumption would likely not hold true in all cases so the model version with natural drainage not simulated was selected and can be interpreted as representing the worst-case response to sea level rise (Befus et al. 2020)

Shoreline Change Scenario Selection

CoSMoS shoreline change projections are available for transects spaced 100 meters apart along the coast. For each transect, the location of the present-day shoreline (defined as Mean High Water) is indicated along with the location of the future shoreline for a series of scenario and time horizons. Table E-4 summarizes the model parameters, options within each, the selected option (bold green text), and a rationale for the decision. Projected cliff retreat is not shown on the coastal hazard maps to maintain map legibility; however, cliff erosion hazard zones will be evaluated in the vulnerability assessment.

Table E-4. Summary of Shoreline Change Model Parameters

Parameter	Available/Selected Options	Rationale
Beach Nourishment	With beach nourishment **No beach nourishment**	The beach nourishment parameter determines whether to include long-term beach nourishment programs in the shoreline projections. The no beach nourishment option was selected, not because it is assumed that this management approach will be favored in the future, but because this option will produce outputs that are representative of exposure with no human intervention.
Hold the Line	Hold the line **No hold the line**	The hold the line parameter determines whether to limit shoreline retreat to a pre-determined, fixed backshore feature. The no hold the line option was selected, not because it is assumed that this management approach will be favored in the future, but because this option will produce outputs that extend beyond the pre-determined backshore feature. This will allow for the identification of shorelines where strong erosive forces are occurring, even if they are armored

Parameter	Available/Selected Options	Rationale
		(see Projected Shoreline Change below). In addition, the no hold the line scenario does not make any assumptions regarding which segments of the coast will be armored and held in place versus areas that will be allowed to respond naturally to coastal forcing.
Sea Level Rise Curve	100 cm 125 cm 150 cm 175 cm **200 cm** 500 cm	The sea level rise curve parameter determines the rate of sea level rise assumed in the shoreline change model (measured in cm by 2100). The 200 cm by 2100 curve was selected because this most closely matches the sea level rise projections used for this project (see Table 1).

Interpreting the Coastal Hazard Maps

The Coastal Hazard Maps consist of 27 maps that represent potential future exposure of the nine San Diego park units to tidal inundation, 100-year coastal storm flooding, emergent groundwater flooding, and shoreline change considering three sea level rise scenarios. Each map displays all four coastal hazards for a given sea level rise projection along with the park unit boundary and a satellite imagery base map.

Areas exposed to tidal inundation and storm surge are symbolized with transparent shades of blue. For visualization purposes, the Coastal Hazards Maps depict emergent groundwater inundation in green (above the land surface), but not shallow groundwater (less than one meter below the land surface) due to the high degree of overlap between tidal inundation zones and shallow groundwater zones. However, both exposure to shallow and emergent groundwater will be included in the vulnerability assessment.

Shoreline change is depicted by shading the area between the baseline mean high water shoreline and future mean high water shoreline for sandy beaches. If the future shoreline is seaward of the baseline shoreline (accretion, i.e., the beach has gained width), the area is shaded yellow, but if the future shoreline is inland of the baseline shoreline (erosion, i.e., the beach has lost width), the area is shaded orange. Note that for each sea level rise scenario, the future shoreline is compared to the same baseline shoreline, not the previous scenario. Therefore, in cases where the shoreline accretes slightly from the baseline by 2035 and then erodes beyond the baseline shoreline by 2050, only the retreat between the baseline shoreline and the 2050 shoreline is depicted on the 2050 map.

Projected Shoreline Change

For each transect, two shoreline change metrics were calculated for each scenario: beach width and a shoreline change index (SCI) formulated to indicate the degree of shoreline change (either accretion or erosion) relative to the baseline beach width. Beach width and SCI were measured relative to the line used in the CoSMoS model to represent the backshore feature.

