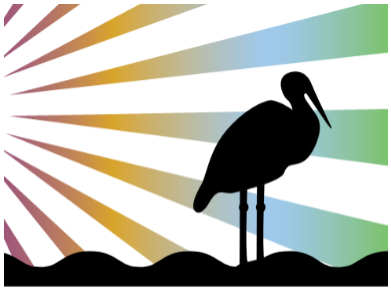
PUBLIC REVIEW DRAFT

Sonoma County
Local Coastal Plan

APPENDIX G:
BODEGA BAY FOCUSED VULNERABILITY ASSESSMENT AND ADAPTATION STRATEGIES
September 2019



Local Coastal Program
Permit Sonoma

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County of Sonoma

Bodega Bay Focused Sea Level Rise Vulnerability Assessment and Adaptation Strategies

April 30, 2017

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California Ocean Protection Council

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Table of Contents

List of Tables

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Executive Summary

This Sonoma County Coast Focused Vulnerability Assessment has been prepared under the County's California Ocean Protection Council Sea Level Rise Adaptation Planning Grant. It focuses on Bodega Bay, the coastal community most at risk from the impacts of sea level rise based on the results of the Sonoma County Coast *General Vulnerability Assessment*.

This Vulnerability Assessment: (1) identifies the coastal areas and assets in Bodega Bay exposed to sea level rise and storm events; (2) analyzes the location and extent of assets projected to be inundated by sea level rise and flooded by storm events; (3) assesses the impacts of inundation and flooding; and (4) identifies potential adaptation measures to minimize the risks and impacts of inundation and flooding.

Sea levels are expected to rise over 6 feet by the end of this century. The sea level rise and storm scenarios used in the analysis are based on: (1) the range of sea level rise projections for California adopted by the National Research Council in 2012; and (2) the Our Coast Our Future website and tool that uses the U.S. Geological Survey's Digital Elevation Model and Coastal Storm Modeling System. The model incorporates several factors that can be analyzed individually and collectively under various scenarios, including: sea level rise, tides, storm surge, El Niño effects, wave set up, and wave run up. Sonoma County selected five sea level rise and storm scenarios that cover a full range of impact to affected coastal communities by the end of the century.

The northern section of Bodega Bay is referred to as the Bodega Harbor Area. It contains all of the marinas, the only rural residential development, and the largest area of urban residential development in the Bodega Bay study area. By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 59% to 99% of marinas; 28% to 76% of County roads; 53% of a coastal wetland, and less than 1% to 14% of residential areas.

The eastern section of Bodega Bay is referred to as the Highway 1 Area. It contains all of the commercial development and the only public utility (Bodega Bay PUD Wastewater Treatment Plant) in the Bodega Bay study area. By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 9% to 70% of commercial areas, 51% of the Bodega Harbour Yacht Club, 13% to 22% of residential areas, and 2% of a public access and recreation area (Dredge Spoil Disposal Ponds Site).

The southern section of Bodega Bay is referred to as the County Regional Parks Area. It contains the only County parks (Westside and Doran Beach Regional Parks) and institutional development (U.C. Davis Bodega Marine Laboratory) in the Bodega Bay study area. By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 20% to 73% of coastal wetlands, almost 100% of Westside Regional Park and 36% of Doran Beach Regional Park, 26% to 39% of County roads, 23% of the Links at Bodega Harbor Golf Course, and less than 1% of the U.C. Davis Bodega Marine Laboratory.

1. Introduction

Sea Level Rise Adaptation Planning Grant

The June 2016, *General Sea Level Rise Vulnerability Assessment for the Sonoma County Coast* prepared by staff evaluated coastal areas, communities, land uses, development, public infrastructure, and habitats most vulnerable to sea level rise impacts. This General Vulnerability Assessment also identified Bodega Bay and Jenner as the communities most at risk from the impacts of sea level rise. Permit Sonoma chose Bodega Bay as the first community for a Focused Vulnerability Assessment. This Focused Vulnerability Assessment for Bodega Bay is based on the process outlined in the California Coastal Commission's Sea Level Rise Policy Guidance, and incorporates the results of the *Focused Vulnerability Assessment: Sonoma County* (July 29, 2016) by the Center for Ocean Solutions (COS). **Figure 1** shows the Bodega Bay Study Area.

Local Coastal Plan Update

The California Coastal Commission recently adopted policy guidance on assessing and addressing sea level rise risks in local communities. While only advisory, the guidance includes steps for analyzing sea level rise in Local Coastal Plans, including choosing a range of sea level rise projections, identifying potential impacts, and assessing risks coastal habitats and development. With this analysis, the guidance provides example adaptation measures and Local Coastal Plan policy options to use when drafting updated or new Local Coastal Plan policies for certification with the Coastal Commission. The guidance further provides steps to implementing the policy in an updated Local Coastal Plan, monitoring, and amending the Local Coastal Plan as scientific and engineering fields advance our knowledge of adapting to sea level rise. The Local Coastal Plan regulates lands in the Coastal Zone as defined under California Law.

In the last few years, Sonoma County has focused on climate change and sea level rise. The County is updating its Local Coastal Plan for several reasons, one of which is to reflect the potential impacts of sea level rise and storm events on its coastal residents, infrastructure, and natural resources and to develop appropriate policies and actions to avoid and minimize those impacts. This Focused Vulnerability Assessment informs the Sonoma County Local Coastal Plan Update, and is part of an ongoing scientific, engineering, and public process to understand and prepare for the impacts of sea level rise.

This Focused Vulnerability Assessment tracks the Coastal Commission's Guidance, is consistent with planning standards used in hazards mitigation planning, and will be used to inform policies in the Local Coastal Plan Update. The Assessment is advisory and not regulatory.

Climate Change and Sea Level Rise

Climate change is affecting natural and built systems around the world, including the California coast. In the past century, average global temperature has increased about 1.4°F, and average global sea level has increased 7 to 8 inches. Sea level at the San Francisco tide gauge has risen 8 inches over the past century, and the National Research Council (NRC) projects that by 2100, sea level in California south of Cape Mendocino may rise 66 inches. Recent research shows that

in the worst case scenario, sea-level could rise 70 inches by 2100. The two major causes of global sea level rise are thermal expansion of warming oceans and the melting of land-based glaciers and polar ice caps. While Sonoma County's ocean coast regularly experiences erosion, flooding, and significant storm events, sea level rise would exacerbate these natural processes, and lead to significant social, environmental, and economic impacts. The third National Climate Assessment cites strong evidence showing that the cost of doing nothing exceeds the costs associated with adapting to sea level rise by 4 to 10 times. Therefore, it is critically important that Sonoma County plan and prepare to adapt to sea level rise to ensure public resources and coastal communities are resilient for present and future generations.

The Sonoma County coastline encompasses two characteristically distinct coasts (1) north of the Russian River is a rocky coast with tall bluffs punctuated with small coves; and (2) south of its mouth the coastline if comprised of low-lying grassland, sandy dunes, and pocket beaches. Exposure to coastal erosion and inundation caused by sea level rise and storm events differs significantly along the Sonoma County coastline, with distinct breaks north and south of the mouth of the Russian River. North of Jenner, the high rocky cliffs shelter much of the coastline, and extend into a rocky continental shelf dominated by kelp beds to the border with Mendocino County. The coastline south of Jenner includes the Russian River Estuary and sediment deposition influences hydrology and fisheries through inland Sonoma County. Moving south of Jenner the open coast and low lying beaches allow for greater coastal exposure; and habitats include beaches, high and low dunes, and wetlands extending south along the coast around Bodega Head and to the border with Marin County. These habitats provide some buffering of the coastline from the effects of erosion and inundation. The inland extent of Bodega Harbor is open to wave erosion due to the shallow waters and small amount of fetch. (Center for Ocean Solutions 2016a & b).

The high dunes at Doran Beach along the southern extent of Bodega Bay protect the inner harbor from northwest swells and the impacts of waves. This protection has allowed for the formation of diverse and complex inner harbor tidal mudflat, eelgrass beds, and salt marsh habitats. These habitats host a diversity of species including endangered salmonids, shorebirds, and occasionally seals, which feed on shellfish and invertebrates and seek refuge in the inner harbor. These inner harbor habitats also buffer the effects of shoreline erosion, sedimentation, and inundation during storm events by absorbing excess sediment and the nutrients necessary for production of eelgrass, shellfish, and invertebrates. (Center for Ocean Solutions 2016a & b).

2. Methods

This Focused Vulnerability Assessment process is guided by the California Coastal Commission's August 2015 *Sea Level Rise Policy Guidance*, similar to the California Emergency Management Agency's July 2012 *Climate Adaptation Planning Guide*, used by Marin County in its *Draft Marin Coast Sea Level Rise Vulnerability Assessment*. The Focused Vulnerability Assessment provides background and analysis for individuals, communities, Sonoma County, and local and state agencies to use in planning for and adapting to sea level rise.

This Focused Vulnerability Assessment does not address erosion. In addition, it does not address property under the jurisdiction of the state or federal government, including the Sonoma Coast State Park and Beach and U.S. Coast Guard Station.

In order to organize the analysis of Bodega Bay for this Assessment, we sectioned the community into three Areas: the Bodega Harbor Area to the north, Highway 1 Area to the east, and County Regional Parks Area to the south **(Figure 2)**.

Modeling

Table 1 shows the range of sea level rise projections for the San Francisco, California region adopted by the National Research Council (NRC) in 2012. The NRC projections are the basis for the projections used in this Focused Vulnerability Assessment. Given the uncertainty in the magnitude and timing of future sea level rise, Sonoma County (and Marin County) used a scenario-based approach to assess a range of potential sea level rise impacts. Assessing a range of scenarios provides a framework for analyzing the vulnerability of Sonoma County's assets to sea level rise and storm events. The five scenarios selected for this Vulnerability Assessment are derived from the U.S. Geological Survey's (USGS) Coastal Storm Modeling System (CoSMoS; Storm Model).

Table 1. Sea Level Rise Projections for San Francisco, CA Region

Year	Projected Rise in Sea Level
2030	0.13 – 0.98 feet (4 – 30 cm)
2050	0.39 – 2 feet (12 – 61 cm)
2100	1.38 – 5.48 feet (42 – 167 cm)

Source: National Research Council (2012)

Sea level rise projections used in this analysis are from the Our Coast Our Future (OCOF) website and tool. OCOF was developed through a partnership of several notable institutions and agencies and represents the best available sea level rise and coastal storm science for the Bay Area Region and other parts of coastal California. OCOF uses the USGS Digital Elevation Model (DEM; Elevation Model) constructed for the region with 2-meter horizontal grid resolution and the Storm Model to produce a combination of 40 different sea level rise and storm scenarios. These scenarios include sea level rise, tides, storm surge, El Niño effects, wave set up, and wave run up. High quality elevation data incorporated into the Elevation Model delineates the current mean higher high water (MHHW) tidal elevation plus sea level rise heights and provides the option to add storm scenarios. Because the Elevation Model uses the highest tide measured, properties exposed to MHHW could be dry at lower tides. It is important to note that this tool only accounts for ocean levels and does not incorporate impacts from creek flooding or changes in the coastline (geomorphology) as erosion continues.

Sonoma County selected the sea level rise and storm scenarios in **Table 2** based on the National Research Council sea level rise projections in **Table 1** and the geographic extent and variety of storm severity. When combined, these scenarios cover a full range of impact to affected coastal communities by the end of this century. Scenarios 2-5 are the same scenarios Marin County used in its *Marin Coast Sea Level Rise Vulnerability Assessment*. Scenario 1 represents existing conditions. Scenario 2 represents near-term, and corresponds to the 2030 National Research Council projected range in sea level rise. Scenario 3 is considered medium-term and is within the 2050 National Research Council sea level rise range. Scenarios 4 and 5 represent the long-term. Scenario 4 corresponds to the 2100 National Research Council sea level rise range. Scenario 5 represents sea level rise by 2100 based on additional research theorizing the worst case scenario for sea level rise summarized by the California Ocean Protection Council Science Advisory Team Working Group in *Rising Seas in California – An Update on Sea Level Rise Science* (Griggs et. al. 2017).

The Scenarios include storm events because they have the potential to cause catastrophic damage and hazardous coastal conditions that could increase in geographic extent as sea-levels rise. The storm frequencies presented in **Table 2** are the annual, 20-year, and 100-year storms. An annual storm has a high likelihood of happening in most years; a 20-year storm has a five percent chance of happening annually; and a 100-year storm has a one percent chance of happening in any given year.

Future storm conditions depend on the complicated interaction between the Earth's atmosphere and ocean systems, which the Storm Model attempts to simulate. Replicating storm scenarios

within the model is also difficult due to altered wave conditions varying between different storm events. Lower lying portions of Bodega Bay may experience more inundation during a five or 10-year storm event due to increased water levels, wave heights, storm surges, and altered patterns of erosion and accretion of the ocean floor. For example, the Storm Model has higher wave heights offshore than the 20-year storm; however the waves approach the coast from a more northerly direction.

Table 2. Sea Level Rise and Storm Scenarios Used in Focused Vulnerability Assessment

Scenario	Projected Sea Level Rise		Storm Event
	feet	cm	
1 - 2016	0	0	annual
2 - 2030	0.83	25	20-year
3 - 2050	1.67	50	20-year
4 – 2100 Best Case	3.33	100	100-year
5 – 2100 Worst Case	6.56	200	100-year

Assessment

An asset's vulnerability depends on its exposure, sensitivity, and its capacity to adapt to sea level rise and storm events. This Focused Vulnerability Assessment analyzes almost 40 exposed Residential, Commercial, Marine Industrial, Public Utility, Public Infrastructure, Public Access & Recreation, Private Recreation, and Wetland assets. We identified the assets that could be vulnerable to sea level rise and storm events by developing a "Sonoma County Sea Level Rise Viewer" based on the National Oceanic and Atmospheric Administration (NOAA) *Sea Level Rise and Coastal Flooding Impacts Viewer.* Geographic data layers for parcels, building footprints, land use, public & protected lands, trails, infrastructure, schools, riparian corridors, wetlands, and marine habitats were added.

To assess the potential flooding or inundation of an asset other than roads and the California Coastal Trail (Coastal Trail), a GIS shapefile was created and then entered into the Storm Model on the OCOF site to produce an "OCOF Sea Level Rise and Scenario Report". The OCOF Report includes area and elevation information and two tables: "Projected Percent Area Flooded for the Selected Area" and "Projected Average Flood Depth for the Selected Area." Based on that information, a Table was prepared showing projections for inundation (sea level rise alone) and flood (sea level rise plus storm event) as percent of the selected area.

