



CALIFORNIA COASTAL COMMISSION STATEWIDE SEA LEVEL RISE VULNERABILITY SYNTHESIS



Arcata | Humboldt BayKeeper



Ventura | David Powdrell



Oceanside | Dan Jarvis



Solana Beach | Coastal Records Project

DECEMBER 31, 2016

This product was funded with qualified outer continental shelf oil and gas revenues by the Coastal Impact Assistance Program of the Fish and Wildlife Service, U.S. Department of the Interior

This page intentionally left blank

ADDRESSING SEA LEVEL RISE IN THE COASTAL COMMISSION'S PLANNING AND REGULATORY WORK

Statewide Sea Level Rise Vulnerability Synthesis Report

Contents

1. Introduction	1
2. Key Findings of the Statewide Synthesis of Vulnerability to Support Sea Level Rise Policy Planning and Preparedness	2
2.1 Ocean Economy	4
2.2 Coastal Hazards and Impacts to Populations and Development	6
2.2.1 Risks to Populations	6
2.2.2 Environmental Justice and Social Vulnerability	7
2.2.3 Development and Shoreline Protective Devices.....	8
2.3 Coastal Act Resource Vulnerability	10
2.3.1 Public Access and Recreation.....	10
2.3.2 Coastal Habitats, ESHA, and Wetlands	11
2.3.3 Agricultural Resources	14
2.3.4 Energy and Other Infrastructure.....	15
2.4 Interagency Coordination	16
2.5 Tribal Lands and Cultural Resources	18
2.6 Lessons Learned from Local Coastal Program Planning Case Studies	18
3. Summary of Key Findings, Conclusions and Next Steps	20
3.1 Common Themes	20
3.2 LCP Planning.....	21
3.3 Interagency Coordination	23
3.4 Environmental Justice	23
4. References	27
Appendices.....	29
Appendix A. County Snapshots	
Appendix B. LCP Case Studies	
Appendix C. Methods and Vulnerability Assessment Data Sources	

List of Figures

Figure 1. National Research Council sea level rise projections for California (2012)	3
Figure 2. Sectors comprising California’s statewide ocean economy (Source: 2016 NOEP)	4
Figure 3. Ocean dependent gross domestic product (GDP) by county (Source: 2016 NOEP)	5
Figure 4. Population (2010 U.S. Census) vulnerable to flooding under current 100-year storm and with 55 inches sea level rise scenarios inside and outside the coastal zone (CZ) (Flood area data source: Heberger et al., 2009).	7
Figure 5. Summary of percent shoreline with coastal armoring for three California regions.....	9
Figure 6. Number of public access coastal areas by county (Source: California Coastal Commission, July 2016)	11
Figure 7. Existing Coastal Zone Wetlands by County (Source: National Wetlands Inventory, 2016)	13

1. Introduction

Climate change now affects almost every facet of California's natural and built environment, and sea level rise will have widespread adverse consequences for California's coastal resources and shoreline development. A 2009 Pacific Institute study estimates that with 1.4 m of potential sea level rise, over 200,000 Californians and development valued at \$36.5 billion will be at risk in a 100-year flood event. And these risks will only increase with population growth (Heberger et al., 2009).

California's coastal resources, including natural habitats like beaches and wetlands as well as public access and recreational areas are also increasingly in danger, particularly as seawalls, rock revetments, and other kinds of shoreline protection are approved to protect development. Beaches, dunes, and wetlands that cannot migrate inland because of seawalls or other barriers will eventually be squeezed out and lost, caught between rising tides and immovable shoreline structures. The loss of California's popular beaches would take a huge toll on the state's economy, much of which derives from coastal tourism and recreation.

The Coastal Commission has a unique and important role in assisting the state in preparing for climate change and in particular, sea level rise. The Coastal Commission is charged with implementing the Coastal Act through regulation of development and in land use planning with local governments. The Coastal Act establishes strong resource protection and coastal development policies for California's coastal zone, which extends 3 miles seaward to the outer extent of state jurisdiction, and which on land can be as narrow as several blocks in certain urban areas and up to 5 miles inland in rural areas. The Coastal Commission also plays a central role in assuring that new development minimizes coastal hazards, including flooding, erosion and extreme storm events that will be exacerbated by global climate change and sea level rise, and also avoids and minimizes impacts to coastal resources.

In addition to regulating development in the coastal zone, the Coastal Commission works with local governments to develop Local Coastal Programs (LCPs) so that local governments can permit development at the local level consistent with the policies of Coastal Act. LCPs provide the legally-controlling local land use policies and zoning to address statewide coastal resource management issues like coastal hazards, sea level rise and extreme events and drought conditions, and protecting public beach recreational resources. In this way, California has the legal and planning structure in place necessary for effective coastal adaptation planning – the California Coastal Act and Local Coastal Programs. In fact, the State's Climate Adaptation Strategy, *Safeguarding California*, calls for the Commission to work with local governments to amend their LCPs to provide for effective state and local response to climate change impacts, including sea level rise.

Overview and Purpose of this Report

In implementing the Coastal Act, the Coastal Commission provides guidance and technical assistance to local governments, other state agencies and partners and the public to ensure effective planning and permitting of development in the coastal zone. To build on this ongoing work, Coastal Commission staff leveraged funding provided by the US Coastal Impact Assistance Program to develop a series of products to assist the agency, its staff, local governments, other state agencies, interested stakeholders and the public in addressing climate change, and in particular sea level rise, in its planning and regulatory work. The products showcased in this report will enhance the ability of Coastal Commission and other decision-makers to make well-informed decisions about the long-term planning and management of

critical resources along the coast. In addition, the information developed will help prioritize future Commission efforts in addressing hazards and vulnerabilities related to sea level rise with a specific focus on Coastal Act resources most at risk.

This report showcases the products the Coastal Commission produced using funds from the Coastal Impact Assistance Program of the Fish and Wildlife Service, U.S. Department of the Interior. These include:

- *A Statewide Sea Level Rise Vulnerability Synthesis* which presents key statewide findings on vulnerability to inform sea level rise planning and preparedness;
- County-level Snapshots (*County Snapshots*) which describe sea level rise vulnerability at a county scale, local planning efforts underway, and discussion of Coastal Act resource management priorities (Appendix A); and
- Four *Local Coastal Program Case Studies* which highlight examples of how the Coastal Commission, local governments, and other stakeholders are working collaboratively to address sea level rise in LCPs (Appendix B).


2. Key Findings of the Statewide Synthesis of Vulnerability to Support Sea Level Rise Policy Planning and Preparedness

At the outset of this project, Commission staff recognized that there were many efforts currently underway throughout the state to better understand potential climate change impacts at regional and local levels and to identify vulnerable areas and assets that need to be addressed. These vulnerability assessments are critical for identifying resources at risk and developing strategies to address them. While many assessments are currently underway or have been completed, there was a need for a statewide overview of identified coastal vulnerabilities and identification of existing data or planning gaps. As such, under this project, Coastal Commission staff reviewed and compiled vulnerability assessments of urban and rural areas in coastal counties statewide to identify priority areas for adaptation planning. This synthesis of existing studies was augmented and enhanced by input from Coastal Commission staff working throughout the state, about known vulnerabilities and critical areas at risk from sea level rise or associated impacts.

While climate science is an evolving field, the best available science on sea level rise can guide policy and help communities plan for resiliency. This science is currently identified as the National Research Council's (NRC) 2012 west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100 for California south of Cape Mendocino (Figure 1). However, more recent examinations of climate change and sea level rise dynamics are also raising the possibility that global sea level rise could be significantly greater than the current NRC projections for California. One study, for example, projects an additional sea level rise of as much as 3 feet by 2100, depending on what happens to the great ice sheets in Antarctica and Greenland (DeConto & Pollard, 2016). In response to this evolving science, the California Ocean Protection Council is planning to update the *State of California Sea-Level Rise Guidance* within the year to better represent ice melt into their new sea level rise projections. In the meantime, the results of vulnerability assessments using early estimates for scenarios

begin to represent the variety of sea level rise planning challenges for coastal communities. These findings and others are described in more detail in the analysis by topic area below.

- Ocean economy
- Coastal hazards and impacts to development and populations
- Coastal Act resource vulnerability
- Interagency coordination
- Environmental justice and social vulnerability
- Tribal lands and cultural resources
- Local Coastal Program planning to address sea level rise

TIME PERIOD*	NORTH OF CAPE MENDOCINO ¹⁹	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

Figure 1. National Research Council sea level rise projections for California (2012)

2.1 Ocean Economy

Key Finding: The Ocean Economy makes up a significant portion of California's total economy. Communities should analyze the impacts of sea level rise on economic livelihood and assess the related impacts to their local ocean economy, especially tourism and recreation.

A review of ocean economy statistics highlights the importance of coastal resources to the economic livelihood and quality of life in coastal communities. Overall, America's coasts and oceans contribute a disproportionately high value per acre of land to the U.S. economy (NOEP, 2016). In 2013, the ocean economy generated more than \$44 billion to California's gross domestic product (GDP) and provided over 500,000 jobs and more than \$19 billion in wages and salaries (NOEP, 2016). The term, "ocean economy" is used to describe the economic value of various sectors of activities directly related to the use of ocean resources or access. In contrast, the "coastal economy" is the sum of all economic activity occurring in coastal counties (NOEP, 2016). It is important to note that terrestrial agriculture is not directly dependent on the ocean, so its economic activity is not incorporated into the ocean economy, but is instead a component of California's coastal economy.

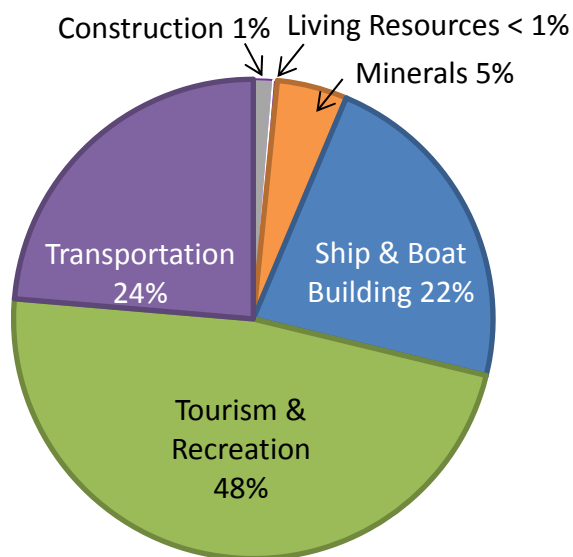


Figure 2. Sectors comprising California's statewide ocean economy (Source: 2016 NOEP)

The ocean economy is an aggregate of the following six sectors: tourism and recreation, transportation, ship and boat building, offshore minerals, construction, and living resources (Figure 2). Each of the six ocean economy sectors is composed of multiple industries and/or activities (See Appendix C).

California has three of the U.S.'s busiest ports, with the Ports of Los Angeles and Long Beach ranking as the top two busiest for numerous years. Large ports such as these import and export a majority of the state and nation's products and their importance can be seen in Figure 3. This graph represents county contributions to California's ocean economy, much of which depends on tourism and recreation in addition to transportation (i.e., port activity).

Numerous coastal resources, including tourism and recreation areas along California’s coast, are assets that are vulnerable to rising sea levels, signaling potential future impacts to the ocean and coastal economy. Economies rooted in coastal dependent development (e.g., ports and port facilities) also face vulnerabilities to future sea level rise. Ports might be able to adapt to changing water levels through elevation and other adaptation efforts. However, without adequate planning for sea level rise for both water and land components, ports may face a range of negative economic impacts.

In fact, sustaining economic success from the ocean economy for years to come depends on adequate planning for sea level rise along the coastline, protecting fragile habitats and nursery areas for young and juvenile fish, maintaining public access and recreation, and future planning for critical infrastructure, ports and harbors. However, few vulnerability studies examined economic benefits that could be threatened by rising sea level, or undertook any analysis of the costs and benefits of various adaptation options. While many communities recognize and value their beaches as a recreational asset, many communities did not analyze the impacts of sea level rise on their sandy beach area or their tourism economy, nor did they address the habitat benefits from beaches or consider the economic costs of habitat losses that can result from coastal armoring. Finally, many of the benefits that derive from coastal habitats extend beyond the local community (e.g., flood protection from dunes, avian and fish richness/diversity, etc.). Regional and multi-agency coordination may be needed to adapt to changing conditions while maintaining and enhancing these habitat values.

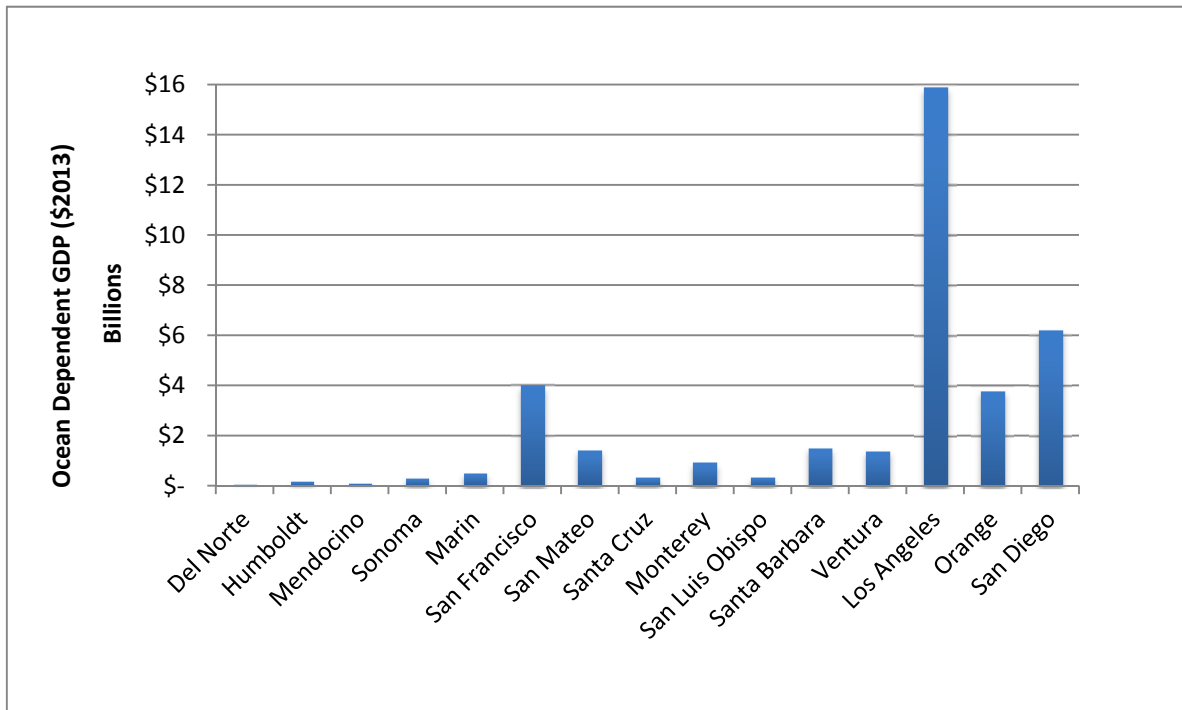


Figure 3. Ocean dependent gross domestic product (GDP) by county (Source: 2016 NOEP)

2.2 Coastal Hazards and Impacts to Populations and Development

2.2.1 Risks to Populations

Key Finding: The largest coastal zone populations vulnerable to flooding from a 100-year storm plus 55 inches sea level rise are Los Angeles, Orange, and San Diego counties.

Statewide reporting of populations vulnerable to floods using the Pacific Institute’s sea level rise scenario of 55 inches (1.4 meters) with a 100-year storm help inform a broad scale understanding of California’s vulnerabilities, as do many other sea level rise tools (e.g., CalAdapt, NOAA Sea Level Rise Viewer, Surging Seas, see Appendix C in Coastal Commission Sea Level Rise Policy Guidance). Figure 4 shows the county-wide and coastal zone populations vulnerable to Pacific coast flooding, based on an overlay of 2010 US Census numbers and the Pacific Institute current 100-year storm with (a) no sea level rise and (b) with 55 inches of sea level rise. Flood risk to populations in the coastal zone is a subset of vulnerable populations on the coast—many people live outside of the coastal zone boundary but are still located on low-lying land. The largest coastal zone populations vulnerable to flooding from a 100-year storm plus 55 inches sea level rise are in Los Angeles, Orange, and San Diego counties. It is important to note that Orange County has the largest population projected to be vulnerable to flooding under the 55 inch (1.4 meter) sea level rise scenario, but of the total population in Orange County who will be at risk from future storm flooding, only 25% live in the coastal zone. Thus, while flood-resilience policies will be an important part of the LCP, flooding policies should also be included in the planning instruments that extend inland of the coastal zone boundary to address flood risks. Agency coordination on developing and implementing flood risk policies will also be important.

The 2009 Pacific Institute study also explored population vulnerable to erosion risk, excluding counties south of Santa Barbara. Erosion risk was characterized by the Pacific Institute study as either dune or cliff erosion. For the analyzed counties, 14,000 people could be vulnerable to erosion by 2100 with 55 inches of sea level rise, while 63,000 people could be vulnerable to flooding under the 1.4 m scenario for the same counties. The largest populations vulnerable to erosion are in San Mateo, Santa Cruz, and Santa Barbara counties. The Pacific Institute study did not present erosion information for counties south of Santa Barbara. Thus, estimates of potential erosion impacts in the *County Snapshots* for Southern California counties use Coastal Storm Modeling System (CoSMoS) 3.0 bluff erosion projections for 59 inches of sea level rise plus a 100-year storm—but these numbers do not include dune or beach erosion and are not directly comparable to findings from the Pacific Institute study erosion hazard zones.

Overall, while more people are likely to be at risk from flooding than erosion, some coastal residences will be at risk from both. Flooding and erosion are not mutually exclusive hazards. However, development can recover from flood damage or suffer damage on multiple occasions, as represented by the multiple loss claims to Federal Emergency Management Agency (FEMA). Erosion, by contrast is usually a one-time loss and recovery is not always possible. The long-term consequences from erosion and flooding are often quite different, and the planning and adaptation approaches to these two hazards should also be different.

Planning for sea level rise at river mouths also needs special consideration of the interacting factors that can result in flooding and erosion. In particular, climate change impacts that can affect coastal hazards in these areas include sea level rise, as well as changes in precipitation and in extreme storm event frequency and magnitude, all of which could result in changing river flow patterns. However, climate change scenarios of higher/lower river flows are not always modeled in vulnerability assessments. Thus,

there is a need for more studies and integration of coastal process modeling with hydraulic river models in jurisdictions with estuaries, lagoons, and ocean/riparian confluences to understand how these different processes could combine to impact adjacent development and coastal resources.

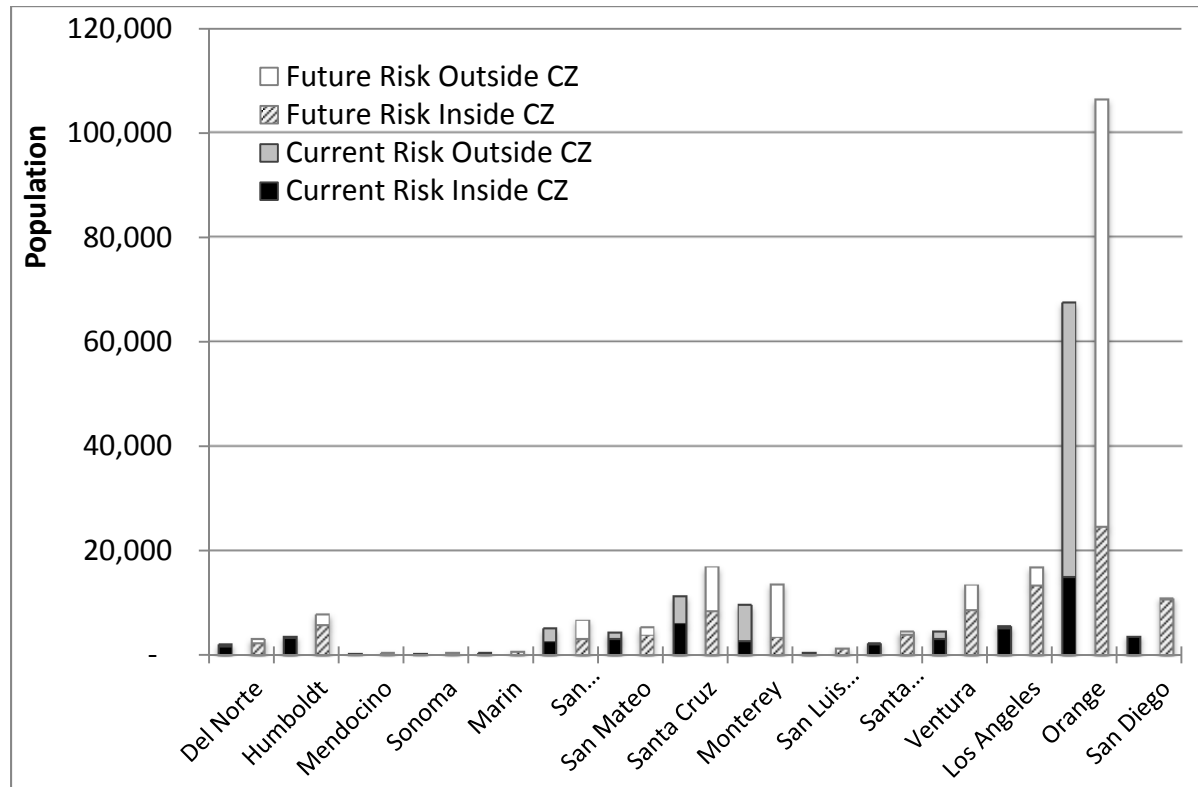


Figure 4. Population (2010 U.S. Census) vulnerable to flooding under current 100-year storm and with 55 inches sea level rise scenarios inside and outside the coastal zone (CZ) (Flood area data source: Heberger et al., 2009).

2.2.2 Environmental Justice and Social Vulnerability

Key Findings: Many vulnerability assessments did not account for the full range of social impacts linked to sea level rise. Vulnerability to hazards from sea level rise will have a disproportionate impact on communities with the least capacity to adapt; as such, a comprehensive approach to assessing social vulnerabilities should be used going forward to identify communities that may have higher vulnerabilities due to socio-economic factors and other risks that may be present in that community. Furthermore, as sea levels rise and public access points and recreational opportunities are lost, public access opportunities will become fewer and more limited for those who cannot afford to live at the coast.

Sea level rise poses environmental and social justice challenges. This is particularly true for communities that are already suffering from economic hardship or have limited capacity to adapt, including lower-income, linguistically isolated, elderly, and other vulnerable populations. Due to current development patterns along the coast, sea level rise hazards may affect various sections of the population differently, as could the implementation and effectiveness of various adaptation measures. The number of people living along the open coast in areas exposed to flooding from a 100-year flood would increase to 210,000 with a 4.6 feet (1.4 meter) increase in sea level; approximately 27% or 56,000 of these are lower income people (those earning less than \$30,000 annually); 45,000 are renters; and 4,700 are

linguistically isolated and less likely to understand flood warnings (Heberger et al. 2009). According to Heberger et al. (2009), the greatest increases in the number of people vulnerable to flooding will occur in Los Angeles, San Diego, Ventura, Humboldt, and San Luis Obispo counties. Hazards in vulnerable areas will have disproportionate impacts on communities with the least capacity to adapt, which could also deepen and expand existing environmental injustices if adaptation responses are not managed appropriately.

Sea level rise may also create significant environmental justice issues in the coastal zone because a disproportionate burden will be placed on those who cannot afford to live near the coast as public access points and low-cost recreational opportunities become inaccessible or access ways become inundated or regularly flooded. The loss of shoreline open spaces and lower cost recreational areas may discourage and eventually prevent inland residents from accessing the coast at all. This inability to access clean air, cool temperatures, and recreational opportunities will have a profound impact on populations that live in inland areas that are more prone to heat waves and air pollution. Further, decisions to protect vulnerable public and private property in the coastal zone may also diminish currently available public beach resources.

A limitation of many local sea level rise vulnerability assessments is that many jurisdictions do not account for or underestimate the magnitude of social impacts in a community that will be caused by sea level rise. Including a social vulnerability assessment within the sea level rise vulnerability assessment can provide planners and decision makers with insight on whether sea level rise in their community will result in unequal burdens on some segments of the population over others. While some vulnerability assessments do evaluate population vulnerable to sea level rise, they often focus only on populations living in direct exposure to a coastal hazard and might not evaluate how burdens might vary across different segments of the population.

However, a few sea level rise vulnerability assessments, such as those for the cities of Hermosa and Los Angeles (LA), include an integrated social vulnerability approach that considers how different segments of the population will be affected by sea level rise and compares how the local jurisdiction's social vulnerability compares with regards to the entire county (Hermosa) or assesses social vulnerability for the entire city, including areas outside of the coastal zone (LA). These assessments identify how people not living in areas exposed to coastal hazards might still face consequences. Another limitation with social vulnerability assessments is that they might not capture how decreases in low-cost recreation opportunities and public access further exacerbates population vulnerability, particularly for communities of color and low-income residents who live inland, resulting in an underestimation of social vulnerability to sea level rise and possible environmental justice impacts.

2.2.3 Development and Shoreline Protective Devices

Key Finding: Despite many miles of existing armoring, erosion will continue to threaten existing developed areas in vulnerable communities, and this threat will increase with rising sea level.

Residential development shapes land use patterns along much of California's coast. A typical at-risk development pattern that is especially prevalent in central and southern California is a line of residential development along sandy beaches or the edge of coastal bluff-tops, the coastal areas that are most prone to flooding and erosion. This ocean-front residential development poses complex hazards management challenges because this also includes a system of roads and utilities such as electricity, gas, water, cable, and sewer or, in rural areas, wells and septic systems, which also may be at risk from flooding or erosion.

Many of these residential areas were planned and developed prior to the Coastal Act and are often protected by a patchwork of privately constructed seawalls and revetments. One consequence of shoreline protection is the halted inland movement of the beach, which will eventually cause the beach area, along with its recreational and habitat values, to be lost as sea levels rise. Figure 5 shows that most shoreline armoring structures exist in southern California, and that the length of structures built after 1971 are more than double those before that period. Despite the significant miles of existing armoring, the statistics for at-risk communities shows that erosion will continue to threaten existing developed areas and that this threat will increase with rising sea level (Griggs, et al. 2005). The continued or expanded reliance upon shoreline armoring will lead to loss of beach and the conflicts between protecting development and ensuring the continuation of beaches will intensify. As discussed in the later sections on public access and beaches, the combined effect of rising sea level and coastal armoring will result in accelerated loss of access and recreational opportunities.

Some communities may have the opportunity to use regional sediment management and beach nourishment efforts to maintain beach area, possibly for many decades, without the need for allowing beaches to migrate inland through such adaptation strategies as managed retreat of development. For other communities, regional sediment management and beach nourishment may offer only a short-term solution or may not be feasible at all. In these communities, beaches will be lost unless other strategies are used to ensure beaches can migrate inland. Despite the recognition by most vulnerability assessments that beaches are valuable community assets, most communities use a property-by-property or project-by-project approach to permitting shoreline armoring. This discourages a larger, more cumulative assessment of armoring impacts or identification of short, mid and long-term adaptation options. However, under the Coastal Act the Coastal Commission is required to assess cumulative impacts for shoreline armoring project proposals that come before the Coastal Commission for review.

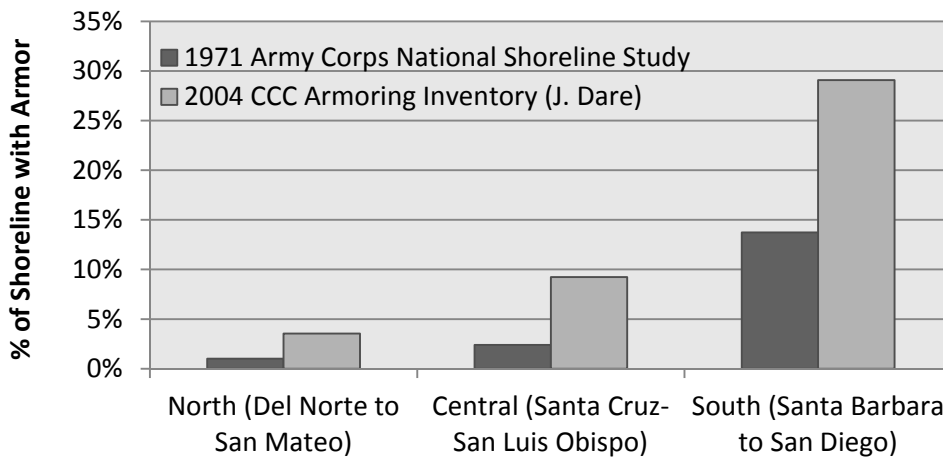


Figure 5. Summary of percent shoreline with coastal armoring for three California regions.

2.3 Coastal Act Resource Vulnerability

2.3.1 Public Access and Recreation

Key Finding: Public access and recreational assets are threatened by sea level rise in every county. However, with planning, funding, and collaboration, local governments can lay the groundwork for resilient public access ways and preservation of beach areas, even as sea levels rise.

The Coastal Act has a key mandate to protect and maximize public access and recreation. Of the over 1500 public access coastal areas in the California coastal zone, beach access is the most common (<https://www.coastal.ca.gov/YourCoast/#/map>; California Coastal Access Guide, 7th edition). However, many other types of access are available, including historic/cultural sites, natural resource areas such as parks, nature preserves and trails, boat access, and campgrounds. The *County Snapshots* highlight the number of public coastal access areas in every county, and these generally refer to places with physical access to the shore, city or county parks, and other recreational areas (national/state/regional) (Figure 6). Historic/cultural sites are typically facilities and recreation areas and natural resources are typically recreation or park areas, nature preserves, and trails.

Public access and recreational assets are threatened by sea level rise in every county. Loss of public access and recreational opportunities due to sea level rise will stem from increased areas of permanent inundation and episodic flooding or erosion of beaches, recreational areas, parking lots, and trails. Threats to public access and recreation were among the top three most frequent concerns of Commission staff statewide, with most public access concerns cited in San Mateo, Santa Barbara, Los Angeles, Orange, and San Diego Counties. Many public access location vulnerabilities coincide with additional vulnerable asset types, such as natural resources or infrastructure. Consequently, threats to public access will likely affect the local tourism and recreation industry. Reduced public access opportunities also raises environmental justice concerns due to the already limited ability of disadvantaged communities to enjoy the benefits of coastal resources, such as recreation at beaches.

With planning, funding, and collaboration, local governments can lay the groundwork for future relocation of access ways and actions to preserve beach area as sea levels rise. For example, communities in San Diego County, collaborating through the San Diego Association of Governments (SANDAG), have already joined together on two regional beach sand projects. A restored coastal trail project at Surfer's Beach in Ventura County has already begun to protect public access through the use of a planned retreat. In order to encourage more proactive planning to protect public access, jurisdictions would benefit from understanding the vulnerabilities of public access points and structures, such as boardwalks, piers, stairs, and pathways, and the potential social and economic impact the community will incur if sea level rise encroaches on and diminishes the value of these public access sites. Additionally, threats to public access sites in California Department of Parks and Recreation (State Parks) and the infrastructure that supports public access, such as the coastal state highway system (Highway One/Pacific Coast Highway), highlight the importance of collaborating with other state agencies such as State Parks and California Department of Transportation (Caltrans).

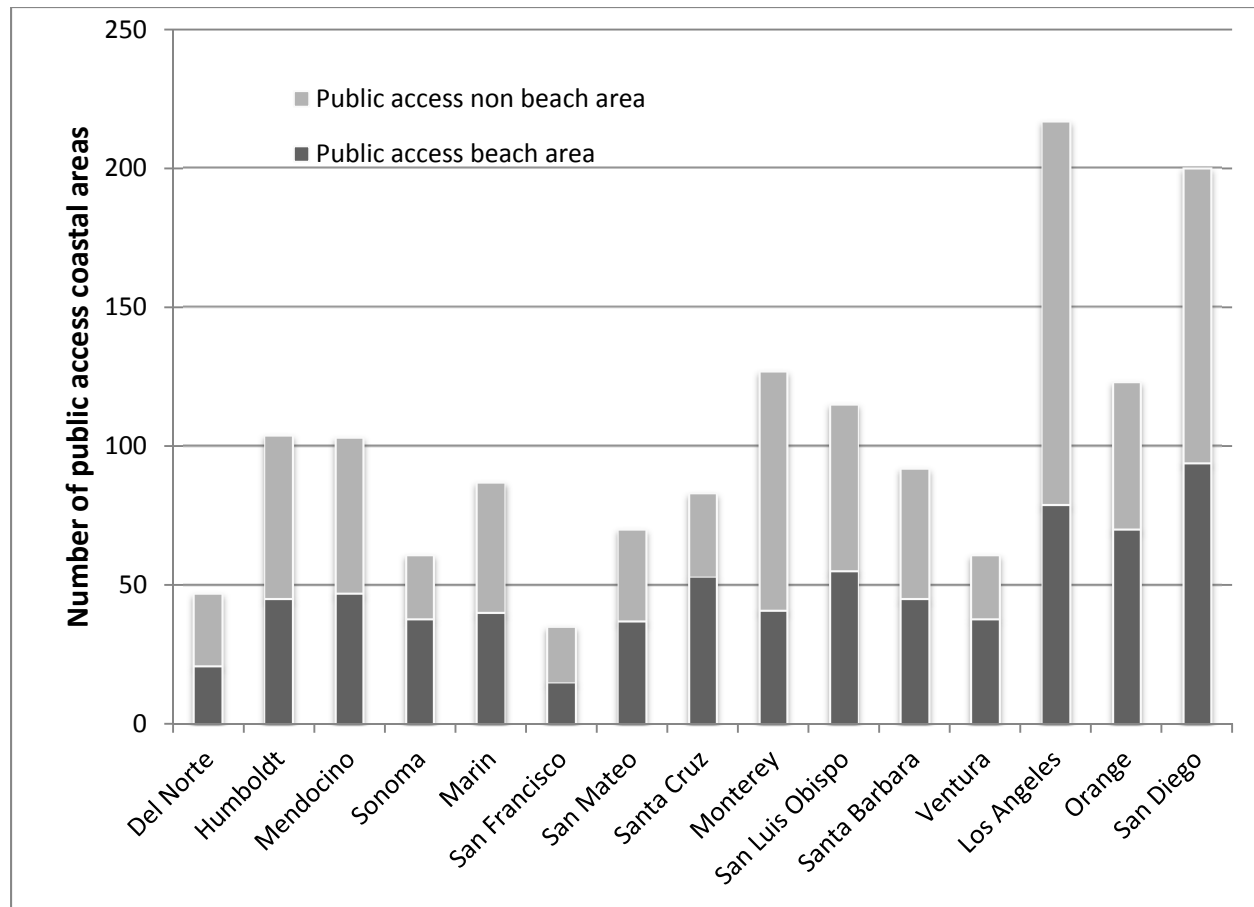


Figure 6. Number of public access coastal areas by county (Source: California Coastal Commission, July 2016)

2.3.2 Coastal Habitats, ESHA, and Wetlands

Coastal habitats, especially those that have a connection to water, such as beaches, intertidal areas, and wetlands, can be highly sensitive to changes in sea level. Environmentally Sensitive Habitat Areas (ESHA), as defined by the Coastal Act--locations that are critically important for the survival of species or valuable for maintaining biodiversity--can include nursery grounds, spawning areas, or highly diverse shoreline areas. Where ESHA and other coastal habitats are vulnerable to sea level rise impacts, protection of migration zones, habitat corridors, and other strategies, will be necessary to ensure the continued viability of the habitat areas.

2.3.2.1 Beaches: Vulnerable Habitat and Open Space

Key Finding: Many communities have not yet addressed the vulnerability of their sandy beaches to rising sea levels. Of those assessments that did evaluate sediment management and beach replenishment to maintain beach area as sea levels rise, few examined the ecological consequences or the long-term economic feasibility of these responses.

Beaches are vulnerable to sea level rise impacts in all counties. Sea level rise means beach areas might be lost due to increased storm erosion or under conditions of higher levels of tidal inundation. However, the amount and extent of risks and consequences to beach environments depend greatly upon the characteristics of the inland area. Beaches are most at risk when they are unable to migrate

inland; fixed inland development and coastal armoring to protect inland development are and will continue to be major barriers to beach migration. For example, beaches backed by dense urban development, like many of those in Southern California, will be more vulnerable over time because they will be unable to migrate inland as sea levels rise if existing development remains in place. More development close to low-lying beaches typically means more assets are potentially exposed to erosion and flooding, and in places where development currently has high hazard exposure, seawalls and other types of shoreline protection are often already used. Unless these structures and the development they protect are removed, beaches will be inundated and lost.

Understanding the impacts of sea level rise on beaches, along with the associated impacts to coastal resources like access and habitats, is crucial for planners. These resources are protected by the Coastal Act and usually comprise important components of coastal economies. While many studies cited vulnerability of assets to flooding near beaches, few examined the timelines for expected beach area loss as a result of sea level rise scenarios. In addition, many vulnerability assessments fail to adequately capture all assumptions relevant to the sustainability of their sandy beaches. For example, studies should address the impact of shoreline protective devices like seawalls that halt the inland migration of beaches and whether current nourishment regimes (primarily for Southern California) can be feasibly maintained under future conditions.

2.3.2.2 Regional Sediment Management and Beach Nourishment

Many communities currently maintain beach area through some type of regional sediment management or beach nourishment program. Many of the nourished Southern California beaches rely upon 'opportunistic sand' that is available because another project is taking place. For example, some beaches are routinely nourished with sand dredged from nearby harbors or other sand in the littoral system. California has only a few nourishment projects that use sand that is dredged from an offshore borrow site for use as beach nourishment. Examples include the Army Corps of Engineers' Surfside-Sunset Project that has placed offshore sand on the beach in 12 separate events, two SANDAG Regional Beach Sand Projects, and the planned Encinitas-Solana Beach Nourishment Program that has not yet started. As noted by some regional beach management studies, rising sea level will necessitate increasingly larger volumes of sand to maintain the same area of beach. Some community sediment management plans (i.e., the Los Angeles Draft Regional Sediment Management Plan) already recognize that sand is a valuable resource and that beach nourishment may not be able to sustain all beaches over time.

In addition to the physical challenges of beach nourishment, the ecological consequences of beach nourishment are increasingly being recognized, although quantification of negative nourishment impacts remains difficult. These negative impacts include disturbance of sandy beach biota (e.g., burrowing macroinvertebrates) and disrupting species (e.g., birds) using these sandy habitats for foraging, nesting, nursing, and breeding (Defeo, et al. 2009). As more inland development is threatened by erosion or flooding, communities are likely to view beach nourishment as a beneficial adaptation option for offsetting the impacts of coastal armoring. While many vulnerability assessments proposed beach nourishment as a way to adapt to rising sea level, few of the vulnerability assessments examined the long-term economic feasibility or ecological consequences of this approach. An additional concern is the increase in greenhouse gas emissions that will result from moving large volumes of sand, potentially far distances. More study is also needed on the ecological changes that occur on nourished beaches to help inform these efforts and to ensure that they can be done consistent with the Coastal Act.

2.3.2.3 Wetlands and Other Vulnerable Habitat

Key Finding: As sea levels rise, wetland habitat will be lost unless it can migrate inland or accrete upward. Thus, planning for wetland migration buffers and/or other adaptation strategies for sustaining wetlands will be vital to conserving the remaining wetland habitat area on the California coast.

Coastal habitat areas likely to be affected by sea level rise also include bluffs and cliffs, rocky intertidal areas, wetlands, estuaries, lagoons, tidal marshes, tidal flats, eelgrass beds, and tidally-influenced streams and rivers. Of particular concern statewide is the stress of sea level rise on the remaining saltwater marshes, which have already decreased by about 90% from their historical levels in the early 1900s (CNRA 2010). Some of the main human activities that have resulted in wetland losses have been diking and filling of wetlands to create dry land for agriculture or development, severing or greatly reducing the wetland connection to tidal influence with roads or rail corridors, or dredging the wetlands to create ports, harbors and marinas. Many of California’s wetlands have already experienced significant loss from human activities and sea level rise will lead to additional wetland habitat loss unless the habitat can move as the intertidal zone shifts inland.

The largest areas of current coastal zone wetland habitat are concentrated in Humboldt, Monterey, Santa Barbara and San Diego counties, with an approximate statewide total of 104,000 acres in the coastal zone (Figure 7). Wetland areas identified as important statewide due to their size and resource value include many areas in the Humboldt Bay region, Elkhorn Slough in Monterey County, Ormond wetland restoration area in Ventura County, and many lagoon areas in San Diego County. In the future, these remaining significant areas of wetland acreage will be submerged by rising seas unless wetlands can migrate inland.

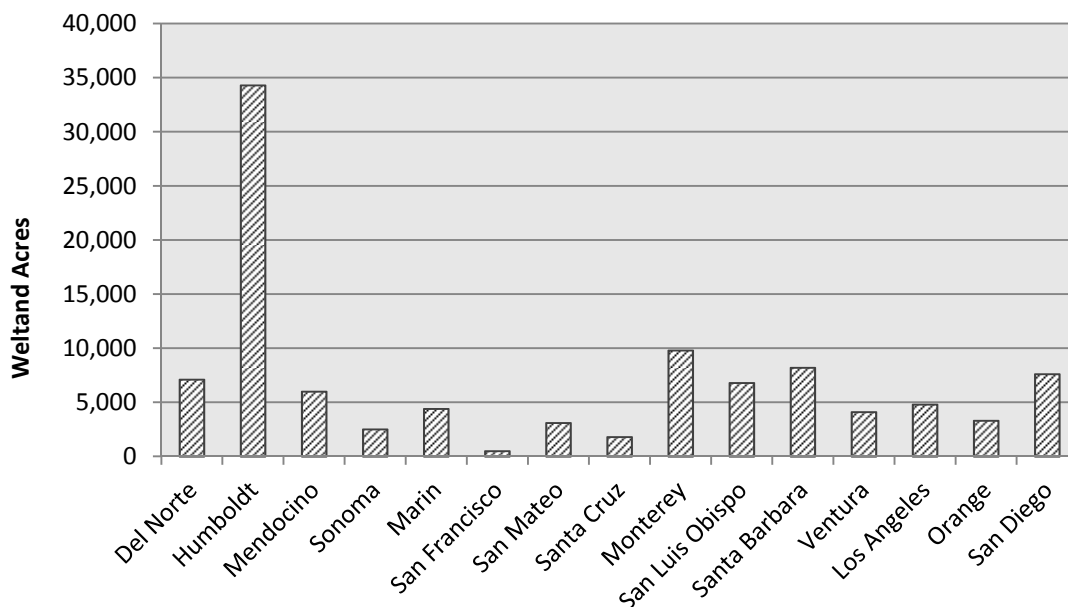


Figure 7. Existing Coastal Zone Wetlands by County (Source: National Wetlands Inventory, 2016)

The data do not exist to calculate wetland migration capacity statewide, but a 2009 Pacific Institute study evaluated land cover adjacent to existing wetlands as a proxy for migration viability (Heberger, et

al. 2009). The study found that 55% of existing wetlands could potentially migrate inland (under a 55 inches sea level rise tidal inundation scenario). Another 15% could migrate if existing parks, orchards or agricultural lands were converted to wetlands. About 30% of the upland migration area is blocked by roads, buildings or other more “permanent” land uses. Thus, while some inland areas might support wetland conversion, it would require loss of park/open space, or agricultural land, important coastal resources protected by provisions in the Coastal Act.

Planning for wetland migration buffers and/or other adaptation strategies for sustaining wetlands in the decades to come will be vital to conserving the small remaining wetland habitat area on the California coast. Wetlands have adjusted naturally to rising sea level for thousands of years through upland migration and sediment build-up within the wetland. Humans have also modified wetland zones by controlling water levels, using weirs and tide gates to mute or control the tide range. These adjustment mechanisms – upland migration, substrate elevation, and water level controls – are the key levers for sustaining coastal wetland systems. In locations where inland migration can maintain viable wetland habitat, local governments will need to consider appropriate land use policies to avoid changes to this transitional land that might preclude eventual wetland conversion. In locations where local governments cannot rely upon inland migration for wetland sustainability, some type of sediment management option for substrate elevation might be appropriate, such as sediment augmentation to allow wetlands to adapt in place to rising sea level for an interim period of time.

2.3.3 Agricultural Resources

Key Finding: Sea level rise poses significant threats to agricultural resources where it can cause an increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and/or a decrease in the amount of freshwater available for agricultural uses. Protecting agricultural resources in these cases will necessitate collaboration and long-term planning with all stakeholders, including local governments, utilities, landowners, state and federal agencies.