The formula below describes how the SCI is calculated for each transect. Table E-5 provides guidance for interpreting the resulting values and Figure 2 provides an illustrative example to help visualize the concept.

$$SCI = (W_{future} - W_{baseline}) / W_{baseline}$$

$W_{baseline}$ = baseline beach width, measured between the baseline mean high water (MHW) shoreline and the CoSMoS backshore feature (baseline is year 2000 for the shoreline change model)

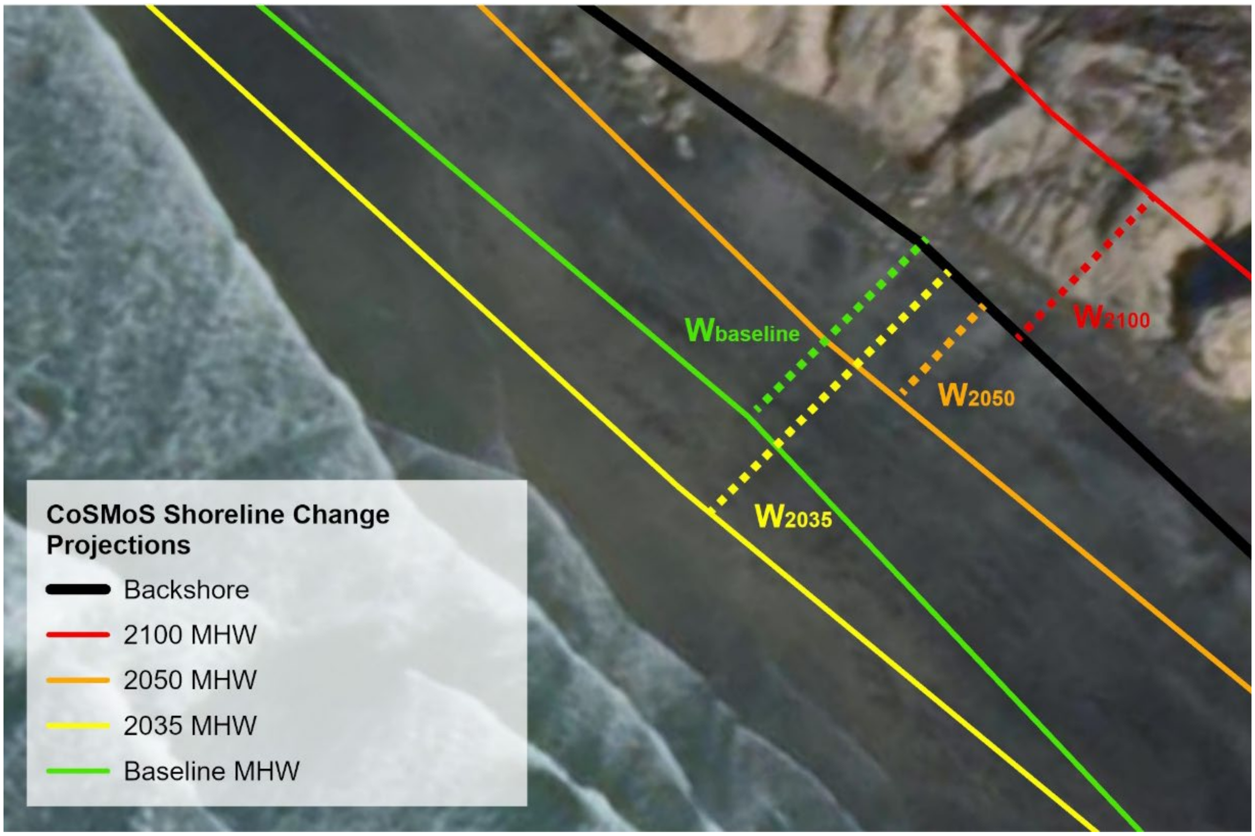
W_{future} = future beach width, measured between the future MHW shoreline and the CoSMoS backshore feature