Permit Sonoma staff assessed the potential temporary flooding or permanent inundation of County Roads or the Coastal Trail (linear assets), by measuring the total length of the road or trail on the Sonoma County Sea Level Rise Viewer. Then using the OCOF site to measure the projected temporary flooding or permanent inundation of the road or trail, staff then went back to the Sonoma County Coast Sea Level Rise Viewer to approximate and measure the extent of the flood or inundation impacts. Staff added the lengths of sections of affected road or trail together to obtain the total length of affected road or trail. Staff used the total affected length divided by the entire road length or trail to obtain the percent of road or trail inundated or flooded. Using the process above, Staff formulated the potential temporary flooding or permanent inundation of linear assets for all Sea Level Rise and Storm Scenarios in **Table 2**.

Coastal Wetland Categories

Data on the location and size of coastal wetlands is from the San Francisco Estuary Institute and Aquatic Science Center, part of the California Aquatic Resource Inventory (CARI; Inventory). The Inventory is a compilation of wetlands, streams, and riparian areas in California. This statewide dataset pulls together many sources of wetland data. In the case of Sonoma County, the National Wetlands Inventory, originally from the U.S. Fish and Wildlife Service, is the source of the wetland data. The National Wetlands Inventory was last updated in 2010 and was acquired by the San Francisco Estuary Institute in 2011. **Table 3** identifies the California Aquatic Resource Inventory wetland classifications comprising the Coastal Freshwater Marsh, Coastal Brackish Marsh, and Bodega Harbor Tidal Mudflat wetland categories.

Coastal Brackish Marsh

Table 3. California Aquatic Resource Inventory Classifications Comprising Wetland Categories

Coastal Freshwater Marsh
Freshwater Emergent Wetland - Depressional Seasonal Natural Emergent Freshwater Emergent Wetland - Depressional Seasonal Natural Emergent Freshwater Emergent Wetland - Depressional Seasonal Unnatural Emergent Freshwater Forested/Shrub Wetland - Depressional Seasonal Natural Shrub-Scrub Freshwater Forested/Shrub Wetland - Depressional Seasonal Natural Shrub-Scrub Freshwater Forested/Shrub Wetland - Depressional Seasonal Unnatural Shrub-Scrub
Coastal Brackish Marsh
Estuarine and Marine Wetland - Estuarine Saline Natural Intertidal Emergent Estuarine and Marine Wetland - Estuarine Saline Natural Intertidal Emergent
Bodega Harbor Tidal Mudflat
Estuarine and Marine Wetland - Estuarine Saline Unnatural Intertidal Non-Vegetated Estuarine and Marine Wetland - Estuarine Saline Unnatural Intertidal Vegetated

3. Bodega Bay Community Profile

Bodega Bay is a small rural community and harbor located approximately 40 miles northwest of San Francisco and 20 miles west of Santa Rosa in Sonoma County, California. The Bodega Bay Census Designated Place (CDP) has a total area of 12.5 square miles, of which 8.3 square miles of it is land and 4.2 square miles of it is water. The population of Bodega Bay was 1,411 in 2014 and 1,077 in 2010. Residential density is concentrated along Bay Flat Road and Westshore Road and near Highway 1.

Bodega Bay is a marine habitat used for navigation, recreation, and commercial and sport fishing. It is about 5 miles across and straddles the boundary between Sonoma County to the north and Marin County to the south, connecting to the mouth of Tomales Bay in Marin County. Bodega Head protects the Bay on its north end from the Pacific Ocean. Bodega Head shelters the harbor and separates it from the main bay by a jetty. The village of Bodega Bay sits on the east side of the harbor. North of the village lies a long coastal exposure of alternating rock outcrops and the sandy beaches of Sonoma Coast State Park. On the coast immediately north of Bodega Head is the University of California's Bodega Bay Marine Laboratory.

All coastal drainages between Salmon Creek and Point Reyes flow into Bodega Bay, creating a complex of fresh and brackish water marshes, tidal mudflats and coastal wetlands. Two main freshwater inputs are Johnson Gulch to the north and Cheney Gulch towards the east. The Bodega Harbor estuary empties southerly into Bodega Bay. The Estero Americano and Estero de San Antonio empty into Bodega Bay along its eastern side and Tomales Bay flows northerly into Bodega Bay. The Tomales Bay Peninsula lies across from Bodega Head, and together they create a neck for the outflow and allow Bodega Bay to function as a marine estuary (2014 Pacific Coast Joint Venture Strategic Plan). **Figures 3 and 4** show the coastal wetlands in the Bodega Bay study area.

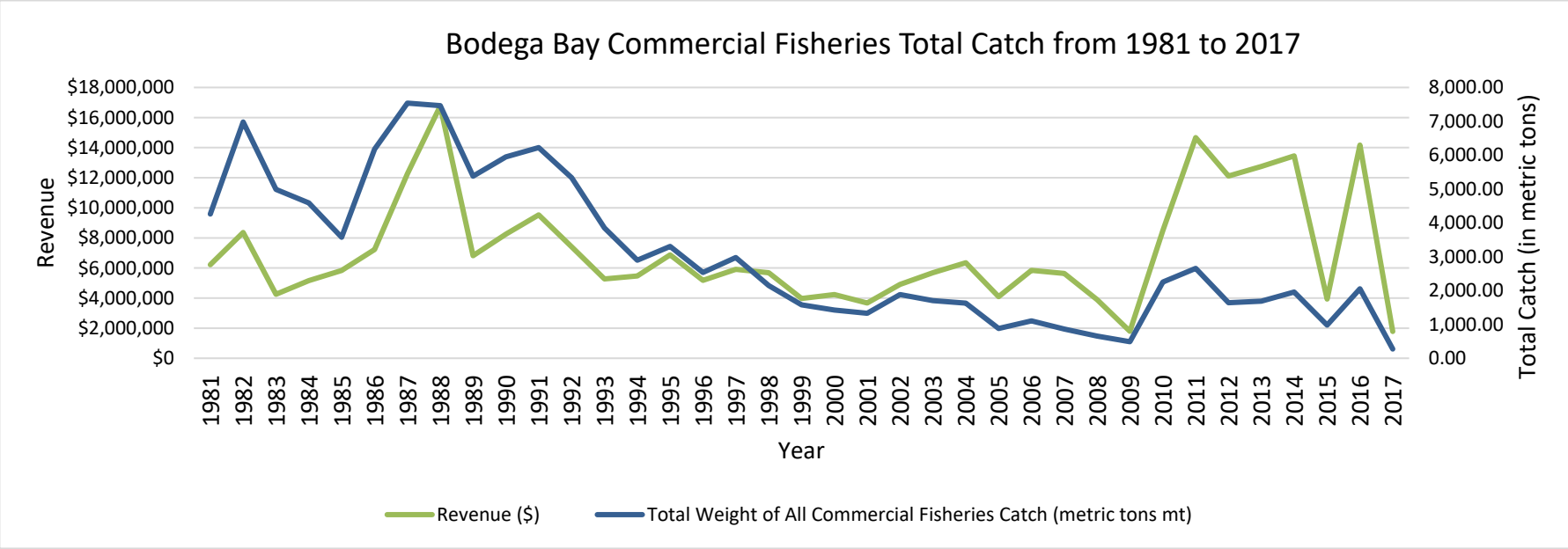
Commercial fishing remains a major component of Bodega Bay's economy. As of 2007, there was one commercial fish processing plant to which 317 commercially registered vessels delivered fish. **Figure 5** depicts the total catch in Bodega Bay commercial fisheries from 1981 to 2017. The sharp decline in 2015 is due to state officials closing the Dungeness crab fishery due to a harmful algal bloom. **Table 4** shows the 2016 total catch by west coast fishery and revenue in Bodega Bay commercial fisheries.

Table 4. 2016 Total Catch (Metric Tons) and Revenue in Bodega Bay Commercial Fisheries

West Coast Fishery	Total Catch (metric tons)	Revenue
Coastal Pelagic	0	$0
Crab	1,816.5	$1,047,625
Groundfish	89	$639,074
Highly Migratory Species	0	$0
Rockfish	3.4	$13,759
Salmon	48.9	$836,848

Source: Pacific Fisheries Information Network (2017)

Figure 5. Bodega Bay Commercial Fisheries: Total Catch (Metric Tons) 1981 to 2017



Marinas in Bodega Bay include the private Porto Bodega Marina & RV Park; and Mason's Marina, Spud Point Marina, and Bodega Bay Sport Fishing Center managed by Sonoma County Regional Parks. At Spud Point Marina, 80 percent of the berths are allocated to commercial fishing. Sonoma County Regional Parks also provides public boat launches at Doran Beach and Westside Regional Parks.

Commercial fishing remains a major component of Bodega Bay's economy. Expanding recreational opportunities to State and County parks in the region has increased exponentially in recent years, substantially increasing tourism to Bodega Bay. Sonoma Coast State Park encompasses 10,272 acres immediately west and north of the bay. Sonoma County Regional Parks manages Doran Beach Regional Park at the south end of the harbor and Westside Regional Park on the west side of the harbor.

About 20 businesses in Bodega Bay offer overnight accommodations including inns, hotels, bed and breakfasts, and an RV park. Four campgrounds provide low cost visitor-serving accommodations. California State Parks manages the Dunes and Wrights Beach Campgrounds in Sonoma Coast State Park, and Sonoma County Regional Parks manages the campgrounds at Doran Beach and Westside Regional Parks. **Figures 6-7** show the locations of the California Coastal Trail and County Regional Parks trails in the Bodega Bay study area.

Annual festivals demonstrate the economic and cultural significance of fishing to the Bodega Bay community: the Fisherman's Festival and Blessing of the Fleet for the approaching salmon season in April and The Seafood, Art, Music, and Wine Festival in August.

Spud Point Marina

4. Flooding and Sea Level Rise Inundation: Impacts at Bodega Bay

Bodega Harbor Area

The Bodega Harbor Area is the North Bay, encompassing the area from Spud Point Marina to the north end of the bay, and to the Bodega Bay Sports Fishing Center on the east. Bodega Harbor Area contains all of the Marine Industrial uses (marinas), the only Rural Residential development, and the largest area of Urban Residential development in Bodega Bay. Additional Bodega Harbor Area assets include Wetlands, County Roads, and County Trails. **Figure 8a** shows the location of and number assigned to each asset.

Assets in the Bodega Harbor Area vulnerable to sea level rise and storm events include Westshore, Eastshore, and Bay Flat Roads; public and private marinas; residential development; and coastal freshwater marsh and tidal mudflat. Sea level rise will impact these valuable assets leading to potential impacts on access; land use; habitats, including critical habitat; recreation and tourism; and commercial fishing. The floating docks at some of the marinas are resilient to rising tides; however, the residential development and the low-cost visitor-serving facilities at marinas are not as adaptable. Some residential buildings may not have direct impacts from sea level rise due to their elevation, but could become isolated and cut-off from all services due to compromised access and damaged utilities.

Bodega Harbor Area

Sea level rise will increase the salinity in freshwater sources, such as Johnson Gulch and Cheney Gulch, the two main sources freshwater to the harbor. The U.S. Fish and Wildlife Service have designated the coastal brackish water marsh at Johnson Gulch along Eastshore Road (FWMARSH-1 on **Figure 8a**) as a tidewater goby (*Eucyclogobius newberryi*) recovery sub-unit. Johnson Gulch marsh supports special status aquatic and terrestrial species. Bodega Harbor also provides rearing habitat for listed salmonids. The flow of freshwater from Johnson and Cheney Gulches into Bodega Harbor has created brackish tidal mudflats at their convergence. As sea level rise results in higher tides, the brackish mixing of these two systems will occur further upstream, which would impact the type and diversity of plant and animal species in the gulches, potentially jeopardizing critical habitat for listed species.

The sections below provide information on the percentage area of each asset that would be inundated or flooded as a result of sea level rise and storm events and potential impacts.

Coastal Wetlands

The Bodega Harbor Area contains two types of coastal wetlands exposed to sea level rise and storm events: (1) Coastal Freshwater Marsh and (2) Bodega Harbor Tidal Mudflat.

Coastal Freshwater Marsh

Coastal Freshwater Marsh occurs in two locations: 1) the boat storage area at the eastern end of Porto Bodega Marina & RV Park to the east toward State Highway 1 (FWMARSH-1 on **Figure 8a**); and 2) north and west of Westshore Road near where it becomes Bay Flat Road (Rail Ponds; FWMARSH-2). The Rail Ponds have some characteristics of coastal brackish marsh. The Rail Ponds area was originally a coastal marsh connected to Bodega Harbor. Development of Westshore Road in 1963 separated the Rail Ponds from the bay shoreline. The Rail Ponds are labeled coastal freshwater marsh but are tidally influenced by an existing connection to Bodega Harbor. They receive freshwater from groundwater inputs and saltwater through culverts carrying the tidal flow under Westshore Road from Bodega Harbor (California Coastal Commission 2012). Vegetation in the Rail Ponds includes coastal brackish marsh plant species - salt grass (*Distichlis spicata*), franconia (*Frankenia salina*), pickleweed (S*alicornia sp.*), and cordgrass (*Spartina foliosa*).

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Coastal Freshwater Marsh. **Table 5** shows the projected percent of marsh area permanently inundated by sea level rise and with storm event flooding. **Figure 8b** illustrates the projected permanent inundation, and **Figure 8c** illustrates the projected permanent inundation with storm event flooding of Coastal Freshwater Marsh under Scenario 5 (2100 Sea Level Rise Worst Case).

FWMARSH-1 is not projected to be at risk of permanent inundation from sea level rise by 2100. However, in 2100 the marsh would experience periodic flooding during storm events at less than 1% of the marsh under the best case scenario and 3% under the worst case scenario.

FWMARSH-2 is projected to be at risk of inundation from sea level rise by 2100. In 2030 the marsh would not be permanently inundated by sea level rise and 17% of the marsh would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 37% of the marsh would be permanently inundated and 53% would be subject to periodic flooding during storm events. In 2100 under the worst case scenario, 53% of the marsh would be permanently inundated and subject to periodic flooding.

Coastal habitats are likely to differ in their vulnerability and response to climate related stressors depending on coastal exposure and local conditions. For example, as sea level rises, coastal deltas and mudflats are likely to be lost to open water. Wetlands and coastal dunes exposed to coastal hazards can migrate upslope given a path free of barriers from coastal development or shoreline hardening. The California Department of Fish and Wildlife has identified wetlands as a sensitive natural community that is vulnerable to further degradation from sea level rise inundation, flooding, and development.