Sea level rise could lead to a significant increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and a decrease in the amount of freshwater available for agricultural uses. These impacts will be especially significant in in the Humboldt Bay area, Marin’s Estero Americano, Santa Cruz’s Pajaro Valley, and Ventura’s Oxnard Plain.

The Humboldt Bay region, one of the areas with the highest agricultural vulnerability, faces all of the threats noted above. Heavily diked and drained for agricultural use from 1880 to 1910, Humboldt Bay now has approximately 8,000 acres of agricultural land vulnerable to tidal inundation and flooding from shoreline breaching or overtopping, backwater effects in tributaries draining to Humboldt Bay, reduced efficiency of shoreline water control structures, rising groundwater, and salt water intrusion (Laird, 2013). These lands are critically important to the long term sustainability of Humboldt County’s agricultural economy. A majority of these vulnerable agricultural lands along Humboldt Bay are also seasonal freshwater wetlands and provide habitats for many critical species.

The California Coastal Act protects both agriculture and wetlands, and encourages restoration of lost and disturbed wetland landscapes. Because many vulnerable agricultural lands are also seasonal wetlands, management and protection of these lands are important to the policy objectives defined in the Coastal Act. With sea level rise affecting these areas, some communities will likely experience competing priorities between agricultural uses and wetland habitats. Therefore, understanding how sea level rise will affect the productivity and habitat co-benefits of agriculture lands will require: 1)

knowledge of the dikes and levees that protect them; 2) knowledge of the effects of saltwater intrusion into groundwater; 3) identification of which lands may be candidates for retreat strategies and/or marsh restoration; and 4) collaboration among all stakeholders to develop effective strategies and adaptation plans. Early collaboration and long-term planning will also be necessary in order to ensure the protection of both wetland and agricultural landscapes.

2.3.4 Energy and Other Infrastructure

Key Finding: Because of the interconnected nature of critical infrastructure, the high cost of networks and central facilities, and the long-term expectations for years of use, planning for sea level rise in infrastructure investments will be increasingly important. This planning will require proactive approaches, interagency collaboration, and funding to maintain community services in the most cost effective way.

Critical infrastructure located along the coast, such as wastewater treatment and energy plants, transportation corridors like Highway One and railroad lines, and communication networks, is increasingly vulnerable to coastal erosion and inundation that can lead to impaired functioning and/or catastrophic failure to provide essential community services. The Pacific Institute Study of California's sea level rise vulnerability estimated that existing infrastructure at risk in a 100-year flood event with 55 inches of sea level rise could result in impacts on an estimated 3,500 miles of roads and highways, 280 miles of railways, 30 coastal power plants, and 28 wastewater treatment plants – 21 on the San Francisco Bay and 7 on the Pacific coast (Heberger et al., 2009). In individual communities, any key coastal infrastructure vulnerable to sea level rise increases overall community vulnerability in coastal areas due to potential loss of essential daily services necessary to support quality of life and local economies. Thus, planning for resilient critical infrastructure before a disaster is vital and provides the opportunity to most cost-effectively maintain community services before, during, and after a major event. Failure to plan effectively will result in unnecessary costs for the maintenance, protection, and reconstruction of vulnerable critical infrastructure.

To address sea level rise vulnerability of large-scale infrastructure projects like waste water treatment plants and power plants, the Commission is generally requiring as part of its review that project proponents identify the predicted effects of sea level rise during the expected operating life of proposed infrastructure projects and identify how the project will avoid, mitigate, or retreat from those adverse effects. In 2005, for example, the Commission's approval of a desalination facility in the City of Sand City was based in part on the City successfully developing a "managed retreat" plan for those components of the facility predicted to be undermined by sea level rise or coastal erosion during the facility's operating life. In 2013, the Coastal Commission denied a permit for redevelopment of the Morro Bay Wastewater Treatment Plant in its existing location just inland of the beach in part due to unavoidable coastal hazards at the site. In 2016, the Commission approved a spent nuclear fuel storage facility at the San Onofre Nuclear Generating Station with a requirement that the location be re-assessed in 20 years (i.e., before predicted sea level rise would affect the facility) and that the facility be able to move, if needed, at that time. Also in 2016, the Commission recommended to the state's Energy Commission that it select an alternative location for a proposed power plant due to predicted flooding and coastal erosion risks during the expected life of the facility. These types of approaches, along with coordination with the companion regulatory agencies who have purview over these large infrastructure projects, will be crucial in addressing sea level rise vulnerabilities going forward.

Another area where sea level rise planning should be considered in this context is in mitigation requirements. The Coastal Commission requires mitigation for many large energy and water supply-type projects that cause unavoidable wetland and marine life loss. For example, the Poseidon Desalination Plant in Carlsbad approved by the Coastal Commission in 2007 (E-06-13) requires the establishment of a 66-acre wetland restoration project at the Otay River Floodplain in south San Diego Bay to mitigate for the loss of marine life caused by facility. The design of this mitigation project incorporates projected rising sea levels to allow the restored habitat to continue to function in the face of rising water levels, which is meant to ensure the long-term success of the mitigation project.

Planning for water infrastructure poses unique challenges for communities facing not only potential flooding and inundation, but also saltwater intrusion. A significant unknown in many areas along the coast is the timing or extent of sea level rise impacts on individual septic systems and wells, and vulnerability of other assets (whether infrastructure or even agriculture) to saltwater intrusion. There are also numerous locations with water supply concerns in multiple counties. Water quality threats exacerbated by sea level rise are important not just for small septic fields, but for some large-scale wastewater management systems throughout the state (including in Humboldt Bay's Arcata, San Francisco, San Mateo, Morro Bay, and Orange County-Huntington Beach). Reduction in wastewater treatment efficiency, increased risk of flow capacity exceedance, and saltwater intrusion into treatment systems are potential consequences of sea level rise for this type of infrastructure.

Finally, throughout the coastal zone, transportation related infrastructure assets are vulnerable to impacts from sea level rise, and these threats will increase with rising sea level. Under a scenario of a 100 year storm and 55 inches of sea level rise, threatened miles of Pacific Coast highways and roads will increase by 60 percent compared to current conditions (Heberger et al., 2009). Miles of rail line up and down the coast, including in Humboldt Bay, Elkhorn Slough, Ventura, Orange and San Diego Counties, will be flooded or put at risk due to erosion. Public transit might reduce the pressure for automobile access, and communities in several counties (e.g., Monterey and Los Angeles) are also examining threats to and opportunities for public transit. Importantly, the vulnerability of Highway 1 across the multiple regions of the California coast and the potential cost of disruption and damage could have far reaching effects on local, state, and national economies.

2.4 Interagency Coordination

Key Finding: This statewide synthesis of sea level rise vulnerability assessments highlights the importance of interagency coordination for addressing sea level rise threats that cross boundaries of individual parcels, jurisdictions, and state and federal lands.

This statewide synthesis of sea level rise vulnerability assessments has underscored the importance of multi-agency coordination for addressing vulnerabilities to achieve successful sea level rise planning in California, especially for asset types and coastal jurisdictions that are managed by other agencies (e.g., for roads/Caltrans, for public trust resources/State Lands Commission, for state parks and beaches/State Parks, for power plants/California Energy Commission). The Coastal Commission also continues to work with many other partners such as: 1) with the Coastal Conservancy on local assistance and other grant programs and public access improvements; 2) with the Federal Emergency Management Agency (FEMA) on aligning Local Coastal Program planning with the local hazard mitigation plans, which will be important for aligning federal dollars with sea level rise planning; and 3) with ports on how to address sea level rise in Port Master Plans. Through interagency coordination, the state can leverage more resources to support planning for sea level rise and begin implementation.

Transportation Networks

Recently, the Coastal Commission and Caltrans co-developed a framework for addressing sea level rise for transportation infrastructure along the coast. The Coastal Commission and Caltrans identified and agreed upon points of engagement to ensure that Coastal Commission input on sea level rise is addressed at all stages of the highway planning process. This collaboration builds on years of work with Caltrans, including work on realignment of 3 miles of Highway 1 at Piedras Blancas in San Luis Obispo County, as well as planning for sea level rise adaptation at Surfer's Beach in Half Moon Bay, and also a realignment project at Gleason Beach in Sonoma County.

Public Trust Lands

Public Trust Lands refer to all lands subject to the Common Law Public Trust for commerce, navigation, fisheries, recreation, and other public purposes. Public Trust Lands include tidelands, submerged lands, the beds of navigable lakes and rivers, and historic tidelands and submerged lands that are presently filled or reclaimed and which were subject to the Public Trust at any time. In coastal areas, the landward location and extent of these public trust lands are generally defined by reference to the ordinary high water mark, as measured by the mean high tide line; these boundaries remain ambulatory, except where there has been fill or artificial accretion. Over time, sea level rise will cause the public trust boundary to migrate inland. If seawalls or other shoreline protection structures are located on uplands that become subject to the public trust in the future, the State Lands Commission or any local government or other entity acting as trustee for public trust lands could require the structures to be removed. Thus, collaboration with agencies that are trustees of public trust lands will be important to ensure permitted development is consistent with public trust uses and prioritizes public trust needs, values, and principles.

Public Lands

Of the approximately 1.5 million acres of California coastal zone, about 16% are federal lands. Much of this land is maintained as open space, such as National Monuments, National Wildlife Refuges, National Estuarine Research Reserves (NERRs), and military bases. Very little of this land has fixed development immediately adjacent to the coast, or has shoreline protective structures along the shoreline, which means that these areas likely have higher capacity for both habitats and structures to move inland in comparison to more developed sections of the coast. Natural resources are the most vulnerable coastal asset on federal lands, followed by infrastructure and public access. Due to the large amount of the coastal zone that is in federal management, coordination between federal land managers and local government planners will be important for maintaining resilience to sea level rise. However, the level of coordination between federal landowners and nearby local governments can vary. Many federal land areas are governed by management plans; however, it appears there is little information about the extent to which these management plans address sea level rise or include adaptation measures.

In addition, about one third of the state's coastline is owned by State Parks. How the agency plans for and addresses sea level rise vulnerabilities will also have far reaching effects for the coast. Cultural resources as well as historic trails, beaches, and structures will face threats due to accelerating sea level rise.

2.5 Tribal Lands and Cultural Resources

Sea level rise also threatens tribal cultural resources and lands along the coast. Tribal communities might face additional challenges in adapting to sea level rise because they are often rooted in specific locations, making relocation or planned retreat difficult to impossible. The Coastal Commission's Sea Level Rise Guidance highlights the importance of working with tribal nations to understand areas of cultural importance and ensure that their knowledge of the land is incorporated into sea level rise vulnerability assessments and adaptation plans. Direct outreach to tribes and including them in the decision-making process is another way to ensure their knowledge is included as well as to address negative impacts that tribal nations might experience from sea level rise and their priority concerns for adaptation planning. The Commission is currently preparing additional guidance for consultation with tribes during the local planning process to facilitate engagement that respects tribal sovereignty, confidentiality, and cultural values.

2.6 Lessons Learned from Local Coastal Program Planning Case Studies

Key Finding: LCP policies to address new development, known vulnerabilities, general hazard response, and future specific adaptation methods provide the mechanism to develop resilience to sea level rise. Communities should begin planning so that actions now do not preclude future adaptation options.

LCPs are essential tools for addressing the vulnerabilities identified by this synthesis and analysis. LCPs establish the ground rules for future development and protection of resources in the coastal zone through a Land Use Plan (LUP) and an Implementation Plan (IP). The LUP specifies the kinds, locations, and intensity of allowable uses, and the IP includes measures to implement the LUP, such as zoning ordinances. LCPs are prepared by local governments and submitted to the Coastal Commission for review for consistency with Coastal Act requirements. Once an LCP's certification becomes effective, the local government becomes responsible for reviewing most Coastal Development Permit (CDP) applications. However, the Commission retains continuing permit authority over some lands (for example, over tidelands, submerged lands, and public trust lands) and authority to act on appeals for certain categories of local CDP decisions.

To be consistent with the Coastal Act hazard avoidance and resource protection policies, it is critical that local governments with coastal resources at risk from sea level rise certify or update Local Coastal Programs that provide a means to prepare for and minimize these impacts. Since many existing LCPs were certified in the 1980s and 1990s, it is important that future amendments or updates of LCPs consider sea level rise and adaptation planning at the project and community level, as appropriate. Although the existing LCP certification and update processes are still the same, sea level rise calls for new regional planning approaches, new strategies, and enhanced community participation.

This project highlights some recent LCP update efforts that demonstrate a variety of approaches to updating LCPs to address sea level rise. Case studies for four jurisdictions—Marin, Pacific Grove, Goleta, and Newport Beach—were developed to understand how communities are addressing sea level rise in LCP certification and update efforts. These jurisdictions were chosen because they are all in the process of developing LCP updates to address sea level rise with grant support from the Coastal Commission, and because they represent a variety of geographic areas as well as different planning approaches (See Appendix B).

While each of these case study jurisdictions has completed some level of LCP policy development to address sea level rise, the policy work for each LCP relied on different levels of vulnerability assessment and adaptation planning. For example, Marin, Pacific Grove, and Goleta all completed sea level rise vulnerability assessments, though using modeling and tools of differing sophistication. Additionally, Goleta performed an analysis of the fiscal implications of sea level rise impacts and potential adaptation responses, and Marin has been working on a standalone adaptation plan that identifies and analyzes potential adaptation strategies. Pacific Grove has not completed any additional studies related to sea level rise impacts or adaptation planning. As somewhat of an outlier, the City of Newport Beach used LCP grant funding to complete the certification of a new Implementation Plan without any separate sea level rise vulnerability assessment or adaptation planning, and the LCP does include policies to address hazards posed by rising seas.

Lessons Learned

Although Commission staff will continue to examine the progress of adaptation planning and LCP updates, a number of lessons learned were drawn from the four local case studies. For performing vulnerability assessments, the level of vulnerability detail matters in terms of how information will be translated into adaptation approaches and LCP policies. Both Goleta and Marin have more detailed vulnerability assessments with more locally specific modelling than Pacific Grove, and therefore have more actionable information regarding timing and extent of impacts. However, highly detailed vulnerability assessments based on the most technologically advanced modelling, is not possible or even necessary in all circumstances. As the work completed by Pacific Grove shows, any amount of assessment will provide valuable information for adaptation planning, and limitations can be somewhat alleviated by clearly stating any information gaps or assumptions; by qualitatively describing what these shortcomings mean in terms of identified (or unidentified) vulnerabilities; by including adaptive LCP policies; and by committing to continuing assessment and planning work.

For adaptation planning, a separate adaptation planning stage in between the vulnerability assessment and LCP policy development stages, or as a follow-up effort to trigger a second round of policy development, is a useful approach. This allows for a broader discussion of preferred adaptation approaches with stakeholders, without the need to identify specific policy language early on in the process. All of these four case studies show the critical need for LCP policies to be adaptive. Implicit in most of these lessons learned is that information available to local jurisdictions regarding sea level rise impacts and possible adaptation responses is continually evolving. This of course makes policy development a challenge, but ensuring protection of coastal resources over time requires planning now rather than waiting for highly detailed information. Thus, laying out a set of LCP policies to address new development and known existing vulnerabilities combined with policies related to general hazard response and future specific adaptation methods is important. Pacific Grove's draft LCP uses this approach. Newport Beach is also a good example showing how a baseline set of LCP policies to address sea level rise can be developed even without the benefit of a vulnerability assessment. The important point is to begin planning now so that actions are not taken that would preclude future adaptation options.

3. Summary of Key Findings, Conclusions and Next Steps

Each coastal county has characteristics and coastal resources that make that coastal area unique. The available vulnerability assessments, staff surveys and studies provide details on the specific assets and resources that could be at risk now or in the future due to sea level rise. The *LCP Case Studies*, *County Snapshots*, and this *Statewide Synthesis Report* highlight the major threats to coastal resources, lessons learned from LCP planning for sea level rise and adaptation, and needs for greater focus on key coastal resources, economic drivers, utilities and infrastructure, issues of environmental justice and public trust, and opportunities for interagency coordination. Despite the location-specific nature of most vulnerability, many common themes emerged through this project. While each community will need to address its vulnerabilities, asset risks and options for adaptation, the common themes signify opportunities for communities to work collaboratively to address sea level rise and learn from one another in finding solutions.

3.1 Common Themes

Most vulnerability assessments reviewed were in agreement with sea level rise scenarios that were presented in the *California Coastal Commission Sea Level Rise Policy Guidance*. Moving forward, it will be important for planning efforts to continue to rely on the current best available science on sea level rise. Because the science is developing and future sea level projections are trending higher, planners should include mechanisms to trigger periodic reassessment of their LCPs and other planning documents to capture any new or changing information.

Beaches, coastal access, and coastal recreation areas will be vulnerable to sea level rise in all coastal counties. In more rural areas, the risks are from inundation of beach areas and roads, erosion of upland trails, and the loss of vertical access. In more urban areas, the largest threat to these areas arises from efforts to protect inland development from flooding and erosion. Protection of inland development through the use of shoreline armoring will restrict the inland migration of a beach. Likewise, the inland migration of beaches and natural erosion of coastal bluffs will threaten inland development.

Most vulnerability assessments recognize the importance of beaches, beach access and beach recreation to coastal communities; however most of the analyses focused on risks to the built environment and failed to fully consider the accompanying threat to beaches and other natural coastal systems. Nevertheless, decisions on how the built environment will adapt to these current and future threats and the role that armoring plays in future adaptation will greatly affect beach area, access and recreation.

Communities are examining multiple options--some that could add to the stresses on beach resources and have adverse impacts on the beach economy and some that could put limitations on armoring and promote more beach use and recreational opportunities. Some counties, like Santa Cruz and Ventura, that already have a high percentage of armored shoreline, will likely experience pressure to rely upon armoring for currently unarmored sections of the coast. Communities in Santa Cruz, Ventura and Los Angeles Counties could use regional sediment management as an option to relieve some of the pressure for shoreline armoring or to slow the loss of beach area due to sea level rise. These communities, along with some communities in Orange County, are also considering revised standards for future shoreline protection. Marin, Orange, and San Diego Counties are trying to address issues of expansion and redevelopment in areas of high hazard. San Luis Obispo and San Mateo Counties are considering the development of criteria or an analytic framework that might be used to initiate managed retreat.

Habitat protection and provisions for habitat migration are important concerns for many coastal counties. Some counties highlighted the need to better understand and quantify the benefits from natural coastal systems; others focused more on the need to test out and study options for adaptation, such as thin sediment applications or living shoreline projects.

Protection of agricultural lands is also important in several coastal counties. However, large areas of coastal agriculture exist now on former converted or diked wetlands. Efforts to protect the agricultural function of these lands, through maintenance or expansion of the dikes, can result in space conflicts with adjacent wetlands that need the same space for inland migration. Other threats to coastal agriculture include salt water intrusion, diminished fresh water supplies and more frequent erosive high flow events.

Transportation vulnerability was another common theme apparent in many counties. Many sections of coastal highways (PCH or Route 1) will be vulnerable to flooding or coastal erosion. Threatened sections of Highway 1 in San Luis Obispo and San Mateo and a section of the Great Highway in San Francisco have been moved inland and Caltrans is analyzing inland rerouting for other highway sections in San Mateo, Sonoma and Mendocino Counties. Miles of rail line up and down the coast, including in Humboldt Bay, Elkhorn Slough, Ventura, Orange and San Diego Counties will be flooded or put at risk due to erosion. The railroad is already analyzing inland rerouting of sections of rail corridors in Orange and San Diego Counties and more rerouting will be likely in the future. Parking is an element of vehicle travel and in San Francisco, Los Angeles and Orange Counties beach parking is being threatened by erosion, forcing tradeoffs between land for beach use and land for beach access. Public transit might reduce the pressure for automobile access and communities in several counties are also examining threats to and opportunities for public transit. In Monterey County some existing public transit will be vulnerable to rising sea level, while in Los Angeles County, public transit is being analyzed as an option to optimize use of existing travel routes.

Finally, many coastal counties have important energy, water or wastewater facilities in areas that are or will be vulnerable to flooding and erosion. Risk to the main facilities can often be identified; however, underground utilities and pipe routes are less easy to assess, yet damage to these components of the system can affect service to either local areas or system-wide, depending on the type of loss. In many counties, it will be important to understand the vulnerabilities to the buried utility components, as well as the service interdependencies. Failure of one utility service could have cascading effects to other utilities and a good understanding of these linkages will be important to the full understanding of community vulnerabilities.

3.2 LCP Planning

As discussed, sea level rise planning is underway in California through the Commission's LCP Program. Most of the work to date has been focused on gaining a more detailed understanding of sea level rise vulnerability at the local level. Although local governments have made great strides on this effort, especially related to the vulnerability of structures, additional attention needs to be focused on the vulnerability of coastal resources, including sandy beaches, dunes, and wetlands.

After vulnerability assessments are completed, the next major step will be to develop adaptation plans and certify LCP policies that reduce risks while protecting and preserving coastal resources. In many cases, adaptation and LCP policies will need to phase approaches (such as protection, accommodation, or retreat) in order to be successful. For example, beach nourishment along developed stretches of coast may be a feasible option to sustain sandy beaches for an interim period of time, while planned

retreat will be necessary in the long run to ensure the protection of beaches and other coastal resources for future generations. In many areas, planned retreat might eventually be the only adaptation approach that will save beaches, dunes and wetlands from inundation and ensure safety of development.

Developing adaptation plans and certifying LCPs that address sea level rise consistent with the Coastal Act is difficult for many reasons. First, local governments are not required by law to update LCPs to address sea level rise, and therefore, there is no legal mechanism to ensure that planning processes are completed to certification. Second, state and local decision makers are often focused on the short term impacts they are faced with during their time in office and are sometimes hesitant to address the long-term challenges of sea level rise. Moreover, the constituents who are most often vocal in the public discourse are the property owners whose economic investments may be viewed as threatened by longer term adaptation options like planned retreat. This can lead to pursuit of adaptation strategies that protect development, but do not always protect coastal resources over the long term, which sustain the state's economy and way of life and support public access and recreational opportunities for a much larger portion of the populace. As discussed earlier in this report, the loss of public access and recreational opportunities provided by beaches and other public areas is also a critical environmental and social justice issue that also requires more attention and study moving forward.

Third, there is not currently adequate funding for addressing sea level rise in all LCPs and to begin implementing adaptation approaches. Without additional funding for sea level rise planning and implementation, local governments and other entities are reluctant to even consider all potential options for addressing sea level rise, because they are considered economically infeasible. This again encourages protective approaches that are less costly in the short term, but potentially more damaging to coastal resources in the long term, especially in terms of the long term economic vitality and ecosystem services these resources provide.

Planning for sea level rise now is a more cost effective way to respond to sea level rise hazards because adaptation costs will increase in the future. This is because right now, most development that is being constructed has an economic life of 75 to 100 years or longer. Outdated LCPs continue to allow development to occur in areas that will be subject to coastal hazards over their economic life. In the future, much of this development will either remain in hazardous shoreline areas, eliminating beaches, dunes and wetlands as they migrate inland, and impairing the associated economic and ecosystem services; or, the development will be threatened or damaged, hurting private and public investments and requiring costly repair or removal that the government and taxpayers could be burdened with. Implementing LCP policies now that limit development in future hazardous areas and require property owners to bear the costs of relocation and removal in the future, will help avoid this future statewide dilemma. It will also protect investment in new development by guiding it to areas that are safe from future hazards.

Finally, local governments also face a challenge in that successful adaptation to sea level rise almost always requires coordination with entities outside their own jurisdiction and over whom they may have little influence. For example, many segments of highways and railroads are located in close proximity to the shoreline and in some cases act as lateral barriers to successful managed retreat. As sea level rises, coastal resources will be lost to inundation as they are caught between rising seas and lateral infrastructure or other development. Therefore, even if a local government intends to proactively plan to sustain their precious coastal resources over time, they may face challenges if they do not have a willing and active partnership established with key landowners and relevant agencies.

To address these challenges two important next steps to address known vulnerabilities and plan for sea level rise going forward are: (1) educating the public, decision makers and other key stakeholders about likely future impacts from sea level rise to ensure decisions reflect a broad understanding of future impacts and address the needs of all people equally, and; (2) creating a stable and adequate funding source for implementation of sea level rise adaptation plans and strategies that protect and preserve coastal resources, so that local governments can evaluate these options through the LCP planning process, leading to prudent adaptation approaches that protect the state's economy and environment for future generations.

3.3 Interagency Coordination

Interagency coordination at the state level is also critical to successfully addressing sea level rise in California. The Commission will continue to engage with key state agencies, including but not limited to Caltrans, the Coastal Conservancy, SWRCB, the Department of Water Resources, State Lands Commission, State Parks, the Ocean Protection Council and the Governor's Office of Planning and Research. Through these partnerships, the Coastal Commission will continue to track and disseminate the latest science-based sea level rise projections, impacts, and adaptation best practices, as well as ensure alignment between state efforts on climate change adaptation.

As discussed above, a significant partnership agreement has been made between Caltrans and the Coastal Commission to address sea level rise in the state highway system. In addition, the coordination efforts between the State Lands Commission and the Coastal Commission will be strengthened through a federally-funded grant project that is currently underway. State Parks is another key landowner along the coast; therefore, an important next step will be for the Commission to continue to build on its collaborative relationship with State Parks and engage on planning for sea level rise on State Parks' property statewide. In addition, a vulnerability assessment of state park resources conducted by the State Coastal Conservancy that will soon be made available will be critical to informing future efforts on addressing sea level rise vulnerabilities to coastal state park and beach resources.

Finally, continued technical and financial assistance from the National Oceanic and Atmospheric Administration (NOAA) through our partnership under the Coastal Zone Management Act (CZMA) is critical to the Commission's ability to further its sea level rise planning work, to provide guidance to local governments, and to addressing sea level rise in our regulatory work. In addition, the Commission should continue coordination and training with FEMA, other state agencies and local officials on aligning Local Coastal Program planning with local hazard mitigation plans, which will be important for aligning federal funding opportunities with state sea level rise planning efforts.

3.4 Environmental Justice

Environmental justice is critical to address in all aspects of sea level rise planning. To address the lack of information on social vulnerabilities to sea level rise in current vulnerability assessments, the Commission should ensure that future vulnerability studies identify social vulnerabilities in coastal communities throughout the state. Special efforts should be made to ensure traditionally underserved or under-represented communities are engaged in local assessments and planning efforts in addition to being made aware of the impacts of sea level rise in their communities and the coastal resources they may rely upon.

In addition, starting in 2017, a new law (AB 2616) gives the Coastal Commission explicit authority to consider environmental justice in its permit decisions. This will allow the Coastal Commission to more directly evaluate and address impacts of a proposed project that might pose undue or disproportionate

burdens on certain segments of the populations or groups of people both in and outside the coastal zone.

In conclusion, this *Statewide Synthesis Report* provides many important key findings about California's vulnerabilities to sea level rise throughout the coastal areas of the state. These findings, the *County Snapshots* and the *LCP Case Studies* will be used to guide and promote future efforts, including in funding decisions on LCP local assistance grants and for pursuing financial support to address identified gaps and needs for additional information on sea level rise vulnerabilities and impacts.

Key Findings

Ocean Economy: The Ocean Economy makes up a significant portion of California's total economy. Communities should analyze the impacts of sea level rise on economic livelihood and assess the related impacts to their local ocean economy, especially tourism and recreation.

Risks to Populations: The largest coastal zone populations vulnerable to flooding from a 100-year storm plus 55 inches sea level rise are in Los Angeles, Orange, and San Diego counties.

Environmental Justice and Social Vulnerability: Many vulnerability assessments did not account for the full range of social impacts linked to sea level rise. Vulnerability to hazards from sea level rise will have a disproportionate impact on communities with the least capacity to adapt; as such, a comprehensive approach to assessing social vulnerabilities should be used going forward to identify communities that may have higher vulnerabilities due to socio-economic factors and other risks that may be present in that community. Furthermore, as sea levels rise and public access points and recreational opportunities are lost, public access opportunities will become fewer and more limited for those who cannot afford to live at the coast.

Development and Shoreline Protective Devices: Despite many miles of existing armoring, erosion will continue to threaten existing developed areas in vulnerable communities, and this threat will increase with rising sea level.

Public Access and Recreation: Public access and recreational assets are threatened by sea level rise in every county. However, with planning, funding, and collaboration, local governments can lay the groundwork for resilient public access ways and preservation of beach areas, even as sea levels rise. Beaches: Vulnerable Habitat and Open Space: Many communities have not yet addressed the vulnerability of their sandy beaches to rising sea levels. Of those assessments that did evaluate sediment management and beach replenishment to maintain beach area as sea levels rise, few examined the ecological consequences or the long-term economic feasibility of these responses.

Wetlands and Other Vulnerable Habitat: As sea levels rise, wetland habitat will be lost unless it can migrate inland or accrete upward. Thus, planning for wetland migration buffers and/or other adaptation strategies for sustaining wetlands will be vital to conserving the remaining wetland habitat area on the California coast.

Agricultural Resources: Sea level rise poses significant threats to agricultural resources where it can cause an increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and/or a decrease in the amount of freshwater available for agricultural uses. Protecting agricultural resources in these cases will necessitate collaboration and long-term planning with all stakeholders, including local governments, utilities, landowners, state and federal agencies.

Energy and Other Infrastructure: Because of the interconnected nature of critical infrastructure, the high cost of networks and central facilities, and the long-term expectations for years of use, planning for sea level rise in infrastructure investments will be increasingly important. This planning will require proactive approaches, interagency collaboration, and funding to maintain community services in the most cost effective way.

Interagency Coordination: This statewide synthesis of sea level rise vulnerability assessments highlights the importance of interagency coordination for addressing sea level rise threats that cross boundaries of individual parcels, jurisdictions, and state and federal lands.

Lessons Learned from Local Coastal Program Planning Case Studies: LCP policies to address new development, known vulnerabilities, general hazard response, and future specific adaptation methods provide the mechanism to develop resilience to sea level rise. Communities should begin planning so that actions now do not preclude future adaptation options.

4. References

- California Coastal Commission. 2016. YourCoast Accessway Data.
<https://www.coastal.ca.gov/YourCoast/#/map>
- California Coastal Commission. 2015. Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. Sacramento, CA. <https://www.coastal.ca.gov/climate/slrguidance.html>.
- California Coastal Commission. 2004. Coastal Armoring Inventory prepared by J. Dare.
- California Department of Public Health Office of Health and Equity and University of California Department of Public Health Sciences, Davis, California. 2015. "Climate and Health Profiles Report. Orange County." <https://www.cdph.ca.gov/programs/Pages/CalBRACE-ClimateHealthProfiles.aspx>.
- California Natural Resources Agency (CNRA). 2010. State of the State's Wetlands: 10 Years of Challenges and Progress. 42pp.
http://www.resources.ca.gov/docs/SOSW_report_with_cover_memo_10182010.pdf.
- California Natural Resources Agency (CNRA). 2014. *Safeguarding California: Reducing Climate Risk. An update to the 2009 California Climate Assessment*. 343pp.
http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf.
- DeConto, R. M., & Pollard, D. 2016. Contribution of Antarctica to past and future sea-level rise. *Nature*, 531(7596), 591-597.
- Defeo, O., McLachlan, A., Schoeman, D.S., Schlacher, T.A., Dugan, J., Jones, A., Lastra, M. and Scapini, F., 2009. Threats to sandy beach ecosystems: a review. *Estuarine, Coastal and Shelf Science*, 81(1):1-12.
- Griggs, G.B., Patsch, K. and Savoy, L.E., 2005. Living with the changing California Coast. 1st ed., University of California Press, www.jstor.org/stable/10.1525/j.ctt1pppdw.
- Heberger M., H. Cooley, P. Herrera, P.H. Gleick, E. Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center.
- Laird, A. 2013. "Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase 1. Shoreline Inventory, Mapping, and Vulnerability Assessment." Prepared by Trinity Associates.
- National Ocean Economics Program (NOEP). 2016. Coastal and Ocean Economic Summaries

of the Coastal States for 2013.

<http://www.oceaneconomics.org/Market/ocean/oceanEcon.asp>

National Research Council (NRC). 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Report by the Committee on Sea Level Rise in California, Oregon, and Washington. National Academies Press, Washington, DC. 250 pp. <http://www.nap.edu/catalog/13389/sea-level-rise-for-the-coasts-of-california-oregon-and-washington>.

National Wetlands Inventory (NWI). 2016. <https://www.fws.gov/wetlands/data/State-Downloads.html>

U.S. Army Corps of Engineers. 1971. National Shoreline Study, California Regional Inventory. U.S. Army Engineer Division, South Pacific, San Francisco, CA.

U.S. Census Blocks. 2010. Population Data
https://www.census.gov/geo/reference/gtc/gtc_block.html.

Appendices

Appendix A. County Snapshots



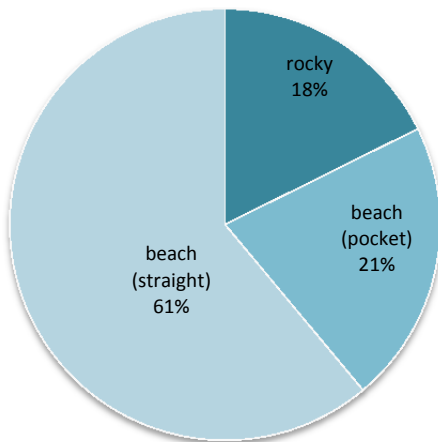
Del Norte County

Coastal Zone



Del Norte County has approximately 49 miles of shoreline extending from the Oregon border to the Humboldt County line. Much of the coastline is sandy beach while rocky shores and rugged beaches also provide significant habitat for coastal species. The county contains special rural communities and tribal lands of several Native American tribes (e.g. the Yurok tribe and the Tolowa Dee-ni Nation). The 39,680 acres (62 square miles) of terrestrial coastal zone also includes significant forest, agriculture and fisheries resources, state beaches and parks that protect coastal redwood habitat and provide access and recreation, and extensive coastal dunes. Key wetland areas are at Lakes Earl and Talawa and at the mouth of the Smith and Klamath Rivers. In addition, the Crescent City Harbor lies just south of the City of Crescent City, and provides significant moorage for commercial fishing and recreational vessels.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Crescent City, Klamath
 Publicly Owned/Accessible: 15,300 acres
 Public Access Coastal Areas: 47 locations
 Coastal Zone Wetlands: 7,100 acres

Ocean Economy

2013 County Ocean Sectors GDP \$51.0 M

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$28.2 M
Living Resources GDP	\$17.0 M

0.1%
of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Accounting for 0.1% of the state's total ocean sector Gross Domestic Product (GDP), Del Norte County's ocean economy is comprised mainly of tourism and recreation, and living resources sectors. Living Resources includes all fish hatcheries, aquaculture, fishing, seafood markets, and seafood processing. While tourism and recreation GDP is about 50% larger than that of the living resource sector, this industry employs ten times the number of people. Impacts from sea level rise can affect the tourism and recreation assets (harbors, beaches) and living resources (e.g. fisher closures due to ocean conditions or shifts in species locations).



Del Norte County

Hazards and Vulnerability

Del Norte County is the northernmost county in California and is less developed than most coastal counties in the state. While the county lacks a comprehensive assessment of sea level rise hazards and would benefit from a county specific vulnerability study, Commission staff identified areas of concern based on their professional experience and expertise. Sea level rise poses threats to development, agriculture, and habitat in Del Norte County, though tectonic uplift is a mitigating factor. A Cascadia earthquake, however, could result in a massive subsidence event that would expose large areas to higher sea levels [1]. Understanding the effects of extreme precipitation events on river flows combined with sea level rise and storms is a data gap in



Vulnerable Development near Elk Creek, Del Norte County

The Crescent City airport near Point St. George has possible erosion/bluff retreat issues, and vulnerable wetlands and sensitive habitats [1].

Crescent City harbor repeatedly experienced significant tsunami damage (most recently from 2006 and 2011 earthquakes off the coast of Japan) and despite reconstruction, it remains vulnerable to extreme events combined with rising sea level [1].

Del Norte County also has infrastructure that is vulnerable to sea level rise. The county's wastewater treatment plant has been identified as a vulnerable asset [1]. Some regions of Highway 101 (e.g. Last Chance

Population at risk to 100yr Flood
 1,800 = current risk | 2,600 = future w/
 1.4m SLR
 Source: Heberger et al., 2009

Potential Bluff Erosion Risk w/ 1.4m SLR
 700 properties | 620 people
 Source: Heberger et al., 2009, County parcel data

the county and will also be especially important to understanding flooding risks at river mouths.

In the northernmost part of the county, the Smith River area has low lying dunes and vulnerable agricultural land [1]. Many of the agricultural lands are protected by older levees, which may be vulnerable to increased storms, flooding, and rising sea levels. South of the Smith River, a wide sandy beach extends to Lakes Talawa and Earl, where development already experiences flooding and where protection of sensitive habitat area is a concern [1].

Grade, Crescent Beach and Wilson Creek and Beach), bridges, and parking lots have experienced flooding, landslides, and have been noted as highly vulnerable to future sea level rise [1]. Mass wasting earthflows also currently threaten Highway 101 and planning to reroute those sections of the road has begun [1].

The county has many natural resources, several of which have been recognized as vulnerable to rising sea levels and increased storm surge. Wetlands, marshes, state and national parks, rivers, and beaches have all begun to experience negative impacts from rising sea levels [1]. The loss of these resources will also likely reduce or eliminate public access and recreation at these places.



Del Norte County

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. No local governments in Del Norte County have applied or been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have studies or LCPs that address sea level rise. While staff reviewed a Caltrans vulnerability assessment focused on roads for a region that included Del Norte County, it is not listed as a vulnerability study because it does not go into the level of detail necessary to be useful at the LCP segment planning scale [3]. "In part" means an LCP segment has some explicit policy language addressing sea level rise.

Table 1. LCP Planning in Del Norte County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction
Del Norte County	No	No	No	No	50%
County Segment	Yes (1983)	No	No	No	
Harbor Segment	Yes (1987)	No	No	No	
Lopez Creek Segment	Yes (1987)	No	No	No	
Pt. St. George Segment	No	No	No	No	
City of Crescent City					3%
Crescent City Segment	Yes (1983)	No	No	In Part	
McNamara-Gillespie Segment	Yes (1984)	No	No	No	
Federal Lands and Ports					47%

Coastal Act Management Priorities

Priority sea level rise adaptation issues in Del Norte County include coordinating with other agencies to protect natural habitat, to preserve agricultural land, and to evaluate and address vulnerabilities to important public infrastructure and development such as the Crescent City Harbor, U.S. Highway 101, and certain County roads. As this county is relatively undeveloped, more agriculture and sensitive natural resources are vulnerable to sea level rise impacts.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Where marsh, lagoon, and tidal estuarine habitat, near the mouths of major rivers habitat is vulnerable to sea level rise, opportunities for habitats to migrate inland should be evaluated as potential adaptation strategies (e.g., South of Crescent city near Highway 101). Some adaptation strategies might require advanced actions now in order to ensure those strategies are viable in the future (i.e. protecting lands adjacent to wetlands to ensure they have room to move).



Del Norte County

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Del Norte County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. Collaboration with the state with tribal governments and the National Park Service will be important to plan for possible sea level rise impacts on public access, recreation, and cultural resources along the county coastline because of its substantial natural resources and park lands.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Many developed areas in Del Norte County already experience hazards related to bluff erosion and flooding (e.g., Crescent City, Klamath town site, and the bluffs north of the Smith River). While Crescent City has updated its LCP with some sea level rise policies, more work remains to be done on addressing growing risks to existing development. The potential for flooding of Highway 101 and habitat loss in Crescent City requires further study. The tide gate at Elk Creek currently provides flood protection to developed areas (that occasionally experience coastal flooding), but the gate's expected performance under sea level rise scenarios is unknown. The city has a Tsunami Ready program and efforts to promote tsunami-resilient development should also be examined for possible benefits in adaptation to rising sea level. Another important issue for improving understanding of hazards in the northern part of the county relates to the pace of regional uplift, and how long it might outpace sea level rise.

Additional Consideration

- More information is needed for planners to make informed decisions about future relative sea level rise, accounting for regional uplift, riverine flooding, and possible co-seismic subsidence.
- More information is needed county-wide, to describe flooding and erosion risks posed to agricultural resources, development, and infrastructure.
- Increased river flows and extreme storm conditions may be an issue in this county because there are no dams regulating river flows. The combination of river flows in high precipitation events with sea level rise and storm conditions will likely cause backwater flooding and erosion of river channels. As such, there is a need for hydraulic modeling of river flows, precipitation events, and ocean processes to better understand flood risks in these river mouth areas.
- Multi-agency coordination and collaboration among local governments, Caltrans, Crescent City Harbor District, and local utilities will be needed to include sea level rise adaptation in new infrastructure projects, regional transportation plans, and planning for Crescent City Harbor.

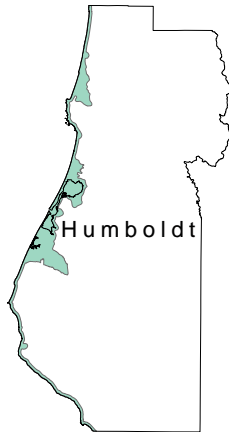
References

- [1] California Coastal Commission North Coast District Staff Interview. July 18, 2016.
- [2] [Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. *The Impacts of Sea-Level Rise on the California Coast*. Prepared by the Pacific Institute for the California Climate Change Center.](#)
- [3] [GHD, ESA PWA, Trinity Associates. 2014. "District 1 Climate Change Vulnerability Assessment and Pilot Studies FHWA Climate Resilience Pilot Final Report."](#)



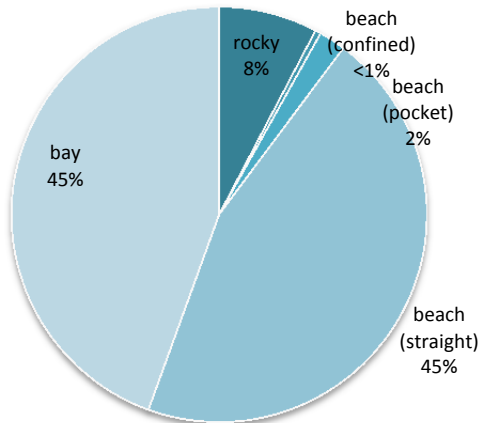
Humboldt County

Coastal Zone



With approximately 124 miles of mainland outer shoreline, plus an additional 390 miles of other shoreline which includes Humboldt Bay and many riverine areas, Humboldt County leads the state with the most coastal wetlands (44% of the state total), as well as the greatest intertidal frontage. The terrestrial coastal zone is approximately 130,000 acres. Humboldt Bay is the second largest natural bay in California and the largest estuary between San Francisco Bay and Coos Bay, Oregon. The bay is a significant harbor for port-related commercial and industrial uses as well as valuable for its ecological (especially eelgrass and salmonids), aesthetic, and recreational resources. Historically, the bay supported 10,000 acres of tidal marsh habitats. Since the mid- 1800s, the majority of the historic tidelands were diked or filled, and today, only 10% of the historic tidal marsh habitat remains. Federal lands, such as the Humboldt Bay National Wildlife Refuge and Bureau of Land Management areas of Samoa Dunes and King Range National Conservation area, support conservation for coastal resources and complex marine and dune ecosystems as well as providing additional recreation areas in Humboldt’s coastal zone.

Outer Coast Shoreline (includes Humboldt Bay)



Coastal Zone Resources

- Ports & Harbors: Humboldt Bay, Trinidad, Shelter Cove
- Publicly Owned/Accessible: 29,500 acres
- Public Access Coastal Areas: 104 locations
- Coastal Zone Wetlands: 34,300 acres

Ocean Economy

2013 County Ocean Sectors GDP **\$151 M**

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$118 M
Living Resources GDP	\$17 M
Transportation GDP	\$2.2 M

0.4%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

While Humboldt County accounts for only 0.4% of the state’s total ocean sector Gross Domestic Product (GDP), roughly 77% of the county’s ocean economy relies on tourism and recreation. Many individuals travel to Humboldt County to enjoy its natural beauty: its national and state parks, pristine beaches, camping, and fishing. Many of these activities could be limited by rising sea levels, and negatively affect the county’s economy. The county also has a large fishing economy. Humboldt Bay, declared the “Oyster Capital of California” by the state legislature [1], supports 70% of the state’s aquaculture (oysters, clams). Although not part of the ocean economy, coastal agricultural also contribute to the county’s economy and a loss of agricultural lands to sea level rise could also have negative economic impacts.