Table E-5. Guidance for Interpreting Shoreline Change Index

SCI	Interpretation	Example
> 0	If the SCI is greater than zero (i.e., a positive value) this means that the beach has gained width.	An SCI of 0.25 indicates that the beach has increased in width by 25%
0 to -1	If the SCI is less than zero but greater than -1, this means that the beach has decreased in width but some beach remains.	An SCI of -0.25 indicates that the beach has decreased in width by 25% and 75% of the beach's original width remains.
< -1	If the SCI is less than -1, this means that the beach has been fully eroded (relative to the "no hold the line" backshore feature). For armored shorelines, the lower the number is below -1, the greater the erosive forces on the backshore feature. For unarmored shorelines, the lower the number is below -1, the greater the erosion distance beyond the backshore feature.	An SCI of -1.25 indicates that the beach has fully eroded and if the shoreline were allowed to continue eroding past the backshore feature it would erode an additional 25% of the original beach width. For armored shorelines, larger negative values of SCI can be interpreted as a proxy for the erosive forces (i.e., scour, wave attack) on the coastal armoring structure.

Figure E-2 illustrates how the SCI is calculated based on $W_{baseline}$ and W_{future} (2035, 2050, 2100). For 2035, W_{future} is greater than $W_{baseline}$, meaning that the beach has gained width and the resulting SCI will be positive (~0.25, i.e., an increase in beach width of 25 percent). For 2050, W_{future} is less than $W_{baseline}$, meaning that the beach has lost width but some beach remains and the resulting SCI will be negative but greater than -1 (~ -0.5, i.e., a decrease in beach width of 50 percent). For 2100, W_{future} is inland of $W_{baseline}$, meaning that the beach is completely lost (if unarmored) band the resulting SCI will be negative and below -1 (~ -1.8, i.e., a decrease in beach width of 100 percent plus an additional shoreline recession equal to 80 percent of the initial beach width).

Figure E-2. Illustrative Example of Shoreline Change Index (SCI) Calculations



SCI and beach width were calculated for each transect along the park unit shorelines. Table E-6 and Table E-7 summarize the results by presenting the median values across all transects for each park unit. From these tables, insights regarding trends in shoreline erosion across the park units can be identified. For example, median beach width decreases for almost all park units. This indicates that sea level rise-induced retreat supersedes the coastal processes that have historically resulted in beach widening.

Note that presenting the median value for each park unit does obscure some more nuanced results. For example, the median values for Moonlight State Beach (SB) suggest that all beach is lost by 2050. However, while the beach is projected to be completely eroded for the majority of the length of the park unit, the models indicate that the central portion of the park where the beach extends further inland would still have some beach remaining even at 2100.

While median results by park unit are useful for identifying general trends, it is important to use transect-level results that capture the variation within individual park units. For this reason, transect-level shoreline change values will be used in the vulnerability assessment to characterize exposure to shoreline change within each park unit. See the Coastal Hazard Maps for a visualization of projected shoreline change across each park unit.

Table E-6. Median Shoreline Change Index (SCI) by Park Unit

Park Unit (North to South)	2035	2050	2100
Carlsbad SB	-0.26	-0.95	-2.76
South Carlsbad SB	-1.24	-1.73	-3.20
Leucadia SB	-2.12	-3.86	-8.65
Moonlight SB	-0.80	-1.17	-4.68
San Elijo SB	-0.11	-1.90	-7.50
Cardiff SB	-0.65	-1.24	-3.94
Torrey Pines SB	-0.95	-1.10	-2.39
Silver Strand SB	-0.18	-0.26	-0.56
Tijuana River NERR / Borderfield SP	-0.69	-0.60	-1.70

Note: Negative SCI values indicate reduction in beach width and position SCI values indicate increase in beach width relative to baseline conditions.

Table E-7. Median Beach Width Relative to USGS Backshore Feature by Park Unit

Park Unit	Baseline (2000) (feet)	2035 (feet)	2050 (feet)	2100 (feet)
Carlsbad SB	75	60	5	-135
South Carlsbad SB	90	-25	-70	-220
Leucadia SB	30	-40	-100	-245
Moonlight SB	45	10	-10	-150
San Elijo SB	25	20	-20	-145
Cardiff SB	30	15	-10	-115
Torrey Pines SB	90	10	-5	-135
Silver Strand SB	500	390	340	195
Tijuana River NERR / Borderfield SP	150	105	95	-25

Note: Negative beach widths indicate projected shoreline positions that are landward of the USGS “hold the line” backshore feature.