Table 5. Bodega Harbor Area: Coastal Freshwater Marsh – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*FWMARSH-1* *9.95 acres*		*FWMARSH-2* *1.97 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	----	----
2 - 2030	0.83	25	20-year	----	----	----	17%
3 - 2050	1.67	50	20-year	----	----	----	39%
4 – 2100 Best Case	3.33	100	100-year	----	< 1%	37%	53%
5 – 2100 Worst Case	6.56	200	100-year	----	3%	53%	53%

Bodega Harbor contains about 107 acres of Coastal Freshwater Marsh and 70 acres of Coastal Brackish Marsh. There are three major ways by which sea level rise can disrupt a marsh: inundation, erosion, and saltwater intrusion. The natural impact of a rising sea is to cause marsh systems to migrate upward and inland. Sea level rise increases the frequency and/or duration of tidal flooding throughout a marsh. If no inorganic sediment or peat is added to the marsh, the seaward portions become flooded so much that marsh grass drowns and marsh soil erodes; portions of the high marsh become low marsh; and upland areas immediately above the former spring tide level are temporarily flooded at spring tide, becoming high marsh. If nearby rivers or floods supply additional sediment, sea level rise slows the rate at which the marsh advances seaward.

Wetlands can grow upward fast enough to keep pace with the slow rise in sea level that most areas have experienced in the recent past. Thus, areas that might have been covered with two or three meters of water (or more) have wetlands instead. If sea level rise accelerates only slightly, marshes that are advancing today may have sufficient sediment to keep pace with sea level. But if sea level rise accelerates more rapidly, the sea will be rising much more rapidly than the demonstrated ability of wetlands to grow upward in most areas, and the increase in wetland acreage of the last few thousand years will be negated. If adjacent upland areas are developed, all the wetlands could be lost.

The net change in total marsh acreage depends on the slopes of the marsh and upland areas. If the land has a constant slope throughout the marsh and upland, then the area lost to marsh drowning will be equal to the area gained by the landward encroachment of spring high tides. In most areas, however, the slope above the marsh is steeper than the marsh, so a rise in sea level causes a net loss of marsh acreage.

The U.S. Fish and Wildlife Service has designated the coastal freshwater marsh at Johnson Gulch along Eastshore Road (FWMARSH-1 on **Figure 3**) as a tidewater goby (*Eucyclogobius newberryi*) recovery sub-unit. This marsh supports special status aquatic and terrestrial species. The ability of this freshwater marsh to migrate inland is limited because the marsh is already narrow and backed by residential development. However, under the near-term and medium-term sea level rise scenarios, this marsh habitat would buffer the effects of sea level rise for the residential development by absorbing the rising water and sediment.

Bodega Harbor Tidal Mudflat

Bodega Harbor Tidal Mudflat occurs in two locations: (1) west of Porto Bodega Marina & RV Park (1.70 acres; TIDFLT-1 on **Figure 8a**) and (2) east of the Porto Bodega Marina & RV Park and south of the Bodega Bay Sport Fishing Center (5.12 acres; TIDFLT-2).

Potential Flooding and Inundation Impacts

Data on projected inundation and flooding of Bodega Harbor Tidal Mudflat is not available.

Bodega Harbor contains about 480 acres of Tidal Mudflat that support about 130 acres of Eelgrass Bed. Bodega Harbor Tidal Mudflat links marine, freshwater, and terrestrial habitats; as well as provides economic and recreational benefits to the community. Tidal mudflats form unique habitats and maintain valuable ecosystems, buffering eelgrass beds from excess sedimentation, providing habitat for wildlife, and protecting terrestrial infrastructure from inundation (Thorne 2015). Bodega Harbor tidal waters ebb and flow over the central harbor mudflats depositing suspended sediments and organic matter from local plant production. This ecosystem is particularly unique in that the tidal velocity profile of Bodega Harbor show that water within the channel moves uniformly from top to bottom at fairly rapid flow rates, indicating a large throughput through the system and that the harbor flushes itself, contaminants, and sediments out daily (Rasmussen 2004).

Climate change effects such as sea level rise are altering this habitat, and coastal models are available to extrapolate potential effects until more site specific research is conducted. Tidal mudflat survival depends on the balance between the forces that lead to their creation (mineral and organic sediment accumulation) and the forces that lead to their deterioration (sea level rise, subsidence, and wave erosion). Sea level rise impacts to mudflats over the short and mid-term are controlled by the rate of vertical development (when accumulation exceeds deterioration) compared to relative sea level rise (the combination of the change in sea level and the change in land level; Cahoon 2010).

USGS models predict that over long-term sea level rise, mudflat deterioration will overpower accumulation, vertical development will lag behind sea level rise, permanent inundation will result in below optimum growth range for eelgrass, and tidal mudflat will convert to intertidal mudflat or subtidal open water (Cahoon 2010).

The flow of freshwater from Johnson Gulch into Bodega Harbor has created brackish tidal mudflat at their convergence. As sea level rise results in higher tides, the brackish mixing of these two systems will occur further upstream, which would impact the type and diversity of plant and animal species in the gulches, potentially jeopardizing important habitat for endangered species.

Public Access & Recreation – Trails

The Bodega Harbor Area contains a portion of one segment of the California Coastal Trail (Coastal Trail) exposed to sea level rise and storm events: an Existing Coastal Trail segment along the east side of Bodega Bay (0.54 miles, 2,849 feet). **Figure 6** shows the locations of Coastal Trail segments in the Bodega Bay Study Area.

Potential Inundation and Flood Impacts

Sea level rise and storm events may result in inundation and would result in flooding of the Coastal Trail segment. **Figure 8b** illustrates the projected permanent inundation, and **Figure 8c** illustrates the projected permanent inundation with storm event flooding of the Coastal Trail segment under Scenario 5 (2100 Sea Level Rise Worst Case).

Temporary flooding of an Existing Coastal Trail segment would result in trail damage and disrepair and require temporary closure or routing to an alternative trail segment during trail repair or re-construction. Permanent inundation of an Existing Coastal Trail segment would require relocation of the segment. The level of difficulty in relocating a Coastal Trail segment would depend on the sources of funding and the specific terms of easements with private property owners.

Marine Industrial

Bodega Harbor is the hub of commercial and sport fishing in Sonoma County, and is a popular destination during crab and salmon seasons. The marinas in the Bodega Harbor Area exposed to sea level rise and storm events include Porto Bodega Marina & RV Park (MI-1 on **Figure 8a**), Bodega Bay Sport Fishing Center (MI-2); Mason's Marina (MI-3E: east side of Westshore Road, MI-3BW: west side of Westshore Road); and Spud Point Marina (MI-4).

Porto Bodega Marina & RV Park (MI-1). The Porto Bodega Marina & RV Park is a privately owned resort off Bay Flat Road consisting of 75 open boat slips, guest docks, 58 RV sites, 2 vacation rentals, boat trailer parking, club house, and laundry.

Bodega Bay Sport Fishing Center (MI-2). The Bodega Bay Sport Fishing Center is a County-owned and operated facility east of the Porto Bodega Marina & RV Park. The County has a license agreement with sport fishing boat operators to allow them to use the Bodega Bay Sport Fishing Center License for party boats for fishing, whale watching, pelagic bird watching, and sightseeing. The facility includes a dock, boat launch, bait and tackle shop, and parking.

Mason's Marina (MI-3E & MI-3W). Mason's Marina is a County-owned and operated marina off Westshore Road that serves commercial fishing boats as well as recreational vessels including sailboats and motor launches. A small paved parking area and dock are used for fish-buying (MI-3E). The area on the west side of Westshore Road is used for storing crab pots (MI-3W).

Spud Point Marina (MI-4). Spud Point Marina is a County-owned and operated marina off Westshore Road that serves users of overnight and monthly berths and yacht club cruisers. It

consists of stable docks, fuel dock, guest dock and overnight berths, fishing and observation piers, tenant and public restrooms, laundry, dry dock storage, and parking.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Marine Industrial assets. The marina assets analyzed comprise landside facilities only and do not include the piers or docks. **Table 6** shows the projected percent area of the marinas permanently inundated by sea level rise and with storm event flooding. **Figure 8b** illustrates the projected permanent inundation, and **Figure 8c** illustrates the projected permanent inundation with storm event flooding of the marinas under Scenario 5 (2100 Sea Level Rise Worst Case).

All of the marinas are projected to be at risk of inundation from sea level rise by 2100. Porto Bodega Marina & RV Park and Mason's Marina would be more at risk than the other marinas.

Porto Bodega Marina & RV Park. In 2030 3% of the marina would be permanently inundated by sea level rise and less than 1% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 55% of the marina would be permanently inundated and 86% would be subject to periodic flooding during storm events. Under the worst case scenario, 65% of the marina would be permanently inundated and 95% would be subject to periodic flooding.

Bodega Bay Sport Fishing Center. In 2030 the marina would not be permanently inundated by sea level rise and less than 1% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, less than 1% of the marina would be permanently inundated and 18% would be subject to periodic flooding during storm events. Under the worst case scenario, 59% of the marina would be permanently inundated and 84% would be subject to periodic flooding.

Mason's Marina (East). In 2030 less than 1% of the marina would be permanently inundated by sea level rise and 44% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 91% of the marina would be permanently inundated and 99% would be subject to periodic flooding during storm events. Under the worst case scenario, 99% of the marina would be permanently inundated and subject to periodic flooding.

Mason's Marina (West). In 2030 the marina would not be permanently inundated by sea level rise and less than 1% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 50% of the marina would be permanently inundated and 86% would be subject to periodic flooding during storm events. Under the worst case scenario, 69% of the marina would be permanently inundated and 95% would be subject to periodic flooding.

Spud Point Marina. In 2030 the marina would not be permanently inundated by sea level rise and 2% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 8% of the marina would be permanently inundated and 45% would be subject to periodic flooding during storm events. Under the worst case scenario, 63% of the marina would be permanently inundated and 81% would be subject to periodic flooding.

Table 6. Bodega Harbor Area: Marine Industrial Assets – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	Porto Bodega Marina & RV Park *MI-1* *10.34 acres*		Bodega Bay Sport Fishing Center *MI-2* *1.54 acres*		Mason's Marina *MI-3E* *1.51 acres*		Mason's Marina *MI-3W* *3.45 acres*		*Spud Point Marina* *MI-4* *3.32 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	< 1%	----	----	----	----	6%	----	----	----	----
2 - 2030	0.83	25	20-year	3%	< 1%	----	< 1%	< 1%	44%	----	< 1%	----	2%
3 - 2050	1.67	50	20-year	7%	50%	< 1%	< 1%	< 1%	94%	----	50%	----	9%
4 – 2100 Best Case	3.33	100	100-year	55%	86%	< 1%	18%	91%	99%	50%	86%	8%	45%
5 – 2100 Worst Case	6.56	200	100-year	65%	95%	59%	84%	99%	99%	69%	95%	63%	81%

Permanent inundation of all or a portion of marinas would result in the loss of marine industrial land area to bay waters.

Porto Bodega Marina & RV Park

Temporary flooding and permanent inundation from sea level rise would damage and impair land-based facilities at marinas, potentially rendering them inoperable, including: the clubhouse, laundry, and boat trailer parking at Porto Bodega Marina & RV Park; bait and tackle shop, boat launch, and parking at the Bodega Bay Sport Fishing Center; crab pot storage and parking area at Mason's Marina; and restrooms, laundry, dry dock storage, and parking area at Spud Point Marina. Storm flooding, sea level rise, daily tidal flooding, and erosion would damage and impair docks. Temporary flooding and permanent inundation would impede or prevent access to and from the marinas.

Permanent inundation of the land-based portion of the marinas would result in loss of marine industrial area land.

Permanent inundation of Porto Bodega Marina & RV Park would result in loss of some or all of the RV sites, which would result in the temporary or permanent relocation of residents and loss of affordable housing.

Impacts on land-based facilities, docks, and public access at the marinas and the loss of marine industrial land would decrease sport fishing and other recreational opportunities at Bodega Bay, which would decrease tourism to Bodega Bay and result in the loss of tourist revenue.

Impacts on land-based facilities, docks, and public access at Mason's Marina and Spud Point Marina and the loss of marine industrial area land would decrease commercial fishing opportunities at Bodega Bay, which would reduce the viability of Bodega Bay's commercial fishing industry.

County Roads

The Bodega Harbor Area includes three County Roads exposed to sea level rise and storm events – Eastshore Road, Bay Flat Road, and Westshore Road. **Figure 8a** shows the location of these roads.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Eastshore Road, Bay Flat Road, and Westshore Road. **Table 7** shows the projected percent of road alignment permanently inundated by sea level rise and with storm event flooding. **Figure 8b** illustrates the projected permanent inundation, and **Figure 8c** illustrates the projected permanent inundation with storm event flooding of the roads under Scenario 5 (2100 Sea Level Rise Worst Case).

Table 7. Bodega Harbor Area: County Roads – Inundation and Flood Projections (Percent Alignment)

Scenario	Projected Sea Level Rise		Storm Event	*Eastshore Road* *2,791.5 feet* *(0.53 mi)*		*Bay Flat Road* *8,435.1 feet* *(1.60 mi)*		*Westshore Road* *4,896.2 feet* *(0.93 mi)*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	----	----	----	3%
2 - 2030	0.83	25	20-year	----	11%	----	2%	< 1%	16%
3 - 2050	1.67	50	20-year	< 1%	32%	----	16%	< 1%	48%
4 – 2100 Best Case	3.33	100	100-year	33%	37%	16%	26%	52%	78%
5 – 2100 Worst Case	6.56	200	100-year	35%	39%	28%	44%	76%	82%

These County Roads are projected to be at risk of inundation from sea level rise between 2050 and 2100. Westshore Road is the more at risk than the other County Roads.

Eastshore Road. In 2030 the road would not be permanently inundated by sea level rise and 11% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 33% of the road would be permanently inundated and 37% would be subject to periodic flooding during storm events. Under the worst case scenario, 35% of the road would be permanently inundated and 39% would be subject to periodic flooding during storm events.

Bay Flat Road. In 2030 the road would not be permanently inundated by sea level rise and 2% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 16% of the road would be permanently inundated and 26% would be subject to periodic flooding during storm events. Under the worst case scenario, 28% of the road would be permanently inundated and 44% would be subject to periodic flooding.

Westshore Road. In 2030 less than 1% of the road would be permanently inundated by sea level rise and 16% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 52% of the road would be permanently inundated and 78% would be

subject to periodic flooding during storm events. Under the worst case scenario, 76% of the road would be permanently inundated and 82% would be subject to periodic flooding.