Humboldt County

Hazards and Vulnerability

Multiple vulnerability assessments conducted in Humboldt County identified several imminent vulnerabilities to sea level rise. Although most of the Pacific Northwest coastline north of Cape Mendocino is actively experiencing vertical land uplift, the Humboldt Bay region is experiencing a significant rate of land subsidence, and its average rate of sea level rise is the highest in the state [2,4]. Subsidence, tectonic uplift, and soil compaction could affect inundation with future sea level rise, highlighting the importance of local adjustments for vertical land motion. For Humboldt Bay, the vulnerability assessments demonstrate that sea level rise will have significant implications for daily tidal water level changes as well as storm flooding [2-7].



Pasture near Liscom Slough during a King Tide, Arcata CA, Dec 2012

and local roads, urban residential and commercial areas, cultural resources, and thousands of acres of agricultural lands are located in areas

vulnerable to inundation if the dikes and levees are breached or overtopped. The Cities of Eureka and Arcata identified similar vulnerabilities to those in Humboldt County's jurisdiction. The City of Eureka developed its own assessments for priority assets using

Outer Pacific Coast Population* at risk to 100yr Flood
 3,700 = current risk | 7,800 = future w/ 1.4m SLR Source: Heberger et al., 2009

**Note that if Humboldt Bay coastal population is considered, the population at risk to 100-year storm flooding with 1.5 m sea level rise will be significantly higher [1,2].*

The 2013 Humboldt Bay Shoreline Inventory, Mapping and Sea Level Rise Vulnerability Assessment found that 50% of Humboldt Bay's 102-mile long shoreline is composed of artificial dike and railroad structures constructed over 100 years ago and in varying stages of disrepair. Some 26 miles of shoreline are rated as highly vulnerable to breaching and/or overtopping under today's higher high tide events [2]. Using sea level rise projections of 12 inches by 2050 and 36 inches by 2100, the study shows that numerous critical regional assets and coastal resources in the county, including municipal utility and storm water infrastructure, state highways

Potential Dune/Bluff Erosion Risk with 1.4m SLR
 570 properties | 580 people
 Source: Heberger et al., 2009

vulnerability work done for Humboldt Bay. Failure of the dikes and levees could threaten the Eureka's sewer lines and lift stations which could overwhelm the city's wastewater treatment plant, its primary drinking water transmission lines, natural gas lines, U.S. Highway 101, Murray Field airport, streets, commercial, and agricultural properties, state wildlife refuges and valuable coastal wetlands and wildlife habitats [4]. Other high priority assets in low-lying areas threatened by 2050 (with 1.9ft sea level rise) are commercial fishing docks and facilities and recreational boating docks and launches [4]. The Eureka Vulnerability and Risk Assessment report also states that by 2100, 80% of the coastal zone in the city could become subject to tidal inundation [4], putting land uses and development, utilities, roads, coastal resources and public access at risk. Breaching or overtopping of the shoreline on Arcata Bay has the potential to flood the City of Arcata's wastewater treatment facility and the City's marsh and wildlife area in addition to residential and industrial properties [2].



Humboldt County

The City of Trinidad’s vulnerability assessment identified that an increase in mean sea level could reduce the size of public beaches, increase coastal bluff erosion, and threaten Trinidad harbor as

well as land uses adjacent to coastal bluffs [3]. These effects would also reduce public access and recreational opportunities there.

SEA LEVEL RISE VULNERABILITY AND HUMBOLDT BAY

In March 2015, a group of California state coastal agencies, including the California Coastal Commission, sponsored a one-day workshop in Eureka for stakeholders and partners from Humboldt Bay to learn about local and regional priorities as well as to discuss opportunities for state agencies to support the region and communities working on sea level rise planning and adaptation projects. As a result of the feedback from community members at the workshop, state agencies concluded that the top ten priority issues or areas for sea level rise planning were:

- | | |
|--------------------------------------|---------------------------|
| 1. Natural resources | 6. Utilities |
| 2. Dikes & levees | 7. Wastewater |
| 3. Agricultural lands | 8. Local economic impacts |
| 4. Transportation | 9. Stormwater |
| 5. Saltwater intrusion & groundwater | 10. Education & outreach |



Workshop participants found priority needs to involve planning for reinforcement of dikes and levees, engaging utilities in identifying vulnerable buried infrastructure, and collecting data on sediment dynamics, dune ecosystem processes, and groundwater vulnerabilities. Lastly, developing capacity to address sea level rise will be crucial as a variety of public and private entities will need to be engaged for effective regional planning. This direct community feedback can be used to help focus state and regional efforts for future sea level rise planning, regional collaboration and inter-agency work.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the Humboldt Bay Segment (Round 1 and 2) and the Cities of Trinidad (Round 2) and Arcata (Round 1) have all been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise.



Humboldt County

Table 1. LCP Planning in Humboldt County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
Humboldt County	No		Yes [2,5,6,7]	No	72%
Northcoast segment	Yes (1986)	No	No	No	
Trinidad Area Segment	Yes (1986)	No	No	No	
McKinleyville Segment	Yes (1986)	No	No	No	
Humboldt Bay Segment	Yes (1986)	SCC, OPC, CCC	Yes [2,5,6,7]	In Progress	
Eel River Segment	Yes (1986)	No	No	No	
Southcoast Segment	Yes (1986)	No	No	No	
City of Trinidad	Yes (1980)	CCC	Yes [3,6]	In Progress	1%
City of Arcata	Yes (1989)	CCC	Yes [2,5,6,7]	In Progress	2%
City of Eureka	Yes (1984)	OPC	Yes [2,4,5,6,7]	In Progress	9%
City of Fortuna	No	No	No	No	<1%
Federal Lands and Ports					16%

Coastal Act Management Priorities

Humboldt County faces significant sea level rise risks in many sectors, including coastal agriculture. The natural and built assets in and around Humboldt Bay are particularly vulnerable due to local subsidence and the condition of dikes and levees.

Coastal Agriculture (Coastal Act Sections 30241- 30243)

Sea level rise could lead to a significant increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and a decrease in the amount of freshwater available for agricultural uses around Humboldt Bay. In addition, adaptation planning for vulnerable levees in and around Humboldt Bay raises potential Coastal Act policy conflicts between preserving agricultural lands, currently located behind levees, and restoring these areas to tidal wetlands as an adaptation approach for managing higher sea levels.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Under current tidal conditions, seasonal freshwater wetlands, inter-tidal wetlands and wildlife refuges are already experiencing seasonal inundation. Opportunities for restoring former salt marsh habitat are promising (e.g. White Slough Restoration Project in South Humboldt Bay); however, land subsidence and sediment availability will be key factors to successful restoration efforts.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Humboldt County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. Planning is needed to address future erosion and flooding of a significant portion of the Humboldt Bay Trail, a planned section of the California Coastal Trail, that is proposed between Eureka and Arcata, within the U.S. Highway 101 and railroad transportation corridors—locations already noted as highly vulnerable to sea level rise impacts.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)



Humboldt County

Many types of development are threatened by sea level rise in Humboldt County: roads, railroads, water pipelines, gas lines, wastewater infrastructure, industrial uses, and residential areas. While reinforcing levees and elevating structures might allow development to adapt in the short and medium term, planning for the long-term impacts of sea level rise will require additional adaptation strategies. In addition, multi-agency and stakeholder collaboration is essential for developing meaningful long-term plans, including with tribes, Caltrans, Humboldt County Association of Governments, State Lands Commission, Pacific Gas and Electric, and others, especially for vulnerable critical infrastructure located in/behind levees and for residential development on former tidelands.

Additional Considerations

- Knowledge gaps related to land subsidence, sediment transport, and saltwater intrusion are areas that should be a priority for further study.
- Adaptation measures for sea level rise in the county should be mindful to presence and preservation of cultural resources.
- Current planning efforts underway for Humboldt County and the City of Eureka should include sea level rise considerations in evaluating land use and zoning changes for under-utilized coastal dependent industrial use areas.
- Living shorelines should be considered as a future adaptation strategy option for areas along Humboldt Bay; however, design, planning and permitting issues will need to be evaluated to determine feasibility, permissibility, and long-term success.

References

- [1] California Coastal Commission North Coast District Staff Interview. July 18, 2016.
- [2] [Trinity Associates. 2013. "Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase 1. Shoreline Inventory, Mapping, and Vulnerability Assessment."](#)
- [3] [GHD. 2016. "City of Trinidad Draft Climate Change Vulnerability Report and Adaptation Response."](#)
- [4] [Trinity Associates. 2016. "City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment."](#)
- [5] [McBain & Trush and Trinity Associates. 2013. "Humboldt Bay Shoreline Inventory, Mapping and Sea Level Rise Vulnerability Assessment. Addendum: Dike and Railroad Shoreline Vulnerability Rating."](#)
- [6] [GHD, ESA PWA, Trinity Associates. 2014. "Caltrans District 1 Climate Change Vulnerability Assessment and Pilot Studies. FHWA Climate Resilience Pilot Final Report."](#)
- [7] [Northern Hydrology & Engineering. 2015. "Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping"](#)
- [8] [Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center.](#)



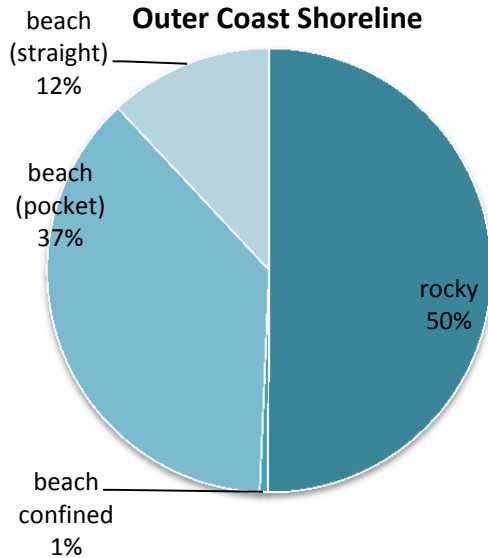
Mendocino County

Coastal Zone



Mendocino County has about 159 miles of shoreline. The terrestrial coastal zone area totals approximately 93,000 acres (about 145 square miles), includes numerous rural coastal communities, a portion of the California Coastal National Monument, and state beaches and parks that provide significant public access and recreational opportunities. Scenic Highway 1 winds along the coast for over 90 miles. The county includes the remote, rugged norther shoreline of the Sinkyone Wilderness State park and visitor-serving, tourism oriented towns of Fort Bragg, Little River, Albion, Elk, Point Arena, Gualala, and the Town of Mendocino, which is designated as a special community under the LCP. Noyo Harbor, adjacent to Fort Bragg, contains a U.S. Coast Guard Station, commercial fishing fleet, and numerous recreational water craft. The harbor at Point Arena includes a pier that also supports commercial and recreational fishing activities and provides for public access. Mendocino County has substantial agricultural and timberland resources along the uplifted marine terraces and within the lower watersheds of the Ten Mile, Big, Albion, Navarro, Garcia, and Gualala Rivers.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Albion, Fort Bragg, Mendocino, Port Arena
 Publicly Owned/Accessible: 15,800 acres
 Public Access Coastal Areas: 103 locations
 Coastal Zone Wetlands: 6,000 acres

Ocean Economy

2013 County Ocean Sectors GDP **\$101 M**

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$75 M
Living Resources GDP	\$18 M
Transportation GDP	\$3 M

0.2%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

While Mendocino County's ocean sectors Gross Domestic Product (GDP) accounts only for 0.2% of the state's total GDP, its pristine natural resources are heavily utilized for recreational purposes and tourism, such as abalone diving, camping, beachcombing, hiking, and fishing. The Tourism and Recreation Sector account for a major component of Mendocino County's ocean economy. Many public access points are vulnerable in Mendocino County. Losing public access points to rising sea levels would negatively impact the local coastal economy.



Mendocino County

Hazards and Vulnerability

Vulnerabilities associated with sea level rise are not well known in Mendocino County. The county would benefit from a regional vulnerability assessment to identify vulnerable assets and better understand potential impacts to its plentiful natural resources to adequately prepare for rising sea levels. Statewide assessments [1] and Commission staff expertise [2] were used for a preliminary identification of the resources that will face flooding and erosion threats exacerbated by sea level rise in the future.



Westport Union campground

Population at risk to 100yr Flood

530 = current risk | 650 = future with
1.4m SLR

Source: Heberger et al., 2009

storm surge, wave run-up, and flooding [2]. State beaches and their amenities, such as parking, beach access and recreational use facilities (i.e. facilities for kayaks, abalone diving, and boating) are already vulnerable. Beaches and their amenities should be studied more thoroughly to determine if they are able to retreat and/or if the

infrastructure should be moved to a less vulnerable location.

Potential Bluff Erosion Risk w/ 1.4m SLR

1,400 properties | 930 people

Source: Heberger et al., 2009, County parcel data

A 2009 Pacific Institute study found that Mendocino County has higher vulnerability to erosion than flooding impacts given a 1.4 m sea level rise and 100-year storm. In fact, the county was projected to have the largest area (7.5 sq. miles) of coastal cliff erosion for any county north of Santa Barbara County under this scenario [1].

Westport Union Landing State Park has already begun experiencing some impacts from sea level rise. The state park area, some campgrounds, and a vista point are all vulnerable to bluff erosion [2]. Caltrans has begun planning retreat for some of the parking areas here and relocation of a low-lying section of Highway 1 just inland of Seaside Beach [3].

Many public access points and coastal trails are currently experiencing erosion, damage from

Mendocino County has recently experienced water supply shortages due to drought conditions. With the Town of Mendocino, over 400 privately owned water wells draw from a discontinuous and unevenly distributed ground water supply, contributing to well failures and/or inadequate year-round on-site supply [4]. Ensuring adequate on-site water supply to serve new development is an issue in the Commission’s review of the Mendocino Town Plan update [4]. However, the proposed LCP update does not address the potential threats of sea level rise to water supply. Some areas of the county’s coastal zone with shallow groundwater are already experiencing tidal water infiltration and groundwater supplies will likely become more vulnerable in the future.

Another area of concern is the City of Fort Bragg wastewater treatment plant, which is currently not considered vulnerable, but it is located on a bluff edge and may become vulnerable with higher rates of erosion accelerated by sea level rise [2].



Mendocino County

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. No local governments in Mendocino County have applied for a grant from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have studies or LCPs that address sea level rise. While staff reviewed a Caltrans vulnerability assessment focused on roads for a region that included Mendocino County, it is not listed as a vulnerability study because it does not go into the level of detail necessary to be useful at the LCP segment planning scale [3]. "In part" means an LCP segment has some explicit policy language addressing sea level rise. Fort Bragg and Point Arena LCPs both require siting and design of new development to take into account the effects of future sea level rise.

Table 1. LCP Planning in Mendocino County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
Mendocino County	No	No	No	No	91%
County Balance Segment	Yes (1992)	No	No	No	
Town Segment	Yes (1996)	No	No	No	
Pygmy Forest Segment	No	No	No	No	
City of Ft. Bragg	Yes (1983)	No	No	In Part	3%
City of Pt. Arena	Yes (1981)	No	No	In Part	1%
Federal Lands and Ports					4%

Coastal Act Management Priorities

Mendocino County faces multiple sea level rise vulnerabilities related to public access and recreation, natural resources, and water supply for residential development.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Mendocino County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches and recreational areas, and increased bluff erosion affecting bluff top trails. Planning is needed to address erosion of bluff top and dune segments of the Coastal Trail and loss of access/parking at state beaches. State parks and Caltrans will be important partners in the planning for preservation of public access points, campgrounds, and stretches of beach that are vulnerable to flooding and erosion.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas.



Mendocino County

Mendocino riparian areas also face potential sea level rise related habitat loss that should be further investigated (e.g., 10-mile River, Noyo River, Big River, Gualala River).

Water quality and supply (Coastal Act Section 30231)

Sea level rise can lead to saltwater intrusion into valuable groundwater aquifers, potentially rendering some existing wells unusable and decreasing the total groundwater supply in coastal areas. In fact, many private wells supplying residences in Mendocino County already face threats due to drought and insufficient recharge. Considering the high vulnerability of water supply in many locations (Cleone, Fort Bragg, the Town of Mendocino), developing an understanding of the saltwater intrusion threat into groundwater supplies should be a top priority.

Additional Considerations

- In Point Arena, storm surge impacts have already impacted commercial and recreational fishing and visitor serving facilities at the harbor, and future planning should integrate sea level rise effects on threats to coastal dependent uses there.
- Transportation infrastructure is vulnerable to coastal erosion that will be exacerbated by sea level rise as well as flooding from sea level rise itself in low lying areas[1]. Adaptation options to address these vulnerabilities may differ (i.e flooding vs. erosion); however, multi-agency coordination with Caltrans and others will be critical to evaluating appropriate adaptation options and long-term planning solutions.
- As discussed above, vulnerabilities to sea level rise and the related increase in coastal erosion in Mendocino County are not well known. There is a need for additional study and analysis, including conducting vulnerability assessments, to better understand and plan for likely impacts from sea level rise. The Coastal Commission's Local Assistance Grant Program and the Coastal Conservancy's Climate Ready Program could be potential funding sources that could support such efforts.

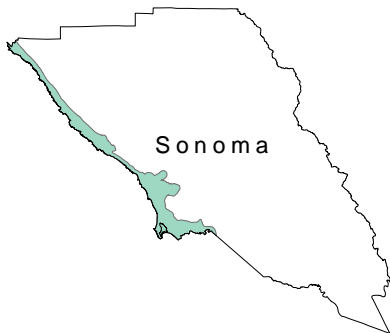
References

- [1] [Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center.](#)
- [2] California Coastal Commission North Coast District Staff Interview. July 18, 2016.
- [3] [GHD, ESA PWA, Trinity Associates. 2014. "District 1 Climate Change Vulnerability Assessment and Pilot Studies FHWA Climate Resilience Pilot Final Report."](#)
- [4] [Mendocino Town LCP Update.](#)



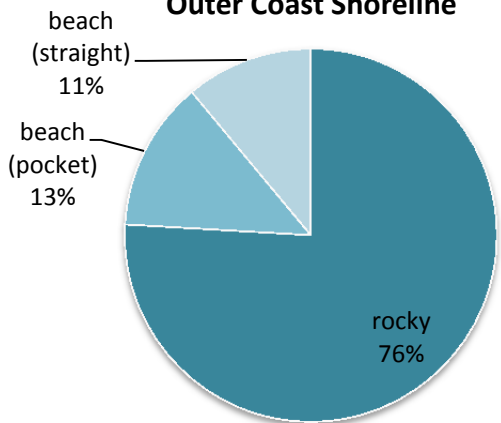
Sonoma County

Coastal Zone



Sonoma County's 70 miles of shoreline and 56,233 acres (88 square miles) of coastal zone includes agricultural lands, timber preserves, open space areas, and an extensive network of recreational lands, parks, and beaches. A significant portion of the coastline property is in public ownership, including holdings of the Sonoma County Regional Parks Department and the University of California's Bodega Marine facility. California State Parks owns Fort Ross State Historic Park, Salt Point State Park, Kruse Rhododendron State Natural Reserve, and Sonoma Coast State Park, with 17 miles of coastline from Bodega Point to Jenner. The Sonoma County coast also supports an important harbor facility for commercial and recreational boating as well as a U.S. Coast Guard Station at Bodega Bay. Greater Farallones National Marine Sanctuary encompasses the offshore marine area.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Bodega Bay
 Publicly Owned/Accessible: 14,600 acres
 Public Access Coastal Areas: 61 locations
 Coastal Zone Wetlands: 2,500 acres

Ocean Economy

2013 County Ocean Sectors GDP \$303 M

2013 Major Ocean Economic Sectors in 2013

Tourism and Recreation GDP	\$197 M
Transportation GDP	\$14 M
Construction GDP	\$12 M

1%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Sonoma County's ocean economy accounts for 1% of the State's total ocean sector gross domestic product (GDP). Tourism and recreation make up approximately two-thirds of Sonoma County's ocean economy. Transportation is also a very important sector in this county, however, many transportation routes are at risk, and vulnerability assessments have highlighted the economic consequences associated with damages and closures to roads. Damage and closures of roads will also hamper the public's ability to access the coast and has financial implications for the tourism and recreation sectors of the county's economy.



Sonoma County

Hazards and Vulnerability

Sonoma County’s “Climate Ready Hazards and Vulnerabilities” study provides an in depth analysis of climate hazards and vulnerabilities, and uses the National Research Council’s (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100. According to the study, Sonoma County is expected to have higher sea levels and storm surge, more frequent inundation, increased erosion and saltwater intrusion [1]. Erosion is currently a problem along the Sonoma coastline, and increased erosion from rising sea levels will threaten coastal infrastructure [1]. The study also highlights that coastal communities will face a number of public safety hazards associated with rising seas including flooding, larger waves, increased storm surges, and wave run up. Diked areas adjacent to Petaluma and Russian Rivers and in Bodega Bay that are used for agriculture or residential use will be at risk from even low or moderate amounts of rising sea level as flooding is expected to be the worst in areas where streams and rivers meet the ocean or bay [1]. Many levees in the county do not meet current construction standards, putting the land behind it (mostly agricultural land in formal tidal areas) at high risk of levee breaches and inundation [1].



Failing seawalls at Gleason’s Beach, Sonoma County, 2005

level rise and a 20 year storm (using Our Coast Our Future Flood Maps) [2,3]. The three regions with highest vulnerability are highlighted here.

In the Highcliff/Muniz-Jenner area, public access, public and protected land, and residential development were found to be at risk [2]. In the Pacific View/Willow Creek and State Beach-Bodega regions, multiple public access points and trails, recreation, public and protected land, habitat, public infrastructure,

and development, and marinas are highly vulnerable [2].

Population at risk to 100yr Flood
580 = current risk | 700 = future 1.4m SLR
Source: Heberger et al., 2009

Potential Bluff Erosion Risk w/ 1.4m SLR
500 properties | 300 people
Source: Heberger et al., 2009

Regarding public infrastructure, Sonoma County has many roads and highways that were constructed on former estuarine and tide lands. These roads are highly vulnerable to rising sea levels, and even now are subject to closure and flood damage (during storms)[4]. Some of the major roads highlighted as vulnerable are Highway 1, Highway 101, Lakeville Highway (US 116), and Carneros Highway (US 121) [1]. Not only will sea level rise cause physical danger to those living along the coast, but the study predicts that it will also impact the economy of people living near bay lands or the coast by disrupting the movement of people and goods [1]. This could also be a major problem during extreme storms, as transportation routes provide emergency and recovery services to those residing in low-lying communities. Facilities for the Sonoma Valley County Sanitation District are also located in low lying



Sonoma County

areas that are expected to see increased flooding [1].

Many prime recreational and natural areas, including marshes, beaches, mudflats, and dunes, and anadromous fish habitats at the mouth of Russian River are at high risk of being lost to rising sea levels [4]. This could lead to a loss of biodiverse transitional habitats which

currently also serve as a buffer against storm surge.

Habitat loss will also lead to losses in fishing, recreational and other commercial activities which are dependent on bay or ocean habitats. This could also be detrimental to Sonoma County’s ocean economy.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change, since January 2014. Sonoma County has not received any of these grants from the Coastal Commission, but the county has received a grant from the Ocean Protection Council. Table 1 below shows the County’s LCP “progress” to address sea level rise.

Table 1. LCP Planning in Sonoma County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
Sonoma County	1982	OPC	Yes [1,2,3]	In progress	100%

Coastal Act Management Priorities

Sonoma County’s Pacific coast faces multiple sea level rise vulnerabilities related to infrastructure (including Highway 1), public access, and natural resources (including wetlands, tidal zones, beaches, and dunes).

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Highway 1 is probably the most prominent infrastructure asset threatened by sea level rise along Sonoma County’s Pacific coast. One particularly vulnerable area is the residential and highway infrastructure development located at Gleason’s Beach, about 5 miles north of Bodega Bay. At Gleason’s Caltrans is in the early stages of devising a highway realignment project that would move Highway 1 inland. The county, with Caltrans and other relevant agencies, should prioritize planning for road improvements, replacements, and relocations at already identified hazardous locations, especially along Highway 1 where there is a history of damaging events due to landslides and coastal erosion. Landslides, erosion and flooding also pose risks to agriculture and community development. The county should begin to evaluate adaptation responses for targeted, highly vulnerable areas like diked lands along Russian River (i.e. Jenner) and Bodega Bay.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Sonoma County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. Because a significant portion of coastal property in Sonoma County is in public ownership,



Sonoma County

State Parks and Sonoma County Regional Parks are also important partners with the county and the Coastal Commission in working toward maximizing public access and recreation in light of sea level rise.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Planning for the migration of the sandy beaches, tidal salt marsh, and extensive lagoon mudflats and sandflats near and around Bodega Bay should be a top priority. These areas provide critically important ecosystem services and functions (i.e., water quality, wave attenuation, carbon storage, etc.) in addition to providing critical habitat for numerous species.

Additional Considerations

- Due to the open space and rural nature of most of the Sonoma coast, it will be important for the county to account for natural resource benefits and values in exploring and determining feasibility of various adaptation strategies.
- In southern Sonoma County, adaptation planning should address risks of flooding of agricultural lands as well as for residential development and public infrastructure.

References

- [1] [North Bay Climate Adaptation Initiative. 2014. "Climate Ready Sonoma County: Climate Hazards and Vulnerabilities."](#)
- [2] Sonoma County Permit and Resource Management Department. 2016. "County of Sonoma County General Vulnerability Assessment." OPC LCP Sea-Level Rise Grant Program grant deliverable.
- [3] [USGS, Point Blue Conservation Science, and University of Southern California. 2016. Our Coast, Our Future Flood Maps.](#)
- [4] California Coastal Commission North Central Coast District Staff Interview. May 26, 2016.



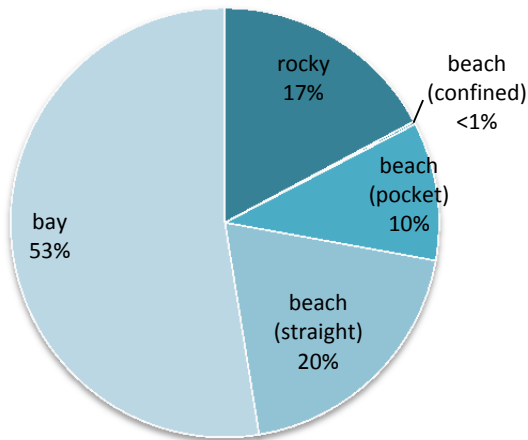
Marin County

Coastal Zone



Marin County has approximately 116 miles of mainland coastline from Sonoma County to Point Bonita near the Golden Gate Bridge. The coastal zone contains approximately 82,000 acres (130 square miles) of which approximately 34,000 acres (53 square miles) are owned and managed by the federal government, mostly within either Point Reyes National Seashore or Golden Gate National Recreation Area. About 60% of the coastal zone is in the County's jurisdiction and of that, nearly two-thirds is zoned for agricultural use. Tomales Bay supports oyster farming and the area includes the towns of Inverness, Point Reyes Station, and Marshall. The tidal estuary of Bolinas Lagoon is an important wetland region and borders the Greater Farallones National Marine Sanctuary (GFNMS) and towns of Bolinas and Stinson Beach.

Outer Coast Shoreline (includes Tomales Bay)



Coastal Zone Resources

- Ports & Harbors: Point Reyes, Sausalito*, Tomales Bay
- Publicly Owned/Accessible: 72,300 acres
- Public Access Coastal Areas: 87 locations
- Coastal Zone Wetlands: 4,400 acres
- *Not in CCC coastal zone

Ocean Economy

2013 Total County Sectors GDP \$521 M

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$483 M
Construction GDP	\$9.8 M
Minerals GDP	\$0.5 M

1%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

While Marin County's ocean economy may only account for 1% of the state's total ocean related gross domestic product (GDP), the county's wetlands, coast, and harbors are heavily used for tourism and recreation. Many of the natural resources associated with this economy are vulnerable to sea level rise in the near future. The loss and/or degradation of these natural resources will affect access to and enjoyment of these resources, which could also negatively affect the county's ocean economy.



Marin County

Hazards and Vulnerability

Marin County is conducting a vulnerability assessment through the “Collaboration: Sea-level Marin Adaptation Response Team”(C-SMART), which aims to understand Marin’s ocean coast vulnerability to prepare for the challenges of sea level rise. The C-SMART vulnerability assessment uses the National Research Council’s (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100, and lays out timeframes of expected sea level rise impacts based on different time horizons (2030, 2050, and 2100).



Stinson beach, Marin County

opportunities, the scenic beauty, and visitor experience along Marin coast.

Areas in and around Tomales Bay, Dillon Beach, Lawson’s Landing, Inverness, East Shore and Point Reyes Station are all vulnerable to sea level rise in the near term [1]. Beaches, bluff-top buildings, boating facilities, pipelines, a sewage pump station, multiple access points, recreational areas, state park facilities, and many natural

resources have all been highlighted as being vulnerable to rising sea levels in the short term [1]. At Point Reyes Station, one of the most vulnerable assets identified is the water distribution pipelines beneath Sir Francis Drake Boulevard and Shoreline Highway. The highly vulnerable wetlands and marshes in this region also provide significant habitat for coastal and marine species [2].

Population at risk to 100yr Flood

530 = current risk

630 = future with 1.4m SLR

Source: Heberger et al., 2009

The county’s vulnerability assessment lists the most vulnerable assets in order of timing and flood depth. It also notes that disruptions to the transportation network, which is highly vulnerable, would negatively impact daily life, access to goods and services, recreational activities, safety, and economic viability of its coastal communities [1]. Marin’s low lying roads that are already susceptible to flooding at high tides will experience more problems with rising sea levels [1]. In addition, beaches, estuaries, marshes, wetlands, and intertidal areas on the Marin Coast are identified as vulnerable to rising sea levels and increased storm intensity [1]. Many of these natural resources will experience inundation, erosion, and the potential for complete loss. This would in turn alter public access and recreational

Potential Bluff Erosion Risk w/ 1.4m SLR

1,300 properties | 570 people

Source: Heberger et al., 2009

In the near term, Bolinas Lagoon contains wetlands that will be squeezed out with sea level rise due to Highway 1’s location [1]. Bluff top buildings, the tsunami evacuation route, Brighton Beach, downtown Bolinas, Wharf Road, Agate Beach and County Park, and Pine Gulch Creek are also highly vulnerable [2].

At Muir Beach, bluff top buildings, Green Gulch Creek, and Redwood Creek are of highest vulnerability in the near term. Access to homes and recreational areas in Muir Beach will likely be compromised by flooding on Highway 1 in the long-term.



Marin County

Stinson Beach is vulnerable to sea level rise as soon as 2030 in many areas, including septic systems west of Shoreline Highway, water distribution lines, Calle del Arroyo, Upton Beach, Patio and Calle residences, Shoreline Highway, the water district office, Walla Vista Walkway, and Easkoot Creek [1]. Due to development in this area, beaches that would naturally move inland with rising seas will not

be able to retreat, ultimately leading to loss of beach area unless existing development is moved or removed. In the long-term (with 80 inches of sea level rise + 100-year storm), this analysis of sea level rise determined that nearly \$200 million of assessed value and \$1.5 billion in market value from properties could be exposed to flooding [1].

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Marin County has been awarded a Round 1 grant from the Coastal Commission to address the impacts of sea level rise within its LCP jurisdiction. Table 1 below shows that the county has multiple vulnerability studies and an LCP update to address sea level rise is in progress. A case study for Marin County is available to highlight the Commission’s LCP planning [3].

Table 1. LCP Planning in Marin County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
Marin County	1981/82	OPC, CCC	Yes [1,4]	In progress	35%
Federal Lands and Ports					65%

Coastal Act Management Priorities

Marin County faces significant sea level rise threats to natural resources, infrastructure, and recreational assets. Marin is also one of the first local communities to conduct an extensive climate change vulnerability assessment, begin work on adaptation planning, and put forth an update to its LCP that addresses sea level rise to the Coastal Commission. The county must address likely long-term impacts to its extremely valuable beach and wetland resources and deal with flooding and continued shoreline erosion threatening development and public infrastructure. Some top priorities by Coastal Act themes are presented below.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Sea level rise threatens wetland habitats in the county because of saltwater intrusion, drowning of marsh habitat, and vegetation conversion. Thus, there is a need to better understand how to facilitate habitat migration with sea level rise because it will be critical to inform efforts to preserve or restore coastal habitat. Natural resources should be monitored over time to inform plans for preserving habitat areas as well. Given the large expanse of federal lands in the county, collaboration with federal partners, such as the Greater Farallones National Marine Sanctuary and National Park Service is critical.



Marin County

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

While accommodation of vulnerable structures, roads and utilities, primarily through elevation and flood-proofing retrofits, is a short- to mid-term priority for more developed areas like Stinson Beach, longer term actions may require the removal of existing development as certain triggers are met, such as the inland migration of the public trust boundary or the loss of essential public services. As beach homes are proposed for redevelopment, they must comply with national flood insurance elevation rules, resulting in elevated structures to levels that potentially raise concerns about visual resources and community character, as well as beach access and recreation. Marin County plans to address road vulnerabilities from sea level rise through future collaboration with Caltrans, the Greater Farallones National Marine Sanctuary, the Coastal Commission and National Park Service.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Marin County could lead to a loss of public access and recreational opportunities due to permanent inundation or restricted use of sandy beach areas under elevated homes along the shoreline, episodic flooding or erosion of beaches, recreational areas, and trails. Beach management strategies in Marin should establish thresholds for minimum beach width, include recommended monitoring frequencies, restrict rope fences or other measures that would prevent the public from traversing the beach under elevated homes, and propose triggers for future actions such as beach nourishment or planned retreat. Long-term changes for retrofitting or relocating recreation and visitor serving facilities, including trails and access points, might require acquisition of new parklands.

Additional Considerations

- In the future, adaptation options for shoreline development might include consideration of beach replenishment (which would require consultation with GFNMS), restrictions on rebuilding structures destroyed by storms, and removal and/or relocation of structures.
- The county should explore options for innovative living shorelines such as dune and wetland restoration, horizontal levees, oyster beds, eelgrass, and bluff vegetation.
- Adaptation planning should also include addressing impacts to historic structures, cultural resources, and archaeological sites.

References

[1] [Sea-Level Marin Adaptation Response Team and Marin County Community Development Agency. 2015. "Marin Ocean Coast Sea Level Rise Vulnerability Assessment."](#)

[2] California Coastal Commission North Central Coast District Staff Interview. May 26, 2016.

[3] California Coastal Commission. December 2016. Marin County Case Study.

[4] [USGS, Point Blue Conservation Science, and University of Southern California. 2017. Our Coast, Our Future Flood Maps.](#)



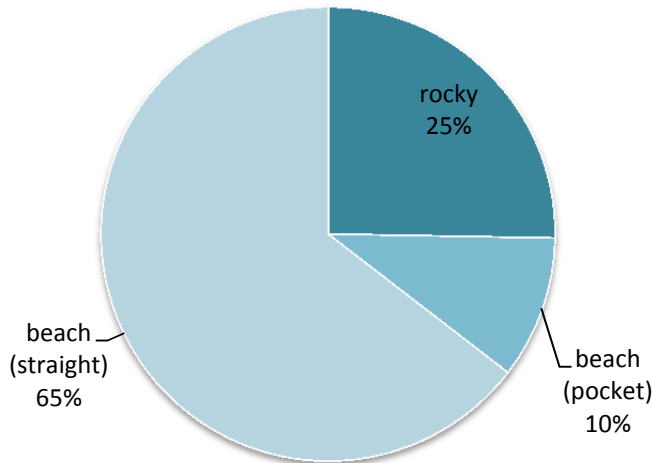
San Francisco County

Coastal Zone



The City and County of San Francisco's coastal zone for the outer Pacific coast extends approximately 6 miles from the Fort Funston cliff area north to the Golden Gate Bridge. Most of the 1,900 acre (3 square miles) coastal zone is publicly owned land. Golden Gate Park, the San Francisco Zoo, and Lake Merced, which are owned by the City and County of San Francisco, make up 60% of the coastal zone area. Another 25% of the coastal zone is within the Golden Gate National Recreation Area, leaving about 15% of the land in the coastal zone as privately owned. San Francisco is a highly visited area with many recreational or visitor-serving destinations like the Cliff House, Sutro Baths, and Ocean Beach, which are all located in the coastal zone. The Greater Farallones National Marine Sanctuary can also be accessed from the San Francisco coast and provides protection for the California Current marine ecosystem.

Outer Coast Shoreline



Coastal Zone Resources

- Ports & Harbors: San Francisco*
 - Publicly Owned/Accessible: 800 acres
 - Public Access Coastal Areas: 35 locations
 - Coastal Zone Wetlands: 500 acres
- *Not in CCC coastal zone

Ocean Economy

2013 County Ocean Sectors GDP \$4.0 B*

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$3.7 B
Transportation GDP	\$37 M
Living Resources GDP	\$22 M

11%

of State Ocean Sector GDP

*Note, includes SF Bay although not in CCC jurisdiction

Source: National Ocean Economics Program, 2016

With the third highest ocean economy in the state, San Francisco County makes up 11% of the State's total ocean sector gross domestic product (GDP). Approximately 93% of San Francisco's \$4 billion ocean related GDP is made up of tourism and recreation. San Francisco is a major site for international and domestic travel. It is a vital region for public access, tourism, and recreation for which many sites can be accessed by public transportation. Damages or losses of these assets would drastically impact the state's and region's ocean economy.



San Francisco County

Hazards and Vulnerability

The City and County of San Francisco conducted two recent vulnerability assessments, the Sea Level Rise Existing Data and Analyses Technical Memorandum, which focuses on San Francisco’s outer coastal zone, and the Ocean Beach Master Plan, which focuses on the public infrastructure and natural assets in the vicinity of San Francisco’s Ocean Beach. Both assessments use the National Research Council’s (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100.



San Francisco Zoo at Great Highway and Sloat Blvd., San Francisco

Most beaches within the City/County of San Francisco are located within the Golden Gate National Recreational Area (GGNRA). Coastal trails, especially ones on bluff tops and/or along

the Great Highway, are the most vulnerable to sea level rise [1,2]. Ocean Beach supports important natural resources, including two threatened birds and dune habitat. Ocean Beach is already experiencing erosion, and dredged material is placed on the beach to replenish it. Ocean Beach is heavily utilized for bird watching,

surfing, and dog walking. Additional loss of this area from sea level rise will greatly impact public access and recreation opportunities.

Along South Ocean Beach, assets with the highest vulnerabilities are infrastructure (e.g., Lake Merced tunnel, Westside Transport Box, Sloat Boulevard, Oceanside Wastewater Treatment Plant, Southwest Ocean Outfall and wet-weather overflow outfalls) and natural resources (e.g., beach and bluff habitats)[2]. Sutro Baths, a historic resource and major tourist and recreational area, and the Cliff House are both vulnerable to rising sea levels and currently experiencing erosion.

Population at risk to 100yr Flood
 4,800 = current risk 6,500 = future w/1.4m SLR
 Source: Heberger et al., 2009

Overall, San Francisco has several vulnerabilities associated with rising sea levels. Sea levels are expected to rise and daily tidal inundation is expected to increase. Although San Francisco’s outer coastal zone is higher in elevation as compared to other regions, and does not currently experience significant tidal inundation [1], this is expected to change with rising sea levels. Extreme tides, extreme coastal waves, tsunami inundation, and stormwater ponding are also expected to occur much more frequently along the coastal zone [1]. Shoreline change and coastal erosion will dramatically increase [2]. Sea level rise will increase the rates of shoreline changes, and with a highly developed coastal zone, there may not be much room for moving structures inland [1]. Sandy beaches, bluff tops, and cliffs are the most vulnerable to shoreline changes.

Potential Bluff Erosion Risk w/ 1.4m SLR
 850 properties | 1,200 people
 Source: Heberger et al., 2009

Along the Great Highway, some major public transportation routes have been identified as highly vulnerable [3]. Fort Funston’s trails and recreational areas are also at risk. Damages or losses to these areas will lead to decreased public access and recreation in the region and affect the ocean economy in the region.



San Francisco County

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. The City/County of San Francisco has been awarded a Round 2 grant from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdiction. Table 1 below shows the City’s LCP progress in addressing sea level rise. “In progress” refers to jurisdictions with LCP grants for addressing sea level rise.

Table 1. LCP Planning in San Francisco County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
City and County of San Francisco	1986	SCC, OPC, & CCC	Yes [1,2,4,5]	In Progress	0% (inland)
City and County of San Francisco/Olympic Club Segment	No	No	No	No	8%
Federal Land (<i>Golden Gate Natural Recreation area covers majority of shoreline</i>)					92%

The City and County received a FY 2014-15 LCP planning grant from the Commission and the Ocean Protection Council to amend its LCP to address sea level rise. The proposed amendment is intended to reflect the vision of the multi-stakeholder process which resulted in the Ocean Beach Master Plan. This plan identifies an approach to address the Ocean beach shoreline, including prominently the shoreline erosion and hazard challenges at South Ocean Beach, in a way that will protect critical stormwater and wastewater infrastructure, provide for continued public access to and along Ocean beach, and ensure a healthy ocean, beach, and dune habitat that will persist even as sea levels rise. The LCP amendment will also include additional general sea level rise adaptation policies. Commission staff participated in the development of the Ocean Beach Master Plan, and coordinated closely with staff from the city and county over the last year in the process of amending the LCP.

Coastal Act Management Priorities

The San Francisco City and County Pacific Coast faces multiple sea level rise vulnerabilities related to public access and recreation, natural resources, and critical public infrastructure development.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in San Francisco City and County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. The Ocean Beach Master Plan covers the majority of San Francisco’s Pacific coastline threatened by erosion, and sets out a comprehensive vision to addressing sea level rise that phases in managed retreat over time. Importantly, public access is provided for as a central part of each phase of the plan.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation, salt water intrusion and increased erosion from sea level rise could convert habitats from one type to another, generally reduce the amount of nearshore habitat, such as sandy beaches and



San Francisco County

rocky intertidal areas and could impact sensitive species and habitats in and around Lake Merced. Planning for restored native dunes and beach replenishment phases will continue to be a priority for Ocean Beach. These dunes have a high potential for ecological restoration, which could help many species by linking habitats through corridors. [2]

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Many types of development are threatened by sea level rise along San Francisco County's Pacific coast: critical roads, wastewater and stormwater infrastructure as well as commercial and residential areas. The Ocean Beach Master Plan provides a long-range vision to address sea level rise, protect infrastructure, restore coastal ecosystems and improve public access, and this broad framework should guide consideration of adaptation options for addressing sea level rise in the area. Adaptation planning should also factor in robust monitoring and trigger points to continually assess the feasibility of the Ocean Beach Master Plan's proposed approaches.

Additional Considerations

- Because the City and County of San Francisco's LCP jurisdiction is inland of the Golden Gate Natural Recreation Area, the local government should work closely with the National Park Service on addressing how federal shoreline management actions could affect adjacent city or county areas.
- Planners should also consult with other agencies and organizations involved with improving our understanding of climate change impacts and sea level rise in the area, including US Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), the state-federal Coastal Sediment Management Working Group, and SPUR.
- There are many options to get to Ocean Beach by bike or public transit, making the beach a no- or low-cost visitor-serving asset. Planners and local governments should prioritize these alternative transportation options, and work to ensure their protection with rising sea levels.