Guidance for Selection of Sea Level Rise Scenarios

Sea level rise projections provide vital information to understand vulnerability, risk, and adaptation options. Considering a range of sea level projections enables the evaluation of vulnerability of park assets under various future conditions. Decisions regarding the selection of sea level rise scenarios should be based on several factors, including exposure and associated impacts, project/asset lifespan, and risk aversion.

Selecting lower sea level rise scenarios may be helpful to understand near-term changes, which can inform near-term management decisions. On the other hand, higher sea level rise scenarios (7 ft) may be selected when trying to understand the 'worst case scenario, 'the potential long-term impacts of sea level rise, or when planning for assets with long lifespans, low adaptability, or low risk tolerance.

Sea level rise scenarios that show the most change and help identify tipping points, defined by an amount of sea level rise that results in widespread hazard exposure of park areas and assets, are recommended and should be selected based on the topographic conditions of each park unit. For example, in park units that have gentle slopes or low topography, the highest sea level rise scenario (7 feet) may show the entire park unit is exposed, whereas lower sea level rise scenarios (1.6 feet and 3.5 feet) may show a progression of inundation, thus providing important information about the phasing of impacts and adaptation options. However, in a park that has a steeper slope or higher topography, assets may not be exposed at lower sea level rise scenarios, which would not provide much information on timing and extent of impact, where a higher scenario may provide that information.

Scenarios that show extreme exposure and impacts can be alarming and make it difficult to identify and plan near-term actions. By choosing scenarios that show incremental change it allows the public to understand the progression of future coastal change and the opportunities for adaptation.

Additional consideration should be given to the value of assessing each park unit consistently with comparable sea level rise scenarios so that comparisons can be made among parks when assessing vulnerability and prioritizing adaptation actions across all park units within the San Diego Coast District. The value of consistent vulnerability information across parks needs to be weighed against the value of having park-specific vulnerability information to inform future decisions.[19]

Guidance for Supplementing USGS CoSMoS Data

The California State Parks SDCD Coastal Hazards Vulnerability Assessment leverages readily available mapping data of coastal hazards from the USGS CoSMoS datasets. CoSMoS datasets include hazard layers of sea level rise inundation and flooding, shoreline change, and shallow and emergent groundwater, providing a consistent resource for vulnerability assessments that will be completed for the State's nine coastal park units. Over the past ten years, USGS has developed complementary products for much of the state's coastline, although not all datasets are available for all portions of the coast. Current data availability as of February 2022 is listed below:

- **Inundation and flooding:** open coast from Point Arena (Mendocino County) to San Diego County, including San Francisco Bay

[19] In advance of the next PMT meeting, AECOM will provide recommendations on which two scenarios should be carried forward for the vulnerability assessment for SDCD. During the PMT meeting, AECOM will in real time walk through each park unit turning on appropriate asset layers for each one with the three sea level rise scenarios to illustrate why AECOM is making these recommendations. Once the scenarios are selected the set of hazard maps with illustrative assets can be created.

- **Sandy beach shoreline change and cliff retreat:** open coast from Golden Gate (San Francisco) to San Diego County
- **Shallow and emergent groundwater:** open coast and San Francisco Bay

Availability of CoSMoS datasets and timing of release of additional products are discussed on the USGS CoSMoS website: https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos.