Temporary flooding of County Roads would cause road closures during a flood event and result in road damage and accelerated deterioration. Recurring damage and deterioration from flooding could result in road failure or capacity restrictions. Road closures would temporarily restrict access to and from homes, businesses, or park and recreation areas. Residents may not be able to evacuate in emergencies, and emergency vehicles may not be able to reach locations in time, or at all. As road access becomes increasingly limited, so will the carrying capacity for visitors that contribute greatly to the regional economy.

Permanent inundation of County Roads would render road segments impassable, resulting in permanent road closures. As for many of these roads alternative routes are not available, access would be limited or non-existing to and from homes, businesses, or park and recreation areas. Homes and businesses would not be able to perform their primary function and become isolated and cut-off from all services. In the Bodega Harbor Area, permanent inundation of Eastshore, Bay Flat, and Westshore Roads would eliminate access to and from rural and urban residential areas and marinas.

Residential

The Bodega Harbor Area contains three urban residential areas and one rural residential area exposed to sea level rise and storm events. The urban residential areas are north of Porto Bodega Marina & RV Park (UR-1 on **Figure 8a**), northwest of Mason's Marina (UR-2), and west of Spud Point Marina (UR-3). The rural residential area (RR-1) is northeast of UR-2. **Table 8** shows the number of developed and vacant lots and number of dwelling units which comprise these residential areas.

Table 8. Bodega Harbor Area: Residential Assets – Lots and Dwelling Units

Asset	Lots	Vacant Lots	Dwelling Units
RR-1	9	2	7
UR-1	6	1	5
UR-2	60	14	46
UR-3	25	5	20

UR-2 and RR-1

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of these residential areas. **Table 9** shows the projected percent area permanently inundated by sea level rise and with storm event flooding. **Figure 8b** illustrates the projected permanent inundation, and **Figure 8c** illustrates the projected permanent inundation with storm event flooding of the areas under Scenario 5 (2100 Sea Level Rise Worst Case).

All of the residential areas are projected to be at risk of inundation from sea level rise by 2100. RR-1 and UR-2 would be more at risk than the other residential areas.

RR-1. In 2030 the residential area would not be permanently inundated by sea level rise and 3% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 7% of the area would be permanently inundated and 14% would be subject to periodic flooding during storm events. Under the worst case scenario, 14% of the area would be permanently inundated and 23% would be subject to periodic flooding.

UR-1. In 2030 the residential area would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. In 2100 under the best case scenario, the area would not be permanently inundated and less than 1% would be subject to periodic flooding during storm events. Under the worst case scenario, less than 1% of the area would be permanently inundated and 6% would be subject to periodic flooding.

UR-2. In 2030 the residential area would not be permanently inundated by sea level rise and 9% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 10% of the area would be permanently inundated and 13% would be subject to

periodic flooding during storm events. Under the worst case scenario, 10% of the area would be permanently inundated and 19% would be subject to periodic flooding.

UR-3. In 2030 the residential area would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. In 2100 under the best case scenario, the area would not be permanently inundated and 2% would be subject to periodic flooding during storm events. Under the worst case scenario, less than 1% of the area would be permanently inundated and 4% would be subject to periodic flooding.

Permanent inundation of all or a portion of residential properties would result in the loss of residential land area to bay waters.

RR-1. Permanent inundation from sea level rise would affect four properties, resulting in: (1) loss of property frontage, hence the size of the useable area; (2) loss of access to and from residences at Bay Flat Road and Westshore Road (see discussion of impacts on County Roads above), potentially isolating and cutting-off residences from essential services; and (3) the bay being closer to properties and residences, decreasing the buffer between them, which could result in inundation of one residence.

UR-1. Permanent inundation from sea level rise would affect all six properties, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to properties and residences, decreasing the buffer between them, which could result in inundation of six residences.

UR-2. Permanent inundation from sea level rise would affect mainly the area between Westshore Road and Bay Flat Road where several vacant or unbuildable properties are located. Permanent inundation would result in: (1) loss of property frontage, hence the size of the useable area; (2) loss of access to residences from Westshore Road and Bay Flat Road, including the entrance to the residential development at Whaleship Road (see the discussion of impacts on County Roads above); and (3) the bay being closer to properties and residences, decreasing the buffer between them, which could result in inundation of four residences.

UR-3. Permanent inundation from sea level rise would affect two properties, resulting in: (1) loss of access to and from the properties at the intersection of Westshore Road and Bay Flat Road; and (2) the bay being closer to the properties and residences, decreasing the buffer between them, which could result in inundation of two residences.

Table 9. Bodega Harbor Area: Residential Assets – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*RR-1* *6.30 acres*		*UR-1* *1.09 acres*		*UR-2* *12.80 acres*		*UR-3* *5.35 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----		----	----	----	----	----	----
2 - 2030	0.83	25	20-year	----	3%	----	----	----	9%	----	----
3 - 2050	1.67	50	20-year	----	8%	----	----	----	10%	----	----
4 – 2100 Best Case	3.33	100	100-year	7%	14%	----	< 1%	10%	13%	----	2%
5 – 2100 Worst Case	6.56	200	100-year	14%	23%	< 1%	6%	10%	19%	< 1%	4%

Bodega Harbor Area - Summary

Potential Impacts

Table 10 summarizes the projected percent of Bodega Harbor Area assets permanently inundated by sea level rise in 2100 under the best and worst case scenarios.

By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 59% to 99% of marinas; 28% to 76% of County Roads; 53% of a coastal wetland, and less than 1% to 14% of residential areas.

Table 10. Bodega Harbor Area: Summary of Projected Percent Area of Assets Permanently Inundated by Sea Level Rise by 2100

Asset	Best Case Scenario	Worst Case Scenario
Coastal Wetlands		
FWMARSH-1	----	----
FWMARSH-2	37%	53%
TIDFLT-1	N/A	N/A
TIDFLT-2	N/A	N/A
Public Access and Recreation		
California Coastal Trail	N/A	N/A
Marine Industrial		
Porto Bodega Marina & RV Park	55%	65%
Mason's Marina (East)	91%	99%
Mason's Marina (West)	50%	69%
Bodega Bay Sport Fishing Center	<1%	59%
Spud Point Marina	8%	63%
County Roads		
Westshore Road	52%	76%
Eastshore Road	33%	35%
Bay Flat Road	16%	28%
Residential		

Asset	Best Case Scenario	Worst Case Scenario
RR-1	7%	14%
UR-1	----	<1%
UR-2	10%	10%
UR-3	----	<1%

Potential Adaptation Strategies

Possible adaptation strategies for the Bodega Harbor Area are retreat and protect. The retreat strategy includes avoiding new development, redeveloping vulnerable infrastructure, and removing damaged infrastructure in hazard areas. Protecting vulnerable road infrastructure in 2030 to 2050 is anticipated until a long-term adaptation strategy has been determined. Section 5 contains a full suite of adaptation strategies for Bodega Bay informed by public outreach.

Bodega Harbor Area adaptation priorities include: (1) avoid new development within mapped hazard areas; (2) consider protection measures for shoreline roads in the short-term, and determine the feasibility of relocating shoreline roads and increasing culvert and roadside ditch capacity in the long-term; and (3) consider developing an abatement program to remove abandoned boats and docks that may degrade harbor water quality.

Highway 1 Area

The Bodega Bay Highway 1 Area is the east bay, encompassing the area from south of the Bodega Bay Sports Fishing Center to the western edge of the Bodega Harbour Subdivision and Golf Course. The Highway 1 Area contains all of the Commercial assets and the only public utility (Bodega Bay Wastewater Treatment Plant) in Bodega Bay; and a smaller area of Urban Residential development compared to the Bodega Harbor Area. Additional Highway 1 Area assets include Wetlands and County Trails. **Figure 9a** shows the location of and number assigned to each asset.

Assets in the Highway 1 Area vulnerable to sea level rise and storm events include Highway 1, residential and commercial buildings on the harbor side of Highway 1; yacht club; wastewater treatment plant; County Regional Parks trails and California Coastal Trail; and coastal freshwater marsh, coastal brackish marsh, and tidal mudflat.

Sea level rise will impact these valuable assets leading to potential impacts on access, land use, recreation and tourism, and habitats. Buildings on the harbor side of Highway 1 are more vulnerable to storm damage and sea level rise than are those on the upland side of Highway 1. Some houses on the harbor side have been elevated on wooden pilings which require maintenance. Boat docks and aquatic infrastructure at the yacht club and other harbor properties are supported by pressure treated wooden piles driven into harbor mud that are not adaptable to changing tidal heights. Residential or commercial buildings that may not be affected by sea level rise due to their elevation could become isolated and cut-off from all services due to compromised access and damaged utilities.

Cheney Gulch is a short drainage that drops steeply from coastal scrub to riparian ravines and freshwater marsh habitat. It supports special status aquatic and terrestrial species such as the California Freshwater Shrimp (*Syncaris pacifica*) and California Red-legged frog (*Rana draytonii*).

The sections below provide information on the percentage area of each asset that would be flooded or inundated as a result of sea level rise and storm events and potential impacts.

Coastal Wetlands

The Highway 1 Area contains two types of coastal wetlands: (1) Coastal Freshwater Marsh and (2) Bodega Harbor Tidal Mudflat.

Coastal Freshwater Marsh

Coastal Freshwater Marsh occurs in three locations: (1) on the north side of State Highway 1 opposite COM-2 at 935 State Highway 1 (FWMARSH-1 on **Figure 9a**; 0.80 acres); (2) on both sides of State Highway 1 in the area of Doran Park Road (FWMARSH-2, 8.58 acres); and (3) on the north side of Highway 1 opposite the Dredge Spoil Disposal Ponds site along Cheney Gulch (FWMARSH-3, 4.72 acres).

Potential Inundation and Flood Impacts

According to the analysis based on the Our Coast Our Future (OCOF) website tool and model, these Coastal Freshwater Marsh areas are not at risk of inundation from sea level rise or flooding from storm events by 2100 under the best and worst case scenarios. However, the model is limited in that it does incorporate tidal flow through culverts. In the case of FWMARSH-3 along Cheney Gulch, there is tidal flow through the culvert under the Highway 1 bridge that affects this marsh, and the Cheney Gulch drainage system extends out to the bay between the Dredge Spoil Disposal Ponds Site and the Bodega Bay PUD Wastewater Treatment Plant. Up to 2050, the coastal freshwater marsh along Cheney Gulch would buffer the effects of sea level rise for the surrounding land uses by absorbing the rising water and sediment. However, sea level rise inundation would have an adverse impact on the non-saline tolerant plant and animal species which occur in or use the marsh. The potential for inland migration of this marsh would be limited because the dredge spoil ponds site, wastewater treatment plant, and residential development confine the drainage.

Public Access & Recreation – Trails and Areas

Trails

The Highway 1 Area contains two County Regional Parks Trails exposed to sea level rise and storm events: (1) Birdwalk Loop Trail (0.6 miles, 3,168 feet) and (2) Cheney Creek Trail (0.5 miles, 2,640 feet). The Area also contains portions of two segments of the California Coastal Trail (Coastal Trail): (1) an Existing Coastal Trail segment at the Dredge Spoil Disposal Ponds Site (0.53 miles, 2,804 feet) and (2) a Proposed Coastal Trail segment along the east side of Bodega Bay (1.1 miles, 5,880 feet). Coastal Trail segments. **Figures 6 and 7** show the locations of Coastal Trail segments and County Regional Parks Trails in the Bodega Bay Study Area.

Potential Inundation and Flood Impacts

Sea level rise and storm events may result in inundation and would result in flooding of the County Regional Parks Trails and Coastal Trail segments. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding in the area of the trails under Scenario 5 (2100 Sea Level Rise Worst Case).

Temporary flooding of a County Regional Parks Trail or Existing Coastal Trail segment would result in trail damage and disrepair and require temporary closure or routing to an alternative trail section during trail repair or re-construction. Permanent inundation of a County Regional Parks Trail or Existing Coastal Trail segment would require relocation of the trail section. The level of difficulty in relocating a County Regional Parks Trail or Existing Coastal Trail segment would depend on the sources of funding and the specific terms of easements with private property owners.

Areas

The Highway 1 Area contains an area consisting of two dredge spoil disposal ponds and a County Regional Parks Trail (Birdwalk Loop Trail). The Dredge Spoil Disposal Ponds Site (PUBACC-1 on **Figure 9a**) is owned and operated by Sonoma County Regional Parks and used by the public for recreation.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of the Dredge Spoil Disposal Ponds Site. **Table 11** shows the projected percent area permanently inundated by sea level rise and with storm event flooding. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding of the Dredge Spoil Disposal Ponds Site under Scenario 5 (2100 Sea Level Rise Worst Case).

The Dredge Spoil Disposal Ponds Site is projected to be at risk of permanent inundation from sea level rise by 2100. In 2030 less than 1% of the site would be permanently inundated by sea level rise and 2% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 2% of the area would be permanently inundated and 3% would be subject to periodic flooding during storm events. Under the worst case scenario, 2% of the area would be permanently inundated and 5% would be subject to periodic flooding.

Birdwalk Loop Trail

Table 11. Highway 1 Area: Dredge Spoil Disposal Ponds Site – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*Dredge Spoil Disposal Ponds Site PUBACC-1* *23.91 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	<1%	<1%
2 - 2030	0.83	25	20-year	<1%	2%
3 - 2050	1.67	50	20-year	<1%	2%
4 – 2100 Best Case	3.33	100	100-year	2%	3%
5 – 2100 Worst Case	6.56	200	100-year	2%	5%

Public Utility

The Highway 1 Area includes the only Public Utility in Bodega Bay – the Bodega Bay PUD Wastewater Treatment Plant (UTIL-1 on **Figure 9a**).

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in flooding of the Bodega Bay PUD Wastewater Treatment Plant. **Table 12** shows the projected percent area permanently inundated by sea level rise and with storm event flooding. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding of the public utility site under Scenario 5 (2100 Sea Level Rise Worst Case).

The Bodega Bay PUD Wastewater Treatment Plant is not projected to be at risk of permanent inundation from sea level rise by 2100. However, the utility site would experience periodic flooding during storm events at 40% of the site under the 2100 worst case scenario. Flooding would occur at the southern boundary of the utility property, not at the structures or systems. Periodic flooding during storm events could result in temporary disruption of plant operations.