References

- [1] [AECOM. 2016. "Final Sea Level Rise Existing Data and Analyses Technical Memorandum."](#)
- [2] [SPUR, AECOM, ESA PWA, Nelson/Nygaard, Sherwood Design Engineers, Phil King. 2012. "Ocean Beach Master Plan."](#)
- [3] California Coastal Commission North Central Coast District Staff Interview. May 26, 2016.
- [4] [SPUR, ESA PWA, Moffatt & Nichol, McMillen Jacobs Associate, AGS INC. 2015. "Coastal Protection Measures and Management Strategy for South Ocean Beach. Ocean Beach Master Plan: Coastal Management Framework."](#)
- [5] [City and County of San Francisco. 2016. "San Francisco Sea Level Rise Action Plan."](#)



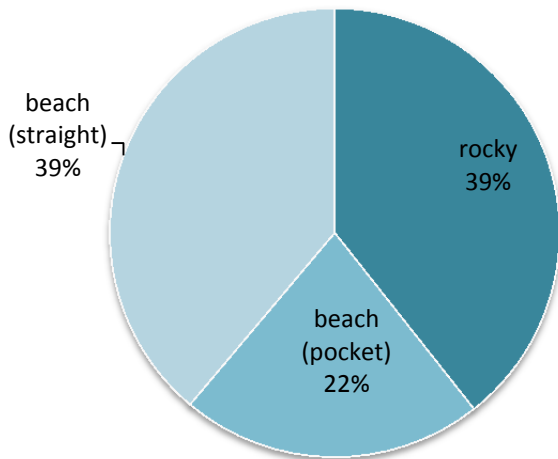
San Mateo County

Coastal Zone



San Mateo County includes 59 miles of shoreline and supports significant agricultural lands, a commercial fishing harbor, and major public access to parks, beaches and other recreational lands, substantial marine and other natural resource areas, and extensive scenic resources. The 98,000 acres (153 sq. miles) of terrestrial coastal zone area includes unincorporated San Mateo County lands and 3 incorporated cities: the Cities of Daly City, Pacifica and Half Moon Bay. San Mateo County has many popular coastal visitor destinations for millions of residents of the Bay Area. The rugged northern coast of the County through the suburban cities of Daly City and Pacifica contain rocky bluff tops and significant beach resources that provide important recreational opportunities but present significant hazards challenges. The City of Half Moon Bay supports urban development and services as well as wetland resources. South of the City of Half Moon Bay to the Santa Cruz County line, mountains drop down to rolling agricultural and grasslands on marine terraces, with redwood forests, oak woodland and chaparral found inland. This area includes the communities of San Gregorio and Pescadero, and contains significant access and recreation areas, agricultural resources, extensive scenic resources, and a major wetland feature, the Pescadero Marsh.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Princeton and Pillar Point Harbor
 Publicly Owned/Accessible: 16,500 acres
 Public Access Coastal Areas: 70 locations
 CZ Wetlands: 3,100 acres

Ocean Economy

2013 County Ocean Sectors GDP	\$1.4 B
2013 Major Ocean Economic Sectors	
Tourism and Recreation GDP	\$1.3 B
Construction GDP	\$0.028 B
Transportation GDP	\$0.020 B

4%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

San Mateo's ocean sector gross domestic product (GDP) makes up 4% of the State's total ocean sector GDP. Bay Area residents contribute greatly to San Mateo County's GDP as 94% of the ocean economy comes from tourism and recreation dollars. Public access and natural resources are assets with the highest vulnerabilities in the county, making the extremely large ocean economy also vulnerable to rising sea levels.



San Mateo County

Hazards and Vulnerability

Through its Sea Change San Mateo County Program, the San Mateo County initiated a sea level rise vulnerability assessment as part of a long-term resilience strategy to ensure that communities, ecosystems, and the economy are prepared for risks from climate change and rising sea levels. San Mateo County has been identified as one of the most vulnerable regions of the Bay Area, especially to the risks associated with rising sea levels. The vulnerability assessment underway use the National Research Council's (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100.



photo by L Ewing
Pacifica, photo by Lesley Ewing

the beach [2]. The City of Pacifica has many assets that are threatened by sea level rise and/or shoreline erosion, including historical assets (e.g., Dollaradio), residential development and multi-unit housing complexes (e.g., bluff edge development along Esplanade Avenue), public access visitor-serving and recreational assets (e.g., RV resorts, parking lots, and trails), public infrastructure (e.g., Beach Boulevard/roads, and outfalls), and natural habitats (e.g., wetlands, creeks, and beaches) [2]. Many of these assets already experience the effects of sea level rise through erosion, flooding, and habitat loss. Additional study is needed to assess risks of critical public infrastructure assets like the wastewater treatment and water recycling plant at Calera Creek.

Pacific coast Population at risk to 100yr Flood
4,700 = current risk | 5,900 = future w/1.4m SLR
Source: Heberger et al., 2009

Sea Change San Mateo used Pacific Institute data to report that the county has \$24 billion in assets at risk from sea level rise [1]. Transportation networks (such as Highway 1), communities in low lying areas (such as Le Mar Trailer Park), and bluff top communities (especially in Pacifica) have all been identified as vulnerable. Public access is highly vulnerable, especially at Surfer's Beach and along most of the shoreline of Half Moon Bay [1]. Wetlands and coastal habitats across the county are vulnerable to sea level rise.

There are gaps in vulnerability information for Daly City, which could be addressed by Sea Change San Mateo County efforts. One known problem area that would benefit from sea level rise planning is Thornton State Beach, currently closed due to cliff erosion threatening trails to

Potential Pacific coast Bluff Erosion Risk w/ 1.4m SLR
1,900 properties | 2,900 people
Source: Heberger et al., 2009, County parcel data

In and around Half Moon Bay, many natural resources are vulnerable to sea level rise. Coastal trails are already disappearing, beaches are vulnerable, and erosion also threatens riparian corridors, associated wetlands, and public access locations [2]. Many important beaches like Surfer's Beach, Maverick's Beach, and Martin's Beach have been identified as vulnerable to erosion and eventual beach loss with sea level rise [2,3]. Many of the accessways (such as trails, stairways, and parking lots) to these and other beaches are already experiencing problems that will be exacerbated with rising sea levels. Pescadero Marsh and Highway 1 are also vulnerable in the southern part of the county [2, 3].



San Mateo County

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change, since January 2014. Within this county, the Cities of Pacifica (Round 3) and Half Moon Bay (Rounds 1 and 3) have been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In progress" refers to jurisdictions with LCP grants for addressing sea level rise.

Table 1. LCP Planning in San Mateo County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
San Mateo County	1981	No	In progress [1]	No	73%
City of Daly City	1984	No	No	No	5%
City of Pacifica	1984	CCC	In Progress	In Progress	10%
City of Half Moon Bay	1996	OPC, CCC	Yes [3]	In Progress	10%
Federal Lands and Ports					<2%

Coastal Act Management Priorities

San Mateo County's Pacific coast faces multiple sea level rise vulnerabilities especially for public access, visitor-serving and recreational resources. Public infrastructure (including Highway 1) and natural resources are also vulnerable to sea level rise.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in San Mateo County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. More recently, emergency situations have required coastal armoring in threatened areas, much of which has the potential to interfere with sandy beach access by taking up beach real estate and lessening sand supply. Priority areas for addressing sea level rise impacts on access include Beach Boulevard and the Sharp Park area in the City of Pacifica, Highway 1 and the Coastside Trail at Surfer's Beach, and Perched Beach at Pillar Point Harbor in Princeton-by-the-Sea. Planning for the West Trail at Pillar Point Harbor and the CCT at Mirada Road in Half Moon Bay is also a priority.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation from flooding and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Planning for the migration of sandy beaches and tidal salt marsh (e.g., Pillar Point Marsh and Pescadero Marsh) should also be a county priority. There is also a need for collaboration with State Parks to understand potential vulnerabilities at state beaches and how threats might be addressed in the future.



San Mateo County

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Pacifica has experienced significant bluff erosion over time. Most recently in early 2016, erosion induced by higher seas resulted in emergency evacuations for blufftop development with insufficient setbacks from the bluff edge. The old landfill at Mussel Rock in Daly City is also threatened and the city is required by the Coastal Commission to devise a long-term managed retreat plan. Consequently, assessing the feasibility of various adaptation approaches for blufftop residential development and the supporting public infrastructure should be a high priority. A feasibility analysis of adaptation options could include evaluating the costs and benefits of managed retreat or removal for blufftop structures against more traditional protection options like shoreline armoring. While sea level rise impact projections and data are available for much of the county, a significant data gap exists south of Half Moon Bay for coverage by more dynamic and robust sea level rise modeling tools (i.e., CoSMoS). The county might consider conducting a targeted vulnerability assessment of potential assets in this area (especially for Daly City).

Additional Considerations

- As many communities in San Mateo face beach loss with sea level rise, accounting for natural resource benefits and value in exploring adaptation strategies should be considered.
- Threats to public access and critical infrastructure (such as Highway 1 at Surfer's Beach in Half Moon Bay) exemplify the importance of multi-agency collaboration and coordination to develop feasible adaptation solutions to minimize/avoid hazards while protecting coastal resources like wetlands and other natural habitats.

References

- [1] [San Mateo County. 2015. "San Mateo County Sea Level Rise Vulnerability Assessment."](#)
- [2] California Coastal Commission North Central Coast District Staff Interview. May 26, 2016.
- [3] [Noble Consultants Inc. and Dyett & Bhatia. 2016. "Plan Half Moon Bay Sea Level Rise Vulnerability Assessment."](#)



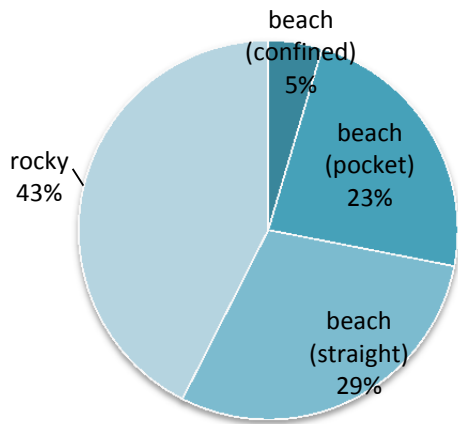
Santa Cruz County

Coastal Zone



Santa Cruz County is located along the Central California coastline, extending 45 miles from south of Año Nuevo State Park to the Pajaro River. The 72,320 acres (113 square miles) of terrestrial coastal zone contains many accessible beaches, and wooded mountains all in close vicinity to several northern California metropolitan areas. Within its borders are several State Parks (including portions of Big Basin State Park) a number of state beaches (including Twin Lakes, Seacliff, and Manresa State Beaches), famous surfing spots (such as Steamer Lane and Pleasure Point, which were included in the World Surfing Reserve designated in 2012), the Santa Cruz Beach Boardwalk, farmlands, and multiple sensitive habitat areas. Also, federally protected Ellicott Slough National Wildlife Refuge provides access to additional natural resources and wildlife conservation in the coastal zone. Santa Cruz Harbor is an important harbor facility for recreational and commercial fisheries.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Santa Cruz
 Publicly Owned/Accessible: 22,700 acres
 Public Access Coastal Areas: 83 locations
 Coastal Zone Wetlands: 1,800 acres

Ocean Economy

2013 County Ocean Sectors GDP		\$332 M
2013 Major Ocean Economic Sectors		
Tourism & Recreation GDP		\$310 M
Transportation GDP		\$7.3 M

1%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Due to its proximity to several metropolitan areas, its mild climate, and variety of landscapes, Santa Cruz County is a popular vacation and recreation destination, especially for people in the San Francisco Bay Area. While Santa Cruz County's ocean economy may only account for 1% of the State's total ocean related gross domestic product (GDP), 93% of Santa Cruz County's ocean economy relies on tourism and recreation activities, which range from hiking in its mountainous state parks to surfing and beachcombing at its highly used pocket beaches.



Santa Cruz County

Hazards and Vulnerability

Multiple vulnerability assessments have been conducted in Santa Cruz County, highlighting locations of sensitive natural resources community development, and infrastructure.

Santa Cruz County's "Santa Cruz Climate Action Strategy- 5.0 Vulnerability Assessment" and the City of Santa Cruz's "City Climate Change Vulnerability Assessment" both use the National Research Council's (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100. Santa Cruz County has many highly visited beaches along its shoreline. Many locations in the county are vulnerable to the incremental loss of recreational beach area and shoreline habitats in front of hard armored shorelines ("coastal squeeze"), particularly in the Live Oak, Pleasure Point and the Opal Cliffs areas [2]. Over a quarter



West Cliff Drive, Santa Cruz (Coastal Records Project, 2015)

The City of Santa Cruz is at high risk to losing shoreline features that support public access and recreation, especially surfing launch points and beaches [3]. In fact, many beaches in the city are already covered by extensive riprap, and the remaining sandy beach areas are likely to

disappear from rising seas. Additional studies are needed to assess how places such as Wilder and Younger Lagoons and Natural Bridges State Beach might retreat. Infrastructure and development within the City of Santa Cruz is also at risk. The Neary Lagoon Wastewater

Treatment Plant (WWTP) is at extremely high risk to sea level rise [1,3]. The anticipated rise in groundwater may have adverse impacts to the WWTP's storage tanks and associated infrastructure. The WWTP's underground pump is also susceptible to saltwater infiltration [1,3]. The city flagged this facility as one of the most immediate threats in the region [3].

Potential Bluff/Dune Erosion Risk w/1.4m SLR
3,000 properties | 2,600 people
Source: Heberger et al., 2009

of the county's shoreline is armored, with most armoring concentrated in urban shoreline areas, making the inland migration of fronting beaches difficult with sea level rise. The county's vulnerability assessment also found that 16 to 66 inches of sea level rise by 2100 would put most of Santa Cruz County's oceanfront properties at greater risk from either inundation and/or coastal flooding, or from increased bluff erosion [1].

In the northern portion of the county, from Waddell to Scotts Creek, Highway 1 is highly vulnerable in several locations [2]. Many public access assets are also at risk [2]. At Davenport, both existing and proposed segments of the coastal trail along the rail line are vulnerable [2].

West Cliff Drive and the adjacent multiuse path, which provides a critical segment of the California Coastal Trail, is one of the most used visitor destinations along the county's coastline. It is also under serious threat from erosion and does not have space to move inland in many locations absent removal of residential development, or

Population at Risk to 100yr Flood
11,000 = current risk | 16,000 = future
w/1.4m SLR
Source: Heberger et al., 2009

road narrowing to one lane [2]. Much of downtown Santa Cruz is low-lying and at risk to current and future flooding [2]. The Santa Cruz Beach Boardwalk, a major visitor attraction, already experiences significant seasonal flooding and is highly vulnerable in the near future to sea level rise and flooding. Loss of popular surf



Santa Cruz County

beaches and damages to both West Cliff Drive and the Santa Cruz Beach Boardwalk would be detrimental to the local economy.

Soquel Creek [2]. The steep Depot Hill bluffs in Capitola are also subject to erosion, which will continue to threaten homes in the adjoining residential neighborhood.

The City of Capitola is also vulnerable to sea level rise impacts. Capitola village is a major tourist attraction and is extremely vulnerable to flooding due to its low lying elevation and the adjacent

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. No local government in Santa Cruz County has currently been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In progress" refers to jurisdictions who are working on LCP updates that will address sea level rise.

Table 1. LCP Planning in Santa Cruz County (as of Dec. 2016)

Jurisdiction/Segment	LCP	Grant?	VA	Updated for SLR?	Shoreline by Jurisdiction
Santa Cruz County	Yes (1983)	No	Yes [1]	In progress	85%
City of Santa Cruz	Yes (1985)	No	Yes [3]	In progress	11%
City of Capitola	Yes (1990)	No	Yes[4]	No	4%
City of Watsonville	Yes (1988)	No	No	No	0%
Federal Lands and Ports					0%

Coastal Act Management Priorities

Santa Cruz County faces significant sea level rise vulnerabilities to natural habitat, coastal development, and public access. Sea level rise poses significant challenges for maintaining the county’s extremely valuable beach resources. The county also must address flooding, continued shoreline erosion, and ongoing pressure for armoring in the urban areas. Some management priorities by Coastal Act resource are presented below.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert coastal habitats from one type to another (e.g., salt marsh to mud flat) and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. There is a need for more studies to better understand how sea level rise might adversely impact significant natural resources within the county (e.g., Wilder and Younger Lagoons and Natural Bridges State Beach, Watsonville Slough system, Pajaro Dunes, valuable agricultural resources (Coastal Act Sections 30241- 30243)), and to develop options to counter expected adverse ecosystem changes.



Santa Cruz County

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Many developed areas in Santa Cruz County already experience hazards related to bluff erosion and flooding on a regular basis (e.g., West Cliff Drive in Santa Cruz, downtown Santa Cruz and Beach Boardwalk, the Live Oak beach area, Capitola village). To address the expectation that these hazards will intensify with sea level rise, Santa Cruz County local governments should consider developing new standards for shoreline protection, redevelopment and evaluation of existing seawalls, as well as developing land use policies that ensure that future shoreline development fully mitigates the impacts to public access, recreation and other coastal shoreline resources. Other important developed assets that need long-term sea level rise planning in the County are Highway 1 in Northern Santa Cruz County, the Neary Lagoon Wastewater Treatment Plant, Depot Hill and Capitola village in the City of Capitola, and West Cliff Drive in the City of Santa Cruz.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Large revetment projects have already covered over 17 acres of beach in Santa Cruz County [4]. With rising sea levels, all dry beach seaward of these structures and public access and recreational opportunities are at risk of being lost due to permanent inundation, episodic flooding, or erosion of beaches, recreational areas, and trails. The county's recreational assets, including pocket beaches and the coastal trail corridor, the Santa Cruz Beach Boardwalk, and urban beaches in the Santa Cruz-Live Oak-Capitola area all need long-term planning to address these threats. Collaboration with Caltrans and the Santa Cruz Regional Transportation Commission will be vital for maintaining access to and along the coast. The four LCP-certified jurisdictions of Santa Cruz County should also work with State Parks to assess the potential long-term impacts to beach recreational resources, including spillover impacts such as overcrowding to adjacent beach areas from the potential loss of urban beach areas.

Additional Considerations

- Multi-agency coordination and collaboration will be critical to developing long-term environmentally sustainable solutions for major public infrastructure systems, including Highway One, wastewater treatment plans, and water supply facilities.
- Zoning overlays could be used in LCPs to ensure that modification to existing buildings or construction of new buildings in vulnerable areas are amortized and removed over time.
- Adaptation strategies that protect existing community development should also account for natural resource and ecosystem function values. Additional studies may be needed to accurately quantify or assess these ecosystem values.
- Surfing is an important coastal activity throughout the county; wave and shoreline conditions may change with sea level rise as areas become more submerged and the surfable zone is lost.
- Shoreline and beach management plans, multi-resource management efforts and regional sediment management will be critical for protection and maintenance of beach and ocean resources for all users in the long run.

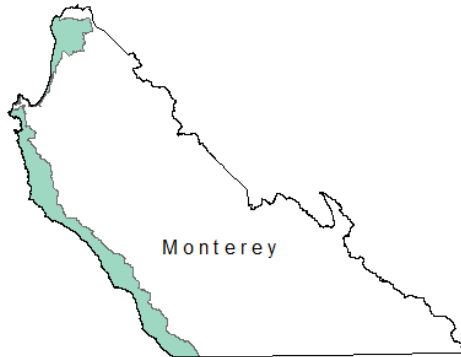
References

- [1] [County of Santa Cruz, Planning Department. 2013. "County of Santa Cruz Climate Action Strategy."](#)
- [2] California Coastal Commission Central Coast District Staff Interview. May 4, 2016.
- [3] [Griggs G and B Haddad. 2011. "City of Santa Cruz Climate Change Vulnerability Assessment."](#)
- [4] ESA PWA. 2012. "Sea Level Rise Assessment: Technical Report for the Safety Element of the General Plan and the Local Hazard Mitigation Plan for the City of Capitola."
- [5] [California Coastal Commission. 1995. ReCAP Pilot Project Finding and Recommendations: Monterey Bay Region.](#)



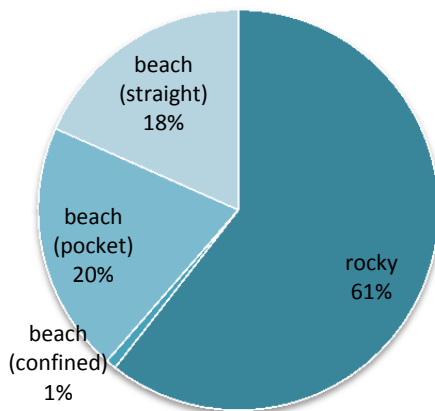
Monterey County

Coastal Zone



Monterey County is located along the Central California Coastline, extending 136 miles from the flat coastal plain south of the Pajaro River to the rugged mountainous shoreline of Big Sur just south of the town Gorda. The 200,960 acres (314 square miles) of terrestrial coastal zone encompasses agricultural resources along Elkhorn Slough and Moss Landing, environmentally sensitive habitat areas (ESHA), important migratory habitats, 15% of all the wetlands in California’s coastal zone, national forests, dunes, numerous access points (3rd highest in the state), and many recreation areas. Monterey County includes several areas of national significance such as the Los Padres National Forest, Salinas River National Wildlife Reserve (NWR), Elkhorn Slough National Estuarine Research Reserve (NERR), and Monterey Bay National Marine Sanctuary. Monterey also includes the world famous Big Sur coast and the many important features of the built and natural environment along the Monterey peninsula.

Outer coast shoreline



Coastal Zone Resources

Ports & Harbors: Moss Landing, Monterey
 Publicly Owned/Accessible: 112,600 acres
 Public Access Coastal Areas: 127 locations
 Coastal Zone Wetlands: 9,800 acres

Ocean Economy

2013 County Ocean Sectors GDP \$931 M

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$777 M
Transportation GDP	\$12 M
Minerals GDP	\$5 M

3%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

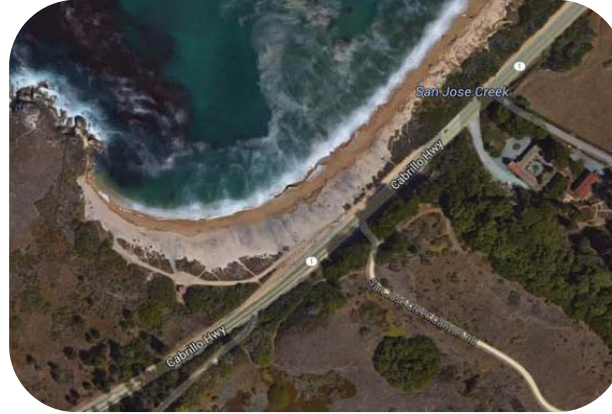
The Monterey County area has a diverse, thriving ocean economy. In 2013, Monterey County accounted for 3% of the state’s total ocean sector gross domestic product (GDP). Approximately 84% of the county’s ocean economy relies on tourism and recreation. Some of Monterey’s most visited sites (e.g., the Monterey Bay Aquarium, Cannery Row, Fisherman’s Wharf, the coastal trail, and Big Sur) have been categorized as highly vulnerable to changes in sea level. Damages to these valuable assets could have severe impacts to Monterey’s coastal economy.



Monterey County

Hazards and Vulnerability

Multiple vulnerability assessments have been conducted in Monterey County, highlighting locations of sensitive natural resources, community development, and infrastructure. Due to its geology, Monterey County has one of the highest erosion and sand loss rates in the state. Not only is infrastructure at risk from rising sea levels in Monterey County, but its highly sensitive coastal habitats are at high risk to “coastal squeeze”--the incremental loss of beach area and shoreline habitats in front of armored/developed shorelines. The City of Pacific Grove’s “Climate Change Vulnerability Assessment” and the City of Monterey’s “Final Sea Level Rise and Vulnerability Analysis” both use the National Research Council’s (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100 [1,2].



Monastery Beach erosion

In the cities of Seaside, Marina, and Monterey, flooding and dune erosion are larger concerns. Sand mining from the Cemex facility in the City of Marina serves to exacerbate such issues [4]. Studies show that sand mining increases erosion rates and that there would be at least a 60-72% decrease in beach loss if the mining stopped [4].

Public transportation in the City of Monterey is vulnerable to flooding, and in particular, the coastal recreational trail and Del Monte Avenue bus routes [2].

In the City of Monterey, flooding was identified as the largest risk associated with climate change [2]. The City of Pacific Grove vulnerability analysis highlighted major threats to Lovers Point, the Hopkins Marine Station, and the Monterey Bay Aquarium[2].

Further south, Carmel-by-the-Sea, renowned for its mile-long stretch of white sand beach and forest of Monterey pine and oak trees, is vulnerable. The city’s scenic roads, public access pathways to its sandy beaches, and the Carmel River Lagoon are all threatened by flooding, which will intensify with sea level rise and increased storm surge [5].

The southernmost portion of Monterey County includes Big Sur, which offers views of the Santa Lucia Mountains, coastal bluffs, rocky coastline, beaches, and the ocean from Highway 1. Much of Highway 1 is already susceptible to damage from erosion and flooding during storm events

Population at risk to 100yr Flood
 11,000 = current risk | 14,000 = future
 w/1.4m SLR
 Source: Heberger et al., 2009

Potential Bluff/Dune Erosion Risk w/ 1.4m SLR 1600 properties | 820 people
 Source: Heberger et al., 2009

In the northernmost part of Monterey County, Elkhorn Slough and north Monterey County generally have begun to experience saltwater intrusion, affecting both agricultural and residential wells. Monterey County supports one of the highest wetland acreages in the California coastal zone, and could lose significant statewide wetland area to sea level rise according to a Pacific Institute Study [3]. According to this study, migration is viable for many of the wetlands in Monterey County under a 55 inch sea level rise scenario. Sea level rise-related flood risks for this county are highest near Monterey Bay and Elkhorn Slough.

The southernmost portion of Monterey County includes Big Sur, which offers views of the Santa Lucia Mountains, coastal bluffs, rocky coastline, beaches, and the ocean from Highway 1. Much of Highway 1 is already susceptible to damage from erosion and flooding during storm events



Monterey County

and major high tides, which is expected to increase with sea level rise. Likewise, the risks of

losing beaches and public access ways are projected to increase.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the City of Monterey (Round 2) and the City of Pacific Grove (Round 1) have been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise; "Acknowledges SLR" means there are no explicit policies addressing sea level rise, but the hazard is recognized in the certified LCP; and "In progress" refers to jurisdictions with LCP grants for addressing sea level rise. A case study for the City of Pacific Grove is available to highlight the Commission's LCP planning work on sea level rise [6].

Table 1. LCP Planning in Monterey County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction
Monterey County					
North Segment	Yes (1988)	OPC, SCC	Yes[7]	In Progress	67%
Del Monte Forest Segment	Yes (1988)	OPC	No	Acknowledges SLR	
Carmel Area Segment	Yes (1988)	OPC	No	In Progress	
Big Sur Segment	Yes (1988)	OPC	No	In Progress	
City of Marina	Yes (1982)	No	Yes[4]	No	2%
City of Sand City	Yes (1984)	No	Yes[4]	No	1%
City of Seaside	Yes (2013)	No	Yes[4]	In Part	<1%
City of Monterey					
Laguna Grande Segment	No	CCC, OPC	Yes[2,4]	In progress	2%
Del Monte Beach Segment			Yes [4,7]	In progress	
Harbor Segment			Yes[4,7]	In progress	
Cannery Row Segment			Yes [7]	In progress	
Skyline Segment			Yes [7]	In progress	
City of Pacific Grove	No	CCC	Yes [1]	In Progress	4%
City of Carmel	Yes (2004)	No	No	Acknowledges SLR	1%
Federal Lands and Ports					23%

Coastal Act Management Priorities

The Monterey County area faces significant sea level rise vulnerabilities to natural habitat, coastal development, and public access. The county must address likely long-term impacts to its extremely valuable beach and wetland resources. It also must deal with storm flooding, shoreline erosion, and urban coastal squeeze. Some top priorities by Coastal Act themes are presented below.



Monterey County

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Inundation and increased erosion from sea level rise could convert coastal habitats from one type to another (e.g., salt marsh to mud flat) and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. There is a need for more studies of wetland migration opportunities and saltwater intrusion threats facing the Elkhorn Slough/Moss Landing area.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

Many developed areas in Monterey County already experience hazards related to dune and bluff erosion and flooding. To address the expectation that these hazards will intensify with sea level rise, local governments should consider a comprehensive set of policies and standards for redevelopment, reevaluation of existing seawalls, and strong policies and direction for ensuring that private shoreline development on public lands fully mitigates the impacts to public access and recreation, and other coastal shoreline resources. Long term planning with Caltrans, State Lands Commission, and other stakeholders should be a priority in order to protect both coastal development and beach access.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is to protect and maximize public access to the coast. Sea level rise in Monterey County could lead to a loss of public access and recreational opportunities due to permanent inundation or episodic flooding or erosion of beaches, recreational areas, and trails. In addition, sea level rise is expected to cause flooding along public transit routes to the coast, including bus stops, raising environmental justice concerns for those dependent on public transportation.

Agriculture (Coastal Act Sections 30241, 30241.5, 30242, 30243)

The Coastal Act places a high priority on agriculture, and north Monterey County includes the Pajaro Valley agricultural regions spreading into the Salinas Valley agricultural region. These areas are significant and important agricultural assets to the State and the Nation, and are threatened currently by sea level intrusion, particularly in the Seaside Groundwater Basin. Sea level rise can exacerbate all of these concerns.

Additional Considerations

- In planning for sea level rise along Monterey Bay, zoning overlays could be used in LCPs to ensure that modification to existing buildings or construction of new buildings in vulnerable areas include designs to avoid or minimize risks from flooding, erosion or tsunamis.
- Quantitative assessment of impacts to beaches from development of seawalls can help inform selection of mitigation options for areas at risk from flooding and erosion from sea level rise.
- Phased implementation of different adaptation strategies, such as a combination of armoring and relocation of development over time, could be considered for pockets of development along erosion-prone areas of Big Sur that are constrained by critical infrastructure, such as Highway 1.
- Since Elkhorn Slough is surrounded by farmland, habitat migration from sea level rise could present conflicts between ESHA and agricultural uses. Additional studies and stakeholder engagement could seek to identify solutions to balance these potential conflicting uses and find opportunities for phased or multi-benefit adaptation approaches.
- A long-term planning strategy for the Highway 1 segment from Carmel to San Luis Obispo County (and beyond) is needed, including potential realignment inland, multi agency coordination, and California Coastal Trail planning.

References

[1] [EMC Planning Group Inc. 2015. "City of Pacific Grove Climate Change Vulnerability Assessment."](#)



Monterey County

- [2] [Revell Coastal, LLC. 2016. "2016 City of Monterey Final Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report"](#)
- [3] [Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. "The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center. "](#)
- [4] [ESA PWA. 2012. "Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay."](#)
- [5] California Coastal Commission Central Coast District Staff Interview. May 4, 2016.
- [6] California Coastal Commission. December 2016. City of Pacific Grove Case Study.
- [7] [ESA PWA, 2014. "Monterey Bay Sea Level Rise Vulnerability Assessment, Technical Methods Report."](#)



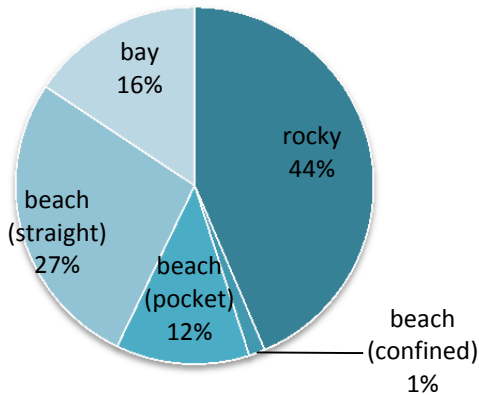
San Luis Obispo County

Coastal Zone



San Luis Obispo (SLO) County is located along 107 miles of California’s central coast, between Guadalupe Dunes in Santa Barbara County to the south and the Big Sur coast area of Monterey County to the north. Several unincorporated areas are located within the San Luis Obispo County coastal zone, including Cambria, Cayucos, Los Osos, Avila Beach, and Oceano, as well as three incorporated cities: Morro Bay, Pismo Beach, and Grover Beach. The 160,000 acres (250 sq. mi.) of terrestrial coastal zone is diverse in terrain and use, and includes significant beaches, dune areas, rocky headlands, and vast woodland areas mixing with recreational uses, agriculture, visitor-serving facilities, and ports, such as Port San Luis in Avila Beach and Morro Bay Harbor in Morro Bay. The City of Morro Bay provides a large number of visitor-serving and recreational facilities and is a popular visitor destination along the central coast. Significant public access is available along much of the City of Pismo Beach’s bluffs, with trail connections from Avila Beach south to the City of Grover Beach. In this southern portion of the county, the coastal zone is generally bisected by Highway 1, with the beach, dunes, and visitor-serving facilities of Pismo State Beach and the Oceano Dunes State Vehicular Recreation Area (SVRA) on the west side of the highway and more urbanized neighborhoods on the east side. Federal coastal resources, such as the Piedras Blancas Light Station and Morro Bay National Estuary, also contribute to the diverse resources found in the county’s coastal zone. Diablo Canyon Nuclear Power Plant, no longer in operation and in the beginning stages of closure, is also located here.

Coastal Shoreline



Coastal Zone Resources

Ports & Harbors: Avila, Morro Bay, SLO
 Publicly Owned/Accessible: 25,500 acres
 Public Access Coastal Areas: 115 locations
 Coastal Zone Wetlands: 6,800 acres

Ocean Economy

2013 County Ocean Sectors GDP \$360 M

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$270 M
Construction GDP	\$32 M
Transportation GDP	\$7.0 M

1%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Though it accounts for only 1% of the state’s total ocean sector gross domestic product (GDP), San Luis Obispo County still has many important public access and recreational areas. With both quaint towns and many undeveloped natural resources, the county draws tourists interested in many different activities, making tourism and recreation its largest ocean economy sector. Much of the county’s coastal development and coastal natural resources are highly vulnerable to sea level rise, putting its ocean economy at risk as well.



San Luis Obispo County

Hazards and Vulnerability

San Luis Obispo County conducted a general climate change vulnerability report in 2010 to develop adaptation strategies. The report considered the effects of climate change to both the socioeconomic and natural systems of the county [1] and a 2012 study explored these vulnerabilities in more detail [2].

Using 12-16 inches of sea level rise by 2050 and 23-55 inches of sea level rise by 2100 as its sea level rise scenarios, the 2012 assessment found the following impacts along San Luis Obispo County: increased erosion on already retreating coastal bluffs and beaches, increased risk of cliff failures, coastal flooding with higher storm surges and flood elevations, inundation of critical transportation and infrastructure (including public transportation, commercial, energy, wastewater, and residential infrastructure in low-lying areas), conversion of coastal wetlands to submerged lands, and salt water intrusion into coastal freshwater wells [2]. Important agricultural areas, particularly those used for cattle ranching, are highly vulnerable to saltwater inundation of wells with sea level rise. The assessment also analyzed social vulnerabilities to sea level rise impacts for coastal residents factoring in age, health, and socioeconomic status [2].



Figure 1. Diablo Canyon Power Plant, Coastal Records Project

necessary to evaluate the hazards posed by sea level rise to facilities remaining on the site.

Cambria and Los Osos, in particular, are currently experiencing severe water supply issues. Local groundwater aquifers are the only water supply for Los Osos, and already experience saltwater intrusion from sea level rise [2]. San Simeon and Santa Rosa Creeks provide drinking water for

Cambrians, and both are heavily impacted by the ongoing drought [3].

Population at risk to 100yr Flood
670 = current risk | 1,300 = future w/ 1.4m SLR
Source: Heberger et al., 2009

Potential Bluff/Dune Erosion Risk w/ 1.4m SLR 1,600 properties | 1,100 people
Source: Heberger et al., 2009, County parcel data

In the north, a portion of Highway 1 is being relocated up to 500 feet inland near Piedras Blancas Lighthouse Station. Additional Highway 1 flooding along the coast will only increase with sea level rise. Despite future closure of the Diablo Canyon Power Plant, further study of the site is

The City of Morro Bay has both bayside and coastal development that is at risk to rising sea levels. In 2013, the Coastal Commission denied redevelopment of the Morro Bay Wastewater Treatment Plant in its existing location just inland of the beach and on former dunes in part due to coastal hazards at the site, including hazards from sea level rise. Both the San Simeon (San Simeon Acres) and the south San Luis Obispo County (Oceano) wastewater treatment facilities are threatened by coastal hazards and sea level rise [3]. Estero Bluffs State Park has also been identified as vulnerable to sea level rise, in turn making public coastal trails, public access, and recreation associated with this state park vulnerable to rising seas [3]. Much of the beachfront property in the community of Cayucos (along Pacific Avenue and Studio Drive) has been armored with rip rap on an emergency basis and seawalls over time (thus impeding inland beach migration as a near-term option to address loss of beach from sea level rise).



San Luis Obispo County

In the community of Avila Beach, San Luis Obispo Creek has often crested its banks during storms into the downtown area; thus, prompting requests for emergency permits to alleviate the flooding impacts. The drought has changed typical river flows so much that lagoons have formed where they did not previously exist [3]. These impacts will be exacerbated with rising sea levels and climate change. There is a high likelihood of

losing many beaches due to sea level rise in the City of Pismo Beach given that many beaches to the north of the downtown area are “pocket” beaches surrounded by high cliffs, and these beaches only retain their sand in the summers. Increased sea level rise would mean these beaches would not be accessible or usable in the future.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the City of Morro Bay has been awarded grants from the Coastal Commission (Rounds 2 and 3) to address the impacts of sea level rise within its LCP jurisdiction. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise and "in progress" refers to jurisdictions with LCP grants for addressing sea level rise.

Table 1. LCP Planning in San Luis Obispo County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessment?	Updated for SLR?	Shoreline by Jurisdiction
San Luis Obispo County	1987	No	Yes [2]	In Part	90%
City of Morro Bay	1984	OPC and CCC	Yes [2,4]	In Progress	4%
City of Pismo Beach	1984	No	Yes [2]	No	5%
City of Grover Beach	1982	No	Yes [2]	In Part	<1%

Coastal Act Management Priorities

The San Luis Obispo County area faces significant sea level rise vulnerabilities for coastal development, natural habitat, and water supply. The county must address likely long-term impacts to its extremely valuable beach, wetland and recreational resources. It also must deal with storm flooding, continued shoreline erosion, and threats to critical infrastructure (e.g., roads, wastewater, water supply). Some priorities by Coastal Act issue area are presented below.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

San Luis Obispo County residents, particularly those along eroding beaches and cliffs, as well as in low-lying areas, are vulnerable to sea level rise, flooding, erosion and cliff failure. Planners should consider phasing adaptation approaches that also allow for eventual retreat, especially as relocation of public infrastructure can take substantial amounts of planning lead time and multi-agency coordination. Other important developed assets that need long-term sea level rise planning in the county are the San Simeon Wastewater Treatment Plant and the Diablo Canyon Power Plant, for assets that might be in place for some time despite it being phased out. This planning will require continued coordination with



San Luis Obispo County

utilities (Pacific Gas and Electric) and other agencies such as the Nuclear Regulatory Commission, California Energy Commission, State Lands Commission, and Caltrans and local governments.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

San Luis Obispo County LCP jurisdictions contain unique wetlands that are important for habitat value, threatened and endangered species, and wave attenuation to protect the shoreline. Sea level rise threatens wetlands because of saltwater intrusion, drowning of marsh habitat, and vegetation conversion, particularly if the habitats are unable to migrate over time. In addition to protecting wetlands, there is a need to better understand sea level rise vulnerability of sensitive habitats at Oceano Dunes SVRA to support development of adaptation strategies for snowy plover habitat and nesting and ongoing human uses.

Water supply/Water quality (Coastal Act Section 30231)

Sea level rise could lead to declines in coastal water quality by impacting wastewater facilities, damaging equipment and blocking outfall discharges. It could also increase saltwater intrusion into groundwater aquifers, thus potentially rendering some existing wells unusable and decreasing the total groundwater supply in coastal areas. Because the variation in how sea level rise could impact water supplies based upon local hydrological conditions, continuing research is needed in certain locations, including Cambria, Los Osos and Morro Bay.

Additional Considerations

- Early and often coordination with Caltrans will be important for addressing Highway 1 exposure (including bridges) to accelerated erosion and damage from sea level rise and changes in inland flooding due to climate change. In some areas, such as northern San Luis Obispo County, phasing adaptation might best address risks from sea level rise such as short-term armoring followed by eventual retreat or relocation (i.e., a hybrid approach).
- To address water supply threats, local governments should consider land use policies for new septic systems that require larger shoreline setbacks, limit new wells drawing upon shallow aquifers, and/or establish new community wastewater treatment facilities.
- Defining trigger points for the removal or maintenance of shoreline structures can help reduce pressure on habitat caught between rising seas and hardened backshores. Communities such as Cayucos, Avila Beach and Pismo Beach will lose beach habitat and recreational areas unless adaptation strategies are in place to make room for future inland migration.
- Long-term planning efforts in the City of Morro Bay should include working toward maintaining and enhancing important recreation and visitor serving facilities (including California Coastal Trail enhancements) and a working waterfront in the face of sea level rise.
- Early and often coordination with local community service districts (CSDs) is important for the development of plans to create new public infrastructure in the coastal zone and in plans to relocate important public infrastructure away from sea level rise and flooding hazard areas.

References

[1] The GEOS Institute (previously the National Center for Conservation Science and Policy) and Local Government Commission. 2010. Integrated Climate Change Adaptation Planning in San Luis Obispo County.

[2] [Susanne Moser Research & Consulting and University of California, Berkley. 2012. "Developing Adaptation Strategies for San Luis Obsipo County: Preliminary Climate Change Vulnerability Assessment for Social Systems."](#)

[3] California Coastal Commission Central Coast District Staff Interview. May 4, 2016.

[4] [Morro Bay National Estuary Program. 2015. "Climate Vulnerability Assessment Report."](#)



Santa Barbara County

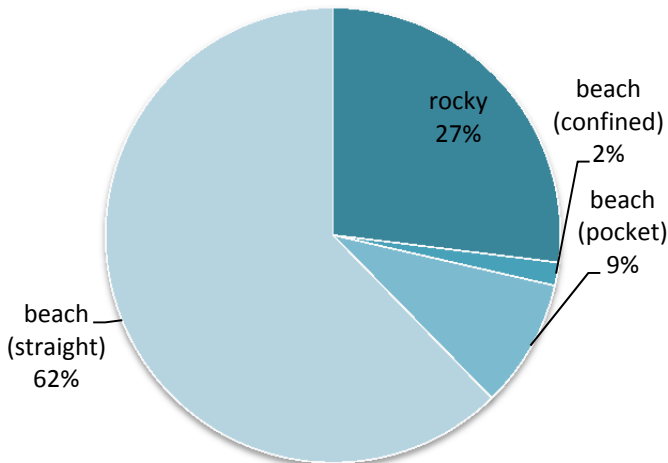
Coastal Zone



Santa Barbara



Outer Coast Shoreline



Santa Barbara County lies in the southern portion of the state, and includes 117 miles of mainland shoreline (not including bays, harbors, or lagoons), as well as San Miguel Island (28 miles), Santa Rosa Island (52 miles), Santa Cruz Island (77 miles), and Santa Barbara Island (7 miles). The coastal zone area totals approximately 240,000 acres (approximately 374 square miles) and includes five incorporated cities and four of the eight Channel Islands. The County is characterized by rugged coastal mountains (Santa Ynez Mountains along the south coast), agricultural valleys, and a scenic views. Resource extraction, particularly petroleum extraction, and tourism are two large economic components of Santa Barbara County. The county also includes the University of California, Santa Barbara, portions of Channel Islands National Marine Sanctuary, and federal lands, such as Gualdaupe-Nipomo Dunes National Wildlife Refuge and Vandenberg Air Force. Base.

Coastal Zone Resources

Ports & Harbors: Santa Barbara Harbor
 Publicly Owned/Accessible: 119,700 acres
 Public Access Coastal Areas: 92 locations
 Coastal Zone Wetlands: 8,200 acres

Ocean Economy

2013 County Ocean Sectors GDP \$1.5 B

2013 Major Ocean Economic Sectors

Tourism and Recreation GDP	\$0.66 B
Minerals GDP	\$0.34 B
Transportation GDP	\$0.014 B

4%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Santa Barbara County's scenic coastline, rugged coastal mountains, and moderate climate make it a popular tourist destination. Given that its tourism is dependent on coastal resources, Santa Barbara County's economy from tourism is also at risk to rising sea levels. Santa Barbara County's ocean economy accounts for 4% of the state's total ocean sector gross domestic product (GDP), with 23% of the county's ocean economy comprising mining, such as oil extraction. Historically, the county has experienced multiple oil spills in its coastal lands and waters, with significant repercussions for its ocean and coastal economy.



Santa Barbara County

Hazards and Vulnerability

Multiple vulnerability assessments and hazard studies have been conducted throughout Santa Barbara County. Using the Intergovernmental Panel on Climate Change (IPCC)'s sea level rise projections (between 0.2 m and 0.6 m of possible sea level rise by 2100), the 2016 county-wide Hazard Mitigation Plan highlights that erosion will increase with rising sea levels along the County coastline [1]. Increases in flooding and erosion from sea level rise could cause damage to coastal structures and residences, and cause saltwater intrusion into delta areas and coastal aquifers [1]. Other studies such as the City of Goleta's Coastal Hazards and Fiscal Impact Report, the City of Santa Barbara's Sea-Level Rise Vulnerability Study, and the City of Santa Barbara Sea Level Rise Vulnerability Assessment, and the County of Santa Barbara's Coastal Resilience Project all used the National Research Council's (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100.



Developed Santa Barbara shoreline

Winchester Canyon neighborhood, the Aero Camino neighborhood, and the Placencia neighborhood [2]. Coastal erosion is expected to accelerate, assuming the existing timber seawall becomes derelict over

time or is removed [2]. Sea level rise poses risks to the community from oil and gas activities, including oils spills from both active and inactive wells.

Studies of the City of Santa Barbara vulnerabilities identify critical transportation features such as roads, bikeways, parking lots, and the railroad, will be exposed to sea level rise-

related hazards. Roughly 21 miles of roads in city were found to be at risk or experiencing hazards associated with sea level rise (i.e.