Although CoSMoS datasets are recommended as a baseline data resource to inform sea level rise adaptation planning for State Parks for consistency across all park units, there are several limitations that should be considered prior to their use:

- Due to the regional scale of the CoSMoS modeling, it was not possible to capture or ground-truth the presence of small-scale local topography or narrow flood protection features, such as seawalls. As a result, projected flooding in areas with shoreline protection structures may be overstated. It is possible to manually modify the flood extents of CoSMoS flood layers to better capture the protection offered by known flood mitigation features, but this involves additional analysis, expert judgment, and a comparison of structure crest elevations and future water level conditions being considered in the assessment.
- Park improvement projects, particularly those affecting the shoreline elevation or grade of park assets, completed after creation of CoSMoS hazard data layers may not be accurately represented in the model results. Similar to treatment of small-scale flood protection features, CoSMoS data layers can be manually modified to account for potential impacts to hazard layer extents after comparing future CoSMoS modeled water levels and relevant project datasets (e.g., design drawings or updated topographic surveys).
- CoSMoS provides a suite of approximately ten future sea level rise scenarios (0 to 2 meters) at 0.25-meter increments and a high-range five meter scenario to meet a broad range of possible management planning time horizons. While this format provides a consistent and flexible dataset to use for planning and design, the scenarios do not directly align with California State Guidance for sea level rise projections. However, State-recommended sea level rise values are not static and will be regularly reviewed and updated (approximately every five years) to reflect the latest climate science. Therefore, CoSMoS sea level rise mapping layers should be selected with the goal of aligning as closely as possible with the latest State-recommended sea level rise projections.

Despite these limitations, CoSMoS is currently viewed as the best available regional dataset that provides the most consistency across different portions of the state in terms of the modeling framework, data products available, and climate change scenarios considered.

Although CoSMoS provides a consistent regional coastal hazard dataset for much of the developed portions of the California coastline, other local and more detailed modeling and hazard mapping data sources may be available to supplement CoSMoS in some areas. Detailed local datasets that provide coverage of State Parks areas may offer advantages over regional CoSMoS datasets due to their ability to capture characteristics unique to the local setting or by providing consistency with local planning initiatives or specific sea level rise and storm scenarios. Examples include the Adapting to Rising Tides Shoreline Flood Explorer in San Francisco Bay[20], the Pacific Institute's California Coastal Erosion and Sea Level Rise Study[21], the Delta Stewardship Council's Delta Adapts flood modeling[22], FEMA's San Francisco Sea Level Rise and Coastal Erosion Pilot Study[23], and Coastal Resilience Ventura[24]. In addition, there are a number of sea level rise related datasets and products that are not specifically related to coastal hazards. For example, there are a growing number of modeling tools and datasets to assist with mapping of potential changes in future wetland and marsh habitats due to sea level rise (e.g., Future San Francisco Bay Tidal Marshes Planning Tool[25], Sea Level Affecting Marshes Model (SLAMM)[26], Sea Level Rise Wetland Impacts and Migration[27]) that may provide additional information on the effects of sea level rise on park resources.

When considering use of local datasets a number of factors should be considered. Detailed local studies are typically conducted for very specific purposes – for example, wetland restoration design, Coastal Development Permit technical studies, coastal structure design, or Local Coastal Program hazards assessments. As a result, the outputs of these studies are very tailored to specific purposes and may not align with State Parks' goals of understanding vulnerabilities to coastal resources and infrastructure and identifying phased adaptation actions. In addition, the sea level rise projections and planning horizons evaluated may not align with the CoSMoS data layers. It is unlikely that a detailed local study would cover all the park units within a park district, so there is the possibility of inconsistent evaluation of coastal hazards within a park district if different sources of hazard data are used. These considerations would have to be weighed against the added benefit of using more detailed local hazard information that may be more recent, more accurate, and more widely accepted by local stakeholders. Despite these challenges, it may be possible to incorporate more detailed local hazard data into the vulnerability assessments for one or more park units within a given district; however, this would likely increase the level of effort required compared to universal application of the CoSMoS datasets within a park district because a vulnerability analysis framework would have to be developed for each local dataset and it is likely that coastal hazard datasets would be "mixed and matched" for different park units (for example, if local coastal flooding and shoreline change hazard layers were available but local groundwater modeling or mapping were not).