Bodega Bay PUD Wastewater Treatment Plant

Table 12. Highway 1 Area: Bodega Bay PUD Wastewater Treatment Plant – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*Bodega Bay PUD Wastewater Treatment Plant UTIL-1 4.08 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----
2 - 2030	0.83	25	20-year	----	----
3 - 2050	1.67	50	20-year	----	----
4 – 2100 Best Case	3.33	100	100-year	----	----
5 – 2100 Worst Case	6.56	200	100-year	----	40%

Commercial

The Highway 1 Area includes five commercial areas along the east side of Bodega Bay, four of which are exposed to sea level rise and storm events: the area currently occupied by Diekmann's Bay Store (COM-1 on **Figure 9a**); the area currently occupied by Harbor View Gifts (COM-2); the area currently occupied by Patrick's of Bodega Bay, Gourmet Au Bay, and Tides Wharf Restaurant (COM-3); and the area currently occupied by Fisheterian Fish Market and Lucas Wharf Restaurant & Bar (COM-4). COM-5 is the area currently occupied by Bodega Bay & Beyond, Sonoma Coast Living Real Estate, Coffee Cove, Bodega Bay Escapes, Jessica Brianne Carpenter Photos, and Bodega Coast Inn & Suites.

Potential Inundation and Flooding

Sea level rise and storm events would result in inundation and flooding of these commercial areas. **Table 13** shows the projected percent area permanently inundated by sea level rise and with storm event flooding. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding of the areas under Scenario 5 (2100 Sea Level Rise Worst Case).

All of these commercial areas except COM-5 are projected to be at risk of inundation from sea level rise by 2100. COM-2 and COM-3 would be more at risk than the other commercial areas.

COM-1. In 2030 5% of the area would be permanently inundated by sea level rise and 9% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 10% of the area would be permanently inundated and 14% would be subject to periodic flooding during storm events. Under the worst case scenario, 9% of the area would be permanently inundated and 19% would be subject to periodic flooding.

Lucas Wharf Restaurant & Bar

COM-2. In 2030 the area would not be permanently inundated by sea level rise and 11% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 12% of the area would be permanently inundated and 66% would be subject to periodic flooding during storm events. Under the worst case scenario, 70% of the area would be permanently inundated and 91% would be subject to periodic flooding.

COM-3. In 2030 2% of the area would be permanently inundated by sea level rise and 9% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 10% of the area would be permanently inundated and 14% would be subject to periodic flooding during storm events. Under the worst case scenario, 69% of the area would be permanently inundated and 84% would be subject to periodic flooding.

COM-4. In 2030 5% of the area would be permanently inundated by sea level rise and 16% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 18% of the area would be permanently inundated and 27% would be subject to periodic flooding during storm events. Under the worst case scenario, 34% of the area would be permanently inundated and 56% would be subject to periodic flooding.

Diekmann's Bay Store

Permanent inundation of all or a portion of commercial properties would result in the loss of commercial land area to bay waters.

COM-1 and COM-4. Permanent inundation from sea level rise would result in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the commercial building and parking area, decreasing the buffer between them, which could result in inundation of the building and parking area.

COM-2 and COM-3. Permanent inundation from sea level rise would result in: (1) partial loss of access to the commercial building and parking area; (2) loss of property frontage, hence the size of the useable area; and (3) the bay being closer to the commercial building and parking area, decreasing the buffer between them., which could result in inundation of the building and parking area.

Table 13. Highway 1 Area: Commercial Assets – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*COM-1* *0.50 acres*		*COM-2* *0.19 acres*		*COM-3* *3.56 acres*		*COM-4* *1.21 acres*		*COM-5* *5.43 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	2%	< 1%*	----	----	< 1%	3%	2%	5%	----	----
2 - 2030	0.83	25	20-year	5%	9%	----	11%	2%	9%	5%	16%	----	----
3 - 2050	1.67	50	20-year	7%	10%	5%	42%	5%	12%	10%	19%	----	----
4 – 2100 Best Case	3.33	100	100-year	10%	14%	39%	73%	12%	66%	18%	27%	----	----
5 – 2100 Worst Case	6.56	200	100-year	9%**	19%	70%	91%	69%	84%	34%	56%	----	----

* Unknown why a decrease in % area affected with a storm event

** Decrease in permanent inundation under an increase in sea level rise is likely due to a small circulation change that occurs as a result of the higher sea-level and its interaction with flood water (Maya Hayden, Point Blue Conservation Science, personal communication, 201

Private Recreation

Owned and operated by the Bodega Harbour HOA, the Bodega Harbour Yacht Club is the only Private Recreation asset in the Highway 1 Area (PRIV-1 on **Figure 9a**). Situated on the bay off Smith Brothers Road, the Bodega Harbour Yacht Club is a two-story hall with kitchen available for rent.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of the Bodega Harbour Yacht Club. **Table 14** shows the projected percent area of the property permanently inundated by sea level rise and with storm event flooding. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding of the Bodega Harbour Yacht Club property under Scenario 5 (2100 Sea Level Rise Worst Case).

The Bodega Harbour Yacht Club is projected to be at risk of permanent inundation from sea level rise by 2100. In 2030 8% of the site would be permanently inundated by sea level rise and 34% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 13% of the site would be permanently inundated and 49% would be subject to periodic flooding during storm events. Under the worst case scenario, 48% of the site would be permanently inundated and 60% would be subject to periodic flooding.

Bodega Harbour Yacht Club

While inundation and flooding would not prevent access to the Bodega Harbour Yacht Club property at the entrance off Smith Brothers Road, it would impact building ingress (and egress) and most if not all of the parking lot. Impacts on access to the Bodega Harbour Yacht Club would decrease private recreational opportunities and the number of private facilities available for social gatherings in Bodega Bay, and would decrease revenue for the Bodega Harbour Homeowners' Association.

Table 14. Highway 1 Area: Bodega Harbour Yacht Club– Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*Bodega Harbour Yacht Club PRIV-1* *0.48 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	4%	< 1%
2 - 2030	0.83	25	20-year	8%	34%
3 - 2050	1.67	50	20-year	13%	49%
4 – 2100 Best Case	3.33	100	100-year	48%	60%
5 – 2100 Worst Case	6.56	200	100-year	51%	73%

Residential

The Highway 1 Area contains two urban residential and three resources and rural development areas along the east side of Bodega Bay exposed to sea level rise and storm events (UR-1 to UR-2 and RRD-1 to RRD-3 on **Figure 9a**). **Table 15** shows the number of developed and vacant lots and number of dwelling units which comprise these residential areas.

Table 15. Highway 1 Area: Residential Assets – Lots and Dwelling Units

Asset	Lots	Vacant Lots	Dwelling Units
UR-1	3	0	3
UR-2	13	2	12
RRD-1	2	1	1
RRD-2	2	0	3
RRD-3	1	0	1

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of these residential areas. **Table 16** shows the projected percent area permanently inundated by sea level rise and with storm event flooding. **Figure 9b** illustrates the projected permanent inundation, and **Figure 9c** illustrates the projected permanent inundation with storm event flooding of the areas under Scenario 5 (2100 Sea Level Rise Worst Case).

All of these residential areas are projected to be at risk of inundation from sea level rise by 2100.

UR-1. In 2030 less than 1% of the area would be permanently inundated by sea level rise and subject to periodic flooding during storm events. In 2100 under the best case scenario, 28% of the area would be permanently inundated and 31% would be subject to periodic flooding during storm events. Under the worst case scenario, 17% of the area would be permanently inundated and 42% would be subject to periodic flooding.

UR-2. In 2030 5% of the area would be permanently inundated by sea level rise and 9% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 11% of the area would be permanently inundated and 15% would be subject to periodic flooding during storm events. Under the worst case scenario, 13% of the area would be permanently inundated and 21% would be subject to periodic flooding.

RRD-1. In 2030 4% of the area would be permanently inundated by sea level rise and 10% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 13% of the area would be permanently inundated and 17% would be subject to periodic flooding during storm events. Under the worst case scenario, 19% of the area would be permanently inundated and 32% would be subject to periodic flooding.

UR-2

RRD-2. In 2030 7% of the area would be permanently inundated by sea level rise and 11% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 14% of the area would be permanently inundated and 20% would be subject to periodic flooding during storm events. Under the worst case scenario, 22% of the area would be permanently inundated and 30% would be subject to periodic flooding.

RRD-3. In 2030 the area would not be permanently inundated by sea level rise and 12% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 14% of the area would be permanently inundated and 16% would be subject to periodic flooding during storm events. Under the worst case scenario, 17% of the area would be permanently inundated and 24% would be subject to periodic flooding.

Permanent inundation of all or a portion of these residential properties would result in the loss of residential land area to bay waters.

UR-1. Permanent inundation from sea level rise would affect one property, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the property and residence, decreasing the buffer between them, which could result in inundation of the residence.

UR-2. Permanent inundation from sea level rise would affect six developed properties, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the properties and residences, decreasing the buffer between them, which could result in inundation of six residences. Permanent inundation of the two vacant properties would result in loss of property frontage, hence the size of the useable area.

RRD-1. Permanent inundation from sea level rise would affect two properties, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the residences, which could result in inundation of one residence.

RRD-2. Permanent inundation from sea level rise would affect two properties, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the two duplexes, which could result in inundation of the duplexes.

RRD-3. Permanent inundation from sea level rise would affect one property, resulting in: (1) loss of property frontage, hence the size of the useable area; and (2) the bay being closer to the residence, which could result in inundation of the residence.

Table 16. Highway 1 Area: Residential Assets – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*UR-1* *0.46 acres*		*UR-2* *1.47 acres*		*RRD-1* *0.5 acres*		*RRD-2* *0.10 acres*		*RRD-3* *0.07 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	2%	2%	< 1%	3%	4%	3%	----	----
2 - 2030	0.83	25	20-year	< 1%	< 1%	5%	9%	4%	10%	7%	11%	----	12%
3 - 2050	1.67	50	20-year	< 1%	28%	7%	11%	6%	13%	8%	14%	6%	14%
4 – 2100 Best Case	3.33	100	100-year	28%	31%	11%	15%	13%	17%	14%	20%	14%	16%
5 – 2100 Worst Case	6.56	200	100-year	17%*	42%	13%	21%	19%	32%	22%	30%	17%	24%

* Decrease in permanent inundation under an increase in sea level rise is likely due to a small circulation change that occurs as a result of the higher sea-level and its interaction with flood water (Maya Hayden, Point Blue Conservation Science, personal communication, 2017)

Summary – Highway 1 Area

Potential Impacts

Table 17 summarizes the projected percent of Highway 1 Area assets permanently inundated by sea level rise in 2100 under the best and worst case scenarios.

By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 9% to 70% of commercial areas, 51% of the Bodega Harbour Yacht Club, 13% to 22% of residential areas, and 2% of a public access and recreation area (Dredge Spoil Disposal Ponds Site).

Table 17. Highway 1 Area: Summary of Projected Percent Area of Assets Permanently Inundated by Sea Level Rise by 2100

Asset	Best Case Scenario	Worst Case Scenario
Coastal Wetlands		
FWMARSH-1	----	----
FWMARSH-2	----	----
FWMARSH-3	----	----
Public Access and Recreation		
Dredge Spoil Disposal Ponds Site	2%	2%
County Regional Parks Trails	N/A	N/A
California Coastal Trail	N/A	N/A
Public Utility		
Bodega Bay PUD Wastewater Treatment Plant	----	----
Commercial		
COM-1	10%	9%
COM-2	39%	70%
COM-3	12%	69%
COM-4	18%	34%
Private Recreation		
Bodega Harbour Yacht Club	48%	51%

Asset	Best Case Scenario	Worst Case Scenario
Residential		
UR-1	28%	17%
UR-2	11%	13%
RRD-1	13%	19%
RRD-2	14%	22%
RRD-3	14%	17%

Potential Adaptation Strategies

Possible adaptation strategies for the Highway 1 Area are accommodate and retreat. Accommodate strategies employ methods that modify existing development to decrease hazard risks and increase resiliency. Because most of the residential and commercial structures have been built on piling, maintenance of these pilings will be necessary as wave and tidal scours undermine footings over time. Some buildings may need to be incrementally relocated and in-water structures removed. Relocation of the wastewater treatment plant would have to comply with Coastal Act policy (Section 30231) to minimize adverse effects of wastewater discharges and entrainment.

Highway 1 Area adaptation priorities include: (1) potentially accommodate sea level rise through redevelopment and maintenance strategies, (2) protect or increase adaptive capacity of shoreline roads and trail access, and (3) consider relocating the wastewater treatment plant.

County Regional Parks Area

The County Regional Parks Area is the west and south bay, encompassing the area from Westside Regional Park south to the tip of Sonoma Coast State Park, east across Bodega Harbor, across Doran Beach Regional Park, to where it meets the Highway 1 Area at the western edge of the Bodega Harbour Subdivision and Golf Course. The County Regional Parks Area includes all of the Institutional and most of the Public Access & Recreation (County Regional Parks) assets in Bodega Bay. Additional County Regional Parks Area assets include Private Recreation, Trails, and Coastal Wetlands. **Figure 10a** shows the location of and number assigned to each asset.

The assets most vulnerable to sea level rise and storm events in the County Regional Parks Area are Westshore Road, Westside Regional Park, and Doran Beach Regional Park.

Westshore Road is a critical north-south access route that originates in the north harbor and terminates at the Bodega Head trailhead. Sea level rise inundation would substantially affect access to and along Westshore Road. West Bodega Harbor residents and U.C. Davis Bodega Marine Laboratory personnel depend on Westshore Road for access to homes and research facilities/employment. County residents and tourists depend on Westshore Road for access to Westside Regional Park. Potential adaptation measures include relocation of the road alignment or elevating the road.

Westside and Doran Beach Regional Parks combined provide recreational and commercial boat launches, campsites, day use areas, picnic areas, and parking. Sea level rise inundation would affect almost the entire Westside Regional Park and almost 40 percent of Doran Beach Regional Park. Parkland and facilities would be lost or damaged, substantially reducing the available recreational opportunities and the Bodega Bay tourism economy.

Doran Beach

Bodega Harbor's inlet is a 100-foot wide channel protected by two rubble mounded jetties built by the U.S. Army Corps of Engineers in 1943. The north jetty is 1,130 feet long, and the south jetty is 1,650 feet long. The north jetty is perpendicular to Doran Beach on the bay side. It may disrupt shoreline currents by reflecting wave energy back towards the beach, exacerbating sand loss between the north jetty and the beach. Sea level rise will increase the frequency of waves overtopping the jetties, which can erode and weaken the structures.

Doran Beach is a two-mile long dune spit that separates Bodega Harbor from Bodega Bay. Its high sand dunes protect the inner harbor by absorbing wave energy. Normally dunes migrate inland on uninhabited shoreline. However, water surrounds Doran Beach on both sides,

increasing erosion potential and reducing the habitat's resiliency to exposure. Sea level rise increases wave height and volume, which would accelerate erosion of these protective dunes.