Potential Bluff Erosion Risk w/ 1.4m SLR
 580 properties | 2,100 people
 Source: Heberger et al., 2009

Population at risk to 100yr Flood
 3,400 = current risk | 6,700= future w/
 1.4m SLR
 Source: Heberger et al., 2009

The City of Goleta's hazards and vulnerability assessment analyzed the fiscal impacts of coastal hazards and identified vulnerable assets to include natural resources, critical infrastructure, and recreational areas. With regional subsidence and uplift taken into consideration, Goleta can expect between 0.04 and 10.2 inches of sea level rise by 2030, between 2.8 and 27.2 inches by 2060, and between 10.6 and 60.2 inches by 2100. The assessment highlights three Goleta neighborhoods that will face flooding with this sea level rise:

flooding, inundation, erosion) [3]. For example, Cabrillo Boulevard was found to be at risk to both permanent inundation and flooding from a 100-year storm with 37 inches of sea level rise. Erosion hazards were also found to threaten roads vital to providing law enforcement and medical services [3]. With an increased erosion rate of 24 inches per year, 1.1 miles of roads were identified as at risk including upper Shoreline Drive, Santa Cruz Boulevard, Mohawk Road, and Edgewater Way [3]. The Estero Wastewater Treatment Plant was ranked as a resource with high sensitivity because its structures are at risk to rising sea levels, and it is critical to the health and safety of the City of Santa Barbara [3]. The pumps are the most



Santa Barbara County

vulnerable to sea level rise, and a malfunction of them could result in the discharge of raw or partially treated wastewater into the ocean or into residential neighborhoods. The Ortega Groundwater Treatment Plant, an important source of drinking water for the city, was also characterized as highly sensitive to rising seas because of saltwater intrusion [3].

The City of Santa Barbara coastline is developed for residential purposes, much of which is at high risk to erosion and flooding with sea level rise. The Santa Barbara Harbor is also very sensitive, as it is vulnerable and is an important component for all ocean-dependent industry and recreation in the city [3]. Arroyo Burro Beach County Park, Leadbetter Beach, East Beach, and West Beach were all found to be very highly sensitive to rising sea levels [4]. Loss of beach will negatively impact public access

and recreation and reduce habitat for species, including the Western Snowy Plover.

On lands owned by the University of California, Santa Barbara (UCSB), sea level rise could diminish vernal pool habitats due to bluff erosion [4]. The UCSB lagoon may also be vulnerable to rising sea levels [4]. Many students live in the Isla Vista community, an area that is highly vulnerable to rising sea levels due to bluff erosion [4]. Some Isla Vista residential properties have already been identified as uninhabitable.

Although less studied, the City of Carpinteria has assets identified as vulnerable to sea level rise [4]. These include dunes and beaches in the area which may experience losses due to adjacent development and a lack of space for these habitats to migrate inland.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the County of Santa Barbara (Round 2), Cities of Goleta (Round 1), Santa Barbara (Round 1 and 3) and Carpinteria (Round 3) have been awarded grants from the Coastal Commission. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In progress" refers to jurisdictions with LCP grants for addressing sea level rise. A case study for the City of Goleta is available to highlight the Commission's LCP planning [5].

Table 1. LCP Planning in Santa Barbara County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction
County of Santa Barbara	1982	SCC, OPC, CCC	Yes [1], In Progress [6]	In Progress	68%
City of Guadalupe	1991	No	Yes [1]	No	None
City of Goleta	No	CCC	Yes [1,2]	In Progress	2%
City of Santa Barbara		CCC	Yes [1,7]	In Progress	6%
City Segment	1986	No	Yes [1,3,7,8]	In Progress	
Airport Segment	1991	No	Yes [1,7]	No	
City of Carpinteria	1982	CCC	Yes [1]	In Progress	2%
Federal Lands (Vandenberg AFB, USCG), UC Santa Barbara					22%



Santa Barbara County

Coastal Act Management Priorities

Santa Barbara County faces significant sea level rise vulnerabilities in critical infrastructure, recreation and access, and ecological resources. The county must address likely long-term impacts of sea level rise to its extremely valuable beach and lagoon resources. It also must deal with flooding and continued shoreline erosion and pressure for seawall development in urban areas. Some top priorities by Coastal Act themes are presented below.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

There is a need throughout Santa Barbara County for shoreline management planning in LCPs to address residential development and critical infrastructure that is vulnerable to sea level rise. With planning, funding, and collaboration, local governments could create shoreline management plans that phase adaptation approaches over time (i.e. protection, accommodation, and retreat). Other critical assets that need long-term sea level rise planning are oil wells, wastewater, water supply, railroads, and roads. In the City of Santa Barbara, a better understanding of the role of tide gates play in flood management is critical to managing future sea level rise. While this is an area of ongoing study, it is widely acknowledged that maintaining the tide gates is a high management priority for preventing flooding in a large section of the city's downtown. Another area of study that could improve planning for sea level rise is to model future creek flooding extents with changes in precipitation and sea level rise, especially considering the extent of existing creek flooding mapped by FEMA in cities like Goleta.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Santa Barbara County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. Long term planning with Caltrans, State Lands Commission, and other stakeholders should be a priority in order to maintain transportation infrastructure as well as beach access.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Sea level rise threatens wetland and lagoon habitats in the county (e.g., Devereux Slough, Goleta Slough, and Carpinteria Salt Marsh) because of saltwater intrusion, drowning of marsh habitat, and vegetation/habitat conversion. Additional study is needed to better understand options for preserving or restoring coastal habitats in light of sea level rise, limited upslope areas for migration, and managed water flows (i.e. tide gates). Unique vernal pools and lagoon resources in the county are also priority areas for planning due to the federally protected species that rely on them. The state should also work with federal agencies, Santa Barbara County, City of Santa Barbara Airport, and the City of Goleta to resolve the management options for Goleta Slough in order to reduce flood risk.

Additional Considerations

- Saltwater intrusion into freshwater aquifers, and permitting issues surrounding private wells in Santa Barbara County, should be addressed in adaptation planning.
- When protective structures are proposed for adaptation, feasibility analyses should assess and account for the recreational and ecological consequences of dune, beach, and wetland loss.
- Santa Barbara Harbor is identified as highly sensitive to sea level rise and is one of the most important sites for ocean-dependent industry and coastal-dependent recreation in the county. It should be a priority for adaptation planning.
- Preserving archaeological resources at risk to sea level rise is important throughout the county.



Santa Barbara County

References

- [1] [Santa Barbara County Office of Emergency Management. 2016. "2016 Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan."](#)
- [2] [City of Goleta and Revell Coastal. 2015. "Draft 2015 City of Goleta Coastal Hazards Vulnerability and Fiscal Impact Report."](#)
- [3] [Denka S, A Hall, and L Nicholson. 2015. "City of Santa Barbara Sea Level Rise Vulnerability Assessment."](#)
- [4] California Coastal Commission South Central Coast District Staff Interview. June 13, 2016.
- [5] California Coastal Commission. December 2016. City of Goleta Case Study.
- [6] County of Santa Barbara Long Range Planning Division. 2016. "County of Santa Barbara Coastal Resiliency Project. Sea Level Rise and Coastal Hazards Vulnerability Assessment."
- [7] [University of California, Santa Cruz. 2012. "City of Santa Barbara Sea-Level Rise Vulnerability Study."](#)
- [8] ESA. 2016. "Updated Coastal Flooding and Erosion Hazards for Santa Barbara City (ESA Ref. #D150417.00)."



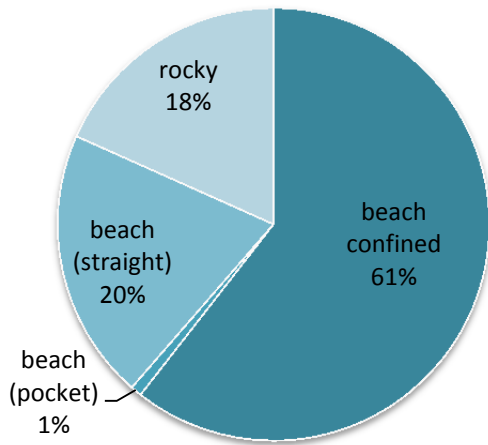
Ventura County

Coastal Zone



Ventura County is located in south central California, comprising about 43 miles of mainland shoreline. The county includes two of the eight Channel Islands, Anacapa Island (part of the Channel Islands National Park and National Marine Sanctuary) and San Nicolas Island (military lands). The 76 square miles of terrestrial coastal zone includes agricultural resources of the Oxnard plain, the Ventura and Santa Clara River estuaries, Mugu Lagoon (one of the largest remaining salt marshes in southern California), recreational boating at Ventura and Channel Islands Harbors, military lands, beach communities, and state beaches and parks that provide significant public access and recreation. Major federal lands in the area include Channel Islands National Park and Naval Base Ventura County made up of naval facilities at Port Hueneme and Point Mugu. The area also contains one of the four major Ports identified in Chapter 8 of the Coastal Act: the Port of Hueneme, the only deep water harbor between Los Angeles and the San Francisco Bay. With approximately 26 miles of armoring, Ventura is the most armored county in California [1].

Outer Coast Shoreline



Coastal Zone Resources

- Ports & Harbors: Oxnard, Port Hueneme, Ventura
- Publicly Owned/Accessible: 15,300 acres*
- Public Access Coastal Areas: 61 locations
- Coastal Zone Wetlands: 4,100 acres

*Does not include military land

Ocean Economy

2013 County Ocean Sectors GDP \$1.4 B

2013 Major Ocean Economic Sectors

Minerals GDP	\$743.0 M
Tourism & Recreation GDP	\$492.0 M
Transportation GDP	\$78.0 M

4%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Ventura County accounts for 4% of the state's total ocean sector gross domestic product (GDP). The offshore ocean minerals sector primarily includes oil and gas production. While offshore minerals account for more than half of Ventura's ocean economy, tourism employs a majority of individuals working in the ocean sectors. Sea level rise poses threats to the tourism and recreation sector as increases in sea level will reduce available beach area and increase the potential for and extent of storm damages on nearby visitor-serving and recreational facilities.



Ventura County

Hazards and Vulnerability

Ventura County’s erosion and flood hazards have been extensively studied, with detailed modeling conducted on potential sea level rise impacts [3,4,5]. The Coastal Resilience Ventura project modeling reflects sea level rise scenarios (with low, medium and high ranges) for 2030, 2060, and 2100, including effects of waves, El Nino frequency, emissions scenarios (for fluvial 100-year storms), erosion, and rising tides. The high sea level rise scenario at 2100 shows 148cm (58.1 in) of rise relative to 2010 [3]. Impacts of sea level rise combined with predicted local tsunamis extents have also been modeled for the county. The Coastal Resilience Ventura project highlights locations of natural resources, community development, and infrastructure that are sensitive to tidal inundation, coastal erosion, and storms, and fluvial flooding [3]. The Coastal Resilience Mapping Portal shows many natural (e.g., beaches, wetlands) and built assets (e.g., roads, wastewater treatment plants, residential areas) of Ventura County are in highly vulnerable areas, and many of these areas are already experiencing erosion and flooding [3,4,5].

Development is vulnerable in Ventura County, with property replacement valued at \$2.2 billion under a 1.4-m sea level rise scenario with a 100-year storm [2]. Also of concern are roads, railroads, three power plants, outfalls, and the Naval Base Ventura County (composed of three sites, Port Hueneme, Point Mugu, and San Nicolas Island). Storm flooding south of Port Hueneme toward Point Mugu could extend over 2 miles inland under 2100 scenarios [3]. The risk



Promenad, Ventura County

of flooded contaminated sites (like Halaco Superfund site in Oxnard) is high and with a 1.4-m rise in sea level, 13 contaminated sites will be vulnerable to a 100-year flood. Visitor-serving coastal development is also vulnerable to erosion and flooding from rising sea levels in much of Ventura’s urban areas. Many recreation areas in the City of Ventura such as the Promenade and public beach are vulnerable to storm flooding and erosion today. Beaches along the coast of the City of Oxnard also face storm flooding threats as early as 2030, with all of Oxnard Shores development projected to be flooded in high sea level rise

scenarios for the year 2100 [3]. Most of the storm drain outfalls in the City of Oxnard LCP Planning Areas are vulnerable at extreme

ocean water levels under current sea level conditions and this will only get worse with sea level rise.

Important natural habitat in Ventura County includes the Ventura River Estuary, Santa Clara River Estuary, Ormond Beach Lagoon and wetland complex, and Mugu Lagoon. In one of the first detailed applications of the Sea Level Affecting Marshes Model (SLAMM) to California, wetland conversion for Ormond to Mugu Lagoon was modeled for sea level rise scenarios using inundation, erosion, saturation, and accretion [6]. Model results show how the Ormond Beach region in Oxnard, considered one of the most important wetland restoration opportunities in southern California where restoration efforts are underway, can provide for wetland migration as sea levels rise [6]. However, even at low sea level rise projections,

Population at risk to 100yr Flood
 7,300 = current risk | 16,000 = future
 w/1.4m SLR
 Source: Heberger et al., 2009



Ventura County

storm flood and wave impacts threaten most of the county’s beach and dune habitats and Mugu Lagoon by 2030. This flooding will also have detrimental consequences for many species that inhabit the region, including 18 state and/or federally-listed threatened or endangered species like the Western Snowy Plover [3].

Groundwater, providing the principal water supply for irrigation and urban uses over much of Ventura’s Oxnard Plain, is also vulnerable to sea level rise impacts [3]. Saltwater intrusion has already started to take place in the deep aquifer system of the South Oxnard Plains and

could be exacerbated by sea level rise as groundwater levels decline below sea level [3]. Agriculture in this area will suffer from saltwater intrusion, but is also vulnerable to some overland flooding [3].

A 2015 study supports adaptation planning for Ventura County by providing economic analysis of potential adaptation strategies to address the climate change hazards facing the area [6]. This synthesis of coastal hazard modeling and alternative adaptation scenarios relies on quantifying impacts of coastal armoring and the value of nature-based ecosystem services.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, Ventura County (Round 3) and the City of Oxnard (Round 2) have been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise and "in progress" refers to jurisdictions with LCP grants for addressing sea level rise.

Table 1. LCP Planning in Ventura County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction
Ventura County	Yes (1983)	CCC	Yes [4,5,6], In Progress [4]	In Progress	54%
City of Ventura	Yes (1983)	No	Yes [4,5,6]	In Part	12%
City of Oxnard	Yes (1985)	OPC, CCC	Yes [4,5,6,7]	In Progress	16%
City of Point Hueneme	Yes (1984)	No	Yes [4,5,6]	No	2%
Federal Lands and Ports*					16%

Coastal Act Management Priorities

Ventura County faces significant sea level rise vulnerabilities in every sector, especially in natural resources and infrastructure. Communities must deal with flooding and continued shoreline erosion and resulting pressure for shoreline armoring in the urban areas. Some top priorities by Coastal Act themes are presented below.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

There is a need throughout Ventura County for shoreline management planning in LCPs to address residential development vulnerable to sea level rise. A common, challenging development pattern in



Ventura County

Ventura is a row of beachfront houses all protected by a single, long revetment, which will eventually cause the existing beach area seaward to be squeezed out as sea levels rise. Other important developed assets that need long-term sea level rise planning in the County are energy plants, wastewater facilities, railroads, and roads (particularly the Pacific Coast Highway). This planning will require continued state-level coordination with stakeholders like the State Lands Commission, Caltrans, Southern California Regional Rail Authority, Ventura County Transportation Commission, utilities, and other stakeholders.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in Ventura County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. With planning, funding, and collaboration, local governments can lay the groundwork for future relocation of access ways and actions to preserve beach area as sea levels rise. The planned retreat project at Surfer's Point is an early example adaptation to protect access and recreation.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

The Ventura shoreline is heavily armored and sea level rise will eventually threaten shoreline natural habitats, particularly beaches, as they are squeezed between hard structures and rising sea levels. Sediment management practices are fairly common in this county; additional studies and planning efforts may be needed to address whether these practices will continue to be feasible and effective in the future. The natural resources and wetland habitat along the Ormond Beach shoreline to Point Mugu are unique and highly threatened by sea level rise. Planning to preserve these habitats (e.g., through efforts such as the Ormond Wetland Restoration Project funded by the State Coastal Conservancy) and allow them to migrate inland should be a priority. As many of these wetlands are located on U.S. Navy lands, collaboration with the military will be important.

Additional Considerations

- Planning efforts should consider significant coastal agricultural resources are vulnerable to flooding and saltwater intrusion in the Oxnard Plain.
- When protective structures are proposed for adaptation, feasibility analyses should assess and account for the recreational and ecological consequences of dune, beach, and wetland loss.

References

- [1] California Coastal Commission. 2005. California Shoreline Armoring Dataset.
- [2] [Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. "The Impacts of Sea level Rise on the California Coast." Prepared by the Pacific Institute for the California Climate Change Center.](#)
- [3] [The Nature Conservancy. 2016. Coastal Resilience Ventura County Project.](#)
- [4] [ESA PWA. 2013. "Coastal Resilience Ventura, Technical Report for Coastal Hazards Mapping."](#)
- [5] [The Planning Center | DC&E. 2013. "Coastal Resilience Ventura Catalogue and Analysis of Local Sea-Level Rise Planning Tools."](#)
- [6] [ENVIRON International Corporation. 2015. "Economic Analysis of Nature-Based Adaptation for Climate Change. Ventura County, California."](#)
- [7] [City of Oxnard Planning Division. 2016. "A Sea Level Rise Atlas for the City of Oxnard."](#)
- [8] California Coastal Commission South Central Coast District Staff Interview. June 13, 2016.



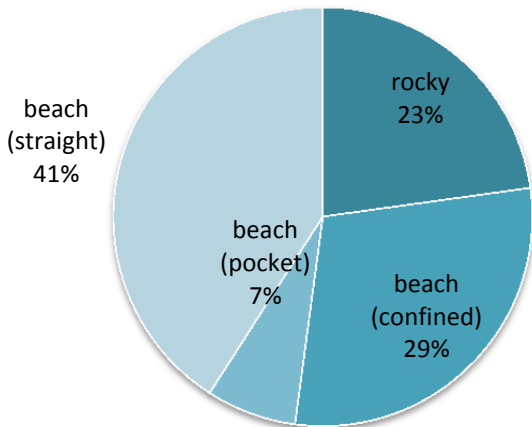
Los Angeles County

Coastal Zone



Los Angeles (LA) County includes 101 miles of mainland shoreline (encompassing the Ports of LA and Long Beach) as well as Santa Catalina Island (65 miles) and San Clemente Island (57 miles). The coastal zone area totals approximately 177,000 acres (about 276 square miles) and includes portions of the County of Los Angeles and 12 incorporated cities. The county includes the Santa Monica Mountains in the northwest, an area with significant natural resources and scenic qualities; a series of broad sandy beaches in several beach cities extending around Santa Monica Bay; the hills, rocky beaches and coves of the Palos Verdes Peninsula, industrial harbor complexes at San Pedro Bay; and sandy beaches from Long Beach to Alamitos Bay. There are also thousands of recreational and commercial boating slips at facilities throughout the county. Over 10 million residents (around 26% of the state) reside in the county and cities in Los Angeles, having some of the most diverse populations in the state. The coastal jurisdictions support significant urban development, beaches, visitor and commercial recreation and varied natural resources.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Los Angeles, Long Beach, San Pedro, Wilmington, Marina del Rey
 Publicly Owned/Accessible: 82,000 acres
 Public Access Coastal Areas: 217 locations
 Coastal Zone Wetlands: 4,800 acres

Ocean Economy

2013 County Ocean Sectors GDP \$15.9 B

2013 Major Ocean Economic Sectors

Transportation GDP	\$6.40 B
Tourism and Recreation GDP	\$2.20 B
Minerals GDP	\$0.48 B

43%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Los Angeles County is the largest ocean economy in the state, accounting for 43% of the state's total ocean sector gross domestic product (GDP). The Ports of Los Angeles and Long Beach are two of the busiest ports in California and the U.S. More than 40% of all imports arriving in the U.S. come through the Ports of Los Angeles and Long Beach [1], making the stability of these ports incredibly important to the U.S. economy. The tourism economy is also vital to LA County; certain assets that support tourism and recreation in the county (i.e. beaches) could be negatively impacted by rising sea levels without efforts to prepare and adapt.



Los Angeles County

Hazards and Vulnerability

Many vulnerability assessments have been completed or are currently underway for Los Angeles County. A comprehensive shoreline change and coastal erosion model for Los Angeles is being developed through the AdaptLA Program, which produced maps showing vulnerabilities from sea level rise that are viewable online [2]. Los Angeles County, the City of Los Angeles, the City of Hermosa Beach, and the City of Long Beach have all conducted vulnerability assessments or climate resiliency assessments using the National Research Council's (NRC) west coast projections of 2-12 inches of sea level rise by 2030, 5-24 inches by 2050 and 17-66 inches by 2100. Topic specific vulnerability assessments have also been conducted, such as the LA County Department of Beaches and Harbor's 2016 [1] assessment of public beach facility vulnerability. This study found that the Malibu beaches may lose significant width with some locations losing their entire sandy beach by 2100 using 39 to 79 inches of sea level rise. In addition, facilities between Dockweiler State Beach and Torrance County Beach may be reduced by at least half of their present day width.



Marine Stadium (Belmont Shore), Long Beach, CA - High Tide

water) and cultural assets (museums, cultural centers, parks and open space) are vulnerable to sea level rise and associated storm surge [4]. Many City assets are already very vulnerable to damages

occurring during high tide and large storm events. Specific areas that have the highest vulnerability to the impacts from sea level rise were found to be the low-lying San Pedro and Wilmington as well as Venice [4]. Venice has begun to experience flooding during El Nino conditions.

Since most of the City of Los Angeles' coastal zone is highly urbanized, there appear to be fewer ecological vulnerabilities in the area. However, the Ballona Wetlands Ecological Reserve, the largest remaining coastal wetland within urban LA County, is at risk to saltwater intrusion and flooding over the current flood control levees that divide Ballona Creek from the wetlands [3].

Since most of the City

Potential Bluff Erosion Risk w/ 1.5m SLR

1,100 properties | 1,600 people

Source: CoSMoS Phase 1 (2016), County parcel data, 2010 U.S. Census Data

The City of Los Angeles owns and maintains critical coastal infrastructure, including two power plants and two wastewater treatment plants. Currently, some of this infrastructure is vulnerable to flooding during high tides and severe storms. These events are expected to significantly worsen with rising sea levels [3]. The City of Los Angeles's Sea Level Rise Vulnerability Assessment found the city's roads, water systems (wastewater, stormwater, potable

Population at risk to 100yr Flood

3,700 = current risk | 14,000 = future w/
1.4m SLR

Source: Heberger et al., 2009

In the Santa Monica region, beaches are a critical asset and sea level rise will likely make it more difficult to maintain beach widths and associated economic, cultural, recreational, and ecological benefits. For example, the parking lot north of, and adjacent to, the Santa Monica Pier has experienced flooding in the past, and is expected to undergo more regular flooding with rising sea levels. The pier, coastal residences, and hotels have all sustained storm damage, which is expected to increase with sea level rise [3].



Los Angeles County

The City of Hermosa Beach's vulnerability assessment found that increased erosion, coastal flooding, higher storm surges and flood elevations, permanent inundation, reduced capacity to absorb runoff, and saltwater intrusion into coastal groundwater basins would be expected with rising sea levels [5]. Infrastructure vulnerabilities include the city's sewage system, city streets, and some iconic structures (i.e., the Pier, the Strand, and Land Motor Home Park) and associated business activities, particularly in the central and southern parts of the city where there is the greatest exposure to flooding in a future 100-year flood with 66 inches of sea level rise [5]. In addition, some communities or populations within Hermosa Beach were found to be more socially vulnerable to flooding than others communities in the city [5]. Some of the most important factors shaping social vulnerability include income and poverty, race, females as head of household, age, housing type, physical and mental illnesses and disabilities, and transient populations. Sea level rise planning should consider the additional needs associated with addressing vulnerabilities for these communities.

The City of Long Beach's Climate Resiliency Assessment Report's states that increased storm frequency and high tides combined with El Nino conditions [6] will have a large impact on coastal residents, development, and infrastructure along the highly developed coastline in the city. Increased coastal flooding, erosion, and permanent inundation has been predicted for low lying areas of Long Beach, and is already happening along the Peninsula and Alamitos Bay [6]. The Port of Long Beach is conducting work on sea level rise and coastal flooding impacts where the movement of goods might be impacted, in order to adequately prepare the port for these vulnerabilities in their Port Master Plan (PMP) update.

Vulnerabilities to sea level rise for the Cities of El Segundo, Manhattan Beach, Redondo Beach, Palos Verdes, Rancho Palos Verdes, Torrance, and Avalon are not well known. However, it is likely that some of these areas will experience similar vulnerabilities that occur county-wide because of the shoreline conditions in these areas, including saltwater intrusion and drowning of marsh habitat, loss of public access, and flooding risk to coastal development and infrastructure [3].

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the Cities of Santa Monica (Round 2), Los Angeles (Round 2) and Hermosa Beach (Round 1 and 3) have been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise and "In progress" refers to jurisdictions with LCP grants for addressing sea level rise.



Los Angeles County

Table 1. LCP Planning in Los Angeles County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments ^[1]	Updated for SLR?	Shoreline by Jurisdiction
City of Malibu	2002	No	No	In Part	23%
Los Angeles County	No	No	Yes ^[1,2]	No	3%
Malibu Santa Monica Mountains Segment	2014	No	No	In Part	
Marina del Ray Segment	1990	No	No	In Part	
Playa Vista A Segment*	No	No	No	No	
Santa Catalina Island Segment**	1990	No	No	No	
City of Los Angeles	No	Yes	Yes ^[4]	No	14%
Pacific Palisades Segment	No	No	Yes ^[1]	No	
Venice Segment	No	CCC	Yes ^[1]	In Progress	
Playa Vista Segment*	No	No	No	No	
Del Rey Lagoon Segment	No	No	No	No	
Airport/Dunes Segment*	No	No	No	No	
San Pedro Segment	No	No	Yes ^[1]	No	
City of Santa Monica	No	CCC, OPC	Yes ^[1]	In Progress	3%
City of El Segundo	1982	No	No	No	1%
City of Manhattan Beach	1994	No	No	No	2%
City of Hermosa Beach	No	CCC	Yes ^[5] , In Progress ^[7]	In Progress	2%
City of Redondo Beach	2010	No	No	In Part	2%
City of Torrance	No	No	No	No	1%
City of Palos Verdes Estates	1991	No	No	No	5%
City of Rancho Palos Verdes	1983	No	No	No	8%
City of Long Beach	1980	No	Yes ^[6]	No	6%
City of Avalon	1981	No	No	No	***
Federal Lands and Ports					30%

* Santa Catalina Island shoreline = 64.6 miles, ** LCP segments are inland of shoreline, ***City of Avalon length = 6.76 miles

Coastal Act Management Priorities

Los Angeles County faces significant sea level rise vulnerabilities in every sector, especially for its extremely valuable beaches and ports. The county also must deal with flooding, continued shoreline erosion and increasing pressure for seawall development in the urban areas. Some top priorities by Coastal Act themes are presented below.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

There is a need throughout Los Angeles County for shoreline management planning to address residential development vulnerable to sea level rise. To protect shoreline development in the county,



Los Angeles County

many jurisdictions have relied on sand replenishment projects and seasonal berms as storm defenses. For example, many beaches in the Santa Monica Bay region were historically narrow, but starting in the 1930s, they were artificially widened through large scale beach nourishment projects and the construction of sand retention structures such as breakwaters and groins. Understanding the viability of future reliance on seasonal berms and sand replenishment in the face of sea level rise will be pivotal for many jurisdictions, especially those in the Santa Monica Bay region. The Regional Sediment Management Plan for the LA Basin indicates that nourishment may be effective for the more urban beaches in Santa Monica and points south. Other important developed assets that need long-term sea level rise planning in the county are energy plants, wastewater facilities, railroads, and roads. This planning will require continued multi-agency coordination and collaboration with stakeholders like the State Lands Commission, Caltrans, utilities, and the railroad authority.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise could increase further loss of public access and recreational opportunities, especially for the many public beaches in LA County that are backed by parking lots. Some beach areas already have conflicts for space between recreational land and parking. With planning, funding, and collaboration, local governments can lay the groundwork for replacement of private vehicle access with public transit options, maintaining public access, and actions to preserve beach area as sea levels rise. In addition, as discussed above, many beaches in the county also receive seasonal sand replenishment – the viability of this practice and approach to maintaining beaches in the long term should be evaluated in light of sea level rise, changing wave conditions along the shoreline and other feasibility constraints (i.e., sand availability, costs of sand transport, ecological impacts, GHG emissions, etc.).

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

Since most of the County of Los Angeles' coastal zone is highly urbanized, its few remaining ecological resources are important to sustain. Preserving existing and potential wetlands like those at the Ballona Wetlands Ecological Reserve and least tern nesting sites on Venice Beach, Santa Monica Beach, Dockweiler Beach should be a priority as sea level rise causes saltwater intrusion, drowning of habitat, and vegetation conversion. There is a need for additional study on how managing water flows with tide gates can affect shoreline habitats and their ability to migrate with sea level rise because understanding this relationship will be critical to informing options to preserve or restore coastal wetlands. Where environmentally sensitive lands are outside the jurisdiction of local government (e.g., military land, ports), coordination with federal agencies or other landowners will be very important.

Ports (Coastal Act Sections 30703 – 30708)

Sea level rise could cause a variety of impacts to ports, including flooding and inundation of port infrastructure and damage to piers and marina facilities from wave action and higher water levels. Sea level rise will not only affect port development and the port's economic viability, but if not properly planned for, it will also impact public access and how public access is planned for in the future. The Ports of Long Beach and Los Angeles should consider sea level rise when building new infrastructure or conducting major renovations of existing facilities. The Commission will need to work through these sea level rise planning issues with the Port through amendments to their Port Master Plans.

Additional Considerations

- Vulnerability studies are needed for communities of El Segundo, Manhattan Beach, Redondo Beach, Palos Verdes, Ranchos Palos Verdes, Torrance, and Avalon. This information is crucial to inform long-term planning for these jurisdictions.



Los Angeles County

- To address the challenge of redevelopment, local governments should consider developing a comprehensive set of rules for redevelopment and reevaluation of existing seawalls, as well as strong land use policies to assure that private shoreline structure development on public lands fully mitigates for the impact these structures have on ecological function, public access and recreation, and other coastal shoreline resources.
- One potential accommodation strategy for developed areas (e.g., Malibu, Long Beach, or Hermosa Beach) is to create zoning overlays with specific design standards to ensure that modifications to existing buildings or construction of new buildings in vulnerable areas can withstand coastal flooding and tsunamis.
- Special attention should be paid to sea level rise planning for socially vulnerable populations such as those identified in Hermosa Beach [5], City of Long Beach [6], and City of Los Angeles [7] to ensure these communities have the awareness, information and support they need to prepare for sea level rise hazards.
- Beach communities in the county should analyze public transit opportunities and incentives to encourage beach users to reduce private vehicle use.
- For certain land use types and coastal-dependent uses (i.e. ports, breakwaters, piers) adaptation options to address sea level rise may be more limited.
- Adapt LA Program is helping to build local capacity throughout the region to help coastal jurisdictions to share and use best available science and information in their adaptation planning.

References

- [1] [Nobel Consultants - G.E.C., Inc. 2016. "Los Angeles County Public Beach Sea-Level Rise Vulnerability Assessment." Report prepared for the Los Angeles County Department of Beaches and Harbors.](#)
- [2] [University of Southern California Sea Grant Program. 2016. "Regional AdaptLA: Coastal Impacts Planning in the Los Angeles Region."](#)
- [3] California Coastal Commission South Coast District Staff Interview. July 22, 2016.
- [4] [Grifman, P. M., J. F. Hart, J. Ladwig, A. G. Newton Mann, M. Schulhof. 2013. "Sea Level Rise Vulnerability Study for the City of Los Angeles."](#)
- [5] [Ekstrom J. and S. Moser. 2014. "Vulnerability and Adaptation to Sea-Level Rise: An Assessment for the City of Hermosa Beach."](#)
- [6] [Aquarium of the Pacific. 2015. "City of Long Beach Climate Resiliency Assessment Report."](#)
- [7] [Geosyntec Consultants. 2016. "Assessment of Infrastructure Vulnerability to Sea-Level Rise Hermosa Beach, California."](#)



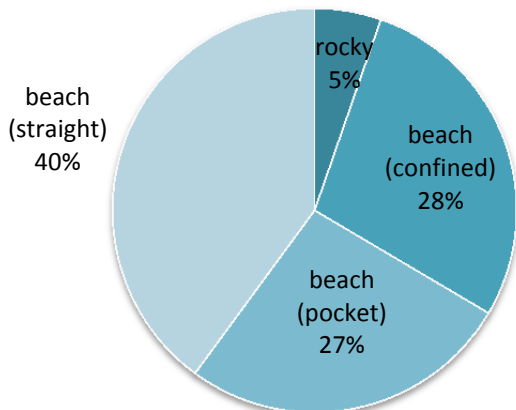
Orange County

Coastal Zone



Orange County has approximately 43 miles of shoreline, extending from the border of Los Angeles County to San Diego County. The coastal zone area encompasses approximately 37,800 acres (59 square miles), not including bays, harbors, or lagoons and includes portions of the County of Orange and 10 incorporated cities. Orange County is the third most populous county in California, and has also been identified by the Pacific Institute as the county with the highest population at risk to sea level rise. Orange County is well known for its touristic activities, beautiful beaches, and iconic coastal cities such as Seal Beach, Huntington Beach, Newport Beach, Laguna Beach, and Dana Point. Miles of uninterrupted beaches lead to a range of recreational activities, including swimming, body boarding, surfing, volleyball and others. Orange County is also home to the Seal Beach National Wildlife Refuge (NWR) which is located within the Naval Weapons Station Seal Beach.

Outer Coast Shoreline



Coastal Zone Resources

Ports & Harbors: Dana Point, Newport Beach
 Publicly Owned/Accessible: 4,100 acres
 Public Access Coastal Areas: 123 locations
 Coastal Zone Wetlands: 3,300 acres

Ocean Economy

2013 County Ocean Sector GDP \$3.8 B

2013 Major Ocean Economic Sectors

Tourism & Recreation GDP	\$2.0 B
Transportation GDP	\$1.6 B
Minerals GDP	\$0.04 B

10%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Orange County is famous for its tourist locations and miles of uninterrupted beaches and recreational assets. The ocean economy is the fourth largest in the state and accounts for 10% of the State's total ocean sector gross domestic product (GDP). More than half of the county's ocean economy is associated with beach tourism and recreation. In turn, this makes the ocean economy susceptible to the vulnerabilities associated with rising sea levels.



Orange County

Hazards and Vulnerability

Regions in Orange County have been assessed for vulnerabilities to rising sea levels, and continue to be heavily studied through further vulnerability assessments. With moderate sea level rise projections (55 inches by 2100), the Orange County Climate and Health Profile Report highlights the vulnerabilities of coastal aquifers to saltwater intrusion, and coastal erosion's negative impacts to recreation, infrastructure and public safety. The report states that 28% more land in Orange County will be vulnerable to 100-year floods [1]. According to Pacific Institute data,

Orange County will have the highest population vulnerable to 100-year flooding. CoSMoS 3.0: Southern California, a modeling tool used to predict coastal flooding due to both sea level rise and storms driven by climate change, also shows several large contiguous areas in the northern part of Orange County susceptible to flooding with 59 inches of sea level rise by 2100 [2].

The U.S. Department of the Interior's analysis of sea level rise in the Santa Ana River Watershed states that rising sea levels are likely to reduce the area of beaches and wetlands, increase erosion of cliffs, bluffs, sand bars, dunes, and beaches [3]. This analysis reiterated that a high number of people will be vulnerable to inundation with sea level rise, as well as a high vulnerability of saltwater inundation into coastal aquifers for Orange County [5].

The Huntington Beach Sea Level Rise Vulnerability Assessment's key findings showed that the city is most vulnerable in the future to flooding during extreme high tides which are expected to overtop protective barriers (such as seawalls and levees) as early as 2030 [4]. Coastal infrastructure and resources are most vulnerable to flooding from

extreme wave events and extreme high tides. The assessment also found that between 2030 and 2050, major roadways, public facilities, and residential areas will be vulnerable to extreme high tide and storm events [4]. Similarly, by 2100

there is a high potential for even more widespread inundation across northern Huntington Beach (in the vicinity of Huntington Harbor and Bolsa Chica). Facilities such as the AES Southland power plant, the Orange County Sanitation District wastewater treatment facility, stormwater and transportation infrastructure, public

facilities, beaches, ecosystems, and commercial and residential buildings are vulnerable to tidal inundation, extreme wave events, and stormwater runoff [4]. Specifically, the Pacific Coast Highway (PCH) at Warner Avenue and some areas of Sunset Beach currently experience flooding with high tides and rain events [4], and PCH along with other roads are expected to experience tidal inundation as early as 2030. By 2030, properties in Sunset Beach and Huntington Harbor will become vulnerable to flooding from tides, and by 2050 there is expected to be widespread inundation of residential and commercial property [4]. Estuary and bay ecosystems are also incredibly vulnerable to inundation, which could result in habitat shifts [4]. Beaches throughout the City of Huntington Beach are vulnerable to significant erosion.



Pacific Coast Highway at Sunset Beach
(Coastal Records Project, 2013).

Potential Bluff Erosion Risk w/ 1.5m SLR

1,500 properties

Source: CoSMoS 3.0 (2016), County parcel data

The City of Newport Beach is particularly vulnerable to sea level rise as parts of the city already experience flooding. Areas around



Orange County

Newport Harbor and Newport Bay are known to experience flooding of streets and walkways around the Balboa Peninsula, Balboa Island and other parts of the Newport Beach when high water levels occur, even though much of the shoreline in these areas is armored [5]. Wave overtopping and flooding cause damages to businesses, residences, public infrastructure, and the surrounding coastal habitat. The City of Newport Beach’s storm drains empty by gravity into the Newport Bay, causing the system to be unable to provide flood relief when Bay water levels are high [5]. On the Balboa Islands, high water levels can cause sewer and storm drain effluent to spill into the streets during floods which can expose both people and the environment to raw sewage [5]. These vulnerabilities are projected to increase with rising sea levels, increased flooding and storm surge, potentially leading to a rise of public health and safety concerns. A tool that could be useful for addressing potential flooding in this area is FloodRISE, an advance computer model that maps flood hazards on a house by house basis in Newport Bay [6]

those surrounding Aliso Beach, are frequently washed out.

The Dana Point Harbor Revitalization Preliminary Shoreline Management Plan sets goals and objectives for managing sea level rise and potential impacts of flooding resulting from significant storm events. The plan found potential impacts from sea level rise related flooding and inundation in Dana Point Harbor to be in low lying parking areas, pedestrian walkways located immediately adjacent to seawalls, wastewater, stormwater infrastructure, boat launch areas, vertical accessways, and utility infrastructure [8]. Increased wave action and higher water levels are expected to damage piers, docks, and marina facilities [8]. The Island Bridge may have less bridge clearance due to increased and prolonged increases in tidal heights and higher likelihood of bridge failure from water damage to the bridge structure [8]. Decreased beach and sand areas, resulting in loss of recreational areas are also expected to occur with rising sea levels [8]. Saltwater intrusion and increased groundwater levels in the region are also expected to limit the effectiveness of existing stormwater management practices [8].

Many beach facilities in the City of San Clemente are experiencing flooding, which will be exacerbated with rising seas [7]. Walkways to Poche Beach, parking lots (including the North Beach parking lot, which is the City’s main beach parking reservoir), and trails to beaches are already threatened by erosion and flooding, which will increase with sea level rise [7].

Population at risk to 100yr Flood
72,000 = current risk | 110,000 = future w/1.4m SLR
Source: Heberger et al., 2009

The City of Laguna Beach has a low lying downtown region, which may be vulnerable to rising sea levels. The Main Beach Park public walkway is vulnerable to both ocean and stream flooding [7]. Other walkways, such as

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, the Cities of Seal Beach (Round 3), Newport Beach (Round 2), Dana Point (Round 3), and San Clemente (Round 1 and



Orange County

Round 3) have all been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise and "in progress" refers to jurisdictions with LCP grants or other sources for addressing sea level rise. A case study for the City of Newport Beach is available to highlight the Commission's LCP planning work on sea level rise [10].

Table 1. LCP Planning in Orange County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction*
Orange County	No	No	In Progress [9] Yes [1,2]	No	13%
Bolsa Chica Segment	No	No	Yes [3]	No	
Santa Ana River Segment	No	No	Yes [3]	No	
Santa Ana Heights Segment	No	No	Yes [3]	No	
Newport Coast Segment	1988	No	No	No	
Emerald Bay Segment	1989	No	No	No	
Aliso Viejo Segment	1983	No	No	No	
City of Seal Beach	No	CCC	No	In Progress	2%
City of Huntington Beach	1985	No	Yes [4]	No	22%
Sunset Beach Segment	No	No	Yes [3]	In Progress	
City of Costa Mesa	No	No	No	No	1%
City of Newport Beach	No	CCC	Yes [4,5]	In Part	27%
City of Irvine	1982	No	No	No	None
City of Laguna Beach	1993	No	No	In Part	7%
City of Aliso Viejo	No	No	No	No	None
City of Laguna Niguel	1990	No	No	No	None
City of Dana Point	1989	CCC	Yes [8]	In Progress	6%
City of San Clemente	No	CCC	No	In Progress	4%
Federal Lands					18%

*harbors included in shoreline length percentages

Coastal Act Management Priorities

Orange County faces significant sea level rise vulnerabilities in every sector. The county must address likely long term impacts to its extremely valuable beach and recreational resources. It also must deal with storm flooding, continued shoreline erosion, increasing pressure for seawall development in the urban areas and managing public-serving infrastructure susceptible to sea level rise impacts in urban areas (e.g., tidal flooding damaging stormwater operations). Some top priorities by Coastal Act themes are presented below.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

There is a need throughout Orange County for shoreline management planning in LCPs to address residential development vulnerable to sea level rise, especially because models show this county has the highest number of people living in areas vulnerable to flooding from sea level rise as compared to any other coastal county in the state. To protect shoreline development in the county, many jurisdictions have relied on sand replenishment projects and seasonal berms as storm defenses. Some Orange



Orange County

County jurisdictions must also prioritize planning for operations of stormwater, wastewater, and transportation infrastructure that could be susceptible to tidal flooding as early as 2030. Other important developed assets that need multi-entity/agency collaboration and coordination for long-term sea level rise planning in the county are energy plants, harbors, wastewater facilities, railroads, and roads. Additional study of erosion threats to Highway 1 and the potential for riverine flooding in some areas of the county are also needed to inform this planning.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. In addition, many public beaches in Orange County are backed by parking lots and some of these beach areas already have space conflicts between parking and sandy beach area. Providing or improving public transportation opportunities to these beaches could help alleviate space conflicts. Given the prevalence of flooding impacts already affecting public parking lots and access ways in cities like Newport Beach, Laguna Beach, Dana Point, and San Clemente, planning for future relocation of access ways and actions to preserve beach area as sea levels rise is particularly important.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

While much of the Orange County shoreline is heavily developed, there are pockets of unique wetland habitats in areas of Seal Beach, Bolsa Chica and Santa Ana River mouth. Sea level rise threatens wetland and lagoon habitats with saltwater intrusion, drowning of marsh habitat, and vegetation conversion. Thus, there is a need for additional study of management options to preserve wetlands like those at Bolsa Chica, the Seal Beach NWR, and Santa Ana River mouth. Testing adaptation strategies can help examine options to preserve coastal habitat, like a sediment augmentation project underway at Seal Beach NWR. Where environmentally sensitive lands are outside the jurisdiction of a local government (e.g., Naval Weapons Station Seal Beach, Seal Beach NWR, or Bolsa Chica Basin State Marine Conservation Areas), coordination with the appropriate federal agencies and/or land owners will continue to be very important.