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[20] https://explorer.adaptingtorisingtides.org/explorer
[21] https://pacinst.org/reports/sea_level_rise/
[22] https://deltascience.shinyapps.io/delta_flood_map/
[23] https://default.sfplanning.org/plans-and-programs/local_coastal_prgm/CCAMP_OPC_SLR_PilotStudy_FINAL_25Jan2016.pdf
[24] https://coastalresilience.org/project/ventura-county/
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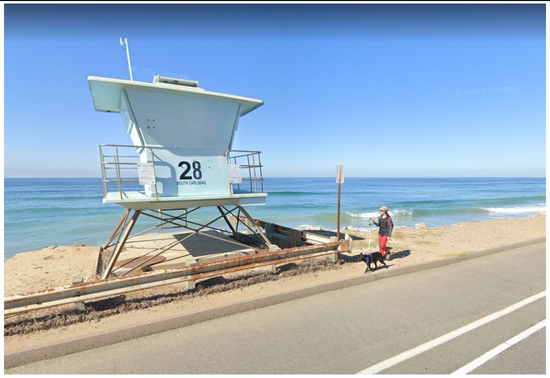
Appendix F : Potential Adaptation Strategies

Table F-1. Menu of Potential Adaptation Strategies by Shoreline Typology

Adaptation Strategy		Sandy Beach Backed by Armor (Revetment or Riprap or Sewall)	Sandy Beach Backed by Road, Parking Lot, or Other Infrastructure	Sandy Beach Backed by Soft Natural Bluff	Sandy Beach Backed by Hard Natural Bluff
No Action[1 2]		X	X	X	X
Managed Retreat[1 2]		X	X	X	X
Phased Closure[1 2]		X	X	X	X
Habitat Restoration	Dune Restoration[1]	X	X		
	Beach Nourishment[1]	X	X	X	X
	Marsh Augmentation[1]				
	Ecotone Levee[1]				
	Stabilization with Native Plantings[1]	X	X	X	X
Subtidal Habitat Creation[1]		X	X	X	X
Reduce Stormwater Runoff[1]			X	X	X
Artificial Reef[1]		X	X	X	X

Adaptation Strategy	Sandy Beach Backed by Armor (Revetment or Riprap or Sewall)	Sandy Beach Backed by Road, Parking Lot, or Other Infrastructure	Sandy Beach Backed by Soft Natural Bluff	Sandy Beach Backed by Hard Natural Bluff
Inlet Maintenance[1]				
Improving Circulation[1]				
Sediment Trapping[1]				
Geotextile Bags/Sandbags[1 2]		X	X	
Revetment[1]	X	X	X	
Groins[1]	X	X		
Breakwater[1]	X	X	X	X
Shotcrete Wall[1]			X	
Seawall/Caisson Wall[1]	X	X	X	
Raise Roadways/ Infrastructure[2]	X	X	X	X
Tide Gates				
Raise Asset Components[2]	X	X	X	X
Notes: [1]Denotes shoreline strategies [2]Denotes park asset strategies				

Table F-2. Summary Potential Strategies for Moonlight SB

Strategy	Photo	Description	Relevant Coastal Hazards	Co-benefits
No Action		Shoreline naturally transitions, no action is taken to relocate assets or intervene in physical processes.	Tidal Inundation Shoreline Change 100-year Coastal Storm Rising Groundwater	Facilitates natural coastal processes. Maintains recreational and habitat interface with ocean.
Managed Retreat		Creating space for shoreline to naturally transition landward and purposefully relocate at-risk assets or resources.	Tidal Inundation Shoreline Change 100-year Coastal Storm Rising Groundwater	Facilitates natural coastal processes. Maintains recreational and habitat interface with ocean.

Strategy	Photo	Description	Relevant Coastal Hazards	Co-benefits
Beach Nourishment		Enhancing, restoring or creating a beach through strategic placement of sand in a manner that attenuates waves in front of assets, resources, or bluffs.	Tidal Inundation Shoreline Change 100-year Coastal Storm	Enhanced habitats, improves coastal landscape, maintained recreation
Stabilize with Native Plantings		Native plantings used to stabilize eroding shorelines or slow bluff retreat	Shoreline Change	Enhanced habitats, increased aesthetic appeal, reduces water use

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