The sections below provide information on the percentage area of each asset that would be inundated or flooded as a result of sea level rise and storm events and potential impacts.

Coastal Wetlands

The County Regional Parks Area contains three types of coastal wetlands exposed to sea level rise and storm events: (1) Coastal Freshwater Marsh, Coastal Brackish Marsh, and (3) Bodega Harbor Tidal Mudflat.

Coastal Freshwater Marsh

Coastal Freshwater Marsh occurs in three locations: (1) west of Westside Regional Park (FWMARSH-1 on **Figure 10a**); (2) south of Westside Regional Park, west of Westshore Road (FWMARSH-2); and (3) south of FWMARSH-2 (FWMARSH-3).

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Coastal Freshwater Marsh. **Table 18** shows the projected percent of marsh area permanently inundated by sea level rise and with storm event flooding. **Figure 10b** illustrates the projected permanent inundation, and **Figure 10c** illustrates the projected permanent inundation with storm event flooding of Coastal Freshwater Marsh under Scenario 5 (2100 Sea Level Rise Worst Case).

FWMARSH-1 and FWMARSH-2 are projected to be at risk of permanent inundation from sea level rise by 2100.

FWMARSH-1. In 2030 the marsh would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. In 2100 under the best case scenario, less than 1% of the marsh would be permanently inundated and 3% would be subject to periodic flooding during storm events. Under the worst case scenario, 35% of the marsh would be permanently inundated and 76% would be subject to periodic flooding.

FWMARSH-2. In 2030 and in 2100 under the best case scenario, the marsh would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. Under the worst case scenario, 20% of the marsh would be permanently inundated and 37% would be subject to periodic flooding.

Table 18. County Regional Parks Area: Coastal Freshwater Marsh – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*FWMARSH-1* *42.26 acres*		*FWMARSH-2* *8.74 acres*		*FWMARSH-3* *1.1 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	----	----	----	----
2 - 2030	0.83	25	20-year	----	----	----	----	----	----
3 - 2050	1.67	50	20-year	----	<1%	----	----	----	----
4 – 2100 Best Case	3.33	100	100-year	<1%	3%	----	----	----	----
5 – 2100 Worst Case	6.56	200	100-year	35%	76%	20%	37%	----	----

Coastal Brackish Marsh

Coastal Brackish Marsh occurs in both the Highway 1 and County Regional Parks Areas, but mainly in the County Regional Parks Area, at the following location: north and south of the Dredge Spoil Disposal Ponds Site and south of the Bodega Bay PUD Wastewater Treatment Plant; west of the Bodega Harbour Subdivision and within and west of the Links at Bodega Harbour Golf Course; and along the northern boundary of Doran Beach Regional Park (BRMARSH-1 on **Figure 10a**).

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Coastal Brackish Marsh. **Table 19** shows the projected percent of marsh area permanently inundated by sea level rise and with storm event flooding. **Figure 10b** illustrates the projected permanent inundation, and **Figure 10c** illustrates the projected permanent inundation with storm event flooding of Coastal Brackish Marsh under Scenario 5 (2100 Sea Level Rise Worst Case).

BRMARSH-1 is currently at risk of permanent inundation from sea level rise. In 2030 32% of the marsh would be permanently inundated by sea level rise and 70% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, less than 72% of the marsh would be permanently inundated and 74% would be subject to periodic flooding during storm events. Under the worst case scenario, 73% of the marsh would be permanently inundated and 78% would be subject to periodic flooding.

See Coastal Freshwater Marsh – Inundation and Flood Impacts under the Bodega Harbor Area.

Table 19. County Regional Parks Area: Coastal Brackish Marsh – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*BRMARSH-1* *69.56 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	21%	32%
2 - 2030	0.83	25	20-year	32%	70%
3 - 2050	1.67	50	20-year	61%	71%
4 – 2100 Best Case	3.33	100	100-year	72%	74%
5 – 2100 Worst Case	6.56	200	100-year	73%	78%

Bodega Harbor Tidal Mudflat

Bodega Harbor Tidal Mudflat occurs in both the Highway 1 and County Regional Parks Areas, but mainly in the County Regional Parks Area in four locations: (1) along the west side of Bodega Bay, west of the main bay channel, from Westside Regional Park south to the first turnout off Westshore north of the access to Bodega Head (134.48 acres; TIDFLT-1 on **Figure 10a**); (2) east of the main bay channel, along and north of Doran Beach Regional Park, and west of the Dredge Spoil Disposal Ponds Site and COM-5 (278.70 acres; TIDFLT-2); (3) east of the Bodega Head turnout and parking area along Campbell Cove State Beach (5.57 acres; TIDFLAT-3); and (4) west of the Links at Bodega Harbour Golf Course north of Doran Beach Road (6.42 acres; TIDFLAT-4).

Potential Inundation and Flood Impacts

Data on projected permanent inundation and storm event flooding of Bodega Harbor Tidal Mudflat is not available.

See Bodega Harbor Tidal Mudflat - Potential Inundation and Flood Impacts under the Bodega Harbor Area.

Public Access & Recreation – Parks and Trails

County Regional Parks

The County Regional Parks Area contains the only Sonoma County Regional Parks in Bodega Bay – Westside Regional Park (PUBACC-1 on **Figure 10a**) and Doran Beach Regional Park (PUBACC-2).

Westside Regional Park. Westside Regional Park features campsites and boat launch facilities. Amenities include 47 RV and tent campsites, 76 boat trailer and 31 day use parking spaces, three boat and kayak launch lanes, docks and gangway, fish-cleaning and boat rinsing stations, day use picnic area, and RV dump station.

Doran Beach Regional Park. Doran Beach Regional Park has a wide, 2-mile stretch of beach on Bodega Bay and is ideal for walking, picnicking, playing in the sand, flying kites, surfing, and bird-watching. Over 120 tent and RV campsites are available. A boat launch provides access to Bodega Harbor for sport fishing, kayaking, stand-up paddling, and kite surfing. A jetty at the harbor mouth is a popular spot for rock fishing and exploring sea life.

Doran Beach Regional Park

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Westside Regional Park and Doran Beach Regional Park. The Regional Parks assets analyzed comprise landside facilities only and do not include piers or docks. **Table 20** shows the projected percent area of the Regional Parks permanently inundated by sea level rise and with storm event flooding. **Figure 10c** illustrates the projected permanent inundation, and **Figure 10b** illustrates the

projected permanent inundation with storm event flooding of the Regional Parks under Scenario 5 (2100 Sea Level Rise Worst Case).

Westside Regional Park is projected to be more at risk than Doran Regional Park of permanent inundation from sea level rise by 2100.

Westside Regional Park. In 2030 the park would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. In 2100 under the best case scenario, less than 1% of the park would be permanently inundated and 83% would be subject to periodic flooding during storm events. Under the worst case scenario, 98% of the park would be permanently inundated and 100% would be subject to periodic flooding. Permanent inundation would affect almost the entire park, resulting in the loss of recreational land area and many Bodega Bay recreational amenities, including RV and tent campsites and parking. The loss of these recreational amenities would result in a decrease in tourism to Bodega Bay and the loss of tourist revenue.

Doran Beach Regional Park. In 2030 7% of the area would be permanently inundated by sea level rise and 17% would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 19% of the area would be permanently inundated and 35% would be subject to periodic flooding during storm events. Under the worst case scenario, 36% of the area would be permanently inundated and 75% would be subject to periodic flooding. Permanent inundation of the park would result in loss of the following recreational amenities: (1) entire Doran Beach, (2) Jetty Day Use Area, (3) Miwok Tent Campground, and (4) Boat Launch & Parking.

Doran Beach Regional Park – Jetty Campground

Westside Regional Park

Table 20. County Regional Parks Area: Regional Parks – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*Westside Regional Park (PUBBACC-1)* *12.54 acres*		*Doran Beach Regional Park (PUBACC-2)* *102.51 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	< 1%	8%
2 - 2030	0.83	25	20-year	----	----	7%	17%
3 - 2050	1.67	50	20-year	----	2%	12%	20%
4 – 2100 Best Case	3.33	100	100-year	< 1%	83%	19%	35%
5 – 2100 Worst Case	6.56	200	100-year	98%	100%	36%	75%

Permanent inundation would also affect a portion of, or bring sea level closer to, the following facilities, decreasing their buffer from sea level rise: (1) Jetty Campground; (2) Cove, Gull, and Shell Campgrounds; (3) Cypress Day Use Area; and (4) day use parking areas. It would also render eastern and western segments of Doran Beach Road permanently impassible. The above impacts of temporary flooding and permanent inundation could result in temporary or permanent closure of Doran Beach Regional Park. Temporary or permanent closure of the park would result in loss of a significant recreational opportunity in Bodega Bay, and a decrease in tourism and loss of tourist revenue.

Trails

The County Regional Parks Area includes sections of four segments of the California Coastal Trail: (1) an Existing Coastal Trail segment at the Cheney Creek Trail (0.2 miles, 1,261 feet), (2) an Existing Coastal Trail along Doran Beach Regional Park Beach (1.8 miles, 9,504 feet), (3) an Existing Coastal Trail segment on the coast south of Doran Beach Regional Park Beach (0.8 miles, 4,475 feet), and (4) a Future Coastal Trail segment from Doran Beach Regional Park to Sonoma Coast State Beach (1.1 miles, 5,987 feet). **Figure 6** shows the locations of Coastal Trail segments.

Potential Inundation and Flood Impacts

Sea level rise and storm events may result in inundation and would result in flooding of the County Coastal Trail segments. **Figure 10b** illustrates the projected permanent inundation, and **Figure 10c** illustrates the projected permanent inundation with storm event flooding in the area of the trails under Scenario 5 (2100 Sea Level Rise Worst Case).

Periodic flooding during storm events of an Existing Coastal Trail segment would result in trail damage and disrepair and require temporary closure or routing to an alternative trail section during trail repair or re-construction. Permanent inundation of an Existing Coastal Trail segment would require relocation of the trail section. The level of difficulty in relocating an Existing Coastal Trail segment would depend on the sources of funding and the specific terms of easements with private property owners.

County Roads

The County Regional Parks Area includes two County Roads exposed to sea level rise and storm events – Doran Beach Road and Westshore Road.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of Doran Beach and Westshore Roads. **Table 21** shows the projected percent of road alignment permanently inundated by sea level rise and with storm event flooding. **Figure 10a** illustrates the projected permanent inundation, and **Figure 10b** illustrates the projected permanent inundation with storm event flooding of the roads under Scenario 5 (2100 Sea Level Rise Worst Case).

Westshore Road is projected to be more at risk than Doran Beach Road of permanent inundation from sea level rise by 2100.

Doran Beach Road. In 2030 the road would not be permanently inundated by sea level rise and 10% of the road would be subject to periodic flooding during storm events. In 2100 under the best case scenario, 12% of the road would be permanently inundated and 25% would be subject to periodic flooding during storm events. Under the worst case scenario, 26% of the road would be permanently inundated and 68% would be subject to periodic flooding.

Westshore Road. In 2030 the road would not be permanently inundated by sea level rise or subject to periodic flooding during storm events. In 2100 under the best case scenario, 3% of the road would be permanently inundated and 18% would be subject to periodic flooding

during storm events. Under the worst case scenario, 39% of the road would be permanently inundated and 90% would be subject to periodic flooding.

Table 21. County Regional Parks Area: County Roads – Inundation and Flood Projections (Percent of Alignment)

Scenario	Projected Sea Level Rise		Storm Event	*Doran Beach Road* *9,503.2 feet* *(1.80 miles)*		*Westshore Road* *9,025.9 feet* *(1.71 miles)*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood	Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----	----	----
2 - 2030	0.83	25	20-year	----	10%	----	----
3 - 2050	1.67	50	20-year	7%	12%	----	5%
4 – 2100 Best Case	3.33	100	100-year	12%	25%	3%	18%
5 – 2100 Worst Case	6.56	200	100-year	26%	68%	39%	90%

See Potential Inundation and Flood Impacts under County Roads in the Bodega Harbor Area. In the County Regional Parks Area, permanent inundation of Westshore Road would affect access to and from Westside Regional Park and the U.C. Davis Marine Laboratory. Permanent inundation of Doran Beach Road would affect access to and from Doran Beach Regional Park.

Westshore Road

Institutional

The County Regional Parks Area includes the only Institutional asset in Bodega Bay – the U.C. Davis Bodega Marine Laboratory (INST-1 on **Figure 10a**). For nearly 50 years, the Bodega Marine Laboratory has provided hands-on training to students who have become leaders in the fields of marine science and policy. Faculty and researchers address a diverse array of basic and applied research problems. An Organized Research Unit of U.C. Davis, the Bodega Marine Laboratory is a specialized facility equipped with a meteorological and oceanographic observation network and long-term data set, Cadet Hand Library, teaching classrooms, wet labs, seawater system, greenhouses, dive training facility, facility-wide animal care and support, Bodega Marine Reserve, housing and conference facilities, and vessel fleet.

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in negligible inundation and flooding of the U.C. Davis Bodega Marine Laboratory property. **Table 22** shows the projected percent area of the property permanently inundated by sea level rise and with storm event flooding. **Figure 10b** illustrates the projected permanent inundation, and **Figure 10c** illustrates the projected permanent inundation with storm event flooding of the Marine Laboratory property under Scenario 5 (2100 Sea Level Rise Worst Case).

Table 22. County Regional Parks Area: U.C. Davis Marine Laboratory Property – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*INST-1* *274.69 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	< 1%	< 1%
2 - 2030	0.83	25	20-year	< 1%	< 1%
3 - 2050	1.67	50	20-year	< 1%	< 1%
4 – 2100 Best Case	3.33	100	100-year	< 1%	< 1%
5 – 2100 Worst Case	6.56	200	100-year	< 1%	2%

In 2030 and 2100 under the best case scenario, less than 1% of the property would be permanently inundated by sea level rise and subject to periodic flooding during storm events. Under the worst case scenario, less than 1% of the property would be permanently inundated and 2% would be subject to periodic flooding. Under the 2100 worst case scenario, flooding would prevent access to the property entrance off Westshore Road and to Westshore Road itself. While inundation would not prevent access to the property right at the entrance, it would

prevent access to Westshore Road, essentially preventing access to the property. If there is no access to the property, it may become necessary to close the facility. Closure of the U.C. Davis Marine Laboratory would result in the loss of a major marine science and policy training and research facility in California.