Additional Considerations

- Long term planning with Caltrans, State Lands Commission, California State Parks, Orange County Transit Authority and others should be a priority to address vulnerabilities to transportation infrastructure and beach access.
- Some areas such as Highway 1 in Huntington Beach and along the Newport Coast south of Crystal Cove face erosion threats that might require adaptation strategies that are a phased combination of armoring and managed retreat over time (i.e. a hybrid approach).
- Bulkheads are often used to protect development along harbors and islands – development in these areas will likely need to be elevated in the future to address sea level rise. Local governments should consider developing a more comprehensive set of standards for redevelopment and for evaluating the efficacy of existing bulkheads that factor in how flooding will impact properties and public infrastructure (i.e. utilities) as a whole in any given area.
- Land use policies are needed to assure that shoreline structures that are built to protect existing private development on public and private lands fully mitigates for the impacts they have on shoreline ecosystems, public access, recreation, and other coastal resources.
- One potential adaptation strategy for cities such as Huntington Beach is to create zoning overlays to ensure that modification to existing buildings or construction of new buildings in vulnerable areas would include designs standards to withstand coastal flooding.



Orange County

- Planning for saltwater intrusion and higher groundwater levels in the region will be vital to maintain the effectiveness of stormwater/wastewater management and protect water quality.
- Beach communities in the county should analyze public transit opportunities and incentives to encourage beach users to reduce private vehicle use.

References

- [1] [California Department of Public Health Office of Health and Equity and University of California Department of Public Health Sciences, Davis, California. 2015. "Climate and Health Profiles Report: Orange County."](#)
- [2] [United States Geological Survey. 2015. CoSMoS 3.0: Southern California](#)
- [3] [U.S. Department of the Interior. 2013. "Climate and Sea Level Rise in the Santa Ana River Watershed Results Summary."](#)
- [4] [City of Huntington Beach. 2014. "City of Huntington Beach Sea Level Rise Vulnerability Assessment."](#)
- [5] [Everest International Consultants, Inc. 2011. "Assessment of Seawall Structure Integrity and Potential for Seawall Over-Topping for Balboa Island and Little Balboa Island."](#)
- [6] [University of California, Irvine. 2017. FloodRISE Project](#)
- [7] California Coastal Commission South Coast District Staff Interview. July 22, 2016.
- [8] [Project Dimensions. 2014. "Dana Point Harbor Revitalization: Preliminary Shoreline Management Plan."](#)
- [9] [University of Southern California Sea Grant. 2015. "Orange County Regional Sea Level Rise & Coastal Impacts Workshop"](#)
- [10] California Coastal Commission. December 2016. City of Newport Beach Case Study.



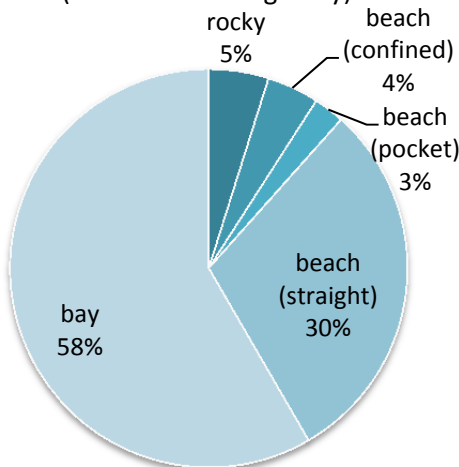
San Diego County

Coastal Zone



The San Diego County coastal zone, extending south from the Orange County line to the Mexican border, is rich in resources and geographic diversity. The county shoreline, including the shoreline of San Diego Bay and Mission Bay but excluding the lagoons, is approximately 177 miles long. The coastal zone area, approximately 87,888 acres (137 square miles), contains a wide variety of significant coastal resources including major state and local beaches, marine terraces, bluffs, coastal marshes, estuaries and lagoons, canyon-cut mesas, seaside beach communities, significant urban development, state university campus lands, cultural resources, recreational harbors, and the Port of San Diego. There are also major federal lands within the county, including Camp Pendleton Marine Corps Base, and numerous U.S. Navy facilities adjacent to San Diego Bay (North Island Naval Air Station, Naval Amphibious Base, Naval Station San Diego and Naval Submarine Base). The Tijuana River National Estuarine Research Reserve (NERR) sits along the US-Mexico border. The unincorporated coastal area of San Diego County contains no oceanfront lands, but the county's coastal zone includes the shoreline of 10 cities.

Outer Coast Shoreline (includes San Diego Bay)



Coastal Zone Resources

- Ports & Harbors: Oceanside, San Diego, San Diego Area
- Publicly Owned/Accessible: 18,900 acres
- Public Access Coastal Areas: 200 locations
- Coastal Zone Wetlands: 7,600 acres

Ocean Economy

2013 County Ocean Sectors GDP	\$6.2 B
2013 Major Ocean Economic Sectors	
Tourism and Recreation GDP	\$4.0 B
Transportation GDP	\$1.2 B
Ship and Boat Building GDP	\$0.70 B

17%

of State Ocean Sector GDP

Source: National Ocean Economics Program, 2016

Accounting for 17% of the state's total ocean sector GDP, San Diego County has the second largest ocean economy in the state. Tourism and recreation are essential for the county's economic stability. Many of San Diego County's iconic beaches, natural resources, and recreational areas that drive its tourism and recreation economy are vulnerable to sea level rise. The Port of San Diego accounts for a major component of the transportation GDP in this county, and thus sea level rise impacts on port assets (in addition to tourism and recreation assets) could threaten the county's large ocean economy.



San Diego County

Hazards and Vulnerability

According to the “Climate Change-Related Impacts in the San Diego Region by 2050” report, under moderate sea level rise (SLR) scenarios (12-18 inches) will lead to loss of public access, recreation, natural resources, and rocky beach habitat [1]. Intertidal reserves, such as Cabrillo National Monument and Scripps Coastal Reserve which are bordered by steep cliffs, will likely lose much of their intertidal habitats since there is no room to move inland [1]. The potential loss of habitat and species composition may also affect marine productivity and fisheries [1].



Bluff top development in Solana Beach

The City of Oceanside is currently experiencing hazardous shoreline conditions, which are expected to increase with rising sea levels [2]. The ocean regularly reaches revetments along some coastal residential areas. The Loma Alta Marsh and Buena Vista Lagoon may be impacted by sea level rise and have vulnerable recreational trail elements [2].

acres of shoreline by 2100 [3]. The assessment also found all of the beach access ways to be vulnerable to flooding and inundation by 2100, with approximately half of them vulnerable to flooding by 2050 [3]. Sewer pump stations and the commercial uses adjacent to Agua Hedionda Lagoon were also found to be vulnerable to rising sea levels. Transportation infrastructure, including major and private roads, was found to be vulnerable to flooding

and bluff erosion by the year 2050[3]. Sensitive habitats such as wetlands, riparian areas, coastal prairies, woodlands and forests, and other natural resources in the coastal zone were found to be vulnerable to flooding; however, in some areas, there might be room for habitats to move in land with rising seas [3].

Population at risk to 100yr Flood
 3,000 = current risk | 9,300 = future
 w/1.4m SLR
 Source: Heberzer et al., 2009

Potential Bluff Erosion Risk w/55in SLR
 1,800 properties
 Source: CoSMoS 3.0 (2016), County parcel data

Using high CoSMoS 3.0 sea level rise projections (55.2 inches of sea level rise by 2050 and 79.2 inches of sea level rise by 2100), the City of Carlsbad’s draft sea level rise vulnerability assessment highlights key vulnerable assets subject to inundation, erosion, and flooding. These assets include beaches, environmentally sensitive lands, public access ways, transportation, and other critical infrastructure. While beach erosion impacts are not expected to be significant until after year 2050, many planning areas were found to lose 26 to 66

In the City of Encinitas and City of Solana Beach, many assets such as bluff-top development, public access ways, parking lots, and beaches are vulnerable to erosion and the impacts associated with rising sea levels [2]. The Commission recently approved a 50-year Army Corps of Engineers beach replenishment project for Solana Beach and Encinitas to help maintain beaches in this area [2].

Hazards from rising sea levels will impact many coastal resources and assets in Del Mar including residential properties, roads and bridges, sewer infrastructure, emergency



San Diego County

services, public access, and the San Dieguito River lagoon wetland habitats [2]. A City of Del Mar assessment found that beaches above high tide will be lost to erosion with 1-2 feet of sea level rise, at which point coastal storms will threaten sea wall integrity and the City's North Beach District [4]. Flooding of the San Dieguito River will inundate the City's North Beach District, the Valley District, and the Del Mar Fairgrounds more frequently and at greater depths [4]. The assessment also found that the wetlands in the San Dieguito Lagoon could be drowned out by sea level rise. Del Mar is conducting a follow-up study to identify the potential for wetland migration in this area [2].

For the City of San Diego, many beaches (such as Mission Beach, Ocean Beach, La Jolla Shores, and Blacks Beach) and homes are already experiencing flooding and erosion, and both are expected to increase with sea level rise [2]. Torrey Pines State Beach, a highly visited area, is currently experiencing flooding to its parking lot located at sea level. Access roads to Blacks Beach, a popular surf and beach recreational area, have collapsed and more impact associated with rising sea levels is expected to occur over time [2].

The vulnerability assessment for the San Diego Bay region used high sea level rise projections (17 inches of sea level rise by 2050 and 69 inches of sea level rise by 2100) to determine the most vulnerable sectors in the Bay region. These sectors include stormwater management, wastewater collection, shoreline parks and public access, transportation facilities,

commercial buildings, and ecosystems, many of which will experience regular inundation in certain locations around the Bay in the longer term [4]. The Sea Level Rise Adaptation Strategy for San Diego Bay report also found that within the next few decades, the greatest concern will be an increase in frequency of flooding that the region already experiences due to waves, storm surge, El Nino events, and very high tides. In addition, the Port of San Diego, located within San Diego Bay, is developing a Climate Mitigation and Adaptation Plan (Climate Plan) to address both reductions in greenhouse gases and local vulnerabilities to climate change. Preliminary sea level rise mapping efforts reveal that much of the Port's infrastructure will be inundated by higher sea levels when combined with storm events at 2050 and 2100 [4].

Imperial Beach faces unique challenges from sea level rise as it is surrounded on three sides by water and has a relatively high population of lower to moderate income demographics [2]. The city plans to complete an update to their shoreline protection inventory and do an economic analysis of vulnerabilities and adaptation options in early 2017.

Tijuana River NERR is currently in the process of assessing vulnerabilities in the reserve to inform development of adaptation strategies. Vulnerabilities in this region are largely related to riverine flooding [6]. This effort will also analyze the river-ocean connection, sediment dynamics, flooding and inundation, and surface and ground water salinity.

LCP and Sea Level Rise Planning

Local Coastal Programs (LCPs) are planning tools used by local governments to guide development in the coastal zone, in partnership with the Coastal Commission. LCPs specify the appropriate location, type, and scale of new or changed uses of land and water and include a land use plan and measures to implement the plan (such as zoning ordinances). The Coastal Commission has awarded three rounds of the Local Assistance Grant Program since January 2014 to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change. Within this county, San Diego County (Round 2) and the Cities of Oceanside (Round 3), Carlsbad (Round 2), Solana Beach (Round 1), Del Mar (Round 2 and 3), and Imperial Beach (Round 3) have all been awarded grants from the Coastal Commission to address the impacts of sea level rise within their LCP jurisdictions. Other state agencies



San Diego County

such as the State Coastal Conservancy and Ocean Protection Council (OPC) have awarded grants to support addressing sea level rise in LCPs, including grants to conduct local vulnerability assessments. Table 1 below shows whether jurisdictions have LCPs that address sea level rise. "In part" means an LCP segment has some explicit policy language addressing sea level rise and "in progress" refers to jurisdictions with LCP grants for addressing sea level rise.

Table 1. LCP Planning in San Diego County (as of Dec. 2016)

Jurisdiction/Segment	Certified LCP?	State Grant?	Vulnerability Assessments	Updated for SLR?	Shoreline by Jurisdiction
San Diego County	No	CCC	Yes [1,5]	In Progress	None
City of Oceanside	1986	CCC	Yes [1]	In Progress	5%
City of Carlsbad	-	OPC,CCC	Yes [3]	In progress	9%
Agua Hedionda Segment	No	(See above)	(See above)	(See above)	
Mellos I Segment	1996				
Mello II Segment	1996				
West Batiquitos/Sammis Segment	1996				
East Batiquitos/ Hung Segment	1996				
Village Redevelopment Area Segment	1987				
City of Encinitas	1995	No	Yes [7]	No	8%
City of Solana Beach	No	CCC	No	In Progress	2%
City of Del Mar	2001	OPC, CCC	Yes [1,4,8]	In Progress	4%
City of San Diego	No	No	Yes [5]	No	23%
North City Segment	1988	No	No	No	
La Jolla Segment	1988	No	Yes [1]	No	
Pacific Beach Segment	1988	No	Yes [1]	No	
Mission Beach Segment	1988	No	Yes [1]	No	
Mission Bay Segment	No	No	Yes [9]	No	
Ocean Beach Segment	1988	No	No	Yes	
Peninsula Segment	1988	No	No	No	
Centre City Segment	1988	No	No	No	
Barrio Logan Segment	1988	No	No	No	
Otay Mesa/ Nestor Segment	1988	No	No	No	
Tijuana River Segment	1988	No	Yes [6]	No	
Border Highlands Segment	1988	No	No	No	
City of Coronado	1984	No	Yes [1,5]	No	5%
City of National City	1991	No	Yes [5]	No	None
City of Chula Vista	1985	No	Yes [5]	In Part	None
City of Imperial Beach	1984	SCC, CCC	Yes [1,5], In Progress [10]	In Progress	3%
Federal Lands, State lands, University lands, and Ports					41%



Coastal Act Management Priorities

San Diego County faces significant sea level rise vulnerabilities in every sector. The county must address longer-term impacts to its extremely valuable beach and lagoon resources, as well as flooding, continued shoreline erosion and increased demand for shoreline protection in the urban areas. Some top priorities by Coastal Act themes are presented below.

Public Access and Recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221)

One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise in San Diego County could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding or erosion of beaches, recreational areas, and trails. Coastal communities in San Diego County, through SANDAG, have already joined together on two regional beach sand replenishment projects. With planning, funding, and collaboration, local governments can expand this coordination into regional efforts to preserve beach areas and relocate public access ways that will be lost as sea level rises. Coordinated regional shoreline management planning with federal government, state agencies and local governments will help in this process. Adaptation planning should include analysis of the costs and benefits of sand replenishment as a long-term adaptation approach to help San Diego communities better understand the feasibility and consequences of implementing this strategy. This analysis should also account for the greenhouse gas contributions associated with beach replenishment projects.

Coastal Habitats, ESHA, and Wetlands (Coastal Act Sections 30230, 30231, 30233, 30240)

San Diego County contains more lagoons and wetland habitats than any other coastal county. Sea level rise threatens sandy beach, intertidal, wetland and lagoon habitats because of saltwater intrusion, drowning of marsh habitat, and vegetation conversion. There is a need for additional study on how managing water flows with tide gates can affect shoreline habitats and their ability to migrate with sea level rise because understanding this relationship will be critical to informing options to preserve or restore coastal wetlands. With sea level rise, it is possible that habitat mitigation and restoration projects (e.g., efforts in San Dieguito Lagoon restoration for Southern California Edison) will fail to meet restoration benchmarks in the long term. Where environmentally sensitive lands are outside the jurisdiction of local government (e.g., military land, ports), Coastal Commission review of federal activities will continue to be very important.

Coastal Development and Hazards (Coastal Act Sections 30235, 30236, 30250, 30253)

There is a need throughout San Diego County for shoreline management planning in LCPs to address residential development vulnerable to sea level rise. A common, challenging development pattern in most coastal communities is the proximity of residential development directly adjacent to sandy beaches or the edge of coastal bluffs. These communities are often protected by a patchwork of private seawalls and revetments which will eventually cause the beach area (which hosts habitat and recreational amenities) to be lost as sea levels rise. To address this challenge, local governments should consider a comprehensive set of rules for redevelopment and reevaluation of existing seawalls, as well as strong policies and direction for assuring that private shoreline structure development on public lands fully mitigates the impacts to public access and recreation, and other coastal shoreline resources. Other important developed assets that need long-term sea level rise planning in the county are energy plants, wastewater facilities, railroads, and roads. Adaptation planning for these assets will require multi-agency coordination and collaboration to develop feasible and cost-effective solutions that are consistent with the Coastal Act.



San Diego County

Coastal-dependent Development/Ports (Coastal Act Sections 30703 – 30708)

Sea level rise could cause a variety of impacts to ports, including flooding and inundation of port infrastructure and damage to piers and marina facilities from wave action and higher water levels. There is a need for additional study to better understand vulnerability for the varied coastal dependent resources located in the Port of San Diego, Mission Bay, Agua Hedionda Lagoon and Oceanside Harbor (shipyards, industrial, commercial, public lands, military), as well as vulnerability of habitats, and public access and recreation in these areas.

Additional Considerations

- With planning, funding, and collaboration, local governments could create shoreline management plans for phasing adaptation actions that are a combination of protection, accommodation, and retreat strategies.
- For communities with significant residential development along the shoreline, establishing zoning overlays with design standards for new development or modification of existing buildings in vulnerable areas could be an effective way to ensure that structures can withstand flooding.
- For many San Diego County coastal-dependent uses, adaptation options to address sea level rise may be more limited (i.e. elevation approaches for ports, piers, breakwaters, etc.).
- Local governments in San Diego County should also capitalize on the results of NOAA's Regional Coastal Resilience Grant award to the San Diego Regional Climate Collaborative for regional coordination on sea level rise adaptation planning.

References

- [1] [Messner S, K Green, C Phillips, J Dudley, D Cayan, E Young. 2009. "Climate Change Related Impacts in the San Diego Region by 2050."](#)
- [2] California Coastal Commission South Coast District Staff Interview. July 22, 2016.
- [3] [City of Carlsbad. 2016. "Draft City of Carlsbad Sea Level Vulnerability Assessment."](#)
- [4] [ESA. 2016. "Administrative Draft: City of Del Mar Sea-Level Rise Adaptation Plan."](#)
- [5] [ICLEI-Local Governments for Sustainability. 2012. "Sea Level Rise Adaptation Strategy for San Diego Bay."](#)
- [6] [Tijuana River National Estuarine Research Reserve. 2014. Climate Understanding & Resilience in the River Valley \(CURRV\) Project Workshop on Scenario Planning](#)
- [7] City of Encinitas. 2010. "City of Encinitas General Plan Update. Current Conditions Report. Chapter 16: Coastal Conditions."
- [8] [ESA. 2016. "Final Draft. Coastal Hazards, Vulnerability, and Risk Assessment Del Mar, CA."](#)
- [9] [Gersberg R. "Mission Bay 2.0 M Sea Level Rise." Maps produced for San Diego Coastkeepers](#)
- [10] [Revell Coastal, LLC. 2016. "City of Imperial Beach Sea Level Rise Study." Coastal Conservancy Climate Ready Grant deliverable](#)

Appendix B. LCP Case Studies

Consideration of Sea Level Rise in Recent LCP Updates: Marin Case Study

Introduction

In August of 2015, the Coastal Commission unanimously adopted its Sea Level Rise Policy Guidance, which provides recommendations for how to address sea level rise within the context of the Coastal Act. In particular, the document discusses the importance of addressing sea level rise in Local Coastal Programs (LCPs). LCPs are a critical tool for addressing sea level rise because they dictate the types, intensities, and locations of allowable land uses in the coastal zone, providing a framework for implementing proactive adaptation strategies to address sea level rise vulnerabilities. However, many LCPs were certified in the 1980s and 1990s and need to be updated to reflect changed conditions, new information and knowledge, and new programs and policies, especially as related to climate change and sea level rise.

To that end, the Coastal Commission, in coordination with other state agencies including the State Coastal Conservancy and the Ocean Protection Council, has provided significant grant funding to support LCP updates with a particular emphasis on addressing sea level rise. To date, the Coastal Commission has awarded 3 rounds of grants totaling approximately \$4.5 million to support the completion of sea level rise vulnerability assessments, adaptation plans, Land Use Plan (LUP) and Implementation Plan (IP) updates, and local adoption and Coastal Commission certification of LCPs. The first round of grants was completed in April of 2016.

Four jurisdictions with grants from the Coastal Commission were chosen as case studies to provide information on how sea level rise adaptation planning and related LCP policy development is carried out on a local scale. The four jurisdictions – Marin County, and the cities of Pacific Grove, Goleta, and Newport Beach, were chosen because they represent a variety of geographic areas as well as different planning approaches. These four case studies provide valuable information and lessons learned on topics such as finding the right level of detail for vulnerability assessments, the utility of including a specific adaptation planning step, and the importance of adaptive LCP policies. More information on these topics can be found in each of the individual case studies.

The schematic below shows a generalized ideal process for how to address sea level rise through an LCP update. As of January 2017, Marin County has completed a vulnerability assessment and has locally adopted updates to the LUP and IP. Commission staff provided the County with guidance at each step in the process, including providing suggested language for hazards related policies. The County then submitted the locally adopted LCP to the Commission for certification, and, as is common during the certification process, Commission staff provided suggested modifications, most of them reflecting the same advice provided to the County as it was processing the amendment locally. The Environmental Hazards chapter of the LCP was presented at the November 2016 Commission hearing, but action was postponed to allow for additional coordination between County and Commission staff to address remaining policy concerns related to hazards and sea level rise. The County is also continuing to work on its adaptation plan, and the additional time for consideration of the Environmental Hazards chapter of the LCP may allow for the adaptation plan to ‘catch up’ to LCP policy development.

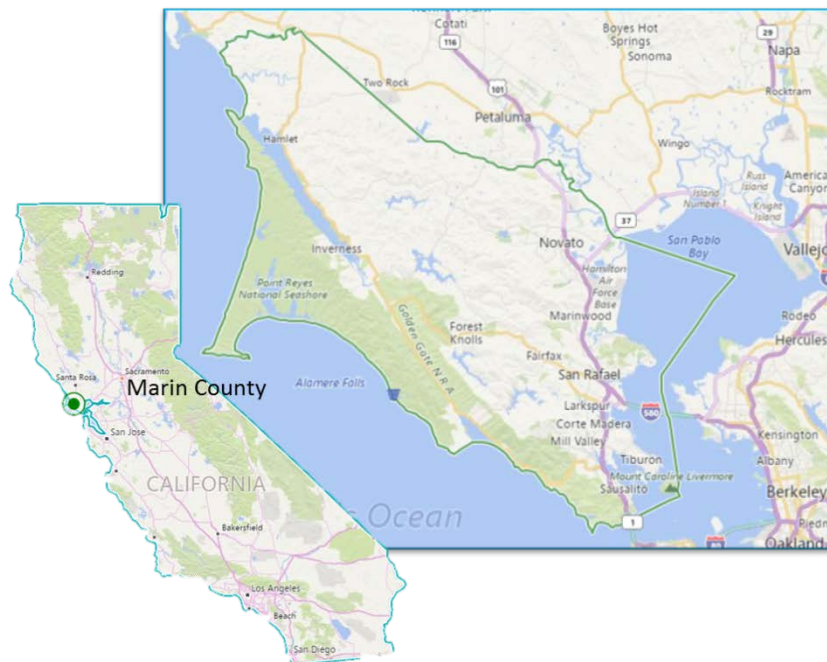
Overall, Marin’s sea level rise planning effort provides a good example of a detailed vulnerability assessment process and report that provides important and actionable information for adaptation planning. However, remaining policy concerns and the lack of proactive policies to address some identified vulnerabilities suggests that the effort would have benefitted from additional adaptation planning time so that the County’s adaptation plan could be better reflected in its proposed LCP policies, as well as additional coordination with Commission staff to better address staff’s concerns prior to local adoption of the LCP.



Figure 1. Marin County sea level rise planning as of January 2017

Background

Marin County is located north of San Francisco and has approximately 106 miles of ocean coastline from Sonoma County to Point Bonita near the Golden Gate Bridge. The coastal zone contains approximately 130 square miles of the County’s 520 square miles of total land area. Of this total, approximately 53 square miles are owned and managed by the federal government, mostly within either Point Reyes National Seashore or Golden Gate National Recreation Area.



Approximately 75 square miles comprise the County’s LCP jurisdiction. The protection of agriculture is a primary LCP concern -- nearly two-thirds of the County’s LCP jurisdictional area is zoned Coastal Agricultural Production Zone. In addition to the federally managed parklands, the County also has important public access and visitor serving locations, scenic resources, and beaches, wetlands, and other habitats throughout its coastal zone, including areas vulnerable to sea level rise in Dillon Beach, Tomales, Bolinas, Stinson Beach, and Muir Beach.

The Marin County LCP was originally certified in 1982. In recent years the County has been working to develop its first major update to the LCP, with extensive collaboration and input from Commission staff throughout the local process. In May of 2014, the Commission conditionally certified the LUP portion of the Update, and in April of 2015 considered the IP portion of the update. At that 2015 hearing, the County withdrew its proposed IP update in order to spend more time addressing their concerns with the Commission approved LUP and Commission staff’s

recommendations on the IP. The Commission's 2014 approval of the LUP lapsed and was not ultimately certified.



In addition to the ongoing effort to comprehensively update the LCP, the County was awarded a Round 1 LCP Grant ([LCP-13-01](#)) in January 2014 (\$54,000) to address coastal hazards and sea level rise. This grant from the Coastal Commission was added to a \$200,000 grant from the Ocean Protection Council to complete a sea level rise vulnerability assessment, an adaptation plan, and an LCP amendment, and to support public outreach. As initially envisioned, this effort was intended to result in targeted amendments to the updated LCP (*i.e.*, amendments to the LUP that was conditionally approved in May 2014 and to the IP that was heard but withdrawn at the April 2015 hearing) that would further refine coastal hazards policies based on the findings of the vulnerability assessment and adaptation planning work. Since the updated IP was withdrawn at the April 2015 hearing, this work effort has moved along concurrently with the larger effort to comprehensively update the LCP. Ultimately, the County-proposed hazard amendments were an essentially new hazards program that differed in significant ways from what the Commission had conditionally approved in 2014.

Throughout the two-year grant term (April 2014 to April 2016), the County developed an extensive public outreach program and completed a detailed sea level rise vulnerability assessment. The County also initiated an adaptation planning process, resulting in a draft adaptation plan that identifies, evaluates, and prioritizes adaptation needs and potential strategies. The County is continuing to meet with stakeholders and members of the public to refine this adaptation plan. Marin County also developed updated policies to address coastal hazards and sea level rise (included primarily within the Environmental Hazards sections of the LCP). The entirety of the updated LCP was heard by the Commission at the November 2016 hearing. Although the balance of the LCP update was conditionally approved, the hearing on the Environmental Hazards section was continued to allow County and Commission staff to address several remaining policy concerns. Coordination on these topics is ongoing.

Vulnerability Assessment

In September 2015, Marin County completed the *Marin Ocean Coast Sea Level Rise Vulnerability Assessment* (materials available on the Collaboration: Sea-level Marin Adaptation Response Team (C-SMART) publications [website](#)). The report identifies assets within the

County that are vulnerable to sea level rise and storm impacts over time and evaluated assets' exposure, sensitivity, and adaptive capacity under various sea level rise and storm scenarios. The assessment was intended to inform and support the County's adaptation planning and LCP update effort, as called for in Program C-EH-22a of the County's LUP that was conditionally approved by the Commission in May 2014.

Sea Level Rise Scenario	Term
1 10 inches + Annual Storm	Near
2 10 inches + 20-year Storm	Near
3 20 inches + 20-year Storm	Medium
4 40 inches + 100-year Storm	Long- Low
5 80 inches + 100-year Storm ^{1b}	Long- High

Table 1. Marin SLR and storm scenarios. Near-term refers to approximately 2030; medium to 2050; and long to 2100.

Marin County benefitted from being able to leverage one of the most advanced sea level rise modeling and mapping tools available in the State, and its vulnerability assessment provides a good example of a highly detailed analysis. Specifically, the County used the Our Coast Our Future tool (OCOF). This tool utilizes the USGS's Coastal Storm Modeling System (CoSMoS) 2.0 to produce 40

different sea level rise and storm scenario combinations that include sea level rise, tides, storm surge, El Niño effects, wave set up, and wave run up. From these 40 combinations, the County identified 5 specific scenarios to focus on for the vulnerability assessment that cover a variety of time horizons and storm conditions as shown in Table 1. Maps showing the areas flooded under each of these scenarios are included in the report. The County also separately assessed increased erosion potential, as CoSMoS 2.0 does not include long-term erosion in its flood modeling. Accelerated erosion rates were developed for each of the sea level rise scenarios (not including storm scenarios), and the bluff and shoreline erosion layers were overlaid with asset layers to assess their vulnerability to erosion.

As with any modeling effort and vulnerability assessment work, it is important to note that there are certain simplifications and assumptions made during the modelling process that should be considered when analyzing vulnerability assessment findings. Because some assumptions can't always be avoided, Commission staff suggests that vulnerability assessments clearly explain what the assumptions are and the effect they have on identified vulnerabilities (*i.e.*, whether results are over- or underestimates of vulnerable assets). Although Marin's vulnerability assessment discussed some modelling assumptions, it could be improved by having a specific section that explains the assumptions more fully. Some of these considerations include the following.

- *Combination of flooding and erosion:* The CoSMoS 2.0 modeling does not include long-term erosion in its flood modeling, which prompted Marin to conduct additional analyses to identify erosion hazard areas. Although this additional information is helpful, the maps showing areas likely to be flooded may still be underestimating flood exposure because these two impacts aren't integrated together in the County's vulnerability assessment (in other words, the flood maps show areas that would be flooded based on the existing shoreline condition rather than areas that would be flooded after the shoreline erodes).
- *Shoreline protective devices and backshore structures:* The additional erosion analyses conducted by Marin assumed that erosion/inland migration would stop at any existing

seawalls, development, or backshore dunes. Because this assumes a persistence of the status quo rather than any changes in development patterns based on continued erosion and/or long-term adaptation planning, Commission staff recommends that modeling also show what would happen if seawalls and other structures or shoreline features are removed or eroded. Looking at both scenarios gives a more holistic picture of what different management approaches may entail.

- *Creek flooding*: The CoSMoS modeling doesn't incorporate any changes to creek dynamics or address how such changes may impact flooding. In particular, an increase in creek inputs (for example from more frequent or stronger precipitation events) may increase flood potential, while changes in dynamics of creek mouths or other features could change what areas are at risk from flooding.

Despite some of these modeling limitations, the County completed a detailed inventory of assets that could be exposed to the different sea level rise and storm scenarios, and then further assessed assets' sensitivity and adaptive capacity to hazards such as inundation at regular high tides, extreme event flooding, erosion, wave run-up, saltwater intrusion, and habitat shifts. Exposure was determined based on overlays of assets and the various sea level rise and erosion scenarios, and sensitivity and adaptive capacity were assessed based on interviews with asset managers.

Results are organized in two main ways: 1) by asset types (sections on parcels and buildings; transportation; utilities; agriculture and aquaculture; natural resources; recreation and public access; emergency services; and historic and archaeological resources), and 2) by community (sections on Muir Beach, Stinson Beach, Bolinas, Inverness, Point Reyes Stations, East Shore, and Dillon Beach). They are also described both qualitatively and quantitatively. For example, each section includes brief summaries (in both narrative and table formats) that describe the vulnerabilities, including discussions of important considerations and consequences. Quantitative descriptions include tables that display information such as the flood depth each asset will be exposed to from each scenario (including distinguishing between the tidal flooding (mean higher high water) and storm flooding); potential monetary losses from buildings damaged by the scenarios (based on FEMA methodologies and modeling); anticipated beach widths and vulnerability index; and the number of assets (or linear/square mileage) of assets exposed (including as a percentage of the County total).

Some of the most vulnerable assets identified by the assessment (in order of timing and flood depth) are listed below.

- Near-term (Scenarios 1 and 2, by approximately 2030):
 - Beaches, underground on-site wastewater treatment systems (OWTS), buildings, and streets in Stinson Beach
 - Shoreline Highway between Stinson Beach and Bolinas, at Green Bridge in Point Reyes Station, the Walker Creek crossing in Marshall, and bridges on Middle Road and Valley Ford Lincoln School Road
 - Beaches, beach front and downtown buildings and streets in Bolinas
 - Septic systems, beaches, marshes, and buildings along the eastern and western shores of Tomales bay on the East Shore and in Inverness

- Water distribution pipe extending underneath Shoreline Highway and Sir Francis Drake serving Inverness residents
- Intertidal rocky lands in Muir Beach and Agate Beach (Duxbury Reef)
- Fire service facilities and tsunami evacuation routes in Stinson Beach
- Recreational facilities at Dillon Beach Resort and Lawson’s Landing
- Bluff top buildings in Muir Beach, Bolinas, and Dillon Beach (may be vulnerable to accelerated erosion)
- Medium-term (Scenario 3, approximately 2050)
 - Olema-Bolinas Road, the only access road to Bolinas
 - Further north into downtown Bolinas, including the historic district
 - Bolinas Public Utilities District lift station
 - Shoreline Highway in Pt. Reyes Station Sir Francis Drake Blvd. in Inverness
- Long-term (Scenarios 4 and 5, approximately 2100)
 - Shoreline Highway along the East Shore in the medium and long-terms
 - Buildings in Inverness west of Sir Francis Drake Blvd
 - Downtown Bolinas up to Bridgton Road along Olema-Bolinas Road, including the market, library, community center, gas station, museum, and several other valued places



Marin’s vulnerability assessment work provides a good example of how a more advanced sea level rise modeling and mapping tool (combined with some additional technical analyses) can be used to develop a highly detailed report with critical information that can be used for adaptation planning at a variety of scales. For example, broadly identifying major vulnerabilities and including information on when different assets are likely to become impacted, and what the consequences of those impacts would be, helps to provide information on how to prioritize the

implementation of different adaptation actions throughout the entire county. On a smaller scale, detailed information, such as the anticipated flood depth at specific assets under various scenarios or the anticipated width of beaches over time, helps to provide site-specific information that could be used for creating adaptation strategies for individual assets.

Relatedly, Marin’s vulnerability assessment provides a good example for how to provide information that can be useful for a variety of audiences. For example, including narrative sections that briefly describe the vulnerabilities and potential consequences, including concise “at a glance” sections, and including economic impact information all help to lay out a story that engages members of the public who are not well-versed in these topics. Conversely, including highly detailed information on specific assets is important for asset managers who can use that

information to identify adaptation approaches. Additionally, organizing the report by both assets and communities allows readers to quickly and easily identify vulnerability information of most interest to them. For example, Caltrans or other roadway managers could look to the Transportation section and see all of the roads that are vulnerable to various sea level rise scenarios throughout the County; whereas a resident or visitor could look at the Stinson Beach or other community sections to understand what is at risk in the community they care about.



Adaptation Plan

As part of its initial grant program, Marin intended to complete an adaptation planning effort that included public outreach and drafting of an adaptation plan that would prioritize adaptive needs, identify potential adaptation strategies, evaluate and prioritize adaptation strategies, and lay out a preliminary implementation phasing plan prior to completing the updates to the Environmental Hazards chapter of the LCP. In general, Commission staff supports and encourages this approach of including a distinct adaptation planning phase in between completing a vulnerability assessment and developing updated LCP policy language. Such a process allows for identification of and buy-in by the public and decision-makers for a specific approach or set of strategies without the complex and sometimes contentious step of determining specific policy language.

Unfortunately, delays and a variety of other factors resulted in the County essentially completing some parts of the adaptation planning process either concurrently with the development of the proposed LCP or following much of the policy development. Although this is not ideal, and in this case partially led to the hazards component of the LCP being postponed (as described above), Commission staff recognizes that there will likely be instances in which jurisdictions complete a first round of LCP updates to address some sea level rise concerns, followed by another phase of adaptation planning and future LCP updates.

Regardless of the specific process, Marin did complete a draft Adaptation Report that was submitted as one of the final grant deliverables. The report discusses potential actions to accommodate, protect against, or retreat from the threats of sea level rise and coastal hazards, and reflects input from a public outreach effort. However, the report should not be considered a final adaptation plan as the County intends to continue to work with stakeholders on further adaptation planning, and will need to develop policies and other actions to implement the preferred adaptation strategies that are ultimately identified.

In its current form, the adaptation planning report lays out the priority planning needs, establishes guiding principles and prioritization criteria, and identifies possible adaptation strategies to address the vulnerabilities identified in the sea level rise vulnerability assessment

(like the vulnerability assessment, adaptation strategies are organized both by asset type and community). The report also includes some information about how strategies could be implemented in a phased manner over time. However, the report broadly discusses adaptation options rather than including specific detail about what strategies should be used in specific circumstances or at specific times. As the County continues its adaptation planning process, it should work to identify and include additional specific detail on these topics in its final adaptation plan, and should translate those strategies into actual policy language that can be used to guide coastal development through the LCP. Absent this final step, the adaptation plan serves only limited utility in terms of coastal zone planning, permitting, and adaptation over time.

Broadly, the report currently states that the recommended adaptation approach for West Marin is to accommodate development with elevation and other retrofits, and protect assets with nature-based strategies in the near- to medium-term, while planning for other adaptation measures, including managed retreat, in the long-term. Some additional findings and recommendations stated within the draft adaptation planning report include the following:

- The County should support ongoing efforts to elevate or otherwise protect electrical, fuel, sewage management and water systems from high tide levels and new public capital improvement projects should account for 3 feet of sea level rise. Other adaptation strategies may include retrofits to water meter connections to withstand salt water and retrofitting septic systems to meet current regulations. The County should also consider forming a task force with representatives from PG&E and local service providers to identify long-term, coordinated approaches for adapting utilities.
- Roads vulnerable to temporary flooding will continue to be subject to temporary closures, in some cases preventing emergency access. The Marin County Department of Public Works should continue to evaluate costs and feasibility of various adaptation approaches and work to collaborate with Caltrans to identify opportunities for adaptive management. Additional recommendations include ensuring that Capital Improvement Projects and road repairs account for sea level rise and to evaluate the feasibility of relocating critical access roads upland.
- Natural resources should be monitored to better understand the impacts of sea level rise to beaches, wetlands, and other habitat areas. The County and key partners should continue to support and pursue funding opportunities for innovative living shorelines approaches to sea level rise protection, such as dune and wetland restoration, horizontal levees, oyster beds, eelgrass, and bluff vegetation.



Overall, the draft adaptation report is a good start and provides a good example for how such plans could be organized. The report clearly explains the County's various adaptation needs, including providing details on assets that need adaptation strategies now, assets that need further studies to assess potential impacts and needs, and assets that should be monitored to assess impacts now; broadly describes a range of adaptation options, including discussion of the costs and benefits of various strategies; and starts to provide detail on options for specific assets and when such strategies could be implemented. This adaptation plan currently falls short in providing a clear approach for what the County intends to do, but this shortcoming is a result of the fact that the County is currently in the middle of its adaptation planning process and is continuing to work with stakeholders to identify a preferred set of strategies. Similarly, it will need to account for the final step identified above of translating potential strategies into actual LCP policy language that can guide coastal development and planning moving forward.

Development of the LCP Update

Marin County has worked on developing coastal hazards and sea level rise policies for many years, including throughout early 2016 following the initial Commission consideration of its LUP update, as described above. During this time, Coastal Commission staff met regularly with County staff to discuss potential policies and to voice concerns. Despite this ongoing coordination, Marin County completed the local adoption process for the updated LCP prior to completing its adaptation planning efforts and prior to reaching agreement on several critical sea level rise related policies. As explained above, when the LCP update was presented at the Coastal Commission hearing in November 2016, the County asked the Commission to postpone a vote on the Environmental Hazards sections of the LCP to allow time for additional coordination with stakeholders and Commission staff, and to allow for the complementary adaptation planning efforts to 'catch up' to the LCP policy development efforts.

Overall, Commission staff's concerns emanate from staff's assessment that the proposed LCP lacked adequate adaptation policies to address identified vulnerabilities. This is potentially a result of the fact that the County had not completed its adaptation planning efforts when it developed its proposed LCP policies. It should be noted that this type of issue is not confined to the Marin LCP – Commission staff's experience so far has been that many proposed LCP policies that attempt to address sea level rise adaptation lack the detail necessary to provide for specific adaptation actions. There are a variety of reasons for this problem, but much of it derives from the fact that adaptation planning often presents contentious and complex issues that are difficult to address. Sea level rise adaptation raises significant questions related to community vision, including the potentially conflicting interplay among public resources, infrastructure, and private development, as well as the costs and benefits of various strategies over time. These are very difficult questions, and as a result many LCP proposals do not reach conclusions on these points. Many of them, like Marin's proposal, defer significant planning to future efforts. This is a common theme up and down the state, and a significant problem impeding the success of LCP updates designed to address sea level rise.

The County and Commission staff are continuing to refine possible draft coastal hazards policies. It should be noted that despite some disagreements, Commission staff supported the intention of many of the initially proposed policies. For example, Marin's draft LCP included policies that directly link to some of the findings of the vulnerability assessment and that are reflective of the

specific conditions in Marin County. The proposed LCP also included some policies and programs that would encourage additional planning and research on ways to address sea level rise. Commission staff agrees that this approach of developing an initial set of policies, when combined with additional adaptation planning and future LCP updates, will help the County address the impacts of sea level rise.

However, Commission staff did suggest a number of modifications to address certain policy concerns. In many cases, these edits were to provide clarity or to update certain policy language to more closely match some of the evolving ways that the Commission has been addressing similar issues. Other edits were meant to add policies to more explicitly address structures in hazardous areas to ensure that development is safe, that coastal resources are protected over time, and that property owners clearly understand and absorb the risks of building in a hazardous area. Commission staff will continue to coordinate with the County and local stakeholders in hopes of reaching agreement on these policies and ensuring that Marin will have a strong, forward-thinking LCP that fully addresses sea level rise concerns.

Next Steps

To date, Marin County has completed a detailed vulnerability assessment, begun working on an adaptation plan, and completed a draft LCP that was locally adopted by the County. Although the LCP contained many polices designed to respond to findings in the vulnerability assessment and to address sea level rise, Commission staff had a number of suggested modifications, including edits to add policies to address major concerns regarding protection of coastal resources and ensuring clarity regarding what will happen to development that is allowed in hazardous areas. Given these concerns, adoption of the Environmental Hazards sections of the LCP was postponed to allow for more coordination between Coastal Commission and County staff, and to allow more time for the County's complementary adaptation planning efforts.

This case study underscores the importance of collaboration between local jurisdictions and Commission staff as early and often as possible in the planning process in order to reach consensus on proposed LCP policies that address sea level rise. It also points to the importance of developing adaption plans before drafting critical hazards policies so that the policies can be reflective of the vision of the plans, and can provide the appropriate policy framework to carry out the plans in the coastal zone. All of this takes time, and it is best accommodated in the local process as opposed to the Commission process, including so that plans can be appropriately vetted and developed through community forums and hearings in the affected local area.

Commission staff looks forward to continuing to work with the County and will seek to reach agreement on several main policy topics including:

- Redevelopment
- Ensuring that there is a clear approach for removing development in hazardous areas when it is no longer safe and/or it results in negative impacts to other coastal resources (*e.g.*, it encroaches on public trust land)
- Addressing existing but unnecessary shoreline protective devices

- Ensuring that future adaptation planning will specifically identify options for protection of beaches (and their associated access, recreation, and habitat values).

Commission staff will also continue to engage with the County as it continues its broader adaptation planning process. Significant issues the County should address include transportation vulnerabilities, identification of funding or other options to assist with managed retreat programs, and ensuring that the needs of both homeowners in vulnerable areas as well as non-local users of beaches and other recreation areas are met in a fair and equitable manner.

Consideration of Sea Level Rise in Recent LCP Updates: City of Pacific Grove Case Study

Introduction

In August of 2015, the Coastal Commission unanimously adopted its Sea Level Rise Policy Guidance, which provides recommendations for how to address sea level rise within the context of the Coastal Act. In particular, the document discusses the importance of addressing sea level rise in Local Coastal Programs (LCPs). LCPs are a critical tool for addressing sea level rise because they dictate the types, intensities, and locations of allowable land uses in the coastal zone, providing a framework for implementing proactive adaptation strategies to address sea level rise vulnerabilities. However, many LCPs were certified in the 1980s and 1990s and would benefit from updates to reflect changed conditions, new information and knowledge, and new programs and policies, especially those related to climate change and sea level rise.

To that end, the Coastal Commission, in coordination with other state agencies including the State Coastal Conservancy and the Ocean Protection Council, has provided significant grant funding to support LCP updates with a particular emphasis on addressing sea level rise. To date, the Coastal Commission has awarded 3 rounds of grants totaling approximately \$4.5 million to support the completion of sea level rise vulnerability assessments, adaptation plans, Land Use Plan (LUP) and Implementation Plan (IP) updates, and local adoption and Coastal Commission certification of LCPs. The first round of grants was completed in April of 2016.

Four jurisdictions with grants from the Coastal Commission were chosen as case studies to provide information on how sea level rise adaptation planning and related LCP policy development is carried out on a local scale. The four jurisdictions – Marin County, and the cities of Pacific Grove, Goleta, and Newport Beach, were chosen because they represent a variety of geographic areas as well as different planning approaches. These four case studies provide valuable information and lessons learned on topics such as finding the right level of detail for vulnerability assessments, the utility of including a specific adaptation planning step, and the importance of adaptive LCP policies. More information on these topics can be found in each of the individual case studies.

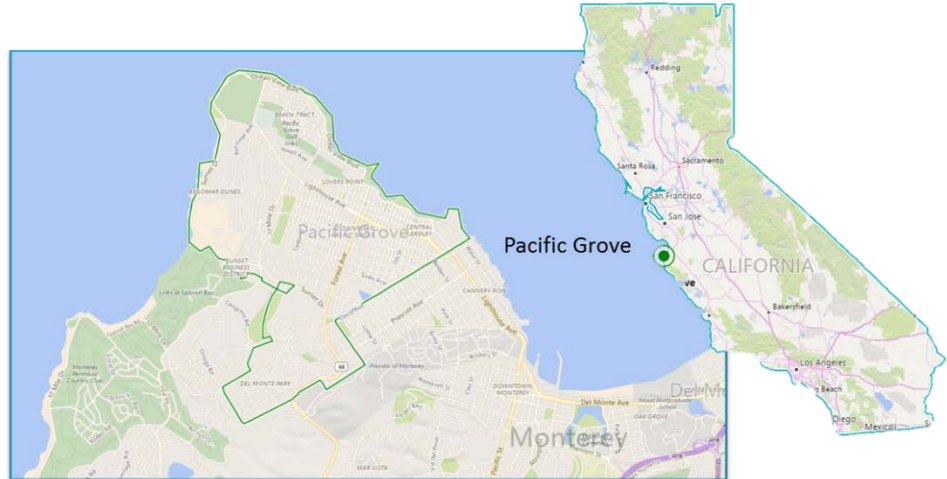
The schematic below shows a generalized ideal process for how to address sea level rise through an LCP update. As of January 2017, Pacific Grove has completed a vulnerability assessment and a draft update to the LUP, as well as developing an entirely new IP. The LUP and IP are currently being considered through the local process which will be followed by consideration by the Coastal Commission. Pacific Grove provides a good example of utilizing existing data sources to complete a vulnerability assessment and using that information to craft an updated LCP that, despite some limitations in the vulnerability assessment, includes policies to ensure safety of new development and to set up a phased adaptation planning approach that explicitly calls for additional assessment and planning work.



Figure 1. Pacific Grove sea level rise planning as of January 2017

Background

The City of Pacific Grove is a relatively small coastal city in Monterey County, located immediately northwest of the City of Monterey on the northern tip of the Monterey Peninsula. The city's coastal zone is 458 acres, stretching from the Monterey



Bay Aquarium through the Asilomar Conference Grounds. The coastal zone includes numerous land use types, including residential and commercial development near its downtown core, as well as significant coastal resources including Asilomar State Beach, the Asilomar Dunes Natural Preserve, numerous coastal access points and trails along Sunset Drive and Ocean View Boulevard, several offshore Marine Reserves, and important habitat for migrating monarch butterflies.



Aerial view of Pacific Grove, looking southward
(from Pacific Grove LCP)

The City's Land Use Plan (LUP) was certified by the Commission in 1991, and a Coastal Parks Plan was adopted as an element of the LUP in 1998. The Coastal Parks Plan provides a tool for implementing various trail, bikeway, parking and circulation, and visual resource policies of the LUP, and applies to areas including the Lighthouse Reservation, Lovers Point Park, Asilomar, and other lands seaward of and including Ocean View Boulevard and Sunset Drive. The City's Implementation Plan has not yet been finalized or approved by the Commission. As such, the Commission continues to issue coastal development permits in Pacific Grove's coastal zone.

Recognizing the need to achieve a fully certified LCP for the City of Pacific Grove, the Commission approved a Round 1 LCP Grant ([LCP-13-08](#)) in 2013 (\$130,000) for the city to complete its LCP. The overall goal of the project was to update the existing LUP and develop a newly certified IP to provide for an efficient and consistent City-administered coastal zone development review process that promotes sustainable development, coastal access, and conservation of coastal resources. The grant period ran from April 2014 to April 2016, and resulted in extensive public outreach on core coastal resource issues and development of a Climate Change Vulnerability Assessment. Both efforts helped form the basis for an updated LUP and a new IP which have been heard by the City's Planning Commission and are currently before the City Council for consideration. The City's proposed LCP is anticipated to be submitted to the Coastal Commission in mid-2017.

Vulnerability Assessment

In January 2015, the City of Pacific Grove published the [Final City of Pacific Grove Climate Change Vulnerability Assessment](#). The report provides an evaluation of potentially significant impacts of climate change for the City's coastal zone with an emphasis on how anticipated climate change may affect people, resources, and infrastructure along the coast. The intent of this assessment was to inform and support the City's LCP, specifically the LCP policies related to climate change adaptation and coastal hazards planning.

Overall, the City of Pacific Grove used an approach that focused on providing a broad overview of climate change impacts and vulnerabilities based on existing resources, rather than developing new, locally-specific, detailed modeling of climate change impacts. This aligns with the recommendations of the Coastal Commission's *Sea Level Rise Policy Guidance*, as well as other State resources (e.g., the *California Adaptation Planning Guide*). The Coastal Commission in particular recognizes that it may not always be feasible or appropriate to use the most state of the art modeling for all vulnerability assessments due to timing, staffing, and funding constraints, and instead recommends using the best and most locally-relevant tools and resources available at the time of the assessment. Where impacts cannot be quantitatively assessed in a highly detailed manner, potential vulnerabilities can instead be qualitatively discussed, and even a preliminary assessment can be useful for planning purposes. The City of Pacific Grove's vulnerability assessment and related planning work, combined with anticipated future efforts (discussed below), provides a good example for this more limited approach.

The City's climate change vulnerability assessment identified potential impacts from changes in temperature, precipitation, sea level rise, severe storms and ocean acidification, and wildfire. The report is broken down into 5 sections by resource/topic type – public health and safety, recreational resources and access, water management, biodiversity and habitat, and coastal development and infrastructure – and each section discusses the asset's exposure, sensitivity, potential impacts, adaptive capacity, and risk and onset to/from the various potential climate change impacts. Considering a suite of climate change impacts allowed the City to consider LCP policies (and other relevant plans and programs) that address a broad range of anticipated future conditions.

To address sea level rise, the City relied primarily on sea level rise hazard mapping completed by the Pacific Institute, one of several recommended existing resources for sea level rise information in the Commission’s *Sea Level Rise Policy Guidance*. This mapping shows both current flooding from a 100-year storm event and the anticipated flooding extent from a 100-year storm event with 55 inches of sea level rise (the projection for 2100 used in that effort). Separate hazards maps also show the projected erosion for 55 inches of sea level rise by 2100, using a method that accelerates historical rates to account for increasing sea levels over time.

It is important to note that there are several limitations to the Pacific Institute work. First, the hazard mapping was completed prior to the release of the 2012 NRC Report – considered the current best available science on sea level rise projections for the state of California – and therefore uses a projection of just 55 inches by the year 2100 rather than the 66 inches identified in the NRC report. Second, the flooding analysis uses a “bathtub model” approach which means that areas below the elevation of the projected sea level rise will show up as flooded whether or not there is a hydrological connection. Third, the erosion layer and the flooding layer are not aggregated together. In other words, the maps do not show the additional areas that will flood after the shoreline has eroded over time. Lastly, because these maps only show the 100-year flood plus 55 inches of sea level rise, they don’t illustrate the impacts of day-to-day inundation or small storm flooding in 2100, nor is there a good way of seeing interim impacts (*e.g.*, impacts for 2030, 2050, 2070).

Despite these limitations, the Pacific Institute hazards maps are a good tool for providing a broad overview of what assets could be potentially vulnerable to flooding and/or erosion from sea level rise by the year 2100.



In the case of Pacific Grove, the City is fortunate in that much of its coastline is made up of granitic rock that is fairly resistant to wave attack and is therefore slow to erode. Further, much of the City’s development is both elevated on the rocky bluffs and separated from the bluff edge by open space that is devoted to parkland and blufftop trails. Thus, the majority of the City’s built environment will be relatively safe from many of the impacts associated with sea level rise through the next few decades.

Development identified in the assessment as being vulnerable to sea level rise (specifically, the 55 inches of SLR plus a 100-year storm) includes:

- ~75 residential structures

- Visitor-serving amenities along Ocean View Boulevard (e.g., restaurant, motel, inn)
- Hopkins Marine Station
- Ocean View Boulevard (a portion of which is designated as an evacuation route) and Sunset Drive and related public recreational trails and resources in this area
- 7 wastewater pump stations and numerous stormwater outfalls



The assets most vulnerable to sea level rise impacts in the City of Pacific Grove are open space areas including parks, trails, and related recreational amenities, as well as natural habitats including beaches and tide pools. As identified above, because the City has reserved most of the areas immediately adjacent to the coastline for open space and public recreation, it is these recreational and natural habitat assets that will be impacted first. Unfortunately, the natural habitats may be fairly sensitive to impacts to sea level rise and may not have a high adaptive capacity. This is partially a result

of the rocky bluffs that help to protect much of the City’s assets – because these bluffs are more resistant to erosion, beaches or rocky tidepools in front of the bluffs may be drowned as sea levels rise rather than being able to migrate inland. Conversely, most of the recreational assets have a low sensitivity to impacts from sea level rise. For example, whereas it may not be acceptable for a wastewater pump station or a single family residence to be flooded during a severe storm even on a rare occurrence, parks and trails can still be used even if they are partially or fully flooded on an occasional basis.

Thus, research questions remain regarding the ability of Pacific Grove’s natural assets to persist as sea levels rise and planning questions remain for the recreational assets – specifically, how often they can be flooded or what percentage of the area could be permanently lost to erosion or inundation before the impacts are no longer tolerable for the public.

The City’s vulnerability assessment does not answer these questions, nor is there a detailed discussion of the limitations of the modelling work or the data and information gaps. Overall, the shortcomings in the assessment largely stem from the limitations of the modelling resource used (as explained above, the Pacific Institute Hazard maps don’t integrate erosion and flooding and only show a single sea level rise scenario), and therefore many of the remaining planning questions couldn’t be answered by this work. However, this vulnerability assessment could have been improved somewhat by more clearly explaining the limitations of the modeling and laying out topics that future assessments could or should focus on to provide more useful planning information.

Despite the limitations of the sea level rise modeling work and the related shortcomings of the vulnerability assessment, the assessment did provide important information on sea level rise

vulnerabilities that has been incorporated into the (ongoing) LCP policy development, as discussed below.

Development of the LCP Update

The City of Pacific Grove currently has a draft LUP and draft IP that are reflective of coordination and iterative review with Coastal Commission staff and the public over the course of the past year. The City has had several Planning Commission meetings on the draft LUP and IP documents, and the draft LCP will next be reviewed by the City Council, before being submitted to the Coastal Commission for review and ultimate certification.

Although the current draft policies are still subject to change in response to comments from the Planning Commission, City Council, and the public, as well as through future coordination with the Coastal Commission, the draft LCP currently contains a variety of policies to address sea level rise. This includes policies that ensure new development is designed to be safe from hazards; policies that address current known vulnerabilities; and policies that call for and lay out a framework for future vulnerability assessment and adaptation planning and implementation. These policies are described in the bullet points below.

- **Best available science and future updates:** Land Use Plan (LUP) policies HAZ-1 and HAZ-2 call for the City to continue to gather information on the impacts of sea level rise and other coastal hazards. HAZ-1 states that the City shall use the best available science in future vulnerability assessments and shall analyze a variety of time horizons as applicable and feasible. HAZ-2 states that the City shall complete periodic evaluations based on evolving science to assess the need for updated LCP policies to address hazards. This policy also sets up a trigger for when these periodic evaluations should commence, specifically at the time when “the mean high water tidal datum has risen 3 inches on average for an entire year above the forthcoming updated tidal epoch mean high water level at the Monterey Tide Gauge¹”.
- **Hazards reports:** LUP policy HAZ-12 states that development proposed in potential hazard areas shall be evaluated for potential coastal hazards at the site based on readily available information, and that if it is found to be in an area potentially subject to coastal hazards over its anticipated lifetime, a site specific hazard report prepared by a qualified geologist/engineer shall be required. This policy also sets up a trigger (in line with the 3 inches of sea level rise after the next tidal epoch is established, as discussed in HAZ-2) upon which all development either in or near a potential hazard area shall require a site specific hazards analysis.
- **Siting and design:** LUP policies HAZ-8 through HAZ-11 require new development, including public recreational and access facilities and infrastructure, to be sited and designed in a manner that minimizes risks to life and property, avoids impacts from

¹ The National Tidal Datum Epoch is the 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken to obtain mean values (such as Mean High Water). The present NTDE is the average tide observations over the years 1983-2001. The NTDE is considered for revision every 20-25 years, suggesting that the next NTDE could be established within the next 5-10 years.

coastal hazards, and avoids impacts to coastal resources over its lifetime. HAZ-10 specifically states that no new major critical public infrastructure should be allowed in an area potentially subject to coastal hazards. HAZ-11 specifies that development and use of land below the 20-foot elevation (as measured from mean high tide) shall be limited to open space, low-intensity public recreational and access facilities, and coastal dependent or coastal related structures.

- **Shoreline protective devices:** LUP policies HAZ-13 through HAZ-17 lay out a suite of policies related to shoreline protective devices (SPDs). HAZ-13 states that it is the intent of the LCP to ensure that SPDs are only utilized when they protect priority development and uses, and only when all coastal resource impacts are appropriately mitigated. HAZ-15 states that new SPDs shall only be allowed where required to protect public recreational facilities, public-infrastructure, and coastal-dependent development in critical danger from erosion, and shall not be constructed to protect non-coastal-dependent private development. HAZ-15 also lays out a preference for non-structural or soft approaches such as vegetation, and states that these options shall be prioritized over hard structures. HAZ-16 lays out details for ensuring that unavoidable impacts to coastal resources from SPDs will be appropriately mitigated. HAZ-14 states that repair and maintenance of existing SPDs shall only be allowed if required to protect public recreational facilities, public-infrastructure, or coastal-dependent development. HAZ-17 states that new development associated with or protected by an existing SPD shall assess the efficacy of the existing SPD, including assessing whether or not the device is still required. Further, if the assessment indicates that the existing SPD can be removed or modified, or if there are greater coastal resource benefits from removal or modifications of the SPD, then such removal or modifications shall be required as a condition of approval for the new development. This policy also states that in all cases, SPDs shall be authorized only until the time when the qualifying development being protected is no longer present or no longer requires armoring.
- **Hazard response:** Several LUP policies touch on the potential need for existing (or new) development to be modified or removed to address coastal hazards. For example, HAZ-10 states that public recreational access facilities and coastal-dependent development shall address existing related facilities and infrastructure (such as stormwater or sewer infrastructure) adjacent to the project site as applicable and feasible to ensure that this infrastructure can better withstand or accommodate sea level rise and other coastal hazards. HAZ-10 also states that such coastal-dependent development and public access or recreational development in shoreline areas shall be designed such that it can be removed without significant damage to shoreline or bluff areas. HAZ-11 states that existing development or uses that are below the 20 foot elevation (not including open space, low-intensity public recreational and access facilities, or coastal dependent or coastal related structures) should be relocated or removed when they become threatened or when they are redeveloped. Additionally, as noted in the above bullet, several policies suggest removing shoreline protective devices when they are no longer required and/or if there are less damaging options available.

- **Future adaptation:** LUP policy HAZ-6 calls for future adaptation planning, and particularly for using a future update to the Coastal Parks Plan to implement various adaptation strategies for addressing anticipated impacts to public access and other coastal resources. This policy does not currently provide a time horizon for when such adaptation planning would occur, but does lay out a variety of topics and possible adaptation strategies that should be considered. These include requiring existing or planned development to be relocated to safer areas and restoring shoreline areas to their natural condition; modifying land uses allowed in hazardous areas and updating siting and design standards to better protect coastal resources; updating standards for determining erosion rates; ensuring long-term, function and connectivity of existing recreation and access resources; and requiring modifications to existing shoreline protective devices to ensure that such devices have the least impact on coastal resources as possible. The City has indicated that an update to the Coastal Parks Plan is a priority, and has proposed undertaking that effort after the LCP is certified.
- **Coastal Hazards Overlay:** Section 23.90.140 of the Implementation Plan (IP) establishes a coastal hazards overlay zone that implements the LUP policies described above. This zone currently includes the area below the 20-foot elevation (as measured from the mean high tide elevation), but specific policies state that it will be re-evaluated with the trigger described in LUP policy HAZ-2 (3 inches of sea level rise above the next tidal epoch mean high tide elevation), and approximately once every 5 years thereafter. This section calls out additional actions the City shall undertake in the future including establishing an inundation elevation based on sea level rise projections below which new habitable development shall not be allowed; completing studies to better understand flooding and erosion hazards, particularly for the Asilomar Dunes area; installing emergency response and warning signage; monitoring and reporting on changes in sea level based on data from the Monterey Tide Gauge; and updating the LCP every five years.

This section also provides more detail on development allowed in the hazards overlay zone as well as more detail on policies related to shoreline protective devices (consistent with the LUP policies described above). For example, subsections state that the LCP shall be updated to change the land use designation within areas subject to sea level rise or storm surge when it is determined that sea level rise poses an impending and significant risk to vulnerable land uses and that property owners are responsible for demolition and removal of debris from structures that have been condemned as in danger from natural hazards. Policies also state that new development shall not rely on a shoreline protective device and shall include “no future armoring” and “removal and restoration” conditions should the development become threatened by coastal hazards. Additionally, subsection D(7) states that if at-risk trails and viewpoints cannot be feasibly relocated within 10 years, the City may, as an interim measure, construct walls up to 36 inches high approximately 2 feet seaward of these features to reduce wave overtopping onto trails and viewpoints (if consistent with the other LUP and IP policies governing SPDs).

Overall, the LCP lays out an initial set of policies to ensure the safety of new development and to address sea level rise impacts identified in the 2015 vulnerability assessment while also addressing the limitations and shortcomings of that assessment by clearly explaining the need for

future updates and identifying a set of next steps and potential triggers for future changes. In this way the City lays out an adaptive approach, as recommended by the Commission's Sea Level Rise Policy Guidance, that accounts for current vulnerabilities and best available science and information but that also ensures future steps will be taken to improve adaptation planning and to address the evolving understanding of potential sea level rise impacts and best management practices.

Importantly, the City's proposed policies also respond to the particular built and natural environment context in Pacific Grove where the overwhelming majority of shoreline land is public recreational and open space in nature, and where the underlying granitic landform is fairly resistant to erosion. This context is unlike most coastal zone jurisdictions that instead include significant private development at the shoreline interface, which presents its own set of issues and challenges for adaptation planning, as well as those that include larger bluff areas that introduce their own set of complications. In contrast, Pacific Grove's fairly uniform shoreline setting allows for policies that can appropriately recognize that context, and provide policies specific to it that can continue to ensure that the vision for the shoreline is maintained through the LCP in the future.

Next Steps

As of January 2017, the City of Pacific Grove has made significant progress towards completing certification of an updated LUP and a new IP. The City, Coastal Commission staff, and members of the public and other stakeholders have engaged in iterative review and comment on draft documents, and the City will next take the LUP and IP to the City Council, with the submittal to the Coastal Commission to follow in mid-2017. Commission staff will continue to coordinate with the City throughout the local adoption process as well as upon submittal.

Further, as identified above, policies within the draft LCP call for future efforts to update the Coastal Parks Plan as a tool to implement additional sea level rise adaptation strategies, as well as to eventually update the LCP as necessary to reflect evolving science and impacts from sea level rise. Prior to the update of the Coastal Parks Plan, the City should consider doing a targeted vulnerability assessment that better identifies the likely timing of impacts to park land and associated trails and amenities, as well as a fiscal analysis that assesses the costs and benefits of different adaptation approaches.

Although there is still significant work ahead to complete the certification of the LCP, as well as future efforts to implement adaptation strategies, the City of Pacific Grove provides a strong example of phased sea level rise adaptation planning through the development of a Local Coastal Program.

Consideration of Sea Level Rise in Recent LCP Updates: City of Goleta Case Study

In August of 2015, the Coastal Commission unanimously adopted its Sea Level Rise Policy Guidance, which provides recommendations for how to address sea level rise within the context of the Coastal Act. In particular, the document discusses the importance of addressing sea level rise in Local Coastal Programs (LCPs). LCPs are a critical tool for addressing sea level rise because they dictate the types, intensities, and locations of allowable land uses, and therefore provide a framework for implementing proactive adaptation strategies to address sea level rise vulnerabilities. However, many LCPs were certified in the 1980s and 1990s and would benefit from updates to reflect changed conditions, new information and knowledge, and new programs and policies, especially those related to climate change and sea level rise.

To that end, the Coastal Commission, in coordination with other state agencies including the State Coastal Conservancy and the Ocean Protection Council, has provided significant grant funding to support LCP updates with a particular emphasis on addressing sea level rise. To date, the Coastal Commission has awarded 3 rounds of grants totaling approximately \$4.5 million to support the completion of sea level rise vulnerability assessments, adaptation plans, Land Use Plan (LUP) and Implementation Plan (IP) updates, and local adoption and Coastal Commission certification of LCPs. The first round of grants was completed in April of 2016.

Four jurisdictions with grants from the Coastal Commission were chosen as case studies to provide information on various ways that sea level rise adaptation planning and related LCP policy development can be carried out on a local scale. The four jurisdictions – Marin County, and the cities of Pacific Grove, Goleta, and Newport Beach, were chosen because they represent a variety of geographic areas as well as different planning approaches. These four case studies provide valuable information and lessons learned on topics such as finding the right level of detail for vulnerability assessment, the utility of including a specific adaptation planning step, and the importance of adaptive LCP policies. More information on these topics can be found in each of the individual case studies.

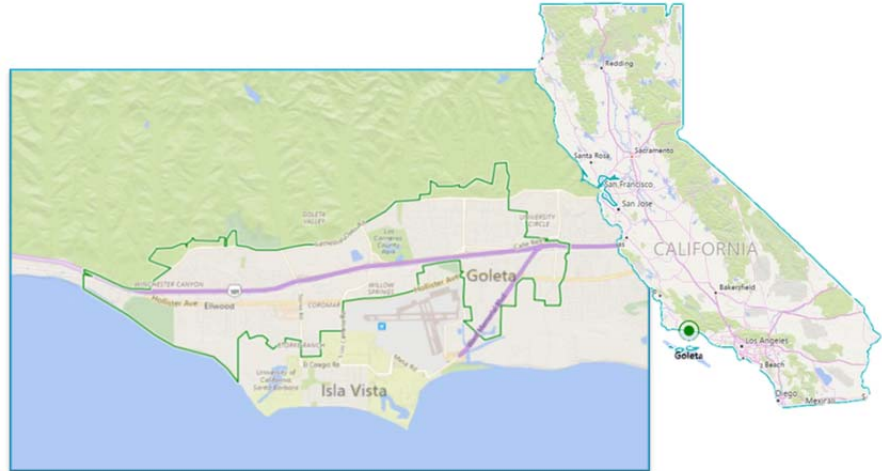
The schematic below shows a generalized ideal process for how to address sea level rise through an LCP update. Between 2014 and January 2017, Goleta completed several steps in the development of an LCP, including a vulnerability assessment and draft updates to the LUP and IP. Goleta's process to complete this work provides a good example of using a highly detailed vulnerability assessment to support adaptation planning and LCP policy development. Not only did this vulnerability assessment analyze the expected physical hazards and potential resource impacts associated with sea level rise, it also analyzed the costs associated with those impacts and potential adaptation strategies. Including this fiscal analysis provided the city information that facilitated and streamlined the decision making process for adaptation planning. The Draft LUP and IP now provide a framework for sea level rise adaptation in the city that includes strong policies as well as a trigger-based adaptation approach.



Figure 1. Goleta sea level rise planning as of January 2017

Background

The City of Goleta is a small coastal community in southern Santa Barbara County that does not currently have a certified Local Coastal Program. Situated on the coastal plain between the Santa Ynez Mountains and the Pacific Ocean, the city's shoreline includes a large coastal resort, a golf



course, and oil and gas facilities, residential development, commercial and industrial areas, as well as open lands and resources such as the Ellwood Mesa/Sperling Preserve, Devereux Creek, and two coastal estuaries at Bell and Tecolote creeks. Parts of the city are separated from the shoreline by the community of Isla Vista, the University of California Santa Barbara campus, Goleta Slough, and the Santa Barbara airport. With this variety of development and resources, Goleta is known for its beautiful open spaces and mix of both urban and rural land uses.



By John Wiley User:Jw4nvc - Santa Barbara, California - Own work, CC BY 3.0, <https://commons.wikimedia.org/w/index.php?curid=5815032>

The city was incorporated in 2002, and its General Plan was prepared in 2006. The city intended for the General Plan to serve as the Land Use Plan (LUP) portion of Local Coastal Program (LCP), but it was not certified due to the need for an expanded level of detail to ensure Coastal Act consistency. In 2009, the Goleta City Council adopted General Plan amendments, and between 2009 and 2014, the city conducted a greenhouse gas inventory, developed a Municipal Energy Efficiency Action Plan, and produced a Climate Action Plan.

Despite this body of work, the extent to which the city's currently certified planning documents address sea level rise is limited. The [2009 General Plan](#) includes a Safety Element that addresses coastal hazards, but it lacks detailed measures to address hazards from sea level rise. The Safety Element includes sections on bluff erosion and retreat, beach erosion and shoreline hazards, and several other topics related to hazards and emergency preparedness. The section on beach erosion and shoreline hazards includes a policy requiring, where appropriate, applications for new development on a beach, dune, or bluff-top property to include a wave uprush and impact

report that addresses the effects of sea level rise on the proposed development. Beyond this policy, however, the General Plan does not include other measures to address hazards specifically as they relate to sea level rise or measures for city-wide adaptation responses or programs.

However, in 2014 the city undertook a renewed effort to work toward LCP certification with the support of a Coastal Commission LCP grant ([LCP-13-07](#)), and this effort specifically targeted sea level rise as an issue of concern. The work plan included several tasks scheduled for April 2014 through April 2016, including a sea level rise vulnerability assessment, the development of a Draft Land Use Plan, development of a Draft Implementation Plan, and certification of the LCP.



Sea Level Rise Vulnerability Assessment

In December 2015, the City of Goleta published a [Coastal Hazards Vulnerability and Fiscal Impact Report](#). The overall purpose of this report was to better inform land use planning in the city by providing information on the geographic extent and economic consequences of coastal hazards.

To conduct the necessary analysis to produce this report, the city's consultant selected several planning horizons for the analysis, including 2030, 2060, and 2100 and obtained sea level rise projections for each using the current best available science on sea level rise projections, the National Research Council's 2012 report, *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future*. The consultant then adjusted the NRC 2012 projections to account for local uplift along certain parts of the city's coastline, thus producing adjusted low, medium, and high sea level rise scenarios for each identified time step.



Next, the consultant analyzed how sea level rise scenarios could impact various coastal hazards including king tide flooding, high tide flooding, wave impacts, coastal erosion, and storm flooding, along with their combined effects. Locally relevant coastal processes such as barrier beach flooding and lagoon flooding were also examined. Existing models and information were used to inform these analyses, including existing sea level

rise modeling (ESA 2015), FEMA flood maps (FEMA 2012), and spatial data from the City and County of Santa Barbara and the Nature Conservancy (TNC 2015). The consultant then produced categories of resource sectors to assess, including land use and structures, coastal armoring, natural resources, public access, hazardous materials, transportation, water supply, wastewater, utilities, and oil and gas facilities. The vulnerability assessment quantitatively and qualitatively discussed the specific resources at risk in each sector at each planning horizon (the present day, 2030, 2060, and 2100).

The assessment found that by 2030, creek flooding, coastal erosion, and coastal flooding will threaten development such as the buildings in Bacara Resort, active and inactive oil wells, some neighborhoods, and certain wastewater treatment infrastructure. By 2060, more development will become vulnerable, including leaking underground fuel tanks and other buildings at the Bacara Resort. By 2100, additional residential areas become impacted, along with several holes of the Sandpiper Golf Course and parts of the light-manufacturing sector in the Old Town Area.





In addition to analyzing the vulnerability of each sector to physical hazards, the report also included a heavy emphasis on the fiscal implications of sea level rise impacts and potential adaptation responses. It analyzed costs associated with the loss of resources due to sea level rise impacts along with the costs of potential adaptation and mitigation approaches, thus producing a fiscal analysis of various adaptation pathways that are available to the City – from “do nothing” to proactive

adaptation options. For example, it found that while capping at-risk oil wells could cost \$7.9-63.2 million, an oil spill could equate to \$257 million in remediation costs. More and more, coastal jurisdictions undertaking similar efforts to update their LCPs for sea level rise are finding that fiscal analyses provide critical information needed to inform decision making and planning processes.

Goleta’s report included a series of sector profiles (example above) along with maps of the physical extent the coastal hazard. The sector profile included an overview of the expected impacts, a description of existing conditions, a discussion of the economic consequences of the

Land Use and Structures - Old Town Area

Land Use and Structures: Overview

There are 5 land use categories that occur within the Old Town Area which includes Old Town and portions of the surrounding City, including: (1) residential, (2) industrial, (3) commercial, (4) infrastructure, and (5) recreation/open space.

Existing Conditions

Description: Old Town is recognized as a unique asset and historic center of Goleta. Future development and redevelopment actions are required to respect the current diversity of uses while maintaining Old Town’s unique character.

Vulnerabilities: Land use and structures are primarily subject to existing creek flooding and coastal flooding associated with a closed Goleta Slough Mouth. This barrier beach flooding mainly impacts structures and land uses in the Palencia neighborhood, Aero Camino, Storke Ranch, and the neighborhoods between Fairview Ave and Highway 217. For details on the locations of the impacted neighborhoods, refer to Figure A.

Measures of Impact:

- Parcels by land use
- Structures by land use (flooding)
- Square footage of structures by land use (adaptation)

Vulnerabilities: Flooding of Structures

Adaptation Strategies

Range of Strategies: Includes “No Action” and clean up, policy, and regulations, as well as retreat, accommodate, and protection strategies as defined by the California Coastal Commission.

Retreat: Includes policy and/or regulatory options (e.g., downzoning, transfer of development, FEMA repetitive loss clause, and rolling easements) as well as purchase of the vulnerable properties.

Accommodate: Includes elevating structures and inlet management. The reduction in vulnerabilities associated with inlet management supports some hybrid approaches, but management of the Goleta Slough inlet is outside the City’s authority.

Elevating: In the short term (approximately 2030) elevating buildings less than 1 foot to avoid flood cleanup costs at a cost of approximately \$3.8 million makes more economical sense considering damages and cleanup costs from a large flood event (approximately \$5.1 million). Over the medium and long term time horizons (2060, 2100), elevating structures more than 2 feet appears to be maladaptive. By 2100, estimated damages and cleanup costs could be approximately \$18.5 million following a major storm event versus the cost to elevate all of the vulnerable structures at an estimate cost of approximately \$188.4 million.

Inlet Management: With inlet management, the number of structures exposed by 2100 drops from 129 to 14. Furthermore, inlet management with elevation of at risk structures equates to about \$5.1 million, whereas inlet management with purchase of at risk parcels would cost an estimated \$4.6 million in 2012 dollars.

Protect: The construction of levees to prevent flooding within the most vulnerable neighborhoods is a “gray” protection approach, whereas a “green” protection approach would consist of contoured transitional slopes to accommodate flooding.

Secondary Impacts: Retreat and elevation strategies have few secondary impacts. Inlet management could impact ESHA and listed species. Gray protection options would result in a loss of ESHA wetlands over time Green protection strategies may benefit wetlands by increasing wetland transition slopes.

Fiscal Impacts

Damages: Caused primarily by barrier beach flooding. Residential damages are relatively small in comparison to those of the light-manufacturing sector located within Old Town, which by the year 2100 includes 50 industrial businesses that may contain specialized equipment with replacement costs higher than estimated by FEMA.

Damages	2010	2030	2060	2100
Residential	\$0.2 M	\$0.3 M	\$0.4 M	\$1.4 M
Industrial	\$0.2 M	\$0.5 M	\$0.7 M	\$10.0 M
Commercial	\$0.1 M	\$0.2 M	\$0.4 M	\$2.6 M
Total	\$0.6 M	\$1.0 M	\$1.5 M	\$14.0 M

Cleanup costs: could range between \$0.5 million and \$4.5 million depending on the magnitude and extent of the flooding.

Cost to Elevate	2010	2030	2060	2100
Residential	\$1.9 M	\$1.9 M	\$1.9 M	\$9.6 M
Industrial	\$1.2 M	\$30.0 M	\$31.0 M	\$130.0 M
Commercial	\$0.7 M	\$2.7 M	\$3.9 M	\$48.5 M
Total	\$3.8M	\$35.0 M	\$37.0M	\$188.4 M

Findings and Recommendations

Findings:

- Existing creek hazards (FEMA) are the highest hazard in the City. Coastal flooding will be exacerbated by SLR, however future climate impacts on creek flooding not available.
- Coastal flooding damages to structures in Goleta could increase dramatically by 416% between the time horizons of 2060 and 2100.
- Adaptation costs to elevate and accommodate coastal flooding by 2100 (\$175 million) exceed damages (\$14 million) and cleanup (approximately \$5 million) by an order of magnitude.
- The Storke Ranch neighborhood becomes exposed around 2100, when Goleta and Devereux Sloughs come together.
- Coastal flooding impacts the light manufacturing sector the greatest between 2 and 5 feet of SLR during the time period of 2060 to 2100.

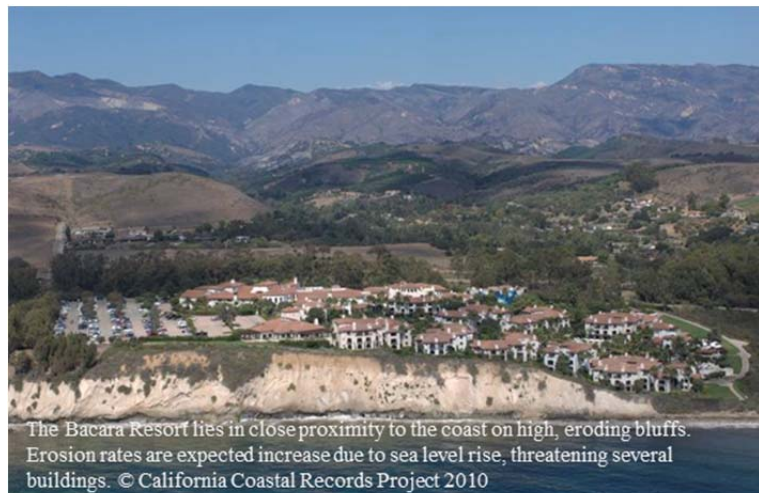
Recommendations:

- Conduct coastal confluence modeling to better assess future vulnerabilities associated with stream flood hazards exacerbated by sea level rise to provide projections of future flood extents and depths.
- Engage in regional inlet management discussions with the City of Santa Barbara and the County of Santa Barbara.
- Establish a repetitive loss policy to trigger eminent domain in combination with a Transfer of Development (TDR) Program. Once a property had multiple flood insurance claims the policy would take effect.
- Adjust building codes to allow for increased building heights by additional freeboard based on sea level rise projections for parcels projected to be impacted by flooding after 2060.

expected impacts, a list of potential adaptation strategies, and summary findings and recommendations. These short, standalone sector profiles were useful communication tools because they summarized key information to an extent that made the information easy to digest and understand. Notably, the maps showed the coastal hazard areas associated with the highest amount of predicted sea level rise for each time step, 2010, 2030, 2060, and 2100, rather than showing the medium or low sea level rise scenarios.

While the report was clear and user-friendly, the sector profiles could be improved by including footnotes explaining which sea level rise scenario and hazard types (e.g., inundation or flooding) are included to generate the physical extent of the “coastal hazard zone” shown on each map. Currently, the maps leave that information unspecified and a user must find that information in the body of the report. Coastal Commission staff has found that an important but commonly overlooked aspect of communicating the findings of a vulnerability assessment is the clear explanation of the assumptions behind the described result. Maps should specify what sea level rise scenarios – i.e., the low, medium, high scenario, or combination of scenarios –are depicted, along with which coastal processes—i.e., inundation, storm flooding (and if so, what size storm), or erosion, or combination thereof. Distinguishing between these possible scenarios is critical to properly convey the type of hazard being depicted and therefore type of planning actions that are needed in response. The storm and non-storm analyses in particular will lead to different adaptation approaches to be implemented through the LCP.

In addition to findings on potential impacts, the city’s vulnerability assessment includes discussions of possible adaptation approaches to reduce risks from sea level rise, as well as policy recommendations for use in the development of the LCP. The report categorizes possible adaptation approaches into the protection approach, the accommodation approach, the retreat approach, the hybrid approach, and the “do nothing” approach along with examples of each. This information was then applied to the development of a Draft Land Use Plan.



Development of the Draft LCP

The Draft Land Use Plan was developed using the General Plan as a starting point. The Safety Element of the General Plan was used to develop the coastal hazards section of the LUP, and this section contained the majority of policies related to sea level rise. Over the course of many months, city and Coastal Commission staff exchanged several iterations of LUP, focusing on adding the level of detail necessary to carry out the requirements of the Coastal Act as well as

implement the findings of the *Coastal Hazards Vulnerability and Fiscal Impact Report* (Report). The city drafted a number of policies that implemented the recommendations of the Report, such as an elevated height restriction in Old Town Goleta designed to accommodate an increase of freeboard elevations in response to expected flooding impacts; a prohibition of shoreline protective devices for bluff-top and non-bluff development; sediment management programs; increased consideration of sea level rise in site-specific coastal hazard reports; a repetitive loss clause program to rezone at-risk areas over time to less intensive land uses; a fee simple acquisition program for lands in hazardous areas; rolling easements that enable natural coastal processes to continue; and establishment of sand mitigation and public recreation fees.



These draft policies represent a relatively progressive approach to sea level rise planning in that they include more innovative ideas for sea level rise adaptation policies being considered in the sea level rise adaptation field. While the LUP has not been certified yet, the draft policies have been used to develop a conceptual framework for the Draft Implementation Plan, including triggers for the implementation of certain policies.

While the triggers in the Draft IP have not been reviewed in detail by Coastal Commission staff, they represent a practical method for the application of policies due to their connection to actual, observed increases in sea level. For example, in the case of bluff top areas, when 1 foot of sea level rise is observed, the city would prioritize soft solutions for protection of public access on Haskell’s Beach and require that bluff and shoreline protective devices for existing development not be permitted without meeting required conditions. After observing 2 feet of sea level rise, the city would update cliff erosion setback policy to account for increased erosion rates, include funds for critical infrastructure like bridges and roadways in the 5-year Capital Improvement Plan, and establish appropriate hazard abatement districts. Three feet of sea level rise would trigger phased removal of existing development, including two buildings at the Bacara resort, 6 holes of the Sandpiper Golf Course, and trail re-alignment in the Ellwood Preserve. In addition to these triggers for bluff top areas, similar triggers are also drafted for low-lying areas. While the specifics of phased adaptation strategies need more careful review by Coastal Commission staff for consistency with the Coastal Act, they represent a good conceptual approach of the application of sea level rise adaptation measures.

Next Steps

To date, the city has completed a sea level rise vulnerability assessment, a Draft LUP that has gone through extensive iterative review with Commission staff, and a Draft IP; however,

certification of the LCP has not yet occurred. The LUP and IP both remain in draft form, and additional iterative reviews and collaboration must occur between the city and Coastal Commission staffs to address various subjects of concern before the LCP is ready for both local and Coastal Commission adoption hearings. Therefore, considerable work remains to achieve certification of the LCP. However, this jurisdiction provides a strong example of sea level rise adaptation planning through the development of a Local Coastal Program.

Consideration of Sea Level Rise in Recent LCP Updates: Newport Beach Case Study

Introduction

In August of 2015, the Coastal Commission unanimously adopted its Sea Level Rise Policy Guidance, which provides recommendations for how to address sea level rise within the context of the Coastal Act. In particular, the document discusses the importance of addressing sea level rise in Local Coastal Programs (LCPs). LCPs are a critical tool for addressing sea level rise because they dictate the types, intensities, and locations of allowable land uses, and therefore provide a framework for implementing proactive adaptation strategies to address sea level rise vulnerabilities. However, many LCPs were certified in the 1980s and 1990s and need updates to reflect changed conditions, new information and knowledge, and new programs and policies, especially those related to climate change and sea level rise.

To that end, the Coastal Commission, in coordination with other state agencies including the State Coastal Conservancy and the Ocean Protection Council, has provided significant grant funding to support LCP updates with a particular emphasis on addressing sea level rise. By the end of 2016, the Coastal Commission awarded 3 rounds of grants totaling approximately \$4.5 million to support the completion of sea level rise vulnerability assessments, adaptation plans, Land Use Plan (LUP) and Implementation Plan (IP) updates, and local adoption and Coastal Commission certification of LCPs. The first round of grants was completed in April of 2016.

Four jurisdictions with grants from the Coastal Commission were chosen as case studies to provide information on how sea level rise adaptation planning and related LCP policy development are carried out on a local scale. The four jurisdictions – Marin County, and the cities of Pacific Grove, Goleta, and Newport Beach, were chosen because they represent a variety of geographic areas as well as different planning approaches. These four case studies provide valuable information and lessons learned on topics such as finding the right level of detail for vulnerability assessments, the utility of including a specific adaptation planning step, and the importance of adaptive LCP policies. More information on these topics can be found in each of the individual case studies.

The schematic below shows a generalized process for how to address sea level rise through an LCP update. As exemplified by the following case studies, there are several ways to approach this process and each of the four example communities took different approaches for development of their Local Coastal Programs.



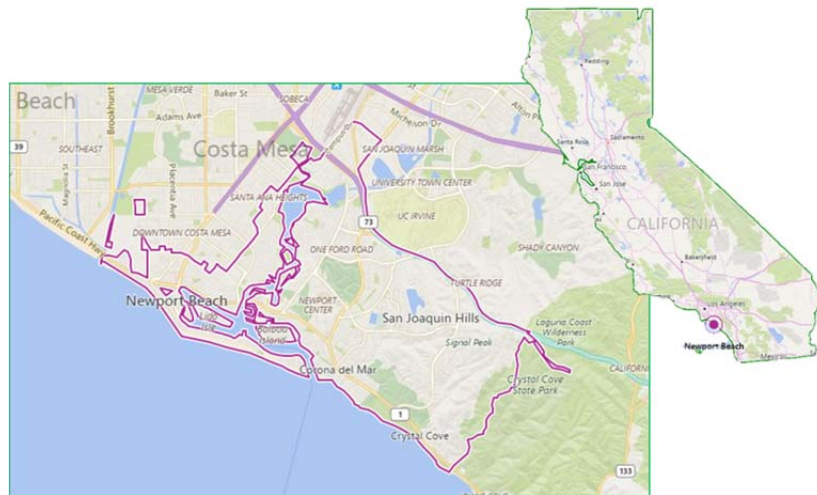
Newport Beach is an example of a jurisdiction that did not have a certified LCP and focused its efforts on completion of the IP using an existing, certified LUP as the standard of review. As shown in the schematic below, the city did not complete a sea level rise vulnerability assessment or adaptation plan; rather, the certified LUP policies were used to develop the content of the IP related to sea level rise. Despite the lack of a city-specific sea level rise vulnerability assessment, the city was able to incorporate sea level rise considerations into the IP using existing resources, such as the Coastal Commission's 2015 Sea Level Rise Policy Guidance and existing regional studies on sea level rise. The IP was approved with modifications by the Coastal Commission on September 8, 2016, and became fully certified on January 13, 2017. To address the lack of a city-specific vulnerability assessment, the IP includes a commitment to conduct a sea level rise vulnerability assessment for the city's entire coastal zone to inform a future LCP update.



Figure 1. Newport Beach sea level rise planning as of February 2017. Green indicates the steps described herein.

Background

The City of Newport Beach lies in a relatively heavily developed portion of Orange County. With a community of over 75,000 residents, the city covers a 25.4 square mile area, including 2.5 square miles of bay and harbor waters. The city has over 30 miles of bay and ocean waterfront stretching from



the northern border at the Santa Ana River mouth to Crystal Cove State Park in the south. The coastal zone covers 63 percent of the city's total land area.