Private Recreation

The Links at Bodega Harbour Golf Course is the only Private Recreation asset in the County Regional Parks Area. This analysis addresses only the grounds of the Golf Course exposed to sea level rise and storm events (PRIV-1 on **Figure 10a**).

Potential Inundation and Flood Impacts

Sea level rise and storm events would result in inundation and flooding of the affected grounds of the Links at Bodega Harbour Golf Course. **Table 23** shows the projected percent area of the affected grounds permanently inundated by sea level rise and with storm event flooding. **Figure 10b** illustrates the projected permanent inundation, and **Figure 10c** illustrates the projected permanent inundation with storm event flooding of the affected grounds under Scenario 5 (2100 Sea Level Rise Worst Case).

In 2030 the grounds would not be permanently inundated by sea level rise, and 6% of the grounds would be subject to periodic flooding during storm events. In 2100 under the best case scenario 9% of the grounds would be permanently inundated and 21% would be subject to periodic flooding during storm events. Under the worst case scenario, 23% of the grounds would be permanently inundated and 40% would be subject to periodic flooding.

Links at Bodega Harbour Golf Course

Table 23. County Regional Parks Area: Links at Bodega Harbour Golf Course (affected grounds) – Inundation and Flood Projections (Percent Area)

Scenario	Projected Sea Level Rise		Storm Event	*PRIV-1* *19.07 acres*	
	feet	cm		Inundated by Sea Level	Plus Storm Event Flood
1 - 2016	0	0	annual	----	----
2 - 2030	0.83	25	20-year	----	6%
3 - 2050	1.67	50	20-year	----	15%
4 – 2100 Best Case	3.33	100	100-year	9%	21%
5 – 2100 Worst Case	6.56	200	100-year	23%	40%

Permanent inundation and periodic flooding would affect the grounds of three of 18 holes at the Links at Bodega Harbour Golf Course - those located south of Heron Drive and southwest of the Bodega Harbour Clubhouse. Periodic flooding could result in damage and disrepair to the grounds of three holes, which may result in temporary closure of the grounds while they are being repaired or reconstructed. Permanent inundation of the grounds of two holes could result in temporary closure of the grounds while they are being relocated and constructed, or in their permanent closure. Temporary or permanent closure of the grounds for up to three holes at the golf course could decrease tourist attraction to the golf course, hence could decrease revenue for the Bodega Harbour Homeowners' Association.

Summary – County Regional Parks Area

Potential Impacts

Table 24 summarizes the projected percent of County Regional Parks Area assets permanently inundated by sea level rise in 2100 under the best and worst case scenarios.

By 2100 under the worst case scenario, permanent inundation from sea level rise would affect 20% to 73% of coastal wetlands, almost 100% of Westside Regional Park and 36% of Doran Beach Regional Park, 26% to 39% of County Roads, 23% of the Links at Bodega Harbour Golf Course, and less than 1% of the U.C. Davis Bodega Marine Laboratory.

Table 24. Highway 1 Area: Summary of Projected Percent Area of Assets Permanently Inundated by Sea Level Rise by 2100

Asset	Best Case Scenario	Worst Case Scenario
Coastal Wetlands		
FWMARSH -1	<1%	35%
FWMARSH -2	----	20%
FWMARSH -3	----	----
BRMARSH-1	72%	73%
TIDFLT-1	N/A	N/A
TIDFLT-2	N/A	N/A
TIDFLT-3	N/A	N/A
TIDFLT-4	N/A	N/A
Public Access and Recreation		
Westside Regional Park	<1%	98%
Doran Beach Regional Park	19%	36%
California Coastal Trail	N/A	N/A
County Roads		
Doran Beach Road	12%	26%
Westshore Road	3%	39%
Institutional		

Asset	Best Case Scenario	Worst Case Scenario
U.C. Davis Bodega Marine Laboratory	<1%	<1%
Private Recreation		
Links at Bodega Harbour Golf Course	9%	23%

Potential Adaptation Strategies

Possible adaptation strategies for the County Regional Parks Area are accommodate and retreat. Accommodate strategies employ methods that modify existing development to decrease hazard risks and increase resiliency of the development. Sonoma County Regional Parks may consider moving the campgrounds and parking areas upland to a higher elevation. Potential adaptation strategies for Westshore Road are addressed under the Bodega Harbor Area.

County Regional Parks Area adaptation priorities include: (1) potentially accommodate sea level rise through redevelopment, (2) relocate facilities out of hazard areas, and (3) protect beaches through a sand enrichment program.

5. Adaptation Strategies

Introduction

As described in this Focused Vulnerability Assessment, Bodega Bay faces a number of threats from a rising sea and bay. Sea level rise exacerbates existing climate-related hazards such as an increased number of flooding incidents, increased ocean acidification, or bluff erosion and failure. The previous sections of this assessment identify the assets and resources of Bodega Bay vulnerable to sea level rise and coastal storms; and in this section the County considers potential adaptation strategies to prepare for future changes in coastal hazards. Vulnerable assets and resources identified include development and infrastructure; public access and recreational opportunities; beaches, wetlands, and other environmentally sensitive habitat areas; scenic and visual resources; agricultural resources; and water quality.

As the County prepares for these changes, we must evaluate the feasibility of adaptation strategies necessary to protect public safety, health, and quality of life. Such strategies are still developing and evolving, so the County will have to evaluate whether the cost, legal, or permitting constraints for these strategies are manageable. The strategies we present below are not panaceas to protect, accommodate, or retreat the Sonoma County assets impacted by sea level rise. Rather, these strategies are meant to continue our discussion with the community about the suite of possibilities and constraints to consider for climate adaptation starting from the sea level rise adaptation workshop we held in November.

Legal Context for Sea Level Rise Adaptation

The California Coastal Act, the public trust doctrine, California Environmental Quality Act (CEQA), Coastal Zone Management Act, Clean Water Act, Porter Cologne Act, River and Harbors Act, constitutional protections for property, and other laws provide the context for evaluation of appropriate adaptation measures for Bodega Bay. Section 30235 of the Coastal Act states:

> *Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply…*

Section 30253(b) requires new development to avoid risk and prohibits new development from in any way requiring the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. The Coastal Commission guidance suggests rezoning hazard areas as open space; and anticipating that sea level rise will impact new development, assuring that critical infrastructure will be safe from inundation.

Some of the adaptation strategies may involve the adoption of Local Coastal Plan policies and programs, changes to zoning and building codes, or permit conditions that focus on avoidance and minimization of risks and protection of coastal resources. Other adaptation strategies could build adaptive capacity into projects themselves, thus addressing future changes in hazard risks while ensuring long-term resource protection.

General Adaptation Categories

Adaptation strategies for vulnerable resources or assets fall into three broad categories: protect, accommodate, and retreat. These strategies are reciprocal, and one strategy does not preclude using another later in time. For purposes of implementing the Coastal Act, no single category or specific strategy should be considered the "best" option (California Coastal Commission 2015). Sea Level Rise planning for Bodega Bay includes strategies from multiple adaption categories, and may be modified over time as science and engineering evolve. Some adaptation strategies may have legal or procedural constraints. For example, in order to construct and maintain coastal armoring, the County would need to work closely with various regional, state, and federal permitting agencies to meet design standards, both for the structures themselves and the adjacent shoreline environment. Adaptive responses will also need to be consistent with the Coastal Act, California Environmental Quality Act, and outside agency permit conditions.

The following paragraphs describe each adaptation strategy and potential areas for implementation in the Bodega Bay community.

Strategies to Protect Assets

Protection strategies generally employ some sort of engineered structure or other measure to defend development or other resources from sea level rise while allowing the resource or asset to remain in its current location. There are two main types of protection strategies: hard and soft defensive measures or armoring. Hard armoring refers to engineered structures such as seawalls, revetments, and bulkheads that defend against coastal hazards such as wave impacts, erosion, and flooding. Armoring is a common response to coastal hazards, but it can result in serious negative impacts to coastal resources, particularly as sea level rises (California Coastal Commission 2015). Soft armoring refers to the use of natural or green infrastructure like beaches, dune systems, wetlands, and other natural systems to buffer coastal areas.

Hard armoring is common along the harbor in Bodega Bay - large rock boulders protect Westshore Road substructure and pavement from tidal erosion and storm surges. The Bodega Harbor Jetty is a rubble mound jetty seawall and another example of a hard protection strategy. Hard structures have an ecological cost since they form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise. Passive erosion is the narrowing of beaches because the back of the beach on an eroding shoreline is fixed in place (Flick et al. 2012). In Bodega Bay, this occurs on the harbor side of Doran Beach where the back of the beach is lined with large rock boulders. Other detrimental impacts of hard armoring may include negative visual impacts or interference with other ecosystem services (California Coastal Commission 2015).

Soft armor buffering strategies like using wetlands, beach nourishment, dune management or the construction of living shorelines capitalize on the natural ability of these systems to protect coastlines. At the same time, these strategies provide benefits such as habitat enhancement, recreational areas, more pleasing views, and the continuation or enhancement of ecosystem services. The engineering of green infrastructure is a somewhat newer concept, and because of this the effectiveness of some of these strategy types is not well known or tested. In cases where soft armor strategies might not be completely effective or preferred, a hybrid approach

using both hard and soft armoring could be considered. A potential adaptation strategy for Doran Beach would be beach nourishment.

Although the Coastal Act provides for potential protection strategies for existing development, it requires adaptive capacity in new development to prevent altering a natural shoreline (California Coastal Commission 2015). The Coastal Commission recommends prioritizing "hard" or "soft" protection options that enhance and maximize coastal resources and access. Innovative nature-based approaches such as living shoreline techniques or managed/planned retreat should be considered in Sonoma County.

Strategies to Accommodate Sea Level Rise

Accommodation strategies employ methods that design or modify developments to decrease hazard risks and thus increase the resiliency of developments to the impacts of sea level rise. Accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or using extra setbacks. Sonoma County Regional Parks' Doran Beach and Westside Regional Parks boat launches use floating docks that will fall and rise with the tides and rising harbor water levels.

On a community scale, accommodation strategies could include zoning ordinances for redevelopment actions that will help support the resiliency of the built environment. For example, the County could create a combining district for vulnerable areas that would setback development from bluffs or beaches. Strategies to accommodate sea level rise seek to prevent exposure by clustering development in less vulnerable areas.

As with protection strategies, some accommodation strategies could result in negative impacts to coastal resources. For example, redevelopment such as elevating structures may block coastal views and degrade community character and beach ambience. Pile-supported structures could erode into a form of shoreline protection that interferes with coastal processes, blocks beach and trail access, and deters from the scenic character of the bay. Pile-supported structures that occur on the southside of Highway 1 will accommodate sea level rise, but may require reinforcing due to scour.

Strategies to Retreat from Sea Level Rise

Retreat strategies are those that relocate or remove existing development out of hazard areas and limit the construction of new development within vulnerable areas. These strategies include providing land use designations and zoning to encourage building in more resilient areas, or gradually removing and relocating existing development. Acquisition and buyout programs, transfer of development credits programs, and removal of structures (i.e., after reasonable amortization periods) are examples of strategies designed to encourage managed retreat.

Potential Adaption Strategies for Bodega Bay

In this section, the County cautiously applied the general adaptation categories defined above to vulnerable assets to help increase resilience to sea level rise. These potential strategies may change over time as science and engineering evolve. The County will refine these potential adaptation strategies during the development of Local Coastal Plan programs and policies for

the diverse geography and conditions of the Sonoma Coast. For this focused vulnerability assessment, the adaptation strategies focus on Bodega Bay.

Sonoma County hosted a Sea Level Rise Adaptation Planning Workshop for the community of Bodega Bay on November 29, 2016 at the U. C. Davis Bodega Bay Marine Laboratory. The County provided members of the community with a presentation of the three broad categories of strategies for adaptation, along with examples of how and where different adaptation strategies might be used. County staff requested that the community consider implementation locations for adaptation measures by marking aerial photomaps of Bodega Bay. The County incorporated these suggestions into the adaptation strategies discussion for each Bodega Bay area below.

Bodega Harbor Area

Assets vulnerable to sea level rise and storms in the Bodega Harbor Area include: Westshore, Eastshore, and Bay Flat Roads; public and private marinas; residential development; and coastal habitats. Anticipated impacts include road substructure and pavement degradation, ditches clogged with excess sediment, and the possibility of saltwater contaminating private wells and coastal freshwater habitats.

Possible adaptation strategies for Bodega Harbor fall into the categories of retreat and protect. The retreat strategy includes avoiding new development, redeveloping vulnerable infrastructure, and removing damaged infrastructure in hazard areas. Protecting vulnerable road infrastructure in the near to mid-term is anticipated until a long-term relocation strategy has been determined. The measures below combine suggestions from the community and guidance from the Coastal Commission.

Land Use Adaptation Strategies

Bodega Harbor Area Priorities: Avoid new development within mapped hazard areas, protect or relocate shoreline roads and access, remove boats and infrastructure that may damage or degrade harbor water quality, and increase culvert and roadside ditch capacity.

Retreat:

- **Consider avoiding new development in hazardous areas:** avoid construction of new development in zones or overlay areas identified or designated as hazardous due to potential flooding and inundation.

- **Determine the feasibility of a "Transfer of Development Credit" program (TDC):** Restrict development in one area ("sending area") and allow for the transfer of development credits to another area more appropriate for intensive use ("receiving area"). Local Coastal Plans can establish policies to implement a TDC program to restrict development in areas vulnerable to sea level rise and allow for transfer of development credits to parcels with less vulnerability to hazards. A TDC program can encourage the relocation of development away from at-risk locations, and may be used in combination with a buy-out program.

- **Consider options for future removal when planning and designing new development:** Design options should not place an undue burden on future property owners or coastal resources. For new development in high hazard areas or resource-constrained areas, ensure that foundation designs or other aspects of the development will not preclude future incremental relocation or managed retreat. Certain foundation and building elements such as deep perimeter foundations may be difficult to remove in the future, thus alternative design options should be considered.

- **Consider developing a plan to remove or relocate structures that become threatened:** This measure would require authorization through a Coastal Development Permit for removal or relocation of new development vulnerable to wave action, erosion, or other hazards should it become threatened in the future.

- **Consider developing a plan to remove or relocate existing structures that become threatened:** This measure would require authorization through a Coastal Development Permit for removal or relocation of redevelopment subject to wave action, erosion, or other hazards should it become threatened in the future.

- **Consider developing a boat abatement program:** Sea level rise and coastal storms may result in the sinking, breaking apart, or washing ashore of boats abandoned in Bodega Harbor. This program would prevent abandoned, unregistered boats moored at Sonoma County Regional Parks and marinas from contaminating the harbor or damaging other infrastructure; and would include evaluating and enforcing anchorage rules.