The development of Newport Bay Harbor was authorized in 1934 and carried out by the Army Corps of Engineers. Islands within Newport Bay were created using dredged sediments within the estuary and are now built out with bulkheaded residential lots and small piers. Newport Beach's coastal zone is incredibly rich in coastal resources, including the Upper Newport Bay Ecological Reserve, which is home to sensitive biological resources including sand dunes, coastal bluffs, and riparian areas. The city has extensive visitor-serving uses that provide vital recreational areas and infrastructure, like trails, parks, beaches, and commercial areas, walkable shopping districts and visitor accommodations



By D Ramey Logan – Own work, 1/11/13, CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Newport_Beach_2013_c_Photo_D_Ramey_Logan.jpg

for the millions of visitors to the city each year. Many areas of the city are subject to coastal hazards, including development protected by bulkheads, low-lying areas subject to flooding, and bluffs susceptible to erosion.

The city's Land Use Plan (LUP) was first certified on May 18, 1982. It was comprehensively updated in 2005, and the most recent update was effectively certified on October 8, 2009. In 2012, the city began formulating the

Implementation Plan (IP), and following three years of public involvement, hearings, and extensive deliberation by the City Planning Commission, Harbor Commission and City Council, the city submitted the IP for Coastal Commission consideration. On September 8, 2016, the Coastal Commission approved the IP with modifications, and on November 22, 2016, the Newport Beach City Council approved the Implementation Plan as modified by the Coastal Commission. Following a check off by the Coastal Commission Executive Director, the LCP became certified by the CCC on January 13, 2017, transferring permit review authority to the city.

Existing LUP and Sea Level Rise

The City of Newport's certified Land Use Plan (2009) includes both background information on sea level rise (Section 2.5.8) and various policies that address or relate to the subject of sea level rise. The background information section acknowledges the physical hazards associated with sea level rise, including erosion, flooding, and saltwater intrusion, and describes potential associated impacts to coastal resources and development



within the city. These impacts include a reduction in beach width due to erosion, increased bluff retreat rates, inundation of coastal wetlands, and increased salinity of bays and aquifers. The background section also notes that sea levels have increased 4-10 inches over the last century. It does not, however, include a discussion of more recent studies on future sea level rise such as the National Research Council's 2012 report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future* (NRC 2012), which is now considered to be the best available science on sea level rise in California. While NRC

2012 describes a likely acceleration in sea level rise rates and projects sea level rise of up to 66 inches by 2100, the background section of the LUP instead contemplates the continuation of the observed rate of sea level rise from tide gauge records in Los Angeles and San Diego. It states that projections of accelerating sea level rise *“are too poorly constrained to engender policy changes and development of appropriate mitigation strategies. However, sea level rise would lead to the permanent inundation of low-lying areas, with potentially significant changes in land use, so it is not too soon to develop longer-term strategies that can be implemented to cope with these changes.”* Therefore, the LUP background section conveys an intent to address sea level rise through broad, long term strategies.

Policies in the LUP address several issues related to sea level rise. First, several policies in section 2.8 require new development to avoid hazardous areas and assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices. Permit applications for new coastal development must provide a wave uprush and impact report that, among other things, includes projections of sea level rise over a 75-year time period. Section 4.4 of the LUP includes policies regarding the calculation of setbacks, providing for the setback to be increased where necessary to ensure safety and stability of the development, and section 8.2 includes a policy to site and design new structures to avoid the need for a shoreline or bluff protective device for a 75-year economic life.

Other policies provide for comprehensive studies of long-term shoreline change with sea level rise, along with monitoring of beach widths and elevations to establish thresholds for when backshore development may be exposed to flooding or damage from storm waves. The LUP also contains a number of policies regarding the use, siting, and design of protective devices that aim to minimize impacts to coastal resources and shoreline processes, and requires a waiver of future shoreline protection as a condition of approval for new development projects. Together, these and other relevant LUP policies provided the basis for specific regulatory measures necessary to carry out the LUP and address sea level rise in the IP.

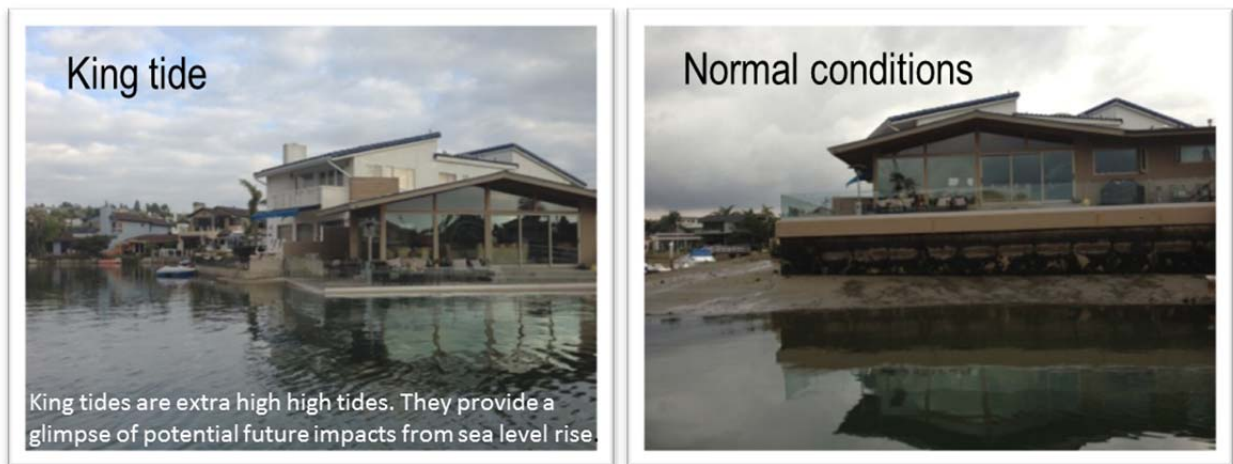


By D Ramey Logan - Own work, 1/14/13, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=23860936>

IP Development Process

The city's recent efforts to complete its Implementation Plan and fully certify its LCP began in 2012. The work generally fell into two phases, with the first phase involving the formation of a General Plan/Local Coastal Program Implementation Committee to provide oversight and direction to city staff and the preparation of the Administrative Draft Implementation Plan. Phase II involved community outreach, continued coordination with Coastal Commission staff, local public hearings, and submittal of the Implementation Plan to the California Coastal Commission. The second phase was partially funded by an LCP Local Assistance Grant from the Coastal Commission ([LCP-14-10](#)).

The Coastal Commission broadly encourages the use of sea level rise vulnerability assessments to inform LCP development, and this process is discussed in detail in the Coastal Commission's 2015 Sea Level Rise Policy Guidance document. Many coastal jurisdictions currently undertaking projects to develop or update LCPs perform various technical studies, including a sea level rise vulnerability assessment, prior to beginning policy development. Such studies can provide geographically explicit information needed to develop, for instance, hazard overlays that depict the areas that might be impacted by hazards related to sea level rise and required actions to be carried out through policies and ordinances in the LCP. However, because Newport's recent effort was focused on certification of the LCP, the city did not perform a vulnerability assessment and used only the existing LUP as the standard of review for the regulations in the IP. Despite this lack of information, the policies of the certified LUP provided the basis that was needed for development standards and requirements in the IP that promote sea level rise resiliency. This subject was an area of extensive coordination between city and Coastal Commission staff during the pre-and post-submittal development of the IP.



Photos by: Danny Sullivan (<http://dannysullivan.com/king-tides-hit-newport-beach-3232>)

Adopted IP and Sea Level Rise

The Implementation Plan was developed using the certified policies of the 2009 LUP as the standard of review. The following bullet points summarize some of the key sections in the approved IP that carry out the LUP policies related to sea level rise. While these sections address a wide variety of subjects beyond just sea level rise, the intention of the summary below is to describe the key ways the IP promotes adaptation to sea level rise, minimizes coastal hazards, and maximizes protection of coastal resources.

The bullets below also represent many of the subjects of coordination between the city and Coastal Commission staff. Since the city had not performed a sea level rise vulnerability assessment to inform the IP, it was particularly important to Coastal Commission staff to work with city staff to develop language for the IP that carried out the certified sea level rise-related policies of the LUP to the maximum extent possible. While Coastal Commission staff recognize that not all planning efforts will be able to include a sea level rise vulnerability assessment, it is still critical to address sea level rise using the best available information in order to carry out the hazard minimization and resource protection policies of the Coastal Act and certified LUP, as well as lay the foundation for additional future work on the LCP.

As described below, Coastal Commission staff worked with city staff to add detail from the best available science and resources to Appendix A—a new element of the IP created to address sea level rise. The appendix was revised to specify the various elements that should be included in site-specific analyses of sea level rise, and the IP was revised elsewhere to ensure the Appendix was cross referenced in the sections of the IP that included requirements for such analyses. Coastal Commission staff also worked with the city on standards for waterfront development and development in shoreline hazardous areas to promote sea level rise resiliency. These subjects are described further in the bullet points below.

- **Appendix A: Sea Level Rise** – This appendix provides background information on sea level rise and references the current best available science on sea level rise projections, NRC 2012. It provides a step-by-step process, consistent with the Coastal Commission’s 2015 Sea Level Rise Policy Guidance, describing how sea level rise should be considered in the preparation and review of CDP applications. These steps include detail on 1) selecting sea level rise projections; 2) performing site-specific analysis, considering sea level rise, wave uprush, geologic stability, erosion, flooding, and other impacts; 3) analyzing impacts to coastal resources; 4) analyzing adaptation strategies and project alternatives to minimize hazards and impacts to resources; and 5) implementing those alternatives or adaptation strategies through conditions of approval. Several sections of the IP cross reference the methodology in Appendix A, including but not limited to Wave Uprush and Wave Impacts (see Section 21.30.015.C.3), and Geologic Stability (see Section 21.30.015.C.4).
- **Finished flood elevation** – Section 21.30.015(D)(3) includes development standards for waterfront development. It generally requires that the minimum top

of slab/finished floor elevation comply with those established in the Flood Insurance Rate Maps (FIRMs), but provides for the elevation to be increased to account for sea level rise when recommended by a site-specific Coastal Hazards Report. This concept is repeated in Section 21.30.060 (Height Limits and Exceptions).

- **Waterfront development resiliency standards** – Along with the provision for an increase in finish floor elevation for new structures, Section 21.30.015(D) provides additional standards for waterfront development to promote sea level rise resiliency, including: to minimize, and where feasible, avoid shoreline hazards identified in, for example, coastal hazards and/or geologic stability reports described in Section 21.30.015(E); to require the property owner/applicant to acknowledge any hazards present at the site, assume the risk of injury and damage from such hazards, and unconditionally waive any claim of damage or liability against the decision authority from such hazards; to remove nonconforming structures particularly when located on State tidelands or beaches available to the public; and to bring new development and/or replacement structures into conformity with current standards for setbacks from the shoreline, bluff and/or bulkhead.
- **Coastal hazards reports** – Section 21.30.015(E) addresses development in hazardous shoreline areas, including areas identified as hazardous in the most current Local Hazard Mitigation Plan, areas identified in Appendix A as potentially impacted by sea level rise, and shoreline areas that are reasonably expected to be impacted by sea level rise based on best available science over the lifetime of the new development. In addition to cross referencing the detailed methodology set forth in Appendix A for conducting an analysis of sea level rise, the section provides a detailed list of various elements required in these studies, including analysis of erosion, slope stability, and storm waves, all as influenced by sea level rise over a 75-year period. It also requires that the report include identification of necessary mitigation measures to address increased erosion and flooding due to sea level rise, such as waterproofing, flood shields, watertight doors, moveable floodwalls, partitions, water-resistive sealant devices, sandbagging and other similar flood-proofing techniques.
- **Geologic stability reports** – In addition to coastal hazards reports, Section 21.30.015(E) requires that development proposed in shoreline areas of known or potential geologic or seismic hazards include a Geologic Stability Report that uses the methodology described in Appendix A. This includes accounting for sea level rise in long-term (75-year) coastal bluff retreat projections.
- **Designing for adaptive capacity** – One of the standards for development proposed on coastal bluffs, canyons, and shoreline areas (Section 21.30.030) states that design techniques include designing structures to include sea level rise adaptation measures for an identified sea level rise scenario (as described in Appendix A) as well as allow for the implementation of planned adaptation measures that could be needed under other sea level rise scenarios in the future.

- Protective devices** – Several sections of the IP address protective structures, and certain standards serve the purpose of reducing the impacts of protective devices on coastal resources considering the effects of sea level rise. Section 21.30.030 (Natural Landform and Shoreline Protection) includes a prohibition on construction of protective devices except to protect coastal-dependent uses or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply; and existing development that is not subject to a recorded waiver of future protection and threatened by hazards. In these cases, the protective device must be located on private land, not state tidelands. It also includes standards for approvable bulkheads for waterfront development, including allowing for realignment as far landward as possible and requiring a waiver of rights to future activities that would result in the encroachment seaward of the approved footprint.



Photo by: Danny Sullivan (<http://dannysullivan.com/king-tides-hit-newport-beach-3232>)

- Waiver of Future Protection** – The standards for development in shoreline hazardous areas in Section 21.30.015(E) require as a condition of approval of new development, a waiver of any potential right to future protection to address situations in the future in which development is threatened by, among other things, hazards associated with sea level rise. It also requires removal and relocation of development if a government agency determines that the development is hazardous or a threat to the public.
- Bluff setbacks** – Section 21.28.040 (Bluff B Overlay District) and Section 21.30.030 (Natural Landform and Shoreline Protection) provide for setbacks to be increased based on the results of a Coastal Hazards and Geologic Stability Reports as described Section 21.30.015 (C) (Development in Hazardous Areas), which includes an analysis of an increase in future erosion rates due to sea level rise.
- Limits on subdivisions** – Section 21.30.025 requires that proposed subdivisions be designed to avoid current hazardous areas, as well as areas that may become hazardous due to future changes such as sea level rise, and will not be approved unless the new or reconfigured parcels can be safe from geologic and other hazards for a minimum of 75 years, and unless shoreline protective devices are prohibited to protect development on the resultant parcels.

- **Determination of Public Access/Recreation Impacts** – Section 21.30A.050 provides standards for the location and configuration of public access, and states that public access improvements shall be designed to, among other things, account for long-term projections in sea level rise and coastal bluff erosion rates according to the methodology set forth in Appendix A: Sea Level Rise.

Next steps

Appendix A of the IP includes additional information about the city's plans for future analysis of sea level rise. As mentioned above, the city and Coastal Commission staff worked together to develop this section and explain what future steps the city will take to address sea level rise in greater detail. As a result of this coordination, Appendix A states that the city will conduct a full sea level rise vulnerability assessment for the city's entire coastal zone as part of a future LCP update. It will use the current best available science on projections of sea level rise, along with the information gained from analysis of wave-run up and flooding potential for individual development projects, and will develop additional adaptation measures to be implemented through the LCP. The city will also coordinate with local and regional partners to share information and adaptation planning ideas related to sea level rise.

Appendix A also describes how the city will re-examine the best available science periodically in conjunction with the release of new information on sea level rise. The city will consider relevant science that is current, peer-reviewed, and widely accepted among the scientific community, such as the newly developed FloodRISE project from UC Irvine. [FloodRISE](#) is an academic project to model future flood extents in Newport Harbor under different sea level rise scenarios using fine-scale, ground-truthed data on the elevations of existing bulkheads, small concrete barriers, streets, and other features. By carrying out the requirements set forth in the certified LUP and approved IP using emerging, best available sea level rise science, the city will continue to promote sea level rise resiliency in a manner that reflects developing science and maximizes resource protection while minimizing coastal hazard impacts.

Appendix C. Methods and Vulnerability Assessment Data Sources

The snapshots for each county contain: 1) an introduction to the county, detailing its shoreline characteristics, and its coastal zone resources; 2) a description of the county's ocean economy; 3) identification of hazards and vulnerabilities to rising sea levels, which was identified by synthesizing vulnerability assessments and by conducting district staff interviews; 3) the status of Local Coastal Programs and sea level rise planning as of December 2016; 4) specialized Coastal Act management priorities geared to the county's identified vulnerabilities and needs; and 5) a list of references.

Each snapshot begins with an introduction to the county. In this section, there is background on the county's coastal zone, a description of its shoreline characteristics, and lastly, its coastal zone resources. Coastal zone resources in a county include ports and harbors, how much land is publicly owned and/or accessible, how many public access locations exist, and the wetland acreage in the county.

Where possible, the same data sources for each coastal county were used for each of the following categories:

Outer coast shoreline

Shoreline length and types were summarized for each county using the Coast_status.shp file created December 2, 1999, and last modified May 17, 2000, by Melanie Coyne, NOAA Coastal Management Fellow at the California Coastal Commission. The data for this shapefile were derived from the Department of Navigation and Ocean Development's 1977 Assessment and Atlas of Shoreline Erosion along the California Coast, as digitized by the Office of Emergency Services (OES). Shapefiles were obtained from an OES CD. The attribute available to describe the shoreline was Coastfeature—the type of coastal segment: beach, beach (confined by groin or other), beach (straight), beach (pocket-natural confinement); rocky; inlet, bay or harbor; revetment, seawall, jetty or breakwater. Percentages of the outer coast were derived using selected features: beach (confined by groin or other), beach (straight), beach (pocket-natural confinement); and rocky.

Coastal Zone Resources

Ports and Harbors-Major ports and harbors in each county were identified referencing a GIS point dataset (cowport_b2bl.shp) of US West Coast Ports and Harbors derived from the Pacific Fisheries Information Network (PacFIN) database. The list of ports and harbors by county was refined by Coastal Commission staff to inform counts.

Public Access Locations-Coastal Commission public access locations (as of July 29, 2016) for the state were examined and summarized by coastal county, <https://www.coastal.ca.gov/YourCoast/#/map>.

Shoreline Miles- Mainland shoreline mileage was derived from the Coastal Indicators Project report by K. Cuffee, G. Benoit, and J. Van Coops (revised October 2010).

Publicly Owned Lands- Commission staff calculated publicly owned acreage in 2014 using Public, Conservation and Trust Lands (PCTL), State Parks and county park lands within the coastal zone. It includes Channel Islands, but not the Farallones Islands or offshore rocks/islands which are publicly owned but not accessible by the general public.

Coastal Zone Wetlands-The USFWS National Wetlands Inventory data updated May 1, 2016, were used to calculate acres of existing coastal zone wetlands. The coastal zone boundary was used in a GIS to extract wetland types (including Estuarine and Marine Wetland, Freshwater Emergent Wetland, Freshwater Forested/Shrub Wetland, Freshwater Pond, Lake and Riverine wetland types) by county. <https://www.fws.gov/wetlands/data/State-Downloads.html>

Ocean Economy

The National Ocean Economics Program (NOEP) provides a full range of the most current policy-relevant demographic information available on changes and trends along the U.S. coast, Great Lakes, and coastal waters. Ocean economy data include only ocean related activities and industries compiled from the databases of the Bureau of Labor Statistics. This data is separated into six sectors; tourism and recreation, transportation, ship and boat building, offshore minerals, construction, and living resources. Each of the six ocean economy sectors is composed of multiple industries and/or activities. Living resources is comprised of fishing, seafood markets, fish hatcheries, aquaculture, and seafood processing. Offshore minerals includes limestone, sand and gravel mining, oil and gas exploration and production. Ship and boatbuilding is made up of both vessel construction and repairs. Tourism and recreation includes amusement and recreation services, boat dealers, eating and drinking places, hotels and lodging places, marinas, recreational vehicle parks and campgrounds, scenic water tours, sporting goods retailers, zoos and aquaria. Transportation includes deep sea freight transportation, marine passenger transportation, marine transportation services, and search and navigation equipment.

We used 2013 values in this analysis, which is currently the NOEP's latest ocean economy data available. The attributes we selected for this analysis were; state (California), county (Del Norte, Mendocino, Humboldt, Sonoma, Marin, San Francisco, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, San Diego), year (2013), and sectors (all ocean sectors, construction, living resources, minerals, ship & boat building, tourism & recreation, transportation), <http://www.oceaneconomics.org/Market/ocean/oceanEcon.asp>.

Hazards and Vulnerability

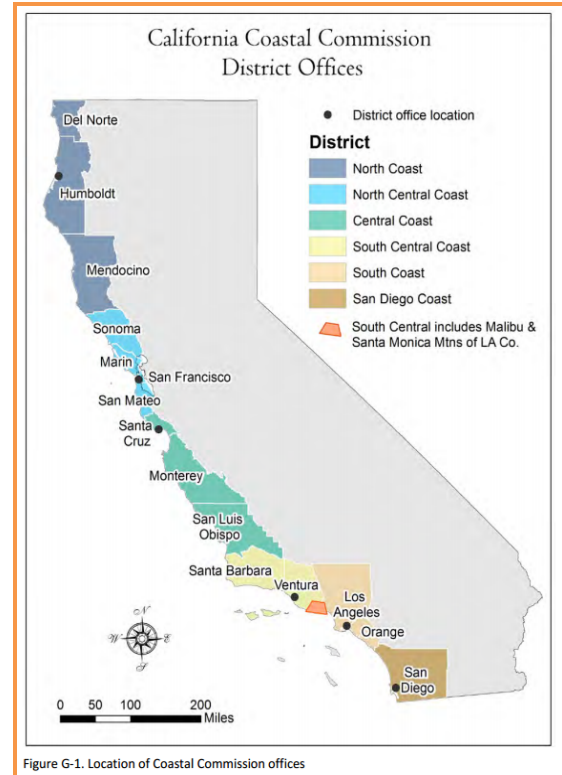
Commission staff consulted statewide data sets where possible to draw upon comparable hazard assessments for the outer coast counties. The Pacific Institute Report (2009) statistics on erosion and flooding referenced in the county snapshot boxes in this section reference the work done by Heberger MM, Cooley H, Herrera P, Gleick PH, and Moore E.¹ Where the Pacific Institute Report summaries lacked information, county parcel data were overlaid with the Pacific Institute erosion projections (given 55 inches sea level rise) to assess the number of parcels potentially vulnerable to erosion by 2100.² Where data were unavailable on the extent of erosion in southern California, erosion hazard zones were taken from CoSMoS 3.0 Phase 1 cliff retreat polygons for 0 to 150 cm sea level rise scenarios. Parcels and 2010 US Census Blocks (https://www.census.gov/geo/reference/gtc/gtc_block.html) were overlaid on these hazard zones and summarized in population counts and vulnerable parcel statistics using the methods detailed in the Pacific Institute Report. Note that the CoSMoS datasets used only account for bluff and

¹ Heberger M., H. Cooley, P. Herrera, P.H. Gleick, E. Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center. <http://pacinst.org/app/uploads/2014/04/sea-level-rise.pdf>

² Statistics on erosion generated for Del Norte, Mendocino and San Luis Obispo Counties.

cliff erosion, not beach or dune erosion, so a direct comparison of erosion risk is not possible for counties assessed using different methods.

Staff began identifying specific vulnerabilities through a review of vulnerability assessments. Vulnerability assessments for each county were gathered and synthesized, with an emphasis on sea level rise issues that relate to the California Coastal Commission. Vulnerability assessments have been funded through various sources, including state Local Coastal Program grants. Through this process, staff also identified other resources available to counties, such as flood maps and sea level rise viewers. While the Coastal Commission recommends using the National Research Council's sea level rise projections, not all vulnerability assessments were conducted using these projections. In order to account for these differences, the sea level rise scenarios used in each vulnerability assessment were noted in the snapshots. Each snapshot also contains links to the vulnerability assessment that were utilized. It is important to note that there may be other studies done that were not included in this synthesis.



Coastal Commission District Staff Interviews

Sea level rise vulnerabilities were also identified through conducting interviews with Coastal Commission staff working throughout the state. The California Coastal Commission jurisdictional territory is divided into 6 districts, each with its own office. As shown in this map, the North Coast District contains Del Norte, Humboldt, and Mendocino counties; the North Central Coast District contains Sonoma, Marin, San Francisco, and San Mateo counties; the Central Coast District contains Santa Cruz, Monterey, and San Luis Obispo counties; the South Central District contains Santa Barbara and Ventura counties; the South Coast District contains the Malibu and Santa Monica Mountains segments of the City of Los Angeles as well as Los Angeles and Orange counties; and the San Diego Coast District includes the County of San Diego.

Interviews were conducted with each of the 6 district offices and with staff in the Coastal Commission's Energy and Ocean Resources Unit. District office interview dates are given below:

- Central Coast: 5/4/16
- North Central: 5/26/16
- South Central: 6/13/16
- North Coast: 7/18/16
- South Coast: 7/22/16
- Energy and Ocean Resources: 8/10/16
- San Diego: 9/2/16
- Central Coast: 5/4/16

During these interviews, staff carefully reviewed their district's jurisdiction, and described the known vulnerabilities to sea level rise. The information gathered in these interviews was then used to help inform the vulnerabilities identified in the county-level snapshot descriptions.

Local Coastal Program Planning and Sea Level Rise Planning

Through its planning and regulatory program, the Coastal Commission has facilitated the implementation of numerous sea level rise adaptation projects through land use policies or coastal development permit requirements that protect coastal resources while increasing local capacity to withstand and recover from sea level rise impacts. Local Coastal Programs, also known as LCPs, are basic planning tools used by local governments to guide development in the coastal zone. LCPs contain the ground rules for future development and protection of coastal resources. The LCPs specify appropriate location, type, and scale of new or changed uses of land and water. Each LCP includes a land use plan and measures to implement the plan (such as zoning ordinances). Prepared by local government, these plans govern decisions that determine the short- and long-term conservation and use of coastal resources. While each LCP reflects unique characteristics of individual local coastal communities, regional and statewide interests and concerns must also be addressed in conformity with Coastal Act goals and policies. Following adoption by a city council or county board of supervisors, an LCP is submitted to the Coastal Commission for review for consistency with Coastal Act requirements. The Coastal Commission has awarded 3 rounds of the Local Assistance Grant Program to support certification and updates of LCPs, with an emphasis on addressing the impacts of climate change.

Each snapshot has an LCP Planning chart with details of the counties LCP jurisdictions and segments, certification date if certified, whether the jurisdiction received a state grant to update or certify its LCP, if vulnerability assessments have been conducted, and if the LCP has been updated for sea level rise. There are 3 broad descriptions to track if an LCP has been updated for SLR: 'in progress' means that the jurisdiction has grant or other ongoing work to address the impacts of climate change; 'in part' means the LCP has mentioned sea level rise to some extent; and 'no' means the LCP has no mention of sea level rise.

Coastal Act Management Priorities

The last section of each snapshot aims to translate the information from previous sections by identifying the coastal resources most at risk in each county. Through this process, six main Coastal Act Management Priority themes were identified and described. The most common priorities along the California coast were found to be Coastal Habitats, Environmentally Sensitive Habitat Areas (ESHA), and Wetlands, Public Access and Recreation, and Coastal Development and Hazards, while Water Quality and Supply, Coastal-dependent Development/Ports, and Coastal Agriculture priorities were identified as priorities on a more regional basis. In this section, we also identified gaps and/or areas of further study.

List of Vulnerability Assessments by LCP jurisdiction (as of December 2016)

Staff reviewed vulnerability assessments as of December 2016 that were development under the Coastal Commission's LCP Local Assistance Grant Program and also surveyed other widely available reports through local government and others' webpages. When vulnerability assessments did not go into the level of detail necessary to be useful at the LCP segment planning scale, staff did not list a vulnerability assessment as complete for a particular segment or jurisdiction, but the source is noted as a reference. The table below shows whether jurisdictions have completed vulnerability assessments or addressed sea level rise in their LCP. "In part" means an LCP segment has some explicit policy language addressing sea level rise.

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
Del Norte County	No	No	No	No
County Segment	Yes (1983)	No	No	No
Harbor Segment	Yes (1987)	No	No	No
Lopez Creek Segment	Yes (1987)	No	No	No
Pt. St. George Segment	No	No	No	No
City of Crescent City				
Crescent City Segment	Yes (1983)	No	No	In Part
McNamara-Gillespie Segment	Yes (1984)	No	No	No
References				
[1] GHD, ESA PWA, Trinity Associates. 2014. "District 1 Climate Change Vulnerability Assessment and Pilot Studies FHWA Climate Resilience Pilot Final Report."				
Humboldt County	No		Yes [1,4,5,6]	No
Northcoast segment	Yes (1986)	No	No	No
Trinidad Area Segment	Yes (1986)	No	No	No
McKinleyville Segment	Yes (1986)	No	No	No
Humboldt Bay Segment	Yes (1986)	SCC, OPC, CCC	Yes [1,4,5]	In Progress
Eel River Segment	Yes (1986)	No	No	No
Southcoast Segment	Yes (1986)	No	No	No
City of Trinidad	Yes (1980)	CCC	Yes [2,5]	In Progress
City of Arcata	Yes (1989)	CCC	Yes [1,4,5]	In Progress
City of Eureka	Yes (1984)	OPC	Yes [1,3,4,5]	In Progress
City of Fortuna	No	No	No	No
References				
[1] Trinity Associates. 2013. "Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase 1. Shoreline Inventory, Mapping, and Vulnerability Assessment."				
[2] GHD. 2016. "City of Trinidad Draft Climate Change Vulnerability Report and Adaptation Response."				
[3] Trinity Associates. 2016. "City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment."				
[4] McBain & Trush and Trinity Associates. 2013. "Humboldt Bay Shoreline Inventory, Mapping and Sea Level Rise Vulnerability Assessment. Addendum: Dike and Railroad Shoreline Vulnerability Rating."				
[5] GHD, ESA PWA, and Trinity Associates. 2014. "District 1 Climate Change Vulnerability Assessment and Pilot Studies FHWA Climate Resilience Pilot Final Report."				
[6] Northern Hydrology & Engineering. 2015. "Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping."				
Mendocino County	No	No	No	No
County Balance Segment	Yes (1992)	No	No	No
Town Segment	Yes (1996)	No	No	No
Pygmy Forest Segment	No	No	No	No
City of Ft. Bragg	Yes (1983)	No	No	In Part
City of Pt. Arena	Yes (1981)	No	No	In Part
References				
[1] GHD, ESA PWA, and Trinity Associates. 2014. "District 1 Climate Change Vulnerability Assessment and Pilot Studies FHWA Climate Resilience Pilot Final Report."				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
Sonoma County	1982	OPC	Yes [1,2,3]	In progress
References [1] North Bay Climate Adaptation Initiative. 2014. "Climate Ready Sonoma County: Climate Hazards and Vulnerabilities." [2] Sonoma County Permit and Resource Management Department. 2016. "County of Sonoma County General Vulnerability Assessment." OPC LCP Sea-Level Rise Grant Program grant deliverable. [3] USGS, Point Blue Conservation Science, and University of Southern California. 2016. Our Coast, Our Future Flood Maps.				
Marin County	1981/82	OPC, CCC	Yes [1,2]	In progress
References [1] Sea-Level Marin Adaptation Response Team and Marin County Community Development Agency. 2015. "Marin Ocean Coast Sea Level Rise Vulnerability Assessment." [2] USGS, Point Blue Conservation Science, and University of Southern California. 2017. Our Coast, Our Future Flood Maps.				
City/County of San Francisco	1986	SCC, OPC, & CCC	Yes [1,2, 3, 4]	In Progress
Olympic Club Segment	No	No	No	No
References [1] AECOM. 2016. "Final Sea Level Rise Existing Data and Analyses Technical Memorandum." [2] SPUR, AECOM, ESA PWA, Nelson/Nygaard, Sherwood Design Engineers, and Phil D. King. 2012. "Ocean Beach Master Plan." [3] SPUR, ESA PWA, Moffatt & Nichol, McMillen Jacobs Associate, AGS INC. 2015. "Coastal Protection Measures and Management Strategy for South Ocean Beach. Ocean Beach Master Plan: Coastal Management Framework." [4] City and County of San Francisco. 2016. "San Francisco Sea Level Rise Action Plan."				
San Mateo County	1981	No	In progress [1]	No
City of Daly City	1984	No	No	No
City of Pacifica	1984	CCC	In Progress [2]	In Progress
City of Half Moon Bay	1996	OPC, CCC	Yes	In Progress
References [1] San Mateo County. 2015. "San Mateo County Sea Level Rise Vulnerability Assessment." [2] Noble Consultants Inc. and Dyett & Bhatia. 2016. "Plan Half Moon Bay Sea Level Rise Vulnerability Assessment."				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
Santa Cruz County	Yes (1983)	No	Yes [1]	In progress
City of Santa Cruz	Yes (1985)	No	Yes [2]	In progress
City of Capitola	Yes (1990)	No	Yes[3]	No
City of Watsonville	Yes (1988)	No	No	No
References				
[1] County of Santa Cruz, Planning Department. 2013. "County of Santa Cruz Climate Action Strategy."				
[2] Griggs G and B Haddad. 2011. "City of Santa Cruz Climate Change Vulnerability Assessment."				
[3] ESA PWA. 2012. "Sea Level Rise Assessment: Technical Report for the Safety Element of the General Plan and the Local Hazard Mitigation Plan for the City of Capitola."				
[4] California Coastal Commission. 1995. ReCAP Pilot Project Finding and Recommendations: Monterey Bay Region.				
Monterey County				
North Segment	Yes (1988)	OPC, SCC	Yes[5]	In Progress
Del Monte Forest Segment	Yes (1988)	OPC	No	In Progress
Carmel Area Segment	Yes (1988)	OPC	No	In Progress
Big Sur Segment	Yes (1988)	OPC	No	In Progress
City of Marina	Yes (1982)	No	Yes[4]	No
City of Sand City	Yes (1984)	No	Yes[4]	No
City of Seaside	Yes (2013)	No	Yes[4]	In Part
City of Monterey	No	CCC, OPC	Yes	In Progress
Laguna Grande Segment			Yes[2,4]	In progress
Del Monte Beach Segment			Yes [4,5]	In progress
Harbor Segment			Yes[4,5]	In progress
Cannery Row Segment			Yes [5]	In progress
Skyline Segment			Yes [5]	In progress
City of Pacific Grove	No	CCC	Yes [1]	In Progress
City of Carmel	Yes (2004)	No	No	No
References				
[1] EMC Planning Group Inc. 2015. "City of Pacific Grove Climate Change Vulnerability Assessment."				
[2] Revell Coastal, LLC. 2016. "2016 City of Monterey Final Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report"				
[3] Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. "The Impacts of Sea-Level Rise on the California Coast. Prepared by the Pacific Institute for the California Climate Change Center."				
[4] ESA PWA. 2012. "Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay."				
[5] ESA PWA. 2014. "Monterey Bay Sea Level Rise Vulnerability Assessment, Technical Methods Report."				
San Luis Obispo County				
	1987	No	Yes [1]	In Part
City of Morro Bay	1984	OPC and CCC	Yes [1,2]	In Progress
City of Pismo Beach	1984	No	Yes [1]	No
City of Grover Beach	1982	No	Yes [1]	In Part
References				
[1] Susanne Moser Research & Consulting and University of California, Berkley. 2012. "Developing Adaptation Strategies for San Luis Obispo County: Preliminary Climate Change Vulnerability Assessment for Social Systems."				
[2] Morro Bay National Estuary Program. 2015. "Climate Vulnerability Assessment Report."				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
County of Santa Barbara	1982	SCC, OPC, CCC	Yes [1] , In Progress [4]	In Progress
City of Guadalupe	1991	No	Yes [1]	No
City of Goleta	No	CCC	Yes [1,2]	In Progress
City of Santa Barbara		CCC	Yes [1,5]	In Progress
City Segment	1986	No	Yes [1,3,5,6]	In Progress
Airport Segment	1991	No	Yes [1,5]	No
City of Carpenteria	1982	CCC	Yes [1]	In Progress
References				
[1] Santa Barbara County Office of Emergency Management. 2016. "2016 Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan."				
[2] City of Goleta and Revell Coastal. 2015. "Draft 2015 City of Goleta Coastal Hazards Vulnerability and Fiscal Impact Report."				
[3] Denka S, A Hall, and L Nicholson. 2015. "City of Santa Barbara Sea Level Rise Vulnerability Assessment."				
[4] County of Santa Barbara Long Range Planning Division. 2016. "County of Santa Barbara Coastal Resiliency Project, and Coastal Hazards Vulnerability Assessment."				
[5] University of California, Santa Cruz. 2012. "City of Santa Barbara Sea-Level Rise Vulnerability Study."				
[6] ESA. 2016. "Updated Coastal Flooding and Erosion Hazards for Santa Barbara City (ESA Ref. #D150417.00)."				
Ventura County	Yes (1983)	CCC	Yes [1,2,3], In Progress [4]	In Progress
City of Ventura	Yes (1983)	No	Yes [1,2,3]	In Part
City of Oxnard	Yes (1985)	OPC, CCC	Yes [1,2,3,5]	In Progress
City of Point Hueneme	Yes (1984)	No	Yes [1,2,3]	No
References				
[1] Heberger M, H Cooley, P Herrera, PH Gleick, E Moore. 2009. "The Impacts of Sea-Level Rise on the California Coast." Prepared by the Pacific Institute for the California Climate Change Center.				
[2] California Coastal Commission. 2005. California Shoreline Armoring Database.				
[3] The Nature Conservancy. 2016. Coastal Resilience Ventura County Project.				
[4] ESA PWA. 2013. "Coastal Resilience Ventura, Technical Report for Coastal Hazards Mapping."				
[5] The Planning Center DC&E. 2013. "Coastal Resilience Ventura Catalogue and Analysis of Local Sea-Level Rise Planning Tools."				
[6] ENVIRON International Corporation. 2015. "Economic Analysis of Nature-Based Adaptation for Climate Change. Ventura County, California."				
[7] Ventura County LCP Amendment - Sea Level Rise				
[8] City of Oxnard Planning Division. 2016. "A Sea Level Rise Atlas for the City of Oxnard."				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
Los Angeles County				
City of Malibu	2002	No	No	In Part
Los Angeles County	No	No	Yes [1,2]	No
Malibu Santa Monica Mountains Segment	2014	No?	No	In Part
Marina del Ray Segment	1990	No	No	In Part
Playa Vista A Segment*	No	No	No	No
Santa Catalina Island Segment**	1990	No	No	No
City of Los Angeles	No	Yes	Yes [4]	No
Pacific Palisades Segment	No	No	Yes [1]	No
Venice Segment	No	CCC	Yes [1]	In Progress
Playa Vista Segment*	No	No	No	No
Del Rey Lagoon Segment	No	No	No	No
Airport/Dunes Segment*	No	No	No	No
San Pedro Segment	No	No	Yes [1]	No
City of Santa Monica	No	CCC, OPC	Yes [1]	In Progress
City of El Segundo	1982	No	No	No
City of Manhattan Beach	1994	No	No	No
City of Hermosa Beach	No	CCC	Yes [5], In Progress [7]	In Progress
City of Redondo Beach	2010	No	No	In Part
City of Torrance	No	No	No	No
City of Palos Verdes Estates	1991	No	No	No
City of Rancho Palos Verdes	1983	No	No	No
City of Long Beach	1980	No	Yes [6]	No
City of Avalon	1981	No	No	No
References				
[1] Noble Consultants G.E.C., Inc. 2016. "Los Angeles County Public Beach Sea-Level Rise Vulnerability Assessment." California Coastal Conservancy Climate Ready Grant No. 13-085				
[2] University of Southern California Sea Grant Program. 2016. "Regional AdaptLA: Coastal Impacts Planning in the Los Angeles Region."				
[3] United States Geological Survey. 2015. CoSMoS 3.0: Southern California.				
[4] Grifman, P. M., J. F. Hart, J. Ladwig, A. G. Newton Mann, M. Schulhof. 2013. "Sea Level Rise Vulnerability Study for the City of Los Angeles."				
[5] Ekstrom J. and S. Moser. 2014. "Vulnerability and Adaptation to Sea-Level Rise: An Assessment for the City of Hermosa Beach."				
[6] Aquarium of the Pacific. 2015. "City of Long Beach Climate Resiliency Assessment Report."				
[7] Geosyntec Consultants. 2016. "Assessment of Infrastructure Vulnerability to Sea-Level Rise Hermosa Beach, California."				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
Orange County	No	No	In Progress [8] Yes [1,2]	No
Bolsa Chica Segment	No	No	Yes [3]	No
Santa Ana River Segment	No	No	Yes [3]	No
Santa Ana Heights Segment	No	No	Yes [3]	No
Newport Coast Segment	1988	No	No	No
Emerald Bay Segment	1989	No	No	No
Aliso Viejo Segment	1983	No	No	No
City of Seal Beach	No	CCC	No	In Progress
City of Huntington Beach	1985	No	Yes [4]	No
Sunset Beach Segment	No	No	Yes [3]	In Progress
City of Costa Mesa	No	No	No	No
City of Newport Beach	No	CCC	Yes [4,5]	In Part
City of Irvine	1982	No	No	No
City of Laguna Beach	1993	No	No	In Part
City of Aliso Viejo	No	No	No	No
City of Laguna Niguel	1990	No	No	No
City of Dana Point	1989	CCC	Yes [7]	In Progress
City of San Clemente	No	CCC	No	In Progress
References				
[1] California Department of Public Health Office of Health and Equity and University of California Department of Public Health Sciences, Davis, California. 2015. "Climate and Health Profiles Report: Orange County."				
[2] United States Geological Survey. 2015. CoSMoS 3.0: Southern California				
[3] U.S. Department of the Interior Bureau of Reclamation. 2013. "Climate and Sea Level Rise in the Santa Ana River Watershed Results Summary."				
[4] City of Huntington Beach. 2014. "City of Huntington Beach Sea Level Rise Vulnerability Assessment."				
[5] Everest International Consultants, Inc. 2011. "Assessment of Seawall Structure Integrity and Potential for Seawall Over-Topping for Balboa Island and Little Balboa Island."				
[6] University of California, Irvine. 2017. FloodRISE Project				
[7] Project Dimensions. 2014. "Dana Point Harbor Revitalization: Preliminary Shoreline Management Plan."				
[8] University of Southern California Sea Grant. 2015. "Orange County Regional Sea Level Rise & Coastal Impacts Workshop"				

Jurisdiction/Segment	Certified LCP?	Grant?	Vulnerability Assessments	Updated for SLR?
San Diego County	No	CCC	Yes [1,4]	In Progress
City of Oceanside	1986	CCC	Yes [1]	In Progress
City of Carlsbad	-	OPC,CCC	Yes [2]	In Progress
Agua Hedionda Segment	No			
Mellos I Segment	1996			
Mello II Segment	1996			
West Batiquitos/Sammis Segment	1996	(See above)	(See above)	(See above)
East Batiquitos/ Hung Segment	1996			
Village Redevelopment Area Segment	1987			
City of Encinitas	1995	No	Yes [6]	No
City of Solana Beach	No	CCC	No	In Progress
City of Del Mar	2001	OPC, CCC	Yes [1,3,7]	In Progress
City of San Diego	No	No	Yes [4]	No
North City Segment	1988	No	No	No
La Jolla Segment	1988	No	Yes [1]	No
Pacific Beach Segment	1988	No	No	No
Mission Beach Segment	1988	No	Yes [1]	No
Mission Bay Segment	No	No	Yes [8]	No
Ocean Beach Segment	1988	No	No	In part
Peninsula Segment	1988	No	No	No
Centre City Segment	1988	No	No	No
Barrio Logan Segment	1988	No	No	No
Otay Mesa/ Nestor Segment	1988	No	No	No
Tijuana River Segment	1988	No	Yes [5]	No
Border Highlands Segment	1988	No		No
City of Coronado	1984	No	Yes [1,4]	No
City of National City	1991	No	Yes [4]	No
City of Chula Vista	1985	No	Yes [4]	In Part
City of Imperial Beach	1984	SCC, CCC	Yes [1,4], In Progress [9]	In Progress
References				
[1] Messner S, K Green, C Phillips, J Dudley, D Cayan, E Young. 2009. "Climate Change Related Impacts in the San Diego Region by 2050."				
[2] City of Carlsbad. 2016. "Draft City of Carlsbad Sea Level Vulnerability Assessment."				
[3] ESA. 2016. "Administrative Draft: City of Del Mar Sea-Level Rise Adaptation Plan."				
[4] ICLEI-Local Governments for Sustainability. 2012. "Sea Level Rise Adaptation Strategy for San Diego Bay."				
[5] Tijuana River National Estuarine Research Reserve. 2014. Climate Understanding & Resilience in the River Valley (CURRV) Project Workshop on Scenario Planning				
[6] City of Encinitas. 2010. "City of Encinitas General Plan Update Current Conditions Report Chapter 16: Coastal Conditions."				
[7] ESA. 2016. "Final Draft Coastal Hazards, Vulnerability, and Risk Assessment Del Mar, CA."				
[8] Gersberg R. "Mission Bay 2.0 M Sea Level Rise." Maps produced for San Diego Coastkeepers.				
[9] Revell Coastal, LLC. 2016. "City of Imperial Beach Sea Level Rise Study." Coastal Conservancy Climate Ready Grant deliverable				