- **Plan and design transportation systems to accommodate anticipated sea level rise impacts:** Ensure that transportation networks are designed to function even if the highest projected sea level rise occurs. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, and coastal planning efforts. Individual transportation projects would be implemented through Coastal Development Permits.

- **Consider retrofitting existing transportation infrastructure as necessary:** In instances where relocation of existing transportation infrastructure is not an option, repair the damage and/or retrofit the existing structures to better withstand sea level rise impacts. For example, use stronger materials, elevate bridges or sections of roadway, and build larger or additional drainage systems to address flooding concerns.

- **Attempt to build redundancy into the transportation system:** Provide alternate routes, as possible, to allow for access to and along the coast for instances in which sections of roadways may become temporarily impassible as a result of coastal hazards. Ensure that alternate route information is provided to residents and visitors to coastal areas.

Protect:

- **Evaluate locations for hard protection use only if allowable and if no feasible less damaging alternative exists:** "Hard" coastal protection is a broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. In some cases, caissons and pilings may also be

considered hard shoreline protective devices. Due to adverse effects on shoreline sand supply and beach area available for public use, such protective devices should be avoided where feasible. Under current law, shoreline protection for existing structures in danger from erosion may be allowed if coastal resource impacts are avoided or minimized and mitigated.

- **Potentially survey and determine feasibility of retaining existing shoreline protection:** Westshore Road, Highway 1, and Bayflat Road run along developed shoreline with no or limited alternate routes. The structural integrity of existing armoring along these roads should be determined, and potential long-term strategies for road resiliency to sea level rise should be considered.

- **Consider increasing capacity of stormwater infrastructure:** Actions to reduce impacts from higher water levels could include widening drainage ditches, improving carrying and storage capacity of tidally-influenced streams, installing larger pipes and culverts, adding pumps, converting culverts to bridges, creating retention and detention basins, and developing contingency plans for extreme storm events. Encouraging and supporting these types of efforts upstream may also be important.

Highway 1 Area

The assets vulnerable to sea level rise and storms in the Highway 1 Area include Highway 1, residential and commercial buildings on the harbor side of Highway 1, yacht club, wastewater treatment plant, Regional Parks and California Coastal Trails access, and environmentally sensitive habitat areas. Soldier pile walls and hard armoring reinforce the low-lying areas of Highway 1. Residential and commercial buildings on the harbor side of Highway 1 are more vulnerable to storm surges, kind tide inundation, and sea level rise. Some of the buildings have been elevated on wooden pilings, which require maintenance.

The adaptation strategies to consider for these assets are based on accommodate and retreat. Accommodate strategies employ methods that modify existing developments to decrease hazard risks and increase resiliency of the development. Because most of the residential and commercial structures have been built on pilings already, maintenance of these pilings will be necessary as wave and tidal scours undermine footings over time. Some buildings may need to be incrementally relocated and in-water structures removed. Relocation of the wastewater treatment plant would be required to follow Coastal Act policy (Section 30231) to minimize the adverse effects of wastewater discharges and entrainment.

Land Use Adaptation Strategies

Highway 1 Area Priorities: Potentially accommodate sea level rise through redevelopment and maintenance strategies, protect or increase adaptive capacity of shoreline roads and trail access, determine wastewater treatment plant resiliency.

Accommodate:

- **Consider revising setbacks for new development:** Ensure structures (especially wells and septic systems) are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced

erosion) over the life of the structure, without the use of a shoreline protective device. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway.

- **Examine non-conforming structure policies and definitions:** Consider developing policies and regulations to define development in the area between the sea and the first coastal roadway or other known hazard zones as non-conforming, in order to avoid perpetuating development that may become at risk.

- **Consider policies for the gradual phase out of uses in hazardous areas subject to future sea level rise:** Over time, sea level rise is going to create hazardous or harmful conditions that will make some uses unworkable. In some cases it will be difficult or not feasible to mitigate impacts of sea level rise. In these cases, the County will consider policies to phase out existing uses in high hazard or emerging nuisance areas over time. Consider the adoption of policies, including phase out times, for amortization of the uses. Until an amortization schedule is adopted, existing uses that become non-conforming will be allowed to remain for their economic life, but would not be allowed to be rebuilt.

- **Scrutinize redevelopment or upgrades to existing structures in at risk locations:** Use redevelopment policies or regulations to limit expansions, additions, or substantial renovations of existing structures in danger from erosion. Require removal of non-conforming portions of the existing structure, when possible, when a remodel or renovation is proposed.

- **Evaluate redevelopment of existing structures and encourage use of current standards.** Use Local Coastal Plans and CDPs to require that renovations meeting the threshold for redevelopment not be approved unless the entire structure meets the standards for new development, including but not limited to a waiver of right to protection. Specify that if any existing non-conforming elements are permitted to remain, those non-conforming elements are not subject to rights to protection pursuant to Coastal Act Section 30235. Consider limiting cumulative improvement or additions to existing structures:

- **Consider retrofitting existing transportation infrastructure as necessary:** In instances where relocation is not an option, repair damage and/or retrofit existing structures to better withstand sea level rise impacts. For example, use stronger materials, elevate bridges or sections of roadways, and build larger or additional drainage systems to address flooding concerns.

- **Consider developing ecological buffer zones and/or increase the size of buffers:** Buffer zones are intended to protect sensitive habitats from the adverse impacts of development and human disturbance. An important aspect of buffers is that they are distinct ecologically from the habitat they are designed to protect. Local Coastal Plans can establish requirements for ecological buffers and provide guidance on how to establish or adjust these buffers to accommodate sea level rise. Coastal Permits should require buffers to be designed, where applicable, to provide "habitat migration corridors" that allow sensitive habitats and species to migrate inland or upland as sea level rises.

- **Carefully consider siting and design of wastewater disposal systems to avoid risks from sea level rise:** Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Damage to these facilities could result in impacts to water quality or other coastal resources. New facilities should not be sited in hazardous areas. Existing facilities already located within hazardous areas should be modified to withstand worst-case scenario sea level rise impacts.

- **Encourage siting and design wastewater disposal systems to avoid risks from sea level rise:** Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts.

- **Evaluate water quality risks from wastewater treatment plants, septic systems, and ocean outfalls:** Consider conducting a feasibility study of wastewater treatment plant operations, berm stability, and emergency operations. Consider establishing a program to retrofit, decommission, relocate, or eliminate ocean outfalls and other wastewater infrastructure deemed at risk. Alternatives include modifications to outfall lines, the use of green infrastructure, and redesign of waste and stormwater systems.

- **Identify research and monitoring needs to more precisely understand local issues:** Research programs may be established to analyze the particular local challenges related to water quality and supply as a result of sea level rise. Opportunities for innovative solutions to these challenges should be identified.

Retreat:

- **Consider avoiding the expansion or perpetuation of existing structures in at-risk locations:** On an eroding shoreline, the seaward portions of an existing structure may become threatened as the setback or buffer zone between the structure and the mean high tide line or bluff edge is reduced due to erosion of the beach or bluff. When the seaward portion of the structure no longer meets the standards or setback that would be required for new development, it becomes a "non-conforming" structure for purposes of redevelopment policies and regulations. The following should be considered, as consistent with the Coastal Act, FEMA policies, and other relevant standards, to address existing non-conforming development to avoid the need for shoreline or bluff protective devices and associated impacts to coastal resources.

- **Consider retrofitting or relocating vertical accessways:** Consider options to retrofit existing accessways to reduce impacts from sea level rise. Such retrofits could include using different materials that can better withstand impacts, or re-orienting the

layout or other features of accessways to lessen damage and other impacts. Also begin to plan for and identify triggers and options for relocating accessways over time as conditions change.

- **Evaluate the potential of retrofitting or relocating sections of the Coastal Trail:** Use boardwalks, bridges, and/or other design features to ensure continuity of the California Coastal Trail (Coastal Trail) in sections that are vulnerable to sea level rise hazards. Some sections may need to be relocated over time. A Local Coastal Plan could identify vulnerable sections of the Coastal Trail and establish a phased approach to relocate sections of the trail in such a way that is consistent with provisions of the Coastal Act and ensures that the Coastal Trail remains within sight, sound, or smell of the sea.

- **Determine the feasibility of establishing conservation easements or other development restrictions to protect habitat:** Establish a formalized program to identify, acquire, and manage areas appropriate for some form of conservation protection. Easements or other strategies may be used to limit or restrict development on portions of a lot parcel that are most vulnerable to sea level rise impacts. The program might develop standard agreements to be used for easements and identify the entities that could hold the easements. A conservation easement program could be established on a community wide basis through a Local Coastal Plan and implemented on a parcel by parcel basis through individual Coastal Permits.

- **Encourage open space protection as a component of new development located adjacent to coastal habitats:** The Local Coastal Plan can require permit conditions for new development in certain areas that buffers around natural resource areas be protected through a conservation easement, deed restrictions, or other comparable mechanism.

- **Identify opportunities for Regional Sediment Management:** Sediment supplies will be important for the long-term sustainability of many beaches and wetland areas. Strategies to maintain or restore natural sediment supplies and to coordinate sediment removal efforts with opportunities for reuse can provide multiple benefits to coastal ecosystems. See Strategy A.19c above for more detail on RSM programs.

County Regional Parks Area

The assets most vulnerable to sea level rise and storms are Westshore Road, Doran Beach, and Westside Regional Parks, and the inlet to Bodega Harbor. Sea level rise inundation would affect access to and along Westshore Road. Permanent sea level rise inundation would affect almost all of Westside Regional Park facilities including parking and campgrounds by 2100. Doran Beach Regional Park will have permanent inundation of up to 35 percent of the beach and campground by 2100.

The adaptation strategies to consider for these assets are accommodate and retreat. Accommodate strategies employ methods that modify existing developments to decrease hazard risks and increase resiliency of the development. Sonoma County Regional Parks may consider moving the campgrounds and parking areas higher upland. Potential adaptation strategies for Westshore Road have been discussed in the Bodega Harbor Area section.

Land Use Adaptation Strategies

County Regional Parks Area Priorities: Potentially accommodate sea level rise through redevelopment, relocate facilities out of hazard areas, and protect beaches through a sand enrichment program.

Accommodate:

- **Consider long-term hazards in site design for access sites and facilities to minimize impacts:** May include policies that encourage public access sites, segments of the CCT, and recreation and visitor-serving facilities to be sited and designed to avoid impacts from sea level rise, while maximizing public access and recreation opportunities. Examples of siting and design standards for development can be found in section A. Where facilities can be safely sited for the near term but future impacts are likely, require an adaptive management plan detailing steps for maintenance, retrofitting, and/or relocation.

- **Consider protecting existing Parks and Open Space adjacent to the coast:** Plan for future coastal recreational space and parkland by protecting open space adjacent to coastal habitats so that beaches and other habitats can migrate or so that there is open space available as parkland or other areas are lost.

- **Support research on impacts to recreation and public access:** Changes in sea level will affect wave conditions and sediment transport, but additional research is needed to understand how these changes will affect specific conditions for surfing and other recreation activities. While such research programs may be outside the scope of individual local jurisdictions, statements of support for the local issues that need to be addressed can help guide research agendas at the regional state or federal level. Or, such needs can serve to guide grant applications to undertake the needed projects within a jurisdiction. To the extent possible, add policies to promote research on sea level rise impacts to recreational activities like surfing or other coastal recreational uses in the Local Coastal Plan jurisdiction.

Retreat:

- **Consider the feasibility of retrofit or relocate recreation and visitor-serving facilities:** Consider options to retrofit existing recreation and visitor-serving facilities to better accommodate sea level rise impacts. Such retrofits could include use of different building materials and/or relocating facilities.

Protect:

- **Consider incorporating sea level rise into a comprehensive beach management strategy:** Potentially develop a new comprehensive beach management strategy to address loss of beach areas, including loss of lateral access, or changes in beach management due to sea level rise. Establish a program to minimize loss of beach area through, as may be appropriate, a beach nourishment program; restoring sand and sediment supply to the littoral cell; removal, adjustments, or maintenance to shoreline

protection structures; use of man-made structures such as terminal groins or artificial reefs to retain sediment; or other actions.

- **Determine the feasibility of establishing a beach nourishment program and protocols:** The County may need to develop new policies to address the need for beach nourishment with sea level rise. Policies within a Local Coastal Plan may identify locations where nourishment may be appropriate or ecologically feasible. Beach nourishment programs should also consider how nourishment options may need to change over time as sea level rises.

- **Determine the feasibility of establishing management actions to maintain and restore dunes and natural dune processes.** Dunes provide buffers against erosion and flooding by trapping windblown sand, storing excess beach sand, and protecting inland areas, and they provide habitat. Doran Beach is a sand spit with dune habitat that provides wind protection to the inner Harbor, and is a sensitive ecosystem. The County would have to determine the ecological feasibility of this adaptation strategy. This is likely most effective for areas with some existing dune habitat and where there is sufficient space to expand a foredune beach for sand exchange between the more active (beach) and stable (dune) parts of the ecosystem. This strategy requires incremental amounts of sand due to increased erosion from sea level rise.

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7. Glossary

Land Use Categories

Marine Industrial (MI). Land designated for or occupied by marine industrial development. The MI land use category encompasses land to accommodate a variety of commercial, light to medium industrial, and service uses which support the commercial fishing and other coastal dependent industries which depend on the marine environment and resources.

Rural Residential (RR). Land designated for very low density residential development (1 to 20 acres per dwelling unit) which has few if any public services but which has access to county maintained roads.

Urban Residential (UR). Land planned for public services for low and medium density residential development (1 to 6 dwelling units per acre) to accommodate a variety of housing and tenure types.

Resources and Rural Development (RRD). Land designated for very low density residential development and to protect lands needed for use and production of natural resources (e.g., water, timber, geothermal steam, or aggregate production); protect water resources and biotic habitats; and protect from intensive development lands constrained by geologic, flood, or fire hazards or other constraints.

Inundation and Flooding

Permanent Inundation. Permanently covered by water from sea level rise.

Temporary Flooding. Temporarily covered by flood water from storm events.

California Coastal Trail

Existing Coastal Trail. The trail has been constructed.

Proposed Coastal Trail. The approximate location of the trail alignment has been identified as described in the Public Access Plan of the Local Coastal Plan Update.

Future Coastal Trail. The trail alignment between two end points is unknown. In some cases, where the alignment has not been identified, the beginning and end points of the trail are shown and the future alignment is illustrated along State Highway 1.

Coastal Wetlands

Section 30122 of the 1976 California Coastal Act defines wetlands as lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens.