CALIFORNIA COASTAL COMMISSION
455 MARKET STREET, SUITE 300
SAN FRANCISCO, CA 94105-2421
VOICE (415) 904-5200
WEB: WWW.COASTAL.CA.GOV

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Draft Sea Level Rise Policy Guidance Update

July 19, 2024

EXHIBITS

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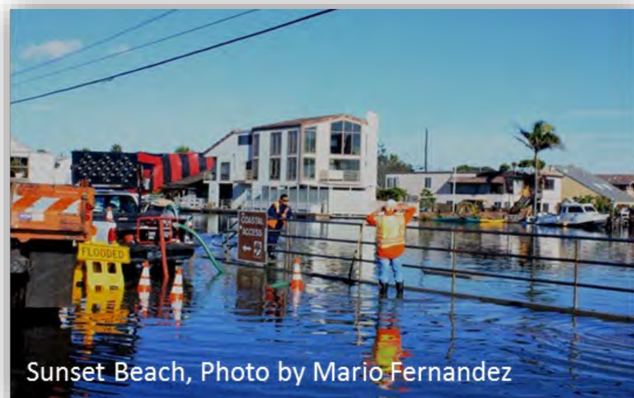
Note: New/updated language is generally highlighted in the July 2024 Public Review Draft Update version of the Sea Level Rise Policy Guidance (attached) using the following color scheme:

- Yellow: Sea level rise science
- Green: SB 272
- Blue: Environmental justice
- Gray: Other targeted updates where possible (e.g., updated agency resources or additional context related to evolving adaptation planning concepts, such as the work of the Local Government Working Group)

Where large portions of text have been added/updated, such as multi-page sections or whole appendices, the titles of those sections have been highlighted rather than the entirety of the content.

CALIFORNIA COASTAL COMMISSION
SEA LEVEL RISE POLICY GUIDANCE

Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits



Sunset Beach, Photo by Mario Fernandez

Chula Vista, Photo by Lisa Cox

San Francisco, Photo by Mike Baird

Arcata, Photo by Humboldt Baykeeper

Original Guidance unanimously adopted – August 12, 2015
Science Update unanimously adopted – November 7, 2018

DRAFT 2024 UPDATE

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The **original** *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* was unanimously adopted by the California Coastal Commission on August 12, 2015.

Commissioners

Steve Kinsey, *Chair*
Dayna Bochco, *Vice Chair*
Gregory Cox
Carole Groom
Erik Howell
Martha McClure
Wendy Mitchell
Mary K. Shallenberger
Effie Turnbull-Sanders
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Alternate Commissioners

Olga Diaz
Belinda Faustinos
Sarah Glade Gurney
Steve Kram
Marciela Morales
Randy Pestor
Dr. Paul Song

Ex Officio Members

John Laird/Janelle Beland

Lt. Gov. Gavin Newsom/
Jennifer Lucchesi/
Kevin Schmidt

Brian P. Kelly/Dale Jones

A 2018 **Science Update** to the *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* was unanimously adopted by the California Coastal Commission on November 7, 2018.

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Aaron Peskin
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Roberto Uranga
Mark Vargas

Alternate Commissioners

Linda Escalante
Belinda Faustinos
Zahirah Mann
Maricela Morales
Brian Pendleton
Bryan Urias
Christopher Ward

Ex Officio Members

John Laird/
Thomas Gibson

Betty Yee/
Anne Baker/
Nicole Jones

Brian Annis/
Jeremiah Ketchum

This report was prepared with financial assistance from the National Oceanic and Atmospheric Administration under the Coastal Zone Management Act Section 309 Enhancement Grant Program

SUMMARY OF DOCUMENT REVISIONS

The Coastal Commission intends to periodically update this policy guidance to reflect developing scientific research on sea level rise projections as well as the evolving understanding of adaptation options and planning practices. Updates will be roughly timed to follow updates of other state and national sea level rise reports or other significant changes in the field of sea level rise adaptation planning.

The first version of this Guidance was adopted by the Coastal Commission on August 12, 2015. That version of the guidance referenced the best available science on sea level rise available at the time, the National Research Council's 2012 Report, Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future. In 2017, the Ocean Protection Council (OPC), acting on direction from Governor Brown, released a scientific report entitled Rising Seas in California: An Update on Sea-Level Rise Science, which synthesized the evolving research on sea level rise science. OPC then updated the State of California Sea-Level Rise Guidance to reflect this new science, and the Coastal Commission followed with a complementary update (adopted on November 7, 2018) to this Sea Level Rise Policy Guidance.

In 2019, the Coastal Commission adopted its Environmental Justice Policy to provide guidance for Commissioners, staff, and the public on how the Commission will implement its environmental justice authority and integrate the principles of environmental justice, equality, and social equity into all aspects of the Commission's program and operations. The Environmental Justice Policy contains a set of guiding principles, including one on climate change, and complements the Sea Level Rise Policy Guidance section on environmental justice and equity. This update to the Guidance builds upon the Commission's Environmental Justice Policy and intentionally integrates environmental justice and equity considerations to further inform recommendations that address sea level rise.

Most recently, in June 2024, the OPC adopted its most recent update to the State of California Sea Level Rise Guidance (OPC 2024), which reflects the previous five years of scientific research on sea level rise projections, including the IPCC's Sixth Assessment Report (2021) and NOAA's national report, Global and National Sea Level Rise Scenarios for the United States (Sweet et al., 2022). The Coastal Commission Guidance is now being updated to be consistent with the State Sea Level Rise Guidance (OPC 2024), provide additional detail specific to the Coastal Act, and address other developments that have occurred since 2018. Key updates include:

- Updates to sea level rise scenarios to reflect 1) more certainty about near-term sea level rise amounts as compared to the 2018 numbers, and 2) updated understanding of the potential timing of worst-case Antarctica ice sheet melt, which has the effect of slightly slowing the possible worst case SLR scenario.
- Discussion of SB 272 (Laird, 2023), which requires local governments to develop sea level rise adaptation plans as part of new or updated LCPs by January 1, 2034. The new information in this Guidance related to SB 272 is intended to fulfill the legislation's

requirement for the Coastal Commission to establish guidelines (by December 31, 2024) for the preparation of those plans.

- Integration of environmental justice principles as detailed in the Commission's Environmental Justice Policy, including additional information on consequences of sea level rise to environmental justice communities, the importance of meaningful engagement, how to consider and include environmental justice communities in the planning and permitting process, and equitable adaptation strategies. This work was supported by eight external subject matter experts in sea level rise science and environmental justice, who acted as project advisors. These advisors were consulted at the beginning of and throughout the process to ensure guidelines reflect the priorities of environmental justice communities.

How to Use this Document

What this document IS and IS NOT:

This document is guidance, it is NOT regulations

This Guidance is advisory and not a regulatory document or legal standard of review for the actions that the Commission or local governments may take under the Coastal Act. Such actions are subject to the applicable requirements of the Coastal Act, the federal Coastal Zone Management Act, certified Local Coastal Programs, and other applicable laws and regulations as applied in the context of the evidence in the record for that action. This Guidance also fulfills the Commission's duty, pursuant to Public Resources Code Section 30985.2, to establish guidelines for the preparation of the sea level rise plans required pursuant to subdivision (a) of Public Resources Code Section 30985.

This document is dynamic, it is NOT static

This Guidance will be updated periodically to address new sea level rise science, information, and approaches regarding sea level rise adaptation, and new legal precedent. Updates will occur with public notice, opportunities for public input, and public Commission meetings. The Commission will also continue working on SLR through other projects, as outlined in Chapter 9: Next Steps.

This document is multi-purpose for multiple audiences, it is NOT meant to be read cover-to-cover

This Guidance is a comprehensive, multi-purpose resource and it is intended to be useful for many audiences. As such, it includes a high level of detail on many subjects. However, chapters were written as stand-alone documents to provide usable tools for readers.

This document is a menu of options, it is NOT a checklist

Since this document is intended for use statewide, it is not specific to a particular geographic location or development intensity (e.g., urban or rural locations). Therefore, not all of the content will be applicable to all users, and readers should view the content as a menu of options to use only if relevant, rather than a checklist of required actions.

Reading Tips

- Look carefully at the Table of Contents and identify sections of interest.
- Do not expect all of the content to apply to your particular situation. As a statewide document, a wide variety of information is included to address the concerns of various users.
- Navigate to your desired level of detail: The *Executive Summary* provides a basic summary of the content; the body of the document provides a detailed discussion; and the *Appendices* provide more scientific and technical detail and a variety of useful resources.

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Commonly Used Acronyms and Agency Names

(See the Glossary for definitions and explanations of key terms)

Terms:

AR6 – IPCC Sixth Assessment Report

CDP – Coastal Development Permit

CoSMoS – Coastal Storm Modeling System

EJ – Environmental Justice

ENSO – El Niño Southern Oscillation

ESHA – Environmentally Sensitive Habitat Area

GHG – Greenhouse gas

IP – Implementation Plan

IPCC – Intergovernmental Panel on Climate Change

LCP – Local Coastal Program

LUP – Land Use Plan

PDO – Pacific Decadal Oscillation

SLR – Sea level rise

Agency Names:

BCDC – San Francisco Bay Conservation and Development Commission

BOEM – Bureau of Ocean Energy Management

Cal OES – California Governor's Office of Emergency Services

Caltrans – California Department of Transportation

CCC/Commission – California Coastal Commission

CDFW – California Department of Fish and Wildlife

CNRA – California Natural Resources Agency

Conservancy – California State Coastal Conservancy

EPA – Environmental Protection Agency

FEMA – Federal Emergency Management Agency

NASA – National Aeronautics and Space Administration

NERR – National Estuarine Research Reserve

NMS – National Marine Sanctuary

NOAA – National Oceanic and Atmospheric Administration

OPC – California Ocean Protection Council

OPR – California Governor's Office of Planning and Research

State Lands – California State Lands Commission

State Parks – California Department of Parks and Recreation

SWRCB – State Water Resources Control Board

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

Executive Summary

Climate change is upon us, affecting almost every facet of California's natural, social, and built environment. Rising global temperatures are causing significant effects at global, regional, and local scales. In the past century, average global temperature has increased by about 0.8°C (1.4°F), and average global sea level has increased by nearly 8 inches (20 cm; Fox-Kemper *et al*., 2021). According to the most recent best available science, by the year 2100, sea levels in California may rise by 1 to 6.6 feet (0.3 to 2.0 meters) depending on emissions levels (OPC 2024). While the California coast regularly experiences erosion, flooding, and significant storm events, sea level rise will exacerbate these natural forces, leading to significant social, environmental, and economic impacts.

Importantly, sea level rise will exacerbate burdens already felt among environmental justice and tribal communities who have a higher social vulnerability to climate change. In California, generations of discriminatory land use policies and practices have resulted in an inequitable distribution of environmental burdens, including a lack of investments in creating or maintaining natural resource benefits within these communities. Meaningful engagement[1] and equitable planning that centers environmental justice and tribal communities are important for addressing these specific burdens while seeking to holistically address sea level rise risks and vulnerabilities across the state.

The evidence of the value of proactive planning to prepare for sea level rise is compelling. The Third National Climate Assessment notes that there is strong evidence showing that the cost of doing nothing to prepare for the impacts of sea level rise exceeds the costs associated with adapting to them by about 4 to 10 times (Moser *et al*., 2014). Similarly, several studies show that the cumulative costs of keeping infrastructure safely in place within areas vulnerable to sea level rise could eventually outweigh the costs of relocation (Cutler *et al*., 2020; Turner *et al*., 2007; King *et al*. 2011). Therefore, it is critically important that California proactively plan and prepare for the impacts of sea level rise to ensure a resilient California coast for present and future generations.

The California Coastal Act is one of the state's primary coastal management laws for addressing land use, public access and recreation, and the protection of coast and ocean resources in the coastal zone. It is also the primary coastal hazards law governing development along the coast. Using the Coastal Act, the Coastal Commission and local governments have nearly five decades of experience managing coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion as well as responses to these hazards such as armoring. However, sea level rise and the changing climate present management challenges of a new magnitude, with the potential to significantly threaten many coastal resources, including shoreline development, coastal beach access and recreation, habitats, agricultural lands, cultural resources, and scenic resources, all of which are subject to specific protections and

[1] Meaningful engagement is the intentional outreach, inclusion, and consideration of the voices and perspectives from presently and historically underserved and marginalized communities in the design, development, implementation, and policies that may impact the health, environment, and livelihood of their communities. For more information about meaningful engagement best practices and resources, see Chapter 4.

regulations in the Coastal Act. Therefore, effective implementation of the Coastal Act and the protection of California's coast must address global sea level rise and the greater management challenges it will bring. In recognition of this fact, the California Legislature added Section 30270 to the Coastal Act in 2021, which requires the Commission to take the effects of sea level rise into account in its policies and activities.[2]

This document focuses specifically on how to apply the Coastal Act to the challenges presented by sea level rise through Local Coastal Program (LCP) certifications and updates and Coastal Development Permit (CDP) decisions. It organizes current science, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local level. This Guidance also includes environmental justice perspectives that build upon the Commission's existing Environmental Justice Policy, and provides information on how to address impacts to, benefits for, and engagement with environmental justice communities[3] when planning and analyzing for sea level rise.

Additionally, this document provides guidance on how local governments can comply with their obligations under SB 272 (Laird, 2023)[4,5], which requires local governments in the Coastal Zone to submit an LCP, or amendment to their existing LCP, that contains a sea level rise plan. However, while the document is intended to guide LCP planning and development decisions to ensure effective coastal management actions, it is advisory and does not alter or supersede existing legal requirements, such as the policies of SB 272, the Coastal Act, and certified LCPs. One of the Commission's priority goals continues to be coordinating with local governments to complete and update LCPs in a manner that adequately addresses sea level rise within the context of local conditions and reflects the recommendations in this Guidance.

This Guidance document is also part of a larger statewide strategy to respond to climate change that includes both emissions reductions and adaptation planning to address the impacts of a changing climate. Recent efforts include the California Climate Adaptation Strategy (2021) (an update to the 2014 Safeguarding California plan and the 2009 California Climate Adaptation Strategy), the California Air Resources Board's Scoping Plan for Achieving Carbon Neutrality

[2] Senate Bill (SB) 1 (Atkins, 2021).

[3] The term "environmental justice communities" is used in this Guidance to refer low-income communities, communities of color, and other historically marginalized communities that have been disproportionately burdened by or less able to prevent, respond to, and recover from, adverse environmental impacts and discriminatory land use practices.

[4] SB 272 added Division 20.6.9 (Section 30985 et seq.) to the California Public Resources Code. This document uses "SB 272" and "Section 30985 et seq." interchangeably.

[5] Note that SB 272 also includes a requirement for local jurisdictions within San Francisco Bay to develop plans that are subject to review by the Bay Conservation and Development Commission (BCDC). The basic requirements are the same for both agencies/plan types, and Commission and BCDC staff have coordinated to develop guidelines pursuant to the requirements of SB 272; however, some specific details and best practices will vary based on differences between relevant enacting legislation (the Coastal Act versus the McAteer-Petris Act) and planning contexts. More information on BCDC's work to implement SB 272 can be found through the BCDC Regional Shoreline Adaptation Plan.

(2022), the California Natural Resources Agency's Environmental Justice Policy (2020), the General Plan Guidelines (Cal OPR 2023), the California State Hazard Mitigation Plan (2023), and several documents developed by the Ocean Protection Council (OPC) in collaboration with other state agencies, including the State Sea Level Rise Guidance (2024), Making California's Coast Resilience to Sea Level Rise: Principles for Aligned State Action (2020), and the State Agency Sea-Level Rise Action Plan for California (2022).

The Commission has also been providing, and will continue to provide, funding for SLR adaptation planning through its LCP Local Assistance Grant Program, and Commission staff participate in multi-agency partnerships, including the Sea Level Rise State and Regional Support Collaborative, formerly known as the Sea Level Rise Leadership Team, convened by the OPC. For more detail on these efforts, see the Introduction.

PRINCIPLES FOR ADDRESSING SEA LEVEL RISE IN THE COASTAL ZONE

This Guidance is rooted in certain fundamental guiding principles, many of which derive directly from the requirements of the Coastal Act. These Principles broadly lay out the common ideas and a framework by which sea level rise planning and permitting actions can be assessed, and as such represent the goals to which actions should aspire. Individual actions and outcomes may vary based on a variety of factors, including applicable policies and location- or project-specific factors that may affect feasibility. The Guiding Principles are summarized below and discussed in greater detail in Chapter 2.

Use Science to Guide Decisions [Coastal Act Sections 30006.5; 30335.5; 30270]

1. Recognize and address sea level rise as necessary in planning and permitting decisions.
2. Use the best available science to determine locally relevant and context-specific sea level rise scenarios and potential impacts for all Coastal Act planning processes, project design, and permitting reviews.
3. Recognize scientific uncertainty by using scenario planning and adaptive management techniques.
4. Use a precautionary approach by planning and providing adaptive capacity for the higher end of the range of possible sea level rise.
5. Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.

Minimize Coastal Hazard Risks through Planning and Development Standards [Coastal Act Sections 30253; 30235; 30270; 30001; 30001.5]

6. Avoid significant coastal hazard risks to new development where feasible.
7. Minimize hazard risks to new development over the life of authorized structures.
8. Minimize coastal hazard risks and resource impacts when making redevelopment decisions.

9. Account for the social and economic needs of the people of the state, including environmental justice and tribal priorities; assure priority for coastal-dependent and coastal-related development over other development.
10. Ensure that property owners understand and assume the risks, and mitigate the coastal resource impacts, of new development in hazardous areas.

Maximize Protection of Public Access, Recreation, and Sensitive Coastal Resources [Coastal Act Chapter 3 policies]

11. Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.
12. Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.
13. Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.
14. Address other potential coastal resource impacts (to wetlands, habitat, agriculture, scenic, *etc.*) from hazard management decisions, consistent with the Coastal Act.
15. Address the cumulative impacts and regional contexts of planning and permitting decisions.
16. Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.
17. Consider best available information on resource valuation when mitigating coastal resource impacts.

Maximize Agency and Tribal Coordination, Meaningful Engagement, and Public Participation [Coastal Act Chapter 5 policies; Sections 30006; 30320; 30339; 30500; 30503; 30711]

18. Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.
19. Coordinate with tribes to address tribal priorities and concerns when making planning decisions.
20. Consider conducting vulnerability assessments and adaptation planning at the regional level.
21. Provide for maximum public participation and meaningful engagement in planning and regulatory processes.

Prioritize Environmental Justice Communities [California Coastal Commission Environmental Justice Policy; Coastal Act Sections 30006; 30013; 30320; 30339; 30500; 30503; 30604(h); 30711]

22. Consider environmental justice when making planning and permitting decisions. Evaluate and address any disproportionate environmental and public health burdens these communities may experience as a result of sea level rise impacts.

BEST AVAILABLE SCIENCE AND CONSEQUENCES OF SEA LEVEL RISE

The Coastal Act directs the Coastal Commission and local governments to use the best available science in coastal land use planning and development. This Guidance recommends using the best available science on sea level rise scenarios to inform planning decisions and project design.

The State of California has long supported the preparation and provision of scientific information on climate change and sea level rise to help guide appropriate and resilient planning, permitting, investment, and other decisions. For example, California Fourth Climate Change Assessment advances actionable science on the impacts of climate change, including sea level rise, that serves the needs of state and local-level decision-makers.[6] The Ocean Protection Council updates the State Sea Level Rise Guidance roughly every five years to synthesize best available science on sea level rise. The 2024 State Sea Level Rise Guidance contains a set of sea level rise scenarios for statewide use (which reflects a statewide average rate of vertical land motion), as well as sets for each of the 14 tide gauges throughout California. The Coastal Commission recommends using these scenarios and related information as best available science on sea level rise in California (see Table 1 for the statewide scenarios and Appendix F for scenarios for other tide gauges). The Coastal Commission will re-examine best available science periodically and as needed with the release of new information.

In addition to sea level rise scenarios, the State Sea Level Rise Guidance (OPC 2024) and many other publications provide information on the impacts of sea level rise in California. According to these reports, sea level rise will cause flooding and inundation, increased coastal erosion, changes in sediment supply and movement, and saltwater intrusion to varying degrees along the California coast. These effects in turn could have a significant impact on the coastal economy and could put important coastal resources and development at risk, including ports, marine terminals, commercial fishing infrastructure, public access, recreation, wetlands and other coastal habitats, water quality, biological productivity in coastal waters, coastal agriculture, and archaeological and paleontological resources. These impacts and their consequences for coastal resources and communities are discussed in more detail in Chapters 3 and 4.

[6] Fifth California Climate Assessment research is underway and will be released in 2026. Some of the new data products, including SLR projections data, are already available via the Cal-Adapt Analytics Engine.

Table 1. Sea Level Rise Scenarios for California [7]

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

ADDRESSING SEA LEVEL RISE IN LOCAL COASTAL PROGRAMS

This document provides a step-by-step process for addressing sea level rise and adaptation planning in new and updated Local Coastal Programs in a manner that prioritizes the needs of environmental justice communities. These Steps, summarized below in text and in Figure 1, can be tailored to fit the needs of individual communities and address the specific coastal resource and development issues of a community, such as dealing with bluff erosion or providing for effective redevelopment, urban infill, and concentration of development in already developed areas. Ideally, Commission and local government staff will establish regular coordination and work together in the early steps of any LCP planning process. For a detailed explanation of these LCP planning Steps, see Chapter 5. Communities in areas where sea level rise vulnerability assessment work is already underway can start later in the process, at Step 5, or other relevant Step(s).

[7] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the State Sea Level Rise Guidance and this guidance recommend for use in various planning and project contexts.

Step 1. **Initiate planning effort**, identify key goals and stakeholders, and engage with environmental justice communities.

Step 2. **Determine a range of sea level rise scenarios relevant to LCP planning area/segment** using best-available science, which is currently the State Sea Level Rise Guidance (OPC 2024).

Step 3. **Identify potential physical sea level rise impacts in the LCP planning area/segment**, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.

Step 4. **Assess potential risks from sea level rise to coastal resources, development, and environmental justice communities in the LCP planning area/segment,** including those resources addressed in Chapter 3 of the Coastal Act.

Step 5. **Identify equitable adaptation measures** to address identified risks in the planning area, considering different coastal resource needs and local and statewide goals.

Step 6. **Draft updated or new LCP for certification by California Coastal Commission**, incorporating updates to the Land Use Plan and Implementing Ordinances.

Step 7. **Implement the LCP and monitor and re-evaluate strategies as needed** to address new circumstances relevant to the area.

Planning Process for Local Coastal Programs and Other Plans

Figure 1. Flowchart for addressing sea level rise in Local Coastal Programs and other plans.

ADDRESSING SEA LEVEL RISE IN COASTAL DEVELOPMENT PERMITS

New development within the coastal zone generally requires a Coastal Development Permit (CDP). Many projects reviewed through the CDP application process already examine sea level rise impacts as part of the hazards analysis, though not every CDP application will need to consider sea level rise. In general, sea level rise is only likely to affect those projects that are on low-lying land, on eroding coastal bluffs, in close proximity to water, or rely upon a shallow aquifer for water supply. This document offers a step-by-step outline, summarized below in text and in Figure 2, for how to conduct such an analysis as a standard part of the CDP application process. The goal of these Steps is to ensure careful attention to minimizing risk to development and avoiding, minimizing, and mitigating impacts to coastal resources, including any coastal resource-related impacts to environmental justice communities, over the life of the project. Early coordination with Coastal Commission staff is highly recommended, and staff will be available to consult with applicants during this process. Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where a closer review of sea level rise concerns is necessary. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate. For a detailed explanation of these steps, see Chapter 6 of this Guidance.

Step 1. **Initiate CDP application**, gather proposed project information, and engage with environmental justice communities.

Step 2. **Establish the projected sea level rise range for the proposed project**'s planning horizon using the best available science, which is currently the State Sea Level Rise Guidance (OPC 2024).

Step 3. **Determine how physical impacts from sea level rise may constrain the project site,** including erosion, structural and geologic stability, flooding, and inundation.

Step 4. **Determine how the project may impact coastal resources, including as they relate to environmental justice communities, considering the influence of future sea level rise upon the landscape** as well as potential impacts of sea level rise adaptation strategies that may be used over the lifetime of the project.

Step 5. **Identify alternatives to both avoid resource and related environmental justice impacts and minimize risks** throughout the expected life of the development.

Step 6. **Finalize project design and submit CDP application.**

Planning Process for Coastal Development Permits

1. Initiate CDP application, gather proposed project information, and engage with EJ communities

- Gather materials such as blueprints, site plans, and information regarding coastal resources to inform hazards and resource analyses.
- Identify EJ communities near to or with an important connection to the project site.

2. Establish the projected sea level rise range for the proposed project

- Determine time period of concern using expected project life.
- Use range of SLR scenarios based on best available science (*e.g. 2024 OPC SLR Guidance*).

3. Determine how sea level rise impacts may constrain the project site

Using locally relevant SLR projections, determine site- or project-specific hazards or impacts for the time period of concern, including current and future hazard impacts. Consider:

- Geologic Stability
- Erosion
- Flooding and Inundation
- Groundwater Rise
- Wave Impacts
- Tsunami

4. Determine how the project may impact coastal resources, including as they relate to EJ communities over time, considering SLR

Determine how the project may impact coastal resources (below) considering how SLR may alter the resources over the expected lifetime of the project.

- Public Access and Recreation
- Agriculture
- Archaeological/Paleontological resources
- Environmental Justice communities
- Coastal Habitats
- Water Quality
- Scenic Resources

5. Identify project alternatives to both avoid resource and related EJ impacts and minimize risks to the project

- Ideally, site/design the project to avoids conflicts with natural resources, EJ, and SLR impacts.
- Alternatively, minimize the likelihood that the project will be impacted by hazards, and design an adaptation strategy for unavoidable impacts.
- Modify the project if impacts cannot be avoided/minimized.
- Summarize these alternatives.

6. Finalize project design and submit permit application

Complete the CDP application. Submit the application. Receive permit action. Monitor and revise project as needed.

Figure 2. Flowchart for addressing sea level rise in Coastal Development Permits

ADAPTATION STRATEGIES

Steps 1 through 4 of the processes for addressing sea level rise in LCPs and CDPs will help planners and project applicants identify particular vulnerabilities to the planning region and specific project sites. Such vulnerabilities may include impacts to communities, including environmental justice communities, as well as a number of resources identified in the Coastal Act, including development and infrastructure; public access and recreational opportunities; beaches, wetlands, environmentally sensitive habitat areas (ESHA), and other coastal habitats; agricultural resources; water quality; archaeological and paleontological resources; and scenic and visual resources. Planners and project applicants will need to identify, develop, and implement various adaptation strategies designed to protect or enhance coastal resources that do not exacerbate burdens to environmental justice communities. These strategies should fulfill the hazard minimization and resource protection policies of the Coastal Act and should account for local conditions and environmental justice concerns. In many cases, strategies will need to be implemented incrementally (or in a phased approach) as conditions change, and planners, project applicants, and partners will need to think creatively and progressively to ensure that coastal resources and development are protected over time. Chapter 7 of this Guidance summarizes a number of strategies to protect different coastal resources and meet the goals and requirements of the Coastal Act, as well as different approaches to adaptation planning such as phased adaptation.

ADDITIONAL INFORMATION

In addition to providing a summary of best available science on sea level rise, step-by-step approaches for addressing sea level rise in LCPs and CDPs, and a discussion of numerous adaptation strategies, the Guidance includes the following supplemental information:

- Chapter 8: A brief discussion of the legal context of adaptation
- Chapter 9: Next steps for Commission staff in coordination with other relevant partners and research institutions, based on objectives and actions from the Commission adopted California Coastal Commission Strategic Plan 2021-2025 (2021)
- Appendix A: Detailed information on the drivers of sea level rise and sea level rise scenarios
- Appendix B: Technical information for how to assess local hazard conditions based on regional sea level rise scenarios, which is applicable to both LCPs and CDPs
- Appendix C: Lists of useful resources and references, including examples of sea level rise adaptation documents from other state agencies
- Appendix D: General steps for processing an LCP amendment
- Appendix E: Key Coastal Act policies relevant to sea level rise and coastal hazards
- Appendix F: Sea level rise scenarios for the 14 California tide gauges
- Appendix G: Coastal Commission contact information

CONTEXT OF THIS DOCUMENT

This Guidance is part of a larger body of work on climate change by State agencies, regional collaborations, local leadership, academic research, and other organizations. Many of these efforts are included as resources in Appendix C. Users of the document should take advantage of these existing resources, collaborate with others, and share best practices as much as possible.

Finally, this document is intended to function as interpretive guidance for effective implementation of the Coastal Act and LCPs in light of sea level rise. It also provides the guidance to local governments that is required pursuant to Public Resources Code Section 30985.2 regarding the preparation of sea level rise plans. It is not a regulatory document and does not contain any new regulations. Further, it does not amend or supersede existing legal authorities or the standard of review for Local Coastal Programs and Coastal Development Permit decisions pursuant to the Coastal Act. Those actions are subject to the applicable requirements of the Coastal Act, the Coastal Zone Management Act, certified LCPs, and other applicable laws and regulations as applied in the context of the evidence in the records for those actions. The Commission is adopting this Guidance as interpretive guidelines pursuant to its authority under Public Resources Code Sections 30620.

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Chapter 1. Introduction

Climate change is happening now. Rapidly melting ice caps, rising sea levels, floods, extreme heat waves, droughts, and fires are just a few of the effects of climate change. These effects are having profound impacts on our coast and are changing coastal management planning and decision making at global, national, state, regional, local, and individual scales.

Given current trends in greenhouse gas emissions, sea levels are expected to rise at an accelerating rate in the future, and scientists project an increase in California's sea level in coming decades. Until mid-century, the most damaging events for the California coast will likely be dominated by large El Niño-driven storm events in combination with high tides and large waves. Eventually, sea level will rise enough that even small storms will cause significant damage, and large events will have unprecedented consequences (Caldwell *et al*. 2013; Vitousek *et al*., 2017).

With a 1,270-mile coastline, adequately planning for sea level rise in California is a challenging but vital task. Underlying this complexity are generations of discriminatory land use practices and policies and loss of native sacred lands and cultural resources, which has resulted in an inequitable distribution of environmental burdens and benefits among different groups of people (US EPA, 2022). At its core, the California Coastal Act of 1976 is a statute inherently grounded in the principle of equality. Yet, despite numerous victories, the statute's vision of coastal protection and access for all people has not been fully realized. Further, the long-term legacy of institutional racism in land use planning, public policy, lending institutes, and policing continues to be reflected in the built environment and demographic and socioeconomic make-up of the California coast today. As a result, sea level rise will affect different communities throughout California disproportionately based on several factors such as geography, geology, hydrology, ecology, land use, and social characteristics.

This Guidance provides a framework for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). Importantly, environmental justice and equity principles, as described in the Commission's Environmental Justice Policy, have been integrated into this Guidance with the goal that the impacts of climate change are addressed in a way that is fair and equitable, particularly for communities that have been disproportionately impacted by climate-related hazards. The intended audience for this document includes the Commission and Commission staff, local governments, other public agencies, permit applicants, community-based organizations, environmental justice communities, tribal governments, members of the public, and others who are interested in how to implement and comply with the California Coastal Act (Coastal Act) while taking steps to address sea level rise.

Environmental, Economic, and Social Impacts of Sea Level Rise

Environmental Impacts: The environmental impacts of sea level rise in California are both extensive and multifaceted, demanding a nuanced understanding to inform effective land use and conservation strategies. As sea level rise continues, key habitats such as coastal wetlands and beach ecosystems face significant threats, which in turn affect the biodiversity and ecological services they provide. Coastal wetlands, for example, serve as crucial buffers against storm surges and flooding, while also acting as vital carbon sinks. Similarly, beaches, which offer vital nesting grounds for wildlife and recreational spaces for communities, risk severe erosion and habitat degradation due to encroaching seas, undermining their protective and ecological functions. However, rising sea levels could inundate these areas, leading to habitat loss and diminished capacity to support wildlife and mitigate climate impacts.

The degradation of coastal habitats due to rising sea levels poses a direct threat not only to California's ecological systems but also forecasts broader economic and social repercussions. The erosion of beaches and the inundation of wetlands, which provide critical ecosystem services, foreshadow potential disruptions across various sectors reliant on these natural resources. The looming threats extend beyond environmental loss, predicting significant impacts on tourism, recreation, and the livelihoods of communities that depend heavily on these coastal resources.

Economic and Social Impacts: The potential economic and social impacts of sea level rise in California underscore the importance of addressing the issue in land use planning and regulatory work. According to the NOAA Office for Coastal Management, just over 26 million people lived in California's coastal counties as of 2015. In 2020, California's marine economy supported over 26,000 businesses employing over 470,000 people, which accounted for $23.1 billion in wages and $41.9 billion in gross domestic product (NOAA, 2023).

Many aspects of the coastal economy, as well as California's broader economy, are at risk from sea level rise, including coastal-related tourism, beach and ocean recreational activities, transfer of goods and services through ports and transportation networks, coastal agriculture, and commercial fishing and aquaculture facilities. Importantly, many of these industries include historically marginalized groups that are reliant on coastal resources for their livelihood, and safeguards for their job security are critical for the coastal economy.

In addition to potential losses in revenue, the U.S. Geological Survey's Hazard Exposure Reporting and Analytics (HERA) tool estimates that parcels valued at $176 billion total are at risk from 2 meters of sea level rise, which represents almost 200,000 housing units, over 440,000 residents, and over 470,000 employees (Wood et al., 2020). This property also includes over 3,500 miles of roads, 289 miles of railroad, 24 wastewater treatment plants, 32 drinking water plants, and 18 solid waste landfills (Wood et al., 2020). The Fourth California Climate Assessment found that statewide damages could reach nearly $17.9 billion from inundation of development with ~20 inches of sea level rise, and those damages would double with the addition of a 100-year flood (Bedsworth et al., 2018). Furthermore, a USGS study found that in Southern California alone, sea level rise of 3 to 6 feet could cause up to two-thirds of beaches to disappear (Vitousek et al., 2017) if no actions are taken. Some common adaptation actions include armoring with seawalls and revetments, which have commonly been employed to protect infrastructure. Other strategies include implementing nature-based adaptation strategies such as restoring coastal wetlands and using native vegetation that could mitigate erosion and enhance the resilience of coastal ecosystems.

Sea level rise will also have far-reaching effects for coastal communities and populations beyond direct economic impacts. This is particularly true for communities dependent on at-risk industries that are reliant on being adjacent to the coastline, those already facing economic hardship, and populations with limited capacity to adapt, including lower-income, linguistically isolated, elderly, and other vulnerable populations. Sea level rise presents paramount environmental and social justice challenges in a manner that may unequally burden different communities, and it is important to examine social vulnerability to fully understand the community and human livelihood components of climate change and sea level rise vulnerability.

Social vulnerability focuses on the susceptibility of a given community or population to harm from exposure to a hazard and affects the ability of that population to prepare for, respond to, and recover from the hazard (Cutter *et al.*, 2009). This is partly influenced by existing social inequities among various groups of people (Cutter *et al.*, 2003). Socially vulnerable communities experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by physical (built and environmental), social, political, and/or economic factor(s), such as race, class, sexual orientation and identification, national origin, and income inequality, and disability (Governor's Office of Planning and Research, 2024). For example, low-income residents in the coastal zone or those who reside in affordable housing near the coast may have a higher vulnerability to sea level rise and coastal flooding as they have fewer financial resources to protect against and recover from flood damage or property loss (US EPA, 2021).

Discussed further in Chapter 4, the loss of coastal areas will also adversely affect tribal communities for whom these lands support ancestral and cultural practices. The projected impacts of rising seas threaten to inundate sacred sites and disrupt traditional activities, exacerbating historical injustices faced by these communities. Addressing sea level rise in areas significant to tribal communities requires tailored strategies that prioritize the protection of these culturally significant sites and support the continuation of traditional ecological knowledge and practices. This nuanced approach is essential for ensuring that adaptation efforts respect and integrate the unique needs and rights of tribal communities within broader environmental justice frameworks.

Environmental justice is inclusive of tribal and indigenous communities due to their disproportionate exposure to environmental burdens, lack of access to environmental benefits, and systemic oppression. However, it is imperative to recognize both the overlap and the distinction between environmental justice and tribal issues, especially since the lack of meaningful involvement, accountability, and transparency from government has resulted in inequities for both groups. The Commission's Tribal Consultation Policy provides guidance to Commission staff for maintaining effective communication with tribes, including for LCPs and CDPs that may have a sea level rise component affecting tribal communities. The Tribal Consultation Policy outlines procedures for government-to-government consultation and meaningful engagement between staff and tribes to strengthen the agency's relationships with California Native American Tribes, while encouraging further outreach and collaboration. Proactive steps are needed to prepare for sea level rise and to protect the coastal economy, California livelihoods, and coastal resources and the ecosystem services they provide. The magnitude of the challenge is clear – not only might the impacts of sea level rise be severe, the costs, complexity, and time associated with planning for them can be daunting. The third National Climate Assessment, released in May 2014, notes that there is strong evidence to suggest that the costs of inaction are 4 to 10 times greater than the costs associated with proactive adaptation and hazard mitigation (Moser *et al*. 2014). It is critical for California to take proactive steps, with a concerted focus on equity and justice, to address the impacts sea level rise may have on the state's economy, natural systems, built environment, human health, and ultimately, its way of life.

SEA LEVEL RISE AND THE CALIFORNIA COASTAL ACT

The potential impacts of sea level rise fall directly within the Coastal Commission's (and coastal zone local governments') planning and regulatory responsibilities under the Coastal Act. Sea level rise increases the risk of flooding, coastal erosion, and saltwater intrusion into freshwater supplies, which have the potential to threaten many of the resources[8] that are integral to the California coast, including coastal development, coastal access and recreation, habitats (e.g., wetlands, coastal bluffs, dunes, and beaches), coastal agricultural lands, water quality and supply, cultural resources, community character, and scenic quality. In addition, many possible responses to sea level rise, such as construction of barriers or armoring, can have adverse impacts on coastal resources. For example, beaches, wetlands, and other habitat backed by fixed or permanent development will not be able to migrate inland as sea level rises, and will become permanently inundated over time, which in turn presents serious concerns for future public access and habitat protection.

The Coastal Act mandates the protection of public access and recreation along the coast, coastal habitats, and other sensitive resources, as well as providing priority visitor-serving and coastal-dependent or coastal-related development while simultaneously minimizing risks from coastal hazards. This Guidance document has been created to help planners, project applicants, and other interested parties continue to achieve these goals in the face of sea level rise by addressing its effects in Local Coastal Programs and Coastal Development Permits. Although the focus of the Guidance is on LCPs and CDPs, much of the information contained herein can be useful for other planning documents such as Port Master Plans,[9] Long Range Development

[8] The term "coastal resources" is used throughout this Guidance and is meant to be a general term for those resources addressed in Chapter 3 of the California Coastal Act including but not limited to beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

[9] Ports are generally subject to Chapter 8 of the Coastal Act. The policies of Chapter 8 acknowledge the special role and needs of ports and differ in significant ways from the Chapter 3 policies of the Act. Significant categories of development in ports, however, remain subject to Chapter 3, including categories of development listed as

Plans, and Public Works Plans. For example, the science applies regardless of the planning documents, and the discussions of how to analyze sea level rise impacts as well as a number of adaptation options may be applicable. In all cases, specific analyses performed and actions implemented will vary based on relevant policies, local conditions, feasibility, and other factors as described throughout the rest of this document.

Coastal Commission reports and briefings on sea level rise: Sea level rise is not a new concern for the Commission. The Coastal Act policies on hazard avoidance and coastal resource protection provide the basis for the Commission to consider the impacts of sea level rise (see Appendix E: Coastal Act Policies Relevant to Sea Level Rise and Coastal Hazards), and the Commission has long considered sea level rise, erosion rates, and other effects of a dynamic climate in its analysis of permits and LCPs, staff recommendations, and Commission decisions. In 1992, Section 30006.5 was added to the Coastal Act which, among other things, directs the Commission to both develop its own expertise and interact with the scientific community on various technical issues, including coastal erosion and sea level rise. In 2021, the California legislature added Section 30270 to the Coastal Act, which requires the Commission to take into account the effects of sea level rise in its policies and activities. The Commission's staff also coordinates its work on sea level rise with other state and federal agencies, local governments, academic institutions, non-profit organizations, citizen groups, permit applicants, property owners, and others.

The Commission has documented its sea level rise adaptation and climate change efforts in numerous papers and briefings, including:

- 1989 Report: Planning for Accelerated Sea Level Rise along the California Coast
- 2001 Report: Overview of Sea Level Rise and Some Implications for Coastal California
- 2006 Briefing: Discussion Draft: Global Warming and the California Coastal Commission
- 2008 Briefing: A Summary of the Coastal Commission's Involvement in Climate Change and Global Warming Issues for a Briefing to the Coastal Commission
- 2008 White Paper: Climate Change and Research Considerations
- 2010 Briefing: A Summary of the Coastal Commission's Involvement in Sea Level Rise Issues for a Briefing to the Coastal Commission[10]
- 2016 Report: CCC Statewide Sea Level Rise Vulnerability Synthesis
- 2016 Briefing: Implementation of the Adopted Sea Level Rise Policy Guidance

appealable pursuant to Section 30715 and development located within specified wetlands, estuaries, and recreation areas.

[10] Verbal presentation to the Coastal Commission on December 17, 2010 by Susan Hansch (Item 4.5). This presentation can be viewed at the Cal-Span website from approximately minute 22.00 to 24:30.

- 2019-2020 Commission Sea Level Rise Briefing Series: A series of presentations on the status of local sea level rise adaptation planning efforts at Commission meetings (August 2019, September 2019, October 2019, November 2019, March 2020, September 2020)
- 2021 Report: Critical Infrastructure at Risk: Sea Level Rise Planning Guidance for California's Coastal Zone
- 2023 Report: Public Trust Guiding Principles and Action Plan: Carrying out the California Coastal Act and Public Trust Doctrine in an era of climate change and sea level rise

The Importance of Addressing Sea Level Rise in Local Coastal Programs

The impacts of sea level rise will be felt at the local level, and therefore local responses will necessarily be part of effective management of these impacts. Fortunately, the California Coastal Act lays out a legal and planning framework for community climate preparedness and resiliency planning. LCPs, in combination with Coastal Development Permits (CDPs), provide the implementing mechanisms for addressing many aspects of climate change within coastal communities at the local level. Notably, the State recognized the importance of both sea level rise adaptation planning and the role of LCPs with the passage of SB 272 (Laird) in 2023. This bill requires local governments in the coastal zone to develop (and submit to the Commission) a sea level rise plan as part of an LCP by January 1, 2034.[11] Specific requirements and guidance for ensuring consistency with SB 272 are highlighted in Chapter 5.

The goal of updating or developing a new LCP to prepare for sea level rise is to ensure that adaptation occurs in a way that protects both coastal resources and public safety and allows for sustainable economic growth. This process includes identifying how and where to apply different adaptation mechanisms based on Coastal Act requirements, SB 272 and other relevant laws and policies, acceptable levels of risk, and community priorities. LCP and Coastal Act policies are also reflected in CDPs, which implement sea level rise management measures and adaptation strategies through individual development decisions. By planning ahead, communities can reduce the risk of costly damage from coastal hazards, can ensure the coastal economy continues to thrive, and can protect coastal habitats, public access and recreation, and other coastal resources for current and future generations.

The Coastal Commission has continued to make it a priority to support the update of LCPs to address climate change, as demonstrated by Goals 4 and 6 of the Commission's Strategic Plan (CCC 2021), which are to "support resilient coastal communities in the face of climate change and sea level rise" and to "continue to enhance LCP planning program and refine

[11] Note that SB 272 also includes a requirement for local jurisdictions within San Francisco Bay to develop plans that are subject to review by the Bay Conservation and Development Commission (BCDC). The basic requirements are the same for both agencies/plan types, and Commission and BCDC staff have coordinated to develop guidelines pursuant to the requirements of SB 272; however, some specific details and best practices will vary based on differences between relevant enacting legislation (the Coastal Act versus the McAteer-Petris Act) and planning contexts. More information on BCDC's work to implement SB 272 can be found through the BCDC Regional Shoreline Adaptation Plan.

implementation of regulatory program." Specifically, Objective 4.1 directs the Commission to "address climate change risks in the Commission's planning and permitting work through stakeholder collaboration and integration of sea level rise hazards into Local Coastal Programs (LCPs)."

In furtherance of these goals, the Coastal Commission has been working with a Local Government Working Group (LGWG) since 2019 to develop solutions to better address sea level rise adaptation planning and LCP updates. In November 2020, the LGWG, which consists of representatives from the California State Association of Counties (CSAC), the League of California Cities (Cal Cities), Coastal Commission staff, and a Coastal Commission subcommittee including two Coastal Commissioners, presented (and the Commission adopted) a Joint Statement on Adaptation Planning. The Joint Statement includes a set of guiding principles, challenges, opportunities, and actions associated with proactive and effective sea level rise adaptation for California's coastal communities. In December 2021, the Commission adopted deliverables related to specific requests for tools and coordination improvements (including a "Quick Links" guide and an "Elevation and Concurrence Process) as well as broader-scale recommendations and guidance for LCP updates (including a call for "Regional Approaches to Resiliency and Adaptation" and a "Framework for a Phased Approach to SLR LCP Updates"). The LGWG is continuing to work to better understand the policy conflicts and other challenges facing communities as they attempt to update LCPs to address sea level rise, and developing possible approaches for addressing some of these challenges.

LCPs are also an important tool to help local governments formally acknowledge environmental justice through development of local policies to address equity-related issues in land use planning and in analyses of proposed development in the coastal zone. However, taking steps to consider and address environmental justice requires institutions to challenge the status quo, which can be uncomfortable but crucial if government is to shift its role from perpetuating systemic inequities to addressing them and building a more just and equitable society. Building awareness of and implementing environmental justice principles, proactively engaging with and including environmental justice communities in decision making, and thinking about ways to modify current approaches to land use planning and environmental analysis as it relates to sea level rise are all necessary to achieve environmental justice. The Commission and local governments have an opportunity to act on this by updating LCPs with policies to address environmental justice principles and concerns. Proactive planning can provide decision makers and the public with a framework for talking about and addressing these issues up front, which can significantly reduce conflicts later in the process. Given this, the Commission strongly encourages local governments to develop environmental justice policies and amend their LCPs accordingly.

Funding for LCP updates: Several funding programs are available to support California local governments in updating LCPs to address sea level rise. These grant programs have partially overlapping objectives, as described below.

- **Coastal Commission LCP Local Assistance Grant Program:** This grant program provides funding to local governments to complete the certification of new and updated LCPs, with an emphasis on addressing impacts from sea level rise and climate change. Grant-funded work has included the completion of sea level rise vulnerability assessments, technical studies, economic analyses, adaptation planning and reports, public outreach and engagement, and LCP policy development. Importantly, the evaluation criteria and program priorities for this grant program have been refined over time to recognize environmental justice as its own criterion. Specific changes have clarified that while public outreach and environmental justice are sometimes related, they are not one and the same, and grant changes encourage grant applicants to address environmental justice issues beyond outreach and engagement. Between 2013 and 2024, this program awarded approximately $20 million in grants to over 40 jurisdictions. As of the publication of this guidance, the program has significant funding available to continue supporting local government work. For up-to-date information regarding this program, including program priorities, eligibility, and selection criteria, please visit the Local Assistance Grant Program page on the Coastal Commission website.

- **Ocean Protection Council SB1 Grant Program:** OPC's SB 1 SLR Adaptation Planning Grant Program (SB 1 Grant Program) aims to provide funding for coastal communities to develop consistent SLR adaptation plans and projects to build resilience to SLR along the entire coast of California and San Francisco Bay. One track funds projects in the pre-planning, data collection, and planning phases, and another funds projects in the implementation phase. For more information, please visit the OPC SB 1 grant program website.

- **State Coastal Conservancy Grant Programs:** The Coastal Conservancy has a variety of grant programs to support increased public access to and along the coast, protection and restoration of natural lands and wildlife habitat, preservation of working lands, and increased community resilience to climate change. Funding can support a variety of project stages including feasibility studies, property acquisition, community engagement, environmental review, and monitoring. More information on Conservancy grants can be found on their website.

Coastal Resiliency and Preparing for Sea Level Rise: The Federal and State Context

Sea level rise planning efforts are currently taking place at the local, regional, state, and national levels. Framing the efforts in California is a federal strategy to address climate change by both reducing greenhouse gas emissions and adapting to climate change impacts. In January 2015, President Obama's Executive Order 13960 modified Executive Order 11988, Floodplain Management, by expanding the federal approach for establishing flood risk to include the consideration of climate change. Specifically, it recommends using a new flood standard that accounts for climate change in establishing flood elevation and hazard areas when federal funds are used to build, significantly retrofit, or repair structures.

Additionally, Governor Brown, Supervisor Carbajal (Santa Barbara County), Mayor Garcetti (Los Angeles), and Mayor Johnson (Sacramento) were on President Obama's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, which gave recommendations in 2014 for how to modernize programs and policies to incorporate climate change.[12] The Coastal Commission's Guidance document implements many of the Task Force's recommendations by providing tools and assistance to support sea level rise decision making, by establishing a framework for state, local, and federal partnership and coordination on sea level rise, and by providing guidance on how to improve the resilience of California's coastal infrastructure, natural resources, human communities, and coastal industries.

The State of California has long been a leader in preparing for sea level rise, and in 2008, Governor Schwarzenegger issued an Executive Order (S-13-08) directing state agencies to prepare guidance on sea level rise and to address sea level rise in any state projects located in vulnerable areas. Since then, state agencies have worked collaboratively to accomplish a variety of different actions related to sea level rise adaptation, many of which are listed below. Ten state and federal agencies[13] also commissioned the National Research Council's report, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future (2012), to improve understanding of sea level rise projections for California.

In April 2015, Governor Brown's Executive Order B-30-15 addressed climate change and sea level rise adaptation, stating that state agencies shall take climate change into account in their planning and investment decisions. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas emissions, provide flexible and adaptive approaches, protect the state's most vulnerable populations, and promote natural infrastructure solutions. Additionally, AB 2516, authored by Assemblymember Gordon and approved in September 2014, established a Planning for Sea Level Rise Database, now called the Adaptation Clearinghouse. The database provides the public with a searchable library of resources from which to learn about the actions taken by cities, counties, regions, and various public and private entities to address sea level rise and other climate change impacts.

In the 2010s, much of the state's climate change adaptation work was coordinated with the Coast and Ocean Workgroup of the Climate Action Team (CO-CAT), of which the Commission was a member. In addition, Commission staff has been involved in the State Coastal Leadership Group on Sea-Level Rise (now the California Sea Level Rise State and Regional Support Collaborative), which was established in early 2014 to develop and implement coordinated approaches to address sea level rise across state agencies. The partnership includes staff from the Coastal Zone Management Agencies (Coastal Commission, San Francisco Bay Conservation

[12] https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/resilience/taskforce

[13] The assessment of sea level rise was commissioned by California Department of Water Resources, California Energy Commission, California Department of Transportation, California State Water Resources Control Board, California Ocean Protection Council, Oregon Watershed Enhancement Board, Washington Department of Ecology, National Oceanic and Atmospheric Administration (NOAA), US Army Corps of Engineers (USACE), and US Geological Survey (USGS).

and Development Commission, and State Coastal Conservancy) and land management agencies (State Lands Commission and State Parks) along with the Ocean Protection Council and Natural Resources Agency and others. Under CNRA's leadership, this group co-developed Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action (2020) and the State Agency Sea-Level Rise Action Plan for California (2022).

The content of this Guidance is also aligned with several key concepts in the California Climate Adaptation Strategy, including hazard avoidance for new development, increasing meaningful engagement and partnerships with underserved communities to develop adaptation strategies, encouraging innovative designs and nature-based adaptation strategies for areas vulnerable to sea level rise hazards, and addressing climate impacts in coastal adaptation plans, Local Coastal Programs, and General Plan updates, among many others. As the Climate Adaptation Strategy promotes, this Guidance will be a living document that will be updated and revised as sea level rise science advances and new insights are gained regarding adaptation.

State agency policies and guidance on climate change and sea level rise: As a result of the Executive Order S-13-08 and agency needs for guidance, many state agencies have developed climate change and sea level rise policies and guidance documents. For example:

- The California Natural Resources Agency (CNRA) developed the 2009 California Climate Adaptation Strategy and the 2014, 2018, and 2021 updates
- CNRA and the Governor's Office of Emergency Services (Cal OES) collaboratively developed and updated the California Climate Adaptation Planning Guide (2020)
- The Governor's Office of Planning and Research developed and updated its General Plan Guidelines (2023) to address climate change
- The Ocean Protection Council established *State Sea-Level Rise Guidance* (interim, 2010, 2013, 2018, and 2024) and developed both the Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action (2020) and the State Agency Sea-Level Rise Action Plan for California (2022)
- The San Francisco Bay Conservation and Development Commission (BCDC) amended the San Francisco Bay Plan (1968) to update its policies regarding sea level rise (2011) and to integrate environmental justice and social equity considerations (2019). The agency's San Francisco Bay Plan Climate Change Policy Guidance was adopted in 2021. The agency has also been working on actions to reduce vulnerability to sea level rise throughout the San Francisco Bay through the Adapting to the Rising Tides (ART) program, the Adaptation Roadmap, and the Bay Adapt Joint Platform. BCDC is also developing a Regional Shoreline Adaptation Plan which will provide information on complying with SB 272 within BCDC's jurisdiction.
- The California State Coastal Conservancy (Conservancy) established climate change policies (2011), a sea level rise vulnerability assessment checklist (2019), and a number of grant programs.
- Cal OES updated the California State Hazard Mitigation Plan in 2023.

- The California Department of Transportation (Caltrans) developed a number of resources and reports available here and here, including a Caltrans Climate Change Vulnerability Assessment Summary Report (2021) and Climate Change Vulnerability Assessments (2019) and Adaptation Priorities Reports (2020) for each Caltrans District (which will be updated in 2024 along with the District Adaptation Priorities Investment Strategy (DAPIS) for each District). Caltrans also produced the State Climate Resilience Improvement Plan for Transportation (2024), Adaptation Strategies for Transportation Infrastructure (2023), Climate Change Emphasis Area Guidance for Corridor Planning (2022), as well as guidance on incorporating sea level rise risk analysis into the planning documents and project designs (2011, with an update coming soon). The California State Transportation Agency (CalSTA) also published the Climate Action Plan for Transportation Infrastructure (CAPTI, 2021). The 2023 State Highway System Management Plan (SHSMP) (Caltrans 2023) also includes a sea level rise adaptation needs assessment for roadways and bridges which estimates a need for $15.4 billion by 2033 and $56 billion by 2100 to address impacts. To begin to address these needs, an investment of $1.8 billion was made within this ten-year plan for the state highway system.
- The California State Lands Commission offers resources for addressing SLR here, including an AB 691 Synthesis Report (2022) and individual Sea Level Rise Impact Assessments by local trustees, and has adopted a report entitled, Shoreline Adaptation and the Public Trust: Protecting California's Public Trust Resources from Sea Level Rise (2023).
- California Department of Parks and Recreation have adopted a Sea Level Rise Adaptation Strategy and provide a number of other resources here.
- The California Department of Fish and Wildlife, the Division of Boating and Waterways, and the Department of Water Resources are all actively addressing sea level rise and have taken steps to conduct research on sea level rise impacts, integrate sea level rise into planning documents, and educate staff on climate change impacts.

Federal and State Action on Environmental Justice and Sea Level Rise Planning

There is a growing body of literature examining the disproportionate burdens that climate change places on environmental justice communities throughout the United States. Simultaneously, there is an increase in the frequency of water-related natural disasters such as hurricanes, heavy rainstorms, and coastal flooding. This has led to an increased awareness of the intersection of environmental justice and sea level rise in the United States' political and regulatory landscape. The federal government's recognition of this issue area has resulted in additional studies, policy recommendations, mapping and other digital tools, and increased allocation of funding to environmental justice communities.

In 2021, the Biden Administration signed Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad, which marked a watershed moment for the environmental justice movement and its integration into the federal government. Executive Order 14008 highlights that all Americans deserve to live in healthy, thriving communities, but that many people lack the ability to access safe places to live, work, play, grow, and learn (The White House, 2021). It also established a White House Environmental Justice Interagency Council (IAC), the first-ever advisory committee on environmental justice called the White House Environmental Justice Advisory Council (WHEJAC), and a government-wide environmental justice initiative called Justice40 (The White House, 2022). Justice40 establishes a goal that 40% of the overall benefits of certain federal climate, clean energy, affordable and sustainable housing, and other investments flow to disadvantaged communities that are marginalized by underinvestment and overburdened by pollution. In 2023, the Biden Administration reaffirmed its commitment to environmental justice and its intersection with climate change by signing Executive Order 14096, Revitalizing Our Nation's Commitment to Environmental Justice for All. This executive order includes an emphasis on building climate resiliency within vulnerable populations (The White House, 2023). Major funding opportunities to increase climate resilience within underserved populations, including separate funding for tribal communities, continue to come online to support the capacity building of these communities.

In California, government officials and agencies have taken many steps to elevate and prioritize the issue of environmental justice and sea level rise. In 2017, the Climate Justice Working Group, including environmental justice, public health, and climate equity leaders, convened to develop recommendations for ensuring that the 2017 update of Safeguarding California — California's climate change adaptation strategy — is responsive to environmental justice and climate equity concerns. The final report, Advancing Climate Justice in California: Guiding Principles and Recommendations for Policy and Funding Decisions, includes a number of recommendations regarding sea level rise, such as ensuring that environmental justice communities are actively involved in the development process to identify adaptation co-benefits related to sea level rise, and defining and identifying where environmental justice communities are along the coast in relation to the location of major energy facilities such as power plants, refineries, toxic facilities, and oil drilling sites that may release toxic pollution to surrounding neighborhoods (Climate Justice Working Group, 2019).

Notably, Senate Bill 1 (Atkins), which was signed into state law in 2021, expands funding to assist additional disadvantaged communities along the coast that are vulnerable to the impacts of sea level rise and are actively working to address environmental justice issues related to sea level rise impacts.[14,15] This same bill also added Section 30270 to the Coastal Act, directing the Coastal Commission to take sea level rise into account in its planning, policies, and activities, and established the California Sea Level Rise State and Regional Support Collaborative, a cross-government group tasked with educating the public and advising local, regional, and state government on feasible sea level rise mitigation efforts. Most recently, SB 272 (Laird, 2023), which requires local governments to incorporate a sea level rise plan into an LCP, recognizes

[14] See Senate President pro Tempore Toni G. Atkins' statement on Senate Bill 1.

[15] Senate Bill 1 uses the same definition for disadvantaged communities as California Health and Safety Code § 39711.

the importance of environmental justice by explicitly calling for considerations of equity in developing vulnerability assessments and adaptation strategies.

Coastal Commission Action on Environmental Justice

In 2016, Governor Brown signed Assembly Bill 2616, enabling the Coastal Commission and local governments to consider environmental justice in permits and appeals by adding several new provisions to the Coastal Act. The bill cross-referenced existing civil rights and environmental justice laws (Public Resources Code (PRC) section 30013) in the Coastal Act, added the existing state definition of "environmental justice" in PRC section 30107.3, and required the governor to appoint one environmental justice commissioner to the Coastal Commission. The bill also authorized the Commission and local governments to consider environmental justice in coastal development permit (CDP) decisions (PRC section 30604(h)).

> **30604**(h) *When acting on a coastal development permit, the issuing agency, or the commission on appeal, may consider environmental justice, or the equitable distribution of environmental benefits throughout the state.*

In 2019, the Coastal Commission adopted an Environmental Justice Policy to provide guidance for its Commissioners, staff, and the public on how the Commission will implement its environmental justice authority under the Coastal Act. The Environmental Justice Policy contains a set of guiding principles, including on evaluating and addressing the disproportionate environmental and public health burdens environmental justice communities experience from climate change. With the adoption of this policy in 2019, the Commission has continued to fold the foundations of environmental justice and equitable planning into its sea level rise adaptation work through LCP policies and CDP findings. Since adopting the Environmental Justice Policy, the Commission has been evaluating project proposals for potential impacts that may disproportionately harm overburdened communities or exacerbate long-standing inequities previously overlooked in Coastal Act analyses. By proactively considering potential impacts, the Commission has been able to identify and address environmental justice concerns associated with new development, as appropriate, through the addition of environmental justice findings in staff reports, working with applicants to modify project proposals, and conducting outreach and engagement with environmental justice partners.

Looking Ahead: Planning and Project Design with Sea Level Rise

The coast has always been a place of change due to land modifications such as erosion and vertical land motion, and to water variability such as tides, waves, and storms. Despite this dynamic nature, many areas of the California coast have been developed with an expectation that there will be some permanence to the land area and site safety. Development efforts have used such techniques as setbacks, avoidance of existing floodplain areas, elevation above some base flood level, and compliance with design standards to reduce or minimize coastal risks and to ensure an acceptable level of safety.

However, hazards are rarely eliminated or avoided completely. Sea level rise will exacerbate existing hazards and reduce the period of time over which some existing development can remain relatively safe. As noted in Governing California through Climate Change, "The notion of stable, predictable geography in which to live, work and build permanent buildings will be off the table in decades ahead" (Little Hoover Commission 2014, p. 2). Locations that might have seemed relatively safe from erosion or flooding 20 or 30 years ago may now be shown to have greater vulnerability due to sea level rise. Sites that might have seemed safe for 80 or 100 years might now only be safe for 40 or 50 years.

As coastal change accelerates, it will become more apparent that development close to the coast cannot be treated in the same way as more inland development, where hazardous conditions may be less dynamic. Coastal dynamics have long been part of land use planning considerations and project design; however, the focus on this change will grow in importance with rising sea level. This may mean that as properties are evaluated for proposed development, the type and intensity of the proposed development may need to change to address the dynamic nature of the property and changing nature of the hazards. As coastal areas erode, the carrying capacity of the area may need to be revised. The trend of redeveloping with additions and larger structures may need to change to one of maintaining what is there or redeveloping with smaller structures that better suit site constraints. A variety of nature-based adaptation strategies and other more innovative adaptation strategies must be considered as well. The changing expectations are an important aspect of sea level rise adaptation and are an important part of the following discussions on how to include sea level rise in Local Coastal Programs, applications for Coastal Development Permits, and adaptation planning.

Sea level rise is one of many climate change effects that will have impacts on coastal resources and development along the California coast. Accelerated coastal erosion, changing precipitation patterns, increasing temperatures, and more extreme storms will pose planning challenges in concert with sea level rise. There are other climate change impacts in the coastal zone, such as changes in water supply, terrestrial habitats, and fire hazards, that are also important to consider in decision making, and the Commission intends to provide guidance on a range of anticipated climate change impacts in the future.

Beyond these physical changes, sea level rise poses a significant threat to human livelihoods. Decades of racism, discrimination, and exclusionary policies and practices mean environmental justice communities will face an inequitable burden from sea level rise impacts (Roos, 2018). Planning for sea level rise and coastal resilience should include environmental justice communities as part of the planning and decision-making process to ensure that environmental burdens and benefits in their communities are properly considered and addressed in an equitable manner. Recognizing the need to integrate environmental justice and equity into sea level rise adaptation planning, the Coastal Commission will continue to work with environmental justice communities and leaders to improve and uplift these communities in coastal resilience planning efforts.

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Chapter 2. Principles for Addressing Sea Level Rise in the Coastal Zone

This chapter summarizes the Coastal Commission's framing principles for addressing sea level rise, many of which derive directly from the requirements of the Coastal Act. These principles broadly lay out the common ideas and a framework by which sea level rise planning and permitting actions can be assessed, and as such, represent the goals to which actions should aspire. Individual actions and outcomes may vary based on a variety of factors, including applicable policies and location- or project-specific factors that may affect feasibility. There are five categories of principles: using science to guide decisions; minimizing coastal hazards through planning and development standards; maximizing protection of public access, recreation, and sensitive coastal resources; maximizing agency coordination, meaningful engagement, and public participation; and prioritizing environmental justice communities. Each category groups important and related concepts that are central to addressing the challenge of rising sea levels. Building on the cumulative knowledge and experience of the Commission, subsequent chapters of this Guidance use these principles to frame practical guidance for addressing sea level rise through planning and permitting decisions in the coastal zone, consistent with the statewide policies of the California Coastal Act and SB 272, and the vision of climate resilience outlined in the State Sea Level Rise Guidance (OPC 2024), the California Climate Adaptation Strategy (2021), Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action, and the State Agency Sea-Level Rise Action Plan for California (2022), among other guiding state documents.

USE SCIENCE TO GUIDE DECISIONS [Coastal Act Sections 30006.5; 30335.5; 30270]

1. **Recognize and address sea level rise as necessary in planning and permitting decisions.** Address sea level rise science in all applicable coastal management and decision-making processes, including Local Coastal Programs (LCPs), Port Master Plans (PMPs), Public Works Plans (PWPs), Long Range Development Plans (LRDPs), Coastal Development Permits (CDPs), federal consistency reviews, and other Coastal Act decision processes. Sea level rise should be addressed in both hazard analyses and identification of adaptation strategies/alternative analyses, consistent with the policies of the Coastal Act and LCPs as applicable.[16]

[16] This Guidance document is intended to help implement the Coastal Act and LCPs in the context of sea level rise concerns. However, the standard of review for Commission actions remains the California Coastal Act or applicable certified LCPs. In particular, the recommendations of this Guidance do not constitute "enforceable policies" for purposes of CZMA federal consistency reviews. The enforceable policies for conducting federal consistency reviews will remain the policies of Chapter 3 of the Coastal Act. Also, for federal agency activities, the standard is consistency "to the maximum extent practicable," with Chapter 3, i.e., federal agency activities must be fully consistent unless existing law applicable to the federal agency prohibits full consistency. See 15 CFR. §§ 930.32 and 930.43(d). However, the Commission looks at sea level rise as one part of determining the coastal effects from an activity through CZMA federal consistency reviews and the use of this Guidance by all parties should help determine what those coastal effects may be or how effects from sea level rise may be mitigated. Pursuant to 15 CFR § 930.11(h), implementation of this guidance would not be grounds for an objection (because it is not an "enforceable policy") but it might be one means that "would allow the activity to be conducted consistent with the enforceable policies of the program" in order to avoid an objection. Implementation of this guidance would not be grounds for an objection (because it is not an "enforceable policy") but it might be one means that "would allow

2. **Use the best available science to determine locally relevant (context-specific) sea level rise scenarios and potential impacts for all Coastal Act planning processes, project design, and permitting reviews.** Sea level rise science continues to evolve, and some processes that are not fully understood (e.g., ice sheet dynamics) could potentially have large effects on future sea level rise. At the time of this 2024 update, the best available science on sea level rise in California is the State of California Sea Level Rise Guidance: 2024 Science and Policy Update (OPC 2024) (See Table 2 and Appendix F). As discussed in greater detail in Chapter 3 of this Guidance, these scenarios should be used in a scenario-based analysis to identify potential local impacts from sea level rise, incorporating storms, extreme water levels, and shoreline change. Other authoritative sea level rise science and projections may also be used, in part or in full, provided they are peer-reviewed, widely accepted within the scientific community, and locally relevant. The Commission will re-examine the best available science periodically and as needed with the release of new information on sea level rise.[17]

3. **Recognize and address scientific uncertainty using scenario planning and adaptive management techniques.** Given the uncertainty in the magnitude and timing of future sea level rise, particularly over longer time periods, planners and project designers should use scenario-based analysis to examine a range of possible shoreline changes and sea level rise risks to shape LCPs and other plans and project development designs. As appropriate, development projects, resource management plans, and LCP and other planning updates should incorporate an adaptive, or phased, management framework with regular monitoring, reassessments, and dynamic adjustment in order to account for uncertainty.

4. **Use a precautionary approach by analyzing, planning, and providing adaptive capacity for the higher end of the range of possible sea level rise.** LCPs and CDPs should analyze the Intermediate, Intermediate-High, and/or High sea level rise scenarios, as appropriate, in order to understand the implications of a worst case scenario.[18] In some cases, it may be appropriate to *design* for the local hazard conditions that will result from more moderate sea level rise scenarios, as long as decision makers and project applicants *plan* for adaptation pathways that would allow for the implementation of alternative strategies if conditions change more than anticipated in the initial design. Looking at both high and low scenarios allows users to build an understanding of the overall risk sea level rise poses to the region or site. Chapters 3, 5, and 6 have additional detail regarding how to choose appropriate sea level rise scenarios.

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the activity to be conducted consistent with the enforceable policies of the program" in order to avoid an objection.

[17] Major scientific reports include the release of National and State Climate Assessments, IPCC Assessment Reports, and/or State guidance.

[18] The High scenario in the 2024 OPC State Sea Level Rise Guidance is considered a reasonable worst case scenario to inform adaptation planning. While even higher SLR projections are possible, as reflected in the IPCC's Sixth Assessment Report, those projections rely on a combination of assumptions about the climate future that are deemed too unlikely to inform planning at this time.

5. **Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.** Design adaptation strategies using best management practices for adaptation, and tailor the design to the specific conditions and development patterns of the area, in accordance with the Coastal Act and certified LCPs. LCPs should continue to serve as a key implementing mechanism for these adaptation strategies. Adaptation strategies should be evaluated for their ability to both minimize hazards and protect coastal resources.

Table 2. Sea Level Rise Scenarios for California [19]

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

[19] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the *State Sea Level Rise Guidance* and this guidance recommend for use in various planning and project contexts.

MINIMIZE COASTAL HAZARD RISKS THROUGH PLANNING AND DEVELOPMENT STANDARDS [Coastal Act Sections 30253, 30235, 30270, 30001, 30001.5]

6. **Avoid significant coastal hazard risks to new development where feasible.** Section 30253 of the Coastal Act requires new development to minimize risks to life and property in areas of high geologic and flood hazard. Read together with Section 30270, the Act requires that sea level rise is accounted for when risks are assessed and minimized. The strongest approach for minimizing hazards is to avoid siting new development within areas vulnerable to flooding, inundation, and erosion over the full life of the development, thus ensuring stable site conditions without the need for long-term financial and resource commitments for protective devices. Methods to direct new development away from hazardous locations are included in Chapter 7 of this Guidance.

7. **Minimize hazard risks to new development over the life of the authorized development.** Coastal Act Section 30253 requires that new development minimize coastal hazard risks without the use of bluff retaining or shoreline protection devices that would substantially alter natural landforms along bluffs and cliffs. When hazards from sea level rise cannot be avoided, new development should include provisions to ensure that hazard risks are minimized for the life of the development without shoreline protection, including through future modification, relocation, or removal when development becomes threatened by natural hazards, including as exacerbated by sea level rise.

8. **Minimize coastal hazard risks and resource impacts when making redevelopment decisions.** LCPs should encourage and require, as applicable, existing at-risk structures to be brought into conformance with current standards when redeveloped. Improvements to existing at-risk structures should be limited to basic repair and maintenance activities and not extend the life of such structures or expand at-risk elements of the development, consistent with the Coastal Act.

9. **Account for the social and economic needs of the people of the state, including environmental justice and tribal priorities; assure priority for coastal-dependent and coastal-related development over other development.** In planning and project development concerning sea level rise, assure that the social and economic needs of the people of the state are accounted for in accordance with Coastal Act Section 30001.5(b), with special consideration for working persons employed within the coastal zone (Coastal Act Section 30001(d)). Recognize that environmental justice and tribal communities are less equipped to prepare for and respond to the impacts of sea level rise. Ensure that LCP and CDP decisions account for environmental justice and tribal concerns and engage with these communities early, often, and meaningfully in planning efforts.

10. **Ensure that property owners understand and assume the risks and mitigate the coastal resource impacts of new development in hazardous areas.** Property owners should assume the risks of developing in a hazardous location (often referred to as internalizing risk). They should be responsible for modifying, relocating or removing new development if it is

threatened or damaged in the future. Any actions to minimize risks to new development should not result in current and/or future encroachment onto public lands or in impacts to coastal resources inconsistent with the Coastal Act and Public Trust Doctrine. LCPs and Coastal Development Permits should require recorded assumptions of risk, “no future seawall” conditions, and/or other appropriate mitigation measures to internalize risk decisions with the private landowner.

MAXIMIZE PROTECTION OF PUBLIC ACCESS, RECREATION, AND SENSITIVE COASTAL RESOURCES

[Coastal Act Chapter 3 policies]

11. **Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.** New and existing development, redevelopment, and repair and maintenance activities as well as associated sea level rise adaptation strategies should avoid or minimize impacts to coastal resources, including public access, recreation, marine resources, agricultural areas, sensitive habitats, archaeological resources, and scenic and visual resources in conformity with Coastal Act requirements. Impacts from development and related activities should be avoided or minimized; unavoidable impacts should be mitigated as necessary.

12. **Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.** If existing development (both private and public) is threatened by sea level rise hazards, it should employ the least environmentally damaging feasible adaptation alternatives and minimize hard shoreline protection. Priority should be given to options that enhance and maximize coastal resources and access, including innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. If traditional hard shoreline protection is necessary and allowable under the Coastal Act, use the least-environmentally damaging feasible alternative, incorporate projections of sea level rise into the design of protection, and limit the time-period of approval, for example, to the life of the structure the device is protecting. Major renovations, redevelopment, or other new development should not rely upon existing shore protective devices for site stability or hazard protection. Where feasible, existing shoreline protection that is no longer being relied upon in this way, or no longer needed otherwise, should be phased out.

13. **Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.** Where allowed under the Coastal Act or the relevant LCP, shoreline protective devices should be sited, designed, and conditioned to ensure that they do not result in the loss of public trust lands[20] or encroach

[20] The State holds and manages all tidelands, submerged lands, and beds of navigable waterways for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine (“public trust”). In coastal areas, the landward location and extent of the State's trust lands are generally defined by reference to the ordinary high water mark, as measured by the mean high tide line. Public trust uses include such

onto public trust lands without the permission of the appropriate trustee agency. When sea level rise causes the public trust boundary to move inland such that a protective device that was located on uplands becomes subject to the public trust, the permittee should either obtain permission from the appropriate trustee agency for the encroachment or apply for a permit to remove any encroachments.

14. **Address potential secondary coastal resource impacts (to wetlands, habitat, agriculture, scenic and visual resources, *etc.*) from hazard management decisions, consistent with the Coastal Act.** Actions to address sea level rise in LCPs or permits should not exacerbate other climate-related vulnerabilities or undermine conservation/protection goals and broader ecosystem sustainability. For example, siting and design of new development should not only avoid sea level rise hazards, but also ensure that the development does not have unintended adverse consequences that impact sensitive habitats or species in the area.

15. **Address the cumulative impacts and regional contexts of planning and permitting decisions.** Sea level rise will have impacts at both the site-specific and regional scales. In addition to the evaluation of site-specific sea level rise impacts, LCPs and projects should include an evaluation of the broader region-wide impacts, in two different contexts. First, the LCP or project should consider how sea level rise impacts throughout an entire littoral cell or watershed could affect the LCP jurisdiction or project. Second, the LCP or project should consider how options to adapt to sea level rise could result in cumulative impacts to other areas in the littoral cell or watershed. Actions should be taken to minimize any identified impacts.

16. **Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.** Require mitigation for unavoidable public resource impacts over the life of the structure as a condition of approval for the Coastal Development Permit. For example, for impacts to sand supply or public recreation due to armoring and the loss of sandy beach from erosion in front of shoreline protection devices, require commensurate in-kind mitigations, a sand mitigation fee, and other necessary mitigation fees (for example, public access and recreation mitigation). Because the longer term effects can be difficult to quantify, especially given uncertainty about the exact rate of future sea level rise, consider requiring periodic re-evaluation of the project authorization and mitigation for longer term impacts.

17. **Consider best available information on resource valuation when planning for, managing, and mitigating coastal resource impacts.** Planning, project development, and mitigation planning should evaluate the societal and ecosystem service benefits of coastal resources at risk from sea level rise or actions to prepare for sea level rise. These benefits can include flood protection, carbon sequestration, water purification, tourism and recreation

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uses as maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration.

opportunities, and community character. Resource values can be quantified through restoration costs or various economic valuation models.

MAXIMIZE AGENCY AND TRIBAL COORDINATION, MEANINGFUL ENGAGEMENT, AND PUBLIC PARTICIPATION [Coastal Act Chapter 5; Sections 30006; 30320; 30339; 30500; 30503; 30711]

18. **Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.** Given the multitude of sea level rise planning, research, and guidance efforts occurring in California, it is critical for agencies and organizations to share information, coordinate efforts, and collaborate where feasible to leverage existing work efforts and improve consistency. Additionally, since many sea level rise hazards affect multiple jurisdictions, their management may also need to be coordinated through multi-agency reviews and coordinated decision making. The Commission will continue to meet this goal through coordination, engagement with stakeholders, and trainings. However, ongoing financial support for these Commission efforts is critical.

19. **Coordinate with tribes to address tribal priorities and concerns when making planning decisions**. The Commission will, and local governments should, evaluate and address tribal cultural resources, practices, and traditions that may be affected as a result of sea level rise. The Commission's Tribal Consultation Policy (2018) provides recommendations for government-to-government coordination with tribes and a more specific process to work cooperatively, communicate effectively, and consult with tribes for the mutual benefit of protecting coastal resources.

20. **Consider conducting vulnerability assessments and adaptation planning at the regional level**. Where feasible, local governments should coordinate vulnerability assessments and adaptation planning with other jurisdictions in the region that face common threats from sea level rise. A regional vulnerability assessment provides an opportunity to evaluate impacts that span multiple jurisdictions, assess and implement regional adaptation strategies, coordinate responses, and leverage research and planning funds.

21. **Provide for maximum public participation and meaningful engagement in planning and regulatory processes.** The Coastal Commission will continue to provide avenues for maximum public participation in planning and regulatory processes, and will continue to establish and/or expand non-traditional alliances (e.g., between/among public and private resource managers, tribes, community-based organizations, non-profits, environmental justice leaders, scientists, decision makers), share knowledge openly and actively, and regularly and clearly communicate to the public on the science as well as on a range of solutions to prepare for sea level rise.

PRIORITIZE ENVIRONMENTAL JUSTICE COMMUNITIES

[California Coastal Commission Environmental Justice Policy; Coastal Act Sections 30006, 30013, 30320, 30339, 30500, 30503, 30604(h), 30711]

22. **Consider environmental justice when making planning decisions**. The Commission will, and local governments should, evaluate and address any disproportionate environmental and public health burdens these communities may experience as a result of sea level rise impacts. This includes identifying potentially impacted environmental justice communities and conducting meaningful engagement with these communities throughout the planning process.

This document and its guiding principles both reflect and complement the priorities outlined in the California Climate Adaptation Strategy (2021), Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action (2021), and the State Agency Sea-Level Rise Action Plan for California (2022), among other guiding state documents. While this Guidance specifically focuses on the California Coastal Act and the regulatory work of the Coastal Commission, it also echoes key concepts in these statewide documents. For example, a central goal of the California Climate Adaptation Strategy is to strengthen protections for climate vulnerable communities (Goal A) and Principle 7 of the Principles for Aligned State Action on sea level rise is to integrate and prioritize equity and environmental justice, which is addressed here in Guiding Principle #9. Similarly, this Guidance, the Climate Adaptation Strategy, and the Principles for Aligned State Action all emphasize the use of best available science (Guiding Principle #2, Priority 5, and Principle 1, respectively) and the need for communication, outreach, and public participation to increase understanding of climate risks and adaptation options (Guiding Principle #20 and Principle 3, respectively).

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Chapter 3. Sea Level Rise Science

This chapter covers the following subjects:

- The best available science on sea level rise
- Guidance on the application of best available science for activities subject to Coastal Act review
- Using scenario-based analysis and adaptation pathways in response to the uncertainty regarding anticipated amounts of sea level rise
- The physical impacts of sea level rise
- Storms and extreme events

Sea level rise science continues to evolve, and the discussion below reflects the best available science at the time this document was published.

Best Available Science on Sea Level Rise

Scientists widely agree that the climate is changing and that it has led to global increases in temperature and sea level. In the past century, global mean sea level (GMSL) has increased by nearly 8 inches (20 cm; Fox-Kemper *et al*., 2021). The Intergovernmental Panel on Climate Change's (IPCC) most recent report, the *Sixth Assessment Report* (AR6), states that human activities have unequivocally caused global warming, with global surface temperatures in 2011–2020 reaching 1.1°C above temperatures observed in 1850–1900. It also states that human influence was very likely the main driver of sea level rise since at least 1971, and that GMSL has risen faster since 1900 than over any preceding century in at least the last 3000 years (IPCC 2021).

Observations of sea level rise rates have also shown that global sea level rise has been accelerating in recent decades. While tide gauge measurements show roughly 5 inches of global mean sea level rise during the entirety of the 20th century (Frederikse *et al*., 2020), satellite altimeters have measured an additional 4 inches of sea level rise since 1993, a period of only 30 years (Willis, Hamlington, Fournier, 2023). The current rate of GMSL rise (1.7 inches/decade) is triple the 20th century rate (Dangendorf *et al*., 2019; Nerem *et al*., 2018).

Scientists measure and project sea level change at a variety of scales, from the global down to the local level. The global sea level rise projections in IPCC reports are based on large-scale models as well as scientific understanding of the historical climate and best available information regarding climate sensitivity (IPCC 2021). Global average sea level rise is driven by the expansion of ocean waters as they warm (thermal expansion), the addition of freshwater to the ocean from melting ice sheets and glaciers, and from extractions in groundwater (Figure 3).

However, regional and local factors such as tectonics and ocean and atmospheric circulation patterns can cause different parts of the globe to experience relative sea level rise rates that may be higher or lower than the global average. As such, global-scale models are often "downscaled" through a variety of methods to provide locally relevant data.

For California, the Ocean Protection Council's 2024 State of California Sea Level Rise Guidance, described below (with additional detail in Appendix A), provides both statewide average sea level rise scenarios as well as scenarios that have been refined for 14 tide gauges throughout California.[21] While these tide gauge-specific sea level rise scenarios are fairly similar throughout the state, the physical impacts experienced in each location may be quite different, and locally-specific analysis of impacts will be very important. Detail on physical impacts and how to assess them is provided in this chapter and in Appendix B.

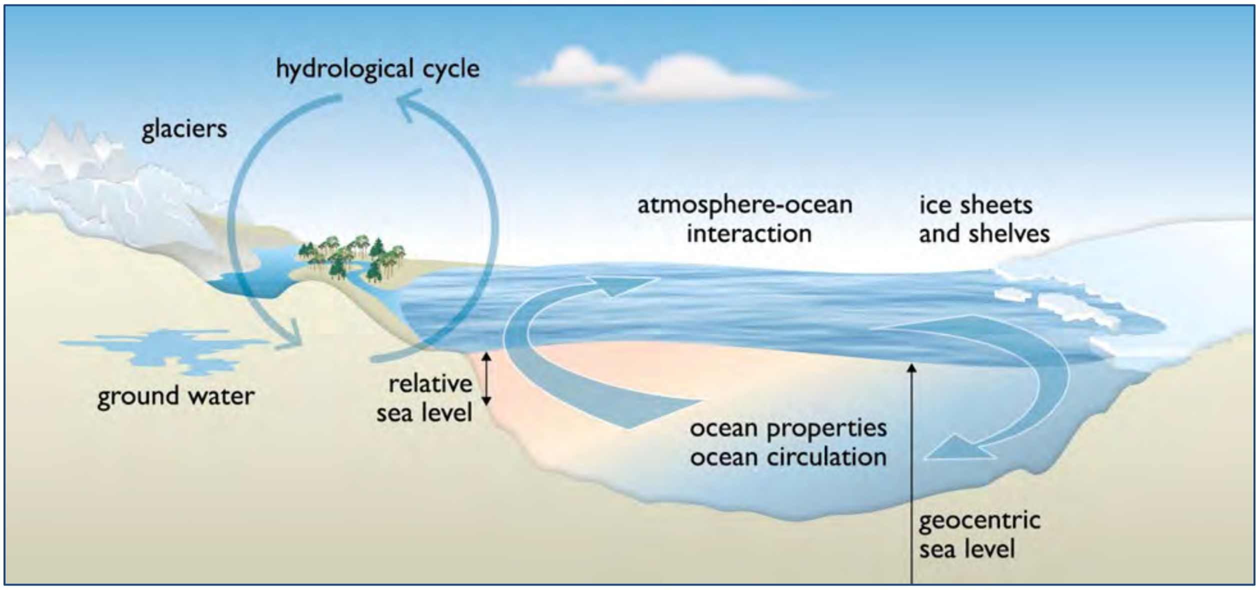

Figure 3. Climate-sensitive processes and components that can influence global and regional sea level. Changes in any one of the components or processes shown will result in a sea level change. The term "ocean properties" refers to aspects such as temperature, salinity, and density, which influence and are dependent on ocean circulation. (*Source*: IPCC 2013, Figure 13.1)

Global Sea Level Rise Projections

The IPCC Sixth Assessment Report, Climate Change 2021: the Physical Science Basis (AR6) was released in 2021 (IPCC 2021). AR6 describes both a *plausible range* of potential future sea level rise, as well as a more narrow *likely range*. IPCC's full *plausible range* of future sea level rise reflects how sea level rise would vary under the IPCC's range of conceivable global development, emissions, and warming futures (which are called Shared Socioeconomic Pathways, or SSPs[22]) as well as the possibility of rapid ice sheet disintegration. Below is a graph

[21] For any given analysis, sea level rise scenarios for the closest of the 14 tide gauges can be used, or where very localized GPS data is available allowing more resolved estimates of vertical land motion, these can be added to the statewide average scenario values provided in this chapter and in Appendix G.

[22] The Scenario Model Intercomparison Project (ScenarioMIP) for the Coupled Model Intercomparison Project Phase 6 (CMIP6) developed five different Shared Socioeconomic Pathways (SSP1 through SSP5) (O'Neill *et al.*, 2016). These SSPs capture different ways the world could evolve in terms of population, economic growth, education, urbanization, and technological development, which would each result in various amounts of radiative

generated by NASA and the IPCC's Sea Level Projection Tool that depicts all of AR6's global mean sea level rise projections (Figure 4).

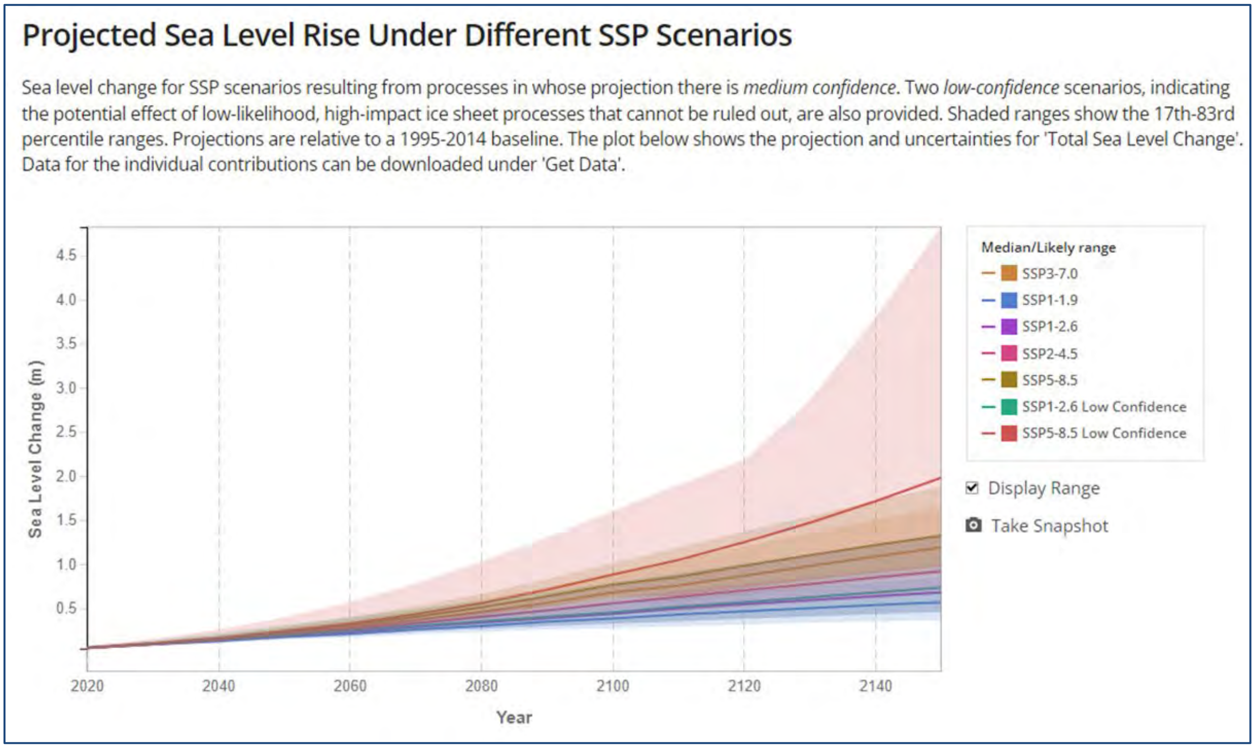

Figure 4. IPCC AR6 plausible range of future sea level rise. A graph generated by NASA and the IPCC's Sea Level Projection Tool that depicts the global mean sea level rise projections under all five SSPs, plus the two additional projections that incorporate additional low confidence ice sheet processes.

In addition to the full plausible range of sea level rise, AR6 identifies a narrower *likely range* of future sea level rise. It distinguishes the projections that are based on processes in which the authors have at least medium confidence (e.g., thermal expansion of seawater and some ice sheet and glacier melt processes) from those in which they have "low confidence" due to a present lack of sufficient research (i.e., processes that would lead to rapid ice sheet disintegration). IPCC therefore describes the shaded regions of Figure 5 below as the likely range of sea level rise by 2100 and the dashed line as a low-likelihood, high impact scenario that includes ice sheet instability processes and cannot be ruled out due to deep uncertainty in those processes.

forcing (a measure of warming), which is expressed in the second half of the SSP name. For example, SSP3-7.0 comes from SSP3 and results in 7.0 Watts/m^2 of radiative forcing.

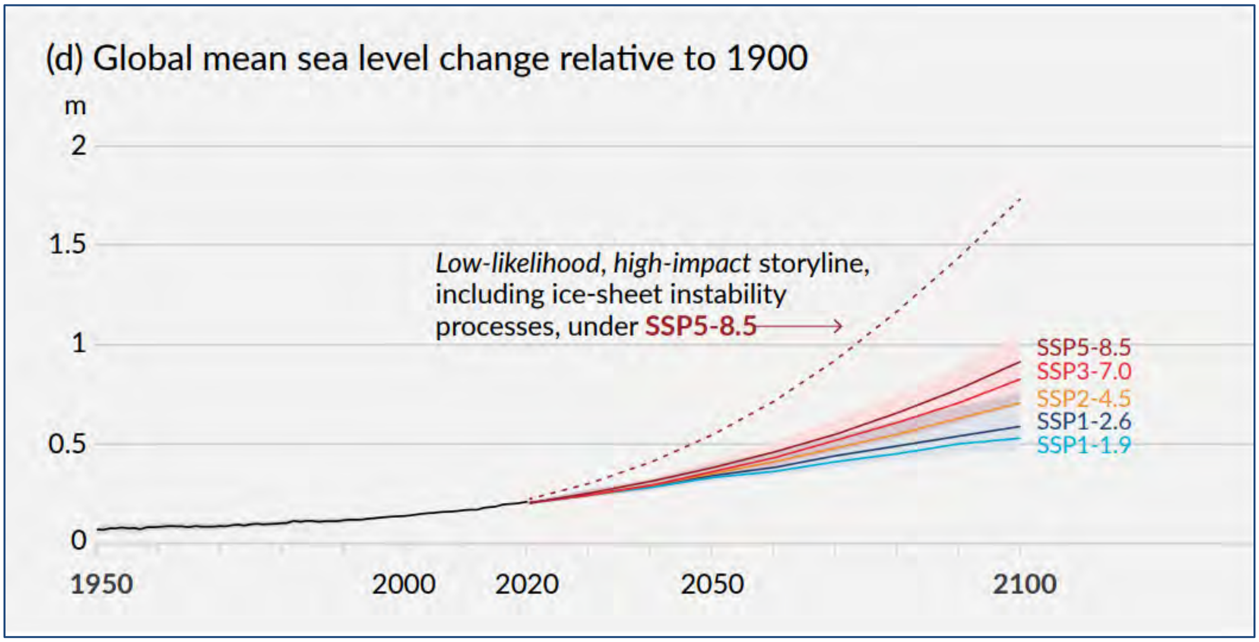

Figure 5. IPCC AR6 SLR projections by 2100. This figure is figure SPM.8(d) in AR6 Summary for Policymakers, and its caption reads, in part, "Only likely ranges are assessed for sea level changes due to difficulties in estimating the distribution of deeply uncertain processes. The dashed curve indicates the potential impact of these deeply uncertain processes. It shows the 83rd percentile of SSP5-8.5 projections that include low-likelihood, high-impact ice-sheet processes that cannot be ruled out; because of low confidence in projections of these processes, this curve does not constitute part of a likely range."

After the publication of sea level rise projections in AR6 in 2021, NOAA's Global and Regional Sea Level Rise Scenarios for the United States (Sweet *et al*., 2022) provided a set of five global mean sea level rise scenarios – hypothetical trajectories of future sea level rise spanning the scientifically plausible range defined by the IPCC[23]. These five scenarios were benchmarked to 0.3, 0.5, 1.0, 1.5, and 2.0 meters-in-2100 and were called the Low, Intermediate-Low, Intermediate, Intermediate-High and High, respectively. Below is a graph generated by NASA Interagency Sea Level Rise Scenario Tool that depicts these five sea level rise scenarios (Figure 6).

NOAA deemed the High scenario, which includes 2.0 meters of sea level rise in the year 2100, to be a reasonable high-end sea level rise scenario for the year 2100 due to updated research on potential mechanisms of rapid ice sheet disintegration. Namely, DeConto *et al*., 2021 used updated regional climate model forcing to find that air temperatures may trigger mechanisms of rapid retreat of the Antarctic Ice Sheet[24] by about the year 2125 – and the associated extreme sea level rise trajectory could reach approximately 2.0 meters in 2100.

[23] For an explanation of the difference between sea level rise projections and sea level rise scenarios, please see Appendix A.

[24] DeConto *et al*., 2021 updated DeConto *et al*., 2016, which provided the basis for the H++ sea level rise scenario included in the past iteration of the OPC *State Sea Level Rise Guidance* and the past iteration of this policy guidance document. DeConto *et al*., 2021 found that, when considering updated climate models, the processes of

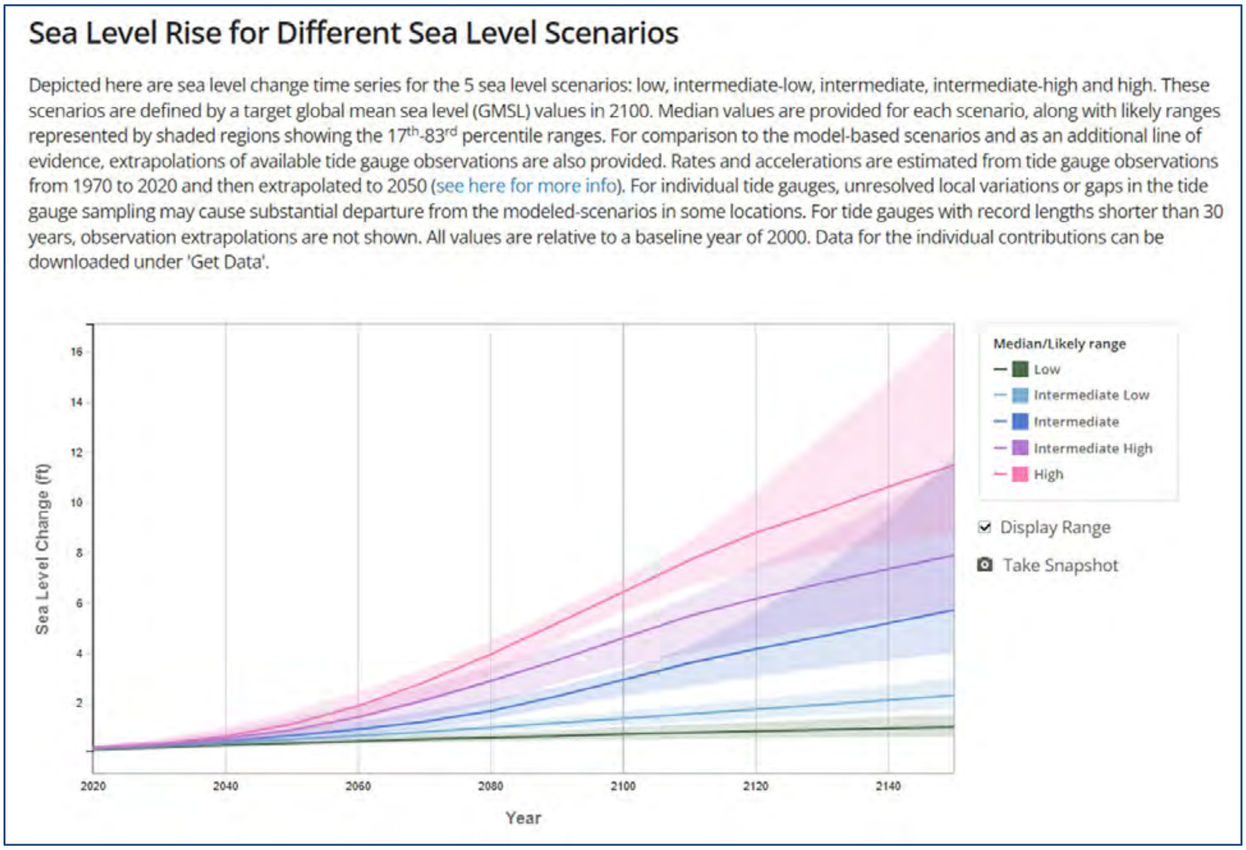

Figure 6. Global Sea Level Rise Scenarios from Sweet *et al*., 2022. This graph was generated by NASA Interagency Sea Level Rise Scenario Tool and depicts Sweet *et al*., 2022's five global mean sea level rise scenarios.

National Sea Level Rise Projections

In addition to providing global mean sea level rise scenarios, Global and Regional Sea Level Rise Scenarios for the United States (Sweet *et al*., 2022) provided scenarios for the contiguous United States by regionalizing its five global scenarios. These regionalized scenarios reflect how sea level rise around the United States may differ from the global average due to ocean dynamics (i.e., changes to the ocean's currents and density due to climate change), large scale vertical land motion (i.e., glacial isostatic adjustment (GIA), tectonics, sediment compaction, and/or groundwater and fossil fuel withdrawals), and the impacts of gravitational, rotational, and deformational (GRD) changes (i.e., ice sheet fingerprinting). In general, sea level rise scenarios for the United States are similar to or higher than global mean sea level rise due to effects from these regional influences on sea level (Sweet *et al*., 2022). Below is a graph generated by NASA Interagency Sea Level Rise Scenario Tool that depicts the five sea level rise scenarios regionalized for the contiguous United States (Figure 7).

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rapid ice sheet disintegration would be delayed about 25 years relative to DeConto et al 2016. (DeConto et al., 2021 states, "With more extreme RCP8.5 warming, thinning and hydrofracturing of buttressing ice shelves becomes widespread, triggering marine ice instabilities in both West and East Antarctica. The RCP8.5 median contribution to GMSL is 34 cm by 2100. This is substantially less than reported by ref. 8 [DeConto & Pollard 2016] (64–105 cm), owing to a combination of improved model physics and revised atmospheric forcing (Methods) that delays the onset of surface melt by about 25 years.")

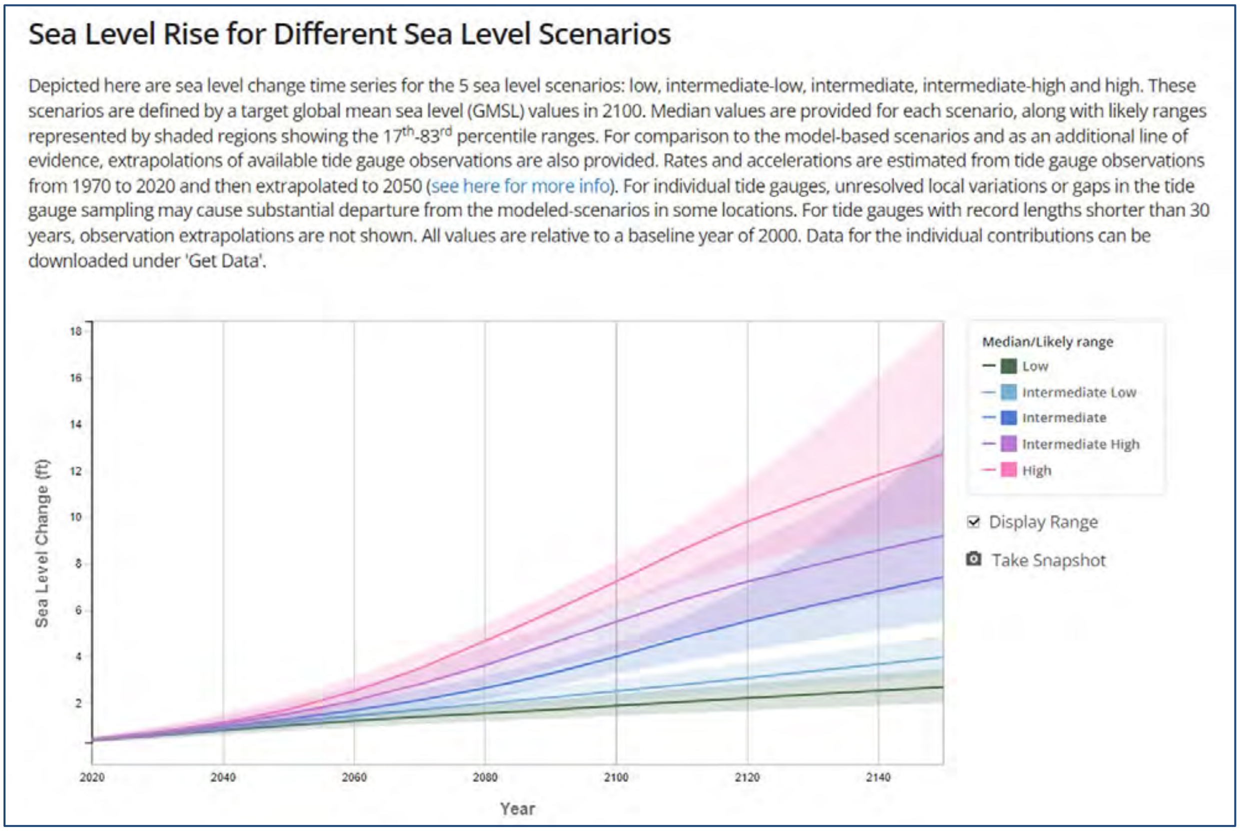

Figure 7. Sea level rise scenarios for the contiguous United States from Sweet *et al*., 2022. This graph was generated by NASA Interagency Sea Level Rise Scenario Tool and depicts Sweet *et al*., 2022's five sea level rise scenarios for the contiguous United States.

Sea Level Rise Projections for California

The State of California has long supported the development of scientific information on climate change and sea level rise to help guide planning and decision-making. Several iterations of the *State Sea Level Rise Guidance* have been informed by key research that, at the time, provided the best available science on sea level rise projections:

- The 2013 State Sea-Level Rise Guidance (OPC 2013) was informed by the 2012 National Research Council (NRC) report, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.
- The 2018 State Sea Level Rise Guidance (OPC 2018) was informed by Rising Seas in California: An Update on Sea-Level Rise Science (Griggs et al., 2017).
- The 2024 State Sea Level Rise Guidance (OPC 2024) was informed by Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al., 2022).

The California Coastal Commission has historically aligned its *Sea Level Rise Policy Guidance* with the best available science provided in each iteration of the *California State Sea Level Rise Guidance*, as has been done here.

The 2024 State Sea Level Rise Guidance (OPC 2024) provides the same five sea level rise scenarios as Sweet *et al*., 2022[25] with further downscaling to reflect regional and local influences on sea level rise in California. Scenarios are provided for California as a whole, reflecting statewide average vertical land motion, as well as for each of the 14 tide gauge locations in the state to reflect local vertical land motion. The median statewide values are shown below in Table 3. The tide gauge-specific scenarios are provided in Appendix 2 of the State Sea Level Rise Guidance (2024) and in Appendix F of this document.

Table 3. Sea Level Rise Scenarios for California [26]

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

[25] Please see Chapter 2 of the 2024 State Sea Level Rise Guidance to read the report's full summary of how the sea level rise scenarios were generated.

[26] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the *State Sea Level Rise Guidance* and this guidance recommend for use in various planning and project contexts.

To describe the likelihood of each scenario occurring in the future, the State Sea Level Rise Guidance (OPC 2024) compares each scenario to AR6 to derive information about what would have to happen in the future climate for each one to come to pass. The State Guidance presents these "storylines" as follows:

- **"Low Scenario**: The target of 1 foot of increase in global sea level rise by 2100 is set under the assumption of the current rate of sea level rise continuing on into the future. This assumption is inconsistent with current observations of an acceleration in sea level rise, but could still be considered plausible under the most aggressive emission reduction scenarios. As a result, the Low Scenario provides the lower bound for plausible sea level rise in 2100 and sits below the median value for all AR6 scenarios at all times between 2020 to 2150. The likelihood of exceeding this Sea Level Scenario is greater than 90% at all warming levels.
    - SUMMARY: Aggressive emissions reductions leading to very low future emissions; the scenario is on the lower bounding edge of plausibility given current warming and sea level trajectories, and current societal and policy momentum.

- **Intermediate-Low Scenario:** This scenario arises under a range of both future warming levels and possible SSPs, spanning low, intermediate and high emissions pathways, and integrates many of the AR6 SSP pathways as a result (see Figure 2.2). This scenario is consistent with the median projected sea level rise in a 2°C world, which means there is a 50% probability of exceeding this scenario with 2°C of additional warming by 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 82%. Given the extrapolation of GMSL to 2100 (approximately 2.2 feet), the current projection of future warming of 3°C, and the range of sea level rise across the IPCC AR6 scenarios (Figure 2.4), the Intermediate Low Scenario provides a reasonable lower bound for the most likely range of sea level rise by 2100. Since the low confidence processes are not important to this scenario, the range of possible sea level rise after 2100 does not expand significantly.
    - SUMMARY: A range of future emissions pathways; a reasonable estimate of the lower bound of most likely sea level rise in 2100 based on support from sea level observations and current estimates of future warming.

- **Intermediate Scenario**: The Intermediate Scenario is driven dominantly by high emissions scenarios, and thus higher warming levels. For the first time in the scenarios, the low confidence projections from the IPCC AR6 contribute significantly and provide about 25% of the pathways for reaching the Intermediate Scenario target by 2100. Given the extrapolation of GMSL to 2100 and the range of sea level rise across the IPCC AR6 scenarios (Figure 2.4), the Intermediate Scenario provides a reasonable upper bound for the most likely range of sea level rise by 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 5%. In a very-high emissions future with low confidence processes, there is about a 50% chance of exceeding the Intermediate scenario in 2100.

  - SUMMARY: A range of future emissions pathways; could include contribution from low confidence processes. Based on sea level observations and current estimates of future warming, a reasonable estimate of the upper bound of most likely sea level rise in 2100.

- **Intermediate-High Scenario**: Pathways combining both higher emissions and low confidence processes become the majority, with over 50% of the samples used to construct this scenario coming from the SSP5-8.5 scenario. At all times from 2020 to 2150, the Intermediate High Scenario exceeds the median value of the AR6 scenarios. This scenario is similar to the high-end estimate from van de Wal et al. (2022) under the assumption of high levels of warming in 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 0.1% when not considering the low confidence processes, emphasizing the degree to which these processes are needed to get to this scenario. With the low confidence processes, the probability of exceeding this scenario is approximately 20% for very high warming levels.
  - SUMMARY: Intermediate-to-high future emissions and high warming; this scenario is heavily reflective of a world where rapid ice sheet processes are contributing to sea level rise.

- **High Scenario:** Pathways combining both high emissions and low confidence processes are dominant, providing over 80% of the samples to construct the scenario. Low emissions pathways are not plausible under this scenario, and intermediate emissions pathways require a significant contribution from rapid ice sheet loss processes. Before 2100, the High Scenario is significantly above the range of SSP AR6 scenarios, although the range of plausible sea level expands beyond 2150. The probability of exceeding the High Scenario in 2100 is less than 0.1% for all warming levels without considering low confidence processes. With very high emissions and warming and contributions from the low confidence processes, this probability increases to 8%.
  - SUMMARY: High future emissions and high warming with large potential contributions from rapid ice-sheet loss processes; given the reliance on sea level contributions for processes in which there is currently low confidence in their understanding, a statement on the likelihood of reaching this scenario is not possible."

The State Sea Level Rise Guidance also provides information about how likely each scenario is to occur in the year 2100 under various amounts of plausible future warming (the first five columns of Table 4). Likelihoods were also provided assuming rapid ice sheet disintegration processes come into play in the 2100s (the last two columns of Table 4). These likelihoods were derived from AR6, and they provide valuable information to inform our understanding of the likelihood that each scenario as well as the risk that the higher or lower scenarios may occur.

As explained in the State Guidance, this table can be read as saying, “assuming 3°C of warming in 2100 and no influence from low-confidence ice sheet processes, there is a 5% chance of exceeding the Intermediate scenario in 2100” or “assuming high levels of warming in 2100 and contributions from the low confidence processes, there is a 49% chance of exceeding the Intermediate Scenario in 2100” and so on. The State Guidance also explains that global surface temperatures are currently on track to reach 3.0°C above pre-industrial levels by 2100, assuming current rates of emissions-driven warming.

Table 4. Exceedance probabilities for the sea level scenarios based on IPCC warming level-based global mean sea level projections[27]

Global Mean Surface Air Temperature 2081-2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Low Confidence Processes, Low Warming	Low Confidence Processes, High Warming
Low Scenario	92%	98%	99.5%	99.9%	>99.9%	90%	99.5%
Intermediate-Low Scenario	37%	50%	82%	97%	99.5%	49%	96%
Intermediate Scenario	0.5%	2%	5%	10%	23%	7%	49%
Intermediate-High Scenario	0.1%	0.1%	0.1%	1%	2%	1%	20%
High Scenario	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	<0.1%	8%

As highlighted in Table 3, the State Sea Level Rise Guidance identifies the Intermediate, Intermediate-High, and the High scenarios as the most appropriate scenarios to use in technical analyses of future sea levels, consistent with its precautionary approach. The following section and Chapters 5 and 6 provide additional detail on how to use these sea level rise scenarios to guide SLR planning in the context of the California Coastal Act.

[27] The State Sea Level Rise Guidance provides the following explanatory information for this table: “Global mean surface air temperature anomalies are projected for years 2081–2100 relative to the 1850–1900 climatology. Global surface temperatures are currently on track to reach 3.0°C above pre-industrial levels by 2100, assuming current rates of emissions-driven warming… The probabilities shown here are imprecise probabilities, representing a consensus among all projection methods applied by the IPCC AR6.”

Comparing the 2024 Best Available Science to the 2018 Science

The previous iteration of this CCC guidance was published in 2018, and this document replaces and supersedes that one. Likewise, the previous iteration of the OPC's California State Sea Level Rise Guidance was published in 2018 and has since been replaced by a revised document published in 2024. Each document synthesized the best available science on sea level rise that was available at the time. The 2024 updates to both documents reflect additional research conducted since 2018.

Both 2018 guidance documents provided SLR projections based on the Rising Seas in California report (Griggs et al., 2017). Like the IPCC Assessment Reports, it provided probabilistic projections of sea level rise tied to high and low Representative Concentration Pathways (RCPs, or the IPCC's scenarios of future emissions levels) (RCP 8.5 and 4.5, respectively), which defined possible future amounts of global warming. In addition, both 2018 documents provided a standalone, extreme SLR scenario called H++, which illustrated the rate of SLR that could occur if the mechanisms of extreme ice sheet collapse occurred as described in the then-recently released paper, DeConto & Pollard, 2016 in a high emissions future (RCP 8.5). The guidance documents went on to define low, medium-high, and extreme (H++) risk aversion scenarios to use in various contexts that depended on the project and planning context.

The 2024 guidance documents provide updated sets of sea level rise amounts. Instead of probabilistic projections and a single H++ scenario, the 2024 updates include five SLR scenarios that span the plausible range of sea level rise included in IPCC's Sixth Assessment Report. These scenarios are slightly lower than the sea level rise amounts provided in the 2018 guidance documents. One main reason for this change is that additional research was conducted on possible extreme ice sheet melt (DeConto et al., 2021). This research incorporated updated climate models which found that the atmospheric warming needed to potentially trigger the processes of rapid ice sheet disintegration were delayed about 25 years relative to the earlier research (DeConto et al., 2016). Thus, the high amounts of SLR associated with the 2018 H++ scenario could occur if the ice sheet disintegration mechanisms begin (which is still an area of developing research), but they would occur about 25-30 years later than previously thought. Thus, while H++ included 10 feet of SLR in the year 2100, the High scenario in the 2024 Guidance documents includes 10 feet in the year 2130.

Similar to how the low, medium-high, and extreme risk aversion scenarios were recommended for use in different contexts in the 2018 guidance, the 2024 guidance recommends using the Intermediate, Intermediate-High, and High scenarios. More information on choosing appropriate SLR amounts is included in the next section and Chapters 5 and 6.

The Coastal Commission considers the State of California Sea Level Rise Guidance (OPC 2024) to be the best available science on sea level rise in California, and recommends using the Intermediate, Intermediate-High, and High scenarios in relevant Coastal Commission planning and permitting decisions. More information on which scenarios to use in certain circumstances can be found in the following section as well as Chapters 5 and 6. The Commission will continue to periodically re-examine and update sea level rise projections as they evolve with the release of new scientific reports and information on local and regional sea level trends. Additionally, as sea level rise science continues to evolve, equivalent resources may be used by local governments and applicants provided the sources are peer-reviewed, widely accepted within the scientific community, and locally relevant.

The Coastal Commission will be using and recommends that local governments and applicants use best available science, currently identified as the scenarios provided in the 2024 OPC California State Sea Level Rise Guidance (Table 3; Appendix F), in all relevant local coastal planning and coastal development permitting decisions.

GUIDANCE FOR APPLICATION OF BEST AVAILABLE SCIENCE

This section offers key pieces of guidance for both the analysis of sea level rise as well as the development of project designs, adaptation strategies, and/or adaptation pathways to be included in Coastal Development Permits (CDPs), adaptation plans, or Local Coastal Programs (LCPs).

Sea level rise analyses

There is a diversity of planning exercises, studies, and development projects that take place in the Coastal Zone, and their associated technical analyses on sea level rise can also vary in terms of level of detail and complexity. This guidance generally recommends analyzing several sea level rise scenarios including a relatively high, precautionary scenario relevant to the planning/project context, as described in the general framework listed below. However, a variety of site- and situation-specific factors may warrant analysis of a different set of sea level rise amounts or a particular number of scenarios.

The overall goal of technical analyses should be to provide sufficient detail on how coastal hazard conditions may develop over time, considering sea level rise, to inform appropriate land use policies and zoning, project siting and design, implementation of adaptation strategies or adaptation pathways, and so on for the subject project, site, or planning area. Considering higher end amounts of sea level rise is important for understanding what types of planning and adaptation options may be necessary if worst case scenarios come to pass, or to inform decisions for new development with long lifetimes that would be hard to relocate, remove, or otherwise adapt to higher amounts of sea level rise in the future. Conversely, analysis of lower sea level rise amounts may assist in identification of tipping points – i.e., amounts of sea level rise or other combinations of hazard conditions that could lead to significant impacts and warrant adaptive responses. Similarly, understanding lower or nearer-term sea level rise amounts may be important for guiding design of restoration projects, or other types of projects that are meant to be within or immediately adjacent to the ocean or intertidal areas.

It is also important to note that it may not always be necessary to evaluate different sea level rise amounts in the same level of detail. In some cases, it may be sufficient to use screening tools such as CoSMoS to analyze high- or low-end scenarios to build a general understanding of the implications of sea level rise amounts, while more detailed analysis may be appropriate for scenarios that constitute important tipping points or on which detailed decision points depend. The following section further discusses the benefits of scenario-based analysis in the context of both LCPs and CDPs, and Chapters 5 and 6 discuss steps for conducting analyses of SLR and incorporating the results into LCPs and CDPs, respectively.

While the above context and caveats will always be important, this guidance offers the following framework to generally guide the selection of sea level rise scenarios to include in technical *analyses* over the life of the proposed development or planning horizon[28], including at the project level and in broader vulnerability assessments:

1. *Intermediate Scenario*: The Intermediate scenario should be included in technical analyses for development with low risk aversion, i.e., development that would have limited consequences or a higher ability to adapt, such as some ancillary development or public access amenities.
2. *Intermediate-High Scenario*: The Intermediate-High scenario should be included in technical analyses for development with medium-high risk aversion, i.e., development that would experience greater consequences and/or have a lower ability to adapt, such as most residential and commercial structures.
3. *High Scenario*: The High scenario should be included in technical analyses for development with extreme risk aversion, i.e., development with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur, such as most critical infrastructure.[29]

Project design and selection of adaptation strategies or pathways

In practice, the Coastal Commission has found that there is an important distinction between selecting sea level rise scenarios to *analyze* (as described above) and selecting scenarios to

[28] Chapters 5 and 6, respectively, discuss appropriate planning horizons for LCP analyses and anticipated project lifetimes in greater detail. In general, LCP analyses should account for long-term planning horizons (75-100 years). For proposed development, temporary structures or ancillary development often have shorter lifetimes (~25 years); residential structures have 75-100 year lifetimes; and critical infrastructure has a 100-year (or greater) lifetime.

[29] For more information on sea level rise planning for critical infrastructure, see also the Coastal Commission's Critical Infrastructure at Risk planning guidance.

inform on-the-ground *siting and design*, including individual project designs and adaptation strategies for sites or regions. Technical analyses should describe the hazards the site might experience from a range of possible sea level rise scenarios, including a likely amount of sea level rise that could occur over the planning horizon at hand as well as sea level rise amounts that are higher and less likely to occur, though still possible, as identified above. This information should inform alternatives analyses, adaptation pathways (or phased adaptation), monitoring programs, and public awareness of the full range of possible risks. In contrast, decisions regarding immediate on-the-ground development – including project siting and design, land use designations, and adaptation projects – may, in some cases, reflect a different amount of sea level rise than the highest amount included in technical analyses.

The Coastal Act sets forth a series of requirements for development in the coastal zone, including that development assure stability and structural integrity (Section 30253(b)). In some cases, the most appropriate way to comply with this requirement may be to completely avoid hazards, including those related to higher end amounts of sea level rise, over the full anticipated lifetime of the development. For some projects or adaptation plans, decision-makers may find that doing so would achieve the best outcomes for coastal resources and pose no significant tradeoffs, costs, or feasibility implications. However, there are a variety of interrelated factors that affect decisions regarding project design (and/or LCP policies that direct project design) that may support or necessitate initially designing for lower sea level rise amounts and incorporating requirements to adapt in some manner if higher, but less likely, sea level rise scenarios come to pass. These factors may directly relate to Coastal Act issues, such as potential coastal resource impacts, while others relate to broader planning considerations such as costs and engineering feasibility. Such factors may include:

- **Coastal resource impacts**: Designing to be safe from the highest scenario included in the technical analysis could present tradeoffs for coastal resources or cause two coastal resource interests to conflict. For example, building higher or longer bridges to account for the highest amounts of potential sea level rise may result in greater fill or other impacts to wetlands or estuarine habitat from more substantial bridge supports. Similarly, setting portions of Coastal Trail further back may avoid the need for future realignments, but doing so may mean the trail is no longer in sight of the ocean in the short and medium-term. Understanding the scope and scale of such resource impacts and weighing them against project design and phasing alternatives will be important.
- **Community impacts**: Similarly, designing to be safe from the highest scenario included in the technical analysis could present tradeoffs for communities, including environmental justice communities that may experience unequal burdens or impacts. For example, redesigning or relocating parking lots or other public access amenities to completely avoid impacts from high-end sea level rise may limit opportunities for visiting the coast, disproportionately impacting those who live further away. And relocating transportation infrastructure farther inland without assessing the communities who live nearby or use the current and alternative routes may result in a pollution or displacement burden to these inland communities. Any adverse impacts such as loss of wages or a disruption in day-to-day routines will have an even greater

impact on low-income workers or individuals who often have less capacity to adapt to these changes.

- **Site Considerations**: Site constraints, such as parcel size, presence of coastal resources, surrounding patterns of development, or property ownership may limit the range of feasible adaptation alternatives. For example, parcel sizes may be too small to allow for setbacks for new houses that account for the highest amounts of sea level rise. Similarly, the presence of ESHA or wetland habitat in a portion of the site may affect where or how development could be sited and designed.
- **Interconnected Systems**: A project or plan's relationship to a networked system of development or infrastructure could limit the range of feasible alternatives due to the necessity of providing connections to the rest of the network. For example, a single pump station may need to be redesigned to account for continued coastal hazards-related damage. Over the long-term, the entire system of wastewater infrastructure may need to be redesigned to account for higher amounts of sea level rise, something that would require significant and complex planning, but in the immediate term, the single pump station will need to adapt in ways that continue to carry out the functions of the connected system, likely only accounting for lesser amounts of sea level rise while a longer term plan is developed.
- **Feasibility and Costs**: Engineering and cost constraints can also affect the analysis of feasible alternatives. In some cases, "over"-designing to account for the highest sea level rise amounts could result in significant cost increases that may jeopardize feasibility and result in a project that cannot be funded and undertaken. "Over"-design could also result in over-engineered projects that result in greater coastal resource impacts. As described above, a bridge designed to account for the highest amount of sea level rise could result in greater wetland fill. Similarly, over-designing development or shoreline protective devices to account for worst-case sea level rise could make such structures more difficult to remove without significant coastal resource impacts in the future. Conversely, "under" designing could result in higher total costs and impacts if the project has no adaptive capacity and has to be completely rebuilt sooner than expected. Cost analyses can compare the marginal cost of designing for higher sea level rise amounts at the outset versus the cost of implementing additional adaptation phases in the future.
- **Adaptation pathway alternatives**: In some cases, it may be possible to design for higher-end sea level rise amounts at the outset, even considering some of the above factors that result in various trade-offs. In other cases, it may be necessary to consider adaptive responses to address higher amounts of sea level rise. Rather than initially designing a project or plan to address the full range of sea level rise included in the technical analysis, adaptation pathways based on monitoring and triggers can allow for stepwise adaptation that maximizes coastal resource benefits over time, avoids overdesigning or overengineering projects, and is cost effective. Depending on the specific hazards, vulnerabilities, coastal resource trade-offs, costs, and so on, adaptation pathways can be fairly basic – such as requiring removal of a structure if and when it

becomes threatened by sea level rise – or more detailed – such as identifying multiple steps for redesigning a City's water infrastructure over time. It also may be prudent to harmonize an adaptation pathway approach with any geographically broader or regional adaptation planning efforts that aim to balance benefits and burdens of adaptation across communities, geographically, and/or across coastal resource types.

The importance of these factors has been borne out by many projects and plans approved by the Coastal Commission in the past. For example, in the Cardiff living shoreline project designed to protect a low-lying stretch of Highway 101 in Encinitas, the dunes of the living shoreline could not be built high enough to fully protect the highway from a full range of sea level rise without blocking views of the ocean from the highway – an adverse scenic and visual impact inconsistent with the Coastal Act. Because it was possible to adaptively manage the height of the dunes, the Commission approved a design with lower dune heights in order to preserve the visual resource.

Similarly, the Gleason Beach Highway 1 Realignment project in Sonoma County was designed to account for sea level rise but had to consider a variety of the above factors, including the presence of agricultural lands, ESHA, wetlands, private property, and public access. The final design sets most of the segment of highway back far enough to be safe from most potential sea level rise impacts over the project's planning horizon except for the parts on either end of the project area that connect with the adjoining highway. To account for possible impacts to these connector points, the project requires monitoring and establishes triggers to initiate future planning if and when they are threatened. At the same time, the project was able to minimize impacts to and actually realize the enhancement of habitat restoration including salmon stream restoration.

Using scenario-based analysis and adaptation pathways in response to uncertainty in sea level rise scenarios

As described in the sections above, sea level rise scenarios, including those in the State Sea Level Rise Guidance (OPC 2024) (Table 3; Appendix G) and other state, national, and global reports, are typically presented in ranges due to several sources of significant uncertainty.

The two primary sources of uncertainty in global sea level projections include:

1) Uncertainty about future greenhouse gas emissions and concentrations of sulfate aerosols, which will depend on future human behavior and decision making, and
2) Uncertainty about future rates of land ice loss (Fox-Kemper *et al*., 2021; Sweet *et al*., 2022).

Additionally, the further into the future sea level rise is projected, the greater the uncertainty (and therefore the range in projections) becomes. This occurs because the longer the projection period, the greater the likelihood that models will deviate from the actual impacts of climate change and the more dependent projections become on the trajectory of greenhouse gas emissions (California State Sea Level Rise Guidance, 2024). According to the 2024 OPC Guidance, near-term sea level rise has been locked in by past greenhouse gas emissions whereas sea level rise over the longer-term will become increasingly dependent on efforts to curtail greenhouse gas emissions.

This Guidance recommends using scenario-based analysis to address the uncertainty in sea level projections. Scenario-based analysis (or planning) refers to the idea of identifying multiple scenarios from which to analyze vulnerabilities, generate new ideas and adaptation options, and/or test strategies. In the context of this Guidance, scenario-based analysis includes choosing several possible sea level rise amounts as a starting point to evaluate impacts to coastal resources and potential risks to development over time. This type of scenario-based approach is useful because it reveals the full range of possible consequences of sea level rise that can be reasonably expected for particular regions or sites according to the best available science. Additionally, a scenario-based analysis helps to reveal the tipping points indicating if or when sea level rise will become a serious issue in a particular location. In many cases, using multiple sea level rise scenarios will help to hone in on the types of hazards for which to prepare.

In general, the Coastal Commission recommends using best available science (currently the 2024 State Sea Level Rise Guidance (OPC 2024)) to identify a range of sea level rise scenarios up to and including an appropriately high, precautionary scenario relevant for the planning or project context at hand. In practice, the process for choosing scenarios and performing scenario-based analysis will be slightly different for LCP planning and CDP applications due to the different planning goals and levels of technical detail required for each.

For a Local Coastal Program (LCP), the general goal is to assess the potential impacts from sea level rise over the entire planning area and over a range of time horizons so that both short and long term adaptation strategies can be identified and implemented. Another important facet of LCP planning is identifying locations and communities that are particularly vulnerable so that additional, more detailed studies can be performed if necessary, and adaptation options and actions can be prioritized. Scenario-based analysis in the context of LCP planning includes choosing a range of sea level rise scenarios to analyze so as to understand the best and worst case scenarios and to identify amounts of sea level rise and related conditions that would trigger severe impacts and the associated time period for when such impacts might occur. This information can lead to the development of adaptation pathways, or series of adaptation measures to deploy when certain triggers or thresholds are crossed. LCP updates can then be developed to reflect the first stage of the adaptation pathway (e.g., land use designations or development standards that carry out the initial adaptation steps), as appropriate, along with policies outlining and establishing the goals for the next stages of the adaptation pathways. Choosing sea level rise scenarios in the context of LCP planning is described in greater detail in Chapter 5.

In the context of a Coastal Development Permit (CDP) application, the goal is to understand how sea level rise will impact a specific site and a specific project over its expected lifetime so as to ensure that the proposed development is safe from hazards and avoids impacts to coastal resources. Thus, in the context of a CDP, it is important to identify the amounts of sea level rise that could result in effects to a particular site as well as the time period(s) over which those effects could occur so that the proposed development can be safely sited and designed to avoid resource and development impacts, or so that adaptation pathways can be developed to address the impacts of sea level rise as they unfold. Some sites will be completely safe from sea level rise under even the highest projection scenarios, while others will depend on the timing and magnitude of sea level rise to determine safety. Therefore, scenario-based planning analysis can be used as a screening process to identify if and when sea level rise might become a problem. Identifying sea level rise scenarios in the context of CDPs is described in greater detail in Chapter 6.

Overall, scenario-based planning should help planners make reasonable and informed decisions about whether their projects or plans are compatible with the local hazards influenced by sea level rise, and identify the types of adaptation measures or pathways that might be appropriate given the local circumstances and requirements of the Coastal Act. By exploring the range of future scenarios based on the best available science, users of this document can make decisions based on full understanding of possible future hazards, ultimately achieve outcomes that are safer for development, coastal resources, and communities, and avoid costly damages to projects.

For more information on scenario-based planning and development of adaptation pathways in the context of LCPs and CDPs see Chapters 5 and 6, respectively.

PHYSICAL EFFECTS OF SEA LEVEL RISE

Accelerating sea level rise has and will continue to have widespread adverse consequences for California's coastal resources (see summary in Figure 10). The main physical effects of sea level rise include increased flooding, inundation, groundwater rise, wave impacts, coastal erosion, changes in sediment dynamics, and saltwater intrusion. These impacts are interrelated and often occur together. Absent any preparatory action, an increase in sea level may have serious implications for coastal resources, development, and communities, as described in Chapter 4. In addition, these physical effects could have disproportionate impacts on environmental justice communities that have a high social vulnerability due to several factors, which can result in their increased exposure and sensitivity to adverse climate impacts as well as a lower ability to adapt.

Physical effects from sea level rise to the coastal zone include the following[30]:

- **Flooding and inundation:** Low lying coastal areas may experience more frequent flooding (temporary wetting) or inundation (permanent wetting), and the inland extents of 100-year floods may increase. Rising sea levels can accelerate flood risk; for example,

[30] Please see Chapter 4 of the State Sea Level Rise Guidance (2024) for additional discussion of the physical impacts of sea level rise.

only a 10 cm rise in sea level could double the flooding potential along the west coast in locations such as San Francisco and Los Angeles (Vitousek *et al*. 2017). Sea level rise will also increase the frequency of what we today consider to be high-tide flooding, especially starting in the 2030s. For example, the frequency of minor high-tide flooding is projected to increase by a factor of three to four from 2030 to 2050 under the Intermediate sea level rise scenario (Thompson *et al*., 2021; NASA Flood Analysis Tool). Riverine and coastal waters come together at river mouths, coastal lagoons, and estuaries, and higher water levels at the coast may cause water to back up and increase upstream flooding (Heberger *et al*. 2009). Drainage systems that discharge close to sea level could have similar problems, and inland areas may become flooded if outfall pipes back up with salt water. In addition, other climate change impacts such as increases in the amount of precipitation falling as rain rather than snow will add to river flooding in some areas.

- **Rising groundwater:** An increase in sea level could cause saltwater to push further into coastal groundwater aquifers, causing groundwater tables to rise (Befus *et al*., 2020; May *et al*., 2020). In general, coastal groundwater tables are expected to rise proportionally with sea level rise at a ratio that depends on the composition of the substrate. With enough sea level rise, groundwater tables could become shallow enough to compromise subsurface infrastructure. Additionally, groundwater could rise high enough to emerge at the surface, causing flooding even in places where overland flooding is curtailed by seawalls or other shoreline protective devices. Rising groundwater may also affect contaminated sites across the state, mobilizing contaminants in shallow soils that were previously above the water table (Cushing *et al*., 2023; Hill *et al*., 2023).
- **Saltwater intrusion:** An increase in sea level could cause saltwater to intrude into groundwater resources, or aquifers. Existing research suggests that rising sea level is likely to degrade fresh groundwater resources in certain areas, but the degree of impact will vary greatly due to local hydrogeological conditions. Generally, the most vulnerable hydrogeological systems are unconfined aquifers along low-lying coasts, or aquifers that have already experienced overdraft and saline intrusion. In California, saline intrusion into groundwater resources is a problem in multiple areas, including but not limited to the Pajaro Valley (Hanson 2003), Salinas Valley (Hanson *et al*. 2002a; MCWRA 2012), Oxnard Plain (Izbicki 1996; Hanson *et al*. 2002b), and the heavily urbanized coastal plains of Los Angeles and Orange Counties (Edwards and Evans 2002; Ponti *et al*. 2007; Nishikawa *et al*. 2009; Barlow and Reichard 2010). Groundwater sources for other coastal agricultural lands may also be susceptible to saltwater intrusion.
- **Wave impacts:** Wave impacts can cause some of the more long-lasting consequences of coastal storms, resulting in high amounts of erosion and damage or destruction of structures. The increase in the extent and elevation of flood waters from sea level rise will also increase wave impacts and move the wave impacts farther inland. Erosion rates of coastal cliffs, beaches, and dunes will increase with rising sea level and are likely to further increase if waves become larger or more frequent (NRC 2012). In addition,

recent research has suggested that winter wave heights and winter storm intensity in the North Pacific have, on average, increased over the last 50 years in parallel with climate change, sending larger and more powerful waves to the California shoreline. Some studies suggest that wave heights could continue to increase in the future, generally extending the reach of wave run up and further exacerbating the erosion that is already expected to increase due to rising sea levels, though this is a subject of ongoing research (Bromirski *et al*., 2023).

- **Erosion:** Large sections of the California coast consist of oceanfront bluffs that are often highly susceptible to erosion. With higher sea levels, the amount of time that bluffs are pounded by waves would increase, causing greater erosion. This erosion could lead to landslides and loss of structural and geologic stability of bluff top development such as homes, infrastructure, the California Coastal Trail, Highway 1, and other roads and public utilities. The Pacific Institute (Heberger *et al*. 2009) estimated that 41 square miles (106 square km) of coastal land from the California-Oregon border through Santa Barbara County could be lost due to increased erosion with 4.6 ft (1.4 m) of sea level rise by the year 2100. Approximately 14,000 people now live in those vulnerable areas. Increased erosion will not occur uniformly throughout the state. Dunes in Humboldt County could erode a distance of approximately 2000 ft (nearly 600 m) by the year 2100 (Heberger *et al*. 2009; Revell *et al*. 2011). In southern California, higher sea level rise could result in a two-fold increase in bluff retreat rates over historic rates, causing a total retreat of 75 feet on average by 2100 (Limber *et al.* 2018). Man-made structures like dikes and levees may also be impacted by erosion, increasing flooding risk of the areas protected by those structures, such as low-lying agricultural land. Over the long term, rising sea levels will also cause landward migration of beaches due to the combined effects inundation and loss of sediment due to erosion (NRC 2012).

Figure 8. Photo of Esplanade Apartments threatened by cliff erosion in 2013 in Pacifica, CA. (Source: California Coastal Records Project)

- **Changes in beaches, sediment supply and movement:** Sediment is important to coastal systems in, for example, forming beaches and mudflats and as the substrate for wetlands. Sea level rise will result in changes to sediment availability. Higher water levels and changing precipitation patterns could change erosion and deposition patterns. Loss of sediment could worsen beach erosion and possibly increase the need for beach nourishment projects (adding sand to a beach or other coastal area), as well as decrease the effectiveness and long-term viability of beach nourishment if sand is quickly washed away after being placed on a beach (Griggs 2010). Shoreline change models predict that by 2100, without changes in coastal management, 30 to 67% of Southern California beaches may be completely lost due to rising sea level (Vitousek *et al.* 2017; 2021; 2023; Bedsworth *et al.* 2018). Sediment supplies in wetland areas will also be important for long-term marsh survival. Higher water levels due to sea level rise, however, may outpace the ability of wetlands to trap sediment and grow vertically (Titus 1988; Ranasinghe *et al*. 2012; Van Dyke 2012).

STORMS AND EXTREME EVENTS

Much of the California coast is currently vulnerable to flooding and wave damage during large storm events, and even more of the coast is vulnerable to storm impacts when they occur during times of heightened water levels, such as high tides, El Niño events, a warm phase of the Pacific Decadal Oscillation, or a combination of these factors. Sea level rise will increase vulnerability to storms even more because rising water levels will result in more areas being impacted. Furthermore, climate change could impact the frequency and intensity of storms.

As summarized above, Bromirski *et al*., 2021 suggested that winter wave heights and winter storm intensity in the North Pacific have, on average, increased over the last 50 years in parallel with climate change, and studies suggest that wave heights could continue to increase in the future, further exacerbating the erosion that is already expected to increase due to rising sea levels. Previous research had shown conflicting evidence on whether storminess and wave size will change in the North Pacific Ocean (Cayan *et al*. 2009; Lowe *et al*. 2010; Dettinger 2011).

Extreme events are of particular concern to the examination of coastal vulnerability and damage because they tend to cause the greatest community upheaval and can result in irreversible changes to the coastal landscape. In the El Niño winter of 1982-1983, for example, a series of storms, several of which coincided with high tide, caused more than $200 million in damage (in 2010 dollars) to coastal California (OPC 2013). Similarly, the 2015/16 El Niño was one of the strongest on record, resulting in significant changes to the shoreline. California also experienced significant damage over a series of storms in January 2023 and January 2024.

Sea level rise will compound the impacts of storms. The 4th California Climate Assessment found that a 100-year coastal flood would almost double the damages associated with just 20 inches of sea level rise alone (Bedsworth *et al.* 2018). Barnard *et al*., 2019 found that approximately 700,000 California residents and $250 billion in property could be exposed to flooding by 2100 under the high scenario and a 100-year storm. These impacts result because a rise in sea level will mean that flooding and damage will likely reach further inland. For these reasons, it is important to include these factors in the analysis of sea level rise hazards. Further discussion of the physical effects of sea level rise and methodologies for these analyses are included in Appendix B.

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Chapter 4. Consequences of Sea Level Rise for Communities, Coastal Resources, & Development

The physical effects of sea level rise described in the previous chapter could have significant consequences for California's citizens, coastal communities, and the resources protected by the Coastal Act. This chapter describes some of these consequences and notes the relevant Coastal Act policies for convenience. It is important to consider both the direct impacts of sea level rise on coastal resources and what these impacts mean for the people and communities who use and enjoy these coastal resources. It is also important to consider environmental justice when analyzing sea level rise impacts because adverse impacts from sea level rise are not distributed equitably among populations, as described in greater detail in the section below.

SEA LEVEL RISE ADAPTATION PLANNING AND ENVIRONMENTAL JUSTICE

The California Coastal Act recognizes and defines environmental justice as "the fair treatment of people of all races, cultures, national origins, and income with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies" (PRC section 30107.3). Born out of the civil rights movement, environmental justice was coined as a term to describe the application of civil rights and social justice to environmental contexts (Environmental Justice for All, 2010). Environmental justice recognizes that low-income communities, communities of color, and other historically marginalized communities across the United States have endured disproportionate environmental burdens and health impacts, including being subjected to disinvestments for creating or preserving natural resources within these communities.[31] The environmental justice movement seeks to rectify environmental racism through procedural, distributive, and restorative justice principles (Pellow, 2000). Procedural justice refers to equitable access to, and participation in, the process of land-use decisions that may significantly burden an underserved community. This includes involvement in the political and scientific platforms and agencies that develop the rules for engagement, governance, and decision-making. Distributive justice is concerned with equitably allocating the "fair share" of environmental resources, benefits, and harms across society. Restorative justice is centered in healing the historic inequities in a community through cross-sectoral partnerships, mediation, and trust-building. Together, procedural, distributive, and restorative environmental justice aim to acknowledge, prevent, and heal from historic environmental racism and injustices within overburdened communities and transition to a more just and equitable society (Taylor, 2000).

Sea level rise and how we respond to it may result in significant changes in the distribution of environmental benefits and burdens in California. As a result, there is a need to incorporate equity principles into sea level rise adaptation planning. The [California Climate Adaptation Strategy] identifies strengthening protections for climate-vulnerable communities as a priority in the state's climate adaptation and resilience planning efforts. Additionally, the Ocean

[31] Disproportionate burdens refer to environmental justice communities being unevenly exposed to environmental burdens, such as pollution or displacement, compared to the rest of the population in a geographic area. (US EPA, 2021).

Protection Council's State Sea Level Rise Guidance recommends prioritizing social equity, environmental justice, and the needs of vulnerable communities in adaptation planning.

The California Coastal Act also recognizes the fundamental importance of the fair distribution of environmental benefits in Section 30001:

> *The Legislature hereby finds and declares: (a) That the California coastal zone is a distinct and valuable natural resource of vital and enduring interest to all the people and exists as a delicately balanced ecosystem. (b) That the permanent protection of the state's natural and scenic resources is a paramount concern to present and future residents of the state and nation. (c) That to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction. (d) That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone.*

The Act thus declares that the protection of the coast is of vital interest to *all* the people, of paramount concern *to present and future residents* of the state and nation, and that careful planning and development is essential to *the economic and social well-being* of the people. This broad direction to protect the coast for everyone is underscored in Section 30006, which declares:

> *. . . the public has a right to fully participate in decisions affecting coastal planning, conservation and development; that achievement of sound coastal conservation and development is dependent upon public understanding and support; and that the continuing planning and implementation of programs for coastal conservation and development should include the widest opportunity for public participation.*

Hence, everyone is entitled to participate in the management decisions that determine how the benefits and burdens of managing California's coast will be distributed. Ensuring low-income and underserved communities are included in environmental decisions is a key tenet of environmental justice and will minimize disproportionate environmental and public health impacts. Whether environmental justice community members live at the coast or visit for work or recreation, they have a stake in the coast's future and a meaningful perspective regarding the potential impacts from proposed development on their communities. Furthermore, in 2016, the Governor signed AB 2616 (Burke), which amended the Coastal Act and gives the Commission new authority to specifically consider environmental justice when making permit decisions.

The Coastal Act's broad concern for all the people is highlighted in its public access policies, which require the maximum provision and protection of the public's rights of access to and along the shoreline (Sections 30210-30214). These policies reflect the judgement of the people of California in passing Proposition 20 in 1972 that public access and recreation along our coast is a fundamental environmental benefit to be protected for and enjoyed by all, not just by those with the good fortune or means to live along the shoreline. Public access to the coast is important to the health and well-being of the public, and promoting public access for all citizens provides low-cost, outdoor recreation that can improve the overall quality of life of the public, including low-income and underserved communities, no matter whether they live near or far from the coast.

Unfortunately, public access is also one of the coastal resources most at risk from accelerating sea level rise. As discussed elsewhere in this Guidance, beaches, accessways, recreational amenities, and even surfing resources may be dramatically impacted by rising seas. Where development already exists, and particularly where there is substantial shoreline armoring to protect this development, California will lose significant recreational beach areas. These places that are at increased risk provide environmental and mental health benefits for everyone, generally at very low cost, or even free. Thus, the potential loss of beach and shoreline recreation areas represents a significant loss of a resource that is especially important to protect for those with fewer economic resources.

The impacts of sea level rise on coastal access will disproportionately burden environmental justice communities who already experience a lesser degree of connectivity to the coast and greater inequalities to coastal access as a result of historic discriminatory public policies and land use practices. For example, redlining and restrictive covenants were used in the United States real estate market to segregate neighborhoods and restrict people of color from living in certain areas. The historic restrictions on property sales to certain groups of people, such as households of color and low-income households, and the high cost of homes in coastal areas have resulted in concentrated wealth in these areas (Uhler & Chu, 2019). Additionally, for much of the 20th century, residents of color were only allowed at certain California beaches such as the Inkwell in Santa Monica and Bruce’s Beach in Manhattan Beach (Garcia & Baltodano, 2005). As a result, environmental justice communities are often located farthest away from coastal areas (Rowland-Shea *et al*., 2020).

California’s dependence on cars and lack of proper or efficient public transit systems, especially in coastal areas, creates another barrier for environmental justice communities to access the coast (Reineman *et al*., 2016). Whether traveling to the coast in their own vehicle or via public transportation, inland communities must account for additional transit time and costs; a burden that coastal communities do not have to consider. Further, coastal or beach parking rates exacerbate this burden and contribute to inequitable coastal access, often disproportionately burdening low-income individuals who may not be able to afford these fees or who will have to park farther away at lower-cost sites. Additionally, the loss of public coastal spaces, such as coast-side parks and beaches with restroom facilities, due to sea level rise will also disproportionately affect inland communities and environmental justice communities who rely on these areas as a space for recreational opportunities, a source of food, community gatherings, cultural practices, and natural sanctuaries that are essential for psychological well-being and stress relief. For example, accessing the relatively cooler coastal temperatures will increasingly become a public health imperative for inland residents as average temperatures in California increase due to climate change. The utility of coastal areas as a respite from inland urban heat islands is especially important for environmental justice communities who often reside in these high heat areas (Hoffman *et al.*, 2020).

Relatedly, the Commission's prior authority to require affordable housing in the coastal zone was stripped in the early 1980s. The lack of extensive affordable and low-cost overnight accommodations on the coast disproportionately affects low-income communities from accessing the coast. And many of the remaining lower-cost rental units and homes in coastal areas that are threatened by sea level rise could potentially displace communities, further exacerbating California's housing crisis. Compounding this challenge, these populations are less likely to be able to take proactive steps to adapt to sea level rise due to resource constraints and procedural inequities. This loss affects not only those directly displaced but also contributes to broader community destabilization, such as limiting access to affordable living near coastal habitats.

Tribal communities will also be particularly impacted and vulnerable to sea level rise. Many tribes hold a historical and cultural connection to specific regions and locations and, therefore, cannot easily relocate. The loss of coastal habitats like beaches, dunes, and wetlands signifies more than an environmental catastrophe for these communities — it is a loss of access to cultural and ancestral lands, eroding ties to heritage and traditional practices essential to their identity and way of life.

Taken together, the impacts of sea level rise on coastal beaches, wetlands, habitats, and public accessways, often available to the public for little or no cost, will disproportionately affect environmental justice communities who cannot afford to live near the coast and/or were forcibly restricted from living in coastal areas.

The exacerbation of environmental injustices by anticipated sea level rise may be particularly concerning when the Commission and local governments need to make decisions about shoreline protection and hazard mitigation. As discussed elsewhere in this Guidance, the Coastal Act provides for the protection and mitigation of coastal hazards for existing and new development. But some hazard mitigation, such as shoreline armoring or elevated development on beaches, may have significant impacts to public trust resources. Thus, we face a situation where widely available public beach resources may be diminished in order to protect private or public development along the shoreline – posing a significant environmental justice concern. Because of this, it will be important for decision makers to proactively consider all aspects of this Guidance to avoid and mitigate the potential impacts to coastal resources from hazard responses. This is particularly true for recommendations to consider alternatives to shoreline armoring and, where armoring must be approved, for recommendations to fully mitigate the impacts of such structures on coastal resources.

A May 2015 decision made by the Coastal Commission emphasizes the importance of analyzing low-cost recreational opportunities in addition to other coastal resource impacts when evaluating shoreline protection and other responses to sea level rise and coastal hazards. The Coastal Commission approved a revetment at the west end of the Goleta Beach County Park to provide protection against erosion. This park is an important public resource in Santa Barbara County and receives up to 1.5 million visitors each year, a large fraction of which are low-income visitors. Park facilities include picnic areas, open parkland, and access to the ocean and a recreational beach for no or low cost. The revetment was approved contingent upon specific conditions, including continued free public access and vehicle parking for the term of the permit. This decision highlights the importance of protecting wide accessibility to shoreline resources even as sea level rises.

The potential impacts of adaptation responses on public shoreline resources, and thus the potential environmental justice impacts of such actions, will need to be considered for all resources protected under the Coastal Act. It is also true that 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 ft (1.4 m) 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. Sea level rise will likely result in the loss of key infrastructure, intrusion of saltwater into water sources, and the creation of additional coastal hazards. Hazards in vulnerable areas will have disproportionate impacts on communities with the least capacity to adapt, which could deepen and expand existing environmental injustices if adaptation responses are not managed appropriately.

It is crucial for planners and decision-makers to consider not only the direct impacts of sea level rise on coastal resources but also how these consequences affect the distribution of environmental benefits and burdens along the coast. This includes communities reliant on these resources, such as workers and visitors, even if they do not reside in the coastal zone. Planners and decision-makers should consider environmental justice concerns in the analysis of alternative project designs and adaptation measures and involve low-income and underserved communities in decision-making and planning efforts, early and often. This practice aims to decrease unintended consequences that may lead to further social or environmental injustices while ensuring that adaptation efforts specifically provide benefits to environmental justice communities both within and outside of the coastal zone. In particular, it will be important to consider the potential impacts of hazard mitigation actions to protect development that may only benefit a few, on the public access and shoreline resources that are available for all Californians to enjoy.

Meaningful Engagement and Environmental Justice

Environmental justice communities can experience both intentional and unintentional procedural barriers that make it difficult to engage in the decision-making process. In many instances, impacted communities say they receive little to no notice regarding a planned project, the passage of a zoning change, or a change in law, and are seldom made aware of the full range of potential adverse impacts that may result from these changes. Further, they often do not have the capital resources nor the established political or administrative connections to decision-making bodies that businesses or other members of the public have. Environmental justice communities also face greater burdens when trying to participate in the public process, including inaccessible meeting times, language and technology access barriers, lack of outreach, and lack of community capacity. Thus, they are rarely consulted or adequately included from the beginning of the planning process, even when it directly impacts their communities.

Meaningful engagement recognizes the historic exclusion of community input and attempts to uplift community voices and perspectives. Meaningful engagement is the intentional outreach, inclusion, and consideration of the voices and perspectives from presently and historically underserved and marginalized communities in the design, development, implementation, and policies that may impact the health, environment, and livelihood of their communities. It is essential to environmental justice and relies on communicating directly with potentially impacted communities and providing an opportunity for their input to inform decision outcomes (EPA, 2024). Essentially, meaningful engagement is the foundation upon which all subsequent policy and decision making depends. When engaging with communities, it is imperative to remind ourselves that members of the public are partners and collaborators, not a “checked box” for outreach. Adopting outreach practices such as early notification, avoiding overpromising, and timeliness are just a few examples of how trust can be built overtime. Many communities, including environmental justice and tribal communities, have experienced land dispossession, displacement, discrimination, and other forms of state-sanctioned violence; therefore, trust, especially as government representatives, must be earned. It is also important to recognize that trust will not always be easily granted, but it is our duty to try our best as decision-makers.

Because environmental justice communities have historically been underrepresented in, or even purposefully excluded from, land use planning and permitting decisions, it is critical for local governments to incorporate meaningful engagement into the development of new or updated Local Coastal Programs (LCPs) and to include meaningful engagement policies and actions in LCPs and subsequent permit reviews. This should also include engagement with inland communities that do not reside on the coast but may be reliant on it for work or recreational purposes. Incorporating meaningful engagement into the adaptation planning process may help institutionalize these efforts and eventually contribute to better protection of natural resources and lands for all communities. Since the adoption of both the Tribal Consultation Policy and Environmental Justice Policy, the Commission has worked to better understand, define, develop, and expand available resources to support staff in implementing meaningful engagement into this work. For more information and resources about how to incorporate environmental justice into sea level rise adaptation planning, see Chapters 5 and 6 of this guidance, the forthcoming Coastal California Environmental Justice Mapping Tool, and the Commission's Toolkit on Resources for Addressing Environmental Justice through Local Coastal Programs.

SEA LEVEL RISE CONSEQUENCES UNIQUE TO TRIBAL COMMUNITIES

Environmental justice applies to communities that have experienced disproportionate environmental burdens, including tribal communities. It is important to recognize that the entirety of California's coastal zone was originally indigenous territory that has certain levels of cultural significance. For over 13,000 years, long before Spanish colonization, indigenous communities have been a part of and shaped what is now California (Scarborough *et al.*, 2022). California is home to the ancestral lands of over 500 native sub-groups; today, only 109 California tribes are federally recognized by the Bureau of Indian Affairs, while the State of California currently recognizes an additional 55 California tribes and tribal communities (California Native American Heritage Commission, 2022). According to the 2020 Census, about 1.7% of Californians, or roughly 660,000 individuals, identify as Native American or Indigenous, underscoring the significant but often overlooked presence of these communities in sea level rise adaptation planning.

California's long history of land theft, suppression, and displacement of indigenous people from coastal (and other) regions early in the colonization and settlement of the State has culminated in a legacy of environmental and racial injustice (Akins and Bauer, 2022). For decades, even after native people were already excluded from coastal areas by settlers and state and federal officials, expressions of indigenous culture, religion, and values led to aggression and persecution, including periods of genocide. Additionally, several tribes were forced to abandon many coastal areas all together. Today, tribal communities with cultural ties to the coast depend on access to ancestral lands and sacred sites to maintain traditional ecological knowledge and practices. Native California coastal tribes such as Chumash, Esselen, Rumsen, Coast Miwok, and others exemplify their connection to the intertidal environment through elaborate fishing practices, hunting and gathering, canoeing, and shell beading (Dartt-Newton and Erlandson, 2006).

The persistence of tribal communities highlights an unwavering ability to adapt to a variety of changes. Historically, indigenous peoples depended on a wide variety of natural resources for food, water, medicine, ceremonies, and shelter. Coastal tribal communities, in particular, harnessed their deep ancestral and traditional ecological knowledge of the land to adapt to tidal fluctuations, saltwater intrusion, and other coastal stressors (Lynn *et al.*, 2021; Leonard, 2021). However, tribal communities are uniquely vulnerable to climate change stressors because of their deep connection to, and reliance on, the environment, illustrated by traditional fishing, hunting, and gathering practices. For example, the Yurok Tribe of the Yurok Reservation located in northern California along the Klamath River relies heavily on traditional practices of fishing, hunting, and gathering since the pre-contact era. In the Tribal Leaders Summit on Climate Change report, the Yurok Tribe highlighted their main concern in relation to climate change as hydrologic impacts to surface waters and aquatic resources on which they depend for sustenance (Black *et al*., 2015).

Sea level rise threatens coastal tribal resources, including coastal access, recreation, and sustenance. Sea level rise also endangers coastal tribal cultural resources such as traditional dwellings, ancestral sites, and sacred places, and poses a significant threat to adjacent ecosystems, local water quality, traditional food systems, and harvesting practices. However, past sea level rise adaptation planning efforts carried out by local and state governments have not sufficiently included the interests of tribal communities. In 2018, after multiple public hearings and extensive coordination with California Native American Tribes and other interested groups, the Coastal Commission adopted its Tribal Consultation Policy. This document sets out procedures for consultation and meaningful engagement between commission staff and tribes, provides for the designation of agency tribal liaisons, and requires consideration of tribal cultural resources (not just archaeological resources) in planning and permitting decisions. Local governments are encouraged to consult the Tribal Consultation Policy and work with Commission staff for assistance with conducting outreach with tribal communities regarding Local Coastal Programs and Coastal Development Permits that have a sea level rise component. Centering environmental justice in sea level rise adaptation planning should prioritize the significance of these vulnerable sacred sites to tribal communities, in addition to tribal food security, monitoring, and building technical capacity.

CONSEQUENCES OF SEA LEVEL RISE FOR COASTAL ACT RESOURCES

- **Coastal development (Coastal Act Sections 30235, 30236, 30250, 30253):** Sea level rise will increase the likelihood of property damage from flooding, inundation, or extreme waves, and will increase the number of people living in areas exposed to significant flooding. Increased erosion and loss or movement of beach sand will lead to an increase in the spatial extent of eroding bluffs and shorelines and could increase instability of coastal structures and recreation areas. Levee systems could also experience damage and overtopping from an increase in water levels, extreme wave conditions, or a loss of wetlands, which buffer impacts from high water. Sea level rise may also impact hazardous sites, mobilizing contaminants and putting communities at risk. The USGS's HERA tool estimates that the value of the property at risk from 2 meters of sea level rise is $176 billion, which represents almost 200,000 housing units for over 440,000 residents (Wood *et al*., 2020).

  Impacts to public infrastructure, ports, and industrial development include:

  - **Public infrastructure:** Low-lying transportation infrastructure, wastewater treatment facilities, energy facilities, stormwater infrastructure, and utility infrastructure such as potable water systems and electricity transfer systems which are vital to local economies as well as public health are at risk of impaired function due to erosion, flooding, and inundation. USGS's HERA tool estimates that 3,500 miles of roads, 289 miles of railroad, 24 wastewater treatment plants, 32 drinking water plants, and 18 solid waste landfills are at risk from 2 meters of sea level rise (Wood *et al*., 2020). Facilities and highways located on coastal bluffs subject to erosion will become more susceptible in the future. Sections of Highway 1 have already had to be realigned due to erosion or are in the planning stages for realignment projects, including areas in San Luis Obispo County, Monterey County, San Mateo County, Half Moon Bay, Marin County, Sonoma County, and others, and the sections at risk in the future will likely increase. The collective impacts to public infrastructure have wide-ranging adverse consequences to public health, safety, and the economy. For example, disruptions to the movement of people, goods, and services can result in extreme risks like the loss of emergency evacuation routes—as well as immediate economic losses associated with emergency repairs and ongoing economic costs associated with repeated repairs and disruptions to freight services and the movement of goods and services from chronically exposed infrastructure. Flood control systems located upstream or outside of the coastal zone may also be impacted where stormwater pipes and channels can become more tidally-influenced as sea level rises, and drain less effectively during high tides and storm surges.

Figure 9. Photo of infrastructure at risk near Rincon Beach, Ventura, CA, during the King Tide in December 2012. (Photo courtesy of David Powdrell, California King Tides Initiative)

- **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. A possible benefit could be a decreased need for dredging. But, unless facilities have already included accommodations for larger ships than they currently service, higher water levels could increase the difficulty for cargo handling facilities due to the higher vessel position (CCC 2001; CNRA 2014). Increased water heights could reduce bridge clearance, reducing the size of ships that can access ports or restricting movement of ships to low tides, and potentially increasing throughput times for cargo delivered to ports. Heberger *et al*. (2009) found that significant flooding from sea level rise is possible at the Ports of Los

Angeles and Long Beach, a finding also reflected in each Port's AB 691 Sea Level Rise Assessment (State Lands Commission, 2022). Given that these two ports handle 45-50% of the containers shipped into the United States, and 77% of goods that leave the state, sea level rise could affect the efficiency of goods movement, and have serious economic implications for California and the nation (Heberger *et al*. 2009). These hazards emphasize the need to upgrade port infrastructure to withstand sea level rise, which should include upgrades to address environmental justice concerns such as reducing air pollution and improving water quality to protect nearby communities from adverse health impacts.

- **Industrial development, refineries, and petrochemical facilities (Coastal Act Sections 30260-30266.5):** Sea level rise could reduce areas available for siting or expansion of industrial development. Inundation of contaminated lands near industrial development could negatively impact water quality and result in polluted runoff. Sea level rise could lead to an increase in flooding damage of refineries or petrochemical facilities, and impacts from sea level rise could be an issue when locating or expanding refineries or petrochemical facilities, or when mitigating any adverse environmental effects. Notably, the University of California, Berkeley's Toxic Tides Project found that over 400 hazardous sites in coastal areas that are at risk of flooding and inundation are also located near environmental justice communities. Facilities that store hazardous waste, such as those associated with industrial development, may experience a decreased ability to contain these materials with sea level rise, thereby exposing surrounding populations and structures to detrimental health hazards or forcing temporary or permanent relocation of these communities if these materials are particularly harmful.
- **Construction altering natural shorelines (Coastal Act Section 30235):** Sea level rise may lead to an increase in demand for construction of shoreline protection for existing development, public access, and coastal-dependent uses in danger of erosion. Shoreline protection devices alter natural shorelines and also generally have negative impacts on beaches, near-shore marine habitat, and scenic and visual qualities of coastal areas.

o **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, or trails. As sea levels rise, many areas along the coast that are developed with infrastructure and/or shoreline protective devices will impede the natural inland migration of the shoreline, resulting in a "coastal squeeze," or the narrowing and eventual loss of the fronting beach, wetland, or other valuable habitat as well as public accessways. "Coastal squeeze" may have far-reaching effects on California's economy and quality of life (Lester and Matella, 2016). The loss of public coastal spaces due to sea level rise will impact not only coastal communities, but also inland communities that rely on the coast for recreation and a respite from higher inland temperatures. Access to, and functionality of, water-oriented activities may also be affected. For instance, by increasing water levels and altering sediment patterns, sea level rise could lead to a change in surfing conditions. If water becomes deeper over known surf spots, only larger waves would be able to break at the same location, and smaller waves would break in shallower water, likely altering the surfing opportunities (Reineman *et al*., 2017; Sadrpour and Reineman, 2023). Likewise, sea level rise could affect the safety of harbors and marinas (Kornell 2012).

- **Coastal habitats (Coastal Act Sections 30230, 30231, 30233, 30240):** Coastal habitat areas likely to be affected by sea level rise include bluffs and cliffs, rocky intertidal areas, beaches, dunes, wetlands, estuaries, lagoons and tidal marshes, tidal flats, eelgrass beds, and tidally-influenced streams and rivers. Importantly, there are many endemic and endangered species in California that are dependent on these coastal environments. For example, grunion need a sandy beach environment in order to reproduce and survive, the California clapper rail is dependent on marshes and wetlands, and the black abalone requires rocky intertidal habitat. Nesting habitat, nursery areas, and haul-out sites important for birds, fish, marine mammals and other animals could also disappear as sea levels rise (Funayama *et al*. 2012).

  Impacts to wetlands, intertidal areas, beaches, and dunes include:

  - **Beaches, dunes, and intertidal areas:** 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. Sea level rise will cause landward migration of beaches over the long term, and could lead to a rapid increase in the retreat rate of dunes. Beaches with seawalls or other barriers will not be able to migrate landward and the sandy beach areas will gradually become inundated (NRC 2012). For example, without changes in coastal management, 30 to 67% of Southern California beaches may be completely lost due to rising sea level (Vitousek *et al.* 2017). A case study from Santa Barbara County found a tipping point at just 0.25 meters of sea level rise at which over 50% of beaches and wetland habitat would be lost (Barnard *et al*., 2019). A loss of beach and dune areas will have significant consequences for beach and adjacent inland ecosystems. Beaches and dunes provide critical habitat for species and act as buffers to interior agricultural lands and habitat during storms (CNRA 2009).

  - **Wetlands:** Sea level rise will lead to wetland habitat conversion and loss as the intertidal zone shifts inland. Of particular concern is the loss of saltwater marshes from sea level rise, which have already decreased by about 90% from their historical levels in California (CNRA 2010). California's 550 square miles (885 km) of critical coastal wetland habitat (Heberger *et al*. 2009, including wetlands in San Francisco Bay) could be converted to open water by 4.6 ft (1.4 m) rise of sea level if they are not able accrete upward or to migrate inland due to natural or anthropogenic barriers. Although barriers are plentiful, inland migration of these wetlands is possible for over 50% of the potentially inundated wetland area based on land use compatibility alone (Heberger *et al*. 2009). Consideration of adequate sediment supply and additional barriers to inland migration would further constrain wetland migration potential. A 4.6 ft (1.4 m) increase in sea level would flood 150 square miles (241 km) of land immediately adjacent to wetlands, which could become future wetlands if that land remains undeveloped. Loss or reduction of wetland habitat would impact many plant and animal species, including migratory birds that depend on these habitats as part of the Pacific Flyway. Species that are salt-tolerant may have an advantage as sea level rise occurs and exposes new areas to salt water, while species that have narrow salinity and temperature tolerances may have difficulty adapting to changing conditions.

- **Biological productivity of coastal waters (Coastal Act Sections 30230, 30231):** Sea level rise could affect biological productivity of coastal waters by changing the types of habitats that are available. This change could alter species composition, and could potentially result in cascading effects through the coastal food chain. Changes in water quality can have differing impacts on biological productivity. For instance, decreased water quality due to increased nutrient pollution has been found to increase biological productivity at the base of the food chain to undesirable levels, and has been linked to harmful algal blooms which result in hypoxic conditions for other marine species (Kudela *et al*. 2010; Ryan *et al.* 2010; Caldwell *et al*. 2013). Furthermore, adverse impacts to biological productivity can result in the loss of subsistence fishing opportunities, which presents a significant challenge to communities that depend on these resources. This not only impacts the economic stability of these communities but could also erode cultural traditions tied to fishing practices.
- **Water quality (Coastal Act Section 30231):** Sea level rise could lead to declines in coastal water quality in several ways. First, coastal water quality could be degraded due to mobilization of contaminants in shallow soils from both overland inundation and rising groundwater as well as due to an increase in nonpoint source pollution from flooding. In particular, the presence of facilities or land containing hazardous materials in coastal areas susceptible to flooding or permanent inundation presents toxic exposure risks for people and ecosystems (Hill *et al.*, 2023). As established earlier, low-income households and people of color are most vulnerable due to the discriminatory siting of hazardous facilities in environmental justice communities or the tendency to place new low-income housing projects near degraded lands and contaminated sites. Second, rising seas could impact wastewater facility infrastructure and other methods and structures designed to protect water quality near the coast. In addition to damaging equipment and blocking discharge from coastal outfall structures, floods could force facilities to release untreated wastewater, threatening nearby water quality (Heberger *et al*. 2009). Saltwater draining into sewer lines as part of extreme weather flooding might also damage biological systems at wastewater facilities if the organisms present in these systems are not salt-tolerant. Third, sea level rise could lead to saltwater intrusion

into valuable groundwater aquifers, potentially rendering some existing wells unusable and decreasing the total groundwater supply in coastal areas. Sea level rise can push contaminated groundwater upwards, potentially introducing volatile organic compounds (VOCs) into communities situated in proximity to polluted sites. The extent of saltwater intrusion will likely vary based upon local hydrogeological conditions, with the worst impacts occurring in unconfined aquifers along low-lying coastal areas that have already experienced overdraft and saline intrusion. This change could force affected communities to turn to more costly water sources such as surface water transfers or desalination, which can exacerbate burdens to low-income communities. Finally, loss of wetlands could decrease water quality given that wetlands act to improve water quality by slowing and filtering water that flows through them.

- **Coastal agriculture (Coastal Act Sections 30241- 30243):** Sea level rise could lead to an 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. Flooding of agricultural lands can cause major impacts on local businesses, national food supplies, and the state's economy. This may result in displacement of farmworkers through loss of wages, health coverage, and housing, which may exacerbate the burdens they already experience.
- **Archaeological and paleontological resources (Coastal Act Section 30244):** Archaeological, tribal cultural, or paleontological resources could be put at risk by inundation, flooding, or by an increase in erosion due to sea level rise. Areas of traditional cultural significance to California Native American tribes, including villages, religious and ceremonial locations, middens, burial sites, and other areas, could be at risk from sea level rise. For example, the Santa Barbara Channel area has thousands of archaeological sites dating over 13,000 years that are at risk of being destroyed or altered from small amounts of sea level rise (Reeder *et al*., 2010).

For a summary of some of the sea level rise impacts and potential consequences for the coast, see Figure 10. Many of these consequences are conditions that coastal managers already deal with on a regular basis, and strategies already exist for minimizing impacts from flooding, erosion, saltwater intrusion, and changing sediment patterns. Preparing for sea level rise involves integrating future projections of sea levels into existing hazard analyses, siting, design, and construction processes, ecosystem management, and community planning practices. Importantly, equitable adaptation planning should consider the consequences of sea level rise impacts on environmental justice communities and ensure that they are meaningfully engaged throughout the planning process. Processes for integrating sea level rise and environmental justice in Local Coastal Programs and Coastal Development Permit applications are described in the following chapters.

Drivers of Global SLR:

Expansion of ocean water as temperature increases

Addition of freshwater to the ocean from melting glaciers and ice sheets

Addition of freshwater to the ocean from groundwater extraction, use, and discharge

Drivers of Local/Regional SLR Variability

Vertical land movement

Oceanographic phenomena including El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO)

Physical Impacts of SLR:

Inundation (permanent wetting)

Flooding (temporary wetting)

Erosion and bluff collapse

Increased tidal prism

Increased tidal and storm surge

Increased wave heights and force

Increased saltwater intrusion

Changes in sediment movement patterns

Summary of Consequences of SLR for Coastal Resources & Development

Coastal Development: Greater likelihood of tidal damage, flooding, and erosion from SLR threatens coastal structures, including the potential loss of property or physical injury; instability from increased erosion and loss/movement of sand; increased areas exposed to a 100-year flood.

Public Infrastructure: Low-lying roads, wastewater treatment facilities, and utility systems are at increased risk from of inundation, flooding, and impaired function, which can lead to health, safety, and economic consequences. Infrastructure on eroding bluffs also subject to geologic hazards.

Coastal Agriculture: Increase in flooding and inundation of low-lying agricultural lands, including from groundwater changes; saltwater intrusion into agricultural water supplies; potential decrease in amount of freshwater available for agricultural uses.

Public Access & Recreation: Loss of beach areas where beaches cannot migrate inland due to development; inaccessibility of public accessways and recreation sites due to flooding and erosion, particularly impacting environmental justice communities that rely on these for affordable recreation.

Coastal Habitats: Transformation of habitats as intertidal zone shifts inland; loss of wetlands and other habitats that cannot migrate up or inland due to inland barriers such as coastal development.

Biological Productivity of Coastal Waters: Possible changes in the types of habitats that are available resulting in altered species compositions and potential cascading effects through the coastal food chain.

Water Quality: Coastal water quality could decline due to inundation of toxic soils and an increase in nonpoint source pollution from flooding. Rising seas could also impact wastewater facilities and cause saltwater intrusion into groundwater supplies, impacting community health.

Cultural Resources: Archaeological and paleontological sites, including many Native American villages, religious and ceremonial locations, burial sites, and other areas could be at risk from sea level rise, underscoring the need for protective measures and inclusion of tribal communities

Environmental Justice: SLR can differentially impact environmental justice communities. For example, rising seas leading to the loss of beachfront areas, limiting access for communities already facing recreational space shortages with a lack of financial resources to enjoy the coast.

Figure 10. Summary of sea level rise impacts and consequences

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Chapter 5. Addressing Sea Level Rise in Local Coastal Programs

The Coastal Act requires that the 61 cities and 15 counties in coastal California prepare Local Coastal Programs (LCPs) to govern land use and development in the coastal zone inland of the mean high tide. LCPs become effective only after the Commission certifies their conformity with the policies of Chapter 3 of the Coastal Act.

LCPs contain the ground rules for future development and protection of resources in the coastal zone. Each LCP includes a Land Use Plan (LUP) and an Implementation Plan (IP). The LUP specifies the kinds, locations, and intensity of uses, and contains a required Public Access Component to ensure that maximum recreational opportunities and public access to the coast is provided. 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.[32]

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 with policies that provide a means to prepare for and mitigate these impacts. Since many existing LCPs were certified in the 1980s and 1990s, it is important that future amendments of the LCPs consider sea level rise and adaptation planning at the project and community level, as appropriate. The overall LCP update and certification process has not changed. Now, however, the impacts of accelerated sea level rise should be addressed in the hazard and coastal resource analyses, alternatives analyses, community outreach, public involvement, and regional coordination. This Guidance is designed to complement and enhance the existing LCP certification and update steps. 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.

Similarly, local governments should strongly consider adopting LCP policies to guide and inform the analysis of environmental justice issues as they relate to sea level rise impacts. Adopting policies and standardized protocols will save time and resources for planning departments, applicants, and the public, while providing transparency about expectations that can build trust with environmental justice communities over time.

[32] In addition, there are other areas of the coast where other plans may be certified by the Commission, including Port Master Plans for ports governed by Chapter 8 of the Coastal Act, Long Range Development Plans for state universities or colleges, and Public Works Plans for public infrastructure and facilities. Following certification of these types of plans by the Commission, some permitting may be delegated pursuant to the Coastal Act provisions governing the specific type of plan.

For general guidance on updating LCPs, see the LCP Update Guide, available on the Coastal Commission's Resources for Local Governments website. For general guidance on how to incorporate environmental justice principles into LCP updates (including to address topics in addition to sea level rise), see the Commission's Toolkit on Resources for Addressing Environmental Justice through Local Coastal Programs.

SENATE BILL 272 AND LCP UPDATES TO ADDRESS SLR

LCPs are essential tools to fully implement sea level rise adaptation efforts. The importance of LCPs in resilience planning has been highlighted by a variety of statewide efforts in the past, and both the California Climate Adaptation Strategy (CNRA 2021) and the State Agency Sea-Level Rise Action Plan for California (OPC 2022) specifically identify LCPs as a critical mechanism for adaptation planning along the California coast. Most recently, the passage of Senate Bill 272[33] (Laird, 2023) will, for the first time, *require* local governments within the Coastal Zone to develop and certify a sea level rise plan as part of an LCP by January 1, 2034, further emphasizing the importance of integrating sea level rise adaptation planning into LCPs.

A summary of SB 272 requirements and a link to the full text of the bill is below. The rest of this chapter provides general guidance for incorporating sea level rise into LCPs and calls out the specific requirements as well as best recommendations for complying with SB 272. As with the rest of this Guidance, the Coastal Commission recognizes that there will be variability in how local governments approach sea level rise adaptation planning and will continue to work with jurisdictions and other stakeholders to update LCPs in a manner that ensures local flexibility and consistency with the Coastal Act.

SB 272 (PRC Section 30985) Summary

Senate Bill 272 (Laird, 2023) added Division 20.6.9 (Section 30985 et seq.) to the California Public Resources Code, and requires local governments lying in whole or in part within the coastal zone to develop a sea level rise plan as part of an LCP that is subject to approval by the Coastal Commission.[34] This sea level rise plan must include, at a minimum, the following:

1. Use of best available science
2. A vulnerability assessment that includes efforts to ensure equity for at-risk communities
3. SLR adaptation strategies and recommended projects

[33] SB 272 added Division 20.6.9 (Section 30985 et seq.) to the California Public Resources Code. This document uses "SB 272" and "Section 30985 et seq." interchangeably.

[34] Note that SB 272 also includes a requirement for local jurisdictions within San Francisco Bay to develop plans that are subject to review by the Bay Conservation and Development Commission (BCDC). The basic requirements are the same for both agencies/plan types, and Commission and BCDC staff have coordinated to develop guidelines pursuant to the requirements of SB 272; however, some specific details and best practices will vary based on differences between relevant enacting legislation (the Coastal Act versus the McAteer-Petris Act) and planning contexts. More information on BCDC's work to implement SB 272 can be found through the BCDC Regional Shoreline Adaptation Plan.

4. Identification of lead planning and implementation agencies
5. An economic impact analysis of, at a minimum, costs to critical public infrastructure[35]
6. A timeline for updates, as needed, based on SLR projections, local conditions, identified adaptation strategies/projects, and other locally relevant factors (as determined by a local government in coordination with the Coastal Commission)

These SLR LCP plans must be completed (and certified by the Coastal Commission) by January 1, 2034. Jurisdictions that obtain Coastal Commission certification by January 1, 2034 for new or updated LCPs meeting these requirements will be prioritized for funding for the implementation of sea level rise adaptation strategies and recommended projects in the approved LCP SLR plan.

Importantly, SB 272 applies to both the *process* of developing or updating an LCP as well as to the *policy content* of an LCP. These planning process stages typically result in documents (e.g. vulnerability assessments, adaptation plans, economic analyses) that inform LCP development but are not, themselves, reviewed and certified by the Coastal Commission. While full consistency with SB 272 will require completion of these documents (by January 2034), the mechanism by which the Commission will determine consistency with SB 272 requirements will be certification of the LCP itself (through the LCP approval and certification processes as defined by the Coastal Act). Thus, jurisdictions will need to undertake these planning processes and then submit new or updated LCPs that have policies consistent with the Coastal Act that reflect, allow for, or otherwise reference the findings of these other documents. For example, development of a vulnerability assessment is a stage in the development or update of an LCP (as described in Steps 2-4 in this chapter), and the LCP itself must include policies that relate to, and address, vulnerabilities identified in the assessment (as described in Step 6).

Relatedly, while SB 272 requires the components listed above, it does not provide additional required standards for those components, and the Commission will continue to allow for flexibility in these efforts provided they are consistent with the requirements of the Coastal Act. In other words, considering the vulnerability assessment example again, SB 272 does not list or require specific details beyond using best available science and including efforts to ensure equity for at-risk communities. The Commission will continue to work with local jurisdictions to support vulnerability assessment efforts that are tailored to meet local needs, capacity, planning stages, and other factors while also considering Coastal Act resources and topics.

Lastly, as discussed later in this chapter, while the above listed components constitute the minimum requirements for an LCP to satisfy SB 272's mandates and be prioritized for funding for implementation of sea level rise adaptation strategies, the Coastal Commission remains committed to supporting phased LCP updates that reflect varying levels of detail. These LCP sea

[35] Critical public infrastructure is defined in SB 272 as including but not limited to "…transit, roads, airports, ports, water storage, and conveyance, wastewater treatment facilities, landfills, powerplants, and railroads." Other critical infrastructure types that should be considered include sewer lines, stormwater facilities, gas lines, and other utility infrastructure.

level rise plans must be completed (and certified by the Coastal Commission) by January 1, 2034; however, jurisdictions do not need to complete every requirement at once. The Coastal Commission will coordinate with local governments to support planning efforts and LCP policies that, in combination with an identified timeline for updates, will meet the SB 272 requirements. In other words, an initial LCP update could comply with the requirements of SB 272 by including baseline sea level rise policies and an explicit timeline for completing any of the missing components referenced in SB 272 (e.g., vulnerability assessment, adaptation plan, list of adaptation projects). By January 1, 2034, jurisdictions will need to have completed the six components identified in SB 272 and new or updated LCPs must reflect that greater level of detail, with background information, maps, policies, and so on that identify and address SLR vulnerabilities and allow for or require implementation of identified adaptation strategies and projects.

Steps 1-7 of this chapter provide more detail on recommendations and best practices for vulnerability assessments, adaptation planning, and LCP policy development to address sea level rise in a manner that is consistent with the Coastal Act, SB 272, and other relevant statewide approaches. Language highlighting the minimum requirements for consistency with SB 272 is also included. A summary of the minimum components for consistency with SB 272, and the related minimum requirements that must be reflected/addressed in each component is included at the end of this chapter.

Steps for Addressing Sea Level Rise in Local Coastal Programs and Other Plans

The Commission recommends the following seven steps to address sea level rise through development of a vulnerability assessment, adaptation plan, and as part of an LCP, LCP Amendment, or other plan.[36] These steps can be modified and adapted to fit the needs of individual planning efforts or communities and to address the specific coastal resource and development issues of a community, such as addressing bluff erosion or providing for effective redevelopment, infill, and concentration of development in already developed areas.

The steps of this process are illustrated in Figure 11 and described below. They are similar to the standard steps of a long-range planning process and should be familiar to local planners. Steps 2-4 are often referred to as a “sea level rise vulnerability assessment” in other sea level rise planning contexts and therefore are similar to other sea level rise-related resources. Steps 5-7 cover the adaptation planning phase and incorporating vulnerability assessment and adaptation planning information into the LCP. As summarized above, this general process is consistent with the requirements of SB 272.

[36] This Guidance uses the term ‘LCP process’ to refer to the LCP process, but many of the concepts included here are applicable to other planning processes, including Long Range Development Plans, Public Works Plans, and Port Master Plans. For example, recommendations for how to analyze sea level rise impacts and perform a vulnerability assessment are broadly applicable. Many adaptation strategies may also be applicable, though in all cases, individual actions taken will vary based on relevant policies, local conditions, feasibility, and other factors.

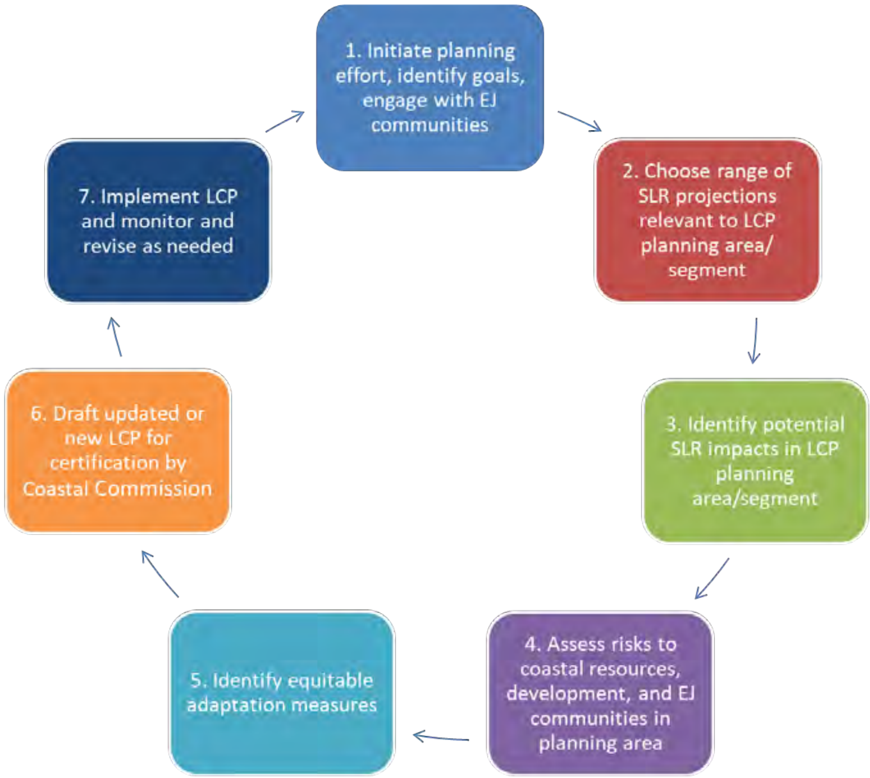

Figure 11. Sea level rise adaptation planning process for new and updated Local Coastal Programs

The Coastal Commission also offers a Local Coastal Program (LCP) Update Guide (2013b) that outlines the broad process for amending or certifying an LCP, and there is naturally some overlap between the content of that document and this Sea Level Rise Policy Guidance document. The general LCP amendment steps are outlined below, in a flow chart (see Appendix D), and in the LCP Tips/Best Practices document (2013c), which is available in the Resources for Local Governments section of the Commission's website (which also contains informational resources for addressing a variety of other LCP-related topics such as housing). Local governments should contact the Coastal Commission planner for their area when pursuing a new LCP or LCP amendment.

- **Initial Amendment scoping and development:** Conduct issues assessment, identify need for amendment, prepare preliminary draft, coordinate with Commission staff, and share early drafts
- **Local Amendment process:** Notify public, conduct local outreach and hearings, meet with Commission staff to discuss any issues, and adopt LCP at the local level
- **Prepare Submittal:** Assemble LCP materials, discuss with Commission staff prior to submittal, transmit to Coastal Commission, and make available to public
- **Process Amendment at Coastal Commission:** Commission staff will review submittal within 10 working days for completeness; will address outstanding information needs;

will prepare and write staff report; hold public hearing and vote; and transmit action to local government

- **Effectuate Amendment:** Local acceptance of any modifications or resubmittal within 6 months, finalize local approval, and complete Coastal Commission Executive Director check-off
- **Implement LCP Amendment, monitor, and revise as necessary.**

The step-by-step process for incorporating sea level rise into LCPs outlined in the rest of this chapter fits into these broader LCP amendment steps. Local government planners should use the LCP Update Guide in conjunction with the Sea Level Rise Policy Guidance to inform the LCP.

Use scenario-based analysis

The Guidance recommends using a method called "scenario-based analysis" (described in Chapter 3 of this Guidance). Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple sea level rise amounts, plus extreme water levels from storms and El Niño events. The goal of scenario-based analysis for sea level rise is to understand where and at what point sea level rise, and the combination of sea level rise and storms, pose risks to coastal resources or threaten the health and safety of a developed area. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise. For example, if there are large changes in the hazard zones between two sea level rise amounts, additional analyses may help determine the tipping points when viable land uses will change. In general, scenario-based analyses can help determine the long-term compatibility of certain areas with certain land uses. For further description of this method, see Chapter 3.

Include other topics as applicable or desired

This Guidance recommends a number of analyses that will generate useful information related to sea level rise and other environmental vulnerabilities. Performing these analyses (and the overall planning process) may provide a useful opportunity to include other studies that will complement the goals of Local Coastal Programs and provide valuable insights for community concerns. For example, when considering lower cost visitor serving facilities, planners should consider social equity and environmental justice in the analyses by determining how climate hazards or the adaptation measures might differentially impact various demographics. It may also be appropriate to consider other sustainability or Climate Action Plan goals in the context of any sea level rise adaptation strategies that are developed as well as strategies to mitigate climate change (such as local options to reduce greenhouse gas emissions). Important topics such as these may be incorporated into the analyses already underway for the sake of efficiency.

Leverage analyses and share information with other planning-related processes and documents

Sea level rise is addressed in many other planning-related documents and by many other agencies and organizations. The Governor's Office of Planning and Research (OPR) published the Coastal Resilience Compass Plan Alignment Guide to describe plans applicable to coastal resilience planning (e.g., LCPs, Local Hazard Mitigation Plans, General Plans, Climate Adaptation Plans) and how they can be aligned. A memo from the Coastal Commission staff includes a summary of key takeaways from the Compass and recommendations for its application to LCP amendments.

Planners should be aware of these various documents and the on-going work of state and federal agencies as well as neighboring regional and local efforts. They should make an effort to share information in cases where analyses required for some of these documents may overlap with the studies appropriate for sea level rise planning in LCPs. Additionally, these agencies, organizations, and planning efforts may be good resources from which to gather information when performing these analyses for LCP updates.

For example, there is overlap between the required elements of a Local Hazard Mitigation Plan (LHMP) and Local Coastal Programs, and the Commission recommends coordinating an LHMP update with an LCP update if possible. As part of an LHMP, local governments identify the natural hazards that impact their community, identify actions to reduce the losses from those hazards, and establish a coordinated process to implement the plan.[37] In order to be eligible for certain types of non-emergency disaster assistance, including funding for hazard mitigation projects, local governments are required by FEMA to complete an LHMP and to update the plan every five years. Any sea level rise hazard avoidance strategies included in an LCP certification or update, such as relocation of critical facilities, must be included in the LHMP narrative to be eligible for funding from FEMA to implement those future projects. If a local government has recently updated their LHMP, the city or county can add narrative information on sea level rise strategies through an addendum to the plan, referred to by FEMA as an annex.[38] Relatedly, FEMA also coordinates the Community Rating System, a voluntary program that encourages National Flood Insurance Program (NFIP) member communities to exceed minimum floodplain management standards in exchange for flood insurance discounts. A variety of actions that would qualify for such discounts are strategies that help to address anticipated sea level rise and which could be incorporated into an LCP.[39]

In many cases, the analyses and adaptation options identified in this Guidance could be used for hazard mitigation plans or vice versa, as the goal of each of these planning processes is to

[37] https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/create-hazard-plan/process

[38] For more information on how to complete or update an LHMP, visit the Cal OES Hazard Mitigation website or contact the Cal OES Local Planning Unit at MitigationPlanning@caloes.ca.gov and a hazard mitigation technical expert can assist local governments with the planning process.

[39] For more information, see FEMA's Community Rating System website.

minimize or avoid impacts from coastal hazards. As a result, there may be opportunities to leverage funding and share work efforts.

A number of other similar planning processes and documents are listed in Figure 12, and planners may be able to use these studies in the LCP planning process, or, alternatively, share analyses and information performed for LCP planning with the groups working on related projects. Additionally, the State of California's Adaptation Clearinghouse is a searchable database that includes resources and examples relevant to climate adaptation planning, including coastal resilience planning. It allows users to search for past and/or ongoing actions that stakeholders have implemented to address sea level rise. This Guidance highly recommends leveraging these resources to promote efficiency.

Coordinate regionally as appropriate

Many impacts of sea level rise will transcend jurisdictional boundaries, necessitating regional collaboration. Similarly, the adaptation decisions made by coastal communities could themselves have consequences that affect areas outside the local jurisdiction. For these reasons, regional coordination will often enhance the effectiveness of local adaptation decisions. Indeed, many of the types of projects identified in Figure 12 have taken this regional approach. Furthermore, mechanisms such as Joint Powers Authorities or financing districts can support climate resilience efforts on a regional scale. Planners should keep this concept in mind as they work through these steps and coordinate regionally where appropriate and possible.

Representative Adaptation Planning Stakeholders

Agencies

Local/Regional:

- City/county governments
- League of Cities
- Association of Counties
- Regional entities (e.g. air districts, water boards, metropolitan planning orgs., regional transportation planning agencies)

State:

- Ocean Protection Council
- State Coastal Conservancy
- State Lands Commission
- Bay Conservation and Devel. Commission
- Natural Resources Agency
- Office of Planning & Research
- CalTrans
- Office of Emergency Svcs.
- CalFire
- CA Geologic Survey
- Dept. of Parks and Recreation
- Dept. of Fish and Wildlife
- Dept. of Water Resources
- SWRCB
- Air Resources Board

Federal:

- FEMA
- EPA
- US Fish and Wildlife Service
- NOAA
- Gulf of the Farallones NMS
- Monterey Bay NMS
- SF Bay NERR
- Elkhorn Slough NERR
- Tijuana River NERR
- USGS
- USACE
- BOEM, BSEE
- NPS
- Sea Grant

Partner Organizations

- Non-Government Organizations (environmental, social etc.)
- Community- or Faith-Based Organizations
- Neighborhood Councils
- Professional organizations (agricultural, fisheries, communications etc.)
- Science organizations
- School Districts, Universities
- Private consultants/industry

Examples include:

- Central Coast Alliance United for a Sustainable Economy (CAUSE)
- Environmental Health Coalition
- Brightline Defense
- The Nature Conservancy
- Surfrider Foundation
- Coastkeeper Alliance
- Point Blue Conservation Science
- American Society of Adaptation Professionals

Coordinated Planning Efforts

Local & Regional Plans/ Planning Efforts

- Local Hazard Mitigation Plans
- General Plans
- Climate Action Plans
- Capital Improvement Plans/Programs
- Caltrans Corridor Plans
- SLR/Climate Change Adaptation Plans
- Integrated Regional Water Management Plans
- Regional Sediment Management Plans
- Sustainable Community Plans
- Regional climate collaboratives
- Working groups
- Technical and stakeholder advisory groups

Figure 12. Agencies, organizations, and planning efforts related to sea level rise adaptation

Step 1 – Initiate planning effort, identify key goals and stakeholders, and engage with environmental justice communities

A key first step for initiating the development of, or an update to, an LCP is to complete a variety of tasks related to defining the scope of the planning project. This includes things like identifying the goals of the planning effort, setting up the project team, identifying key stakeholders, and engaging with environmental justice communities.

As discussed later in this chapter, efforts to develop or update an LCP to address sea level rise can come in a variety of shapes and sizes. For example, a comprehensive update to an LCP (or development of a new LCP), will address sea level rise as well as other Coastal Act topics. In other cases, an LCP amendment may solely focus on updating a coastal hazards chapter or developing a new chapter on sea level rise adaptation. Furthermore, the level of detail associated with sea level rise planning efforts may vary. Some LCP updates may initially include a more general set of baseline sea level rise policies such as requirements to use best available science or calling for the development of an adaptation plan while other LCPs may go into greater detail related to policies or zoning designed to implement specifically identified adaptation responses. Defining the goals of an LCP planning effort at the outset will help both the planning team and members of the public understand the overall scope of the work; timing, information, expertise, funding, and other needs; what the range of outcomes may be; how potential future planning phases could relate to the project, and so on.

Initiating an LCP planning effort also includes setting up the planning team. While LCPs are typically developed by local jurisdiction planning departments, a variety of other City/County departments may be important partners in sea level rise planning efforts. For example, Public Works and Parks and Recreation departments, or other asset and resource managers, will be key partners that can both provide important data and context for understanding potential impacts of sea level rise as well for the implementation of specific adaptation projects. A city or county may choose to establish an interdepartmental sea level rise team of City/County staff representatives. In some cases, such a team may have been formed previously for a climate change or sea level rise planning effort that an LCP update effort can tap into and build from.

Similarly, it is important to identify a variety of key external stakeholders. At the start of an LCP update to address sea level rise or a new LCP project, local government planners should contact their local Coastal Commission district office to discuss the LCP goals and to establish a plan for Coastal Commission staff coordination throughout the process. A variety of other state agencies or regional partners such as Caltrans, State Parks, Ports, harbor districts, community services districts, transit agencies, and so on may also be important partners. Members of the public – including both residents of a City/County and those who work in or visit the coastal zone – are also critical partners who should be incorporated into LCP planning efforts. Coordination with external partners can include establishing technical and community stakeholder advisory committees, as well as planning for robust public outreach. LCP planning efforts should include a variety of means for gathering feedback, including a project website, FAQs/general explainers, social media, mailings, and public meetings in addition to the required public hearings on the LCP.

Critically, local governments should identify and engage with environmental justice and tribal communities, early and often. As discussed in Chapter 4, many environmental justice communities have been overlooked or systemically barred from participating in community planning decisions. Overcoming these injustices requires an intentional effort, and public involvement should center meaningful engagement with environmental justice communities within and surrounding the local jurisdiction. The following section describes steps for meaningfully including these communities in an LCP planning effort.

MEANINGFUL ENGAGEMENT WITH ENVIRONMENTAL JUSTICE COMMUNITIES

The Coastal Commission's Environmental Justice Policy expressly recognizes that environmental justice communities have coastal assets and are valuable stakeholders in the protection of the coast. Furthermore, addressing environmental justice in the coastal zone should reflect the intent of PRC Section 30604(h) and incorporate input from environmental justice communities affected by coastal development in the local jurisdiction. Proactively engaging with environmental justice communities, and organizations that serve them and have shared interests, early on or prior to initiating development of a new or updated LCP lays the groundwork for meaningful collaboration and fosters trust between local governments and affected communities. This approach not only streamlines project communication but also ensures that environmental justice concerns are identified and addressed from the outset, aligning with SB 272 and overarching Coastal Commission and statewide objectives for inclusive coastal management. As such, this step aims to recognize and set the stage to engage with these communities that have been historically excluded from decision-making processes and from accessing the benefits of coastal development and resources. Further, identification and engagement with environmental justice communities will better inform the CDP application and analysis process, as explained in detail in Chapter 6.

Use quantitative and qualitative data to identify environmental justice communities

Identifying environmental justice communities in and around the LCP planning area is a core step in the outreach and engagement process and for ensuring that vulnerability assessments, adaptation planning, and LCP updates will be developed in ways that consider and address locally-relevant environmental justice issues. Further, as detailed in SB 272, local governments are required to develop a vulnerability assessment that includes efforts to ensure equity for at-risk communities. The Commission recognizes the term environmental justice communities as an umbrella designation that refers to low-income communities, communities of color, and other historically marginalized communities that have been disproportionately burdened by, or less able to prevent, respond to, and recover from, adverse environmental impacts and discriminatory land use practices. This may include communities and groups that are located a distance from the coast but have an important connection with the area.

There are several data tools available that can aid in this step, including quantitative information from resources such as the Commission's forthcoming Coastal California EJ Mapping Tool, the State's CalEnviroScreen tool, U.S. EPA's EJScreen, Cal EPA's SB 535 Disadvantaged Communities map, California State Parks' Outdoor Equity Program Community FactFinder, and U.S. Census data.

- Coastal California Environmental Justice Mapping Tool (forthcoming): Commission staff developed the Coastal California Environmental Justice Mapping Tool, which can be used to assist in the identification and analysis of environmental justice communities and future sea level rise scenarios. This mapping tool compiles public information (including some information available on CalEnviroScreen and EPA EJScreen) such as socioeconomic data, sea level rise projections, Coastal Zone Boundary, LCP segments, and coastal public access points.
- CalEnviroScreen: A mapping tool created by CalEPA Office of Environmental Health Hazards Assessment to identify California communities most affected by multiple sources of pollution. CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in California, which are mapped to compare how pollution burden varies among communities.
- Cal EPA's SB 535 Disadvantaged Communities map: This map shows the disadvantaged communities designated by CalEPA for the purpose of SB 535. These areas represent the 25% highest scoring census tracts in CalEnviroScreen 4.0.
- EPA EJScreen: EJScreen is an EPA's environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic socioeconomic indicators.
- CA State Parks' Outdoor Equity Program Community FactFinder: A mapping tool created by California State Parks to identify and visualize communities' access to parks and open spaces, using environmental, health, and socioeconomic data to highlight areas with the greatest need for improved outdoor equity and access.
- U.S. Census Data: The U.S. Census Bureau provides data about the nation's people and economy. Every 10 years, it conducts a census counting every resident in the United States. The Census Bureau provides a variety of tools (including the EPA EJScreen) to identify environmental justice communities.

It is critical to note that members of environmental justice communities affected by development and land use planning activities in the coastal zone may live outside of a city or county boundary and outside of the coastal zone, but they may travel into or through the jurisdiction for work or to visit coastal resources and recreational opportunities. Therefore, planners should identify environmental justice communities that exist in proximity to, or have a connection with, the LCP planning area.

Characterize historic and current environmental burdens of environmental justice communities

It is important to not only identify where environmental justice communities exist, but to also understand the specific historic and current burdens experienced by these communities. This understanding will better inform how to approach meaningful engagement plans, vulnerability assessments, and adaptation planning. For example, identifying where legacy injustices—such as redlining and restrictive racial covenants that prevented people of color from buying homes in certain neighborhoods or learning about health issues from living near oil refineries, ports, and other industries—can inform changes in land use and development policies. Similarly, acknowledging the historical land theft and displacement of indigenous people from coastal areas, along with ongoing cultural and environmental impacts, can provide additional insights. And, qualitative data such as community testimony, interviews, and outreach can ground-truth quantitative datasets and provide further context to inform resilient coastal planning. Asking communities about their relationship to the coast provides an understanding of how people experience environmental benefits or burdens along the coast. Do their families visit the coast to fish for recreation or for subsistence? Do they visit the coast for work or recreation? If they live along the coast, what health and environmental issues are relevant in their area and important to them? How have historical tribal events and displacement influenced their connection to and use of coastal areas? Understanding the specific factors that distinguish an environmental justice community from other populations will ultimately drive more equitable strategies and outcomes.

Create a meaningful engagement plan

Once a planner has identified environmental justice communities and characterized the environmental burdens these communities experience, they should develop a meaningful engagement plan that will guide how outreach with environmental justice communities will be conducted throughout the LCP planning (see Chapter 4 for an in-depth discussion on meaningful engagement). Without adequate and meaningful engagement, sea level rise policies will lack credibility with the affected community that can result in adverse outcomes later in the process. Direct outreach and engagement with environmental justice communities throughout the LCP scoping and amendment process will ground the foundation of sea level rise policy development in authentic experiences. Within each jurisdiction, there will be opportunities to create nuanced policies that reflect the local context and priorities of environmental justice communities. While each local government might take different approaches to meaningful engagement, generally, they should evaluate whether their engagement efforts achieve the following goals:

- Environmental justice communities and the public receive clearly written/communicated information early on and continuously throughout the process to create a new or amend an existing LCP.
- Individuals of different backgrounds and/or abilities have equitable access to information because informational materials are ADA-compliant, account for language barriers, are culturally appropriate, and include meeting times and locations.

- Environmental justice communities receive responses from local government and their feedback is incorporated into the process to create a new or amend an existing LCP.

Two practices that can help local government planners develop their meaningful engagement plan is through connecting or partnering with community-based organizations (CBOs) working in or with environmental justice communities and developing community surveys. Community organizations can include local nonprofits, faith-based organizations, school associations, and clubs. Planners can begin building trust with these organizations by attending existing community meetings and getting to know organization leaders and members. CBOs often have already gained the community's trust and know who the community members are, who needs to be in the room, and how to reach them. They can have staff that know how to facilitate specific meaningful conversations and discussions, and they continue to be in contact with the community, thus providing an ongoing pathway for communication between local governments and the community. Establishing a relationship with these trusted groups can help a local government to engage a broader audience, dismantle some distrust that communities may have with government entities, and identify a more unified vision of community needs that can be incorporated into an LCP. Conducting community surveys among environmental justice communities can help local governments understand the priorities and problems that their communities currently face regarding land use and development. The greater burdens and barriers that environmental justice communities contend with may shape different priorities and concerns regarding climate change, coastal access, public recreation, and resource protection compared to wealthier communities, as well as other identities of power, race, religion, and culture.

An important part of a meaningful engagement plan includes identifying any unique barriers that environmental justice communities may encounter during the public participation process, including multilingual and technical language access, meeting times, childcare, transportation access, and technology access. These barriers create disproportionate burdens on community members who have less financial flexibility, may be transit-dependent, do not understand English very well, have limited access to technology, or have more constrained schedules and capacities. Some best practices for addressing these barriers can include:

- Translating written materials in languages predominantly spoken among residents including surveys, flyers, notices, and website announcement and providing oral interpretation services for speakers at public meetings.
- Allowing opportunities for pre-recorded public comments via live video stream or phone calls for public meetings.
- Partnering with a community organization to help provide childcare services or holding public meetings at sites where children can go during the meeting, such as recreation centers.
- Holding meetings near public transportation services, within walking distance from where people live, or providing other methods for participation that do not require individuals to physically attend meetings.

- Identifying meeting times that occur during more accessible time ranges so that communities have the opportunity to attend and meaningfully engage while minimizing constraints to their day-to-day schedules.

The Commission's Toolkit on Resources for Addressing Environmental Justice through Local Coastal Programs provides a lot more information regarding participation barriers for environmental justice communities, best practices for creating a meaningful engagement plan, and conducting outreach with environmental justice communities.

SB 272 Consistency: SB 272 requires local governments to update LCPs to address sea level rise. As discussed at the beginning of this chapter and throughout the following steps, this includes completing a vulnerability assessment, identifying adaptation strategies, identifying lead planning and implementation agencies, and ensuring equity for at-risk communities. This step discusses best practices for initiating a planning effort, including identifying key goals, internal and external partners, and environmental justice communities.

Expected outcomes from Step 1: Initiation of the planning process, including identification of planning goals, key stakeholders, and environmental justice communities in or near the LCP planning area/segment. During this step, the planner should work to create a connection with environmental justice communities and develop a meaningful engagement plan that establishes how outreach will be conducted with them throughout the LCP planning process.

Step 2 – Determine range of sea level rise scenarios relevant to LCP planning area/segment

The first step in incorporating sea level rise into the LCP planning process is to identify locally relevant sea level rise scenarios that may occur at given time points in the future. These scenarios will be carried through the rest of the steps in the sea level rise LCP planning process. Follow these steps to determine the locally relevant sea level rise scenarios to use in the subsequent steps:

- **Determine planning horizons of concern:** The Coastal Commission recommends taking a long-term view when analyzing sea level rise impacts because the land use decisions made today will affect what happens over the long-term. For example, development constructed today is likely to remain in place over the next 75-100 years, or longer. After the original publication of this guidance in 2015, many jurisdictions completed assessments that look at sea level rise vulnerabilities through approximately 2100; however, it may be prudent for future assessments to look out to at least 2130. Understanding short-term vulnerabilities is also important, and the Coastal Commission also recommends assessing vulnerabilities in intermediate planning horizons. For example, many jurisdictions have assessed sea level rise scenarios that correspond to nearer-term horizons (e.g., in 2030, 2050, and so on) as these horizons may provide valuable details for implementing priority or short-term adaptation strategies. These time periods may be used, or local governments may identify other relevant planning horizons for their plans and development scenarios, as long as the sea level rise scenarios for those time frames are based on the best available and relevant scientific projections.

- **Determine the full range of sea level rise scenarios from the best available science:** Using best available science, currently the 2024 State Sea Level Rise Guidance (or other comparable study, provided that it is peer reviewed, widely accepted within the scientific community, and locally relevant), determine the range of sea level rise for the planning horizons of concern. The statewide sea level rise scenarios from the 2024 State Sea Level Rise Guidance are presented in Table 5 below (scenario tables for all 14 California tide gauges are presented in Appendix F).[40] See below for a discussion of scenario-based planning in the LCP context.

[40] More detailed refinement of sea level rise projections is not considered necessary at this time, as variations from the nearby tide gauges will often be quite small, and may be insignificant compared to other sources of uncertainty. However, the Coastal Commission recognizes that other studies exist with localized data, for example those completed in the Humboldt Bay region, which may also be appropriate for use.

Table 5. Sea Level Rise Scenarios for California [41]

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

- **Choose multiple sea level rise amounts based on range of sea level rise scenarios.** The Coastal Commission recommends that communities evaluate the impacts from multiple sea level rise amounts that cover the range of SLR scenarios for the identified long-term plan horizon. In practice, assessing impacts from several specific SLR amounts (e.g., 1, 3, 6, and 10 feet) can account for multiple possible futures when compared to the time horizons associated with different SLR scenarios. In other words, evaluating 3 feet of SLR can generally tell us what to expect in 2070 under a worst-case future (the High SLR scenario) or around 2100 or later in better-case scenarios (Intermediate or higher certainty scenarios).

  In general, communities should account for, at a minimum, the full range of sea level rise associated with the Intermediate-High scenario for the identified planning horizon

[41] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the *State Sea Level Rise Guidance* and this guidance recommend for use in various planning and project contexts.

(e.g.¸ up to about 7 feet for a 100-year planning horizon). The Commission also continues to recommend incorporating the High scenario to evaluate the vulnerability of planned or existing assets like critical infrastructure that have little to no adaptive capacity, that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur.[42] Evaluating the lower scenarios (those with a higher certainty) allows planners to gain an understanding of what is likely to be vulnerable under more likely future climate conditions.

In addition to evaluating the higher end/worst-case scenarios, it is helpful to understand the minimum amount of sea level rise that will cause impacts for a community, and how these impacts will change over time, with different amounts of sea level rise. Planners should evaluate enough scenarios to be able to answer the following:

- What are the impacts from the most likely/near-term amounts of sea level rise? What about from the worst-case scenario/longer-term sea level rise?
- How would elevated water levels from King tides, El Niño, a 100-year storm, and other factors exacerbate the impacts of SLR on the community?
- What is the minimum amount of sea level rise that causes inundation, flooding, or erosion concerns?
- How do inundation, flooding, and erosion concerns change with different amounts of sea level rise?
- Are there any tipping points where sea level rise impacts become more severe? (For example, is there a point at which seawalls or levees are overtopped or where beaches or public access are lost?)

There is no single accepted sea level rise mapping methodology for the state of California. Local governments can choose whether to use existing sea level rise tools or to develop their own scenarios and maps. Some existing models and tools provide maps by sea level rise amount that can then be linked to the relevant time period, as described in the box below.

[42] For more information on sea level rise planning for critical infrastructure, see also the Coastal Commission's Critical Infrastructure at Risk planning guidance.

Choosing Scenarios with Existing Sea Level Rise Modeling Tools

A number of jurisdictions throughout California have completed vulnerability assessments using Our Coast Our Future (CoSMoS) or other existing SLR modeling/mapping and visualization tools. Oftentimes, these tools include numerous SLR amounts in regular increments (e.g., for CoSMoS, generally 25 centimeter increments and for the NOAA SLR Viewer, one-foot increments). These types of tools allow users to identify and evaluate SLR amounts, and then relate those amounts to the anticipated time horizons over which they may occur based on current best available science. For example, a jurisdiction may use CoSMoS to evaluate 1m of SLR (approximately 3.3ft), which, based on the 2024 State SLR Guidance, could occur as soon as 2070-2080 under the High and Intermediate-High scenarios, or around 2100 under the Intermediate scenario.

Importantly, this approach for choosing and evaluating SLR amounts generally allows for vulnerability assessments to remain relevant even as best available science changes over time. While the time horizon associated with specific SLR amounts may change with evolving science, the visualization of those associated SLR effects will not. For example, past vulnerability assessments that evaluated 1m of SLR using CoSMoS would have associated those impacts with approximately 2065 (medium-high risk aversion scenario from the 2018 Guidance). That vulnerability assessment doesn't need to be re-done now, but users should understand that that amount of SLR is likely to occur slightly later than previously expected.

Note too that there is often a slight mismatch between exact SLR amounts in the scenario tables and the SLR amounts in the available tools (e.g., 3.3ft is a CoSMoS scenario while the SLR scenarios in Table 5 include 3.0 and 3.1ft). In general, given the uncertainties and ranges associated with sea level rise science, minor differences like these will not matter much, particularly in the context of general vulnerability assessment efforts. Users could also interpolate between the decadal SLR amounts shown in the scenario tables. For example, one could use Table 5 to approximate that 4ft of sea level rise could occur by approximately 2095 under the Intermediate-High scenario.

More information on sea level rise modeling and mapping tools is available in Table 6. Technical information for incorporating other hazards (such as storms, erosion, or waves) can be found in Appendix B.

SB 272 Consistency: SB 272 requires local governments to develop a vulnerability assessment using best available science. This step identifies the 2024 OPC State SLR Guidance (or other comparable, peer-reviewed, widely scientifically accepted, and locally-relevant study) as the current best available science, and provides general recommendations for how to go about choosing sea level rise scenarios to use in a vulnerability assessment.

Expected outcomes from Step 2: Upon completing this step, a range of regionally- or locally-relevant sea level rise scenarios for the time periods of concern should be established. Based on this range, planners will have identified several SLR scenarios that span the planning horizon, including lower/nearer-term, medium/mid-term, and higher/long-term amounts. These sea level rise scenarios will be carried through the rest of the planning process.

Step 3 – Identify potential physical sea level rise impacts in LCP planning area/segment

The next step is to identify the physical hazards and impacts (referred to comprehensively as sea level rise impacts) associated with current and future sea level. As described in Section C of Chapter 3 of this Guidance, broad categories of sea level rise impacts may include inundation, flooding, groundwater rise, wave impacts, erosion, and saltwater intrusion. In this step, planners should analyze these physical impacts and their various sub-components in order to understand current and future local hazard conditions. The analysis should answer the following basic questions:

- What are the existing hazard conditions that threaten the planning area?
- What is the projected change in hazard conditions due to locally appropriate sea level rise scenarios and planning horizons of concern?

This analysis should include the following topics, as applicable (See Appendix B for detailed technical information):

- Coastal Erosion
    - Current trends or dynamics in beach change and evaluation of how sea level rise may change current trends or dynamics
    - Consideration of beach change attributed to extreme events, seasonal change, and decadal forcings such as Pacific Decadal Oscillation or El Niño Southern Oscillation
    - Historic and future bluff erosion, considering the effects of sea level rise
    - Identification of existing dune areas and evaluation of potential erosion from storm events and long-term beach erosion
- Coastal Wetland Change
    - Current trends in wetland change (e.g., erosion or accretion) and evaluation of how sea level rise may change current trends through changes to water levels and exposure to currents or waves

    - Analysis of how changes to tidal inundation may change coastal wetland habitats

- Coastal Flooding
    - Current tidal datums[43] and future inundation
    - Extreme static water levels from a combination of high tides, atmospheric forcing (e.g., storm surge), and oceanographic forcing (e.g., El Niño and Pacific Decadal Oscillation)
    - Wave impacts (runup and/or overtopping), including impacts from a 100-year event considering worst case beach and bluff conditions
- Fluvial/Riverine Flooding
    - Identification of existing fluvial flood control infrastructure and systems
    - Current and future fluvial flooding for 100-year flood events as worsened by sea level rise and climate change
- Pluvial/Stormwater Flooding
    - Identification of existing stormwater systems
    - Current flood risk from intense rainfall events and consideration of how sea level rise and climate change will change or worsen performance of existing stormwater infrastructure
- Shallow or Emergent Groundwater, Saltwater Intrusion
    - Current and future areas of shallow or emergent groundwater or areas subject to saltwater intrusion
    - Identification of current or future potential water quality issues due to saltwater intrusion, inundation of contaminated soils, or mobilization of contaminants from rising water tables and increases in nonpoint source pollution
- Tsunamis
    - Current and future flood risk from extreme tsunamis

Use existing models, tools, reports, historic records, and other materials (Table 6) to develop or double check the identified hazard areas. Document the current and future hazard areas in the Land Use Plan using maps, GIS products, graphics, tables, charts, figures, descriptions, or other means. This process should be repeated for each planning horizon and/or sea level rise scenario defined in Step 2.

[43] Tidal datums are based on the latest National Tidal Datum Epoch (NTDE) published by NOAA and are the mean of the observed sea levels over a 19-year period. The latest published epoch is 1983-2001. This tidal epoch can be considered roughly equivalent to the year 2000 baseline for the OPC projections.

SB 272 Consistency: SB 272 requires local governments to develop a vulnerability assessment using best available science. This step provides basic recommendations for the types of hazards to evaluate to understand the physical impacts projected to occur as sea levels rise. Appendix B provides greater technical detail on methodologies for projecting changes in coastal hazards.

Expected outcomes from Step 3: Upon completing this step, the potential current and future impacts to the planning area from sea level rise hazards should be identified based on the various sea level rise scenarios chosen. Maps, GIS layers, graphics, figures, charts, tables, descriptions, or another system should be developed to communicate the impacts of current and future hazards.

Figure 13. Example of analysis of SLR impacts. Hazards predicted from the CoSMoS mapping of 3.3 feet (100 cm) of sea level rise in Venice, CA. (*Source*: Venice Sea Level Rise Vulnerability Assessment 2018).

Resources for Sea Level Rise Mapping

Table 6 includes a list of sea level rise mapping tools. The tools vary in their complexity: some are considered "bathtub models," because they show future inundation with simple rise in sea level (and no changes to the shoreline caused by other forces). Others include factors like erosion, storms, and fluvial inputs. These tools provide a useful first look at possible sea level rise impacts, but may need to be supplemented with additional, site- or topic-specific analyses, depending on the region. See Appendix B for additional information on determining hazard impacts and tools for mapping sea level rise.

Table 6. Sea Level Rise Mapping Tools

Tool	Description	Link
Our Coast Our Future (CoSMoS)	The USGS's Coastal Storm Modeling System (CoSMoS) provides maps of various SLR-related hazards under half-meter incremental SLR scenarios. CoSMoS provides more detailed predictions of coastal flooding due to both future sea level rise and storms integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat) over large geographic areas (100s of kilometers). While projections of groundwater rise are available statewide, other hazards are available from Point Arena to the Mexico border and will be available statewide in the coming years.	Access the online viewer at ourcoastourfuture.org Download GIS data layers at the USGS website (Data is also hosted on the 30x30 California Climate Explorer)
Hazard Exposure Reporting and Analytics (HERA) (CoSMoS data)	The USGS's CoSMoS data is hosted on both ourcoastourfuture.org (above) and on HERA, the Hazard Exposure Reporting and Analytics website. HERA allows users to overlay the SLR hazard data layers of CoSMoS with a host of different spatial datasets on communities, residents, employees, land types and habitats, parcels, various types of critical infrastructure, and other critical facilities. It provides users the number of people and assets within any give hazard zone.	HERA website
NASA Flooding Analysis Tool	This tool describes the frequency of high-tide flooding will change under various SLR scenarios. Users can view sea-level observations and assess past high-tide flooding frequency, view future changes in high-tide flooding frequency under various SLR scenarios, and view statistics and inflection points that support decision making. The tool was developed with funding from the NASA	Flooding Analysis Tool

	Sea Level Change Team by scientists at the University of Hawaii Sea Level Center and is based on the methods of Thompson *et al*., 2021.	
NOAA Sea Level Rise Viewer	An example of a "bathtub model," this viewer shows areas that are hydrologically connected to the ocean that would become inundated with 1-foot increments of sea level rise up to 10 feet. Storms, waves, erosion, and other coastal processes are not represented.	NOAA SLR Viewer
Cal-Adapt – Exploring California's Climate	Cal-Adapt hosts two datasets on sea level rise hazards: CoSMoS data and CalFloD3D-TFS. The CoSMoS data is the same as the dataset described above. The CalFloD3D-TFS assesses potential coastal flooding exposure to areas of interest to the Transportation Fuel Sector (TFS) over five 20-year planning horizons and the Fourth Assessment scenarios using a 3D hydrodynamic model during extremely high sea level events (72 hour storm event). Due to the inclusion of aboveground objects such as buildings and levees, CalFloD-3D depicts detailed land surface details. Details are described in Radke *et al*., 2018. Cal-Adapt Analytics Engine provides the foundational climate and environmental data that underpins the California Climate Change Assessment, including sea level rise information.	Cal-Adapt Cal-Adapt Analytics Engine
Humboldt Bay Sea Level Rise Mapping	A variety of mapping efforts have been completed in and around Humboldt Bay to characterize the existing shoreline condition and vulnerabilities under the current tidal regime and, through hydrodynamic modeling, to develop maps of areas vulnerable to inundation from existing and future sea levels.	Mapping and numerous related vulnerability assessment reports available at: humboldtslri.org

Step 4 – Assess potential risks from sea level rise to coastal resources, development, and environmental justice communities in LCP planning area/segment

After environmental justice communities are identified in Step 1 and sea level rise impacts are identified and mapped in Step 2, the next Step is to determine whether sea level rise poses risks to coastal resources, development, and if there is a disproportionate impact on environmental justice communities in the LCP planning area (refer to Chapter 4 for a description of the potential consequences of sea level rise for coastal resources and environmental justice communities). Part of this step includes assessing whether the LCP planning area's current and planned land uses are appropriate or consistent with Coastal Act or LCP policies given those impacts, or if those land uses should be revised. Importantly, this step should also identify whether any environmental justice communities (such as those identified in Step 1) may be disproportionately affected by the impacts of sea level rise on coastal resources, development, and any current and planned land uses.

This step requires an understanding of several characteristics of the coastal resources and development typically found within various land use types as well as how the public, including environmental justice communities, interact or relate to the coastal resource or development. This information can be qualitatively and quantitatively described, and should be included in a vulnerability assessment, as required by SB 272. These assessments should account for potential impacts to coastal resources and development, including but not limited to the following, as well as how such impacts may differentially impact environmental justice communities.

- Existing and planned development, such as housing anticipated by a local government's certified Housing Element
- Coastal-dependent development and uses such as harbors, wharfs, ports, marinas, and commercial and recreational fishing areas and facilities
- Critical infrastructure[44] such as water and wastewater facilities and infrastructure, transportation infrastructure, and some power plants and energy transmission infrastructure
- Public accessways, beaches and other recreation areas, and the California Coastal Trail
- Highways 1, 101, and other state and local roads that provide access to the coast
- Wetlands, environmentally sensitive habitat area (ESHA), and other coastal habitats and sensitive species

[44] Critical infrastructure can vary widely from community to community, and may also include fire stations, police stations, and hospitals. For planning purposes, a jurisdiction should determine criticality based on the relative importance of its various assets for the delivery of vital services, the protection of special populations, and other important functions, as well as the social, environmental, and economic risks associated with loss of or damage to such assets.

- Agricultural areas
- Tribal cultural sites and archaeological or paleontological resources
- Visitor-serving development and uses

Conduct the following tasks for each sea level rise amount identified in Step 2. These tasks should be carried out with identified environmental justice communities as well as their defining characteristics in mind. Sharing the information developed in these steps, and gathering feedback on findings, is an important component of meaningful engagement for developing a vulnerability assessment to inform adaptation planning.

1. For the sea level rise amount of interest, determine what development, coastal resources, and environmental justice communities may be subjected to the sea level rise impacts expected for that time period. Map the coastal resources, development, and environmental justice communities that lie within the sea level rise impact areas for the given sea level rise amount. (Remember to address the wide range of resources listed above, including both natural resources and development.)

2. Determine if sea level rise impacts are a problem or benefit for each resource/development, and if so, when and to what degree the resource/development will be impacted. In some instances, sea level rise may result in the creation of new habitat areas that could help to alleviate impacts from the loss of similar habitat in other locations. However, it is more likely, especially in heavily urbanized areas, that sea level rise will result in a net loss of habitat unless steps are taken to preserve these systems. Similarly, determine if sea level rise impacts on the resource are a problem or benefit to identified environmental justice communities.

   To accomplish this, consider a wide range of characteristics of each resource/development, including the following. The questions listed under each characteristic might help guide the consideration of each. These questions are meant to be suggestions rather than a standardized approach, and planners may use scientific literature, best professional judgment, communication and outreach with asset managers, environmental justice communities, or other interested parties, or a variety of other resources to gain a conceptual understanding of the important resources/development and vulnerabilities in their jurisdictions.

   a. **Exposure.** Will sea level rise impacts affect the resource/development at all?
      i. Are coastal resources and community assets exposed to sea level rise impacts?
      ii. Is the resource/development already exposed to hazards such as waves, flooding, erosion, or groundwater rise? If it is, will sea level rise increase hazard exposure?

b. **Sensitivity.** If resources/development are exposed, to what degree will coastal resources/development be affected by sea level rise impacts? A simple way to think about this concept is to consider *how easily affected* the resource or development is in regard to sea level rise impacts.

   i. How quickly will the resource/development respond to the impact from sea level rise?

   ii. Will the resource/development be harmed if environmental conditions change just a small amount? What are the physical characteristics of the resource/asset (e.g., geology, soil characteristics, hydrology, coastal geomorphology, topography, bathymetry, land cover, land use)? Do any of those characteristics make the resource especially sensitive?

   iii. Can the resource/development withstand certain impacts? Can natural resources recover from occasional impacts? Can development be easily repaired from minor impacts?

   iv. Are there thresholds or tipping points beyond which sensitivity to sea level rise increases?

c. **Adaptive Capacity.** How easily can the resource/development successfully adapt to sea level rise impacts?

   i. How well can the resource/development accommodate changes in sea level over time?

   ii. Is the rate of change faster than the ability of the resource/ development to adapt?

   iii. How easily can development be modified to cope with flooding, inundation, and/or erosion? Can structures be elevated or relocated?

   iv. Are there adaptation efforts already underway? Are there any factors that may limit the success of adaptation efforts in the near, mid, or long term?

   v. Do beaches, wetlands, and other coastal habitats have room to migrate inland? What is the overall health of existing wetlands and coastal habitats?

   vi. Are there any other climate change-related impacts to consider? Are there any non-climate stressors that could impair ability to adapt to sea level rise?

   vii. Is there potential for habitat creation as a result of sea level rise?

   viii. What are the options to protect, redesign (e.g., elevate), or relocate inland any existing public accessways, recreational beaches, and segments of the Coastal Trail to cope with rising sea levels? Is lateral access compromised with sea level rise?

d. **Consequences.** When sea level rise and/or sea level rise adaptation measures have impact(s) upon a resource/development, what are the economic, ecological, social, cultural, and legal consequences?

   i. How severely could each resource/development be affected? At what scale?

   ii. Are there cumulative consequences?

   iii. Are there ripple effects, or secondary consequences to consider? For example, would damage to critical infrastructure result in environmental impacts, such as water quality impacts from spills of hazardous substances?

   iv. Will environmental justice communities be disproportionately affected by changes to or loss of coastal resources/development? For example, would loss of beaches adversely affect communities who use these areas as no or low-cost recreational opportunities? Would loss of agricultural lands or coastal-related industry impact low-income workers?

   v. What are the economic costs associated with damage to or loss of coastal resources and development? How will continued damage and repair and maintenance costs compare to costs associated with adaptation options? Note that SB 272 requires an economic impact analysis of, at a minimum, costs to critical public infrastructure.

   vi. Will adaptive responses cause further adverse impacts?

e. **Land Use Constraints.** Given the location of sea level rise impacts and the coastal resources and development currently located in those areas, should the types and intensities of land use be altered to minimize hazards and protect coastal resources?

   i. What is the current pattern of development? Is the area largely developed or does it have significant areas of undeveloped land?

   ii. Is the area served by infrastructure that is vulnerable to sea level rise impacts?

   iii. Are large areas of land under common ownership or is land mostly subdivided into smaller lots in separate ownership?

   iv. What conditions are required for the land use type, development, or resource to either exist or fulfill its intended purpose?

   v. Are there coastal-dependent uses? What are their ideal proximities to the coast?

vi. For potential new development, what is the expected lifespan? Is it economically feasible to locate it in a sea level rise impact area for a certain period of time before it is removed or relocated? Can a phased plan be undertaken to address any changes over time?

vii. For existing development, what are the options available to minimize hazards to the development while protecting coastal resources? Note that in certain situations, the Coastal Act allows existing structures to be protected (Coastal Act Section 30235). What are the coastal resource impacts of such protection, and are there feasible alternatives that avoid negative impacts often associated with shoreline armoring. Are there options to provide incentives to property owners to relocate or remove at-risk structures?

viii. For a natural resource or habitat, what conditions are required for it to persist?

ix. Where would resources/development ideally be located (or relocated to) over time as sea level rise causes environmental conditions to shift?

x. What changes to existing LCP requirements or other land use restrictions are necessary to maximize opportunities for avoiding hazards or relocating threatened existing development?

After going through the questions listed above, and others that may be relevant to the planning exercise, synthesize the information and determine where sea level rise impacts currently pose problems for coastal resources, development, and environmental justice communities, what problems may develop over time as sea level rises, and how urgent the problems are. Create maps illustrating the location and extent of vulnerable land uses, such as critical facilities, wastewater infrastructure, and State Highway 1 and other coastal access roadways. This information should also be summarized in narrative form. The analysis should identify resources and development likely to be impacted by sea level rise at various periods in the future, and thus the issues that need to be resolved in the adaptation and LCP planning process, including in a phased manner as appropriate.

Remember that these assessments are not static; existing risks will change and new risks will arise with changes in a community, changes to coastal resources, the emergence of new threats, new information, and the implementation of adaptation actions. For this reason, the analysis should be updated as needed to reflect changes in sea level rise projections, changes in land use patterns, or new threats.

SB 272 Consistency: SB 272 requires local governments to develop a vulnerability assessment. This step provides recommendations on the types of coastal resources and land uses that are important to consider from a Coastal Act perspective, and provides direction for how to understand the implications of sea level rise depending on factors such as exposure, adaptive capacity, and impacts for environmental justice communities. SB 272 also requires economic impact analyses of, at a minimum, costs to critical public infrastructure. Assessing costs associated with exposure to and impacts from sea level rise over time, and beginning to understand the costs associated with repair and maintenance versus proactive adaptation actions can begin in this step.

Expected outcomes from Step 4: Descriptions of the characteristics that influence risk, including exposure, sensitivity, and adaptive capacity of each coastal resource to sea level rise impacts under each sea level rise scenario identified in Step 2 at the selected planning horizons, along with the expected consequences of those impacts for the resource, environmental justice community, and broader community. Maps of resources and/or land uses at risk could be produced.

Example for Step 4

To illustrate the process described in Step 4, consider a hypothetical planning area that includes multiple coastal resources and land use types, including a coastal wetland, bluff-top residential development with a fronting beach, and a wastewater treatment facility, that need to be addressed in the planning process. After Steps 1-3, portions of the planning area are found to be subject to current and future sea level rise impacts.

Step 4.1: Map the coastal resources and development (in this case the wetland, residential development, and wastewater treatment facility) for the range of time periods and sea level rise scenarios.

Step 4.2

a. **Exposure**

- *Wetland:* The wetland is highly exposed to flooding and inundation from sea level rise. By the year 2030, portions of the wetland will trap sediment at a rate such that the elevation keeps pace with sea level rise. By 2050, a portion of the wetland will become inundated and converted to open water, and by 2100 the entire area will be converted to open water. The wetland will be completely lost by this time period if it is not able to move inland.
- *Bluff-top Residential Development:* Houses in the residential development are not exposed to sea level rise impacts in 2030. However, a high rate of retreat along the fronting beach and bluff will put front-line houses in danger of being undermined by

the year 2050, and the entire development may be lost by 2100 unless adaptation measures are implemented.

- *Wastewater Treatment Facility:* Given that the wastewater treatment plant is set back somewhat from the shoreline, it will not be exposed to impacts from sea level rise until 2050. By 2050, however, portions of the infrastructure will be exposed to impacts from elevated water levels due to 100-year storm events and El Niño occurrences. By 2100, significant portions of the below-grade and above-grade infrastructure will be exposed to groundwater rise and flooding as the surrounding area is eroded and inundated.

b. **Sensitivity**

- *Wetland:* The wetland has high sensitivity to changes in sea level because its functioning is highly-dependent on local physical parameters such as water flow, tidal fluctuation, sediment supply, and water quality. Although it currently has good sediment supply, good water quality, and a number of other characteristics, small changes in sea level rise by 2050 may alter the function of the wetland. In addition, there are concerns that beyond 2050 the wetland will not be able to keep up with accelerated sea level rise, thus increasing sensitivity to further changes in sea level.
- *Bluff-top Residential Development:* The residential development has moderate to high sensitivity to longer-term sea level rise changes. Absent adaptation strategies, by 2050, the front-line houses will no longer be safe enough for occupancy. Moreover, infrastructure such as roads, sewage systems, and power networks may be damaged as the bluff-face erodes.
- *Wastewater Treatment Facility:* The facility is moderately sensitive to sea level rise. Flooding, groundwater rise, and erosion from sea level rise could cause damage to the facility, pumps and other equipment, but the facility was initially built to withstand a high degree of storm and related impacts. Associated damage to the facility could lead to a potential increase in rates for local ratepayers, which could disproportionately impact low-income and environmental justice communities.

c. **Adaptive Capacity**

- *Wetland:* Unlike many wetlands in the State of California, this particular wetland has a moderate-high adaptive capacity because it has the ability to both accumulate sediment and grow upwards, and, given that the land upland of the wetland is preserved as open space, it can migrate inland. However, by 2050, a part or all of the existing wetland area could be converted to open water if the wetland is not able to migrate inland or accumulate sediment at a rate that keeps pace with sea level rise. In this case, for example, a public trail will need to be relocated to allow inland migration of the new intertidal zone. Additionally, adaptive capacity may be reduced if pollution increases (e.g., as a result of damage to adjacent development) and disrupts the normal functioning of the wetland.
- *Bluff-top Residential Development:* The residential development has a moderate adaptive capacity. As houses become threatened over time, a scenario of managed

retreat would allow houses to be removed incrementally and eventually be relocated to safer areas. The feasibility of managed retreat can depend upon lot sizes, ownership patterns, land use restrictions in the safer areas, and the availability of public or private financing. If a protective structure such as a seawall is approvable under the LCP or Coastal Act, it would minimize threats to the residences due to erosion, though if the development is protected by shoreline structures, the fronting beach will eventually be lost.

- *Wastewater Treatment Facility:* The wastewater treatment facility has a very low adaptive capacity. It is large and has expensive and below-grade infrastructure so it cannot be entirely elevated, and relocation is costly and difficult. In order to be protected in its current location, new structures will need to be built and below-grade infrastructure will need to be repaired and maintained.

d. **Consequences**

- *Wetland:* In many situations, the loss of wetland area is a high risk since wetlands provide flood protection, water quality enhancement, carbon sequestration, and essential habitat for plant, fish, bird, and other species. However, in this case, wetland migration is not restricted by inland development, so the risks for this wetland are slight to moderate, depending upon the suitability of the inland area for establishment of wetland plants and potential changes in water temperature and water quality. In the short term, the wetland will likely continue to function at normal levels. However, if it eventually can't keep up with sea level rise or if there are barriers to migration, loss of the habitat will result in a loss of important ecosystem services.
- *Bluff-top Residential Development:* The housing development has medium to high risk through 2100. The option to either relocate houses or protect them with a seawall means that they could continue to exist. Importantly, a system of managed retreat would allow for the continued existence of the fronting beach and all of its social, economic, and environmental benefits, whereas the construction of a seawall would result in the accelerating loss of the beach and these benefits over time.
- *Wastewater Treatment Facility:* Given its low adaptive capacity and high sensitivity to higher levels of sea level rise, the wastewater treatment facility is at high risk. Loss or damage to the facility could result in serious social, economic, and environmental consequences. Flooding of the facility and surrounding areas will cause damage to infrastructure and loss of facility function. This could lead to discharge of untreated sewage, which would have adverse impacts to water quality and could impair the health of nearshore ecosystems and local communities. Sea level rise could also cause outflow pipes to back up with seawater, and groundwater rise can infiltrate collection pipes, leading to sewage backups, overflows, and additional water quality problems. Due to the legacy of environmental injustices in land use planning (see Chapter 4), environmental justice communities are often located near and/or adjacent to industrial facilities, such as wastewater treatment plants, and are thus more likely to be exposed to a higher rate of such environmental toxins and subsequent public health impacts including if such structures are damaged by sea

level rise (Cushing *et al.,* 2023). However, efforts to protect the structure may have unintended consequences including loss of surrounding habitat areas. Costs associated with damages to this facility or implementation of adaptation responses could also impact local ratepayers, which could disproportionately impact low-income and environmental justice communities if special rates or protections are not in place.

e. **Land Use Constraints (discussed further in Step 5)**

- *Wetland:* The high adaptive capacity of the wetland means that minimizing risk to this resource may be accomplished by ensuring that there is space available for it to migrate into. Land use policies designed to protect uplands or areas inland of the current wetland area will be necessary.
- *Bluff-top Residential Development:* The area in question will eventually become incompatible with the current use. Development will not begin to be exposed to sea level rise impacts until 2050, but it is important to start planning now about how best to address the risks to the houses. Phased retreat would necessitate identifying feasible locations into which houses could be moved or a plan to abandon and remove houses. Such a plan might include a Transfer of Development Rights program in which homes are encouraged in less hazardous areas. If a managed retreat strategy is not in place, existing structures may qualify for shoreline protection. Shoreline protection would likely exacerbate beach erosion, degrade public access, impair shoreline habitat, and alter visual character.
- *Wastewater Treatment Facility:* It should be determined how likely it is that the facility will be able to be protected throughout the rest of its expected lifespan under even the highest sea level rise scenarios. It may be that the wastewater treatment facility becomes an incompatible use under future conditions. If so, plans should be made to relocate at-risk portions of the facility, as feasible, or to phase out the facility.

Note that this is a simplified example used to demonstrate the process described in Step 4. Decisions about how to address various challenges presented by sea level rise will be more complex than those illustrated above and may require prioritizing the different resources based on Coastal Act and LCP requirements taking into account the goals and circumstances of the community and the various characteristics of each resource. An understanding of the exposure, sensitivity, adaptive capacity, consequences, and land use constraints for the particular resources and scenarios will need to be kept in mind as planners move into Step 4 to identify possible adaptation strategies. Updated LCP policies and ordinances should be considered to support strategy implementation over the long term.

Step 5 – Identify equitable adaptation measures

In Steps 1-4, planners will have analyzed several possible sea level rise scenarios, and this analysis will have revealed the areas, communities, and specific coastal resources that are vulnerable to sea level rise hazards. The results should show areas that are particularly resilient to future change and trigger points at which sea level hazards will become particularly relevant to certain areas. Under Step 4, tasks 2d (identifying the *Consequences* of sea level rise impacts) and 2e (considering the *Land use constraints*) will be particularly useful in thinking through what resources are particularly vulnerable and what the local priorities may be.

In Step 5, planners should weigh information from the previous steps, keeping in mind the hazard avoidance, resource protection, and environmental justice policies of the Coastal Act, and begin identifying, choosing, and developing adaptation strategies. In practice, this may be its own iterative and multi-step process that starts with more general outreach and communication efforts about a range of adaptation concepts, followed by more specific and detailed identification of adaptation projects that will be implemented. While there is no single best approach for how to identify and begin to implement adaptation strategies, a few key stages and considerations may be helpful in guiding an adaptation planning process:

- **Meaningful Engagement**: Education and outreach efforts are critical components of adaptation planning exercises and can help generate information on and support for various adaptation approaches. It is important to coordinate with partners and include all relevant stakeholders in these processes, including providing education on these topics, to help community members understand the consequences of sea level rise and to take an active role in planning processes. As discussed elsewhere in this Guidance and in the Commission's Resources for Addressing Environmental Justice through LCPs Toolkit, outreach and engagement is an important step in rectifying historical injustices with environmental justice communities. Some equitable engagement best practices include establishing two-way communications where both local governments and environmental justice communities communicate via an equal and mutually beneficial partnership, establishing a shared understanding of expectations and limitations, and clearly explaining decisions and outcomes regarding sea level rise planning made by the local government. Local governments can also continue to improve engagement efforts by setting measures to track and evaluate engagement progress. Documenting efforts can also be helpful to share with environmental justice partners to help increase trust and transparency in the process.

- **Community Visioning**: Understanding sea level rise science, possible impacts, uncertainty, and trade-offs among various approaches can be a challenging and complex topic for many community stakeholders. Stepping back to recognize that coastal communities are dynamic places that will change over time and thinking through what a community's long-term goals are or what its vision of the future is can be a helpful first step to provide context for how to consider more specific adaptation strategies. For example, a community with a key priority of protecting recreational beach space will likely be interested in a different set of adaptation approaches than a community with a key priority of ensuring the continuation of a vibrant harbor or working waterfront. Such visioning, when grounded in Coastal Act principles, can start to lay the foundation for how to consider different trade-offs and how to guide a holistic and balanced approach to protecting various coastal resources and development across a community and over time.

- **Consider a full range of adaptation options**: Adaptation planning processes should initially consider a wide array of options and evaluate the various trade-offs associated with each. Communities should consider how those trade-offs would relate to identified vulnerabilities, community goals, environmental justice concerns, Coastal Act requirements, and other relevant state or federal laws. The options available to minimize risks from sea level rise and protect coastal resources are dependent upon the specifics of the local community and will vary widely depending on whether the area is an urban, fully-developed waterfront, or a rural, undeveloped coastline. In undeveloped areas, the options may be clear: strictly limit new development in sea level rise hazard zones and allow natural processes to continue. In urban areas, sea level rise can present unprecedented challenges, and the options are less clear. The Coastal Act allows for protection of certain coastal-dependent development and existing structures. However, armoring can pose significant impacts to coastal resources, including public access. To minimize impacts, innovative, alternative options will be needed, such as the use of nature-based adaptation strategies to protect existing infrastructure, restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at-risk areas to open space, or transfer of development rights programs. Chapter 7 describes a number of adaptation options and the types of coastal resource issues they can help address.

- **Identify preferred adaptation approaches:** After considering an array of possible options, communities should begin to identify a more specific adaptation plan for what strategies will be implemented. In practice, it is likely that a variety of adaptation options will be chosen to respond to different vulnerabilities throughout a jurisdiction as well as to reflect the different needs and goals of different types of development and different coastal resources. Overall, strategies will need to be tailored to the specific needs of each community based on the resources and development at risk, should reflect an understanding of possible impacts to coastal resources and environmental justice communities, should consider feasibility of implementation (e.g., economic and regulatory constraints), and should be developed through a public process, in close consultation with the Coastal Commission and in line with the Coastal Act.

  Note too that Section 30604(h) of the Coastal Act and the Commission's Environmental Justice Policy directs the Commission to consider environmental justice in all planning and permitting decisions, including with respect to all coastal resource issues. Oftentimes, protecting and preserving coastal resources will benefit environmental justice communities. For example, protecting coastal access and habitats benefits environmental justice communities who rely on those spaces for lower cost recreational opportunities, cultural practices, mental health and wellness, and more. In another example, coastal agricultural lands provide important places for workers (who are often people of color who lack proper health coverage, have limited incomes, and experience higher rates of poverty and unstable housing conditions in California) to earn income, health coverage, and housing.[45] However, there may be instances in which the protection of coastal resources may create or exacerbate burdens to environmental justice communities. For example, relocation of at-risk critical infrastructure such as a wastewater treatment plant may ensure the continued functionality of that facility but may result in rate payer increases that typically come in the form of a flat rate increase due to legislation limiting utility rates. This will disproportionately burden low-income ratepayers. Identification and engagement with affected environmental justice communities is imperative to ensure that these conflicts are addressed in a manner that maximizes protection of coastal resources and uplifts environmental justice communities.

- **Consider phased adaptation options:** More detailed adaptation planning may begin to specify how different adaptation strategies and projects could be phased over time to address evolving vulnerabilities, reflect community goals, and protect coastal resources in line with the Coastal Act. Sometimes referred to as "adaptation pathways," this type of approach can provide a more defined plan for what adaptation projects will be implemented at what time periods or under what conditions. Depending on the specific context, pathways can be fairly straightforward – such as one in which near term beach nourishment or nature-based adaptation strategies are implemented before long-term retreat options that prioritize natural processes – or more complex with multiple decision points and changing approaches – such as use of multiple nature-based strategies, armoring, and realignment or retreat over different time scales. Defined triggers can specify when new strategies or specific projects should be implemented and can be based on a variety of characteristics such as sea level rise amounts, changing conditions (e.g., certain beach widths), or social aspects (e.g., number of days a Coastal Trail segment is flooded and inaccessible). Triggers can also reflect the lead times necessary for planning and implementing next steps.

  Note that phased approaches can also account for economic and feasibility factors, particularly for complex, interconnected assets like critical infrastructure. As discussed in the Coastal Commission's Critical Infrastructure Guidance, the time and complexity associated with adaptation planning, and the need to ensure that the public services provided by these assets are protected over time, will often necessitate a mix of different approaches phased over time. For example, in different situations, it may be

[45] California Department of Housing and Community Development. (2023). *Farmworkers.* https://www.hcd.ca.gov/planning-and-community-development/housing-elements/building-blocks/farmworkers., California Research Bureau. (2013). *Farmworkers in California: A Brief Introduction.* California State Library. https://latinocaucus.legislature.ca.gov/sites/latinocaucus.legislature.ca.gov/files/CRB%20Report%20on%20Farmworkers%20in%20CA%20S-13-017.pdf.

appropriate to maintain status quo repair and maintenance activities, to allow for protective armoring or nature-based strategies, to upgrade, elevate, or realign certain components, or to remove and re-site facilities over time. Economic analyses like a life cycle analysis can evaluate the costs associated with routine repair and maintenance, normal replacement/upgrades of components, and repairs and/or adaptation options associated with anticipated hazard exposure as compared to larger-scale retreat options to help determine when assets cannot function without substantial investment in new infrastructure, protective measures, or relocation. Similarly, these analyses can identify where prioritizing retreat in certain cases may help minimize long-term costs and impacts, ensuring sustainable and equitable investments. SB 272 emphasizes the need for this type of information by requiring economic impacts analyses of, at a minimum, costs to critical public infrastructure.

- **Identify specific adaptation projects:** Once a preferred adaptation approach (or set of adaptation strategies) has been identified, communities should begin to identify specific adaptation projects. In contrast with preferred adaptation approaches which may be more general—such as allowing for armoring in certain areas/for certain development, encouraging phased retreat over time, or calling for development of a beach nourishment program—this stage calls for identifying more concrete and implementable projects. Examples of these might include seeking funding for and constructing a living shoreline for a certain area, buying out properties for removal of development, acquiring land for realignment of a section of Coastal Trail, or upgrading an armoring structure to better integrate lateral or vertical public shoreline access. Identified projects can be ranked by priority, taking into consideration factors such as timing, vulnerability, and cost as well as identifying projects that are more easily achieved as compared to more complex challenges that will necessitate more planning and financial resources. This stage may also help local governments identify those strategies or projects for which additional analysis is needed, such as more detailed technical feasibility or design studies. Identifying specific adaptation projects is called out as a requirement in SB 272 and can be aligned with other planning processes such as Capital Improvement Plans or Local Hazard Mitigation Plans to further prompt on the ground implementation of these adaptation actions. Importantly, identifying specific projects, and completing more detailed feasibility/design studies for such projects, can allow jurisdictions to more easily capitalize on funding that becomes available, as new or one-time funding options often prioritize "shovel-ready" projects.

As mentioned above, identifying adaptation strategies, developing preferred approaches, and narrowing in on specific projects to be implemented will in many cases be a continuous and iterative process. This means that it is not always going to be necessary (or even possible) to have a fully-formed, perfectly defined approach before updating an LCP or starting to take certain adaptation actions. Furthermore, it is likely that adaptation strategies will be updated over time with new information, new understanding of sea level rise projections and impacts, new community goals, and so on. The Commission is supportive of working with local governments and their community partners at all stages of an adaptation planning process to identify opportunities to integrate sea level rise into LCPs with varying levels of detail. As discussed in the next step, the Coastal Commission Local Government Working Group is supportive of taking a phased approach to LCP updates whereby initial updates could include more basic policies and future updates could include greater detail on, for example, more developed adaptation information.

SB 272 Consistency: SB 272 requires local governments to develop equitable adaptation approaches and specific, recommended projects that reflect identified vulnerabilities. This step provides recommendations for how to evaluate adaptation strategies in the context of the Coastal Act, discusses how to incorporate important topics like meaningful engagement and development of adaptation pathways, and recognizes that developing adaptation approaches and specific projects is an iterative process that can be done over time and with varying levels of detail.

Expected outcomes from Step 5: Identification of adaptation approaches and projects in adaptation plans, reports, or similar that reflect vulnerabilities, account for local goals and environmental justice communities, are consistent with the Coastal Act, and can be incorporated into an LCP in Step 6.

Step 6 – Draft updated or new LCP for certification with the California Coastal Commission

Once potential adaptation strategies have been identified, LCP policies that address sea level rise should be incorporated into a new LCP or LCP amendment. Whether as part of a new LCP or as part of an amendment to update an existing LCP, coastal planners should work with the Coastal Commission, environmental justice communities, and relevant stakeholders at all steps, but particularly to develop new or revised land use designations, policies, standards, or ordinances to implement the adaptation strategies identified in Step 5 in the LCP.

For jurisdictions that currently do not have a certified LCP, the sea level rise policies will be part of the development of a new LCP. In areas without a certified LCP, the Coastal Commission generally retains permitting authority, and the standard of review for development is generally Chapter 3 of the California Coastal Act. An LCP as certified by the Commission should already have land use policies, standards, and ordinances to implement Coastal Act Chapter 3 policies, including policies to avoid and mitigate hazards, and to protect coastal resources. However, in older LCPs, many of these policies do not address changing conditions adequately enough to protect coastal resources over time as sea level rises. Similarly, policies to protect resources and address coastal hazards may not reflect new techniques that can be utilized to adaptively manage coastal resources in a dynamic environment. Furthermore, many older LCPs likely do not have policies relating directly to environmental justice and meaningful engagement. As such, the LCP should be evaluated, with consideration and inclusion of environmental justice community concerns, to identify the land use designations, policies, and ordinances that need to be amended to address the vulnerabilities identified in Steps 2-4 and to integrate the adaptation approaches and projects identified in Step 5.

General approaches for updating LCPs to address SLR:

There are a number of overarching approaches and general recommendations for updating or developing an LCP to address sea level rise, as described below. The Commission recognizes that not all LCPs will integrate SLR adaptation approaches in the same ways or with the same level of detail. As discussed in Step 5, adaptation options should be chosen to reflect local conditions, vulnerabilities, and goals, and LCPs will in turn reflect this variation. Furthermore, it is understood that LCP adaptation policies will be developed and implemented in such a way as to be flexible and adaptive enough that they can be changed or updated as conditions change or if sea level rise impacts are significantly different than anticipated. At the same time, LCPs must be consistent with the Coastal Act and reflect the minimum requirements of SB 272. This interplay between allowing for local flexibility and maintaining a level of statewide consistency has and will continue to be a challenge. The Coastal Commission, including through its work with the Local Government Working Group, will continue to coordinate with local governments to identify opportunities, recommendations, and guidance for addressing sea level rise in LCPs in a way that meets local, Commission, and statewide goals.

- **Update or add baseline sea level rise polices:** In 2021, the Coastal Commission Local Government Working Group developed and adopted a set of baseline sea level rise policy topics that the group considered to be appropriate for a first-round sea level rise LCP update. These policy topics include: 1) using best available science, 2) committing to developing or updating vulnerability assessments and adaptation plans, 3) incorporating risk disclosures/assumption of risk, and 4) committing to a phased LCP update approach. The Working Group believes that these policy topics can lay a foundation that both substantively addresses sea level rise in the near term (even for jurisdictions that have not completed more detailed adaptation planning) and allows for the incorporation of greater amounts of detail now or in the future. These baseline policies also align with and help to implement the requirements of SB 272.

- **Update or add policies to implement identified adaptation approaches and projects:** In addition to baseline SLR policies, LCP policies should be developed that lay the foundation for, require, or otherwise implement the adaptation strategies and specific projects identified in Step 5. In some cases, updating land use designations and zoning ordinances or updating siting and design standards, as discussed below, will directly or indirectly implement identified strategies by regulating future development actions. In other cases, more specific policy language, including programmatic policies as also described below, will be needed to implement specific approaches. Chapter 7 describes a number of specific adaptation policies and strategies that can be integrated into an

LCP and is organized by resource type to allow users to easily identify the types of policies that may be relevant to local resource vulnerabilities.

Note that many adaptation strategies, and particularly the more specific adaptation projects that have been identified, will be implemented in a coordinated way through both the LCP and individual CDPs. For example, it may be necessary to update land use designations to allow for a specific adaptation project (e.g., changing zoning to open space or allowing for recreational uses/amenities), and constructing a project (e.g., dune restoration or realignment of the Coastal Trail) will then need a CDP. Identifying the appropriate level of detail in LCP policies to lay the foundation for specific adaptation projects can be challenging, especially if there are not yet the type of detailed technical studies and alternatives analyses that are typically associated with CDPs. The Coastal Commission will continue to work with local governments to develop LCP policies that integrate adaptation approaches.

- **Update land use designations and zoning ordinances**: One of the most common methods of regulating land use is through zoning designations and ordinances, and updating these policies is one of the most fundamental ways of responding to sea level rise impacts. Planners may address particular vulnerabilities and local priorities by updating land use designations and zoning ordinances to protect specific areas and/or resources. For example, areas that are particularly vulnerable to sea level rise impacts can be designated as hazard zones, and specific regulations can be used to limit new development and/or to encourage removal of existing development in such zones. Similarly, open space areas can be designated as conservation zones in order to protect and provide upland areas for beach, wetland, and habitat migration or for additional agricultural land.

- **Update siting and design standards**: Updated siting and design standards may go hand in hand with updated land use designations and zoning ordinances, in that specific standards may be required for development or projects in certain zones. For example, development in hazard zones may require additional setbacks, elevation of first floor habitable space, innovative stormwater management systems, special flood protection measures, mitigation measures for unavoidable impacts, relocation and removal triggers and methodologies, and so on. Siting and design standards may also guide or inform specific adaptation approaches. For example, many LCPs include detailed design standards for shoreline armoring, where approvable, that address methods for minimizing impacts to coastal resources (such as ensuring armoring can blend into natural bluffs or can be integrated with public access features).

- **Establish policies to minimize hazards to current development:** Under the Coastal Act, certain improvements and repairs to existing development are exempt from CDP requirements. Non-exempt improvements and any repairs that involve the replacement of 50% or more of a structure, however, generally require a CDP and must conform to the standards of the relevant Local Coastal Program or Coastal Act.[46] Redevelopment, therefore, should minimize hazard risks from sea level rise. For structures currently sited in at-risk locations, the process of redeveloping the structure may require the structure to be moved or modified to ensure that the structure and coastal resources are not at risk due to impacts from sea level rise. As described in Guiding Principle 6, sequential renovation or replacement of small portions of existing development should be considered in total. LCPs should include policies that specify that multiple smaller renovations that amount to alteration of 50% or more of the original structure should require a CDP, and require that the entire structure to be brought into conformance with the standards of the LCP or Coastal Act.[47]

- **Identify a timeline for updates:** Both SB 272 and the CCC Local Government Working Group baseline SLR policies refer to a need to continue to update LCPs and to identify a specific timeline for doing so. As described throughout this chapter, it is understood that adaptation strategies will change over time to reflect evolving science, changing conditions, new and innovative approaches, and other factors, and LCPs will similarly need to be updated to reflect these changes. Additionally, the Local Government Working Group has emphasized the need to consider more routine and phased LCP updates not only to address evolving adaptation needs, but also to reflect different phases of adaptation planning and differing levels of detail and analysis that local governments have been able to complete. Identifying a specific timeline for updates can help to ensure that necessary next steps are completed.

  Timelines for updates should reflect a variety of factors, including how far along a jurisdiction is in their planning process, identified vulnerabilities, and any specific adaptation approaches. For example, a jurisdiction that that has not completed a vulnerability assessment or adaptation plan may include a policy calling for the development of such documents within 5 years, with an LCP update to follow based on the findings of that work. A jurisdiction that has completed more detailed adaptation planning or has developed specific adaptation pathways may have a policy (or policies) that require LCP updates following implementation of certain projects, or when certain identified triggers have been met. A timeline for updates may also be informed by economic analyses, such as the analysis SB 272 requires for critical public infrastructure.

  There are also a variety of policy approaches for incorporating timelines for updates. A general planning horizon could be associated with the overarching LCP (such as a 30-year horizon typical for General Plans) with a stated intent to comprehensively update

[46] Section 13252(b) of the Commission's regulations states that "unless destroyed by natural disaster, the replacement of 50 percent or more of a single family residence, seawall, revetment, bluff retaining wall, breakwater, groin or any other structure is not repair and maintenance under Coastal Act Section 30610(d) but instead constitutes a replacement structure requiring a Coastal Development Permit."

[47] In addition, for structures located between the first public road and the sea or within 300 feet of the inland extent of a beach or mean high tide line, improvements that increase the height or internal floor area by more than 10% normally require a CDP. (14 Cal. Code Regs §§13250(b)(4), 13253(b)(4).) Depending upon the location of the structure, smaller improvements may also require a CDP. (14 Cal. Code Regs. §§ 13250(b), 13253(b).)

the LCP at the end of the identified timeframe. More specific timeframes associated with specific adaptation strategies could be generally identified in programmatic policies, or could have specific sunset provisions (or similar provisions) that would result in different policies taking effect unless an LCP has been further updated.

Like with developing adaptation strategies, the Commission recognizes that there will be variability in how timelines for updates are developed and implemented through an LCP, as well as the extent to which minor changes or updates to Vulnerability Assessments, Adaptation Plans, or other planning documents will necessitate LCP updates. The Commission will work with local governments to identify appropriate timelines that reflect local contexts. In general, having more vulnerabilities that are left unaddressed, a lack of specificity about adaptation approaches, and/or more controversial short-term adaptation strategies may necessitate nearer term or stricter requirements for updating the LCP. It will also be important to include timelines that allow jurisdictions to obtain certification of LCP policies that meet the basic requirements of SB 272 by January 1, 2034.

- **Update resource inventories, maps, and information on SLR impacts and environmental justice issues**: LCPs themselves can be an important place to summarize the findings of the planning documents that were developed to support the LCP update process. For example, background sections can summarize vulnerability findings, outreach efforts, and general adaptation planning work. This should also include a description of the environmental justice communities that were identified in Step 1 and how they may be more sensitive to sea level rise hazards. Specific documents could be included as LCP appendices, though the LCP should be clear that the LCP policies (not other documents) are the standard of review. Hazards maps developed as part of a vulnerability assessment may also form the basis for hazards overlay or other zoning ordinance information. Local governments may also seek to compile a set of maps that clearly show the current locations of the coastal resources present in an LCP jurisdiction (e.g., beaches and public accessways; agricultural land, wetlands, ESHA, and other coastal habitats; energy, wastewater, transportation, and other critical infrastructure; and archaeological and paleontological resources), as well as existing and future hazard areas and conditions.

- **Incorporate "programmatic" policies that reflect adaptation planning work:** In some cases, LCPs may include broader programmatic policies that don't apply to specific development or permitting actions, but which encourage or require the City/County to undertake continued study or to approach adaptation planning in certain ways. These types of policies may be helpful ways of memorializing both past and ongoing/planned adaptation work. Examples may include:
  - **Identify lead or coordinating partners:** Policies may be included that direct certain city/county departments to carry out identified adaptation strategies (e.g., Public Works or Parks and Recreation) or may call for coordinating with state agency asset managers like Caltrans or State Parks.

- **Identify next steps for adaptation planning:** Policies may call for completion of (or updates to) vulnerability assessments and adaptation plans or for development/analyses of more specific adaptation programs/strategies such as sub-area adaptation plans, a beach nourishment program, a Transfer of Development Credit program, or regional sediment management programs.
- **Establish methods to monitor local changes from sea level rise**: Policies may seek to establish actions to conduct long-term sea level rise monitoring, MHTL surveys, and/or monitoring and tracking of shoreline changes, flooding extent/frequency, or efficacy of different adaptation approaches. In some cases, monitoring and MHTL surveys may also be included as a Coastal Development Permit requirement for specific projects.
- **Research and data collection**: Similarly, policies may call for continued research to address key data gaps and to collaborate with other local, regional, and state partners to pursue new research to better understand sea level rise, baseline shoreline conditions, ecosystem responses to sea level rise, potential impacts and vulnerabilities, and the efficacy of adaptation tools.
- **Outreach and education**: Other policies may call for continued education and outreach efforts related to sea level rise and adaptation. Continued outreach with all relevant stakeholders can help generate support for ongoing adaptation planning, and continued implementation of (and refinements to) the meaningful engagement plan developed in Step 2 can help ensure that environmental justice communities continue to be fully engaged in implementation of adaptation strategies. More information on EJ engagement best practices is discussed in Step 1 of this Chapter and in the Resources for Addressing EJ through LCPs Toolkit.

As stated above, a more extensive and detailed list of possible adaptation strategies, including as related to specific to coastal resources and environmental justice can be found in Chapter 7. The above list and those strategies discussed in Chapter 7 should neither be considered a checklist from which all options need to be added to an LCP nor an exhaustive list of all possible adaptation strategies. Sea level rise adaptation is an evolving field and decision makers will need to be innovative and flexible to respond to changing conditions, new science, community feedback, and new adaptation opportunities. The important point is to analyze current and future risks from sea level rise, determine local priorities and goals for protection of coastal resources and development, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals within the context of the Coastal Act and in consideration of environmental justice principles.

Local government staff should work closely with Coastal Commission staff, environmental justice communities, and other relevant stakeholders to ensure there is opportunity for early and routine public input in developing the new LCP or LCP amendments. Once the updates and plans are complete, local governments will submit them to the Commission for certification.

The Commission may either certify or reject the LCP or LCP amendment as submitted, or it may reject it but suggest modifications. If the Commission adopts suggested modifications, the local government may adopt the modifications for certification or refuse the modifications and resubmit a revised LCP for additional Commission review. More information on the LCP amendment process can be found on the Commission's webpage of Materials & Resources for Coastal Jurisdictions.

SB 272 Consistency: As discussed at the beginning of this chapter, SB 272 includes a set of requirements that relates to both the process of updating an LCP and the content of LCP policies themselves. This step provides general recommendations for the LCP sections and types of LCP policies that should be updated to reflect identified vulnerabilities, environmental justice concerns, and adaptation approaches. While the content and specific policies will vary in each LCP, for consistency with SB 272, the LCP should:

- Require the use of best available science
- Require risk disclosures/assumptions of risk
- Reflect and address identified vulnerabilities in an equitable manner
- Allow for/require the implementation of identified adaptation approaches for specific areas/development types
- Lay the foundation for implementation of identified adaptation projects, recognizing that CDPs for such projects will include more detail
- Identify lead agencies or departments responsible for implementing identified projects
- Identify next steps, such as highlighting topics or strategies for which additional analysis is needed (in combination with the timeline for updates)
- Identify a timeline for completion of, or updates to, the vulnerability assessment, adaptation plan, and LCP (or specific LCP policies) that reflects current information on vulnerabilities, identified adaptation strategies, and an economic impact analysis for critical public infrastructure

Note that these types of policies reflect the minimum requirements of SB 272 to be included in an LCP by January 2034. Importantly, the Coastal Commission is committed to working with local governments to support a phased approach to LCP updates in which initial updates may be built upon and further developed in future updates. The Commission will consider appropriate LCP policies and timelines for updates that reflect where in the process different jurisdictions are, and will coordinate with funding agencies to prioritize funding for appropriate next steps. For example, a more basic initial LCP update may call for (and include a timeline for) completing an adaptation plan, and funding to support such a planning effort should be prioritized.

Expected outcomes from Step 6: Certified/updated LCP with policies and land use designations that address sea level rise and related hazards and ensure protection of coastal resources and communities consistent with the Coastal Act.

Step 7 – Implement LCP and monitor and revise as needed

Upon certification of the new or updated LCP, sea level rise adaptation strategies will be implemented through the certified implementing ordinances and related processes and actions (e.g., local review of CDPs, proactive action plans). Additionally, an important component of successful adaptation is to secure funds for implementation, regularly monitor progress and results, continue engagement with environmental justice communities, and update policies, approaches, and projects as needed and in line with the identified timeline for updates. Sea level rise projections should also be re-evaluated and updated as necessary.

- **Secure resources for implementation:** SB 272 calls for funding for implementation of identified adaptation strategies and projects to be prioritized for those jurisdictions that have completed an LCP update consistent with the relevant guidelines described in this document. As highlighted above, the Commission will work with funding agencies to prioritize funding for implementation of next steps identified in certified LCPs, including funding for continued planning, analysis, and construction of identified adaptation strategies.

  Currently, there are a number of different sources of funds available to help local governments plan and implement adaptation strategies. For example, the Coastal Commission, the Ocean Protection Council, and the Coastal Conservancy have grant programs designed to support local adaptation efforts (see Appendix C for additional details on each of these programs), including significant funds for efforts such as sea level rise vulnerability assessments, adaptation planning, more specific studies such as feasibility assessments and preliminary designs, and implementation of adaptation projects.

  As described previously, there may also be overlap between LCP planning and Local Hazard Mitigation planning. FEMA's Hazard Mitigation Assistance (HMA) grant programs provide significant opportunities to reduce or eliminate potential losses to State, Indian Tribal governments, and local assets through hazard mitigation planning and project grant funding. Currently, there are several programs that provide funding resources for local communities: the Hazard Mitigation Grant Program (HMGP); Pre-Disaster Mitigation (PDM); Flood Mitigation Assistance (FMA); and the Building Resilient Infrastructure and Communities program (BRIC).[48] Cal OES administers the HMA and

[48] Each HMA program was authorized by separate legislative action, and as such, each program differs slightly in scope and intent.

FMA programs. More information can be found at the Cal OES HMGP website and the FEMA HMA website.

The Commission recognizes that funding opportunities are constantly evolving, that demand for funding is increasing, and that there is a significant need for the development of additional funding opportunities.

- **Identify key conditions, resources, and other factors to monitor:** Implementation of certain strategies and future updates to the LCP may be triggered by changing conditions or other identified factors. As discussed previously, these could include characteristics such as sea level rise amounts, changing conditions (e.g., certain beach widths), economic considerations (e.g., damage repair costs), or social aspects (e.g., number of days a Coastal Trail segment is flooded and inaccessible). Certain species can also be indicators of whether and when sea level rise is affecting an ecosystem, such as the presence of certain plant species indicating the salinity of soils. Monitoring programs should ensure that these triggers are recognized and responded to at the appropriate time.

- **Continue engagement with environmental justice communities:** Continued engagement with environmental justice communities will maintain a level of ongoing trust and relationship building even after the adoption of an LCP. Increased trust and partnership between environmental justice communities and the local government can be widely beneficial and can potentially streamline future outreach regarding specific projects or additional updates. Examples of ongoing outreach practices include periodic calls or emails and participation in neighborhood workshops and events to provide updates and an outlet for continuous feedback. Such feedback evaluations can be used as a resource for planners to learn what communication methods work for particular groups and what can be adjusted.

- **Periodically update LCPs:** As discussed in previous steps, local governments should review their vulnerability and risk assessments and adaptation plans on a regular basis as significant new scientific information becomes available, as conditions change, and as various strategies are implemented, and they should propose amendments as appropriate. Given the evolving nature of sea level rise science, policies may need to be updated as major scientific advancements are made, changing what is considered the best available science. It will likely be important to modify maps of current and future hazard areas on a five- to ten-year basis or as necessary to allow for the incorporation of new sea level rise science, monitoring results, and information on coastal conditions. Regular evaluation of LCPs is important to make sure policies and adaptation strategies are effective in reducing impacts from sea level rise.

SB 272 Consistency: SB 272 requires local governments to identify a timeline for updates to the LCP. This step reiterates the importance of periodically updating the LCP and describes implementation of the LCP and identified adaptation strategies.

Expected outcomes from Step 7: Implementation of the LCP and identified adaptation projects; a plan to monitor the LCP planning area for changing conditions and effectiveness of various adaptation strategies; ongoing communication and coordination with environmental justice communities and organizations that serve them; and a plan to update and revise the LCP (and relevant vulnerability assessments and adaptation plans) based on an identified timeline.

The box below provides a summary of the components needed for consistency with SB 272 and a description of the minimum requirements for each component, as discussed throughout this chapter. Following this summary box is a flowchart (Figure 14) that illustrates the seven-step process discussed in this chapter. Notice that the process is circular. Because sea level rise science and adaptation approaches will be refined and updated in the future, planners should periodically, and in line with the identified timeline, repeat this seven-step process to update and improve their LCPs.

For additional resources and examples of ways to incorporate sea level rise into the LCP, see Appendix C.

Summary of Minimum Requirements for Consistency with SB 272

SB 272 requires local governments in the coastal zone to develop a sea level rise plan as part of a new or updated LCP that includes, at a minimum, the following components:

1. Use of best available science
2. A vulnerability assessment that includes efforts to ensure equity for at-risk communities
3. Sea level rise adaptation strategies and recommended projects
4. Identification of lead planning and implementation agencies
5. An economic impact analysis of, at a minimum, costs to critical public infrastructure
6. A timeline for updates, as needed, based on sea level rise projections, local conditions, identified adaptation strategies/projects, and other locally relevant factors

SB 272 applies to both the *process* for updating an LCP as well as the *policy content* of the LCP itself. Although the Coastal Commission does not certify documents such as vulnerability assessments and adaptation plans, for the Commission to certify an LCP as consistent with the requirements of SB 272, the LCP must include policies that reflect, allow for, or otherwise reference the findings of these other documents. Therefore, both the LCP and the associated planning documents must meet certain minimum requirements. These minimum requirements are summarized below. Information on LCP policies and options that would reflect a phased approach to LCP updates is included at the end of this box.

To be fully consistent with SB 272, by January 1, 2034, local governments must complete the six components listed above. More detail on and minimum requirements for each of the six components are summarized below, along with links to additional relevant discussion throughout this chapter. Jurisdictions must then incorporate that greater level of detail in a new or updated LCP. Minimum requirements for LCP policies/zoning that reflect these six components are highlighted following the details for the six components.

Component #1: Best Available Science

- LCP policies must require the use of best available science, currently identified as the 2024 California State Sea Level Rise Guidance, to guide land use planning and permitting decisions and inform risk disclosures/assumptions of risk.
- Other key resources for sea level rise information, including mapping tools, are highlighted throughout the Guidance (see, e.g., Chapter 3; Table 6; Appendices B and C).

Component #2: SLR Vulnerability Assessment

- Use of best available science (**Component #1**) (see Chapter 3).
- Consideration of multiple sea level rise scenarios that cover a long-term planning horizon (through ~2130) (see Step 2).
- Analysis of the physical impacts of sea level rise, including assessing coastal hazards that will be exacerbated by sea level rise (e.g., flooding, erosion, groundwater change) (see Step 3; Appendix B).
- Analysis of how sea level rise and changing coastal hazards will impact coastal resources and development, including but not limited to coastal-dependent development, critical infrastructure, public accessways, the Coastal Trail, beaches, wetlands, agricultural lands, cultural sites, and archaeological resources (see Step 4).
- Identification of EJ communities that may be impacted by sea level rise and consideration of how sea level rise may differentially impact EJ communities (see Chapter 4; Steps 1 and 4).

- Discussion of the findings of the vulnerability assessment including, maps, tables, descriptions, and other quantitative and qualitative information.
- Public outreach, engagement, and education regarding impacts from sea level rise (see Chapter 4; Step 1).
- **Beyond the minimum requirements** – topics for more detailed analyses or refinements to the Vulnerability Assessment:
    - Development of additional technical information to fill specific data gaps, such as more detailed groundwater analyses or consideration of impacts exacerbated by other climate change stressors.
    - Analysis of additional sea level rise scenarios.

Component #3: Adaptation Plan with Strategies and Recommended Projects (see Step 5)

- Use of best available science (**Component #1**) (see Chapter 3).
- Consideration of a range of sea level rise adaptation options. Such options may include, but are not limited to, nature-based adaptation options, retreat and realignment, armoring, elevation, stormwater management, and conservation of open space (see Chapter 7).
- Analysis and discussion of the pros and cons of different adaptation strategies, including a discussion of the consistency of adaptation options with the Coastal Act and other relevant laws/policies and how various strategies will have differential impacts to different types of coastal resources.
- Analysis and discussion of how different adaptation strategies may differentially impact EJ communities (see Chapter 4; Steps 1 and 4).
- Analysis and discussion of the applicability of different adaptation options for the jurisdiction (or for various sub-areas, development types, habitat areas, assets, etc.), and what the consequences/results for implementing different strategies would be for the jurisdiction. Analysis/discussion may initially be high-level or conceptual, with more detailed analysis subject to future planning efforts, which may be reflected in an identified timeline for updates, per **Component #6**.
- Identification of conceptual preferred approach (or combination of approaches) and discussion of how such an approach will ensure equity and balanced protection of coastal resources.
- Identification of specific adaptation projects. Unlike higher level, conceptual ideas, this list should include more concrete and implementable projects or next steps that are geared for completion in the near term (e.g., 10 years), such as constructing a living shoreline for a certain area, buying out properties for removal of development, acquiring land for realignment of a section of Coastal Trail, or upgrading an armoring

structure. Identification of specific adaptation projects may be the subject of a future planning effort (reflected in an identified timeline for updates, per **Component #6**).

- Identification of lead agencies, asset managers, or other entities responsible for carrying out adaptation approaches and identified projects (**Component #4**).
- Public outreach, engagement, and education regarding sea level rise adaptation strategies (see Chapter 4; Step 1).
- **Beyond the minimum requirements** – topics for more detailed analyses or refinements to the Adaptation Plan:
    - Development of a vision/goal statement(s) and analysis and discussion of how different adaptation strategies may support the identified vision/goals.
    - Completion of feasibility studies or other planning/assessment work to aid in refining preferred adaptation approaches.
    - Development and identification of adaptation strategies relevant to certain sub-areas, neighborhoods, assets, development types, etc. based on shared characteristics.
    - Identification of additional, specific adaptation projects or prioritization of various identified projects.
    - Development of phased adaptation approaches or adaptation pathways, along with relevant triggers and threshold conditions for implementing new strategies.

Component #4: Identification of lead planning and implementation agencies (Step 1)

- While SLR planning processes may be initiated or led by a variety of local government departments/individuals, LCPs are developed by local government planning departments, and planning department staff should be an integral part of any planning team.
- LCP policies related to specific adaptation projects, other next steps, or which address City/County-owned assets should identify the lead agency, asset manager, or other entity responsible for carrying out adaptation approaches/identified projects. This information may also be included in the Adaptation Plan (**Component #3**).

Component #5: Economic Analysis

- Economic analysis for, at a minimum, critical public infrastructure, defined in SB 272 as including but not limited to "…transit, roads, airports, ports, water storage and conveyance, wastewater treatment facilities, landfills, powerplants, and railroads." Other critical infrastructure types that should be considered include sewer lines, stormwater facilities, gas lines, and other utility infrastructure.

- Analysis of the costs associated with damage to such critical infrastructure assets from the coastal hazards and SLR scenarios included in the vulnerability assessment, and the subsequent required repairs (see Step 4).
- Analysis of costs associated with adaptation options or specifically identified adaptation projects for such assets (see Step 5).
- Information may be incorporated into the Vulnerability Assessment or Adaptation Plan, or as a standalone document(s). Analyses may also be completed by relevant asset managers.
- **Beyond the minimum requirements** – topics for more detailed analyses or refinements to the Economic Analysis:
  - Completion of an economic analysis that addresses other coastal resources.
  - Assessment of the costs of each of the identified adaptation projects (**Component #3**)
  - Incorporation of more detailed economic information, such as non-market valuation of public trust and natural resources or valuation of lost revenues or tax base associated with changing land uses.
  - Coordination with asset managers to complete life cycle analyses for individual assets/facilities that evaluates the costs associated with routine repair and maintenance, normal replacement/upgrades of components, and repairs and/or adaptation options associated with anticipated hazard exposure as compared to larger-scale retreat options to help determine when assets cannot function without substantial investment in new infrastructure, protective measures, or relocation.

Component #6: Timeline for updates (Steps 6 and 7)

- LCP policies must identify an explicit timeline(s) for updates to completed vulnerability assessments, adaptation plans, other relevant materials, and LCP provisions, as necessary to reflect changing conditions, updated science, and evolving best practices.
- Continued consistency with SB 272 will require local governments to meet the identified deadlines.

As discussed above, to be consistent with SB 272, by January 1, 2034, jurisdictions are required to complete/develop each of the six components identified above and obtain CCC certification of a new or updated LCP that reflects this greater level of detail. Minimum requirements for the LCP certification for this purpose include (Step 6):

- LCP policies that require use of best available science.
- LCP policies that require risk disclosures/assumptions of risk.

- LCP policies/zoning that reflect and address identified vulnerabilities in an equitable manner.
- LCP policies/zoning that allow for/require the implementation of identified adaptation approaches for specific areas/development types.
- LCP policies/zoning that lay the foundation for implementation of identified adaptation projects, recognizing that CDPs for such projects will include more detail.
- LCP policies that identify lead agencies or departments responsible for implementing identified projects.
- LCP policies that identify next steps, such as highlighting topics or strategies for which additional analysis is needed (in combination with the timeline for updates).
- LCP policies that identify a timeline for updates to the vulnerability assessment, adaptation plan, economic analysis, and other relevant studies to reflect, for example, new information on sea level rise science, vulnerabilities, changing conditions, new adaptation options, and completion of specific adaptation projects, as well as for subsequent updates to the LCP (or specific LCP policies).

The Coastal Commission supports a phased approach towards LCP updates. A number of jurisdictions have initiated planning and have completed some but not all of the six components required by SB 272. Rather than waiting for completion of all six components, the Commission encourages jurisdictions to complete phased LCP updates that reflect completed work. Examples of LCP policies that could be included in a phased LCP update include:

- Baseline sea level rise policies, similar in nature to those recommended by the Coastal Commission Local Government Working Group, including requirements to use best available science (**Component #1**) and to incorporate risk disclosures/assumptions of risk.
- Policies like those included in the section above that reflect information that has already been developed. For example, if a jurisdiction has completed a vulnerability assessment but not an adaptation plan, additional policies/zoning should address and reflect the identified vulnerabilities.
- LCP policies that include explicit timelines (**Component #6**) for completion of a vulnerability assessment, adaptation plan, economic analysis, or related document/study that addresses the six minimum components (or any combination thereof that has not yet been completed and/or will be the subject of continued, more detailed planning). Such timelines should account for completion of these components and the subsequent LCP certification that reflects the more detailed information by January 1, 2034 to ensure consistency with SB 272.

Planning Process for Local Coastal Programs and Other Plans

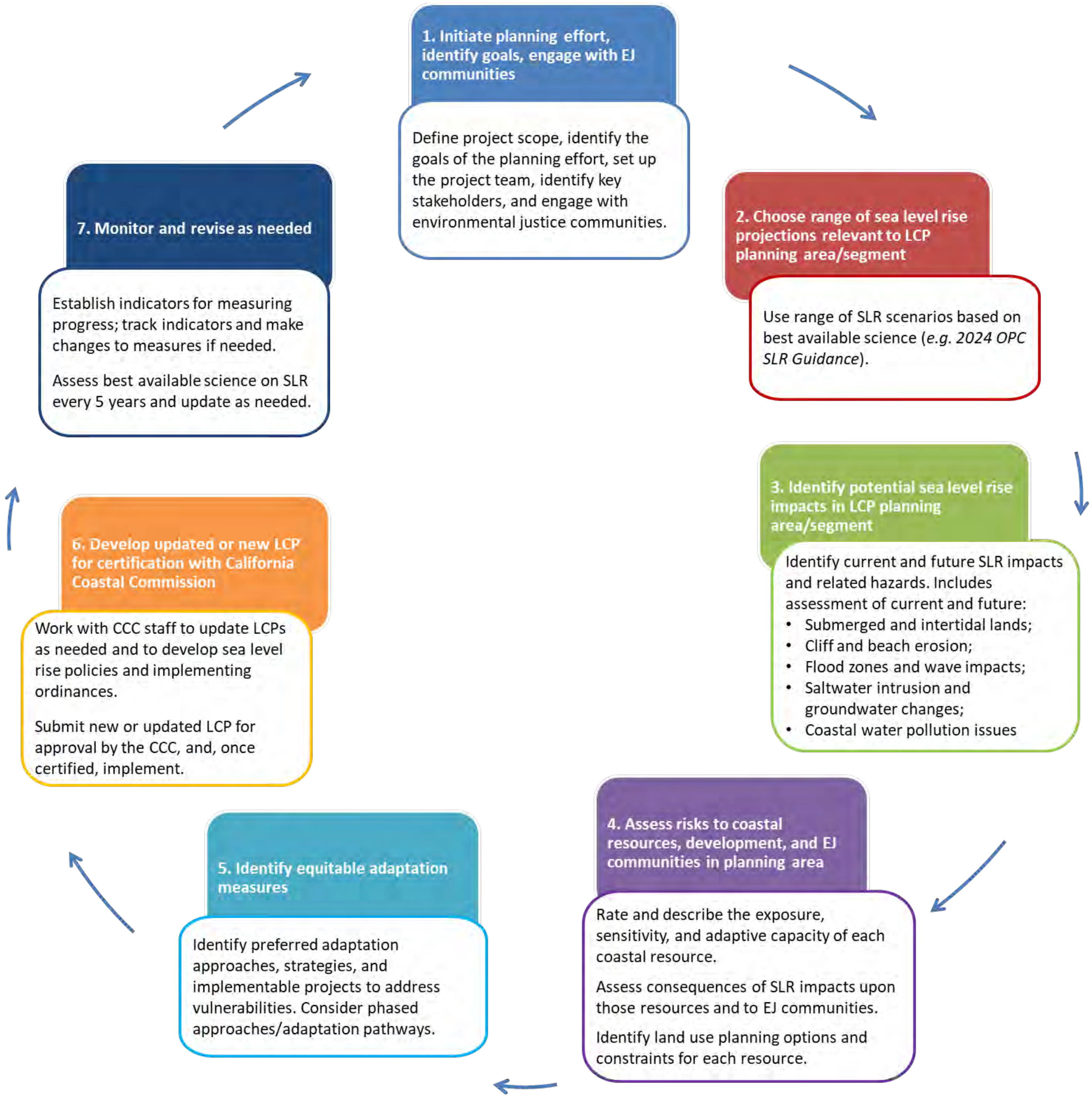

Figure 14. Flowchart for addressing sea level rise in Local Coastal Programs and other plans

Chapter 6. Addressing Sea Level Rise in Coastal Development Permits

Development in the coastal zone generally requires a Coastal Development Permit (CDP).[49] In areas of retained jurisdiction and areas without a certified Local Coastal Program (LCP), the Commission is generally responsible for reviewing the consistency of CDP applications with the policies of Chapter 3 of the Coastal Act (Public Resources Code Sections 30200-30270).[50] In areas with a certified LCP, the local government is responsible for reviewing the compliance of CDP applications with the requirements of the certified LCP and, where applicable, the public access and recreation policies of the Coastal Act. Certain local government actions on CDP applications are appealable to the Commission. On appeal, the Commission also applies the policies of the certified LCP and applicable public access and recreation policies of the Coastal Act.[51] The Commission and local governments may require changes to the project or other mitigation measures in order to assure compliance with Coastal Act policies or LCP requirements by both minimizing risks to the development from coastal hazards and avoiding or compensating for impacts to coastal resources.

The Coastal Act, the LCP, and the CDP Application cover the broad range of information and analyses that must be addressed in a CDP application. This CDP guidance focuses only on sea level rise and those conditions or circumstances that might change as a result of changing sea level. It does not address other Coastal Act or LCP requirements.

Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where close review of sea level rise concerns and related environmental justice impacts is necessary and where it is not. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate.

Sea level rise will be important for some, but not all, of the projects reviewed through the CDP process. Locations currently subject to inundation, flooding, groundwater rise, wave impacts, erosion, or saltwater intrusion will be exposed to increased risks from these coastal hazards

[49] Coastal Act Section 30106 defines "Development" to be, "on land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 (commencing with Section 4511)."

[50] The Commission retains CDP jurisdiction below mean high tide and on public trust lands.

[51] Local governments may assume permitting authority even without a fully certified LCP (*see* Public Resources Code, §§ 30600(b), 30600.5), but only the City of Los Angeles has done so. Any action on a CDP application by a local government without a fully certified LCP may be appealed to the Commission. (Public Resources Code, § 30602.)

with rising sea level and will require review for sea level rise effects on coastal resources, public access, and environmental justice communities. Locations close to, or hydraulically connected to these at-risk locations, will themselves be at risk as sea level rises and increases the inland extent of these hazards. The following box provides some of the general situations for which sea level rise will need to be included in the project analysis.

General situations when sea level rise should be considered in the project analysis include when the project or planning site is:

1. Currently in or adjacent to an identified floodplain (e.g., FEMA flood zone)
2. Currently or has been exposed to flooding or erosion from waves or tides
3. Currently in a location protected by constructed dikes, levees, bulkheads, or other flood-control or protective structures
4. On or close to a beach, estuary, lagoon, or wetland
5. On a coastal bluff with historic evidence of erosion
6. Reliant upon shallow wells for water supply
7. Shown as exposed to hazards under the 2.0m SLR scenario on a SLR viewer such as CoSMoS

Many of the projects reviewed through the CDP application process already examine sea level rise as part of the hazards analysis. Such examination will need to continue, and these guidelines offer direction and support for a thorough examination of sea level rise and its associated impacts based on current climate science, coastal responses to changing sea level and storm events, and consequences of future changes.

To comply with Coastal Act Section 30253 or the equivalent LCP section, projects will need to be sited, designed, or otherwise include adequate adaptation plans for the changing water levels and associated impacts that might occur over the life of the development. In addition, project planning should anticipate the migration and natural adaptation of coastal resources (beaches, access, wetlands, *etc.*) due to future sea level rise conditions in order to avoid future impacts to those resources from the new development. Projects should also consider the equitable distribution of burdens to environmental justice communities, including how the project itself may create disproportionate burdens as well as how any adverse impacts to coastal resources considering sea level rise could exacerbate existing burdens. Conducting outreach and engaging with affected environmental justice communities is key to understanding relevant issues and concerns so that impacts can be avoided or minimized. As LCPs are updated to reflect changing conditions and to implement sea level rise adaptation strategies, it will be important that CDPs are also conditioned and approved in ways that similarly emphasize an adaptive approach to addressing sea level rise hazards. Such coordination between LCP and CDP adaptation policies and strategies will help ensure that coastal development, communities, and resources are resilient over time.

Steps for Addressing Sea Level Rise in Coastal Development Permits

The steps presented in Figure 15 and described in more detail below, provide general guidance for addressing sea level rise in the project design and permitting process for those projects where sea level rise may contribute to or exacerbate hazards, impact coastal resources, and affect surrounding environmental justice communities.

Figure 15. Process for addressing sea level rise in Coastal Development Permits

The goal of these steps is to ensure that projects are designed and built in a way that minimizes risks to the development and avoids impacts to coastal resources, including that these impacts do not exacerbate burdens to environmental justice communities in light of current conditions and the changes that may arise over the life of the project. Many project sites and proposed projects may raise issues not specifically contemplated by the following guidance steps or the permit filing checklist at the end of this section. It remains the responsibility of the project applicant to adequately address these situations so that consistency with the Coastal Act and/or LCP may be fully evaluated. There are many ways to evaluate and minimize the risks associated with sea level rise, and the Commission understands that different types of analyses and actions will be appropriate depending on the type of project or planning effort. The following steps describe these concepts in more detail.

Use scenario-based analysis

This Guidance recommends using various sea level rise scenarios for the analysis of possible resource changes and site risks associated with sea level rise. Given the uncertainty about the magnitude and timing of future sea level rise, a scenario-based analysis will examine the consequences of a range of situations rather than basing project planning and design upon one sea level rise projection.

One approach for scenario-based analysis is to start with the highest sea level rise scenario relevant to the type of development at hand (High, Intermediate-High, or Intermediate, see Chapter 3 and Step 2 below). If a developable area can be identified that is at no or low-risk from inundation, flooding, and erosion, then there may be no benefit to undertaking additional analysis for sea level rise and the project can continue with the rest of the analyses that are part of the Coastal Act or LCP (coastal habitats, public access, scenic and visual qualities, and other issues unrelated to sea level rise).

If the site is constrained under the highest sea level rise scenario that is analyzed, additional analysis of other, lower sea level rise amounts can help determine thresholds for varying impacts to coastal resources (including how those impacts affect environmental justice communities), and types and extent of site constraints that need to be considered during project planning. The analyses of lower and intermediate sea level rise projections are used to better understand the timing and probability of the constraints. For further description of scenario-based analysis, see Chapter 3 of this Guidance.

Step 1 – Initiate CDP application, gather proposed project information, and engage with environmental justice communities

Similar to the process for addressing sea level rise in an LCP, the first step in considering how sea level rise may affect a proposed project is to define the scope of the project and begin to gather relevant information that will be needed to inform the following steps. This includes gathering project-specific and site-related materials such as blueprints, site plans, and information regarding on-site and nearby coastal resources that will be used to inform the hazards and resource analyses described in the following steps. An important part of this step is to identify and engage with environmental justice communities who could be impacted by the proposed project. The following section describes steps and best practices for meaningfully engaging with environmental justice communities.

It is important to note that the type and scope of the proposed project may affect the type and level of community engagement, as well as the level of detail and types of hazard and resource analyses necessary. For example, siting of a new industrial facility will likely raise greater concerns from both an environmental justice perspective and a sea level rise perspective (and the interplay of both issues as well as other Coastal Act topics) than the siting of a single-family residential structure in an infill area away from the shorefront. In some cases, a variety of hazard and environmental justice information may already be available from LCP update work as described in Chapter 5, or from similar planning and engagement efforts. However, this type of information may need to be refined for site specific purposes, or new or updated information may be necessary.

Throughout the CDP analysis, applicants are advised to contact planning staff (either at the Commission or the local government, whichever is appropriate) to discuss the proposed project, project site, and possible resource or hazard concerns. Applicants are also encouraged to contact the Commission's Environmental Justice Team (or relevant local government staff) to discuss meaningful engagement strategies and best practices and potential concerns or impacts from sea level rise to environmental justice communities. The extent and frequency of staff coordination and public engagement may vary with the scale of the proposed project and the constraints of the proposed project site. The following section discusses methods and best practices for meaningful engagement with environmental justice communities, and additional detail information can be found in Chapter 5.

MEANINGFUL ENGAGEMENT WITH ENVIRONMENTAL JUSTICE COMMUNITIES

As highlighted above, the type and extent of engagement efforts with environmental justice communities will vary depending on the type and scope of a proposed project. The Commission's Environmental Justice Policy expands upon on the Coastal Act's mandate to provide the widest opportunity for public participation by expressly recognizing that environmental justice communities are valuable stakeholders in the protection and enjoyment of the coast. As such, this step aims to recognize and set the stage to engage with these communities that have been historically excluded from planning and permitting decisions and from accessing the benefits of coastal development and resources. This step also helps to identify any potential environmental justice concerns and impacts early in the application process to ensure they can be adequately evaluated and accounted for throughout the analysis process. Importantly, applicants should be aware that even though their project may not be located in or near an environmental justice community, individuals may still be affected by the proposed project including workers, visitors, or commuters from these communities.

The questions below are provided as examples for applicants to consider in identifying environmental justice communities and determining the level of engagement with affected communities. Please note that these questions are not exhaustive, and a project may have unique circumstances that warrant outreach and engagement with environmental justice communities.

- Is there an environmental justice community in or near the project area? If the project is not in or near an environmental justice community, are individuals from underserved communities affected in other ways (workers, visitors, unsheltered individuals, etc.)? Are underserved communities in the broader region or state affected by the project?
- How might surrounding environmental justice community members interact with or be affected by the proposed project?
- Are there community members that have expressed opposition to the application due to environmental justice concerns?

Use mapping tools to identify environmental justice communities

Identifying environmental justice communities in and around a project location as well as environmental justice communities that use, have an important connection to a project location, or otherwise are directly affected by the sea level rise range determined in Step 2 is a core step in the outreach and engagement process. As described in Chapter 5, there are several resources that can aid in this step. Applicants are also encouraged to contact their local government office who may have additional survey data on use of an area that may be informative (e.g., cellular surveys of beach use that identifies where beach users travel from).

- Coastal California Environmental Justice Mapping Tool (forthcoming): Commission staff developed the Coastal California Environmental Justice Mapping Tool, which can be used to assist in the identification and analysis of environmental justice communities and future sea level rise scenarios. This mapping tool compiles public information (including some information available on CalEnviroScreen and EPA EJScreen) such as socioeconomic data, sea level rise projections, Coastal Zone Boundary, LCP segments, and coastal public access points.
- CalEnviroScreen: A mapping tool created by CalEPA Office of Environmental Health Hazards Assessment to identify California communities most affected by multiple sources of pollution. CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in California, which are mapped to compare how pollution burden varies among communities.
- Cal EPA's SB 535 Disadvantaged Communities map: This map shows the disadvantaged communities designated by CalEPA for the purpose of SB 535. These areas represent the 25% highest scoring census tracts in CalEnviroScreen 4.0.
- EPA EJScreen: EJScreen is an EPA's environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic socioeconomic indicators.
- CA State Parks' Outdoor Equity Program Community FactFinder: A mapping tool created by California State Parks to identify and visualize communities' access to parks and open

spaces, using environmental, health, and socioeconomic data to highlight areas with the greatest need for improved outdoor equity and access.

- U.S. Census Data: The U.S. Census Bureau provides data about the nation's people and economy. Every 10 years, it conducts a census counting every resident in the United States. The Census Bureau provides a variety of tools (including the EPA EJScreen) to identify environmental justice communities.

In addition to information that can be gathered from the tools listed above, applicants should also consider obtaining qualitative information about environmental justice communities. This information can be gathered from meetings with community members and organizations and social and local news media as well as contacting the local government. As detailed in SB 272, local governments are now required to conduct a vulnerability assessment that includes an assessment of environmental justice communities, identified as at-risk communities, so some of this information may already be available. Project applicants should contact their local government for help with information gathering regarding environmental justice communities in and around, and with connections to, the project site.

As discussed in Chapter 5, understanding historic and current burdens experienced by environmental justice communities can inform more equitable project alternatives and outcomes. However, the level of research that an applicant should conduct to understand the specific reasons that distinguish environmental justice communities from other populations depends on the scale and impact of the proposed project. For example, development of critical infrastructure (such as a wastewater treatment plant) that would have considerable public health, public safety, or environmental impacts are encouraged to explore and note the historic and current burdens of environmental justice communities who may be impacted by the proposed project to ensure that the project does not further exacerbate burdens.

Expected outcomes from Step 1: Initiation of CDP application process, identification of project scope, informational materials, and environmental justice communities in or near the project site or that have an important connection to the project location.

*S*tep 2 – Establish the projected sea level rise range for the proposed project

A range of sea level rise scenarios should be obtained from the best available science, which is summarized below as well as in Chapter 3, Appendix A, and the State Sea Level Rise Guidance (OPC 2024). These scenarios should cover the expected life of the proposed project, as the ultimate objective will be to assure that the project is safe from coastal hazards, without the need for shoreline protection or other detrimental hazard mitigation measures, over its lifetime.

- **Define Expected Project Life**: The expected project life will help determine the amount of sea level rise to which the project site could be exposed while the development is in place. Importantly, the point of this step is not to specify exactly how long a project will exist (and be permitted for), but rather to identify a project life timeframe that is typical for the type of development in question so that the hazard analyses performed in subsequent steps will adequately consider the impacts that may occur over the entire life of the development.

  Some LCPs include a specified design life for new development. If no specified time frame is provided, a more general range may be chosen based on the type of development. For example, temporary structures, ancillary development, amenity structures, or moveable or expendable construction may identify a relatively short expected life such as 25 years or less. Residential or commercial structures will likely be around for some time, so a time frame of 75 to 100 years may be appropriate. A longer time frame of 100 years or more should be considered for critical infrastructure like bridges or industrial facilities and for subdivisions of land. Resource protection or enhancement projects such as coastal habitat conservation or restoration projects should also consider longer time frames of 100 years or more, as these types of projects are typically meant to last in perpetuity.[52]

- **Determine Sea Level Rise Range:** Using the typical project life identified above, the project analysis should identify a range of sea level rise scenarios based on the best available science that may occur over the life of the project. At present, the State Sea Level Rise Guidance (OPC 2024) is considered to be the best available science (see Chapter 3 and Appendix A for more information) though an equivalent resource may be used provided that it is peer-reviewed, widely accepted within the scientific community, and locally relevant. The State Guidance includes a set of sea level rise scenarios for statewide use (Table 7), as well as scenarios for each of the 14 tide gauges in California (Appendix F). Project applicants should identify appropriate scenarios (as described below) from the tide gauge closest to the project location.[53]

  As explained in Chapter 3, the State Sea Level Rise Guidance (OPC 2024) offers the following framework to generally guide the selection of sea level rise scenarios to include in technical analyses, including at the project level and in broader vulnerability assessments:

[52] Determining an anticipated life for restoration activities or other related projects is somewhat more complex than for typical development projects because these activities are typically meant to exist in perpetuity. As such, assessing sea level rise impacts may necessitate analyzing multiple different time frames, including the present, near future, and very long term depending on the overall goals of the project. For restoration projects that are implemented as mitigation for development projects, an expected project life that is at least as long as the expected life of the corresponding development project should be considered.

[53] More detailed refinement of sea level rise scenarios is not considered necessary at this time, as variations from the nearby tide gauges will often be quite small, and may be insignificant compared to other sources of uncertainty. However, the Coastal Commission recognizes that other studies exist with localized data, for example those completed in the Humboldt Bay region, which may also be appropriate for use.

1. *Intermediate Scenario*: The Intermediate scenario should be included in technical analyses for development with low risk aversion, i.e., development that would have limited consequences or a higher ability to adapt, such as some ancillary development or public access amenities like sections of unpaved coastal trail, public accessways, and other small or temporary structures that are easily removable and would not have high costs if damaged.
2. *Intermediate-High Scenario*: The Intermediate-High scenario should be included in technical analyses for development with medium-high risk aversion, i.e., development that would experience greater consequences and/or have a lower ability to adapt, such as most residential and commercial structures.
3. *High Scenario*: The High scenario should be included in technical analyses for development with extreme risk aversion, i.e., development with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur. In the Coastal Commission's jurisdiction, this could include new wastewater treatment plants, power stations, highways, or other critical infrastructure.

In general, the Coastal Commission recommends taking a precautionary approach by evaluating the higher sea level rise scenarios, such as the Intermediate-High scenario, for most development. For critical infrastructure, development with a very long project life (e.g., 100 years or greater), or assets that have little to no adaptive capacity, that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts if damaged, the analysis should consider the High scenario.[54] Considering these higher end amounts of sea level rise is important for understanding what types of planning and adaptation options may be necessary if worst case scenarios come to pass, or to inform decisions for new development with long lifetimes that would be hard to relocate, remove, or otherwise adapt to higher amounts of sea level rise in the future. In addition, analysis of lower sea level rise amounts may assist in identification of tipping points, or amounts of sea level rise or other combinations of hazard conditions that could lead to significant impacts and warrant adaptive responses. These considerations should each be carried forward through the rest of the steps in this chapter.

Expected outcomes from Step 2: A proposed or expected project life and corresponding range of sea level scenarios—up to and including a relatively high, precautionary scenario relevant to the planning/project context —that will be used in the following analytic steps.

[54] For more information on sea level rise planning for critical infrastructure, see also the Coastal Commission's Critical Infrastructure at Risk planning guidance.

Table 7. Sea Level Rise Scenarios for California [55]

Projected SLR Amounts (in feet)					
	Low	Intermediate-Low	Intermediate	Intermediate-High	High
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

Step 3 – Determine how physical impacts from sea level rise may constrain the project site

The Coastal Act requires that development minimize risks from coastal hazards. Sea level rise can both present new hazards and exacerbate hazards that are typically analyzed in CDP applications. In this step, project applicants determine the types and extent of sea level rise impacts that may occur now and into the future.

As described in Chapter 3 of the Guidance, impacts associated with sea level rise generally include erosion, inundation, flooding, groundwater rise, wave impacts, and saltwater intrusion. An assessment of these impacts is often required as part of a routine hazards assessment or the

[55] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the *State Sea Level Rise Guidance* and this guidance recommend for use in various planning and project contexts.

coastal hazards chapter of the LCP. Therefore, information in the local LCP can provide an initial determination of potential hazards for the project in question, if available. However, proposed development will often need a second, site-specific analysis of hazards to augment the more general LCP information.

Analyze relevant sea level rise impacts for each sea level rise scenario.

A CDP application for new development in a hazardous area should include a report analyzing the anticipated impacts to the project site associated with each sea level rise scenario identified in Step 1. Generally, the analyses pertinent to sea level rise include geologic stability, erosion, flooding/inundation, groundwater impacts, wave runup, and wave impacts, and these analyses are described in detail below. Depending on the site, however, different analyses may be required. Applicants should work with planning staff (Coastal Commission or local government staff) to perform a pre-application submittal consultation to determine what analyses are required for their particular project. In some locations with applicable LCPs, LCP policies and zoning code provisions may specify the required components of a site-specific analysis. Analysis of hazards that will not be altered by sea level rise (such as the location of faults, fire zones, *etc.*) should be undertaken at the same time as the assessment of sea level rise-affected hazards so a complete understanding of hazard constraints can be used for identification of safe or low-hazard building areas. After the submission of the CDP application, any additional analyses that are required will be listed in an application filing status review letter.

The professionals who are responsible for technical studies of geologic stability, erosion, flooding/inundation, groundwater, wave runup, and wave impacts should be familiar with the methodologies for examining the respective impacts. However, the methodologies do not always adequately examine potential impacts under rising sea level conditions as established by best available science. Appendix B provides technical information for incorporating the best available science on sea level rise into the more routine analyses, which are summarized below. The analyses should be undertaken for each of the sea level rise scenarios identified in Step 1.

- **Geologic Stability:** The CDP should analyze site-specific stability and structural integrity without reliance upon existing or new protective devices (including cliff-retaining structures, seawalls, revetments, groins, buried retaining walls, and caisson foundations) that would substantially alter natural landforms along bluffs and cliffs. Geologic stability can include, among others, concerns such as landslides, slope failure, liquefiable soils, and seismic activity. In most situations, the analyses of these concerns will be combined with the erosion analysis (below) to fully establish the safe developable area.
- **Erosion:** Both bluff erosion and long-term shoreline change will generally increase with time. Thus, some estimate of project life is needed to determine expected bluff and shoreline change, and to fully assess the viability of a proposed site for long-term development. The CDP application should include an erosion analysis that establishes the extent of erosion that could occur from current processes, as well as future erosion hazards associated with the identified sea level rise scenarios over the life of the project.

If possible, these erosion conditions should be shown on a site map, and the erosion zone, combined with the geologic stability concerns, can be used to help establish locations on the parcel or parcels that can be developed without reliance upon existing or new protective devices (including cliff-retaining structures, seawalls, revetments, groins, buried retaining walls, and caissons) that would substantially alter natural landforms along bluffs and cliffs.

- **Flooding and Inundation:** The CDP application should identify the current tidal datums and include analysis of the extent of flooding or inundation that potentially could occur from the identified sea level rise scenarios, and under a range of conditions that could include high tide, storm surge, water elevation due to El Niños, Pacific Decadal Oscillations, a 100-year storm event, and the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting flood zones should be shown on a site map and/or a typical cross section detailing flood elevations and the elevations of key development features (e.g., finished first floor, future site grade) in relation to a standard vertical datum.[56]
- **Groundwater rise**: The CDP application should include an analysis of potential shallow or emergent groundwater particularly in low-lying areas near tidally connected water bodies (e.g., canals and creeks). The analysis should include discussion of how shallow groundwater may threaten buried components of a development such as basements, foundations, and pipelines such as through increased loads, corrosion, or buoyancy forces.
- **Wave Runup and Wave Impacts:** Building upon the analysis for flooding, the CDP application should include analysis of the wave runup and impacts that potentially could occur over the anticipated life of the project from a 100-year storm event, combined with the identified sea level rise scenarios, and under a range of extreme static water levels considering the potential effects of high tides, atmospheric forcing (e.g., storm surge) and oceanographic forcing (e.g., El Niño) in addition to the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting wave runup zones should be shown on a site map and/or site profile (cross section).
- **Tsunami:** CDP applications should include an analysis of existing tsunami risk and discussion of how tsunami risk may be worsened by sea level rise. The level of analysis will vary depending on the type of development; critical infrastructure should include more extensive discussion on the risks from extreme events like tsunamis.
- **Other Impacts**: Any additional sea level rise related impacts that could be expected to occur over the life of the project, such as saltwater intrusion should be evaluated. This may be especially significant for areas with a high groundwater table such as wetlands or coastal resources that might rely upon groundwater, such as agricultural uses.

[56] Local governments and other stakeholders may be familiar with FEMA flood zones, Flood Insurance Rate Maps (FIRMs), and related building regulations, but it is important to note that these maps do not include climate change and sea level rise in flood hazard analysis. Instead, they typically rely on historical data to determine flood hazards, meaning that they will underestimate flood risks when considering the full life of a proposed project in an area that will be subject to sea level rise.

Expected outcomes from Step 3: Detailed information about the sea level rise related impacts that can occur on the site and changes that will occur over time under various sea level rise scenarios. High risk and low risk areas of the site should be identified. The scenario-based analyses should also provide information on the potential effects of sea level rise, such as coastal erosion, that could occur over the proposed development life, without relying upon existing or new protective devices.

Step 4 – Determine how the project may impact coastal resources, including as they relate to environmental justice communities, considering the influence of sea level rise upon the landscape over time

The Coastal Act requires that development avoid or minimize impacts to coastal resources. Sea level rise will likely cause some coastal resources to change over time, as described in Chapters 3 and 4. The Coastal Act also requires the Commission and local governments to consider environmental justice in CDP decisions, and the Commission's Environmental Justice Policy includes a guiding principle on evaluating and addressing the disproportionate environmental and public health burdens environmental justice communities experience from climate change and sea level rise. Whatever harms to coastal resources resulting from the impacts of sea level rise will likely exacerbate burdens already felt among environmental justice communities who have a higher social vulnerability to climate change (Roos, 2018). Therefore, in this step, applicants should 1) analyze how sea level rise will affect coastal resources now and in the future, and 2) analyze how adverse impacts on coastal resources may exacerbate burdens to environmental justice communities, as well as such communities that may be located farther from the site but have a shared and important connection to the project area, so that alternatives can be developed in Step 5 to minimize the project's impacts to coastal resources, and as they relate to environmental justice communities, throughout its lifetime.

This section discusses only those resources that might change due to rising sea level or possible responses to rising sea levels. As in Step 2, each sea level rise scenario (high, low, and intermediate values) should be carried through this step. A complete CDP application will need to assess possible impacts to all coastal resources – including public access and recreation, water quality, natural resources (such as ESHA and wetlands), agricultural resources, natural landforms, scenic resources, and archaeological and paleontological resources. Analysis of those resources that will not be affected by sea level rise (along with their implications for environmental justice communities) should be undertaken at the same time as the assessment of the sea level rise-affected resources so a complete map of resource constraints can be used for identification of the most resource-protective building area.

4.1 Analyze coastal resource impacts and hazard risks for each sea level rise scenario

Analysis of resource impacts will require information about the type and location of the resources on or in proximity to the proposed project site and the way in which the proposed project will affect such resources and the communities that use and depend on them both initially and over time. The following discussion of each resource will help identify the key impacts to each that might result from either sea level rise or the proposed development, as well as how impacts to each resource may exacerbate or cause new burdens for environmental justice communities.

If coastal resources will be affected by sea level rise, such as changes to the area and extent of a wetland or riparian buffer, these changes must be considered in the analysis. Much of the following discussion recommends analysis of impacts from current and future inundation, flooding, erosion, and from the ways in which the project proposes to address such impacts. Appendix B provides guidance on how to undertake this analysis and includes lists of suggested resources that can provide data, tools, or other resources to help with these analyses. This analysis should be repeated for each sea level rise scenario identified in Step 1. Also, it may be important for local planners to coordinate and share information with environmental justice communities as well as other local partners – including those in charge of emergency management, law enforcement, and related services – in order to identify risks and vulnerabilities. Information on the following coastal resources is included. To skip to a section, click on the links below:

- New Development (addressed in Step 2, above)
- Public Access and Recreation
- Coastal Habitats
- Natural Landforms
- Agricultural Resources
- Water Quality and Groundwater
- Scenic Resources

Public Access and Recreation: Public access and recreation resources include lateral and vertical public accessways, public access easements, beaches, recreation areas, campgrounds public trust lands,[57] parking lots, and trails, including the California Coastal Trail. These areas may become hazardous or unusable during the project life due to sea level rise and/or due to the proposed project. Approaches to identify potential risks to public access and recreation include:

[57] The State Lands Commission has oversight of all public trust lands and many local governments are trustees of granted tidelands. The State Lands Commission or other appropriate trustee should be contacted if there is any possibility that public trust lands might be involved in the proposed project. As a general guide, public trust lands include tide and submerged lands as well as artificially filled tide and submerged lands.

- Identify all public access locations on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project. The analysis should also identify existing public trust areas in relation to the proposed project, which may necessitate a survey of the mean high tide line.
- Determine whether any access locations or public trust lands will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation, shoreline erosion, or from proposed project elements. At a minimum, establish the extent of likely and/or possible changes to public access and recreation and to public trust lands.
- If any access locations will be altered by sea level rise and/or the proposed project, map or otherwise identify the potential changes to the location of these access resources for the identified sea level rise scenarios.
- Describe the potential adverse impacts to environmental justice communities if public access locations and amenities may be affected by sea level rise and/or the proposed project. For example, if sea level rise and/or the proposed project would limit public beach space, this may disproportionately affect environmental justice communities who rely on such beaches to escape inland heat. These areas also provide vital free or low-cost opportunities for environmental justice communities to access and recreate along the coast.
- Identify whether there are locations on the proposed project site that can support development without encroachment onto the existing or future locations of these access areas, and without other impacts to public access and recreation. Overlay with development constraints (e.g., fault zones, landslides, steep slopes, property line setbacks) and with other coastal resource constraints.

Coastal Habitats (e.g., ESHA, 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. Ways to identify potential resource impacts associated with the project include:

- Identify all coastal habitats and species of special biological or economic significance on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project.
- Determine whether any coastal habitats will be altered or affected by sea level rise and/or the proposed project over the proposed life of the project. Such impacts could result from flooding, inundation, shoreline erosion, or changes to surface or groundwater conditions (see discussion below on water quality). At a minimum, use the identified sea level rise scenarios to establish the extent of likely and/or possible changes to coastal habitats.
- If any coastal habitats will be altered by sea level rise and/or the proposed project, map or otherwise identify potential changes to the location of these coastal resources for the identified sea level rise scenarios.

- Describe the potential adverse impacts to environmental justice communities if coastal habitats were affected by sea level rise and/or the proposed project. For example, if sea level rise and/or the proposed project eliminated a coastal habitat, this may disproportionately affect environmental justice communities who rely on it for subsistence fishing. Coastal habitats may contain important cultural and ancestral ties for indigenous communities as well as provide educational opportunities to environmental justice communities.
- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these coastal habitats, and without other impacts to coastal habitats. Overlay with development constraints (e.g., fault zones, landslides, steep slopes, property line setbacks) and with other coastal resource constraints.

Natural Landforms: Natural landforms can include coastal caves, rock formations, bluffs, terraces, ridges, and cliffs. Steps to identify natural landforms at risk include:

- Identify all natural landforms on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project.
- Determine whether any natural landforms will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation, shoreline armoring, or shoreline erosion. At a minimum, use the identified sea level rise scenarios to establish the zone of likely and/or possible changes to natural landforms.
- If any natural landforms will be altered by sea level rise and/or the proposed project, map or otherwise identify the likely changes to location of these coastal resources for the identified sea level rise scenarios.
- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these natural landforms and without other impacts to such landforms. Bluffs and cliffs can often require additional analysis for slope stability to determine the setback from the eroded bluff face that can safely support development over its lifetime. Overlay with development constraints (e.g., fault zones, landslides, steep slopes, property line setbacks) and with other coastal resource constraints.

Agricultural Resources: Agricultural resources may be affected by sea level rise through changes to surface drainage and the groundwater table. Other changes can result from flooding, inundation, or saltwater intrusion. If agricultural lands are protected by levees or dikes, they can be affected by changes to the stability or effectiveness of these structures. Steps to identify risks to agricultural resources include:

- Identify whether the proposed project site is used for or zoned for agricultural uses, contains prime agricultural soils, or is in the vicinity of or upstream of lands in agricultural use.

- Identify surface water drainage patterns across the site or from the site to the agricultural use site.
- If any drainage patterns are closely linked to and potentially influenced by the elevation of sea level, examine changes in drainage patterns with rising sea level on the proposed site or the agricultural use site.
- Describe the potential adverse impacts to environmental justice communities if agricultural resources were affected by sea level rise and/or the proposed project. Impacts to agricultural resources may exacerbate burdens to environmental justice communities who live or work in these areas. For example, if sea level rise and/or the proposed project impacted any nearby lands in agricultural use, this may result in displacement of farmworkers through loss of wages, health coverage, and housing.

Water Quality and Groundwater: Sea level rise may cause drainages with a low elevation discharge to have water back-ups. It may also cause a rise in the groundwater table. Both of these changes could alter on-site drainage and limit future drainage options. If the proposed site must support an on-site wastewater treatment system, or if drainage and on-site stormwater retention will be a concern, consider the following, as appropriate:

- Identify surface water drainage patterns across the site.
- Examine changes with rising sea level of any drainage patterns that are closely linked to and likely influenced by the elevation of sea level. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to drainage patterns.
- Identify the elevation of the groundwater table. Since groundwater can fluctuate during periods of rain and drought, attempt to identify the groundwater zone.
- Estimate the likely future elevation of the groundwater zone, due to sea level rise. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to groundwater.
- Evaluate whether changes in groundwater will alter the proposed site conditions.
- Identify environmental justice communities that may be impacted by changes in water drainage patterns and groundwater elevations and any damage to water and wastewater infrastructure. These impacts may increase financial and health burdens on environmental justice communities which often face additional barriers to accessing resources and seeking aid that other, wealthier, communities may have.

Scenic Resources: Visual and scenic resources include views to and along the ocean and scenic coastal areas. Development modifications to minimize risks from sea level rise could have negative consequences for scenic resources, including creating a structure that is out of character with the surrounding area, blocks a scenic view, or alters natural landforms. Steps to identify impacts to scenic resources, including any impacts from possible adaptation measures, include:

- Identify all scenic views to and through the proposed project site from public vantage points such as overlooks, access locations, beaches, trails, the Coastal Trail, public roads, parks, and if possible, map these views and view lines in relation to the location and maximum allowable elevation of the proposed project.
- Identify locations of the proposed project site that can support development and avoid or minimize impacts to scenic views from current and future vantage points. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

4.2 Synthesize and assess development, resource, and environmental justice constraints

After completing the detailed analysis of each coastal resource, the applicant should summarize the potential resource impacts under each sea level rise scenario identified in Step 1. This set of results, when combined with potential impacts to those coastal resources not affected by sea level rise, should give the applicant valuable information about the degree of risk posed to each coastal resource and to the development itself. If practical, for each sea level rise scenario, applicants should produce a constraints map illustrating the location and the extent of resource impacts that could occur over the life of the development. Based on the analysis of resource impacts and potential hazard risks over the life of the development, the applicant should develop an overlay identifying the development and resource constraints.

In addition to identifying each coastal resource impact, the applicant should also summarize any potential adverse impacts that may exacerbate burdens to environmental justice communities. The purpose of this analysis is to assess how the proposed project combined with sea level rise may result in adverse coastal resource-related impacts to environmental justice communities in order to help develop adaptation measures in Step 5 that prioritizes more equitable outcomes. Furthermore, this can also help shape how outreach and communication with environmental justice communities on the proposed project should be framed and conducted.

4.3 Identify areas suitable for development

The final part of this step is to identify the locations on the project site that could support some level of development without impacts to coastal resources, and without putting the development at risk.

Expected outcomes from Step 4: Upon completing this step, the applicant should have detailed information about the types of coastal resources on the project site and the level of risk that sea level rise poses to each resource under each sea level rise scenario, including resource locations and the extent of resource impacts that could occur over the life of the proposed project. The applicant should also have identified the project's potential coastal resource-related impacts to environmental justice communities. This step should also provide an overlay of all development and resource constraints, and clearly identify the locations on the proposed project site that could support some level of development that appropriately minimizes or avoids risk and protects coastal resources, as well as appropriately considers effects on environmental justice communities.

Step 5 – Identify project alternatives that avoid both resource and related environmental justice impacts and minimize risks to the project

By this step, applicants should have identified environmental justice communities in Step 1, developed a set of factors based on the sea level rise hazards identified in Step 3, identified potential resource impacts in Step 4, and analyzed other site conditions (such as archaeological resources or fault lines) to identify the buildable areas that avoid or minimize both risk from coastal hazards and impacts to coastal resources, including resources that would disproportionately affect environmental justice communities. Hazard and resource avoidance is usually the preferred option, and, in many cases, applicants may find that the site is safe from sea level rise hazards for all the identified sea level rise scenarios and no further identification of project alternatives would be necessary in order to address sea level rise concerns.

For some cases, the site constraints may require consideration of project alternatives that fit with the available buildable area, without the use of protective structures. In these cases, one of the alternatives may be to revise the project design initially considered for the site. In other cases, development that is safe from hazards and is resource protective may be possible if certain adaptation strategies are used to modify the project over time and as the potential hazard areas increase or move closer to the project. For these cases, the possible adaptation pathways would be included as part of the proposed project, along with necessary monitoring and triggers for implementing the adaptation options. In still other cases, hazard minimization may be the only feasible option for development on hazard-constrained sites, in which case the project should be designed and sited appropriately to minimize coastal resource and hazard impacts. In all cases, projects must be sited and designed to address all applicable Coastal Act and LCP requirements, including any new requirements within LCPs that have been updated to adapt to sea level rise.

The results from the analysis of sea level rise scenarios should factor into the decisions made in this step. In particular, after looking at the results from Steps 3 and 4 as a whole, applicants can better decide the project changes, types of adaptation strategies, and design alternatives that would be most appropriate given the degree of risk posed by possible sea level rise and how long the development might be free from risk. The applicant also might identify triggers (e.g., a certain amount of sea level rise or certain physical impacts from sea level rise) when certain adaptation measures should be implemented to reduce risk and/or impacts to coastal resources.

Importantly, land divisions and lot line adjustments in high hazard areas can change hazard exposure and should therefore be undertaken only when they can be shown to not worsen or create new vulnerability. In particular, no new lots or reconfigured lots with new development potential should be created if they cannot be developed without additional shoreline hazard risks.

Strategies to Avoid Resource Impacts and Minimize Risks

The best way to minimize risks to development and coastal resources is to avoid areas that are or will become hazardous as identified by the sea level rise scenarios analysis in the previous steps. Such avoidance often includes changes to the proposed project to bring the size and scale of the proposed development in line with the capacity of the project site. However, if it is not feasible to site or design a structure to completely avoid sea level rise impacts, the applicant may need to modify or relocate the development to minimize risks to the development or to coastal resources. Some changes, such as the use of setbacks, may be necessary at the outset of the project. Other changes, such as managed retreat or added floodproofing, may be useful as adaptive strategies that can be implemented after the initial project completion. Considerations involved in choosing and designing an appropriate adaptation strategy may include those listed below. See Chapter 7 for more information on specific adaptation measures. For a list of other sea level rise adaptation resources, see Appendix C.

- **Assess Design Constraints:** Determine whether there are any significant site or design constraints that might prevent future implementation of possible sea level rise adaptation measures. Some project locations may be constrained due to lot size, sea level related hazards, steep slopes, fault lines, the presence of wetlands or other ESHA, or other constraints such that no safe development area exists on the parcel. Ideally, such parcels would be identified during the LCP vulnerability analysis, and the land use and zoning designations would appropriately reflect the constraints of the site. However, in some cases development may need to be permitted even if it cannot avoid all potential hazards. As stated above, care should be taken in these cases to avoid resource and community impacts and minimize risks as much as possible by developing and implementing a sea level rise adaptation plan for the proposed development. In creating this plan, it is important to identify any design constraints that will limit the ability to implement adaptation strategies in the future, as described below.

- **Identify Adaptation Options:** Identify possible adaptation strategies (such as those found in Chapter 7) for the proposed project and evaluate each adaptation option for efficacy in protecting the development. Also, evaluate the consequences from each proposed adaptation measure to ensure it will not have adverse impacts on coastal and sensitive environmental resources, including visual impacts and public access. Applicants should also consider that adaptation measures do not exacerbate burdens to environmental justice communities.

For example, an option that is often considered for sea level rise is to elevate the development or the structures in order to provide flood protection. However, elevated structures will change the scenic quality and visual character of the area, oftentimes providing more benefit to the individual property owner while negatively affecting scenic views for others who may not live along the coast. Also, elevation of the main development may be of little long-term utility to the property owner if the supporting infrastructure, such as the driveways, roads, utilities, or septic systems are not also elevated or otherwise protected. Elevation of existing levees or dikes can provide flood protection for an area of land and all the development therein. However, the foundation of the levee or dike must have been designed to support the additional height or else it may have to be expanded and the increased footprint of the foundation could have impacts on intertidal area, wetlands, or other natural or cultural resources. Thus, the long-term options for adaptation should be considered as part of any permit action, to ensure that current development decisions are not predetermining resource impacts in the future.

- **Use Adaptation Pathways:** "Adaptation pathways" refers to a planning approach in which planners consider multiple possible futures and analyze the robustness and flexibility of various adaptation options across those multiple futures. In the context of sea level rise planning, if the likelihood of impacts is expected to increase with rising sea level, it may be necessary to design the initial project for some amount of sea level rise but to also include design flexibility that will allow future project changes or modifications to prevent impacts if the amount of sea level rise is more than anticipated in the initial design. Changes and modifications could include the use of foundation elements that will allow for building relocations or removal of portions of a building as it is threatened or reserving space to move on-site waste treatment systems away from eroding areas or areas that will be susceptible to a rising water table or increased flooding.

- **Develop Project Modifications**: Highly constrained sites may not be able to support the amount of development that an applicant initially plans for the site. Even a small building footprint may be at risk from flooding or erosion under high sea level rise scenarios. In such cases, it will be important to work closely with the appropriate planning staff to develop a project option that can minimize hazards from the identified sea level rise scenarios for as long as possible, and then incrementally retreat once certain triggers are met. Some examples of triggers could be that erosion is within some distance of the foundation, or monthly high tides are within some distance of the finished floor elevation. The time period for relocation or removing the structure would be determined by changing site conditions but relocation would most likely occur prior to the time period used in Step 2 to determine long-term site constraints.

- **Plan for Monitoring:** Develop a monitoring program or links to other monitoring efforts to ensure that the proposed adaptation measures will be implemented in a timely manner. Following a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time can help to identify the triggers that would lead to revising project life, other project modifications or additional adaptation efforts.

- **Consider Community Benefits Agreements:** Community Benefits Agreements (CBAs) are contracts between developers and impacted communities and/or their representatives (governmental and non-governmental) that are a way for applicants to address a project's impacts on coastal resources and develop adaptation measures by implementing social, economic, and environmental benefits to support communities affected by proposed development. Depending on the project and its impacts on coastal resources, community benefits could include an increase in open spaces in the development, clean water programs, and local workforce training and hiring programs.[58] CBAs are not in lieu of avoiding impacts and appropriate mitigation, but can provide a benefit to communities by the developer as a way to address some project impacts and garner public support for a project (Akibode, 2017). Thus, CBAs could address both coastal resource impacts as well as other impacts that are important to the community. When community benefits effectively ensure that community interests are well represented, they can empower communities to take part in the planning process, enhance the project approval process, and help achieve social equity.[59] For CDPs, CBAs can be implemented through special condition language and in project descriptions.[60]

Expected outcomes from Step 5: This step may involve an iterative process of project modifications and reexamination of impacts, leading to one or more alternatives for the project site. The alternative that will best minimize risks from coastal hazards and avoid or minimize impacts to coastal resources, including coastal resource-related impacts to environmental justice communities, should be identified. Possible adaptation options could be identified and analyzed, including options to address environmental justice issues, if appropriate. If the site is very constrained, modifications to the expected project life might be suggested.

[58] An increase in open spaces could address impacts to coastal access and recreation, clean water programs could address impacts to water quality and supply, and local workforce training and hiring programs could contribute to a reduction in vehicle miles traveled.

[59] Note that CBAs may not always fulfill community expectations, and all members of the community may not support them.

[60] See Special Condition 22 of A-5-VEN-21-0011 for an example of a CBA that implements access to a garden education program, prioritizes local hiring, increases access to outdoor spaces, and provides free, non-motorized transportation and bicycle parking.

Step 6 – Finalize project design and submit CDP application

After Step 5, the applicant should have developed one or more project alternatives and identified a preferred alternative. The alternatives should include mitigation measures or adaptation strategies to minimize impacts if hazards cannot be avoided entirely. The CDP application step involves the following:

1. **Work with the planning staff to complete the CDP application**. Depending upon the proposed project and extent of prior interactions with the planning staff, the initial submittal may be the first time the planner has been provided with information about the general project or the preferred alternative. Once a proposed project is submitted, the coastal planner will need to become familiar with the project location, area around the project site, the proposed actions and the studies and analyses that have been undertaken in support of the application. The planner will review the application for completeness to ensure that there is sufficient information to analyze the project for all appropriate LCP or Coastal Act Chapter 3 policies and the Commission's Environmental Justice Policy. If analysis for sea level rise concerns is needed, the planner will also check that analyses for sea level rise risks have been included in the submittal. Much of the information developed in Steps 1-5 will be useful for the application process. The Suggested Filing Checklist for CDP Applications (located at the end of this chapter) covers the typical information that might be included in a CDP application necessary for planning review of the sea level rise aspects of the proposed project. Applicants who are unfamiliar with the permit process should consult the local government website, Coastal Commission website, or contact the appropriate district office for instructions on how to complete a CDP application.

   The review of an application might involve an iterative process, wherein planning staff requests more information about the proposed project, project alternatives, analysis of the hazards or identification of potential resource impacts to help in the review for compliance with the LCP or the Coastal Act. At the same time, planning staff may request that some of the technical staff review the submitted material to ensure that there is sufficient information in all technical information and analyses to support a decision on the proposed project. Planning staff may also consult with the Environmental Justice Team to confirm that the environmental justice analysis and planned outreach is appropriate. This process may be repeated until the application provides the studies, analyses and project review necessary for planning review.

2. **Submit a complete CDP application.** Once a complete application has been accepted, the planning staff will do a more thorough review and analysis of the potential hazards and resource impacts associated with the proposed project. Ideally, the planner will have requested all necessary project information at the filing stage. In some instances, additional information may be needed after the application has been accepted. This is normally limited to clarifications of some of the information or further details about some of the possible, but not preferred alternatives. During this stage in the CDP

application process, the planner may identify necessary project modifications that were not part of the initial application and identify various conditions that will be needed if the project is to be approved. Chapter 7 includes many of the possible project modifications and permit conditions that might be used to address sea level rise concerns and potential resource impacts.

During the project analysis, the planning staff will review all submitted material, discussing the proposed project with other staff members, and obtaining further review. Working with their supervisors and managers, they will also develop a staff recommendation and prepare a staff report that supports the proposed recommendation. Please consult the Coastal Commission website or contact your district office for instructions on how to complete a CDP application.

3. **Permit action.** Once the proposed project has been through planning review and a staff recommendation has been prepared, the proposed project will be brought to hearing before either the local government or the California Coastal Commission. The outcome of the hearing process will be project approval, approval with conditions, or denial. Based on the regulatory decision, the project may be constructed, or additional modifications and condition requirements may have to be met.

4. **Monitor and revise.** CDP approvals may include conditions that require monitoring. Applicants should monitor the physical impacts of sea level rise on the project site, provide reports and updates to planning staff and introduce adaptive changes to the project in accordance with the permit and permit conditions.

Expected outcomes from Step 6: This step, combined with supporting documentation from the previous steps, should provide a basis for evaluating the proposed project's hazard risks and impacts that can result from sea level rise. Such an analysis will provide one of the bases for project evaluation and complements the other resource evaluations and analyses that are part of a complete CDP application.

Planning Process for Coastal Development Permits

1. Initiate CDP application, gather proposed project information, and engage with EJ communities

- Gather materials such as blueprints, site plans, and information regarding coastal resources to inform hazards and resource analyses.
- Identify EJ communities near to or with an important connection to the project site.

2. Establish the projected sea level rise range for the proposed project

- Determine time period of concern using expected project life.
- Use range of SLR scenarios based on best available science (*e.g. 2024 OPC SLR Guidance*).

3. Determine how sea level rise impacts may constrain the project site

Using locally relevant SLR projections, determine site- or project-specific hazards or impacts for the time period of concern, including current and future hazard impacts. Consider:

- Geologic Stability
- Erosion
- Flooding and Inundation
- Groundwater Rise
- Wave Impacts
- Tsunami

4. Determine how the project may impact coastal resources, including as they relate to EJ communities over time, considering SLR

Determine how the project may impact coastal resources (below) considering how SLR may alter the resources over the expected lifetime of the project.

- Public Access and Recreation
- Agriculture
- Archaeological/Paleontological resources
- Environmental Justice communities
- Coastal Habitats
- Water Quality
- Scenic Resources

5. Identify project alternatives to both avoid resource and related EJ impacts and minimize risks to the project

- Ideally, site/design the project to avoids conflicts with natural resources, EJ, and SLR impacts.
- Alternatively, minimize the likelihood that the project will be impacted by hazards, and design an adaptation strategy for unavoidable impacts.
- Modify the project if impacts cannot be avoided/minimized.
- Summarize these alternatives.

6. Finalize project design and submit permit application

Complete the CDP application. Submit the application. Receive permit action. Monitor and revise project as needed.

Figure 16. Flowchart for steps to address sea level rise in Coastal Development Permits

Suggested Filing Checklist for Sea Level Rise Analysis

- Identify Environmental Justice Communities (site maps)
- Proposed/Anticipated Project Life
- Sea Level Rise Scenarios used in Impacts Analyses
- Impacts Analyses (possibly from Vulnerability Assessment)
    - **Structural and Geologic Stability**: Identify current tidal datum; perform geotechnical report and erosion analysis; identify blufftop setback and safe building area; show setback, safe building area and proposed project footprint (site maps)
    - **Erosion**: Perform coastal processes study and erosion analysis; quantify total erosion amount for proposed project site; show retreat along with proposed project footprint (site maps)
    - **Groundwater**: Identify groundwater depth and range and local geology and soil porosity; show future depths under relevant sea level rise scenarios
    - **Flooding and Inundation Risks**: Perform coastal processes study and wave runup analysis; quantify flood elevation and flooding extent; show flood extent with proposed project footprint (site map); show flood elevation on site profile, with proposed project elevation; provide flood certificate if in FEMA designated 100-year flood zone
    - **Tipping points for sea level rise impacts**, specific to proposed project site
- Impacts to coastal resources for current conditions and changes due to sea level rise and related impacts
    - **Public Access and Recreation**: Show access resources and future changes (site maps)
    - **Water Quality, surface and groundwater**: Provide surface drainage patterns and runoff and future changes (site maps); provide zone of groundwater elevation
    - **Coastal Habitats**: Provide wetland delineation, ESHA determination, if appropriate; provide boundary determinations or State Lands review, if appropriate; show all coastal habitats and future changes (site maps)
    - **Agricultural Resources**: Show agricultural resources and future changes (site maps)
    - **Natural Landforms**: Show all natural landforms and future changes (site maps)
    - **Scenic Resources**: Show views from public access and future changes due to access changes
    - Overlay all coastal resources to establish areas suitable for devel. (site maps)
    - Identify disproportionate or inequitable effects on environmental justice communities from any of the above impacts
- Analysis of Proposed Project and Alternatives
    - Provide amount(s) of sea level rise used in project planning and design
    - Provide analysis of the proposed project and alternatives
    - Identify proposed current and future adaptation strategies
    - Show avoidance efforts (site map)
    - Identify hazard minimization efforts that avoid resource, EJ impacts (site maps)

Example for Addressing Sea Level Rise in Coastal Development Permits

To illustrate the process described in this chapter for how to address sea level rise in the CDP process, consider three example projects: a wetland restoration project, a new bluff-top residential development with a fronting beach, and a new wastewater treatment facility. These examples will follow each of the recommended CDP steps, showing how the guidance could be applied in specific situations. Note that these are simplified examples used to demonstrate the process described in this chapter. Decisions about how to address various challenges presented by sea level rise will be more complex than those illustrated below, and the Coastal Commission encourages applicants to coordinate with staff as necessary and feasible throughout the process.

Step 1: Initiate CDP application, gather proposed project information, and engage with Environmental Justice communities

- *Wetland Restoration Project:* Gather relevant project materials such as blueprints and site plans. Begin EJ analysis by identifying nearby EJ communities with a connection to the project site. According to an EJ Mapping Tool, there are several environmental justice communities nearby and visitors who could benefit from the recreational value and outdoor space that the wetland restoration project could produce. After consulting with local government representatives, there is also a community-based organization focused on increasing local public health and water quality that is interested in this wetland restoration project. Sea level rise could potentially threaten the viability of the wetland restoration project and lead to a loss of this green space for communities and for the local ecosystem.

- *Bluff-top Residential Development:* Gather relevant project materials such as blueprints and site plans. Begin EJ analysis by identifying nearby EJ communities with a connection to the project site. According to an EJ Mapping Tool, there are zero environmental justice communities who live proximate to this property. However, after consulting with local government staff, non-profit organizations, and community-based organizations, staff is made aware that the beach fronting the property is a well-known pocket beach that many inland and environmental justice communities visit. Sea level rise could severely impact this pocket beach and lead to the loss of this coastal public accessway if armoring for the project leads to “coastal squeeze” and the inability of the sandy beach to migrate inland due to the bluff.

- *Wastewater Treatment Facility:* Gather relevant project materials such as blueprints and site plans. Begin EJ analysis by identifying nearby EJ communities with a connection to the project site. According to an EJ Mapping Tool, a majority of communities adjacent and proximate to the facility are environmental justice communities. Due to historic injustices in land use planning, environmental justice communities are often located near and adjacent to industrial facilities. Flood-damaged or inundated wastewater facilities could limit access to sanitation and hygiene services. Sea level rise could also severely impact the local environmental justice communities by impairing local water quality through the potential seeping of untreated sewage, damage to local sewage transmission pipelines, and subsequent impacts to public health.

Step 2: Establish the projected sea level rise range for the proposed project

- *Wetland Restoration Project:* Sea level rise scenario ranges should be chosen based on the goals of the project. For example, if wetland restoration efforts are intended as mitigation for a development project, the lifetime for the wetland restoration should be, at a minimum, the lifetime of the development project. For wetland restoration projects in which the desired outcome is the protection of the wetland in perpetuity, sea level rise ranges should be projected over a minimum of 100 years, with consideration of the intervening years as well as the even longer term for ongoing adaptive management.
- *Bluff-top Residential Development:* The lifetime of the project is assumed to be at least 75 years, unless the LCP specifies a different time period. Sea level rise scenarios up to and including the Intermediate-High scenario are established, appropriate for the proposed area over the assumed 75-year project life.
- *Wastewater Treatment Facility:* Wastewater treatment facilities are normally critical infrastructure. For this example, a minimum life of 100 years is assumed, unless the LCP specifies a different time period. Sea level rise scenarios up to and including the High scenario are established, appropriate for the proposed area over the assumed 100-year or longer project life.

Step 3: Determine how physical impacts from sea level rise may constrain the project site

- *Wetland Restoration Project:* Current topography of the wetland area is mapped, current barriers to inland migration are identified, and an analysis of erosion and flooding potential (and subsequent effects to wetland extent) is performed for various sea level rise scenarios. Potential changes to groundwater are evaluated. Potential changes in sediment flows or other physical properties as a result of changing conditions are examined. It is determined that in this case, open space exists behind the wetland to allow for inland migration over time.
- *Bluff-top Residential Development:* The average long-term beach and bluff retreat rate, erosion rate due to various sea level rise scenarios, and erosion potential from 100-year storms and other extreme events are determined. Beach and bluff erosion will vary with sea level rise rates. The geologic stability of the bluff over the life of the development is analyzed assuming that no protective structure (such as a seawall) either exists or will be built.
- *Wastewater Treatment Facility:* Erosion and flooding potential over the lifetime of the facility under sea level rise scenarios up to and including the High scenario are analyzed, as are current and future wave runup and storm impacts for 100-year storms. The geologic stability of the site over the life of the facility is analyzed assuming that no protective structure either exists or will be built. Potential damage to infrastructure (for example, corrosion due to saltwater intrusion) is examined.

Step 4: Determine how the project may impact coastal resources and Environmental Justice communities, considering the influence of sea level rise upon the landscape over time

- *Wetland Restoration Project:* Coastal resources present in the proposed project site are mapped and sea level rise impacts to these resources are analyzed over the lifetime of the project. It is unlikely that the project will have any adverse impacts on coastal resources. Barriers to wetland migration are examined and it is determined in this case that enough open space currently exists to allow for the wetland to migrate inland over time. The few barriers that exist can be modified in the future, if necessary. This will allow for continued use and enjoyment by local communities and environmental justice communities, maintenance of habitat area, and ecosystem services.
- *Bluff-top Residential Development:* Maps are developed that identify scenic viewsheds, the bluff extent, and adjacent coastal habitats including the fronting beach, and descriptions of each are provided. Opportunities for public access are identified. Through partnership with local community-based organizations and local government staff, environmental justice communities are consulted and have shared that they enjoy visiting the fronting beach. Impacts to each of these resources as a result of sea level rise are analyzed, as are impacts that would result from the development project. It is determined that the development has the potential to result in the loss of a fronting beach if a protective structure is installed. However, development setbacks are designed to ensure that no such structure is planned over the lifetime of the development under any sea level rise scenario to ensure the protection of coastal public access for all.
- *Wastewater Treatment Facility:* Maps are developed that identify coastal resources in the area and impacts to these resources resulting from sea level rise are analyzed. As with the bluff-top development, any protective structure would have detrimental effects to the fronting beach, but no such structure is determined to be necessary. Any potential impacts to adjacent habitat areas or to water quality as a result of damage to infrastructure (for example sewage outflow or backup of seawater into the system) are examined under the range of sea level rise scenarios for the life of the facility to ensure that subsequent public health and water quality impacts will not affect the public, including members of adjacent environmental justice communities.

Step 5: Identify project alternatives to both avoid resource and EJ impacts and minimize risks to the project

- *Wetland Restoration Project:* In this example, there are no concerns related to detrimental impacts to coastal resources as a result of this project. Natural barriers will be removed through grading and contouring of the land to ensure that the wetland has the ability to migrate inland with sea level rise and that hydrologic function will be maintained. Inland areas are protected into the future to ensure the space will be open for migration. Additionally, a plan is included to monitor changes in sea level, sediment dynamics, and overall health of the wetland so that adaptive management options can be applied as needed.

- *Bluff-top Residential Development:* The optimal site for a bluff-top residential development is one that avoids the hazards identified in Step 3 and impacts to coastal resources identified in Step 4 over the lifetime of the project. If the proposed site does not avoid risks, alternative locations on the project sites should be identified and examined. If no such location exists, efforts should be made to minimize hazards and impacts to resources, or the project should be denied. Minimization efforts may include: increasing the setback from the bluff-face, developing a managed retreat plan, and designing buildings to be easily relocated. If the safe building envelope will not be sufficient for a reasonable-sized building, local governments could consider allowing reduced setbacks on portions of the site located away from the bluff face (e.g., side or front yard setbacks), reduced off-street parking, additional height on safe portions of the site, or other development that doesn't require shore protection. No seawall is planned as such a device would result in the loss of the fronting beach and impacts to coastal public access. A plan to monitor rates of erosion at various places along the bluff as well as any impacts to adjacent resources is developed, and erosion rates/scenarios that would trigger the need for retreat are identified.
- *Wastewater Treatment Facility:* The optimal site for a wastewater treatment facility is one that avoids the hazards identified in Step 3 and impacts to coastal resources identified in Step 4 over the lifetime of the project. If the proposed site does not avoid risks, alternative sites should be identified and examined. If no such site exists, efforts should be made to minimize hazards and impacts to resources. Minimization efforts may include: building the facility further back from the beach, elevating outflow pipes, and adding one-way valves to prevent backflow of sea-water into the system. A plan to monitor erosion rates along the beach as well as wave and storm impacts and any impacts to coastal resources caused by the facility is developed.

Step 6: Finalize project design and submit CDP application

- *Wetland Restoration Project:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes likely options for adaptive management to maintain wetlands and key monitoring needed to examine ongoing wetland function.
- *Bluff-top Residential Development:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazards, potential environmental justice impacts, resource risks, and any plans for adaptive project designs and proposed monitoring.

  Wastewater Treatment Facility: The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazards, potential environmental justice impacts, resource risk, and plans for site monitoring.

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Chapter 7. Adaptation Strategies

Chapters 5 and 6 provide guidance on the sequential processes for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). This chapter describes some of the specific adaptation strategies to consider in these planning and development review processes. Given the range of impacts that could occur as a result of sea level rise, and the uncertainties surrounding the amount of sea level rise to expect over the lifetimes of many coastal projects, communities, planners, coastal managers, and project applicants will need to use adaptation strategies to effectively address coastal hazard risks, environmental justice and equity concerns, and protect coastal resources over time.

As described in Chapters 5 and 6, adaptation strategies should be chosen based on the specific risks and vulnerabilities of a region or project site and the applicable Coastal Act and LCP requirements, with due consideration of local priorities, goals, and environmental justice and equity concerns. Adaptation strategies may involve modifications to land use plans, regulatory changes, project modifications, or permit conditions that focus on avoidance or minimization of risks and the protection of coastal resources.

Some adaptation strategies may require land use plans or proposed projects to anticipate longer-run impacts now, such as assuring that critical infrastructure is built to last a long time without being put in danger (from hazards such as flooding and inundation which could impact local water and energy needs) or rezoning hazardous areas as open space (and implementing appropriate clean-up and restoration measures to address public health and safety concerns). Other adaptation strategies may build adaptive capacity into the plan or project itself, so that future changes in hazard risks can be effectively addressed over time while ensuring long-term resource protection in line with any schedule for updates established per SB 272 requirements. In most cases, especially for LCP land use and implementation plans, multiple adaptation strategies will need to be employed. For projects, adaptation strategies may be addressed through initial siting and design and through conditions that provide for specific adaptation over time.

The next sections provide an overview of the general categories of adaptation options, followed by a description of various specific adaptation strategies organized by type of coastal resource, as outlined in Chapter 3 of the California Coastal Act. The adaptation options described in this chapter are intended to provide guidance for potential LCP and permitting strategies. Many of these strategies constitute approaches to address identified vulnerabilities that could be incorporated into an LCP update to address sea level rise in line with SB 272.

As described in Chapter 4, it is imperative to consider any disproportionate impacts that alternative project designs or adaptation measures may inflict upon environmental justice and tribal communities, and these impacts should be evaluated when considering adaptation strategies for an LCP or permit. For example, some efforts to protect communities from the impacts of climate change and sea level rise could also contribute to or increase displacement of environmental justice communities. Anguelovski et al. (2019) found that these efforts often overlook, minimize, or do not consider the short- and long-term adverse impacts that certain greening projects have on environmental justice communities, while marketing these adaptation strategies to developers, investors, and higher-income residents who value sustainability. Further, studies have identified that building green infrastructure projects within a neighborhood may draw further attention of local government planners, investors, and developers to invest in these neighborhoods by developing more housing, retail, and commercial spaces (Gould & Lewis, 2018). As a result, these investments often attract higher-income earners from outside of the community, thereby excluding the interests and needs of current residents, particularly in terms of affordability. In the long-term, current residents who are low- or moderate-income earners may become priced out of these neighborhoods. Recognizing that these planning patterns may lead to displacement or gentrification of environmental justice communities, practitioners should identify methods and resources that aim to consider and incorporate equity into resilience planning efforts.

Not all strategies listed here will be appropriate for every jurisdiction or every project, nor is this an exhaustive list of options. However, as described in Chapters 5 and 6, all local governments and all project applicants should analyze the possible effects of sea level rise and evaluate how the strategies in this chapter, or additional supplemental strategies, could be implemented in LCPs or CDPs to minimize the adverse effects of sea level rise.

General Adaptation Approaches

There are a number of options for how to address the risks and impacts associated with sea level rise. Choosing to “do nothing” or following a policy of “non-intervention” may be considered an adaptive response, but in most cases, the strategies for addressing sea level rise hazards will require proactive planning to ensure protection of coastal resources and development. Such proactive adaptation strategies generally fall into three main categories: protect, accommodate, and retreat. In practice, a variety of adaptation strategies will be used in combination across a jurisdiction and over time.

For purposes of implementing the Coastal Act, no single category or even specific strategy should be considered the “best” option as a rule. Different types of strategies will be appropriate in different locations and for different hazard management and resource and community protection goals. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time. As discussed later in the document, the legal context of various options will also need to be considered in each situation and ultimately, adaptive responses will need to be consistent with the Coastal Act. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the consideration of land use planning and regulatory options in specific communities and places along the coast.

Protect: Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to physically defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into “hard” and “soft” defensive measures or armoring. “Hard” armoring refers to engineered structures such as seawalls, revetments, and bulkheads that defend against coastal hazards like wave impacts, erosion, and flooding. Such armoring is a fairly common response to coastal hazards. A 2019 study found that about 14% of the California coast is protected by some type of armoring, and in the more populated and developed coast of southern California, 38% is protected (Griggs and Patsch 2019).

Armoring can result in serious negative impacts to coastal resources, particularly as sea level rises. Most significantly, hard structures form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise. This process is commonly referred to as “passive erosion” or “coastal squeeze,” which is the narrowing of beaches due to the fact that the back of the beach on an eroding shoreline has been fixed in place (Flick *et al*., 2012). As sea levels rise, the potential for public trust lands and their associated upland public spaces to be subject to coastal squeeze against private upland development will only increase, exacerbating existing inequalities in coastal access and tipping the scales further toward injustice, particularly for lower income residents living inland. Placement of some hard armoring structures can result in immediate coastal squeeze, which can adversely impact environmental justice, tribal, and inland communities who may rely on public recreational beaches, wetlands, and other habitats as an open space refuge from inland heatwaves and other climate-induced weather events. Furthermore, the loss of public coastal access at one location could exacerbate the use and visitor impacts at a nearby coastal access point. Other detrimental impacts may include negative visual impacts or interference with other ecosystem services.

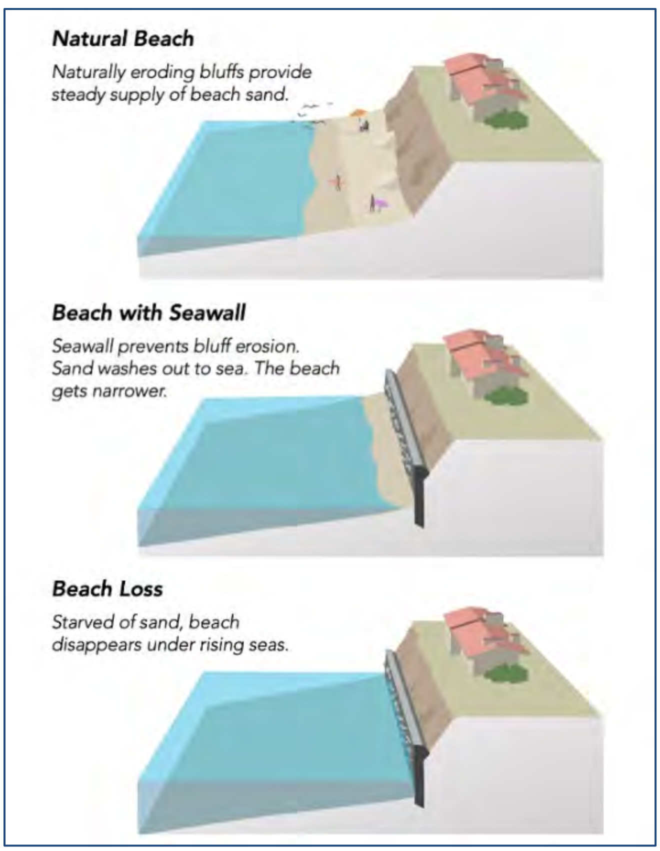

Figure 17. The effects of coastal squeeze (Graphic by Jeremy Smith).

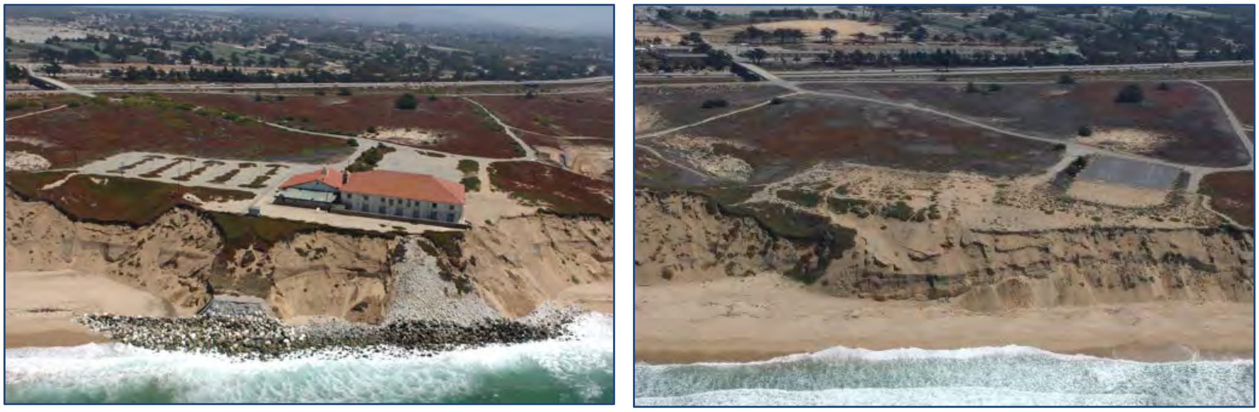

Figure 18. Photo depicting passive erosion. (*Left*) Passive erosion in front of a revetment at Fort Ord, illustrating the loss of beach where the development prevents the shoreline from migrating landward. The beach continues to migrate inland on either side of the revetment. (*Right*) Recovery of the beach following removal of the revetment and blufftop structure. (Source: California Coastal Records Project).

Protection strategies also often come with significant upfront and maintenance costs. For example, a 2019 study estimated that reinforcing and building new protective structures to protect California shorelines vulnerable to inundation by 2040 will cost approximately $22 billion in capital costs, with $2.1 billion per year in maintenance costs (adjusted to 2020 dollars) (LeRoy and Wiles 2019).

"Soft" armoring refers to nature-based adaptation strategies that are comprised of natural or mostly natural elements, and which contributes to the persistence and enhancement of coastal processes and ecological benefits while also offering protection services to inshore areas. Nature-based adaptation strategies can be subcategorized along a spectrum between: 1) soft strategies, which avoid fixing the shoreline with hard structures and instead rely on the use of dynamic systems to attenuate coastal hazards, such as dune or wetland restoration, or sand replenishment; and 2) hybrid armoring, which combines fixing the shoreline, such as with a buried revetment or other shoreline protective device, with a nature-based feature to provide ecological and other benefits. In cases in which soft strategies might not be completely effective or may not be preferred, hybrid armoring using both hard and natural infrastructure could be considered. As used here, the term, "nature-based adaptation strategy" is intended to encompass other synonymous terms, including living shorelines and green infrastructure.

Although the Coastal Act provides for shoreline protective devices in certain cases, it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline. Nature-based adaptation strategies capitalize on the natural ability of these coastal ecosystems to protect coastlines from hazards while also providing benefits such as habitat, recreation area, more pleasing visual impacts, and the continuation or enhancement of ecosystem services. These strategies include those that restore and enable natural features and ecological processes that improve climate resilience. Research has highlighted that nature-based adaptation strategies could also enhance climate adaptation through a variety of co-benefits, including increased carbon sequestration, urban cooling, and stormwater management (Buma *et al.,* 2024). However, meaningful inclusion of environmental justice communities should be considered during the design, planning, and implementation process to mitigate further community displacement and land dispossession (Kato-Huerta *et al.,* 2022; Dunlop *et al.,* 2024).

Accommodate: Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of sea level rise. On an individual project scale, these accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or using extra setbacks. On a community-scale, accommodation strategies include any of the land use designations, zoning ordinances, or other measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas even as development is protected. As with protection strategies, some accommodation strategies could result in negative impacts to coastal resources. Elevated structures may block coastal views or detract from community character; pile-supported structures may, through erosion, develop into a form of shore protection that interferes with coastal processes, blocks access, and, at the extreme, results in structures looming over or directly on top of the beach. Accommodation strategies should avoid negative impacts to coastal resources and potential disproportionate impacts on environmental justice communities, such as loss of coastal public access and loss of subsistence fishing opportunities.

Retreat: Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. Though complicated and controversial, retreat has already occurred in California in a range of cases, and has been occurring for decades (Lester *et al.,* 2021; Anderson *et al*., 2020). These strategies include land use designations and zoning ordinances that encourage building in more resilient areas or gradually removing and relocating existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures where the right to protection was waived (i.e., via permit condition) are examples of strategies designed to encourage managed retreat. Retreat strategies could raise significant issues, such as exacerbating displacement of environmental justice communities by increasing housing and rental prices, and promoting gentrification, by relocating vulnerable coastal communities and neighborhoods farther inland adjacent to or within environmental justice neighborhoods. Meaningful engagement with the community and stakeholders could facilitate a more purposeful, planned, and coordinated retreat plan away from areas of increased environmental degradation and risk exposure (Siders *et al.*, 2021).

Figure 19. Photo depicting "managed retreat" and restoration. Surfers' Point Managed Shoreline Retreat project in which the parking lot was moved back and beach area was restored. (Aerial composite by Rick Wilborne (February 28, 2013); photo courtesy of Surfrider Foundation)

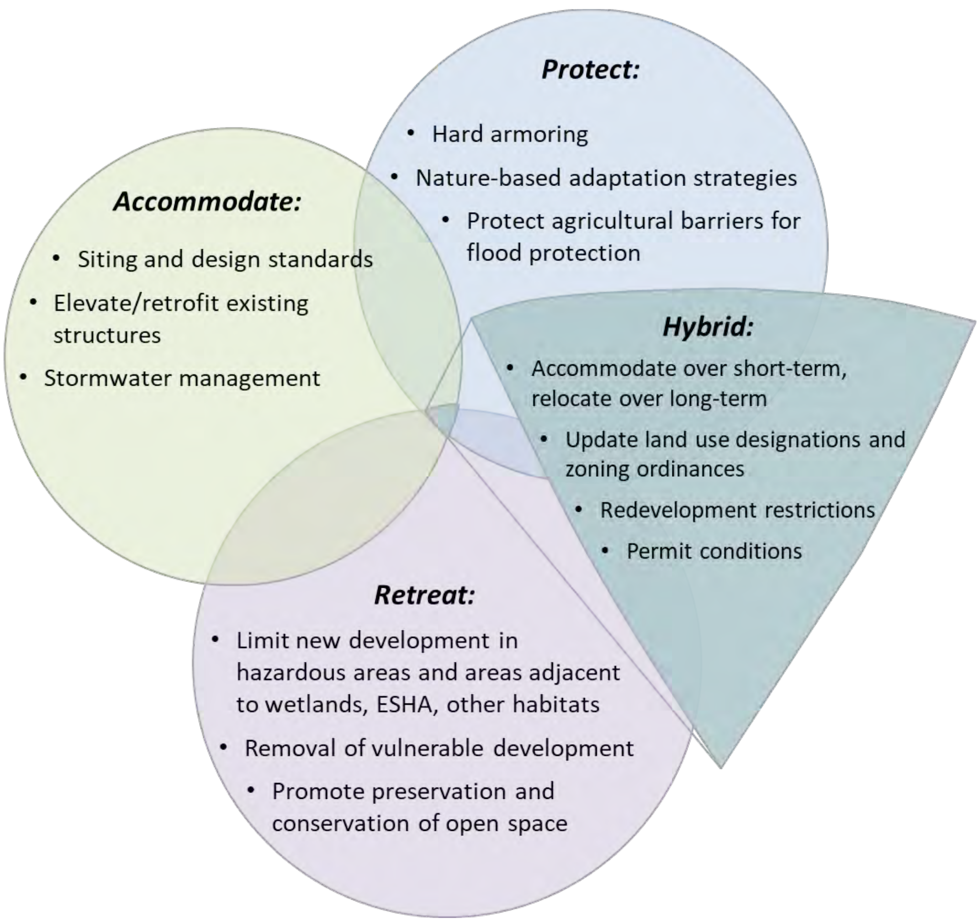

Figure 20. Examples of general adaptation strategies

***Phased adaptation and adaptation pathways*:** Phased adaptation, also called adaptation pathways, are sequences of adaptation actions that can be implemented progressively in response to the unfolding impacts of sea level rise over time (Fazey *et al*., 2015). This approach to adaptation can be especially useful for planning in future coastal hazard conditions given that there is uncertainty regarding the timing and exact magnitude of impacts. Adaptation pathways can include triggers, or thresholds of impacts, after which future phases of adaptation or adaptation planning will be implemented. Many local governments in California are developing sea level rise adaptation plans that provide adaptation pathways, phases, and triggers. Phased adaptation and adaptation pathways are also discussed in Chapter 6.

***Approaching adaptation strategies at a variety of scales*:** In addition to overall consistency with the Coastal Act, including minimizing coastal resource impacts and maximizing the safety and stability of development, adaptation measures must be developed in a way that is responsive to a number of issues affecting their feasibility, costs and benefits, community impacts, and so on. One of the issues that has become especially apparent over the last ten years of the Coastal Commission's work with local governments is the need to develop and implement a mix of adaptation strategies across a jurisdiction (and over time) to reflect the varied nature of our coastlines. In other words, a City/County will not utilize just a single or even a few adaptation strategies across its entire jurisdiction. Rather, a variety of strategies will be implemented to reflect different geological and land use considerations, and the different mix of residential, infrastructure, community, and natural resource needs. This mix of adaptation strategies will also reflect, and proactively balance, various tradeoffs and competing resource needs.

As highlighted in the California Climate Adaptation Strategy*,* the Coastal Commission's Strategic Plan, and many other state and local documents, priority should be given to options that protect, enhance, and maximize coastal resources and access, including giving full consideration to innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. There is growing interest among practitioners to implement new climate-resilient practices to address sea level rise, including through the use of nature-based adaptation strategies that can respond to, adjust to, and withstand changing conditions while minimizing disruptions to communities, including environmental justice and tribal communities, and natural resources.

Adaptation approaches will need to be designed and implemented at a scale that matches the feasible spatial scale of available adaptation strategies (e.g., utility at a parcel scale versus a shoreline scale) as well as the constraints and opportunities of the natural backshore characteristics. Put another way, stretches of the coastline with shared geological characteristics may lend themselves to different sets of adaptation options, and the overall mix of these constraints and opportunities should be considered when developing a set of adaptation approaches that together maximize coastal resource benefits throughout a jurisdiction or wider region. For example, some stretches of shoreline might have the geophysical characteristics conducive to nature-based adaptation measures, whereas others may not, and still others may lend themselves to other broad approaches such as the inland migration of coastal open spaces or to various types of protective measures. Local governments should consider how to spatially distribute these broad approaches along their shorelines to balance the protection of development with coastal resource benefits.

SPECIFIC ADAPTATION STRATEGIES

The following sections, organized by category of coastal resource, present measures that local governments and coastal planners should consider including in their LCPs or individual CDPs. The purpose of this organization is to allow coastal managers and project applicants to easily find strategies that will help address the specific resource vulnerabilities identified in Steps 2-4 of the LCP and CDP processes laid out in Chapters 5 and 6. In the development of LCP policies, local governments should use adaptation measures that best implement the statewide resource protection and hazard policies of the Coastal Act at the local level given the diverse geography and conditions of different areas.

As part of identifying adaptation strategies, local governments should carefully examine the potential impacts to coastal resources that could occur from various adaptation strategies, including impacts to environmental justice communities. Some adaptation strategies will need to be implemented incrementally over time as conditions change, and many strategies will need to be implemented through both the LCP and CDP to be effective. For each issue area, there is a description of potential impacts that could occur due to sea level rise and a list of adaptation tools or actions to minimize impacts. To skip to a topic, click on the links below.

A. Coastal Development and Hazards
B. Public Access and Recreation
C. Coastal Habitats, ESHA, and Wetlands
D. Agricultural Resources
E. Water Quality and Supply
F. Archaeological and Paleontological Resources
G. Scenic and Visual Resources

The lists in these sections should be considered neither checklists from which all options need to be used, nor exhaustive lists of all possible adaptation strategies. Sea level rise adaptation is an evolving field, and policy language, environmental justice concerns, cost considerations, effectiveness of various strategies, and other topics are continuing to be developed. Planners, applicants, and partners will need to think creatively and adaptively respond to changing conditions, new science, and new adaptation opportunities, and the Coastal Commission will continue to support and collaborate on these efforts.

Additionally, sea level rise planning may involve a number of trade-offs among various competing interests, and no single adaptation strategy will be able to accomplish all planning objectives. Economic, social, and environmental justice implications of various adaptation options will likely play into the planning process at the local level. The important point is to analyze current and future risks from sea level rise, engage with affected communities, determine local priorities and goals for protection of coastal resources and development in light of Coastal Act requirements, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals.

A. Coastal Development and Hazards

The Coastal Act requires the Coastal Commission to take into account the effects of sea level rise in its coastal resources planning and management (Coastal Act Section 30270). The Coastal Act also requires that new development be sited and designed to be safe from hazards and to not adversely impact coastal resources (Coastal Act Sections 30235 and 30253). The main goals that relate to hazards and coastal development are:

- Update land use designations, zoning maps, and ordinances to account for changing hazard zones
- Include sea level rise in hazard analyses and policies
- Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources
- Incorporate sea level rise adaptation into redevelopment policies
- Encourage the removal of development that is threatened by sea level rise
- Use nature-based adaptation strategies as a preferred alternative for protection of existing endangered structures
- Limit bluff and shoreline protective devices to protect existing endangered structures
- Require special considerations for critical infrastructure and facilities
- Protect transportation infrastructure

Chapter 3 of the Guidance covers the impacts to coastal development that might result from sea level rise. Certified LCPs should already have policies and standards to assure that coastal development is safe over its anticipated lifetime and that it does not adversely impact other coastal resources. However, LCP policies and standards may need to be updated in light of new knowledge and to consider sea level rise hazards. Adaptation options have been developed to support the development goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Update land use designations, zoning maps, and ordinances to account for changing hazard zones

A.1 Establish mapped hazard zones or overlays: Develop coastal hazard maps or overlay zones that include areas that will be subject to wave action, storm flooding, groundwater rise, and erosion due to sea level rise. Within those mapped areas, update land uses and zoning requirements to minimize risks from sea level rise. For example, limit new development in current and future sea level hazard zones, encourage removal of existing development when threatened, and/or require certain special conditions of approval of Coastal Development Permits such as assumptions of risk or design standards.

A.31a **Identify zones that require a more rigorous sea level rise hazards analysis**: Specify areas where a closer analysis of sea level rise is necessary at the permit application stage to avoid or minimize coastal hazards and impacts to coastal resources and communities. Ensure that the most up-to-date information on sea level rise is incorporated in such analyses.

A.31b **Incorporate wave runup zones and sea level rise in coastal flood hazard maps:** Develop coastal flood maps that include areas that will be subject to wave action and flooding due to sea level rise. These maps may be able to rely upon existing flood maps, such as the FEMA Flood Insurance Rate Maps, for current flood areas and base conditions, but should be augmented to include future conditions, including sea level rise, likely to occur through the life of proposed new development.

Goal: Include sea level rise in hazard analyses and policies

A.2 Update policies to require sea level rise to be included in hazard analyses and management plans: LCP policies should include requirements to analyze projected sea level rise. Consider specific sea level rise scenarios to be analyzed. (See Chapter 3 of the Guidance for a description of scenario-based planning.) LCPs could also specify which analyses are required for various types of projects/development (see Step 3 of Chapters 5 and 6 or Appendix B for suggested analyses).

A.2a **Site-specific evaluation of sea level rise**: Update policies, ordinances, and permit application requirements to include a required site-specific evaluation of coastal hazards due to sea level rise over the full anticipated lifetime of any proposed development. Analyses should be conducted by a certified Civil Engineer or Engineering Geologist with expertise in coastal processes.

A.2b **Incorporate sea level rise into calculations of the Geologic Setback Line**: Update geotechnical report requirements for establishing the Geologic Setback Line (bluff setback) to include consideration of bluff retreat due to sea level rise in addition to historic bluff retreat data, future increase in storm or El Niño events, and any known site-specific conditions. The report should be completed by a licensed Geotechnical Engineer or an Engineering Geologist.

A.2c **Include sea level rise in wave runup, storm surge, and tsunami hazard assessments**[61]: Sea level rise should be included in wave runup analyses, including storm event and tsunami hazard assessments. This should include evaluating tsunami loads/currents on maritime facilities and coastal structures. Since tsunami wave runup can be quite large, sea level rise projections of only a few inches may not have a large impact on these assessments. However, for time periods or scenarios where sea level rise projections are large (perhaps 1 ft or more), it would be appropriate to include sea level rise because it could change the results to a significant degree.

A.3 Establish shoreline management plans to address long-term shoreline change due to sea level rise: Create policies that require a management plan for priority areas that are subject to sea level rise hazards and incorporate the plan into the larger LCP if applicable. Similar to an LCP, shoreline management plans generally include the short and long term goals for the specified area, the management actions and policies necessary for reaching those goals, and any necessary monitoring to ensure effectiveness and success. Incorporate strategies necessary to manage and adapt to changes in wave, flooding, and erosion hazards due to sea level rise. Such plans may identify specific adaptation actions identified per the requirements of SB 272 and may include a recommended or required timeline for updates.

Goal: Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources

A.4 Limit new development in hazardous areas: Restrict or limit construction of new development in zones or overlay areas that have been identified or designated as hazardous areas to avoid or minimize impacts to coastal resources and property from sea level rise impacts.

A.5 Cluster development away from hazard areas: Concentrate development away from hazardous areas. Update any existing policies that cluster development to reflect additional hazard zones due to sea level rise.

A.5a **Concentration of development/smart growth**: Require development to be concentrated in areas that can accommodate it without significant adverse effects on coastal resources or surrounding communities. This strategy is applicable for community wide planning through an LCP but may also apply to

[61] Tsunami evacuation maps are based upon current sea level conditions and they will need to be updated with changes in sea level.

CDPs for subdivisions or for larger developments involving large or multiple lots. See the Commission's Smart Growth Planning & Permitting in the Coastal Zone guidance for more information on integrating smart growth strategies into LCPs and CDPs.

A.5b **Transfer of Development Rights programs (TDR)**: Restrict development in one area ("sending area") and allow for the transfer of development rights to another area more appropriate for intense use ("receiving area"). LCPs can establish policies to implement a TDR program to restrict development in areas vulnerable to sea level rise and allow for transfer of development rights to parcels with less vulnerability to hazards. A TDR program can encourage the relocation of development away from at-risk locations and may be used in combination with a buy-out program.

A.6 Develop adequate setbacks for new development: Ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced erosion) over the life of the structure, *without the use of a shoreline protective device*. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Establish general guidance and criteria for setbacks in LCPs that consider changes in retreat due to sea level rise. Require detailed, site-specific analyses through LCPs and CDPs to determine the size of the setback necessary to assure safety over the anticipated lifetime of the structure, taking into consideration sea level rise.

Figure 21. Photo depicting a development setback in Pismo Beach. (*Source:* California Coastal Records Project)

A.7 Limit subdivisions in areas vulnerable to sea level rise: Prohibit any new land divisions, including subdivisions, lot splits, lot line adjustments, and/or certificates of compliance that create new beachfront or blufftop lots unless the lots can meet specific criteria that ensure that when the lots are developed, the development will not be exposed to hazards or pose any risks to protection of coastal resources.

A.8 Update development siting, code, and design standards to avoid, minimize, or reduce risks from coastal hazards and extreme events: Establish and implement building codes and standards for building siting and construction that avoid or minimize risks from flooding and erosion and increase resilience to extreme events within sea level rise hazard zones. Such standards and applicable building code provisions should be included in LCPs as additional development controls in areas that are identified in the LCP as hazard areas, and applied in specific projects through a CDP.

A.8a **Update flood protection measures to incorporate both FEMA and Coastal Act requirements:** Require new development located in areas subject to current or future flood/wave action to be sited and designed to be capable of withstanding such impacts in compliance with both FEMA and Coastal Act requirements. For example, ensure that implementation of adaptation measures such as elevation of habitable areas, break-away walls, *etc*. will be consistent with both LCP and FEMA provisions.

A.8b **Limit basements and first floor habitable space**: Where applicable, in areas likely to be subject to current or future flood/wave action, revise residential building standards to prohibit habitable space at elevations subject to wave/flood risk. Specifically address potential impacts of basements on long-range adaptation options such as landward relocation or removal.

A.8c **Evaluate impacts from flood protection measures:** Require new development that must be located in areas likely subject to current or future flood/wave action or elevated groundwater to evaluate potential impacts to adjacent or nearby properties from all proposed structural flood protection measures to ensure that these measures will not create adverse direct and/or cumulative impacts either on-site or off-site.

A.9 Analyze options for removal when planning and designing new development: Design options should not place an undue burden on future property owners or coastal resources. For new development in high hazard areas or resource-constrained areas where managed retreat might be an appropriate option at some time in the future, ensure that foundation designs or other aspects of the development will not preclude future incremental relocation or managed retreat. Foundation and building elements, such as deepened perimeter foundations, caissons or basements, may be difficult to remove in the future, or their removal may put adjacent properties at risk. Alternative design options should be considered, and employed if site conditions allow.

A.9a **Develop a plan to remove or relocate structures that become threatened:** Require new development authorized through a CDP that is subject to wave action, erosion, or other hazards to be removed or relocated if it becomes threatened in the future.

A.9b **Identify triggers for incremental removal of structures on constrained lots**: When a lot is not large enough to accommodate development that avoids coastal hazards for the expected life of the development, develop a project option that minimizes hazards from the identified sea level rise scenarios for as long as possible, and then requires incremental retreat once certain triggers are met.

Triggers for relocation or removal of the structure would be determined by changing site conditions such as when essential services to the site (e.g., utilities, roads) can no longer feasibly be maintained due to the coastal hazards; removal is required pursuant to LCP policies for sea level rise adaptation planning; the development requires new and/or augmented shoreline protective devices that conflict with relevant LCP or Coastal Act policies; or at pre-defined physical triggers such as when erosion is within a certain distance of the foundation, when monthly high tides are within a certain distance of the finished floor elevation, when building officials prohibit occupancy, or when the wetland buffer area decreases to a certain width.

A.9c **Avoid shoreline protection for new development:** Require CDPs for new development in hazardous locations to include as a condition of approval a waiver of rights to future shoreline protection that would substantially alter natural landforms or cause other adverse coastal resource impacts.

A.9d **Limit the use of foundations or basements that can interfere with coastal processes:** In locations where foundation or building elements, such as deepened perimeter foundations, caissons or basements may be exposed to wave action through rising sea level or erosion, require analysis of less extensive foundation or building options.

A.9e **Develop triggers for foundation and structure removal:** If no less damaging foundation alternatives are possible, ensure that the foundation design allows for incremental removal as the foundation elements become exposed, and develop pre-established triggers, for example when the bluff edge or shoreline comes within a certain distance of the foundation, for incremental or complete removal that will avoid future resource impacts.

Figure 22. Photo depicting eroding bluff and exposed caissons in Encinitas, CA. (*Photograph by Lesley Ewing*)

A.10 Ensure that current and future risks are assumed by the property owner: New development should be undertaken in such a way that the consequences from development in high hazard areas will not be passed on to public or coastal resources. Recognize that over time, sea level rise will exacerbate hazards, cause the public trust boundary to move inland, and/or impact public services to the site. Establish standards, permit conditions, and deed restrictions that ensure that current and future risks are disclosed to and assumed by the property owner. Consider policies that would encourage or require property owners to set aside money, such as in the form of a bond, as a contingency if it becomes necessary to modify, relocate, or remove development that becomes threatened in the future.

A.11 Real estate disclosure: Require sellers of real estate to disclose permit conditions related to coastal hazards, or property defects or vulnerabilities, including information about known current and potential future vulnerabilities to sea level rise, to prospective buyers prior to closing escrow. Consider translating the real estate disclosure into languages other than English to increase language access.

Goal: Incorporate sea level rise adaptation into redevelopment policies

A.12 Avoid the expansion or perpetuation of existing structures in at-risk locations: On an eroding shoreline, the seaward portions of an existing structure may become threatened as the setback or buffer zone between the structure and the mean high tide line or bluff edge is reduced due to erosion of the beach or bluff. When the seaward portion of the structure no longer meets the standards or setback that would be required for new development, it becomes a “non-conforming” structure for purposes of redevelopment policies and regulations. The following should be considered, as consistent with the Coastal Act, FEMA policies, and other relevant standards, to address existing non-conforming development to avoid the need for shoreline or bluff protective devices and associated impacts to coastal resources.

A.12a **Update non-conforming structure policies and definitions**: Develop policies and regulations to define non-conforming development in the area between the sea and the first coastal roadway or other known hazard zones to avoid perpetuating development that may become at risk and require a new protective device or extend the need for an existing protective device.

A.12b **Limit redevelopment or upgrades to existing structures in at risk locations**: Use redevelopment policies or regulations to limit expansions, additions, or substantial renovations of existing structures in danger from erosion. Require removal of non-conforming portions of the existing structure, when possible, when a remodel or renovation is proposed.

A.12c **Limit foundation work within the geologic setback area:** To facilitate removal of non-conforming portions of an existing structure, use LCP regulations and CDPs to limit new or replacement foundations or substantial improvements, other than repair and maintenance, to the existing foundation when located seaward of the Geologic Setback line. Approve significant new foundation work only when it is located inland of the setback line for new development and when it will not interfere with coastal processes in the future.

A.12d **Limit increases to existing non-conformities:** Use LCP regulations and CDPs to allow non-exempt repair and maintenance and modifications only if they do not increase the size or degree of non-conformity of the existing structure. For shoreline or blufftop development, any decrease in the existing non-conforming setback would increase the degree of non-conformity.

A.12e **Limit additions to non-conforming structures:** Use LCP regulations and CDPs to acknowledge that additions to existing structures should be considered new development that must conform to the standards for new development including but not limited to avoiding future protective devices. Consider limitations on the size of additions unless non-conforming portions of the structure are removed.

A.12f **Address existing protection of non-conforming structures:** Use LCP regulations and CDP conditions to put current and future property owners on notice that if there is currently shoreline or bluff protection for an existing structure, the structure is likely at-risk and improvements to that structure in its current location may be limited. Also, consider acknowledging that any rights to retain the existing protective device(s) apply only to the structure that existed at the time the protective device was constructed or permitted.

A.13 Redevelopment of existing structures: Define "redevelopment" as, at a minimum, replacement of 50% or more of an existing structure. Other options that may be used to define what constitutes redevelopment or a replacement structure could include 1) limits on the extent of replacement of major structural components such as the foundation or exterior walls, or 2) improvements costing more than 50% of the assessed or appraised value of the existing structure. The redevelopment definition should take into consideration existing conditions and pattern of development, potential impacts to coastal resources, and the need for bluff or shoreline protective devices if the structure remains in its current, non-conforming location.

A.13a **Require redevelopment to meet the standards for new development:** Use LCPs and CDPs to require that renovations meeting the threshold for redevelopment should not be approved unless the entire structure meets the standards for new development, including but not limited to a waiver of right to protection. Specify that if any existing non-conforming elements are permitted to remain, those non-conforming elements are not subject to rights to protection pursuant to Coastal Act Section 30235.

A.13b **Include cumulative improvement or additions to existing structures in the definition of redevelopment:** Use LCP regulations to acknowledge that demolition, renovation, or replacement of less than 50% (or less) of an existing structure constitutes redevelopment when the proposed improvements would result cumulatively in replacement of more than 50% of the existing structure from an established date, such as the effective date of the Coastal Act, January 1, 1977.

A.14 Remove existing shoreline protective devices: On properties with existing shoreline protective devices, use regulations to require removal of the protective device when the structure requiring protection is redeveloped or removed. If removal is not possible, require a waiver of any rights to retain the protective device to protect any structure other than the one that existed at the time the protective device was constructed or permitted.

Goal: Encourage the removal of development that is threatened by sea level rise

A.15 Use Rolling Easements: The term "rolling easement" refers to the policy or policies intended to allow coastal lands and habitats including beaches and wetlands to migrate landward over time as the mean high tide line and public trust boundary moves inland with sea level rise. Such policies often restrict the use of shoreline protective structures (such as the "no future seawall" limitation sometimes used by the Commission), limit new development, and encourage the removal of structures that are seaward (or become seaward over time) of a designated boundary. This boundary may be designated based on such variables as the mean high tide line, dune vegetation line, or other dynamic line or legal requirement. Despite the term "rolling easements," not all of the strategies related to rolling easements actually involve the use of recorded easements. The use of rolling easements (or ambulatory easements) can counteract the issues associated with coastal squeeze with the potential loss of coastal public access. Thus, rolling easements can positively impact inland, environmental justice, and tribal communities who seek to gain access to coastal public trust lands.

A.16 **Develop an incentive program to relocate existing development at risk**: Provide incentives to relocate development out of hazardous areas and to acquire oceanfront properties damaged by storms, where relocation is not feasible. Consider creating a relocation fund through increased development fees, *in lieu* fees, or other funding mechanisms.

A.17 **Transfer of Development Rights programs (TDR)**: See Strategy A.5b above.

A.18 **Acquisition and buyout programs**: Acquisition includes the acquiring of land from the individual landowner(s). Structures are typically demolished or relocated, the property is restored, and future development on the land is restricted. Such a program is often used in combination with a TDR program that can provide incentives for relocation. Undeveloped lands are conserved as open space or public parks. LCPs can include policies to encourage the local government to establish an acquisition plan or buyout program to acquire property at risk from flooding or other hazards. However, buyout programs may raise significant social and environmental justice issues, such as exacerbating displacement in low-income, communities of color. Consult the Commission's Environmental Justice Policy for more information on how to engage with community members regarding TDR and buyout programs.

Goal: Use nature-based adaptation strategies as a preferred alternative for protection of existing endangered structures

A.19 **Require the use of nature-based measures as a preferred alternative**: Under appropriate shoreline conditions, require or encourage development to use nature-based adaptation strategies as an alternative to the placement of hard shoreline protection in order to protect development or other resources and to enhance natural resource areas. Examples of nature-based solutions include vegetative planting, dune restoration, and sand nourishment.

A.19a **Establish a beach nourishment program and protocols**: New policies may be needed to address increased demand or need for beach nourishment with sea level rise. Policies within an LCP may identify locations where nourishment may be appropriate; establish a beach nourishment program and protocols for conducting beach nourishment; establish criteria for the design, construction, and management of the nourishment area; and/or establish measures to minimize adverse biological resource impacts from deposition of material, such as sand compatibility specifications, timing or seasonal restrictions, and identification of environmentally preferred locations for deposits. Beach nourishment programs should also consider how nourishment options may need to change over time as sea level rises.

A.19b **Dune management**: Establish management actions to maintain and restore dunes and natural dune processes. Dunes provide buffers against erosion and flooding by trapping windblown sand, storing excess beach sand, and protecting inland areas, and they also provide habitat. This is likely most effective for areas with some existing dune habitat and where there is sufficient space to expand a foredune beach for sand exchange between the more active (beach) and stable (dune) parts of the ecosystem. LCPs can identify existing dune systems and develop or encourage management plans to enhance and restore these areas, including consideration of ways that the system will change with rising sea level. CDPs for dune management plans may need to include periodic reviews so the permitted plans can be updated to address increased erosion from sea level rise, and the need for increased sand retention and replenishment.

Figure 23. Photo depicting dune restoration at Surfer's Point, Ventura. (*Photograph courtesy of Surfrider Foundation*)

A.19c **Regional Sediment Management (RSM) programs**: Develop a Regional Sediment Management (RSM) program including strategies designed to allow the use of natural processes to solve engineering problems. To be most effective, RSM programs include the entire watershed, account for effects of human activities on sediment, protect and enhance coastal ecosystems, and maintain safe access to beaches for recreational purposes. LCPs can support development of an RSM program and its implementation, and the program should be periodically updated to address on-going changes from sea level rise. Natural boundaries for RSM may overlap within several LCPs, so regional cooperation may be needed for best implementation. Individual actions such as a beach nourishment project would be accomplished through a CDP. Many coastal RSM programs have already been developed and can be used as a resource. See the *Coastal Sediment Management Workgroup* website for more information.

A.19d **Maintenance or restoration of natural sand supply**: Adjustment of the sediment supply has been one of the ways natural systems have accommodated changes from sea level. Maintenance or restoration of sediment involves identifying natural sediment supplies and removing and/or modifying existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply. Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise and may identify and designate high priority areas for restoring natural processes. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

A.19e **Beneficial reuse of sediment through dredging management**: Dredging involves the removal of sediment from harbor areas to facilitate boat and ship traffic or from wetland areas for restoration. Dredging management actions and plans may need to be updated to account for elevated water levels. Policies can be developed with an LCP and/or carried out through a CDP to facilitate delivery of clean sediment extracted from dredging to nearby beaches or wetland areas where needed. Beneficial reuse of sediment in this way can be coordinated through a Regional Sediment Management (RSM) program, through a Sand Compatibility and Opportunistic Use Program (SCOUP), and/or through coordination with other jurisdictions.

Goal: Allow bluff and shoreline protective devices only to protect existing endangered structures

A.20 Use hard protection only if allowable and if no feasible less damaging alternative exists: "Hard" coastal protection is a broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. In some cases, caissons and pilings may also be considered hard shoreline protective devices. Due to adverse effects on shoreline sand supply and beach area available for public use, as well as visual and other impacts, such protective devices should be avoided when feasible. Under current law, shoreline protection is allowed when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion if coastal resource impacts are avoided or minimized and fully mitigated where unavoidable.

A.20a **Retention of existing shoreline protection**: On intensely developed, urbanized shorelines, if the removal of armoring would put existing development at risk and not otherwise result in significant protection or enhancement of coastal resources, it may be appropriate to allow properly designed shoreline armoring to remain for the foreseeable future, subject to conditions that provide for potential future removal in coordination with surrounding development. However, the proper short term responses, longer term adaptation measures, and mitigation of ongoing resource impacts should be determined through updated context-specific LCP planning and consideration of the existing rights and responsibilities of development in the area (see strategies A.21 – A.25).

A.21 Require monitoring of the structure: Require periodic monitoring of the shoreline protective device to examine for structural damage, excessive scour, or other impacts from coastal hazards and sea level rise. Ensure that the structures remain within the initial footprint and that they retain functional stability.

A.22 Conditional approval of shoreline protective device: Use LCP regulations and permit conditions to require monitoring of impacts to shoreline processes and beach width both at the project site and the broader area and/or littoral cell as feasible and provide for such actions as removal or modification of armoring in the future if it is no longer needed for protection or if site conditions change.

A.22a **Limit the authorization of shoreline protective devices to the development being protected:** Use LCP regulations and CDP conditions to require permits for bluff and shoreline protective devices to expire when the currently existing structure requiring protection is redeveloped, is no longer present, or no longer requires a protective device, whichever occurs first. Prior to expiration of the permit, the property owner should apply for a CDP to remove the protective device, or to modify or retain it if removal is not feasible at that time.

A.22b **Require assessment of impacts from existing pre-Coastal Act or permitted shoreline armoring:** Use LCP regulations and permit conditions to specify that expansion and/or alteration of a pre-Coastal Act or legally permitted bluff or shoreline protective device requires a new CDP and the review should include an assessment of changes to geologic site and beach conditions including but not limited to, changes in beach width relative to sea level rise, implementation of any long-term, large scale sand replenishment or shoreline restoration programs, and any ongoing impacts to public access and recreation from the existing device.

A.22c **Reassess impacts and need for existing armoring over time:** Use LCP regulations and CDPs to provide for reassessment of the impacts from protective devices at specific trigger points, including when substantial improvement or redevelopment of the structure requiring protection is proposed, or when existing armoring is being modified or expanded. Reassessment should consider the effect any significant improvement to a structure requiring protection will have on the length of time the protective device will remain, and if the existing armoring is still required, acknowledge that it is authorized to protect the existing structure only. The CDP review should assess existing site conditions and evaluate options to modify, replace, or remove the existing device in a manner that would eliminate or mitigate any identified impacts that may be occurring on public access and recreation, scenic views, sand supply, and other coastal resources, if feasible.

A.23 Require mitigation for impacts of shoreline protective devices: For unavoidable public resource impacts from shoreline structures permitted under the Coastal Act, require mitigation of resource impacts over the life of the structure as a condition of approval for the development permit. For example, require landowners to pay mitigation fees and/or complete other mitigation actions for the loss of sandy beach and other adverse impacts on public access and recreation due to shoreline protection devices. Importantly, mitigation measures should be planned in such a way that sea level rise will not impair their efficacy over time. Other mitigation measures could include acquisition of other shoreline property for public recreational purposes, construction of public access and recreational improvements along the shoreline, and/or easements to protect lateral access along the shoreline in areas where seawalls eliminate sandy beach.

A.23a **Reassess mitigation over time as necessary:** Impacts of shoreline structures, including to shoreline and sand supply, public access and recreation, ecosystem values, and other relevant coastal resources, should be fully mitigated. Where reassessment of an approved structure is authorized, phasing of necessary mitigation may be appropriate.

A.24 Limit retention of existing shore protection: On lots with existing pre-Coastal Act or permitted armoring, consider requiring a waiver of rights to retain such protection for any structures other than the structure that existed at the time the armoring was constructed or permitted.

A.25 Removal of shoreline protection structures: The removal of shoreline protection structures can open beach or wetland areas to natural processes and provide for natural responses to sea level rise. LCPs can specify priority areas where shoreline protection structures should be removed if they are no longer needed or in a state of great disrepair, including areas where structures threaten the survival of wetlands and other habitats, beaches, trails, and other recreational areas. Once these priority areas have been identified, assessment of potential re-siting of structures and removal of armoring could be required by a CDP as redevelopment occurs.

Figure 24. Photo depicting removal of shoreline protective structure. Removal of rock revetment restores access and allows natural bluff erosion at the Ritz Carlton in Half Moon Bay. (*Source:* California Coastal Records Project)

A.25a **Remove shoreline protective structures located on public lands:** Over time, sea level rise will cause the public trust boundary to move inland. If the structures as originally approved were located on uplands but that land becomes 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. The Commission or local governments could approve permit conditions to ensure permittees obtain authorization to retain or remove structures if they ever become located on public trust lands. Removal might also be accomplished through non-regulatory means such as offering incentives for removal to property owners or by incorporating removal of public structures into Capital Improvement Plans.

Goal: Require special considerations for critical infrastructure and facilities

A.26 Plan ahead to preserve function of critical facilities: Addressing sea level rise impacts to critical facilities and infrastructure will likely be more complex than for other resources and may require greater amounts of planning time, impacts analyses, public input, and funding. To address these complexities, establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Programs and measures within an LCP could include identification of critical infrastructure that is vulnerable to SLR hazards, development of phased adaptation approaches that reflect cost and feasibility factors, establishment of a plan for managed relocation of at-risk facilities, and/or other measures to ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms. Repair and maintenance, elevation or spot-repair of key components, or fortification of structures where consistent with the Coastal Act may be implemented through CDPs. Ensure that throughout their lifespan, these facilities will not increase impacts on environmental justice communities (e.g., air pollution, water quality, utility rates, public health issues, coastal access limitations).

A.26a **Develop or update a long-term public works plan for critical facilities to address sea level rise**: Develop a long-term management plan to address the complexities of planning for sea level rise that incorporates any potential maintenance, relocation, or retrofits and structural changes to critical facilities to accommodate changes in sea level and obtain Coastal Commission certification. Prioritize the cleanup or relocation of existing hazardous facilities and avoid siting new hazardous facilities in flood-prone areas and/or near or adjacent to environmental justice communities.

A.27 Apply high sea level rise scenarios for siting and design of critical facilities: Given the planning complexities, high costs, and potential impacts resulting from damage, there is reason to be particularly cautious when planning and designing new critical facilities and/or retrofitting existing facilities. Ensure that critical facilities are designed to function even if the high-end amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts. Sea level rise poses a significant risk to these facilities and can create new health hazards or exacerbate existing hazards stemming from these facilities. Identify environmental justice concerns relating to sea level rise impacts to critical infrastructure since these communities are often situated closer to these facilities, and the potential risks stemming from the impacts can increase burdens on these neighborhoods.

A.27a **Design coastal-dependent infrastructure to accommodate worst case scenario sea level rise**: Include policies that would require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation. Incorporate measures during design and construction of development in historically contaminated industrial sites to address soil and water contamination such that any future development will be protective of coastal resources and human health.

A.28 Site and design wastewater disposal systems to avoid risks from sea level rise: Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Flooding and groundwater rise may also impair the functionality of a wastewater treatment facility and lead to sewage contamination of water supplies and soil. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas and near environmental justice communities if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and use pump stations and force mains to transport wastewater from lower, potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts. Consider potential disproportionate impacts to environmental justice communities in the event of system failure.

Goal: Ensure safety and long-term functionality of transportation infrastructure

A.29 **Identify priorities for adaptation planning and response:** Carry out vulnerability analyses to identify chronic problem areas that are highly subject to erosion, wave impacts, flooding, or other coastal hazards or that maybe become so in the near future. Coordinate with Caltrans and local public works/transportation agencies to address high priority areas and increase monitoring efforts of chronic problem areas.

A.30 **Add policies to address impacts to transportation routes**: If transportation facilities are at risk from sea level rise, coordinate with Caltrans and local public works/transportation agencies to establish new alternative transportation routes or a plan to ensure continued alternative transportation and parking is available that allows for continued access to beaches and other recreation areas. Encourage multimodal, affordable transportation, including public transit, vehicles, pedestrians, and bicycles through and around a community to support a diversity of transportation options.

A.30a **Integrate LCP/land use planning processes with transportation planning processes:** Updates and changes to LCPs and other land use planning efforts should be jointly planned, evaluated, and implemented with Coordinated System Management Plans, Regional Transportation Plans, and other transportation planning efforts to ensure that long-term land use and access goals and needs are aligned.

A.31 **Allow for phased implementation of realignment and relocation projects:** In some cases it may be necessary to make incremental changes in transportation networks so that access to and along the coast can be maintained while also addressing coastal hazards over the long-term. For example, a phased approach may allow for interim shoreline protection to maintain an existing road alignment while future realignment plans are evaluated and pursued. Such phased approaches should be coordinated with Caltrans and local public works/transportation agencies and aligned with long-term LCP planning and adaptation goals. Individual projects will be implemented through CDPs.

A.31a **Consider adverse impacts of realignment and relocation projects to environmental justice communities:** Realignment and relocation of transportation routes may have disproportionate burdens on environmental justice communities. For example, when a specific transportation segment is closed due to flooding or erosion, redirecting traffic to an alternate route or relocating a vulnerable highway segment farther inland without assessing the communities who live nearby or use the current and alternate routes may result in a pollution or displacement burden to these inland communities. Relocating important transportation routes can also affect environmental justice communities during emergency evacuations and response efforts, often making it more difficult for these communities to access these services. Ensure that any relocation projects include robust community engagement before and throughout the planning process.

Figure 25. Photo depicting planned retreat for major public infrastructure. The Piedras Blancas Highway 1 Realignment will move nearly 3 miles (5km) of Highway 1 500 ft (152 m) inland. (Source: California Coastal Records Project)

A.32 Plan and design transportation systems to accommodate anticipated sea level rise impacts: Ensure that transportation networks are designed to function even if the highest projected sea level rise amounts occur. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, environmental justice communities, tribal communities, and LCP planning efforts, and individual projects will be implemented through CDPs or possibly Public Works Plans.

A.32a **Retrofit existing transportation infrastructure as necessary:** In instances where relocation is not an option, repair damage and/or retrofit existing structures to better withstand sea level rise impacts. For example, use stronger materials, elevate bridges or sections of roadways, and build larger or additional drainage systems to address flooding concerns.

A.32b **Build redundancy into the system:** Provide alternate routes, as possible, to allow for access to and along the coast in instances in which sections of roadways may become temporarily impassible as a result of coastal hazards. Ensure that alternate route information is provided to residents and visitors to coastal areas. Consider translating the communication materials and signage about the alternative route information into languages other than English to increase language access.

A.33 Incorporate sea level rise considerations into Port Master Plans and other port activities: Ensure that ports and related infrastructure are designed to function given anticipated sea level rise. In some cases, this may mean initially designing structures to accommodate projected sea level rise impacts. Other options may include planning for and ensuring capacity for future adaptive actions.

A.33a **Retrofit existing port infrastructure as necessary**: Given the coastal-dependent nature of many port structures, it may not be feasible to site or relocate development to avoid hazards. In these instances it may be more appropriate to include efforts to accommodate and withstand sea level rise during actions to repair or retrofit existing structures. Options may include using more robust designs or materials or elevating structures.

A.33b **Minimize resource impacts that may result from future use of shoreline protective structures**: If existing, coastal-dependent port structures require shoreline protective structures, minimize resource impacts as feasible and consistent with Chapter 3 and/or Chapter 8 of the Coastal Act, as applicable, by encouraging inland expansion of protective devices rather than further fill of coastal waters.

A.33c **Ensure that linkages to overland transportation networks are able to adapt to sea level rise impacts**: Coordinate with relevant stakeholders to ensure that linkages between port infrastructure and overland transportation networks will be resilient to future sea level rise impacts.

A.33d **Ensure that lessees and other parties understand sea level rise risks and vulnerabilities**: Coordinate with lessees and other stakeholders to ensure that they understand the risks associated with development in hazard areas as well as the responsibilities that come with such development.

B. Public Access and Recreation

One of the highest priorities in the Coastal Act is the mandate to maximize public access and recreational opportunities to and along the coast. The main goals and Coastal Act policies (Sections 30210, 30220, 30221, 30213) that relate to public access and recreation are to:

- Maximize public access and recreational use by protecting beaches and other coastal areas suitable for such use
- Protect lower cost visitor and recreational facilities and accessways

Chapter 3 of the Guidance covers the impacts to public access and recreation that might result from sea level rise or the interaction of sea level rise with development patterns. Chapter 4 of the Guidance explains the importance of protecting coastal public access resources, including for environmental justice communities. Certified LCPs should already have policies and standards to assure that existing public access and visitor serving amenities are protected and that maximum public access is both planned for and provided with new development when warranted. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the access goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Maximize public access and recreational use by protecting beaches and other coastal areas

B.1 **Incorporate sea level rise into a comprehensive beach management strategy**: Update or develop a new comprehensive beach management strategy to address loss of beach areas, including loss of lateral access, or changes in beach management due to sea level rise. Establish a program to minimize loss of beach area through, as may be appropriate, a beach nourishment program; restoring sand and sediment supply to the littoral cell; removal, adjustments, or maintenance to shoreline protection structures; use of man-made structures such as terminal groins or artificial reefs to retain sediment; or other actions. Include any adaptation actions identified as required by SB 272 and identify a relevant timeline for updates. Maximize public access with special attention to environmental justice communities within the LCP jurisdiction, as well as visitors from environmental justice communities outside the jurisdiction. Ensure amenities at coastal access sites are equitably accessible to all visitors (e.g., translated signage and wayfinding, ADA accessible, public restrooms, picnic areas, trails, playgrounds, etc.).

B.1a **Develop a sediment management and sand replenishment strategy**: Identify natural sediment supplies and remove and/or modify existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply. Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

B.2 Plan ahead to replace loss of access and recreation areas: Identify replacement opportunities or otherwise plan ahead for how to replace recreation areas and accessways that will be lost due to inundation or damage associated with sea level rise. An LCP could designate and zone lands for this through, for example, a phased overlay or other regulatory measures that ensure that access and recreational areas are available in the future. Local governments may choose to provide additional incentives to encourage creation of new recreation areas or opportunities. Such incentives could include grants for protecting new recreation areas or tax breaks for recreation related businesses.

B.2a **Protect existing open space adjacent to the coast**: Plan for future coastal recreational space and parkland by protecting open space adjacent to coastal habitats so that beaches and other habitats can migrate or so that there is open space available as parkland or other areas are lost.

B.2b **Plan for removal of structures that limit inland migration of beaches**: Seawalls and other development adjacent to beaches and other coastal habitats will impede the ability of these habitats to migrate inland and will therefore result in the inundation and eventual loss of these areas. Consideration should be given to removing and relocating these structures to ensure that beaches and other habitats are able to persist over time. Additional detail on removal of structures can be found above in the “Coastal Development and Hazards” section of this chapter.

Goal: Protect lower cost visitor and recreational facilities and accessways

B.3 Site and design access sites and facilities to minimize impacts: Add policies that require public access sites, segments of the California Coastal Trail, and recreation and visitor-serving facilities to be sited and designed to avoid impacts from sea level rise, while maximizing public access and recreation opportunities. Examples of siting and design standards for development can be found in section A. Where facilities can be safely sited for the near term but future impacts are likely, require an adaptive management plan detailing steps for maintenance, retrofitting, and/or relocation. Ensure access points are located within reasonable proximity to environmental justice communities and that they are accessible via multiple modes of transportation (e.g., public transit, bikes); require "Complete Streets" planning in transportation projects.[62]

B.3a **Require mitigation of any unavoidable impacts**: For unavoidable impacts to public access or recreation from shoreline armoring or other development, require mitigation of impacts through the addition of new public access, recreation opportunities, visitor-serving accommodations, or Coastal Trail segments, or payment of fees to fund such improvements. Importantly, mitigation measures should be planned in such a way that, if possible, sea level rise will not impair their efficacy over time.

B.4 Plan ahead to replace loss of visitor-serving and recreational facilities: Develop a plan to replace any visitor-serving facilities that are lost due to impacts from sea level rise, maximizing continued provision of affordable options and an appropriate mix of accommodations over time. For example, an LCP could include standards to re-site existing visitor-serving and recreational facilities when they become impacted by sea level rise and/or could identify and zone for future areas to be reserved for these functions.

B.4a. **Consider and prioritize environmental justice and tribal communities in planning for visitor-serving and recreational facilities:** This planning is especially important in the context of environmental justice and equity because the limited supply of low-cost visitor-serving facilities and accommodations exacerbates coastal access inequalities and disproportionately hinders the ability of individuals from low-income and environmental justice communities to recreate or stay overnight on the coast. Reserve areas for and encourage free or lower-cost visitor-serving uses (e.g., picnic grounds or gathering areas, beach equipment rental, concessions, natural and scenic resource viewing, visitor centers, visitor tours). Protect and provide free public access to piers and other areas for subsistence fishing. Require no-net-loss of lower-cost accommodations, such as the conversion of low-cost to high-cost facilities; in the case of unavoidable loss, require mitigation through construction of off-site facilities, in-lieu fees, and/or other community benefits (see Chapter 6 for more information on Community Benefits Agreements). Provide a range of accommodation types that will accommodate a range of income levels; ensure such overnight accommodation prioritizes low-cost alternatives. Prioritize, protect, and preserve facilities or services that are culturally significant to tribal communities.

B.5 Add requirements for retrofit/relocation of public access and recreation sites at risk: The LCP can add policies that require all new public access and recreation areas, sections of the California Coastal Trail, visitor- serving accommodations, or related

[62] Complete Streets is an approach to planning, designing, building, operating, and maintaining streets that enables safe access for all people who need to use them, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.

recreation facilities to be retrofitted or relocated if they become threatened from erosion, flooding, or inundation. For new facilities and public access sites, the CDP conditions of approval can specify how maintenance, retrofit, or relocation will take place. Policies and plans should be designed to be adaptive so that retrofits and or/relocations are implemented as sea level rise impacts occur.

B.5a **Retrofit or relocate recreation and visitor-serving facilities**: Consider options to retrofit existing recreation and visitor-serving facilities to better accommodate sea level rise impacts. Such retrofits could include use of different building materials and/or relocating facilities.

B.5b **Retrofit or relocate vertical accessways**: Consider options to retrofit existing accessways to reduce impacts from sea level rise. Such retrofits could include using different materials that can better withstand impacts or re-orienting the layout or other features of accessways to lessen damage and other impacts. Also begin to plan for and identify triggers and options for relocating accessways over time as conditions change.

B.5c **Retrofit or relocate sections of the Coastal Trail**: Use boardwalks, bridges, and/or other design features to ensure continuity of the California Coastal Trail in sections that are vulnerable to SLR hazards. Some sections may need to be relocated over time. An LCP could identify vulnerable sections of the California Coastal Trail and establish a phased approach to relocate sections of the trail in such a way that is consistent with provisions of the Coastal Act and ensures continued lateral connectivity and that the California Coastal Trail remains within sight, sound, or smell of the sea.

Goal: Foster efforts to better understand impacts of sea level rise

B.6 Support research on impacts to recreation and public access: Changes in sea level will affect wave conditions and sediment transport, but additional research is needed to understand how these changes will affect specific conditions for subsistence fishing, surfing, and other recreation activities. While such research programs may be outside the scope of individual local jurisdictions, statements of support for the local issues that need to be addressed can help guide research agendas at the regional state or federal level. Or, such needs can serve to guide grant applications to undertake the needed projects within a jurisdiction. To the extent possible, add policies to promote research on sea level rise impacts to recreational activities like subsistence fishing, surfing, or other coastal recreational uses in the LCP jurisdiction.

C. Coastal Habitats, ESHA, and Wetlands

The Coastal Act provides for the protection of both land and marine habitats. It mandates that ESHA and marine resources shall be protected against significant disruption of habitat value and shall be maintained, enhanced, and restored as feasible (Sections 30230, 30233, 30240, 30240(a), 30240(b)). The Coastal Act also requires the Commission to account for sea level rise in its coastal resource planning and management and to avoid and mitigate the adverse effects of such sea level rise (Section 30270). The main goals and Coastal Act policies that relate to coastal habitats are to:

- Protect, enhance, and restore sensitive habitats
- Avoid significant disruption to sensitive habitats
- Avoid significant impacts to habitats from adjacent development
- Manage sediment in ways that benefit habitats
- Protect these habitats over time, accounting for sea level rise

Chapter 3 of the Guidance covers the impacts to coastal habitats and resources that might result from sea level rise or the interaction of sea level rise with development patterns. Certified LCPs should already have policies and standards to ensure that ESHA, wetlands, and other coastal habitats and resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the habitat protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect, enhance, and restore sensitive habitats

C.1 **Open space preservation and conservation**: Preserve land for its ecological or recreational value. This may involve limiting or prohibiting development and any uses that conflict with ecological preservation goals. LCPs can establish transfer of development rights programs to offset reduced development potential and can develop open space management plans that evaluate and consider the impacts of sea level rise, extreme events, and other climate change impacts. LCPs can establish open space and conservation areas through land use designations and zoning, redevelopment restrictions, acquisition and easement programs, and setback and buffer requirements.

C.1a **Update policies to provide for new or restored coastal habitat**: Update policies to require new coastal habitat to be provided or for degraded areas to be restored to account for the expected loss of existing habitat that will occur when development blocks the necessary upland migration due to sea level rise. Use an adaptive management approach where applicable. Encourage policies that provide for conservation or restoration of multiple habitat types. Prioritize projects providing equitable co-benefits from habitat protection, such as clean water and ecosystem services, for environmental justice communities.

C.1b **Identify areas for public acquisition**: New or updated LCPs can establish a program to partner with state, federal, and non-profit organizations to acquire and protect natural resource areas for public use, including areas that could serve as refugia for species impacted by sea level rise, or areas that could be appropriate sites for coastal habitat creation or restoration.

C.1c **Establish conservation easements or other development restrictions to protect habitat**: Establish a formalized program to identify, acquire, and manage areas appropriate for some form of conservation protection. Easements or other strategies may be used to limit or restrict development on portions of a lot parcel that are most vulnerable to SLR impacts. The program might develop standard agreements to be used for easements and identify the entities that could hold the easements. A conservation easement program could be established on a community wide basis through an LCP and implemented on a parcel by parcel basis through individual CDPs.

C.1d **Require open space protection as a component of new development located adjacent to coastal habitats**: The LCP can require permit conditions for new development in certain areas that buffers around natural resource areas be protected through a conservation easement, deed restrictions, or other comparable mechanism.

C.1e **Use Rolling Easements**: See Strategy A.15 above.

C.1f **Transfer of Development Rights programs (TDR)**: See Strategy A.5b above.

Goal: Avoid significant disruption to habitats

C.2 Use ecological buffer zones and/or increase the size of buffers: Buffer zones are intended to protect sensitive habitats from the adverse impacts of development and human disturbance. An important aspect of buffers is that they are distinct ecologically from the habitat they are designed to protect. LCPs can establish requirements for ecological buffers and provide guidance on how to establish or adjust these buffers to accommodate sea level rise. CDPs should require buffers to be designed, where applicable, to provide "habitat migration corridors" that allow sensitive habitats and species to migrate inland or upland as sea level rises.

C.2a **Consider sea level rise buffer zones**: Update buffer zone policies to allow room for coastal habitats to migrate with changes in sea level. The size of the buffer needed to allow for migration will vary depending on the individual wetland or habitat type, as well as site-specific features such as natural or artificial topography and existing development. For instance, in flat areas, a larger buffer may be needed, but in steep areas, a smaller buffer may be acceptable.

C.3 Avoid impacts to Marine Protected Areas: Recognize the importance of the State's network of marine protected areas (MPAs) in protecting the diversity and abundance of marine life. Understand that planning and permitting decisions made on land could have impacts on these areas, particularly as conditions change with sea level rise, and avoid disruptions to these habitats as feasible and applicable.

C.4 Protect specific ESHA functions: Environmentally Sensitive Habitat Areas (ESHA) are areas that are critically important for the survival of species or valuable for maintaining biodiversity. These areas can include nursery grounds, spawning areas, or highly diverse areas. Where at risk from sea level rise, the LCP should establish measures to ensure the continued viability of the habitat areas, such as protection of migration zones, habitat corridors, and other applicable adaptation strategies, as listed below. ESHA that is not at risk from sea level rise should also be afforded special protection in the LCP to serve as refugia.

C.4a **Protect wildlife corridors, habitat linkages, and land upland of wetlands to allow habitat migration**: Preserve open areas that are adjacent to wetlands to allow for migration of these habitats as sea levels rise.

C.4b **Protect refugia areas**: Protect refugia, or areas that may be relatively unaltered by global climate change and thus can serve as a refuge for coastal species displaced from their native habitat due to sea level rise or other climate change impacts.

C.4c **Promote increased habitat connectivity to allow species movement**: Connectivity refers to the degree to which the landscape facilitates animal movement and other ecological flows. Roads, highways, median barriers, fences, walls, culverts, and other structures can inhibit movement of animals. Develop LCP policies that will enable identification of important animal movement corridors. Develop regulations to protect these corridors for present and future conditions, taking into account habitat shifts from climate change. In LCPs and through CDPs, require that new structures such as highways, medians, bridges, culverts, and other development are designed to facilitate movement of animals.

C.4d **Facilitate wetland and other habitat migration**: Reserve space for a "habitat migration corridor" or areas into which wetlands and other habitats could migrate as sea level rise induced inundation of existing wetland areas occurs. In the LCP, identify potential habitat migration corridors. These areas could be reserved for this purpose in an LCP through land acquisition, use designations, zoning buffers, setbacks, conservation easement requirements, and clustering development. LCPs should also consider developing a plan for acquisition of important habitat migration corridors.

Goal: Avoid significant impacts to habitats from adjacent development

C.5 Limit new development in areas adjacent to wetlands, ESHA, and other coastal habitats: Restrict the construction of new development in areas that are adjacent to wetlands, ESHA, and other coastal habitats in order to preserve buffers and open areas to allow for habitat migration.

C.5a **Cluster development away from coastal habitats**: Existing LCPs will likely have policies that already require clustering of development. To address sea level rise, these policies might need to be updated to include clustering development away from land where wetlands and other coastal habitats could migrate with sea level rise.

C.5b **Limit subdivisions**: Update subdivision requirements to require provision for inland migration of natural resource areas or to require lots to be configured in a way that allows such migration. Lot line adjustments may sometimes be appropriate if they facilitate locating physical development further away from hazards or sensitive resources.

Figure 26. Photo depicting the preservation and conservation of open space along an urban-rural boundary. North end of Pismo Beach from 1972 (*left*) to 2002 (r*ight*). (*Source:* California Coastal Records Project)

Goal: Manage sediment in ways that benefit habitats

C.6 Identify opportunities for Regional Sediment Management: Sediment supplies will be important for the long-term sustainability of many beaches and wetland areas. Strategies to maintain or restore natural sediment supplies and to coordinate sediment removal efforts with opportunities for reuse can provide multiple benefits to coastal ecosystems. See Strategy A.19c above for more detail on RSM programs.

C.6a **Restore natural sediment sources to wetlands**: Restoration of natural hydrodynamic systems will help to ensure the ability of wetlands to persist with sea level rise by ensuring that sediment is available for wetland accretion. Such actions may include restoring natural channels in streams and waterways that have been armored or channelized. Organizing and coordinating such efforts may be accomplished through a Regional Sediment Management Plan.

C.6b **Identify opportunities for beneficial reuse of sediment to support wetland restoration**: Consider facilitating the delivery of clean, dredged sediment to areas where former wetlands have subsided or to areas where existing wetlands are or may become sediment-limited as sea levels rise.

Goal: Incorporate sea level rise into habitat management actions

C.7 **Include sea level rise in site-specific evaluations**: Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise where appropriate. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion).

C.8 **Incorporate sea level rise in restoration, creation, or enhancement of coastal habitats**: Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion). Habitat restoration, creation, or enhancement projects should be designed to withstand impacts of sea level rise and adapt to future conditions. As applicable, the LCP should contain policies to ensure restoration and management techniques account for future changes in conditions. CDPs for restoration projects should incorporate sea level rise and provisions to ensure habitats can adapt with changing future conditions.

C.9 **Update habitat management plans to address sea level rise**: Add policies stating that the effects of sea level rise should be addressed in management plans for coastal habitats. For example, plans should evaluate the full range of sea level rise impacts to coastal habitats and provide a strategy for managing coastal habitats given changing sea level rise conditions. Existing management plans may need to be updated to add new monitoring and restoration requirements to address sea level rise. The strategies listed below are examples of strategies that could be included in habitat management plans.

C.9a **Use an adaptive management approach in ecosystem management, restoration, or design**: Habitat management plans and/or other habitat projects should establish an adaptive management approach, with clearly defined triggers for adaptive actions. Such an approach would allow for and ensure that coastal habitats are able to migrate and transition with changes in sea level.

Figure 27. Photo depicting habitat protection at Salinas River State Beach. Dunes are roped off to protect Snowy Plover nesting habitat. (*Source:* California Coastal Records Project)

C.10 Pursue strategies to protect ecosystem function under a range of future sea level rise or climate change scenarios: The LCP and/or habitat management plans can recommend coastal habitat management strategies that strive to protect ecosystem function in the future. Strategies include protecting a wide range of ecosystem types, protecting refugia, protecting wildlife and habitat corridors, and establishing methods to monitor ecosystem change over time.

C.10a **Update monitoring requirements for coastal habitats**: As part of the LCP and/or habitat management plans, consider establishing a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time. Such a protocol would also help identify triggers at which additional adaptation options are necessary.

D. Agricultural Resources

Agriculture is a priority use within the Coastal Act, which mandates that the maximum amount of prime agricultural land shall be protected and maintained (Sections 30231, 30241, 30242). The main goals and Coastal Act policies that relate to agriculture are to:

- Protect the maximum amount of prime agricultural land
- Limit conversion of lands suitable for agriculture to non-agricultural uses
- Minimize impacts to water quality that could result from agricultural practices
- Promote water conservation efforts

Chapter 3 of the Guidance describes the impacts to agricultural resources that may result from sea level rise. Certified LCPs should already have policies and standards to ensure that agricultural resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to address sea level rise hazards. Adaptation options have been developed to support the agricultural protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect the maximum amount of prime agricultural land

D.1 Identify and designate areas suitable for agricultural production to replace agricultural production areas that could be lost to sea level rise: Identify any non-sensitive open or developed areas, both within and outside of the Coastal Zone, which could potentially be used to replace agricultural land that is lost to sea level rise. Update LCP designations and/or policies to protect these identified areas for agricultural production and, as applicable, to provide for their conversion to agricultural use. Encourage and support regional coordination as feasible and applicable.

D.1a **Establish SLR-specific agricultural protection program:** Establish a formal program to identify, acquire, incentivize, and manage areas appropriate for new/renewed agricultural use and/or for protection of current and/or future agricultural uses. Such program should target key areas and properties where agricultural conversion threats are highest and should dovetail with existing agricultural protection programs. Easements and other legal restrictions may be used as part of such program to help limit or restrict development in areas where agricultural land and production are most vulnerable to sea level rise impacts. The program might develop standard language and/or legal documents that can be used for easements or other property restrictions. The program should be flexible enough to be able to be implemented on both a large scale (e.g., though LCP policies and programs) as well as on a smaller scale (e.g., through the CDP process).

D.1b **Prioritize and center environmental justice communities when planning for agricultural land protection:** Agricultural lands and farms are important areas that provide wages and housing for low-income and communities of color. Management of existing and future agricultural areas should account for any disruptions to farmworkers and avoid displacement of these communities. Conduct targeted engagement and consultation with affected farmworkers in a manner that accounts for barriers such as work hours, language access and internet connection.

D.2 **Protection, maintenance, and adaptation of dikes and levees**: Repairing and maintaining existing flood barriers such as dikes and levees may be a cost-effective way to continue to protect agricultural areas. While some repair and maintenance activities are exempt from the need for a CDP, the repair and maintenance exemption does not apply to repair and maintenance work that is located within an ESHA, within any sand area, within 50 feet of the edge of a coastal bluff or ESHA, or within 20 feet of coastal waters. LCPs could identify opportunities for these kinds of actions and ensure that they are appropriately permitted, with consideration to the environmental protection and restoration goals of the Coastal Act. While landowners have the right to repair and maintain existing legal levees in their current configurations, the Commission and local governments administering LCPs have the authority to regulate, via the CDP process, the proposed methods of repair and maintenance. To raise, reconfigure, enlarge, or widen levees is not repair and maintenance and requires a Coastal Development Permit. Such activities may not be consistent with the Coastal Act or certified LCP, such as in cases involving wetland fill impacts. However, where there are opportunities to restore marine resources and the biological productivity of wetlands and estuaries, it may be possible to permit a dike/levee reconstruction project that provides for substantial restoration.

Goal: Limit conversion of lands suitable for agriculture to non-agricultural uses

D.3 **Limit conversion of agricultural land to other developed land uses**: Develop policies to assure maximum environmentally feasible protection of rural agricultural land, open space, and other coastal resources, including areas that may be considered non-prime agricultural land at this time. Anticipate areas that could become more difficult to farm and identify strategies to avoid or mitigate the potential impacts.

Goal: Minimize impacts to water quality that could result from agricultural practices

D.4 **Include sea level rise in water quality protection policies**: Where needed, coordinate with regional water quality control boards to add policies to reduce water pollution from runoff should agricultural lands become flooded or inundated due to sea level rise.

D.4a **Minimize water quality impacts from flooding of agricultural lands**: Agricultural practices that are designed to minimize water quality impacts, such as those designed to minimize runoff, may need to be updated or enhanced to ensure water quality protection if sea level rise results in more frequent flooding of agricultural lands.

D.4b **Add policies to address saltwater intrusion**: Add policies to protect water supply for priority coastal agriculture, including policies to address saltwater intrusion, such as limits on groundwater withdrawal or diversification of water supplies. Strategies to pump freshwater and/or highly treated wastewater into aquifers to reduce saltwater intrusion should be minimized in areas with limited freshwater resources.

Goal: Promote water conservation efforts

D.5 **Maximize water conservation to protect priority agricultural water supplies**: Saltwater intrusion and other climate change impacts may result in reduced water availability. LCP policies should be updated to establish or enhance standards related to water conservation and/or to identify opportunities for water recycling, dual plumbing systems, and the like. For more information on options such as relocating wells and reducing pumping in sensitive aquifers, see the following section on Water Quality and Water Control Management.

D.6 **Identify alternate water sources for agriculture**: Establish a program to identify alternate water sources for agriculture.

E. Water Quality and Supply

The main water quality protection policy of the Coastal Act requires minimizing the adverse effects of wastewater discharges, runoff, and groundwater depletion in order to protect the biological productivity and quality of coastal waters, as described in Section 30231. The main goals related to water quality include:

- Control runoff and stormwater pollution
- Minimize adverse effects of wastewater discharges and entrainment
- Prevent depletion of groundwater supplies from saltwater intrusion
- Improve long-term water quality through research

Chapter 3 of the Guidance covers the impacts to coastal waters from increased runoff, wastewater discharge and saltwater intrusion into groundwater sources from sea level rise. Adaptation options have been developed to limit the amount of pollutants that enter coastal waters through runoff or discharges.

Goal: Control runoff and stormwater pollution

E.1 **Update water quality Best Management Practices (BMPs)**: Evaluate and update BMPs to account for changes in water quality and supply issues due to sea level rise, as applicable. Updates could include practices to provide greater infiltration/inflow of rainwater, increased stormwater capture and/or water recycling programs, the use of low impact development, improved maintenance procedures for public sewer mains, policies to address impaired private sewer laterals, and other proactive measures.

E.2 **Include sea level rise in stormwater management plans and actions**: Control the amount of pollutants, sediments, and nutrients entering water bodies through precipitation-generated runoff. LCPs should include sea level rise and extreme storms in stormwater management plans and actions. CDPs for stormwater infrastructure should consider sea level rise.

E.2a **Increase capacity of stormwater infrastructure**: Actions to reduce impacts from higher water levels could include widening drainage ditches, improving carrying and storage capacity of tidally-influenced streams, installing larger pipes and culverts, adding pumps, converting culverts to bridges, creating retention and detention basins, and developing contingency plans for extreme events. Encouraging and supporting these types of efforts upstream may also be important.

E.2b **Use green stormwater infrastructure to the maximum extent feasible**: Employ natural, on-site drainage strategies to minimize the amount of stormwater that flows into pipes or conveyance systems. These strategies include low impact development, green roofs, permeable pavements, bioretention (e.g., vegetated swales, rain gardens) and cisterns. LCPs can include policies that require green infrastructure be used whenever possible *in lieu* of hard structures. Incorporate sea level rise and extreme storms into the design, where available space, soils hydrology, and other site conditions allow.

E.2c **Retrofit existing development with inadequate stormwater infrastructure**: Identify and prioritize development in low-lying or other at-risk areas with inadequate stormwater infrastructure and take steps to retrofit these systems to better accommodate sea level rise driven changes. Retrofits should incorporate the green infrastructure options detailed in strategy E.2b above as applicable.

Goal: Minimize adverse effects of wastewater and stormwater discharges

E.3 Add policies to address water quality risks from wastewater treatment plants, septic systems, and ocean outfalls: Consider establishing a program to retrofit, relocate, or eliminate ocean outfalls and other wastewater infrastructure deemed at risk. Alternatives include modifications to outfall lines, the use of green infrastructure, and redesign of waste or combined waste and stormwater systems.

E.3a **Update siting and design policies**: Add policies to ensure that new ocean outfalls, wastewater treatment facilities, and other facilities that could negatively impact water quality if flooded or inundated, are sited and designed to minimize impacts from sea level rise. Avoid construction of new stormwater outfalls. Direct stormwater to existing facilities with appropriate treatment and filtration where feasible. Where new outfalls cannot be avoided, plan, site, and design stormwater outfalls to minimize adverse impacts on coastal resources, including consolidation of existing and new outfalls where appropriate. Consolidate new and existing outfalls where appropriate.

E.3b **Retrofit, relocate, or eliminate outfalls and other wastewater components deemed "at risk"**: An ocean outfall is a pipeline or tunnel that discharges municipal or industrial wastewater, stormwater, combined sewer overflows, cooling water, or brine effluents from desalination plants to the sea. LCPs should identify areas where sea level rise could affect flow of wastewater from outfalls and lead to backup and inland flooding, and plans should be made to retrofit, relocate, or eliminate these outfalls to prevent damage and impacts to water quality. Similarly, LCPs should identify vulnerabilities to other components of wastewater treatment facilities and plan for necessary changes to these. Additionally, CDPs for new ocean outfalls, treatment plants, and components of treatment plants should consider sea level rise in the design.

E.3c **Reduce or find alternatives for septic systems in hazardous areas**: Flooding, inundation, and changing groundwater dynamics may result in impacts to septic systems, which rely on leach fields for dispersal of wastewater, that could cause water quality impairments. Options to reduce the potential for these impacts by redesigning or eliminating septic systems in hazardous areas should be identified. New development that will rely on septic systems should be limited in hazardous areas.

Goal: Prevent depletion of groundwater supplies from saltwater intrusion

E.4 Groundwater Management: Plan and coordinate monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of fostering long-term sustainability of the resource. The LCP can add policies that specify limits or establish other standards for the use of groundwater and sensitive aquifers. These policies should be made in accordance with other regional water planning efforts, such as Integrated Regional Water Plans as well as relevant state water policies. CDPs involving the use of groundwater should address groundwater management issues.

E.4a **Add policies to address saltwater intrusion into aquifers**: Consider adding policies that establish a long-term strategy for addressing saltwater intrusion in aquifers, including limiting development that would use sensitive aquifers as applicable. For some areas of the state, additional information is needed on the site-specific impacts of sea level rise on aquifers. For these areas, the LCP could identify the local information needs and promote the establishment of a research program to increase understanding of the vulnerability of coastal aquifers.

E.4b **Limit groundwater extraction from shallow aquifers**: Groundwater extraction from shallow aquifers can increase susceptibility to saltwater intrusion. Regulating development to limit or prevent extraction and avoid overdraft from vulnerable aquifers can reduce the impacts of saltwater intrusion and preserve fresh groundwater supplies. LCPs or CDPs can add restrictions to the use of aquifers susceptible to saltwater intrusion and can encourage measures to recharge shallow aquifers that are depleted.

E.4c **Relocate wells and water intake facilities**: Identify opportunities to relocate wells and water intake facilities away from hazards and/or areas where saltwater intrusion may be a problem.

E.4d **Restrict development of new wells in sensitive areas**: Require new water wells to be sited away from areas where saltwater intrusion could occur.

E.4e **Limit development that relies on vulnerable water supplies**: Limit or restrict new development in areas that are dependent on water supplies that are or will become susceptible to saltwater intrusion.

E.4f **Ensure adequate long term water supplies:** When siting and designing new development, ensure that adequate and sustainable water sources are available for the lifetime of the development and suitable for the intended use of the development, considering potential impacts of sea level rise and saltwater intrusion upon groundwater supplies.

E.4g **Limit development in areas subject to hazards from rising groundwater:** Limit or restrict new development in areas where rising or emergent groundwater threatens development, including subsurface utilities and other critical infrastructure.

Goal: Improve long-term water quality through research

E.5 Identify research and monitoring needs to more precisely understand local issues: Research programs may be established to analyze the particular local challenges related to water quality and supply as a result of sea level rise. Opportunities for innovative solutions, such as restoring wetlands, oyster reefs, or other nature-based adaptation strategies, to these challenges should be identified.

E.5a **Clearly define areas at risk**: The LCP should include an updated inventory of potential pollutant sources due to sea level rise, including toxic waste sites, ocean outfalls and wastewater treatment facilities at risk of inundation, as well as aquifers and wells at risk of saltwater intrusion. Policies may also be added to prioritize low-lying contaminated sites for remediation and restoration, especially those that are sited near or adjacent to environmental justice communities.

E.5b **Prioritize safe water quality and supply for environmental justice communities:** Sea level rise poses a significant risk to toxic waste sites and wastewater treatment facilities and can create new health hazards or exacerbate existing hazards stemming from these facilities. Account for environmental justice communities who are often situated closer to these facilities and may experience a greater burden if these systems were to become impaired. Require best available technology in industrial development to minimize environmental impacts and to protect nearby communities and resources. Analyze and address costs of sea level rise adaptation for these facilities on environmental justice communities, including displacement and exposure to environmental hazards and contaminants. Ensure that any new costs or rate payer increases do not disproportionately burden low-income ratepayers.

F. Archaeological, Tribal Cultural, and Paleontological Resources

The Coastal Act provides for the protection of archaeological and paleontological resources, stating in Section 30244 that:

> "Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required."

Chapter 3 of the Guidance discusses the impacts to archaeological and paleontological resources that might result from sea level rise. Certified LCPs should already have policies and standards to ensure that these resources are protected to the maximum extent feasible; however, such policies and standards may need to be updated to consider sea level rise hazards. The following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect archaeological and paleontological resources

F.1 Add policies to protect archeological, tribal cultural, and paleontological resources from sea level rise: Add policies to require site-specific evaluation of potential sea level rise impacts to archeological, tribal cultural, and paleontological resources on a development site. The LCP can also add requirements that a monitoring program and plan be established as a condition of approval for development located on a site with artifacts vulnerable to sea level rise. Adaptation or protection strategies used may depend on the significance of the resources in question.

F.1a **Consult with relevant tribes for guidance:** If tribal cultural resources are at risk, the appropriate entity (including but not limited to the relevant Native American tribe(s)) should be contacted to develop a coordinated management plan for artifacts. See, for example, the California Natural Resources Agency Final Tribal Consultation Policy for additional guidance.

F.1b **Coordinate with the State Historic Preservation Officer (SHPO):** In line with the provisions of the Coastal Act, work with the State Historic Preservation Officer to identify actions to protect archaeological, tribal cultural, and paleontological resources.

G. Scenic and Visual Resources

The scenic value of the coast is a resource of public importance. As noted in Section 30251 of the Coastal Act, development shall be sited and designed to:

> "Protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural landforms…and to restore and enhance visual quality in visually degraded areas."

As stated in Chapter 3 of the Guidance, some options to address rising sea levels, such as elevating structures or utilizing seawalls or bluff retention devices, have the potential to alter or degrade the visual character of an area. Certified LCPs should already have policies and standards to ensure scenic and visual resources are protected to the maximum extent feasible, but these may need to be updated to consider sea level rise hazards. Coastal regions with scenic overlays or designated scenic corridors, or those areas designated as scenic in the California Coastal Preservation and Recreation Plan in particular should pay close attention to actions that could be used to minimize risks to development. The following adaptation options address some of the methods for protecting the scenic qualities of the coast.

Goal: Protect views to and along the ocean and scenic coastal areas

G.1 **Establish design standards to protect visual resources**: Update and/or add design standards to ensure that adaptation measures protect visual resources while minimizing hazards. Adaptation strategies such as shoreline armoring or elevation techniques should be designed such that the visuals are subordinate to, and in character with, the surrounding visual resources of an area.

G.1a **Establish standards for the use of caissons or other means of elevating structures:** Ensure that the use of caissons or other elevation techniques do not result in negative visual impacts. Develop policies regarding where elevation of structures may be allowable and establish standards guiding the use of these techniques. Ensure that the appearance of caissons will not detract from the scenic character of an area if or when they become visible as a result of erosion or other processes.

G.1b **Maintain height limitations in scenic areas**: Avoid modifications to height limits in scenic areas and provide for options to modify roof-lines or elevate the lowest flood elevation for flood protection in a manner that is consistent with scenic character. In some cases it may be appropriate to update height limitations to allow for elevation in response to sea level rise hazards. However, such decisions will require trade-offs and will need to strike a balance in terms of adapting to sea level rise and protecting visual resources and community character in line with the requirements of the Coastal Act.

G.1c **Develop or redevelop property to be safe from hazards without impairing scenic resources**: Emphasize the use of adaptation strategies that will not impact visual resources. Such strategies may include short-term retrofits with plans for longer term relocation or removal.

G.1d **Establish new scenic communities**: Designate areas with significant visual resources that could be negatively impacted by adaptation responses (e.g., due to seawalls or "spider" homes) as scenic communities with special protections. Establish standards in LCPs to specifically protect visual resources in these areas.

Figure 28. Photo depicting protection of visual resources and public access. A seawall visually blends in with the natural bluff while surfing access is also provided at Pleasure Point, Santa Cruz (2013). (*Source:* California Coastal Records Project)

Chapter 8. Legal Context of Adaptation Planning

Land use law is dynamic and must be interpreted and applied based on case-specific factors at the time of decision. Nonetheless, sea level rise and adaptation planning raise a number of important legal issues that coastal managers should consider as they develop and apply adaptation strategies.

This section includes discussion of the legal contexts for addressing:

- Seawalls and other shoreline protective devices
- The public trust boundary
- Potential private property takings issues

Seawalls and Other Shoreline Protective Devices

Section 30235 of the Coastal Act provides that seawalls and other forms of construction that alter natural shoreline processes "shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply." Despite other Coastal Act provisions that could often serve as the basis for denial of shoreline protective devices (for example, new development requiring shoreline protection can also conflict with Coastal Act policies requiring protection of public access and recreation, coastal waters and marine resources, natural landforms, and visual resources), the Coastal Commission has interpreted Section 30235 as a more specific overriding policy that requires the approval of Coastal Development Permits (CDPs) for construction intended to protect coastal-dependent uses[63] or existing structures if the other requirements of Section 30235 are also satisfied.[64] The Commission thus will generally permit a shoreline protective device if (1) there is an existing structure, public beach, or coastal-dependent use that is (2) in danger from erosion; and (3) the shoreline protection is both required to address the danger (the least environmentally-damaging, feasible alternative) and (4) designed to eliminate or mitigate impacts on sand supply.

In contrast to Section 30235, Coastal Act Section 30253 requires that "new development… assure stability and structural integrity, and neither create nor contribute significantly to erosion… or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs." The Commission has long applied this policy to implement appropriate bluff-top and shoreline setbacks for new development. Such setbacks are based on an assessment of projected erosion and related hazards at the site for the life of the proposed development and help ensure that

[63] Coastal-dependent uses are those that require a site on, or adjacent to, the sea to be able to function at all. (Public Resources Code, § 30101.)

[64] Some commenters argue that because shoreline armoring often conflicts with Coastal Act policies other than Section 30235, the Commission should evaluate proposed armoring under the conflict resolution provisions of the Act. (See Public Resources Code, § 30007.5, 30200(b).) Because the conflict resolution provisions require the Commission to resolve the conflict in a manner which on balance is the most protective of significant coastal resources, this approach could result in the more frequent denial of shoreline armoring, especially when it is intended to protect residential development or other uses that the Coastal Act does not identify as priority uses.

seawalls and other protective devices that could lead to adverse impacts would not be necessary in the future.

Additionally, from its earliest days, the Commission has also required that landowners "assume the risks" of developing along shoreline and coastal bluffs where risks of coastal hazards are present. Since at least the late 1990s, the Commission has approved many new developments with required deed restrictions that specifically prohibit any future construction of shoreline protection for these developments. These deed restrictions require that property owners waive any rights that may exist for a shoreline structure under Section 30235 and thus internalize the risks of building in an inherently hazardous location. This, in turn, will protect shoreline areas with natural resources or other access, recreational, or scenic value, including as required by Section 30253. If and when the approved development is threatened by erosion and becomes uninhabitable, these deed restrictions prevent the construction of a shoreline protective device and require property owners to remove the development, as well as clean up any debris that may result from erosion undermining the development.[65]

Read together, the most reasonable and straight-forward interpretation of Coastal Act Sections 30235 and 30253 is that they evince a broad legislative intent to allow shoreline protection for development that was in existence when the Coastal Act was passed, but avoid such protective structures for new development now subject to the Act. In this way, the Coastal Act's broad purpose to protect natural shoreline resources and public access and recreation would be implemented to the maximum extent when new, yet-to-be-entitled development was being considered, while shoreline development that was already entitled in 1976 would be "grandfathered" and allowed to protect itself from shoreline hazards if it otherwise met Coastal Act tests even if this resulted in adverse resource impacts. Such grandfathering of existing conditions is common when new land use and resource protection policies are put in place, and the existing development becomes "non-conforming."

Even still, in the case of Coastal Act Section 30235, existing development is only entitled to shoreline protection if it is in fact in danger, and the proposed shoreline protection is the least environmentally-damaging alternative to abate such danger. It may be that in certain circumstances existing development can be modified or feasibly relocated, or that other non-structural alternatives such as reducing blufftop irrigation or pursuing beach replenishment, may effectively address the risk to the development without the need for a shoreline protective device.

In practice, implementing Sections 30235 and 30253 has been challenging because many urban areas are made up of both developed and undeveloped lots. In addition, many developments in existence in 1976 have since been "redeveloped" through renovations, remodeling, additions, and complete demolition and rebuild. The reality of effective shoreline management is that the

[65] This legal instrument is not an easement but it does provide for "planned retreat" into the future as a site erodes. Once a development is removed, a site may have potential for new development if it is once again set back and restricted against future shoreline protection device construction.

Coastal Act and LCPs must address and be applied to a wide variety of physical and legal circumstances that may not be addressed by a simple application of the clean Coastal Act distinction between existing development that may be entitled to shoreline protection and new development that is not. In some urban areas, for example, one may find intermingled shoreline developments that pre-date the Coastal Act, both with and without shoreline protection, post-Coastal Act developments approved by the Coastal Commission or local governments pursuant to an LCP that theoretically won't need shoreline protection (though some may have it), and developments that may have pre-dated the Coastal Act but that were redeveloped pursuant to a coastal development permit. Moreover, some of the post-Coastal Act developments may have conditions that prohibit shoreline protection while adjacent properties may be eligible for or have a protective device because they pre-date the Act.

For purposes of implementing this Guidance, it is important that local governments, property owners, development applicants, and others take full advantage of available legal tools to mitigate hazards and protect resources, but to do so in way that considers the specific legal context and circumstances of LCP updates and individual development decisions in context and on a case-by-case basis. For example, although the Coastal Act does not explicitly define what qualifies as an "existing structure" for the purposes of Section 30235, how this term is interpreted in specific cases and through LCPs may be critical to the success of an adaptation strategy over the long-run.

The Commission has relatively infrequently evaluated whether structures built after 1976 should be treated as "existing" and thus entitled to shoreline protection pursuant to Section 30235. When it has, the shoreline protection being proposed to protect the structure has often also been identified as necessary to protect adjacent pre-Coastal Act structures.[66] In a few instances, however, the Commission has treated structures built after 1976 as existing structures entitled to shoreline protection even if no adjacent pre-Coastal Act structure also needed protection. Nonetheless, going forward, the Commission recommends the rebuttable presumption that structures built after 1976 pursuant to a coastal development permit are not "existing" as that term was originally intended relative to applications for shoreline protective devices, and that the details of any prior coastal development approvals should be fully understood before concluding that a development is entitled to shoreline protection under Section 30235.

As mentioned, in order to find new development consistent with Section 30253 or related LCP requirements and to limit the potential proliferation of armoring to protect newly approved structures, the Commission has long used setbacks, assumption of risk conditions and, over the last couple of decades, generally required that applicants proposing new development in hazardous shoreline locations waive any rights under Section 30235 (or related LCP policies) to

[66] For example, CDP A-3-CAP-99-023-A1, *Swan and Green Valley Corporation Seawall*. In this situation, repairs to maintain a seawall fronting the pre-coastal Swan Residence could only be undertaken by encroachment onto the adjacent property, Green Valley Corporation; however, the Green Valley Corporation development had been approved with a condition to prohibit any future shore protection.

build shoreline protection for the proposed new development. Notably, no appellate decision addresses whether the term “existing structures” in this context includes only structures built prior to the Coastal Act or instead includes structures in existence at the time the Commission acts on an application for shoreline protection, or otherwise addresses the interplay between 30235 and 30253.

LCP updates are an opportunity to clarify how the distinction between existing and new development will be applied in specific areas, and some LCPs have already done so. For example, local governments have sometimes specified a date by which a structure must have been constructed in order to qualify as an “existing structure” for the purpose of evaluating whether it may be eligible for shoreline protection. In Morro Bay, the Local Coastal Program policy that implements Section 30235 states that new shoreline protective devices “shall only be allowed where required to serve a coastal-dependent use or to protect existing structures (i.e., structures legally constructed prior to January 1, 1977, that have not been redeveloped since then) ….” Similarly, the City of Long Beach’s Local Coastal Program (SEASP) states: “‘existing structure’ means a principal structure (e.g., residential dwelling or accessory dwelling unit) that was legally permitted and in existence prior to the effective date of the Coastal Act (January 1, 1977) and that has not subsequently undergone redevelopment.” In Marin County, the Local Coastal Program policy that implements Section 30235 specifies that existing structures are those that existed on the date the LCP was originally adopted (May 13, 1982). LCPs can also codify the prohibition on shoreline protective devices for new development, such as the following provision from the San Luis Obispo County North Coast Area Plan standard:

> ***Seawall Prohibition****. Shoreline and bluff protection structures shall not be permitted to protect new development. All permits for development on blufftop or shoreline lots that do not have a legally established shoreline protection structure shall be conditioned to require that prior to issuance of any grading or construction permits, the property owner record a deed restriction against the property that ensures that no shoreline protection structure shall be proposed or constructed to protect the development, and which expressly waives any future right to construct such devices that may exist pursuant to Public Resources Code Section 30235 and the San Luis Obispo County certified LCP.*[67]

The distinction between existing and new development inherent in the Coastal Act is often directly raised by proposals for redevelopment as well. This Guidance thus deals directly with potential approaches for managing shoreline hazards and protecting coastal resources as shorelines are redeveloped (see Chapter 7, Strategy A.13). As an example, in 2012, the Commission approved a Land Use Plan for the City of Solana Beach that includes many policies designed to address the existing residential development pattern along the high, eroding bluffs of the City. Although further elaboration is yet to come through the City’s work on the Implementation Plan, the Solana Beach LUP is a good example of an effort to pragmatically address the need to mitigate the risks to residential development, provide for some redevelopment potential while moving the line of new development inland, avoid and minimize new bluff protection and seawalls, and perhaps remove protective devices in the future to

[67] Community-wide standard 15C.

minimize impacts to natural landforms and to protect the beach for long-term public use. In the case of the Morro Bay LCP (updated in 2021), policies prohibit both new development and redevelopment in areas other than along the Embarcadero waterfront from using or requiring shoreline protective devices at any point during the development's life, unless it is required to serve a coastal-dependent use. Further, as a condition of approval for any such development or redevelopment, any existing shoreline protective devices shall be removed and the underlying area restored.

Local governments and other shoreline managers should also take into account that although a public agency may not deny a CDP for a shoreline protective device that meets all of the tests under Section 30235 and equivalent LCP policies, this does not limit the authority of public agencies to refuse to allow construction of shoreline protective devices pursuant to some authority other than the Coastal Act. For example, if a private property owner requests permission from a public agency to build a structure on that agency's property (such as a local or State park or public beach) to protect adjacent private property, the public agency would generally have the authority as the landowner not to agree to the encroachment. Similarly, agencies that are trustees of public trust lands (such as the State Lands Commission and Port Districts) have the authority to prohibit structures that are not consistent with public trust uses and prioritized public trust needs, values, and principles. Public trust uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration, but do not typically include non-water dependent uses such as residential or general commercial and office uses. Thus, trustee agencies have the authority to refuse to allow, or to require removal of, shoreline armoring located on public trust lands, including if that armoring unreasonably interferes with public trust uses.

Approval of a CDP for shoreline armoring under Section 30235 may be unavoidable in certain circumstances. Nonetheless, the construction of shoreline armoring will often cause impacts inconsistent with other Coastal Act requirements, including Section 30235's requirement that a shoreline protective device be the least-environmentally damaging, feasible alternative for addressing shoreline hazards. For example, as discussed above, Section 30253(b) prohibits *new development* from in any way requiring the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. Shoreline protective devices can also adversely affect a wide range of other coastal resources and uses that the Coastal Act protects. They often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelands, by reducing shoreline sand supply, and by fixing the back of the beach, ultimately leading to the loss of the beach. Shoreline protection structures thus raise serious concerns regarding consistency with the public access and recreation policies of the Coastal Act. Such structures can fill coastal waters or tidelands and harm marine resources and biological productivity in conflict with Sections 30230, 30231, and 30233. They often degrade the scenic qualities of coastal areas and alter natural landforms in conflict with Section 30251. Finally, by halting shoreline erosion, they can prevent the inland migration of intertidal habitat, salt marshes, beaches, and other low-lying habitats that rising sea levels will inundate.

Even when an agency approves a CDP for shoreline armoring, the agency has the authority to impose conditions to mitigate impacts on shoreline sand supply and to minimize adverse impacts on other coastal resources. (See *Ocean Harbor House Homeowners Assn. v. California Coastal Comm.* (2008) 163 Cal.App.4th 215, 242; Public Resources Code, §30607.)[68] Any approved shoreline structure, therefore, must avoid or mitigate impacts that are inconsistent with Coastal Act policies.

Because of the wide range of adverse effects that shoreline protective devices typically have on coastal resources, this Guidance recommends avoidance of hard shoreline armoring whenever possible. This can entail denying development in hazardous locations, allowing only development that is easily removable as the shoreline erodes, or requiring new development to be set back far enough from wave runup zones or eroding bluff edges so that the development will not need shoreline armoring during its anticipated lifetime. The Commission's practice when reviewing proposed development in shoreline locations that are potentially vulnerable to shoreline erosion, wave runup, or inundation has been to require applicants to waive rights to shoreline protective devices in the future, and, more recently, to require relocation and/or removal should such development become endangered in the future. See Chapter 7: Adaptation Strategies for further details regarding alternatives to the use of hard armoring structures.

PUBLIC TRUST BOUNDARY

The State of California acquired sovereign ownership most tidelands and submerged lands and beds of navigable waterways upon its admission to the United States in 1850. The State holds and manages these lands for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine ("public trust"). The public trust ensures that title to sovereign land is held by the State in trust for the people of the State. Public trust uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, visitor-serving facilities and environmental preservation and restoration. Non-water dependent uses such as residential and general office or commercial uses are generally inconsistent with public trust protections and do not qualify as public trust uses.

In coastal areas, the landward location and extent of the State's sovereign fee ownership of these public trust lands are generally defined by reference to the ordinary high water mark (Civil Code §670), as measured by the mean high tide line (*Borax Consolidated v. City of Los Angeles* (1935) 210 U.S. 10); these boundaries remain ambulatory, except where there has been fill or artificial accretion. More specifically, in areas unaffected by fill or artificial accretion, the ordinary high water mark and the mean high tide line will generally be the same. In areas where there has been fill or artificial accretion, the ordinary high water mark (and the state's public trust ownership) is generally defined as the location of the mean high tide line just prior to the fill or artificial influence. It is important to note that such boundaries may not be readily

[68] Indeed, as noted above, 30235 itself clarifies that even when approvable, such structures should be designed to eliminate or mitigate any adverse impacts on local shoreline sand supply.

apparent from present day site inspections (*Carpenter v. City of Santa Monica* (1944) 63 C. A. 2nd 772, 787).

The mean high tide line is the intersection of the shoreline with the elevation of the average of all high tides calculated over an 18.6-year tidal epoch. This property line is referred to as "ambulatory" for two reasons: first, gradual changes to the shoreline due to factors such as variations in the height and width of sandy beaches, shoreline erosion or accretion, and uplift or subsidence of land can change the location of where the mean high tide line meets the shoreline. Second, the elevation of the mean high tide line itself changes over time and is likely to increase at an accelerating rate in the future due to sea level rise. Over time, sea level rise will continue to gradually cause the public trust boundary to move inland. Boundaries between publicly-owned waterways and adjoining private properties (referred to as *littoral* along lakes and seas and *riparian* along rivers and streams) have always been subject to the forces of nature and property boundary law reflects these realities.

Accelerating sea level rise will likely lead to more disputes regarding the location of property boundaries along the shoreline, since lands that were previously landward of the mean high tide line have become subject to the State's ownership and protections of the public trust. These disputes, in turn, will affect determinations regarding what kinds of structures and uses may be allowed or maintained in areas that, because of sea level rise, either are already seaward of the mean high tide line, are likely to become seaward of the mean high tide line in the future, or would be seaward of the mean high tide line if it were not for artificial alterations to the shoreline. This subject is discussed in the Coastal Commission Public Trust Guiding Principles and Action Plan.

California case law does not explicitly address how shoreline structures such as seawalls that artificially fix the shoreline temporarily and prevent inland movement of the mean high tide line affect property boundaries, if at all. The Ninth Circuit Court of Appeals, however, has interpreted federal common law as allowing the owner of tidelands to bring a trespass action against a neighboring upland property owner who built a revetment that prevented the natural inland movement of the mean high tide line. The court ruled that the actual property boundary was where the mean high tide line would have been if the revetment were not there and that the owner of the tidelands could require the upland owners to remove the portions of the revetment that were no longer located on the upland owners' properties. (*United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190.)

POTENTIAL PRIVATE PROPERTY TAKINGS ISSUES

The United States and California constitutions prohibit public agencies from taking private property for public use without just compensation. Section 30010 of the Coastal Act similarly prohibits public agencies implementing the Coastal Act from granting or denying a permit in a manner that takes or damages private property for public use without payment of just compensation. The classic "takings" scenario arises when a public agency acquires title to private property in order to build a public facility or otherwise devote the property to public use. In 1922, however, the United States Supreme Court ruled that regulation of private property can constitute a taking even if the regulation does not involve acquisition of title to the property. As Justice Oliver Wendell Holmes stated, "while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking," (*Pennsylvania Coal Co. v. Mahon* (1922) 260 U.S. 393, 415.)

Courts have struggled in the 90 years since then to give agencies and property owners a more definite sense of exactly when a regulation "goes too far." The Supreme Court has identified three basic categories of takings that can occur in the context of land use regulation. Different legal standards apply depending on what kind of taking is at issue. (See, generally, *Lingle v. Chevron USA, Inc.* (2005) 544 U.S. 528).

The most straightforward test applies to what is variously called a categorical, total, *per se,* or *"Lucas"* takings, which occurs when a regulation deprives an owner of all economically beneficial use of the property. (See *Lucas v. South Carolina Coastal Council* (1992) 505 U.S. 1003). An agency that completely deprives a property owner of all economically beneficial use of the property will likely be found liable for a taking unless background principles of nuisance or property law independently restrict the owner's intended use of the property. Courts have generally been very strict about when they apply this test. If any economically beneficial use remains after application of the regulation, even if the value of that use is a very small percentage of the value of the property absent the regulatory restriction, a *Lucas* taking has not occurred.

Where a regulation significantly reduces the value of private property but does not completely deprive the owner of all economically beneficial use, the multi-factor "*Penn-Central"* test applies (*Penn Central Transportation Co. v. City of New York* (1978) 438 U.S. 104). This test has no set formula, but the primary factors include the economic impact of the regulation, the extent to which the regulation interferes with distinct, reasonable investment-backed expectations, and the character of the governmental action. When evaluating the character of the governmental action, courts consider whether the regulation amounts to a physical invasion or instead more generally affects property interests through a program that adjusts the burdens and benefits of economic life for the common good. Whether a regulation was in effect at the time an owner acquired title is also a relevant factor, but is not by itself dispositive. (See *Palazzolo v. Rhode Island* (2001) 533 U.S. 606, 632-633 (O'Connor, J., concurring)). Because this test takes such a wide range of factors into account, caselaw does not provide clear guidance about the situations in which a regulation is likely to qualify as a "*Penn-Central"* taking. A *Penn-Central* claim is unlikely to succeed, however, unless the plaintiff can establish that the regulation very substantially reduces the value of the property.

The third category of takings claims applies to "exactions," that is, government permitting decisions that require a property owner either to convey a property interest or to pay a mitigation fee as a condition of approval. (See *Nollan v. California Coastal Comm.* (1987) 483 U.S. 825; *Dolan v. City of Tigard* (1994) 512 U.S. 374; *Koontz v. St. Johns River Water Management Dist.* (2013) 133 S.Ct. 2586). Under the *Nollan/Dolan* line of cases, the agency must establish a "nexus" between the condition requiring a property interest or payment and the effects of the project that that property interest or payment is mitigating. That property interest or payment must also be roughly proportional to the impact that it is intended to mitigate. In California, the *Ocean Harbor House* case is a good example of a shoreline structure impact mitigation requirement that was found by the courts to meet the relevant standards of nexus and proportionality.

Various recommendations of this Guidance may potentially give rise to takings concerns. Because the determination of whether a particular regulation may in some circumstances be applied in a way that constitutes a taking is so fact-intensive and context-specific, this Guidance cannot provide a simple set of parameters for when agencies should either allow exceptions to a land use regulation or consider purchasing a property interest. That said, land use restrictions that prevent all economically beneficial use of the entirety of a property[69] are vulnerable to *Lucas* takings claims unless those uses would qualify as a nuisance or are prohibited by property law principles such as the public trust doctrine. Agencies can minimize the risk of these claims by allowing economically beneficial uses on some of the property and by exploring whether legal doctrines regarding nuisance, changing shoreline property lines, or the public trust independently allow for significant limitations on the use of the property. Establishing a transferrable development rights program for properties that are subject to significant development restrictions may also minimize potential exposure to takings claims.

Where a proposed development would be safe from hazards related to sea level rise in the near future but cannot be sited so as to avoid those risks for the expected life of the structure, agencies may consider allowing the structure, but requiring removal once it is threatened. Property owners may argue that they have a right to protect threatened structures even if they have waived rights to shoreline protection under the Coastal Act, but a recent federal court of appeal ruling casts significant doubt on the existence of any common law right to attempt to fix an ambulatory shoreline boundary through artificial structures such as seawalls (see *United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190).

If an agency is contemplating requiring property owners to dedicate open space easements or other property interests or requiring the payment of fees to mitigate project impacts, the agency should be careful to adopt findings explaining how requiring the property interest or payment is both logically related to mitigating an adverse impact of the project and roughly proportional to that impact. With respect to mitigation fees, California cities and counties should also comply with applicable requirements of the Mitigation Fee Act (Government Code, §66000 *et seq.*).

[69] What qualifies as the entirety of a property can also be the subject of dispute. The property will normally include all legal lots on which the proposed development would be located but can also include other lots that are in common ownership and adjacent to, or in close proximity with, the lots that would be developed. (See *Murr v. Wisconsin* (2017) 582 U.S. 383).

Chapter 9. Additional Coastal Commission Efforts to Address Sea Level Rise

Since the original development of this policy guidance in draft form in 2013 and its adoption by the Commission in 2015, the Coastal Commission has made significant progress on its work on sea level rise and climate change. Among its many accomplishments over the past ten years were the adoption of Critical Infrastructure At Risk: Sea Level Rise Planning Guidance for California's Coastal Zone (2021) and the Public Trust Guiding Principles and Action Plan (2023), along with extensive interagency work and distribution of grant funding to local governments to support sea level rise adaptation planning. Despite this significant progress, more work is needed.

The Coastal Commission's Strategic Plan for 2021-2025 (CCC 2021) identifies many action items that the Commission or partner organizations plan to take to address the challenges of sea level rise and climate change. These include efforts related to the Commission's normal operating business, such as ongoing coordination with local government partners and other agencies, as well as specially funded projects designed to meet specific needs (see Box below). Coastal Commission staff also participated in the development of the State Agency Sea Level Rise Action Plan for California (2022), which contains nearly 80 trackable actions and serves as a five-year roadmap designed to help formalize and accelerate coordinated state agency efforts to prepare for the impacts of sea level rise.

These next steps, some of which are already underway, are listed below. The Commission anticipates that these items will be completed over the next two to five years, in coordination with other relevant partners and research institutions, as staff capacity and funding allows.

1. **Continue an active program of public outreach on sea level rise.** The Commission will strive to provide public information about sea level rise issues through public workshops, the Commission's website, meetings, outreach, and our public education program. The Commission will work to enhance efforts to coordinate with low-income and underserved populations and communities.

2. **Continue work on advancing environmental justice in sea level rise adaptation planning and LCPs.** Following adoption of this updated guidance, Coastal Commission staff will roll out a series of webinars for local governments and interested stakeholders that aim to further educate and instruct planners on how to integrate environmental justice and equity principles into sea level rise adaptation planning. Commission staff also plan to continue developing and formalizing a team of environmental justice and sea level rise subject matter experts who can be tapped to inform and guide development of future guidance materials.

3. **Develop guidance on nature-based shoreline adaptation measures to address sea level rise**. Coastal Commission staff are developing interpretive policy guidance that will help planners prioritize permitting and analysis of nature-based adaptation strategies such as shoreline restoration and living shorelines projects.

4. **Continue work to carry out the California Coastal Act and Public Trust Doctrine in an era of climate change and sea level rise**. In 2023, the Coastal Commission adopted the Public Trust Guiding Principles and Action Plan which describes how the public trust doctrine relates to the Coastal Commission's and local governments' work on sea level rise planning under the Coastal Act, presents a series of principles that guide the Commission's and local governments' work on this subject, and sets forth next steps and research priorities for the Commission. Coastal Commission staff will continue carrying out these next steps as resources and staff capacity allow.

5. **Develop guidance on maximizing public access and recreational resources, including the California Coastal Trail, in light of sea level rise**. Building on a statewide analysis of the vulnerability of the California Coastal Trail to sea level rise, Coastal Commission staff will develop policy guidance, new information, and a framework for maintaining public access in the future, with an additional focus on addressing the disproportionate impact of public access losses to socially vulnerable or environmental justice communities and promoting the removal of barriers to access.

6. **Explore the concept of neighborhood-scale adaptation**. Explore technical methods to analyze how natural backshore characteristics can help reveal which adaptation approaches are possible and most resource protective in both the short and long term. This information could elucidate which stretches of shorelines have characteristics conducive to inland migration of habitats such as beaches, which do not, and which could if certain adaptation measures are implemented. This information could help define areas, or "neighborhoods," potentially suitable for a cohesive adaptation approach.

7. **Continue robust interagency coordination on sea level rise**. Coastal Commission staff will continue working with its various partners at the federal, state, regional, Tribal, and local levels to address sea level rise. Specifically:
    - Continue coordination with the Local Government Working Group (LGWG). The LGWG (made up of local government representatives from the California Association of Counties and the League of California Cities, two Coastal Commissioners, and CCC staff) was formed in 2019 to advance coordination in support of LCP updates, particularly to address sea level rise. The group has co-developed a number of deliverables including a Joint Statement on Adaptation Planning and a framework for phased approaches to LCP updates, and remains actively committed to developing materials and recommendations to support SLR and LCP planning. Key ongoing work includes supporting phased LCP updates, proactive adaptation planning at neighborhood or other subarea levels, and regional coordination.
    - Continue participation in the State SLR Collaborative, convened by the Ocean Protection Council, and carry out the Principles for Aligned State Action on Sea Level Rise (2021) and the State Agency Sea Level Rise Action Plan for California (2022).

- Continue coordinating closely with Caltrans to address transportation issues. Planning efforts may include integrating LCP planning and regional transportation planning processes; coordinating and supporting phased approaches for realignment projects; and identifying priorities for adaptation response.
- Continue coordinating with State Lands Commission on aligning responses to sea level rise impacts in Coastal Commission permits and State Lands leases. Coordinate on the public trust implications of adaptation strategies reflected in Local Coastal Programs.
- Coordinating with port and harbor authorities and other relevant stakeholders to address vulnerabilities specific to ports, harbors, fisheries, and navigation, and to develop and enhance adaptation strategies that are particularly applicable for coastal-dependent infrastructure and other port needs.
- Coordinating with the State and Regional Water Quality Control Boards to consider vulnerability issues related to water supply, water quality, and wastewater capacity infrastructure in California.

8. **Produce additional guidance documents, including**:
    - Broader climate change guidance addressing other climate change impacts to the coastal zone and land use planning strategies to reduce greenhouse gas emissions in the coastal zone.
    - Additional guidance on how to analyze the impacts of sea level rise upon groundwater, the associated hazards, and potential adaptation strategies.

9. **Continue implementation of the LCP Local Assistance Grant Program.** The Coastal Commission remains committed to supporting LCP updates through its LCP Grant Program. Since 2013, the grant program has awarded approximately $20 million to local governments to support sea level rise and LCP planning efforts and currently has approximately $10 million remaining from a 2021 appropriation for the grant program. Funding has supported a variety of vulnerability assessments, technical studies, adaptation plans, public outreach, policy development, and LCP adoption and certification processes. These types of planning efforts are now required by SB 272, and the Commission will continue to support this work through provision of LCP grant program funds and coordination with other funding agencies such as OPC and the Coastal Conservancy.

10. **Implement the Coastal Commission's responsibilities under other state efforts and legislation.**
    - Governor Brown's April 2015 Executive Order B-30-15 states that state agencies shall take climate change into account in their planning and investment decisions, and employ full life-cycle cost accounting to evaluate and compare infrastructure investments and alternatives. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas

emissions, provide flexible and adaptive approaches, protect the state's most vulnerable populations, and promote natural infrastructure solutions. The Coastal Commission will continue to integrate these principles into its planning and regulatory work.

- AB 2516, authored by Assemblymember Gordon and approved in September 2014, established a Planning for Sea Level Rise Database, and SB 246, authored by Senator Gordon and approved in 2015, established the Adaptation Clearinghouse, the latter of which hosts the information collected through both bills. The database describes the actions taken by cities, counties, regions, and various public and private entities to address sea level rise. The Coastal Commission will continue contributing data to this effort, including information about grant-funded LCP updates.
- The Coastal Commission will also participate in the implementation of the California Climate Adaptation Strategy. Key principles are and will continue to be incorporated into Coastal Commission work, including protection of California’s most vulnerable populations the integration of risk reduction with emissions reductions, and the development of metrics and indicators of progress on efforts to reduce climate risk.

Coastal Commission Strategic Plan 2021-2025 Excerpts
Actions Related to Sea Level Rise and Climate Change

Goal 4: Support Resilient Coastal Communities in the Face of Climate Change and SLR

Objective 4.1 Address Risks Posed by Climate Change and Sea Level Rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs).

Objective 4.2 Support Development and Implementation of Local Sea Level Rise Adaptation Projects.

Objective 4.3 Build the Capacity of Commission and Local Government Staff to Better Address Climate Change and Sea Level Rise Vulnerabilities Through Technical Assistance, Guidance and Training.

Objective 4.4 Protect Beaches, Wetlands and Other Coastal Resources, Including Public Access as Seas Rise. (See also Public Access Objective 2.6, Ensure Continued Public Access in Light of Changing Shoreline Conditions and Sea Level Rise)

Objective 4.5 Facilitate Reduction of Greenhouse Gas (GHGs) in LCPs, CDPs and Other Efforts.

Objective 4.6 Increase Public Awareness and Participation in Planning to Address Climate Change in Coastal Communities and Statewide.

Goal 5: Advance Diversity, Equity, Environmental Justice, and Tribal Relations

Objective 5.1 Strengthen Coastal Protection through Consideration of Environmental Justice in Permit Decisions and Planning Documents.

Please consult the 2021-2025 Coastal Commission Strategic Plan to read the actions associated with each objective listed above.

Glossary

The following terms were collected from the 2009 California Climate Change Adaptation Strategy[70], the Intergovernmental Panel on Climate Change Third Assessment Report[71], the Coastal Commission's Beach Erosion and Response (BEAR) document,[72] the Commission's Environmental Justice Policy, and the California Coastal Act, unless otherwise noted. Some of these definitions are not used in the text of the report but are included as a resource on coastal-related adaptation issues.

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Adaptation Pathway: A planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures, and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures.[73]

Adaptive capacity: The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.[74]

Adaptive management: Involves monitoring the results of a management decision, and updating actions as needed and as based on new information and results from the monitoring.

Ambulatory (*as used in public trust boundaries*): Moveable, subject to change, or capable of alteration.[75]

Aquifer: An underground layer of porous rock, sand, or other earth material containing water, into which wells may be sunk.

Armor: To fortify a topographical feature to protect it from erosion (e.g., constructing a wall to armor the base of a sea cliff), or to construct a feature (e.g., a seawall, dike, or levee) to protect other resources (e.g., development or agricultural land) from flooding, erosion, or other hazards.

Atmosphere-Ocean General Circulation Models (or Atmosphere-Ocean General Climate Models; ACGOM): Three-dimensional global models that dynamically link ocean density,

[70] CNRA 2009

[71] IPCC 2001

[72] Many of these definitions were extracted from: USACE 2002, Griggs and Savoy 1985 and Flick 1994.

[73] Ocean Protection Council 2018

[74] Willows and Connell 2003

[75] *West's Encyclopedia of American Law* 2008

circulation, and sea level using wind stress, heat transfer between air and sea, and freshwater fluxes as critical variables. (See also *General Circulation Models*)

Baseline (or Reference): Any datum against which change is measured. It might be a "current baseline," in which case it represents observable, present-day conditions. It might also be a "future baseline", which is a projected future set of conditions excluding the driving factor of interest (e.g., how would a sector evolve without climate warming). It is critical to be aware of what change is measured against which baseline to ensure proper interpretation. Alternative interpretations of the reference conditions can give rise to multiple baselines.[76]

Beach: The expanse of sand, gravel, cobble or other loose material that extends landward from the low water line to the place where there is distinguishable change in physiographic form, or to the line of permanent vegetation. The seaward limit of a beach (unless specified otherwise) is the mean low water line.

Beach nourishment: Placement of sand and/or sediment (e.g., beneficial re-use of dredged sediment) on a beach to provide protection from storms and erosion, to create or maintain a wide(r) beach, and/or to aid shoreline dynamics throughout the littoral cell. The project may include dunes and/or hard structures as part of the design.

Bluff (or Cliff): A scarp or steep face of rock, weathered rock, sediment and/or soil resulting from erosion, faulting, folding or excavation of the land mass. The cliff or bluff may be a simple planar or curved surface or it may be step-like in section. For purposes of (the Statewide Interpretive Guidelines), "cliff" or "bluff" is limited to those features having vertical relief of ten feet or more and "seacliff" is a cliff whose toe is or may be subject to marine erosion.

Bluff top retreat (or Cliff top retreat): The landward migration of the bluff or cliff edge, caused by marine erosion of the bluff or cliff toe and subaerial erosion of the bluff or cliff face.

Caisson: A supporting piling constructed by drilling a casing hole into a geologic formation and filling it with reinforcing bar and concrete; used for foundations. (See also *Piling*)

Climate change: Any long-term change in average climate conditions in a place or region, whether due to natural causes or as a result of human activity.

Climate variability: Variations in the mean state of the climate and other statistics (e.g., standard deviations, the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events.

[76] Moser 2008

Coastal-dependent development or use: Any development or use which requires a site on, or adjacent to, the sea to be able to function at all.[77]

Coastal Development Permit (CDP): Development in the coastal zone generally requires a Coastal Development Permit (CDP). In areas of retained jurisdiction and areas without a certified Local Coastal Program (LCP), the Commission is generally responsible for reviewing the consistency of CDP applications with the policies of Chapter 3 of the Coastal Act (Public Resources Code Sections 30200-30270). In areas with a certified LCP, the local government is responsible for reviewing the compliance of CDP applications with the requirements of the certified LCP and, where applicable, the public access and recreation policies of the Coastal Act. Certain local government actions on CDP applications are appealable to the Commission. On appeal, the Commission also applies the policies of the certified LCP and applicable public access and recreation policies of the Coastal Act.

Coastal-related development: Any use that is dependent on a coastal-dependent development or use.[78]

Coastal resources: A general term used throughout the Guidance to refer to those resources addressed in Chapter 3 of the California Coastal Act, including beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

Community Benefits Agreements: Community benefits agreements are legal contracts between a developer and the impacted community and/or its representatives (governmental and non-governmental). These strategic agreements are mutually beneficial, as governments need support from their constituencies, developers need government for permit approvals, and community interests can be funded or furnished by the developer for their support of a project. Benefits can include commitments to hire directly from a community, contributions to economic trust funds, local workforce training guarantees, mitigation of increased pollution exposure, and more.[79]

CoSMoS: The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that has been developed by the United States Geological Survey in order to allow more detailed predictions of coastal flooding due to both future sea-level rise and storms integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat) over large geographic areas (100s of kilometers).

[77] Public Resources Code § 30101

[78] Public Resources Code § 30101.3

[79] U.S. Department of Energy

Development: On land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice of 1973 (commencing with Section 4511).[80]

Disadvantaged, Marginalized, Underserved: SB 1000 (Leyva) (Ch. 587, Stats. 2016) added Government Code Section 65302(h)(4)(A), expanding the definition of "disadvantaged communities" for the purpose of general plans to mean "an area identified by the California Environmental Protection Agency pursuant to Section 39711 of the Health and Safety Code or an area that is a low-income area that is disproportionately affected by environmental pollution and other hazards that can lead to negative health effects, exposure, or environmental degradation." This Guidance uses the terms "disadvantaged," "marginalized," and "underserved" interchangeably; it intends to encompass not only the definitions contemplated by SB 1000, but also to include other low-income and minority populations that are disproportionately burdened by or less able to prevent, respond, and recover from adverse environmental impacts.

Ecosystem-Based Management (EBM): An integrated approach to resource management that considers the entire ecosystem, including humans, and the elements that are integral to ecosystem functions.[81]

Ecosystem services: Benefits that nature provides to humans. For example, plants, animals, fungi and micro-organisms produce services or goods like food, wood and other raw materials, as well as provide essential regulating services such as pollination of crops, prevention of soil erosion and water purification, and a vast array of cultural services, like recreation and a sense of place.[82]

El Niño Southern Oscillation: The El Niño-Southern Oscillation (ENSO) is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean. On periods ranging from about three to seven years, the surface waters across a

[80] Public Resources Code § 30106

[81] NOC 2011

[82] Hassan *et al.,* 2005

large swath of the tropical Pacific Ocean warm or cool by anywhere from 1°C to 3°C, compared to normal.[83]

Emissions scenarios: Scenarios representing alternative rates of global greenhouse gas emissions growth, which are dependent on rates of economic growth, the success of emission reduction strategies, and rates of clean technology development and diffusion, among other factors.[84]

Environmental Justice: "Environmental justice" means the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. The United States has a history of racial discrimination that has persisted in multiple forms. During the 20th century, the civil rights movement sought to secure legal rights that were held but not fully realized by African Americans and other marginalized populations. The concept of environmental justice emerged out of this movement to describe the application of civil rights and social justice to environmental contexts. For example, the cumulative effect of siting a disproportionate number of toxic waste and other hazardous facilities in disadvantaged, urban communities of color has led to disproportionate impacts from pollution and lack of environmental services, such as clean drinking water, clean air, and access to parks and open space.

Environmentally Sensitive [Habitat] Area (ESHA): Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.[85]

Equity: This policy uses the term "equity" as defined in the context of social and racial equity, where "equity" refers to the fairness of achieving outcomes for all groups and no one factor, such as race, can be used to predict outcomes.[86]

Erosion: The wearing away of land by natural forces; on a beach, the carrying away of beach material by wave action, currents, or the wind. Development and other non-natural forces (e.g., water leaking from pipes or scour caused by wave action against a seawall) may create or worse erosion problems.

Eustatic: Refers to worldwide changes in sea level.

Feasible (*as used in "least environmentally damaging feasible alternative"*): Capable of being

[83] National Weather Service

[84] Bedsworth and Hanak 2008

[85] Public Resources Code § 30107.5

[86] The Local & Regional Government Alliance on Race and Equity. Advancing Racial Equity and Transforming Government: A Resource Guide to Put Ideas into Action (2015).

accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.[87]

Flood (or Flooding): Refers to normally dry land becoming temporarily covered in water, either periodically (e.g., tidal flooding) or episodically (e.g., storm or tsunami flooding).[88]

General Circulation Models (or General Climate Models; GCM): A global, three-dimensional computer model of the climate system which can be used to simulate human-induced climate change. GCMs are highly complex and they represent the effects of such factors as reflective and absorptive properties of atmospheric water vapor, greenhouse gas concentrations, clouds, annual and daily solar heating, ocean temperatures and ice boundaries. The most recent GCMs include global representations of the atmosphere, oceans, and land surface.[89] (See also *Atmospheric-Ocean General Circulation Models*)

Green infrastructure: Refers to the use of vegetative planting, dune management, beach nourishment or other methods that mimic natural systems to capitalize on the ability of these systems to provide flood and erosion protection, stormwater management, and other ecosystem services while also contributing to the enhancement or creation of natural habitat areas.

Greenhouse gases (GHGs): Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.[90]

Hard protection: A broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. (See also *Revetment, Seawall, Shoreline protective devices*)

Hybrid Armoring: Nature-based adaptation strategies that combines fixing the shoreline, such as with a buried revetment or other shoreline protective device, with a nature-based feature to provide ecological and other benefits. (See also *Nature-Based Adaptation Strategies* and *Soft Strategies*)

Impact assessment: The practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

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[87] Public Resources Code § 30108

[88] Flick *et al.,* 2012

[89] NASA Earth Observatory Glossary

[90] UNFCCC 2004

Inundation: The process of dry land becoming permanently drowned or submerged, such as from dam construction or from sea level rise.[91]

Implementation Plan (IP): Measures to implement a Land Use Plan, such as zoning ordinances, zoning district maps, and other implementing actions.

Land Use Plan (LUP): "Land use plan" means the relevant portions of a local government's general plan, or local coastal element which are sufficiently detailed to indicate the kinds, location, and intensity of land uses, the applicable resource protection and development policies and, where necessary, a listing of implementing actions.[92]

Local Coastal Program (LCP): A local government's (a) land use plans, (b) zoning ordinances, (c) zoning district maps, and (d) within sensitive coastal resources areas, other implementing actions, which, when taken together, meet the requirements of, and implement the provisions and policies of, this division at the local level.[93] Each LCP includes a **Land Use Plan (LUP)** which contains policies, and an **Implementation Plan (IP)** which includes accompanying measures to implement the plan (such as zoning ordinances, zoning district maps, and other implementing actions).

Low-Income Household, Area, or Community: There are several metrics available to identify households, areas or communities that make less income than the median or average area income. It is an indicator of vulnerability or less capacity since these individuals or communities have fewer resources to address environmental burdens. Below are several definitions and metrics that can be used to identify low-income households or communities.

- **Low-Income Household**: In California law, a low-income household is defined as "those with household incomes at or below 80% of the statewide median income or with household incomes at or below the threshold designated as low-income by the Department of Housing and Community Development." A "low-income area" means an area with household incomes at or below 80% of the statewide median income or with household incomes at or below the threshold designated as low income by the Department of Housing and Community Development's list of state income limits adopted pursuant to Section 50093. (Sources: AB 1550 and SB 1000 bill text)
- **Area Median Household Income (AMI):** The AMI is the median family income of a geographic area of the state. It provides a metric of household income that accounts for regional variation in income levels and cost of living. The AMI is calculated every year and used to determine income limits for "lower income households." In California, the Department of Housing and Community Development publishes state income limits

[91] Flick *et al.,* 2012

[92] Public Resources Code § 30108.5

[93] Public Resources Code § 30108.6

annually. (Sources: California Department of Housing and Community development, CA Health and Safety Code Section 50093)

- **Federal Poverty Level (FPL):** Means a measure of income determined by federal poverty guidelines issued every year by the Department of Health and Human Services. FPLs are used to determine eligibility for federal and state assistance programs and benefits. Because the federal poverty level applies nation-wide, areas with a higher cost of living such as California, often use the number of households or individuals with incomes below twice the federal poverty level (200% FPL) as an indicator of poverty. (Source: Healthcare.gov)
- **Housing Burdened Low-Income Households**: Percentage of households in a census tract that is both low income (making less than 80% of the HUD area median income) and paying greater than 50% of their income to housing costs. (Sources: CalEPA Office of Environmental Health and Hazard Assessment, Comprehensive Affordability Housing Strategy)

Mean sea level: The average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. Relative sea level is sea level measured by a tide gauge with respect to the land upon which it is situated. (See also *Sea level change/sea level rise*)

Meaningful Engagement: Meaningful engagement is the intentional outreach, inclusion, and consideration of the voices and perspectives from presently and historically underserved and marginalized communities in the design, development, implementation, and policies that may impact the health, environment, and livelihood of their communities.

Mitigation (*as used in climate science*): A set of policies and programs designed to reduce emissions of greenhouse gases.[94]

Mitigation (*as used in resource management*): Projects or programs intended to minimize or offset impacts to resources.

Monitoring: Systematic collection of physical, biological, chemical, or economic data, or a combination of these data on a project in order to make decisions regarding project operation or to evaluate project performance.

Nature-Based Adaptation Strategies: A coastal adaptation and/or erosion control method that is comprised of natural or mostly natural elements, which contributes to the persistence and enhancement of coastal processes and ecological benefits while also offering protection services to inshore areas. (See also *Soft Strategies* and *Hybrid Armoring*)

[94] Luers and Moser 2006

Pacific Decadal Oscillation: The Pacific Decadal Oscillation (PDO) is a long-term ocean fluctuation of the Pacific Ocean. The PDO waxes and wanes approximately every 20 to 30 years.

Passive erosion: The process whereby erosion causes the shoreline to retreat and migrate landward of any hardened structures that have fixed the location of the back beach therefore resulting in the gradual loss of beach in front of the hardened structure.

Permit: Any license, certificate, approval, or other entitlement for use granted or denied by any public agency which is subject to the provisions of this division.[95]

Piling (or Pile): A long, heavy timber or section of concrete or metal driven or drilled into the earth or seabed to serve as a support or protection. (See also *Caisson*)

Potential impacts: All impacts that may occur given a projected change in climate, including impacts that may result from adaptation measures.

Public Trust Lands: 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.[96] (See also *Tidelands, Submerged lands*)

Radiative forcing: Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In [the IPCC] report radiative forcing values are for changes relative to pre-industrial conditions defined at 1750 and are expressed in Watts per square meter (W/m^2).[97]

Redevelopment: At a minimum, replacement of 50% or more of an existing structure. LCPs may also consider including limits on the extent of replacement of major structural components such as the foundation or exterior walls, or improvements costing more than 50% of the assessed or appraised value of the existing structure**.**

Revetment: A sloped retaining wall; a facing of stone, concrete, blocks, rip-rap, *etc.* built to protect an embankment, bluff, or development against erosion by wave action and currents. (See also *Hard protection, Seawall, Shoreline protective devices*)

[95] Public Resources Code § 30110

[96] 14 Cal. Code Regs § 13577(f)

[97] IPCC 2007

Risk: Commonly considered to be the combination of the likelihood of an event and its consequences – i.e., risk equals the probability of climate hazard occurring multiplied the consequences a given system may experience.[98]

Scenario-based analysis: A tool for developing a science-based decision-making framework to address environmental uncertainty. In general, a range of plausible impacts based on multiple time scales, emissions scenarios, or other factors is developed to inform further decision-making regarding the range of impacts and vulnerabilities.[99]

Sea level: The height of the ocean relative to land; tides, wind, atmospheric pressure changes, heating, cooling, and other factors cause sea level changes.

Sea level change/sea level rise: Sea level can change, both globally and locally, due to (a) changes in the shape of the ocean basins, (b) changes in the total mass of water and (c) changes in water density. Factors leading to sea level rise under global warming include both increases in the total mass of water from the melting of land-based snow and ice, and changes in water density from an increase in ocean water temperatures and salinity changes. Relative sea level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.[100] (See also *Mean sea level*, *Thermal expansion*)

Sea level rise impact: An effect of sea level rise on the structure or function of a system.[101]

Sea level rise projection: Projections are predictions of future sea level rise based on scientific information and models that relate climate and sea level, and they are based on assumed trajectories of future global emissions and warming. Kopp *et al*., 2014 and the 2018 State SLR Guidance are examples of a studies that provided probabilistic sea level rise projections, including a set of projections based on an optimistic emissions scenario that assumed net-negative emissions in the last decades of the 21st century (Representative Concentration Pathway 2.5, or RCP 2.5) and a set based on a high-end, fossil-fuel-intensive emission scenario (RCP 8.5). Since there is uncertainty inherent in climate models and other information sources used to project the various drivers of SLR, projections are presented in ranges that reflect that uncertainty. Particular sea level rise amounts may be predicted more or less frequently by these studies, so projections can be presented probabilistically. Therefore, projections are often called emission-dependent (or conditional) and probabilistic. The median (50th percentile) projection can be reported, along with the likely range (17th to 83rd percentiles) and so on.

[98] Burton *et al.,* 2004

[99] NOAA 2010

[100] IPCC 2007

[101] PCGCC 2007

Sea level rise scenario: Scenarios are sea level rise amounts or trajectories that span the plausible range of future sea level rise. They are usually presented as ranges and are not necessarily actual predictions of how much sea level rise is expected to occur by a certain time. Rather, they are hypothetical futures that span the range of what is considered possible according to the current best available science. Examples of reports that provided sea level rise scenarios include Parris *et al*., 2012 – which provided global mean sea level rise scenarios for the year 2100 of 0.1, 0.5, 1.2, and 2.0 meters – and Hall *et al*., 2016 – which provided scenarios for 2100 including 0.2, 0.5, 1.0, 1.5 and 2.0 meters – with the intent that these roughly even increments of sea level rise span the plausible range of sea level rise that could occur in the year 2100. This report provides five sea level rise scenarios, each constructed from a subset of probabilistic AR6 projections. The information embedded in the projections are used to quantitatively and qualitatively characterize the likelihood that each scenario will occur.

Seawall: A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. It is usually a vertical wood or concrete wall as opposed to a sloped revetment. (See also *Hard protection, Revetment, Shoreline protective devices*)

Sediment: Grains of soil, sand, or rock that have been transported from one location and deposited at another.

Sediment management: The system-based approach to the management of coastal, nearshore and estuarine sediments through activities that affect the transport, removal and deposition of sediment to achieve balanced and sustainable solutions to sediment related needs.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).
Shore protection: Structures or sand placed at or on the shore to reduce or eliminate upland damage from wave action or flooding during storms.

Shared socioeconomic pathways (SSP): The set of conceivable global development, emissions, and warming futures defined by the IPCC in its Sixth Assessment Report. “SSP1, SSP2, …, SSP5” is used to denote the five socio-economic scenario families. SSP1-1.9, SSP1-2.6, …, SSP5-8.5 are used to denote various approximate radiative forcing levels of 1.9, 2.6, …, or 8.5 W m^{-2} reached by the end of the century, respectively.

Shoreline protective devices: A broad term for constructed features such as seawalls, revetments, riprap, earthen berms, cave fills, and bulkheads that block the landward retreat of the shoreline and are used to protect structures or other features from erosion and other hazards. (See also *Hard protection, Revetment, Seawall*)

Soft Strategies: Nature-based adaptation strategies that avoid fixing the shoreline with hard structures and instead rely on the use of dynamic systems to attenuate coastal hazards, such as dune or wetland restoration, or sand replenishment. (See also *Nature-Based Adaptation Strategies* and *Hybrid Armoring*)

Still water level: The elevation that the surface of the water would assume if all wave action were absent.

Storm surge: A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in water level due to atmospheric pressure reduction as well as that due to wind stress.

Submerged lands: Lands which lie below the line of mean low tide.[102] (See also *Public Trust Lands*, *Tidelands*)

Subsidence: Sinking or down-warping of a part of the earth's surface; can result from seismic activity, changes in loadings on the earth's surface, fluid extraction, or soil settlement.

Tectonic: Of or relating to the structure of the earth's crust and the large-scale processes that take place within it.

Thermal expansion: An increase in water volume in response to an increase in temperature, through heat transfer.

Tidal prism: The total amount of water that flows into a harbor or estuary and out again with movement of the tide, excluding any freshwater flow.

Tidal range: The vertical difference between consecutive high and low waters. The Great Diurnal Range is the difference between mean higher high water and mean lower low water; the Mean Range of tide is the difference in height between mean high water and mean low water.[103]

Tidelands: Lands which are located between the lines of mean high tide and mean low tide.[104] (See also *Public Trust Lands*, *Submerged lands*)

Traditional Ecological Knowledge: The phrase "traditional ecological knowledge," also called "indigenous knowledge" or "Native science," refers to the evolving knowledge acquired by indigenous and local peoples over hundreds or thousands of years through direct contact with the environment. This knowledge is specific to a location and includes the relationships

[102] 14 Cal. Code Regs § 13577(e)

[103] NOAA 2013

[104] 14 Cal. Code Regs § 13577(d)

between plants, animals, natural phenomena, landscapes, and timing of events that are used for lifeways, including but not limited to hunting, fishing, trapping, agriculture, and forestry. Traditional ecological knowledge is an accumulating body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (human and non-human) with one another and with the environment. It encompasses the world view of indigenous people which includes ecology, spirituality, human and animal relationships, and more.[105]

Transfer of Development Rights (TDR): A device by which the development potential of a site is severed from its title and made available for transfer to another location. The owner of a site within a transfer area may retain property ownership, but not approval to develop. The owner of a site within a receiving area may purchase transferable development rights, allowing a receptor site to be developed at a greater density.[106]

Tsunami: A long period wave, or seismic sea wave, caused by an underwater disturbance such as an earthquake, submarine landslide, or subaerial landslide (slope failure from land into a water body). Tsunamis can cause significant flooding in low-lying coastal areas and strong currents in harbors. (Commonly misnamed a *Tidal wave*)

Vulnerability: The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity.

Vulnerability assessment: A practice that identifies who and what is exposed and sensitive to change and how able a given system is to cope with extremes and change. It considers the factors that expose and make people or the environment susceptible to harm and access to natural and financial resources available to cope and adapt, including the ability to self-protect, external coping mechanisms, support networks, and so on.[107]

Vulnerable Communities: Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts. Vulnerable communities[108] experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts.

[105] U.S. Fish and Wildlife Service: Traditional Ecological Knowledge for Application by Service Scientists. (https://www.fws.gov/nativeamerican/pdf/tek-fact-sheet.pdf).

[106] Cal OPR 1987

[107] Tompkins *et al.,* 2005

[108] Office of Planning and Research, 2018: Defining Vulnerable Communities in the Context of Climate Adaptation.

These disproportionate effects are caused by physical (built and environmental), social, political, and/ or economic factor(s), which are exacerbated by climate impacts. These factors include, but are not limited to, race, class, sexual orientation and identification, national origin, and income inequality.

Wave: A ridge, deformation, or undulation of the surface of a liquid. On the ocean, most waves are generated by wind and are often referred to as wind waves.

Wave height: The vertical distance from a wave trough to crest.

Wave length (or Wavelength): The horizontal distance between successive wave crests or between successive troughs of waves.

Wave period: The time for a wave crest to traverse a distance equal to one wavelength, which is the time for two successive wave crests to pass a fixed point.

Wave runup: The distance or extent that water from a breaking wave will extend up the shoreline, including up a beach, bluff, or structure.

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References

Akins, Damon, B. and Bauer Jr., William, J. (2022). We Are the Land: A History of Native California. University of California Press. https://www.ucpress.edu/book/9780520280502/we-are-the-land.

Anderson, R., Griggs, G., Lester, C., Patsch, K. (2020). Adapting to shoreline retreat: Finding a path forward. Shore & Beach, 88(4), 1-21.

Anguelovski, I, Connolly, JTT, Pearsall, H, Shokry, G, Checker, M, Maantay, J, Gould, K, Lewis, T, Maroko, A, & J Timmons Roberts. (2019). Why green "climate gentrification" threatens poor and vulnerable populations. Proceedings of the National Academy of Sciences, Volume 116, Issue 52. https://www.pnas.org/doi/full/10.1073/pnas.1920490117.

Assembly Bill No. 2616, Burke. (2016). Chapter 578 An act to amend Sections 30301 and 30604 of, and to add Sections 30013 and 30107.3 to, the Public Resources Code, relating to coastal resources. http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab_2601-2650/ab_2616_bill_20160924_chaptered.htm

Barlow TM, EG Reichard. 2010. Saltwater intrusion in coastal regions of North America. Hydrogeology Journal 18: 247-260. doi: 10.1007/s10040-009-0514-3

Barnard, P.L., Erikson, L.H., Foxgrover, A.C. et al. Dynamic flood modeling essential to assess the coastal impacts of climate change. Sci Rep 9, 4309 (2019). https://doi.org/10.1038/s41598-019-40742-z

Bay Conservation and Development Commission (BCDC). 1968. San Francisco Bay Plan. https://bcdc.ca.gov/pdf/bayplan/bayplan.pdf.

Bay Conservation and Development Commission (BCDC). 2011. Climate Change Bay Plan Amendment. Adopted October 6, 2011. https://bcdc.ca.gov/pdf/bayplan/bayplan.pdf

Bedsworth, L, D Cayan, G Franco, L Fisher, S Ziaja. (CA Governor's Office of Planning and Research, Scripps Institution of Oceanography, CA Energy Commission, CA Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. http://www.climateassessment.ca.gov/state/index.html

Befus, K. M., Barnard, P. L., Hoover, D. J., Finzi Hart, J. A., & Voss, C. I. (2020). Increasing threat of coastal groundwater hazards from sea level rise in California. Nature Climate Change, 10(10), 946–952. https://doi.org/10.1038/s41558-020-0874-1

Berry-James, R.M., Gooden, S.T. and Johnson, R.G., III (2020), Civil Rights, Social Equity, and Census 2020. Public Admin Rev, 80: 1100-1108. https://doi.org/10.1111/puar.13285

Black, M., Chief, K., Jacobs, K; Schuyler, C., & Lynn, R. (2015). Tribal Leaders Summit on Climate Change: A Focus on Climate Adaptation Planning and Implementation. https://www.sciencebase.gov/catalog/item/57daca21e4b090824ffc3161.

Bromirski, P. D. (2023). Climate-Induced Decadal Ocean Wave Height Variability From Microseisms: 1931–2021. Journal of Geophysical Research: Oceans, 128(8), e2023JC019722. https://doi.org/10.1029/2023JC019722

Bromirski, P. D. (2023). Climate-induced decadal ocean wave height variability from microseisms: 1931–2021. Journal of Geophysical Research: Oceans, 128, e2023JC019722. https://doi.org/10.1029/2023JC019722

Buma, B., Gordon, D.R., Kleisner, K.M. et al. 2024. Expert review of the science underlying nature-based climate solutions. Nature Climate Change. https://doi.org/10.1038/s41558-024-01960-0.

Caldwell MR, EH Hartge, LC Ewing, G Griggs, RP Kelly, SC Moser, SG Newkirk, RA Smyth, CB Woodson. 2013. Coastal Issues. In: Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment, [G Garfin, A Jardine, R Merideth, M Black, S LeRoy (eds.)]. Pp. 168-196. A report by the Southwest Climate Alliance. Washington, DC: Island Press. http://www.swcarr.arizona.edu/.

California Air Resources Board. 2022. Scoping Plan for Achieving Carbon Neutrality https://ww2.arb.ca.gov/sites/default/files/2023-04/2022-sp.pdf

California Coastal Commission (CCC). 1989. Planning for an Accelerated Sea Level Along the California Coast. Staff report drafted by L Ewing, J Michaels and D McCarthy. 85 pp. http://www.coastal.ca.gov/climate/PlanningAccelSLR.pdf.

California Coastal Commission (CCC). 2001. Overview of Sea Level Rise and Some Implications for Coastal California. Report prepared by Staff, June 1, 2001. 58pp. http://www.coastal.ca.gov/climate/SeaLevelRise2001.pdf.

California Coastal Commission (CCC). 2006. Discussion Draft: Global Warming and the California Coastal Commission. Briefing prepared by Staff, December 12, 2006. 9 pp. http://documents.coastal.ca.gov/reports/2006/12/Th3-12-2006.pdf.

California Coastal Commission (CCC). 2008a. Climate Change and Research Considerations. White paper prepared by Staff, September 29, 2008. 6 pp. http://www.coastal.ca.gov/climate/ccc_whitepaper.pdf.

California Coastal Commission (CCC). 2008b. A Summary of the Coastal Commission's Involvement in Climate Change and Global Warming Issues for a Briefing to the Coastal Commission. Briefing prepared by Commission Staff Climate Change Task Force, December 12, 2008. 54 pp. http://documents.coastal.ca.gov/reports/2008/12/F3.5-12-2008.pdf.

California Coastal Commission (CCC). 2013b. Local Coastal Program (LCP) Update Guide. Updates to original 2007 document, revised July 2013.129 pp. https://www.coastal.ca.gov/rflg/lcp-planning.html

California Coastal Commission (CCC). 2013c. Tips/Best Practices for Processing LCP Amendments. Prepared November 12, 2013. 3 pp. https://documents.coastal.ca.gov/assets/la/TipsLCPAmend_Nov2013.pdf.

California Coastal Commission (CCC). 2019. Environmental Justice Policy. https://documents.coastal.ca.gov/assets/env-justice/CCC_EJ_Policy_FINAL.pdf

California Coastal Commission (CCC). 2019. Local Coastal Program (LCP): Local Assistance Grant Program https://www.coastal.ca.gov/lcp/grants/

California Coastal Commission (CCC). 2021. Sea Level Rise Coastal Adaptation Planning Guidance for Critical Infrastructure. https://www.coastal.ca.gov/climate/slr/vulnerability-adaptation/infrastructure/

California Coastal Commission (CCC). 2021. Strategic Plan 2021-2025. Approved November 2020. 45 pp. https://documents.coastal.ca.gov/assets/strategicplan/CCC_Strategic_Plan_Adopted_11.06.20_Rev.pdf

California Coastal Commission (CCC). 2023. Public Trust Guiding Principles and Action Plan: Carrying out the California Coastal Act and Public Trust Doctrine in an era of climate change and sea level rise. *https://documents.coastal.ca.gov/assets/public-trust/Public%20Trust%20Guidance%20and%20Action%20Plan_Adopted.pdf*

California Coastal Commission (CCC). 2024. Resources for Addressing Environmental Justice through Local Coastal Programs. 42 pp. https://documents.coastal.ca.gov/assets/lcp/LUPUpdate/EJandLCPResources_CoastalCommission.pdf

California Department of Parks and Recreation. 2015. Sea Level Rise Adaptation Strategy https://www.parks.ca.gov/pages/734/files/StateParks_SLR_Strategy.pdf

California Government. 2018. California Fourth Climate Change Assessment
California Governor's Office of Emergency Services (Cal OES). 2023. California State Hazard Plan. https://www.caloes.ca.gov/wp-content/uploads/Hazard-Mitigation/Documents/2023-California-SHMP_Volume-1_11.10.2023.pdf

California Governor's Office of Emergency Services (Cal OES). 2023. California State Hazard Plan. https://www.caloes.ca.gov/wp-content/uploads/Hazard-Mitigation/Documents/2023-California-SHMP_Volume-1_11.10.2023.pdf

California Native American Heritage Commission (NAHC). 2024. https://nahc.ca.gov/

California Natural Resources Agency (CNRA). 2009. California Climate Adaptation Strategy. 197pp.

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.

California Natural Resources Agency (CNRA). 2021. California Climate Adaptation Strategy. https://climateresilience.ca.gov/

California Natural Resources Agency. (2020). Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action. California Natural Resources Agency. Sacramento, California. http://www.opc.ca.gov/webmaster/_media_library/2020/05/State-SLR-Principles_FINAL_April-2020.pdf

California Natural Resources Agency. 2020. Environmental Justice Policy. https://www.conservation.ca.gov/Documents/Environmental%20Justice%20Policy%20-%20CNRA.pdf

California State Coastal Conservancy. 2009. 2011. Climate Change Policy. https://scc.ca.gov/climatechange/climatechangepolicy/#:~:text=The%20Conservancy%20will%20encourage%20use,Carbon%20Reduction%20and%20Offsets.

California State Lands Commission. 2022. AB 691: Local Trustees Prepare for Sea Level Rise. https://slc.ca.gov/ab691/.

California State Lands Commission. 2023. Shoreline Adaptation and the Public Trust: Protecting California's Public Trust Resources from Sea Level Rise. https://www.slc.ca.gov/sea-level-rise/shorelineadaptationreport/#:~:text=and%20Benchmark%20Information-,Shoreline%20Adaptation%20and%20the%20Public%20Trust%3A%20Protecting%20California's%20Public,Resources%20from%20Sea%20Level%20Rise&text=This%20report%20was%20developed%20to,structures%20on%20ungranted%20state%20tidelands.

California, S. of. (n.d.). California Climate Adaptation Strategy. https://climateresilience.ca.gov/

Cayan D, M Tyree, M Dettinger, H Hidalgo, T Das, E Maurer, P Bromirski, N Graham, R Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment. California Climate Change Center, CEC-500-2009-014-F. 50pp.

https://www.researchgate.net/publication/231181370_Climate_change_scenarios_and_sea_level_rise_estimates_for_the_California_2009_climate_change_scenarios_assessment

Climate Justice Working Group. (2019). Advancing Climate Justice in California: Guiding Principles and Recommendations for Policy and Funding Decisions. https://climatechangepolicies.legislature.ca.gov/sites/climatechangepolicies.legislature.ca.gov/files/Advancing%20Climate%20Justice%20Report.pdf.

Cushing LJ, Y Ju, S Kulp, N Depsky, S Karasaki, J Jaeger, A Raval, B Strauss, R Morello-Frosch. 2023. Toxic Tides and Environmental Injustice: Social Vulnerability to Sea Level Rise and Flooding of Hazardous Sites in Coastal California. Environ. Sci. Technol. 2023, 57, 19, 7370–7381. https://doi.org/10.1021/acs.est.2c07481.

Cutler EM, MR Albert, CD White. 2020. Tradeoffs between beach nourishment and managed retreat: Insights from dynamic programming for climate adaptation decisions https://www.sciencedirect.com/science/article/pii/S1364815219303639

Cutter SL, BL Boruff, WL Shirley. 2003. Social vulnerability to environmental hazards. Social Science Quarterly, p. 243. https://doi.org/10.1111/1540-6237.8402002.

Cutter SL, CT Emrich, JJ Hanney (Webb), D Morath. 2009. Social Vulnerability to Climate Variability Hazards: A Review of Literature. Final Report to Oxfam America. 1-44.

Dangendorf, S., Hay, C., Calafat, F. M., Marcos, M., Piecuch, C. G., Berk, K., & Jensen, J. (2019). Persistent acceleration in global sea level rise since the 1960s. Nature Climate Change, 9(9), 705–710. https://doi.org/10.1038/s41558-019-0531-8

Dartt-Newton D, J Erlandson. 2006. “Little Choice for the Chumash: Colonialism, Cattle, and Coercion in Mission Period California.” The American Indian Quarterly 30. No. 3: 416–30. https://doi.org/10.1353/aiq.2006.0020.

DeConto RM, Pollard D. 2016. Contribution of Antarctica to past and future sea-level rise. Nature 531: 591-7

DeConto, R.M., Pollard, D., Alley, R.B. et al. The Paris Climate Agreement and future sea-level rise from Antarctica. Nature 593, 83–89 (2021). https://doi.org/10.1038/s41586-021-03427-0

Dettinger M. 2011. Climate change, atmospheric rivers, and floods in California – A multimodel analysis of storm frequency and magnitude changes. Journal of the American Water Resources Association 47(3): 514-523. doi: 10.1111/j.1752-1688.2011.00546.x.

Dunlop, T., Khojasteh, D., Cohen-Shacham, E. et al. 2024. The evolution and future of research on Nature-based Solutions to address societal challenges. Commun Earth Environ 5, 132. https://doi.org/10.1038/s43247-024-01308-8

Edwards BD, KR Evans. 2002. Saltwater Intrusion in Los Angeles Area Coastal Aquifers– the Marine Connection. U.S. Geological Survey Fact Sheet 030-02. http://geopubs.wr.usgs.gov/fact-sheet/fs030-02/.

Environmental Justice for All: A Fifty State Survey of Legislation, Policy and Cases, fourth edition (2010).

Fazey, I. R. A., Wise, R. M., Lyon, C., Campeanu, C., Moug, P., & Davies, T. E. (2015). Past and future adaptation pathways. Climate and Development. https://doi.org/10.1080/17565529.2014.989192

Flick RE, DB Chadwick, J Briscoe, KC Harper. 2012. “Flooding” versus “Inundation”, Eos 93(38): 365-366. doi: 10.1029/2012EO380009.

Fox-Kemper, B., H.T. Hewitt, C. Xiao, G. Aðalgeirsdóttir, S.S. Drijfhout, T.L. Edwards, N.R. Golledge, M. Hemer, R.E. Kopp, G. Krinner, A. Mix, D. Notz, S. Nowicki, I.S. Nurhati, L. Ruiz, J.-B. Sallée, A.B.A. Slangen, and Y. Yu, 2021: Ocean, Cryosphere and Sea Level Change. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1211–1362, doi:10.1017/9781009157896.011. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter09.pdf

Frederikse, T., Landerer, F., Caron, L., Adhikari, S., Parkes, D., Humphrey, V. W., Dangendorf, S., Hogarth, P., Zanna, L., Cheng, L., & Wu, Y.-H. (2020). The causes of sea level rise since 1900. Nature, 584(7821), 393–397. https://doi.org/10.1038/s41586-020-2591-3

Funayama K, E Hines, J Davis, S Allen. 2012. Effects of sea-level rise on northern elephant seals at Point Reyes peninsula, California. Aquatic Conservation: Marine and Freshwater Ecosystems 23(2): 233-245. doi: 10.1002/aqc.2318.

Garcia, R., & Flores Baltodano, E. (2005). Free the Beach! Public Access, Equal Justice, and the California Coast. Stanford Journal of Civil Rights and Civil Liberties. 143. https://www.coastal.ca.gov/coastalvoices/resources/StanfordFreetheBeach.pdf.

Gould, K & T Lewis. (2018). From Green Gentrification to Resilience Gentrification: An Example from Brooklyn. City & Community. 17:12-15. http://dx.doi.org/10.1111/cico.12283.

Governor’s Office of Planning and Research. (OPR). 2024. Vulnerable Communities Definition Modification. https://opr.ca.gov/climate/icarp/tac/meetings/2024-03-29/docs/20240329-Item6_Vulnerable_Communities_Definition_Update_Memo.pdf.

Griggs GB. 2010. Introduction to California's Beaches and Coast. University of California Press. 311 pp.

Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017. https://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

Griggs, G. and K. Patsch, 2019. "The protection/hardening of California's coast -- Times are changing." J. Coastal Research, 35(5), 1051-1061.

Hall, J.A., S. Gill, J. Obeysekera, W. Sweet, K. Knuuti, and J. Marburger, 2016: Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide. U.S. Department of Defense, Strategic Environmental Research and Development Program, Alexandria, VA, 224 pp. https://climateandsecurity.files.wordpress.com/2014/01/regional-sea-level-scenarios-for-coastal-risk-management_managing-uncertainty-of-future-sea-level-change-and-extreme-water-levels-fordepartment-of-defense.pdf

Hanson RT, P Martin, KM Koczot. 2002b. Simulation of Ground-Water/Surface-Water Flow in the Santa Clara–Calleguas Ground-Water Basin, Ventura County, California. US Geological Survey Water Resources Investigations Report 02-4136. 157 pp. http://pubs.usgs.gov/wri/wri024136/wrir024136.pdf.

Hanson RT, RR Everett, MW Newhouse, SM Crawford, MI Pimental, GA Smith. 2002a. Geohydrology of a Deep-Aquifer System Monitoring-Well Site at Marina, Monterey County, California. US Geological Survey Water-Resources Investigations Report 02-4003. 36pp. http://pubs.usgs.gov/wri/wri024003/pdf/text.pdf.

Hanson RT. 2003. Geohydrologic Framework of Recharge and Seawater Intrusion in the Pajaro Valley, Santa Cruz and Monterey Counties, California. US Geological Survey Water-Resources Investigations Report 03-4096. 88pp. http://pubs.usgs.gov/wri/wri034096/pdf/wri034096.pdf.

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. https://pacinst.org/wp-content/uploads/2014/04/sea-level-rise.pdf.

Hill, K., Hirschfeld, D., Lindquist, C., Cook, F., & Warner, S. (2023). Rising Coastal Groundwater as a Result of Sea-Level Rise Will Influence Contaminated Coastal Sites and Underground Infrastructure. Earth's Future, 11(9), e2023EF003825. https://doi.org/10.1029/2023EF003825

Hoffman, J.S., Shandas, V., & Pendleton, N. (2020). The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas. Climate, 8(1), 12, https://doi.org/10.3390/cli8010012.

Hoover DJ, KO Odigie, PW Swarzenski, P Barnard. 2016. Sea-level rise and coastal groundwater inundation and shoaling at select sites in California, USA. Journal of Hydrology: Regional Studies 11 (2017) 234–249. http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab_2601-2650/ab_2616_bill_20160924_chaptered.htm

Intergovernmental Panel on Climate Change (IPCC). 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

Izbicki JA. 1996. Seawater Intrusion in a Coastal California Aquifer. USGS Fact Sheet 96-125. http://pubs.usgs.gov/fs/1996/0125/report.pdf.

Jacquelynne R. King, Vera N. Agostini, Christopher J. Harvey, Gordon A. McFarlane, Michael G. G. Foreman, James E. Overland, Emanuele Di Lorenzo, Nicholas A. Bond, Kerim Y. Aydin, Climate forcing and the California Current ecosystem, ICES Journal of Marine Science, Volume 68, Issue 6, July 2011, Pages 1199–1216, https://doi.org/10.1093/icesjms/fsr009

Judicial Council of California, 2022

Kato-Huerta, Jarumi, Geneletti, Davide. 2022. Environmental justice implications of nature-based solutions in urban areas: A systematic review of approaches, indicators, and outcomes. Environmental Science and Policy. Volume 138. Pg. 122-133. https://doi.org/10.1016/j.envsci.2022.07.034

Kopp RE, RM Horton, CM Little, JX Mitrovica, M Oppenheimer, DJ Rassussen, BH Strauss, C Tebaldi. 2014. Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth's Future 2(8): 383-406. doi:10.1002/2014EF000239.

Kornell S. 2012. Will Climate Change Wipe Out Surfing? Pacific Standard. https://psmag.com/social-justice/will-climate-change-wipe-out-surfing-44209.

Kudela RM, S Seeyave, WP Cochlan. 2010. The role of nutrients in regulation and promotion of harmful algal blooms in upwelling systems. Progress in Oceanography 85: 122-135. doi: 10.1016/j.pocean.2010.02.008.

Leonard, K. 2021. WAMPUM Adaptation framework: eastern coastal Tribal Nations and sea level rise impacts on water security. Climate and Development, 13:9, 842-851, 10.1080/17565529.2020.1862739.

LeRoy, S. and R. Wiles. 2019. “High tide tax”, Center for Climate Integrity, 27 pp. https://www.climatecosts2040.org/files/ClimateCosts2040_Report.pdf

Lester C, M Matella. 2016. Managing the Coastal Squeeze: Resilience Planning for Shoreline Residential Development. Stanford Environmental Law, Journal 23, Vol 36. https://law.stanford.edu/wp-content/uploads/2017/11/lester.pdf.

Lester, C.; Griggs, G.; Patsch, K., and Anderson, R., 0000. Shoreline retreat in California: Taking a step back. Journal of Coastal Research, 00(0), 000–000. Coconut Creek (Florida), ISSN 0749-0208.

Limber PW, PL Barnard, S Vitousek, LH Erickson. 2018. A model ensemble for projecting multi-decadal coastal cliff retreat during the 21st century. Journal of Geophysical Research Earth Surface. https://doi.org/10.1029/2017JF004401

Little Hoover Commission (LHC). 2014. Governing California Through Climate Change. Report #221, July 2014. 98pp. https://lhc.ca.gov/report/governing-california-through-climate-change/.

Lowe JA, PL Woodworth, T Knutson, RE McDonald, KI McInnes, K Woth, H von Storch, J Wolf, V Swail, NB Berier, S Gulev, KJ Horsburgh, AS Unnikrishnan, JR Hunter, R Weisse. 2010. Past and future changes in extreme sea levels and waves. In: Understanding Sea-Level Rise and Variability, [JA Church, PL Woodworth, T Aarup, WS Wilson (eds.)]. Wiley-Blackwell, UK, pp. 326-375.

Lynn, Austin, and Tracy Elsey-Quirk. 2024. "Salt Water Exposure Exacerbates the Negative Response of Phragmites australis Haplotypes to Sea-Level Rise" Plants 13, no. 6: 906. https://doi.org/10.3390/plants13060906

May, C. 2020. "Rising groundwater and sea-level rise," Nature Climate Change, Nature, vol. 10(10), pages 889-890, October.

Melillo JM, TC Richmond, GW Yohe (eds). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. Report for the US Global Change Research Program, 841 pp. doi:10.7930/J0Z31WJ2.

Monterey County Water Resources Agency (MCWRA). 2012. Historic Seawater Intrusion Maps. Last accessed: 9 March 2015. http://www.mcwra.co.monterey.ca.us/seawater_intrusion_monitoring/seawater_intrusion_maps.php.

Moser SC, MA Davidson, P Kirshen, P Mulvaney, JF Murley, JE Neumann, L Petes, D Reed. 2014. Chapter 25: Coastal Zone Development and Ecosystems. In: Climate Change Impacts in the United States: The Third National Climate As-sessment, [JM Melillo, TC Richmond, GW Yohe (eds.)], US Global Change Research Program, pp. 579-618. doi:10.7930/J0MS3QNW.

Moser SC, MA Davidson, P Kirshen, P Mulvaney, JF Murley, JE Neumann, L Petes, D Reed. 2014. Chapter 25: Coastal Zone Development and Ecosystems. In: Climate Change Impacts in the United States: The Third National Climate As-sessment, [JM Melillo, TC Richmond, GW Yohe (eds.)], US Global Change Research Program, pp. 579-618. doi:10.7930/J0MS3QNW.

National Oceanic and Atmospheric Administration (NOAA). 2023. 2020 Marine Economy Report: California. Office for Coastal Management. Accessed 27 March 2024. https://coast.noaa.gov/data/digitalcoast/pdf/marine-economy-california.pdf

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.

Nerem, R. S., Beckley, B. D., Fasullo, J. T., Hamlington, B. D., Masters, D., & Mitchum, G. T. (2018). Climate-change–driven accelerated sea level rise detected in the altimeter era. Proceedings of the National Academy of Sciences, 115(9), 2022–2025. https://doi.org/10.1073/pnas.1717312115

Nishikawa T, AJ Siade, EG Reichard, DJ Ponti, AG Canales, TA Johnson. 2009. Stratigraphic controls on seawater intrusion and implications for groundwater management, Dominguez Gap area of Los Angeles, California, USA. Hydrogeology Journal 17(7): 1699-1725. doi: 10.1007/s10040-009-0481-8.

Ocean Protection Council (OPC). 2010. Interim Guidance: Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT). http://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20110311/12.SLR_Resolution/SLR-Guidance-Document.pdf.

Ocean Protection Council (OPC). 2013. State of California Sea-Level Rise Guidance Document. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf.

Ocean Protection Council (OPC). 2017. Rising Seas in California: An Update on Sea-Level Rise Science. https://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

Ocean Protection Council (OPC). 2018. State of California Sea-Level Rise Guidance: 2018 Update. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

Ocean Protection Guidance (OPC). 2024. State of California Sea Level Rise Guidance: 2024 Science & Policy Update https://opc.ca.gov/wp-content/uploads/2024/05/Item-4-Exhibit-A-Final-Draft-Sea-Level-Rise-Guidance-Update-2024-508.pdf

Parris A, P Bromirski, V Burkett, D Cayan, M Culver, J Hall, R Horton, K Knuuti, R Moss, J Obeysekera, A Sallenger, J Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp. http://scenarios.globalchange.gov/sites/default/files/NOAA_SLR_r3_0.pdf.

PELLOW, D. N. (2000). Environmental Inequality Formation: Toward a Theory of Environmental Injustice. American Behavioral Scientist, 43(4), 581-601. https://doi.org/10.1177/0002764200043004004

Ponti DJ, KD Ehman, BD Edwards, JC Tinsley III, T Hildenbrand, JW Hillhouse, RT Hanson, K McDougall, CL Powell II, E Wan, M Land, S Mahan, AM Sarna-Wojcicki. 2007. A 3-Dimensional Model of Water-Bearing Sequences in the Dominguez Gap Region, Long Beach, California. US Geological Survey Open-File Report 2007-1013. http://pubs.usgs.gov/of/2007/1013/.

Radke, J.D, G.S. Biging, K. Roberts, M. Schmidt-Poolman, H. Foster, E. Roe, Y. Ju, S. Lindbergh, T. Beach, L. Maier, Y. He, M. Ashenfarb, P. Norton, M. Wray, A. Alruheili, S. Yi, R. Rau, J. Collins, D. Radke, M. Coufal, S. Marx, A. Gohar, D. Moanga, V. Ulyashin, A. Dalal. (University of California, Berkeley) 2018. Assessing Extreme Weather-Related Vulnerability and Identifying Resilience Options for California's Interdependent Transportation Fuel Sector. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018-012.

Ranasinghe R, TM Duong, S Uhlenbrook, D Roelvink, M Stive. 2012. Climate-change impact assessment for inlet-interrupted coastlines. Nature Climate Change 3(1): 83-87. doi:10.1038/nclimate1664.

Reeder LA, TC Rick, JM Erlandson. 2010. Our disappearing past: a GIS analysis of the vulnerability of coastal archaeological resources in California's Santa Barbara Channel region. Journal of Coastal Conservation 16(2): 187-197. doi: 10.1007/s11852-010-0131-2.

Reineman, D. R., Thomas, L. N., & Caldwell, M. R. (2017). Using local knowledge to project sea level rise impacts on wave resources in California. Ocean & Coastal Management, 138, 181–191. https://doi.org/10.1016/j.ocecoaman.2017.01.020

Reineman, D.R., Wedding, L.M., Hartge, E.H., McEnery W., & Reiblich, J. (2016). Coastal Access Equity and the Implementation of the California Coastal Act. Stanford Environmental Journal of

Law, Vol. 36:89, pp 89-108. https://law.stanford.edu/wpcontent/uploads/2017/11/reineman.pdf.

Revell DL, R Battalio, B Spear, P Ruggiero, J Vandever. 2011. A methodology for predicting future coastal hazards due to sea-level rise on the California coast. Climatic Change 109(Suppl 1): 251-276. doi:10.1007/s10584-011-0315-2.

Roos, M. (2018). Climate Justice Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-012. (E4 Strategic Solutions). https://resourceslegacyfund.org/wp-content/uploads/2018/09/Climate-Justice-Report-4CCCAv.4-00455673xA1C15.pdf

Rowland-Shea, J, S Doshi, S Edberg, R Fanger. 2020. The Nature Gap: Confronting Racial and Economic Disparities in the Destruction and Protection of Nature in America. Center for American Progress. https://www.americanprogress.org/wpcontent/uploads/sites/2/2020/07/The-Nature-Gap4.pdf.

Ryan JP, MA McManus, JM Sullivan. 2010. Interacting physical, chemical and biological forcing of phytoplankton thin-layer variability in Monterey Bay, California. Continental Shelf Research 30(1): 7-16. doi:10.1016/j.csr.2009.10.017.

Sadrpour, N., & Reineman, D. R. (2023). The impacts of climate change on surfing resources. Shore & Beach, 91(1), 32-48. https://doi.org/10.34237/1009113

San Francisco Bay Conservation and Development Commission. 2024. Regional Shoreline Adaptation Plan. Bay Adapt. https://www.bayadapt.org/regional-shoreline-adaptation-plan/

Sea-Level Rise Leadership Team. (January 2022). State Agency Sea-Level Rise Action Plan for California. https://www.opc.ca.gov/webmaster/_media_library/2022/02/Item-7_Exhibit-A_SLR-Action-Plan-Final.pdf

Senate Bill No. 1, Atkins. Coastal resources: sea level rise. 2021. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB1

Senate Bill No. 272, Laird. Sea level rise: planning and adaptation. 2023. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB272

Siders, A.R., Ajibade, I. 2021. Introduction: Managed retreat and environmental justice in a changing climate. J Environ Stud Sci 11, 287–293. https://doi.org/10.1007/s13412-021-00700-6.

State of California: Governor's Office of Planning and Research, Baca, E., McCormick, M., Litchney, S., & Shirazi, S. (n.d.). 2023. General Plan Guidelines. https://opr.ca.gov/docs/OPR_COMPLETE_7.31.17.pdf

Sweet, W. V., Kopp, R. E., Weaver, C. P., Obeysekera, J., Horton, R. M., Thieler, E. R., & Zervas, C. (2022). Global and regional sea level rise scenarios for the United ... GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES. https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nostechrpt01-global-regional-SLR-scenarios-US.pdf

Taylor, D.E. (2000). The Rise of the Environmental Justice Paradigm: Injustice Framing and the Social Construction of Environmental Discourses. American Behavioral Scientist, 43(4), 508-580. https://doi.org/10.1177/0002764200043004003.

The California Department of Transportation (Caltrans). 2019. Climate Change Vulnerability Assessments. https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/air-quality-and-climate-change/2019-climate-change-vulnerability-assessments

The California Department of Transportation (Caltrans). 2020. Adaptation Priorities Reports. https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/air-quality-and-climate-change/2020-adaptation-priorities-reports

The California Department of Transportation (Caltrans). 2021. Caltrans Climate Change Vulnerability Assessment Statewide Summary Report. 28 pp. https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/office-of-smart-mobility-and-climate-change/caltrans-climate-change-vulnerability-assessment-statewide-summary-feb2021-a11y.pdf

The California Department of Transportation (Caltrans). 2021. Climate Action Plan for Transportation Infrastructure (CAPTI). 47 pp. https://calsta.ca.gov/-/media/calsta-media/documents/capti-july-2021-a11y.pdf

The California Department of Transportation (Caltrans). 2022. Climate Change Emphasis Area Guidance for Corridor Planning. 58 pp. https://dot.ca.gov/-/media/dotmedia/programs/transportation-planning/documents/cc-ea-guide-for-corridor-planning-march2022-a11y.pdf

The California Department of Transportation (Caltrans). 2023. Adaptation Strategies for Transportation Infrastructure. 21 pp. https://dot.ca.gov/-

/media/dotmedia/programs/transportation-planning/documents/adaptation-strategies-transportation-infrastructure-a11y.pdf

The California Department of Transportation (Caltrans). 2024. State Climate Resilience Improvement Plan for Transportation. 47pp. https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/division-transportation-planning/2023-script-final-with-letters-a11y.pdf

The San Francisco Bay Conservation and Development Commission (BCDC). 2021. San Francisco Bay Plan Climate Change Policy Guidance. https://bcdc.ca.gov/bpacc/San-Francisco-Bay-Plan-Climate-Change-Policy-Guidance.pdf

The White House. (2021). Executive Order 14008 on Tackling the Climate Crisis at Home and Abroad. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

The White House. (2023). Executive Order 14096 Revitalizing Our Nation's Commitment to Environmental Justice for All. https://www.whitehouse.gov/briefing-room/presidential-actions/2023/04/21/executive-order-on-revitalizing-our-nations-commitment-to-environmental-justice-for-all/

The White House. 2022. Government-Wide Environmental Justice Initiative Called Justice40 https://www.whitehouse.gov/environmentaljustice/justice40/

Thompson, P. R., Widlansky, M. J., Hamlington, B. D., Merrifield, M. A., Marra, J. J., Mitchum, G. T., & Sweet, W. (2021). Rapid increases and extreme months in projections of United States high-tide flooding. Nature Climate Change, 11(7), 584–590. https://doi.org/10.1038/s41558-021-01077-8

Titus JG (ed.). 1988. Greenhouse Effect, Sea Level Rise, and Coastal Wetlands. US Environmental Protection Agency, Office of Wetland Protection. EPA-230-05-86-013. 156 pp. http://papers.risingsea.net/Sea-level-rise-and-coastal-wetlands.html.

Turner BL, EF Lambin, A Reenberg. 2007. The emergence of land change science for global environmental change and sustainability
Uhler, B., & Chu, C. (2019). California's Geography of Wealth. California Legislative Analyst's Office. https://lao.ca.gov/reports/2019/4093/ca-geography-wealth-090519.pdf.

United States Environmental Protection Agency. (2021). Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency. EPA 430-R-21-003. www.epa.gov/cira/social-vulnerability-report.

United States Environmental Protection Agency. (2022). Environmental Justice Timeline. https://www.epa.gov/environmentaljustice/environmental-justice-timeline.

United States Environmental Protection Agency. (2024). "Learn about Environmental Justice." https://www.epa.gov/environmentaljustice/learn-about-environmental-justice

Van Dyke E. 2012. Water levels, wetland elevations, and marsh loss. Elkhorn Slough Technical Report Series 2012: 2. 20pp. http://library.elkhornslough.org/research/bibliography/VanDyke_2012_Water_Levels_Wetland_Elevations.pdf.

Vitousek S, PL Barnard, CH Fletcher, N Frazer, L Erickson, CD Storlazzi. 2017. Doubling of coastal flooding frequency within decades due to sea-level rise. Scientific Reports 7(1399). DOI:10.1038/s41598-017-01362-7

Vitousek, S., Cagigal, L., Montaño, J., Rueda, A., Mendez, F., Coco, G., & Barnard, P. L. (2021). The Application of Ensemble Wave Forcing to Quantify Uncertainty of Shoreline Change Predictions. Journal of Geophysical Research: Earth Surface, 126(7), e2019JF005506. https://doi.org/10.1029/2019JF005506

Vitousek, S., Vos, K., Splinter, K. D., Erikson, L., & Barnard, P. L. (2023). A Model Integrating Satellite-Derived Shoreline Observations for Predicting Fine-Scale Shoreline Response to Waves and Sea-Level Rise Across Large Coastal Regions. Journal of Geophysical Research: Earth Surface, 128(7), e2022JF006936. https://doi.org/10.1029/2022JF006936

Willis, J., Hamlington, B., & Fournier, S. (2023). Global Mean Sea Level, Trajectory and Extrapolation (Version 101) [dataset]. Zenodo. https://doi.org/10.5281/zenodo.7702315

Wood, N., Jones, J.M., Henry K., Ng, P., Hou, C.Y., 2020, Hazard Exposure Reporting and Analytics, U.S.Geological Survey web application, https://www.usgs.gov/apps/hera

Appendices

Appendices: Table of Contents

Appendix A. Sea Level Rise Science and Scenarios of Future Change

Drivers of Sea Level Rise

The main mechanisms driving increases in *global* sea level are: 1) expansion of sea water as it gets warmer (thermal expansion) and, 2) increases in the amount of water in the ocean from melting of land-based ice sheets and glaciers. Less significant contributors include human-induced changes in water storage and groundwater pumping.[109]

Sea level at the *regional and local levels* often differs from the average global sea level.[110] Regional variability in sea level results from large-scale tectonics and ocean and atmospheric circulation patterns. The primary factors influencing local sea level include tides, waves, atmospheric pressure, winds, vertical land motion and short duration changes from seismic events, storms, and tsunamis. Other determinants of local sea level include changes in the ocean floor (Smith and Sandwell 1997), confluence of fresh and saltwater, and proximity to major ice sheets (Clark *et al.* 1978; Perette *et al.* 2013; Fox-Kemper *et al*., 2021). Table 9.7 in the IPCC Sixth Assessment Report summarizes all global, regional, and local processes driving sea level rise. In California, long tide gauge records together with recent observations suggest that the long term sea level rise trend in California will track the global average (Hamlington *et al*., 2021).

Several other factors can influence local water levels in California, and these influences should be analyzed along with local sea level rise when examining local hazard conditions. For example, California's water levels are influenced by large-scale oceanographic phenomena such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), which can increase or decrease coastal water levels for extended periods of time. For example, strong El Niño events can temporarily elevate local sea levels by six to twelve inches over several months, while more sustained changes in ocean temperature and atmospheric circulation patterns can affect sea level on the order of decades. Over the past 30 years, for example, sea level rise was essentially absent during the first 15 years and then substantially accelerated during the second half due to the combined effects of ENSO and PDO (Hamlington *et al*., 2021) Please see Appendix B for more detail on how to incorporate both sea level rise and seasonal and temporary influences on water levels into local hazards analyses.

Approaches for Projecting Future Global Sea Level Rise

As summarized above, there are several different drivers of sea level rise, and scientists are using a variety of methods to research each one and project their future contributions to sea level rise (see box below). For some, like thermal expansion, there is thorough research and fairly high agreement about how it may respond to different levels of warming and contribute

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[109] Large movements of the tectonic plates have been a third major mechanism for changes in global sea level. The time periods for plate movements to significantly influence global sea level are beyond the time horizons used for even the most far-reaching land-use decisions. Plate dynamics will not be included in these discussions of changes to future sea level.

to global sea level rise in the future; whereas others, like certain ice sheet melt processes, are areas of developing research where more work is needed.

Many reports, including the IPCC Assessment Reports, build global mean sea level rise projections by totaling the contributions of each major driver of sea level rise under certain assumptions about what the global climate will look like in the future. Because each driver has its own degree of scientific uncertainty,[111] total sea level rise reflects the various uncertainties associated with each contributor. Total sea level rise projections are then presented as means (or averages) with uncertainty bands around them, and users often look at the mean, the likely range (i.e., the middle 66% of the uncertainty range, or 17th to 83rd percentiles), and the very likely range (i.e., the middle 90% of the uncertainty range, or the 5th to 95th percentiles) to understand how much sea level rise could potentially occur under the given assumptions about emissions and warming. Estimates of sea level rise produced in this manner are known as "probabilistic projections." In addition to the IPCC Assessment Reports, other studies that produced projections include Kopp *et al*., 2014, the Fourth California Climate Assessment, and *Rising Seas in California* (Griggs *et al*., 2017). Each produced projections for various Representative Concentration Pathways (RCPs), the emissions scenarios defined by the IPCC.

Besides probabilistic projections, another way that researchers often present potential future sea level rise is in the form of "scenarios." Unlike projections, which are based on pre-defined assumptions about future greenhouse gas emissions and global warming, scenarios are instead hypothetical futures that span the range of what is considered plausible sea level rise according to the best available science. They often span several sets of projections that cover multiple potential emissions futures, and they can be compared to probabilistic projections to describe their likelihoods under various emissions futures. Examples of reports that provide scenarios include Parris *et al*., 2012, Hall *et al*., 2016, Sweet *et al*., 2017, Sweet *et al*., 2022, and the State Sea Level Rise Guidance (OPC 2024).

[111] To describe the varying statuses of scientific research on different research topics, the IPCC established a common approach for evaluating and communicating the degree of certainty in findings. It defined a range of "confidence levels" to describe the level of evidence and degree of agreement in the body of scientific literature on a particular subject (very low, low, medium, high, and very high). Table 9.7 in the IPCC Sixth Assessment report summarizes the methods used to generate the projections of SLR resulting from each physical driver of SLR as well as the degree of confidence in each.

Categories of methods for projecting future change

Scientists have employed a variety of techniques to model the various mechanisms that contribute to sea level rise, including:

1. **Physical Models**. Physical climate models use mathematical equations that integrate the basic laws of physics, thermodynamics, and fluid dynamics with chemical reactions to represent physical processes such as atmospheric circulation, transfers of heat (thermodynamics), development of precipitation patterns, ocean warming, and other aspects of climate. Some models represent only a few processes, such as the dynamics of ice sheets. Other models represent larger scale atmospheric or oceanic circulation, and some of the more complex General Climate Models (GCMs) include atmospheric and oceanic interactions. AR6 sea level rise projections drew from the sixth Coupled Model Intercomparison Project (CMIP6) climate models, particularly to inform sea level rise contributions based on medium confidence processes (i.e., processes of sea level rise for which the AR6 scientists had medium or higher confidence) from thermal expansion and ice sheets.
2. **Empirical or semi-empirical methods**. The semi-empirical method for projecting sea level rise is based on developing a relationship between sea level and some factor (a proxy) – often atmospheric temperature or radiative forcing – and using this relationship to project changes to sea level. An important aspect for the proxy is that there is fairly high confidence in models of its future changes; a key assumption that is made by this method is that the historical relationship between sea level and the proxy will continue into the future. For example, Rahmstorf 2007 projected future sea levels based on the historical relationship between global temperature changes and sea level changes.
3. **Expert elicitations**. Expert elicitation is a formalized use of experts in climate science and sea level change to help either narrow uncertainty for sea level projections, or to help with specifying extremes of a range. For example, Bamber and Aspinall (2013) used a statistical analysis of a large number of expert estimates to develop their projected range of future sea level, projecting sea level rise by 2100 ranging from 1–4.3 ft (0.33–1.32 m). Bamber *et al*., 2019 used structured expert judgement to quantify contributions to total sea level rise from Greenland and Antarctica ice sheets, and these estimates were incorporated into AR6 sea level rise projections.
4. **Extrapolations of historical trends**. Using extrapolation of historical trends in sea level to project future changes in sea level assumes that there will be no abrupt changes in the processes that drive the long-term trend, and that the driving forces will not change, which is not the case. An alternative approach is to estimate rates of sea level rise during the peak of the last interglacial (LIG) period (~125,000 years before present, when some drivers of sea level rise were similar to those today)[112] and use these as proxy records to project sea level rise rates to the 21st Century. For example, Kopp *et al.* (2009) used sea level rise rates inferred from the LIG to estimate a range of sea level rise for Year 2100 between 1-3 ft (0.3-1 m).

[112] During the last interglacial, global mean temperature was 1-2ºC warmer than the pre-industrial era (Levermann *et al.* 2013), while global mean sea level was likely 16.4-29.5 ft (5-9 m) above present mean sea level (Kopp *et al.* 2009; Dutton and Lambeck 2012; Levermann *et al.* 2013).

The State Sea Level Rise Guidance (OPC 2024) drew from the sea level rise scenarios in a federal report, *Global and Regional Sea Level Rise Scenarios for the United States* (Sweet *et al*., 2022). This report updated a set of global mean sea level rise scenarios that had been included in the previous iteration of the report which was published in 2017. These 2017 scenarios included 0.3, 0.5, 1.0, 1.5, 2.0, and 2.5 meters in 2100, also called Low, Intermediate-Low, Intermediate, Intermediate-High, High, and Extreme. The 2.5-meter-in-2100 scenario was included in this 2017 set of scenarios to capture the amount of sea level rise that could occur due to possible extreme Antarctic ice sheet and ice cliff instability as described in the then-recently released 2016 report by DeConto & Pollard.

However, a subsequent report, DeConto *et al*., 2021, looked at updated regional climate model forcing and found that air temperatures are not expected to rise as quickly in Antarctica as presumed in DeConto & Pollard 2016; rather, warming may take about 25 years longer to rise enough to potentially trigger the mechanisms of rapid retreat of the Antarctic Ice Sheet[113] that were described in DeConto & Pollard 2016 – i.e., by about the year 2125. Due to this change, Sweet *et al*., 2022 did not include the 2.5-meters-in-2100 (or Extreme) sea level rise scenario, leaving 0.3, 0.5, 1.0, 1.5, and 2.0 meter-in-2100 scenarios, which were called the Low, Intermediate-Low, Intermediate, Intermediate-High and High scenarios.

In effect, this action backtracked on the reasoning that led to the inclusion of 2.5 meters-in-2100 (which was regionalized to 10.2 feet-in-2100 in California) in Sweet et al., 2017, Rising Seas in California, and the 2018 version of the State Sea Level Rise Guidance. This change caused Sweet et al., 2022 to state, "the 'Extreme' scenario from the 2017 report (2.5 m global mean sea level rise by 2100) is now viewed as less plausible and has been removed." In other words, while 2.5 meters of sea level rise could occur a few decades after the year 2100 in the worst-case scenario, updated research has concluded that there is not a possibility of that amount of sea level rise occurring as early as the year 2100 (DeConto *et al*., 2021).

Similar to Sweet *et al*., 2017, which overlaid its sea level rise scenarios with probabilistic sea level rise projections based on a group of papers, Sweet *et al*., 2022 overlaid its scenarios with the probabilistic projections from AR6. An associated FAQ describing the methods used in Sweet *et al*., 2022 states,

> "To generate the scenarios used in this report, the ensemble – or set – of projections in the AR6 that are tied to specific shared societal pathways (SSPs) are filtered to identify subsets of pathways that are consistent with the scenario target values in 2100 (i.e., 0.3 m, 0.5 m, 1 m, 1.5 m and 2 m). As in the AR6, these scenarios are regionalized and then

[113] DeConto *et al*., 2021 states, "With more extreme RCP8.5 warming, thinning and hydrofracturing of buttressing ice shelves becomes widespread, triggering marine ice instabilities in both West and East Antarctica. The RCP8.5 median contribution to GMSL is 34 cm by 2100. This is substantially less than reported by ref. 8 [DeConto & Pollard 2016] (64–105 cm), owing to a combination of improved model physics and revised atmospheric forcing (Methods) that delays the onset of surface melt by about 25 years. Nonetheless, the median contribution to GMSL reaches 1 m by 2125 and rates exceed 6 cm yr−1 by 2150 (Extended Data Figs. 6, 7). By 2300, Antarctica contributes 9.6 m of GMSL rise under RCP8.5, almost 10 times more than simulations limiting warming to +1.5 °C."

> provided at individual tide gauge locations. The median, 17th and 83rd percentile values are provided for each scenario at each region and location."

In other words, a subset of sea level rise curves from the sets of AR6 projections that go through 0.3, 0.5, 1.0, 1.5 and 2.0 meters in the year 2100 were identified, thus informing each Sweet *et al*., 2022 scenario. This exercise was also summarized in Chapter 2 of the State Sea Level Rise Guidance (2024).

The information pulled through from AR6 also yielded a "storyline" for each scenario, which is summarized in Figure 4 of the report and copied below. For example, the Intermediate, Intermediate-High and High scenarios correspond to projections in AR6 that assume high emissions and warming and various levels of contribution from low confidence ice sheet processes (see below). The information from AR6 also allowed Sweet *et al*., 2022 to provide exceedance probabilities for various sea level rise amounts at various times in the future and under different amounts of global warming.

BEST AVAILABLE SCIENCE ON SEA LEVEL RISE

In the past century, global mean sea level (GMSL) has increased by nearly 8 inches (20 cm; Fox-Kemper *et al*., 2021). Observations of sea level rise rates have also shown that sea level rise has been accelerating in recent decades. While tide gauge measurements show roughly 5 inches of sea level rise during the entirety of the 20th century (Frederikse *et al*., 2020), satellite altimeters have measured an additional 4 inches of sea level rise since 1993, a period of only 30 years (Willis, Hamlington, Fournier, 2023). The current rate of GMSL rise (1.7 inches/decade) is triple the 20th century rate (Dangendorf *et al*., 2019; Nerem *et al*., 2018). The best available science on projected future sea level rise is summarized here and in the Ocean Protection Council's State Sea Level Rise Guidance (OPC 2024).

Global Projections of Sea Level Rise

IPCC AR6: The best available science on global sea level rise projections is currently the IPCC Sixth Assessment Report: Climate Change 2013 (AR6) released in 2021 (IPCC, 2021). AR6 projects slightly more rapid sea level rise compared to the Fifth Assessment (AR5) released in 2013. By Year 2100, the AR6 projects likely global sea level rise in the year 2100 to be 0.63–1.01 m whereas AR5 projected 0.49–0.95 m (AR5) when comparing similar, high emission scenarios.

Like AR5, AR6 produced projections of sea level rise by compiling the latest research on the various drivers of sea level rise, including thermal expansion of seawater, melting of land-based ice in Antarctica and Greenland, and other processes. Some drivers of sea level rise were well studied and there was strong agreement about their potential future contributions to sea level rise, whereas others were less studied and not as well understood. The AR6 authors distinguished between drivers of sea level rise in which there was at least medium confidence and drivers in which there was low confidence. Projections based on medium-confidence processes were computed for the emissions and global development futures called SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5[114]. For two of these five emissions scenarios, SSP1-2.6 and SSP5-8.5, additional work was done to also incorporate low confidence processes of extreme ice melt in Antarctica, including those described in DeConto *et al*., 2021[115], creating two additional sets of projections for a total of seven different sets of sea level rise projections. Figure A-1 is a graph generated by NASA and the IPCC's Sea Level Projection Tool that depicts the global mean sea level rise projections under all seven SSPs. Together, these seven sets of projections describe the IPCC's full plausible range of future sea level rise, reflecting how sea level rise would vary under the IPCC's range of conceivable global development, emissions, and warming futures as well as the possibility of rapid ice sheet disintegration.

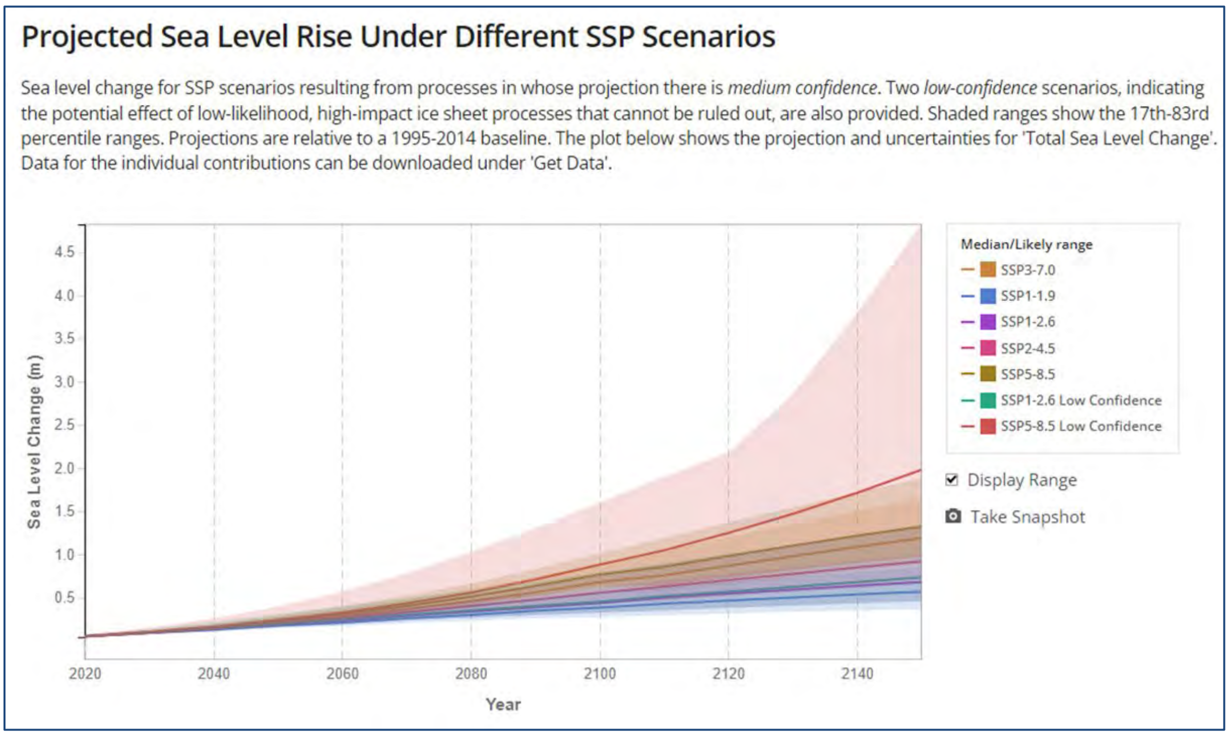


Figure A-1. IPCC AR6 plausible range of future SLR. A graph generated by NASA and the IPCC's Sea Level Projection Tool that depicts the global mean SLR projections under all five SSPs, plus the two additional scenarios that incorporate additional low confidence ice sheet processes.

[114] The Scenario Model Intercomparison Project (ScenarioMIP) for the Coupled Model Intercomparison Project Phase 6 (CMIP6) developed five different Shared Socioeconomic Pathways (SSP1 through SSP5) (O'Neill *et al*., 2016). These SSPs capture different ways the world could evolve in terms of population, economic growth, education, urbanization, and technological development, which, without additional new efforts to curb climate change. Each would result in various amounts of radiative forcing, which is expressed in the second half of the SSP name. For example, SSP3-7.0 comes from SSP3 and results in 7.0 Watts/m^2 of radiative forcing.

[115] Low confidence processes include earlier-than-projected disintegration of marine ice shelves and the abrupt, widespread onset of Marine Ice Sheet Instability (MISI) and Marine Ice Cliff Instability (MICI) around Antarctica, as well as faster-than-projected changes in the surface mass balance and dynamical ice loss from Greenland. AR6's low confidence SLR projections stemmed from a structured expert-judgement study (Bamber *et al*., 2019) and a single Antarctic ice-sheet modeling study (DeConto *et al*., 2021). See §9.6.3.2, §9.6.3.3, and Box 9.4 of Fox-Kemper *et al*., 2021, for further discussion. Box 9.4 of AR6's Chapter 9, in particular, discusses AR6's separation of medium-confidence sea level rise SLR projections from low-confidence sea level rise projections.

NOAA technical report: In 2017, NOAA released a report entitled Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al., 2017) which provided global sea level rise scenarios and projections[116]. It provided scenarios of 0.3, 0.5, 1.0, 1.5, 2.0, and 2.5 meters in 2100 (also called Low, Intermediate-Low, Intermediate, Intermediate-High, High, and Extreme), and overlaid them with emissions-based, probabilistic sea level rise projections compiled from Church *et al*., 2013a (which is IPCC's Fifth Assessment Report, or AR5), Miller *et al*., 2013; Kopp *et al*., 2014, 2016a; Slangen *et al*., 2014; and Mengel *et al*., 2016, which produced probabilistic projections under assumed climate trajectories of RCPs 2.6, 4.5, and 8.5.

When discussing how to apply the scenarios, Sweet *et al* 2017 suggested a potential strategy as follows: "Define a scientifically plausible upper-bound (which might be thought of as a worst-case or extreme scenario) as the amount of sea level rise that, while low probability, cannot be ruled out over the time horizon being considered. Use this upper-bound scenario as a guide for overall system risk and long-term adaptation strategies. Define a central estimate or mid-range scenario (given assumptions about greenhouse gas emissions and other major drivers). Use this scenario as baseline for shorter-term planning, such as setting initial adaptation plans for the next two decades."

In 2022, an update to Sweet et al., 2017 titled, Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al., 2022) was released, which incorporated new research that occurred between 2017 and 2022. Of the many papers published in that time period was DeConto et al., 2021, which built on the DeConto & Pollard 2016 paper that was key in justifying the inclusion of 2.5 meters-in-2100 as a sea level rise scenario in Sweet et al., 2017. DeConto et al., 2021 looked at updated regional climate model forcing and found that air temperatures are not expected to rise as quickly in Antarctica as presumed in DeConto & Pollard 2016; rather, warming may take about 25 years longer to rise enough to potentially trigger the mechanisms of rapid retreat of the Antarctic Ice Sheet[117] that were described in DeConto & Pollard 2016 – i.e., by about the year 2125. Due to this change, Sweet et al., 2022 removed 2.5-meters-in-2100 (or Extreme) sea level rise scenario, leaving 0.3, 0.5, 1.0, 1.5, and 2.0 meter-in-2100 global mean scenarios, which were called the Low, Intermediate-Low, Intermediate, Intermediate-High and High scenarios. Figure A-2 is a graph generated by NASA Interagency Sea Level Rise Scenario Tool that depicts Sweet *et al*., 2022's five sea level rise scenarios.

[116] Note that The Fourth National Climate Assessment (USGCRP, 2018) points to the scenarios of Sweet et al., 2017 and includes a discussion of other studies that provide sea level rise estimates as well as a discussion of overall uncertainty (see pages 106-109).

[117] DeConto et al., 2021 states, "With more extreme RCP8.5 warming, thinning and hydrofracturing of buttressing ice shelves becomes widespread, triggering marine ice instabilities in both West and East Antarctica. The RCP8.5 median contribution to GMSL is 34 cm by 2100. This is substantially less than reported by ref. 8 [DeConto & Pollard 2016] (64–105 cm), owing to a combination of improved model physics and revised atmospheric forcing (Methods) that delays the onset of surface melt by about 25 years. Nonetheless, the median contribution to GMSL reaches 1 m by 2125 and rates exceed 6 cm yr−1 by 2150 (Extended Data Figs. 6, 7). By 2300, Antarctica contributes 9.6 m of GMSL rise under RCP8.5, almost 10 times more than simulations limiting warming to +1.5 °C."

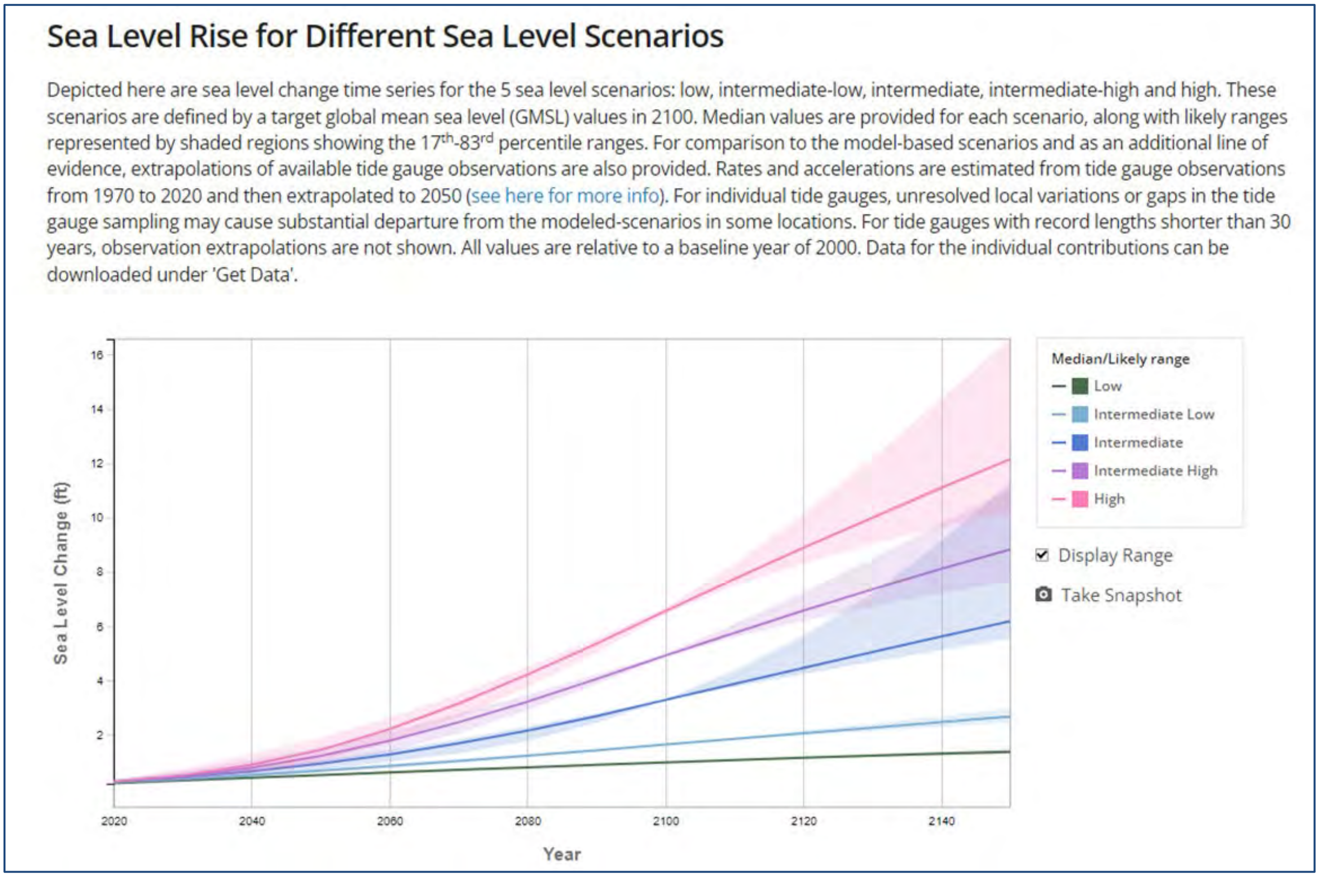


Figure A-2. Global SLR Scenarios from Sweet *et al.*, 2022. This graph was generated by NASA Interagency Sea Level Rise Scenario Tool and depicts Sweet *et al.*, 2022's five global mean sea level rise scenarios.

National Projections of Sea Level Rise

NOAA technical report: In addition to providing global mean sea level rise scenarios, Global and Regional Sea Level Rise Scenarios for the United States (Sweet *et al.*, 2022) provided scenarios for the contiguous United States by regionalizing the global scenarios. This process reflects how sea level rise around the United States may differ from the global average due to ocean dynamics (i.e., changes to the ocean's currents and density due to climate change), large scale vertical land motion (i.e., glacial isostatic adjustment (GIA), tectonics, sediment compaction, and/or groundwater and fossil fuel withdrawals), and the impacts of gravitational, rotational, and deformational changes (i.e., GRD, or ice sheet fingerprinting). In general, sea level rise scenarios for the United States are at or higher than global mean sea level rise due to effects from vertical land motion, GRD, and ocean circulation changes (Sweet *et al.*, 2022). Figure A-3 is a graph generated by NASA Interagency Sea Level Rise Scenario Tool that depicts the five sea level rise scenarios regionalized for the contiguous United States.

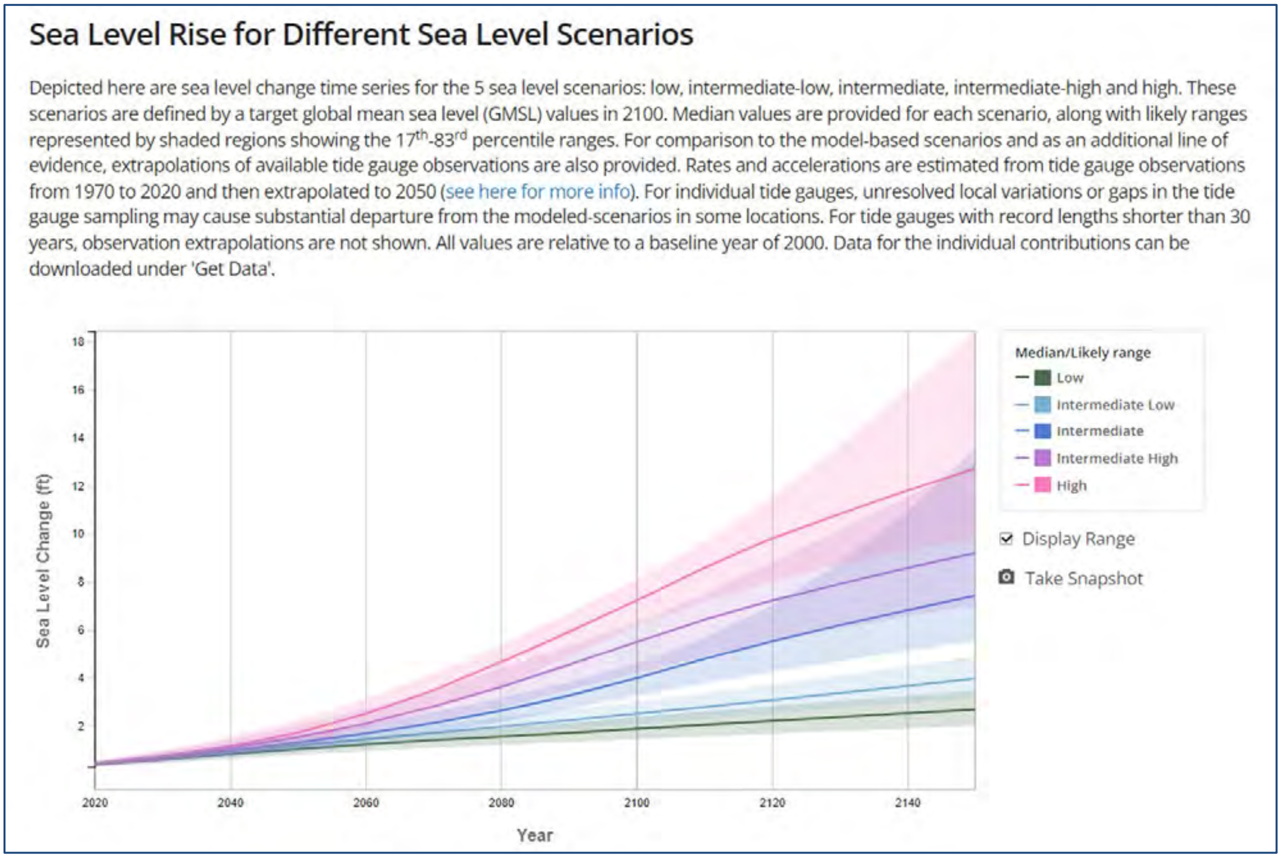


Figure A-3. SLR Scenarios for the contiguous United States from Sweet *et al*., 2022. This graph was generated by NASA [Interagency Sea Level Rise Scenario Tool]() and depicts Sweet *et al*., 2022's five sea level rise scenarios for the contiguous United States.

California-Specific Sea Level Rise Scenarios and Best Available Science

The State of California has long supported the development of scientific information on climate change and sea level rise to help guide planning and decision-making. Several iterations of the *State Sea Level Rise Guidance* have been informed by key research that, at the time, provided the best available science on sea level rise projections:

- The 2013 State Sea-Level Rise Guidance (OPC 2013) was informed by the 2012 National Research Council (NRC) report, Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future.
- The 2018 State Sea Level Rise Guidance (OPC 2018) was informed by Rising Seas in California: An Update on Sea-Level Rise Science (Griggs et al., 2017).
- The 2024 State Sea Level Rise Guidance (OPC 2024) was informed by Global and Regional Sea Level Rise Scenarios for the United States (Sweet et al., 2022).

The 2024 State Sea Level Rise Guidance provides sea level rise scenarios based on Sweet et al., 2022.[118] Like Sweet et al., 2022, the State Guidance establishes the plausible range of global mean sea level rise in 2100 to be between 0.3 and 2.0 m and identifies roughly even increments of sea level rise to span that range: 0.3-, 0.5-, 1.0-, 1.5-, and 2.0 m-in-2100. These five scenarios are named Low, Intermediate-Low, Intermediate, Intermediate-High, and High.

Next, these sea level rise amounts were compared to the thousands of sea level rise projections within the seven sea level rise projections the provided in AR6. A +/- 2 cm "gate" around each scenario was created (i.e., 0.3m +/- 2cm in 2100, 0.5m +/- 2cm in 2100, 1.0m +/- 2cm in 2100, etc.) and the samples of AR6 projections that go through each gate were extracted, creating five sample sets, as shown in Figure A-4.

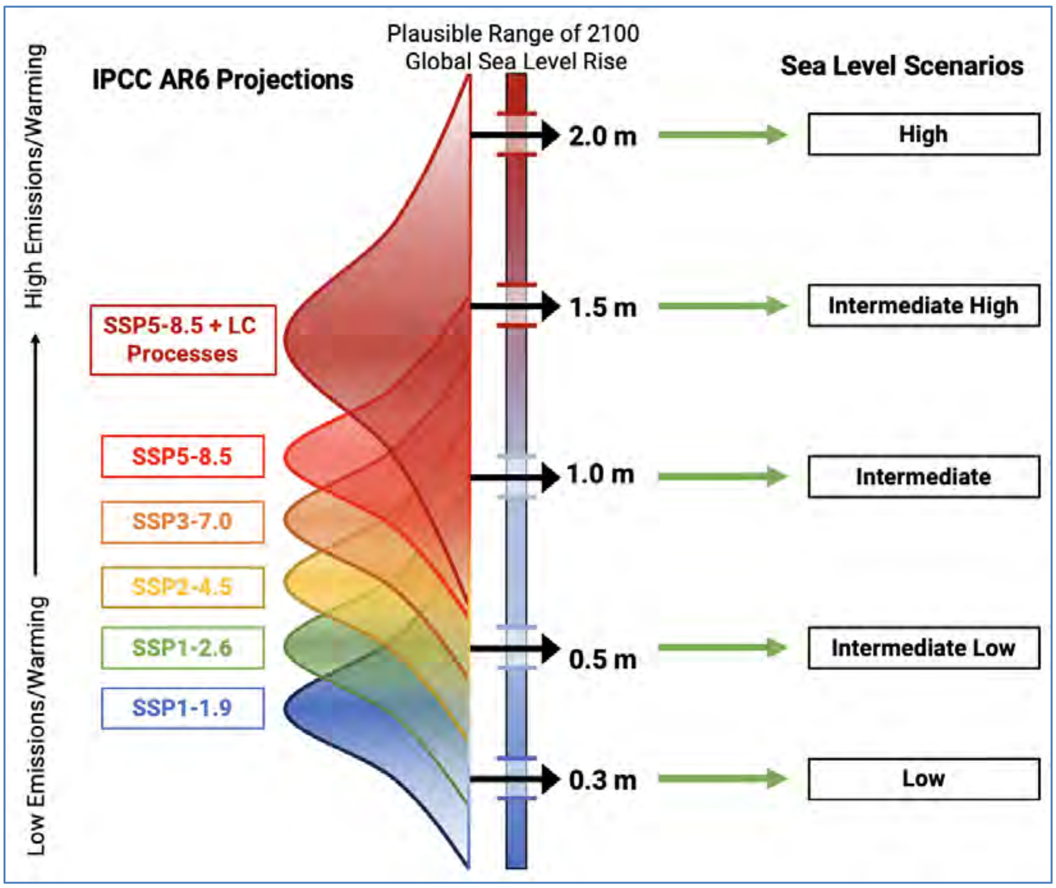


Figure A-4. Schematic showing that the construction of the sea level scenarios is based on SSPs, which inform a range of plausible future sea level rise. Provided as Figure 2.2 in the *California State Sea Level Rise Guidance* (OPC 2024)

The composition of these sample sets informed both the trajectory of each sea level rise scenario over time and a "storyline" for each scenario. In other words, the sample set for each scenario was used to describe the climate conditions under which each may occur. The State

[118] Please see Chapter 2 of the 2024 State Sea Level Rise Guidance to read the report's full summary of how the sea level rise scenarios were generated.

Sea Level Rise Guidance provides these storylines in Section 2.4 and summarizes them in its Executive Summary as follows:

- **"Low Scenario**: The target of 1 foot of increase in global sea level rise by 2100 is set under the assumption of the current rate of sea level rise continuing on into the future. This assumption is inconsistent with current observations of an acceleration in sea level rise, but could still be considered plausible under the most aggressive emission reduction scenarios. As a result, the Low Scenario provides the lower bound for plausible sea level rise in 2100 and sits below the median value for all AR6 scenarios at all times between 2020 to 2150. The likelihood of exceeding this Sea Level Scenario is greater than 90% at all warming levels.
    - SUMMARY: Aggressive emissions reductions leading to very low future emissions; the scenario is on the lower bounding edge of plausibility given current warming and sea level trajectories, and current societal and policy momentum.

- **Intermediate-Low Scenario:** This scenario arises under a range of both future warming levels and possible SSPs, spanning low, intermediate and high emissions pathways, and integrates many of the AR6 SSP pathways as a result (see Figure 2.2) This scenario is consistent with the median projected sea level rise in a 2°C world, which means there is a 50% probability of exceeding this scenario with 2°C of additional warming by 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 82%. Given the extrapolation of GMSL to 2100 (approximately 2.2 feet36), the current projection of future warming of 3°C, and the range of sea level rise across the IPCC AR6 scenarios (Figure 2.4), the Intermediate Low Scenario provides a reasonable lower bound for the most likely range of sea level rise by 2100. Since the low confidence processes are not important to this scenario, the range of possible sea level rise after 2100 does not expand significantly.
    - SUMMARY: A range of future emissions pathways; a reasonable estimate of the lower bound of most likely sea level rise in 2100 based on support from sea level observations and current estimates of future warming.

- **Intermediate Scenario**: The Intermediate Scenario is driven dominantly by high emissions scenarios, and thus higher warming levels. For the first time in the scenarios, the low confidence projections from the IPCC AR6 contribute significantly and provide about 25% of the pathways for reaching the Intermediate Scenario target by 2100. Given the extrapolation of GMSL to 2100 and the range of sea level rise across the IPCC AR6 scenarios (Figure 2.4), the Intermediate Scenario provides a reasonable upper bound for the most likely range of sea level rise by 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 5%. In a very-high emissions future with low confidence processes, there is about a 50% chance of exceeding the Intermediate scenario in 2100.

    - SUMMARY: A range of future emissions pathways; could include contribution from low confidence processes. Based on sea level observations and current estimates of future warming, a reasonable estimate of the upper bound of most likely sea level rise in 2100.

- **Intermediate-High Scenario**: Pathways combining both higher emissions and low confidence processes become the majority, with over 50% of the samples used to construct this scenario coming from the SSP5-8.5 scenario. At all times from 2020 to 2150, the Intermediate High Scenario exceeds the median value of the AR6 scenarios. This scenario is similar to the high-end estimate from van de Wal et al. (2022) under the assumption of high levels of warming in 2100. At a warming level of 3°C in 2100, the probability of exceeding this scenario is 0.1% when not considering the low confidence processes, emphasizing the degree to which these processes are needed to get to this scenario. With the low confidence processes, the probability of exceeding this scenario is approximately 20% for very high warming levels.
    - SUMMARY: Intermediate-to-high future emissions and high warming; this scenario is heavily reflective of a world where rapid ice sheet loss processes are contributing to sea level rise.

- **High Scenario:** Pathways combining both high emissions and low confidence processes are dominant, providing over 80% of the samples to construct the scenario. Low emissions pathways are not plausible under this scenario, and intermediate emissions pathways require a significant contribution from rapid ice sheet loss processes. Before 2100, the High Scenario is significantly above the range of SSP AR6 scenarios, although the range of plausible sea level expands beyond 2150. The probability of exceeding the High Scenario in 2100 is less than 0.1% for all warming levels without considering low confidence processes. With very high emissions and warming and contributions from the low confidence processes, this probability increases to 8%.
    - SUMMARY: High future emissions and high warming with large potential contributions from rapid ice-sheet loss processes; given the reliance on sea level contributions for processes in which there is currently low confidence in their understanding, a statement on the likelihood of reaching this scenario is not possible."

These five trajectories of sea level rise were then regionalized to California, and the California State Sea Level Rise Guidance presented a single set of scenarios representing the median sea level rise scenarios for California that reflect an average statewide value of vertical land motion, which is a negligible rate of 0.1 mm (0.0003 ft) per year uplift. These median statewide values are presented below in Table A-1.

Table A-1. Sea Level Rise Scenarios for California [119]

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.2
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.9	5.4
2100	1.0	1.6	3.1	4.9	6.6
2110	1.1	1.8	3.8	5.7	8.0
2120	1.1	2.0	4.5	6.4	9.1
2130	1.2	2.2	5.0	7.1	10.0
2140	1.3	2.4	5.6	7.7	11.0
2150	1.3	2.6	6.1	8.3	11.9

These average statewide scenarios were also further regionalized to reflect the observed rates of vertical land motion at each of California's 14 coastal tide gauges. These tide gauge-specific scenarios are provided in in Appendix 2 of the State Sea Level Rise Guidance (OPC 2024) and in Appendix G of this document.

The State Sea Level Rise Guidance also provided information about how likely each scenario is to occur in the year 2100 under various amounts of plausible future warming (Table A-2). Likelihoods were also provided assuming rapid ice sheet disintegration processes come into play in the 2100s. These likelihoods were derived from the sample sets of projections from AR6 on which each scenario was based, and they provide valuable information to shape our understanding of the likelihood that each scenario will or will not come to pass, and the risks the higher or lower scenarios may occur. As explained in the State Guidance, this table can be

[119] This table provides median values for sea level scenarios for California, in feet, relative to a year 2000 baseline. These statewide values all incorporate an average statewide value of vertical land motion – a negligible rate of 0.1 mm (0.0003 ft) per year uplift (OPC 2024). The red box highlights the three scenarios that the *State Sea Level Rise Guidance* and this guidance recommend for use in various planning and project contexts.

read as saying, "assuming 3°C of warming in 2100 and no influence from low-confidence ice sheet processes, there is a 5% chance of exceeding the Intermediate scenario in 2100" or "assuming high levels of warming in 2100 and contributions from the low confidence processes, there is a 49% chance of exceeding the Intermediate Scenario in 2100" and so on. The State Guidance also explains that global surface temperatures are currently on track to reach 3.0°C above pre-industrial levels by 2100, assuming current rates of emissions-driven warming.

Table A-2. Exceedance probabilities for the sea level scenarios based on IPCC warming level–based global mean sea level projections[120]

Global Mean Surface Air Temperature 2081-2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Low Confidence Processes, Low Warming	Low Confidence Processes, High Warming
Low Scenario	92%	98%	99.5%	99.9%	>99.9%	90%	99.5%
Intermediate-Low Scenario	37%	50%	82%	97%	99.5%	49%	96%
Intermediate Scenario	0.5%	2%	5%	10%	23%	7%	49%
Intermediate-High Scenario	0.1%	0.1%	0.1%	1%	2%	1%	20%
High Scenario	<0.1%	<0.1%	<0.1%	<0.1%	0.1%	<0.1%	8%

The State Sea Level Rise Guidance (OPC 2024) offers the following Key Takeaways about the best available science on sea level rise:

- **"The California Sea Level Scenarios show greater certainty in the amount of sea level rise expected in the next 30 years** than previous reports and demonstrate a narrow range across all possible emissions scenarios. Statewide, sea levels are most likely to rise 0.8 ft (Intermediate Scenario) by 2050.

- **In the mid-term (2050-2100), the range of possible sea level rise expands** due to more uncertainty in projected future warming from different emissions pathways and certain physical processes (i.e. rapid ice sheet melt). By 2100, statewide averaged sea levels are expected to rise between 1.6 ft and 3.1 ft (Intermediate-Low to Intermediate Scenarios), although higher amounts are possible.

[120] The *California State Sea Level Rise Guidance* provides the following explanatory information for this table: "Global mean surface air temperature anomalies are projected for years 2081–2100 relative to the 1850–1900 climatology. Global surface temperatures are currently on track to reach 3.0°C above pre-industrial levels by 2100, assuming current rates of emissions-driven warming…The probabilities shown here are imprecise probabilities, representing a consensus among all projection methods applied by the IPCC AR6."

- **Over the long-term (towards 2100 and beyond), the range of sea level rise becomes increasingly large** due to uncertainties associated with physical processes, such as earlier-than-expected ice sheet loss and resulting future sea level rise. Sea levels may rise from 2.6 ft to 11.9 ft (Intermediate-Low to High Scenarios) by 2150, and even higher amounts cannot be ruled out.

- **Vertical land motion is the primary driver of local variations in sea level rise across the state**, driven by a combination of tectonics, sediment compaction, and groundwater and hydrocarbon withdrawal. Vertical land motion is incorporated into the sea level scenarios for each National Oceanic and Atmospheric Administration (NOAA) tide gauge and illuminates locations experiencing subsidence or uplift. The pathway associated with the extreme sea level rise scenario (i.e. H++) from Rising Seas 2017 is higher than the best available science now supports. The key lines of evidence that resulted in the extreme sea level rise scenario (i.e. H++) from Rising Seas 2017 have been updated and are now reflected in the Intermediate-High and High Scenarios.

- **Today's coastal storms provide a glimpse into our future** in which storm events will become more damaging and dangerous as climate change and sea level rise continue. Coastal storms under future sea level scenarios will cause accelerated cliff and bluff erosion, coastal flooding and beach loss, and mobilization of subsurface contaminants. Sea level rise will increase the exposure of communities, assets, services and culturally important areas to significant impacts from coastal storms.

- **Sea level rise will increase the frequency of coastal flooding events**, which occur when sea level rise amplifies short-term elevated water levels associated with higher tides, large storms, El Niño events, or when large waves coincide with high tides. California communities need to be aware of and prepared for a likely rapid increase in the frequency of coastal flooding in the 2030s, even beyond the increases in coastal flood frequency already occurring as a result of extreme storms.

- **Groundwater rise poses a threat to below-ground infrastructure and freshwater aquifers under future Sea Level Scenarios**. In areas with shallow unconfined groundwater, the water table will generally rise with sea level, depending on local geomorphology. Rising groundwater may mobilize subsurface contaminants in soils, expose underground infrastructure to corrosive saltwater, and put freshwater aquifers at risk of saltwater intrusion. The low-lying Sacramento-San Joaquin Delta, which supplies fresh water to two-thirds of the state's population and millions of acres of farmland, is particularly vulnerable to saltwater intrusion into freshwater aquifers."

The table of median sea level rise scenarios for California is provided above (Table A-1), and tables for each California tide gauges are presented in Appendix F. The State Sea Level Rise Guidance (OPC 2024) is currently considered best available science on sea level rise for the State of California.

REFERENCES: APPENDIX A

Bamber JL, WP Aspinall. 2013. An expert judgment assessment of future sea level rise from the ice sheets. *Nature Climate Change* 3: 424-427. doi:10.1038/nclimate1778.

Bamber, J.L., M. Oppenheimer, R.E. Kopp, W.P. Aspinall, and R.M. Cooke, 2019: Ice sheet contributions to future sea-level rise from structured expert judgment. Proceedings of the National Academy of Sciences of the United States of America, 116 (23), 11195–11200. https://doi.org/10.1073/pnas.1817205116

California Sea Level Rise Guidance: 2024 Science and Policy Update. 2024. California Sea Level Rise Science Task Force, California Ocean Protection Council, California Ocean Science Trust.

Clark JA, WE Farrell, WR Peltier. 1978. Global changes in postglacial sea level: a numerical calculation. *Quaternary Research* 9(3): 265-287. doi:10.1016/0033-5894(78)90033-9.

Dangendorf, S., Hay, C., Calafat, F. M., Marcos, M., Piecuch, C. G., Berk, K., & Jensen, J. (2019). Persistent acceleration in global sea level rise since the 1960s. *Nature* Climate Change, 9(9), 705–710. https://doi.org/10.1038/s41558-019-0531-8

DeConto RM, Pollard D. 2016. Contribution of Antarctica to past and future sea-level rise. Nature 531: 591-7

DeConto, R.M., Pollard, D., Alley, R.B. et al. The Paris Climate Agreement and future sea-level rise from Antarctica. *Nature* **593**, 83–89 (2021). https://doi.org/10.1038/s41586-021-03427-0

Dutton A, K Lambeck. 2012. Ice volume and sea level during the last interglacial. *Science* 337(6091): 216–219. doi: 10.1126/science.1205749.

Frederikse, T., Landerer, F., Caron, L., Adhikari, S., Parkes, D., Humphrey, V. W., Dangendorf, S., Hogarth, P., Zanna, L., Cheng, L., & Wu, Y.-H. (2020). The causes of sea level rise since 1900. Nature, 584(7821), 393–397. https://doi.org/10.1038/s41586-020-2591-3

Fox-Kemper, B., H.T. Hewitt, C. Xiao, G. Aðalgeirsdóttir, S.S. Drijfhout, T.L. Edwards, N.R. Golledge, M. Hemer, R.E. Kopp, G. Krinner, A. Mix, D. Notz, S. Nowicki, I.S. Nurhati, L. Ruiz, J.-B. Sallée, A.B.A. Slangen, and Y. Yu, 2021: Ocean, Cryosphere and Sea Level Change. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1211–1362, doi:10.1017/9781009157896.011.
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter09.pdf

Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA

(California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017.

Hall, J.A., S. Gill, J. Obeysekera, W. Sweet, K. Knuuti, and J. Marburger, 2016: Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide. U.S. Department of Defense, Strategic Environmental Research and Development Program, Alexandria, VA, 224 pp. https://climateandsecurity.files.wordpress.com/2014/01/regional-sea-level-scenarios-for-coastal-risk-management_managing-uncertainty-of-future-sea-level-change-and-extreme-water-levels-fordepartment-of-defense.pdf

Hamlington, B. D., Frederikse, T., Thompson, P. R., Willis, J. K., Nerem, R. S., & Fasullo, J. T. (2021). Past, Present, and Future Pacific Sea-Level Change. Earth's Future, 9(4), e2020EF001839. https://doi.org/10.1029/2020EF001839

Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change.* [TF Stocker, D Qin, G Plattner, MMB Tignor, SK Allen, J Boschung, A Nauels, Y Xia, V Bex, PM Midgley (eds.)], Cambridge University Press: Cambridge, UK and New York, NY, USA. 1535pp. https://www.ipcc.ch/report/ar5/.

Intergovernmental Panel on Climate Change (IPCC). 2022. Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestvedt, A. Reisinger (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. *Cambridge University Press*, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029.

Intergovernmental Panel on Climate Change (IPCC). 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

Kopp RE, RM Horton, CM Little, JX Mitrovica, M Oppenheimer, DJ Rassussen, BH Strauss, C Tebaldi. 2014. Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. *Earth's Future* 2(8): 383-406. doi:10.1002/2014EF000239.

Kopp R, F Simons, J Mitrovica, A Maloof, M Oppenheimer. 2009. Probabilistic assessment of sea level during the last interglacial stage. *Nature* 462: 863-867. doi:10.1038/nature08686.

Levermann A, P Clark, B Marzeion, G Milne, D Pollard, V Radic, A Robinson. 2013. The multimillennial sea-level commitment of global warming. *Proceedings of the National Academy of Sciences* 110(34): 13745-13750. doi: 10.1073/pnas.1219414110.

Mengel M, Levermann A, Frieler K, Robinson A, Marzeion B, Winkelmann R. 2016. Future sea level rise constrained by observations and long-term commitment. *PNAS* 113(10): 2597-2602. doi.org/10.1073/pnas.1500515113

Miller, K. G., R. E. Kopp, B. P. Horton, J. V. Browning, and A. C. Kemp (2013), A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast, Earth's Future, doi:10.1002/2013EF000135.

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.

Nerem, R. S., Beckley, B. D., Fasullo, J. T., Hamlington, B. D., Masters, D., & Mitchum, G. T. (2018). Climate-change–driven accelerated sea level rise detected in the altimeter era. Proceedings of the National Academy of Sciences, 115(9), 2022–2025. https://doi.org/10.1073/pnas.1717312115

O'Neill, B. C., Tebaldi, C., van Vuuren, D. P., Eyring, V., Friedlingstein, P., Hurtt, G., Knutti, R., Kriegler, E., Lamarque, J.-F., Lowe, J., Meehl, G. A., Moss, R., Riahi, K., and Sanderson, B. M.: The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6, Geosci. Model Dev., 9, 3461–3482, https://doi.org/10.5194/gmd-9-3461-2016, 2016. https://gmd.copernicus.org/articles/9/3461/2016/

Perrette M, F Landerer, R Riva, K Frieler, M Meinshausen. 2013. A scaling approach to project regional sea level rise and its uncertainties. *Earth System Dynamics* 4(1): 11-29. doi:10.5194/esd-4-11-2013.

Rahmstorf S. 2007. A semi-empirical approach to projecting future sea-level rise. *Science* 315(5810): 368-370. doi:10.1126/science.1135456.

Slangen, A.B.A., Carson, M., Katsman, C.A. *et al.* Projecting twenty-first century regional sea-level changes. *Climatic Change* **124**, 317–332 (2014). https://doi.org/10.1007/s10584-014-1080-9

Slangen, A., Palmer, M., Camargo, C., Church, J., Edwards, T., Hermans, T. Hewitt, G., Gregory, J., Kopp, R., Santos, V., Van de Wal, R. (2023). The evolution of 21st century sea-level projections from IPCC AR5 to AR6 and beyond. *Cambridge Prisms: Coastal Futures, 1*, E7. doi:10.1017/cft.2022.8Smith WH, DT Sandwell. 1997. Global sea floor topography from satellite altimetry and ship depth soundings. *Science* 277(5334): 1956-1962. doi: 10.1126/science.277.5334.1956.

Smith, W.H. and Sandwell, D.T. (1997) Global Sea Floor Topography from Satellite Altimetry and Ship Depth Soundings. Science, 277, 1956-1962. http://dx.doi.org/10.1126/science.277.5334.1956

Sweet, W.V., R.E. Kopp, C.P. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler and CZ. Global and Regional Sea Level Rise Scenarios for the United States. 2017.

Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://aambpublicoceanservice.blob.core.windows.net/oceanserviceprod/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf

USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II: [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf

Willis, J., Hamlington, B., & Fournier, S. (2023). Global Mean Sea Level, Trajectory and Extrapolation (Version 101) [dataset]. Zenodo. https://doi.org/10.5281/zenodo.7702315

Appendix B. Developing Local Hazard Conditions Based on Regional or Local Sea Level Rise Using Best Available Science

This Appendix provides technical information addressing how to determine local hazard conditions for sea level rise planning efforts. This process is described more broadly as Steps 1-4 in Chapters 5 and 6 in this document and includes determining a range of sea level rise scenarios and analyzing the physical effects and possible resource impacts of sea level rise hazards.

This appendix provides an overview of the physical effects of sea level rise on coastal hazards and other physical processes. The appendix is organized by the most commonly considered coastal hazards and physical processes and will describe how sea level rise is expected to influence them into the future. Similarly, each section will describe how sea level can be considered in assessments for each coastal hazard or physical process.

It can be challenging to “right size” analyses that look to identify the physical effects of sea level rise. Screening level analyses can be useful to identify the types of hazards that may need to be more closely evaluated, for example with more detailed modeling or analysis, in certain areas. As discussed in more detail in Chapters 5 and 6, it is a good idea to reach out to Coastal Commission Staff early in the process to advise on what level of hazards analyses may be recommended for different planning or permitting processes.

Water level varies locally, so these analyses must be performed on a regional or site-specific basis, and applicants and planners should prioritize obtaining data or conducting research at the correct geographical scale. The 2024 State Sea Level Rise Guidance (OPC 2024) is considered the best available science on California’s regional sea level rise, and the Commission recommends using it when sea level rise projections are needed. Equivalent resources may be used by local governments and applicants provided that the resource is peer-reviewed, widely accepted within the scientific community, and locally relevant.

Sea level rise raises the background water level from which many more dynamic changes start. Sea level rise will have many physical effects, some of which will increase non-linearly, such as the amount of wave energy that reaches California’s coastlines. The following box identifies some of the key situations in which it is important for coastal managers and applicants to consider sea level rise during planning or project reviews.

General situations needing sea level rise analysis include when the project site or planning area is:

- Currently in or adjacent to an identified floodplain
- Currently or has been exposed to flooding or erosion from waves or tides
- Currently in a location protected from flooding by constructed dikes, levees, bulkheads, or other flood-control or protective structures
- On or close to a beach, estuary, lagoon, or wetland
- On a coastal bluff with historic evidence of erosion
- Reliant upon shallow wells for water supply
- Shown as exposed to hazards on a SLR viewer such as COSMOS under the 2.0m SLR scenario

The following coastal hazards and other physical processes are some of the more commonly considered hazards for planning and development in coastal areas in the State. These are described in more detail in the following sections.

- Coastal erosion
- Wetland change
- Coastal flooding
- Fluvial/riverine flooding
- Pluvial/stormwater flooding
- Groundwater rise
- Tsunamis

Coastal Erosion

The coast is shaped by the powerful forces from waves, currents, rainfall, and wind. This section will describe the effects of sea level rise on beach change and bluff erosion.

Beach Change

Beaches are highly dynamic and respond to changes in sediment inputs and wave conditions. Beaches change on a variety of timescales. It can be useful to think about the timescales of this change as long-term, decadal, seasonal, and storm event-driven.

Beaches can be understood generally to be in equilibrium with sea level. As sea level rises, beaches will generally shift upward (vertically) and recede landward (horizontally), proportional to the slope of the beach. This concept is generally known as the Bruun Rule. It involves several key assumptions, including that, at equilibrium, the shape of the beach profile is maintained through time, that sand transport into and out of the area of interest is constant, that the upper beach is eroded as the shore profile moves landward, and that the eroded material is deposited offshore to reestablish the equilibrium profile – meaning that the Bruun Rule assumes an erodible backshore as opposed to, for example, a seawall. As sea level rise accelerates, the retreat of beaches due to the Bruun Rule is expected to become an increasingly large factor in beach change.

There are several approaches to evaluating the potential for beach erosion for the purposes of planning and development. The level of complexity in terms of the processes considered as well as the data and skill needed for analysis varies greatly.

One of the simplest approaches to estimating beach change is to examine long-term shoreline trends. This can be done by looking at historical imagery. Recent advances in the processing of satellite data have opened up large datasets of historic shoreline change, such as CoastSat, that can also be useful for identifying long-term trends. Similarly, looking at historic observed seasonal or event-driven changes can be useful for estimating the potential range of shoreline positions that might be observed beyond long-term shifts in mean shoreline position. Notably, just evaluating historic trends alone will not adequately account for the effects of future sea level rise. Observed trends can be combined with the retreat estimated by the Bruun Rule or other similar equilibrium models.

One of the more comprehensive tools for looking at long-term beach change is the CoSMoS Coastal One-line Assimilated Simulation Tool (CoSMoS-COAST). The CoSMoS-COAST tool uses historic shoreline change data to calibrate a shoreline change model that takes into account many of the easier-to-measure factors that contribute to beach change. These include Bruun Rule recession, longshore drift, and cross-shore beach change. Sand supply, a major factor in beach change, is not explicitly considered due to the difficulty in projecting changes to sand supply; however, observed long-term erosional or accretional trends not explained by the more easily forecastable factors are assumed to continue in the future. While CoSMoS-COAST includes considerable uncertainty, this uncertainty is quantified. CoSMoS-COAST is also available at a 100-meter resolution for all open coast beaches statewide which makes it a powerful tool for evaluating future beach change.

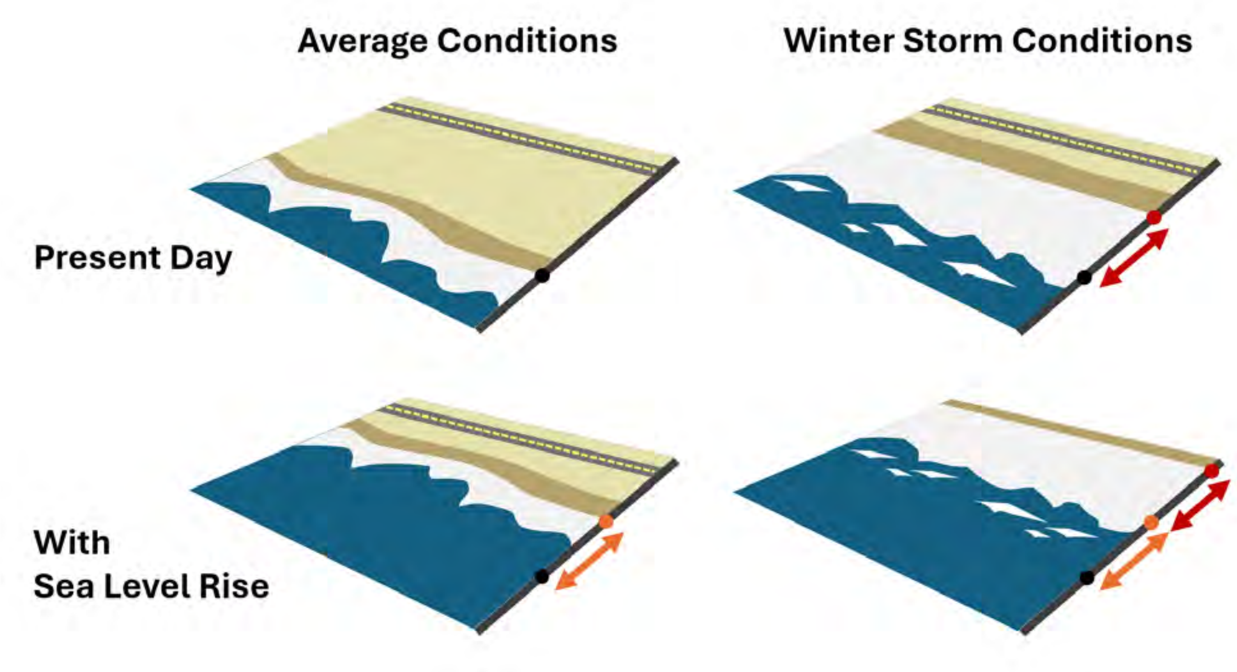


Figure B-1. Diagram showing beach erosion from both sea level rise and winter storm conditions (Source: J. Smith, 2024)

Bluff Erosion

California has a diversity of coastal bluffs which will, in general, continue to erode over time. The rate of a retreat of a coastal bluff is closely related to its geologic composition and the erosional processes at work in a given location. Bluffs composed of hard, resistant bedrock will erode slowly compared to bluffs with a base of relatively weak and poorly cemented terrace deposits. Coastal bluff erosion is also driven by a variety of factors including both marine (e.g., wave attack and wave spray) and subaerial processes (e.g., intense rainfall and runoff). In general, sea level rise will intensify marine erosion by increasing the frequency and force and wave attack at the base of coastal bluffs. For example, with sea level rise, some bluffs that are currently protected by wide sandy beaches and seldom experience significant wave attack may start to erode more quickly when higher water levels or beach erosion causes the frequency and intensity of wave attack to increase.

Long-term historical trends in bluff retreat provide an important indicator of the potential for future bluff erosion with sea level rise. Similar to beach change, past bluff retreat can be estimated through the use of historical aerial imagery. However, bluff retreat is often episodic. In other words, bluffs can remain unchanged for sustained periods then fail and erode relatively rapidly. As a result, a significant amount of time (ideally as long as possible) is often needed to be able to determine long-term average erosional trends for coastal bluffs. There have been several efforts to develop statewide retreat rates for coastal bluffs with varying levels of associated uncertainty and spatial resolution. Some of the most commonly referenced datasets include Hapke & Reid, 2007, which uses georeferenced historical maps and aerial imagery, and Swirad and Young, 2022, which uses airborne LiDAR.

There are several approaches available to estimate how bluff retreat would be accelerated by sea level rise. As part of the work done by USGS for their CoSMoS Cliff Retreat tool, Limber *et al*., 2018, summarize several modeling approaches. One model bluff retreat, an extension of the Bruun Rule discussed above, assumes coastal bluffs are in equilibrium with their fronting beaches and that, with sea level rise, bluff erosion will accelerate in relation to both the shape of the beach profile and amount of beach-quality sediment the bluffs would provide to the beach profile as they erode. Another model assumes that the bluff retreat rate will increase in proportion to the frequency with which waves are able to runup and reach the toe of the bluff with sea level rise. Other models accelerate cliff erosion in proportion to increases in the rate of sea level rise, with options to select the relationship (linear or exponential) between the rate of sea level rise and the bluff erosion response. Still other models relate bluff erosion rates to sea level driven changes in wave energy, the force delivered at the bluff toe, and fronting beach widths. While no single modeling approach can capture all the factors governing how coastal bluffs will respond to sea level rise, these modeling approaches can provide insight into the range of potential outcomes under different sea level rise scenarios.

USGS developed bluff retreat projections statewide using an ensemble of multiple bluff retreat models (some of which are outlined above) for four sea level rise scenarios (CoSMoS-Cliff). The calibrated, but unvalidated, ensemble includes five simple models that project bluff retreat from historical bluff retreat, wave impacts, sea level rise, and the geometry of the shore profile. The projections are available at a spatial resolution of 100 meters, though projections are meant to project time-averaged, multidecadal bluff retreat over large spatial scales. These projections are valuable for community-scale hazards analyses and land use planning, though more detailed analyses are often needed for site-specific analyses, including those used for siting and design of individual development projects.

Most models and tools used for bluff retreat project the long-term time-averaged retreat of a bluff's edge. However, as mentioned previously, bluff retreat typically occurs episodically, with retreat sometimes occurring on the order of tens of feet in a single event, followed by extended periods with little retreat. For this reason, it is critical that development setbacks from bluff edges consider the potential magnitudes of episodic erosion or failure events in addition to long-term, average retreat rates. This can be done through looking at past bluff failure events or analyzing slope stability (e.g., determining the failure plane of a slope with a 1.5 factor of safety).

Additional Considerations

Additionally, there are several important considerations when evaluating the potential for coastal erosion as influenced by sea level rise. Sandy beaches may have significant deposits of coarser material, such as cobble, which may change both their response to seasonal erosion and long-term responses to sea level rise. Beaches may also exist as a relatively thin layer of sand above high bedrock platforms which may influence both their ability to persist in the future (if these platforms form a steep and erosion resistant backshore) as well as how the beaches respond to seasonal forcing from waves. Also, developed backshores can sometimes be made of highly erodible fill material with high percentages of fines which may lead to accelerated erosion, particularly as shorelines retreat and expose these backshores to more frequent storm wave activity.

Sand dunes are also an important part of many beach systems. Dunes can vary greatly in both size and dynamics. Natural dunes in addition to engineered dune or dune-like systems can provide significant flood reduction benefits in addition to being an important source of sand to beaches during erosive events. Portions of dune systems can also be highly dynamic, like beaches, and are also expected to shift upward and inland with sea level rise under equilibrium conditions. Where dunes are a significant part of the shore or where they are being proposed as strategies to address hazards, particular care should be taken to incorporate dune change as part of estimates of coastal erosion.

COASTAL WETLAND CHANGE

Coastal wetlands such as mudflats and saltmarshes are affected by the way sediment moves in and through estuarine systems. Intertidal features and habitats are very sensitive to water levels and will change with sea level rise (Spencer *et al.*, 2016).

Different levels of analysis for evaluating coastal wetland change vary in the amount of data and skill required. Much of this variation comes from how or if changes to landforms are considered. Figure B-2 illustrates how sea level rise will shift the tidal range vertically and vegetated areas may shift in response to both future water levels and changes in landforms.

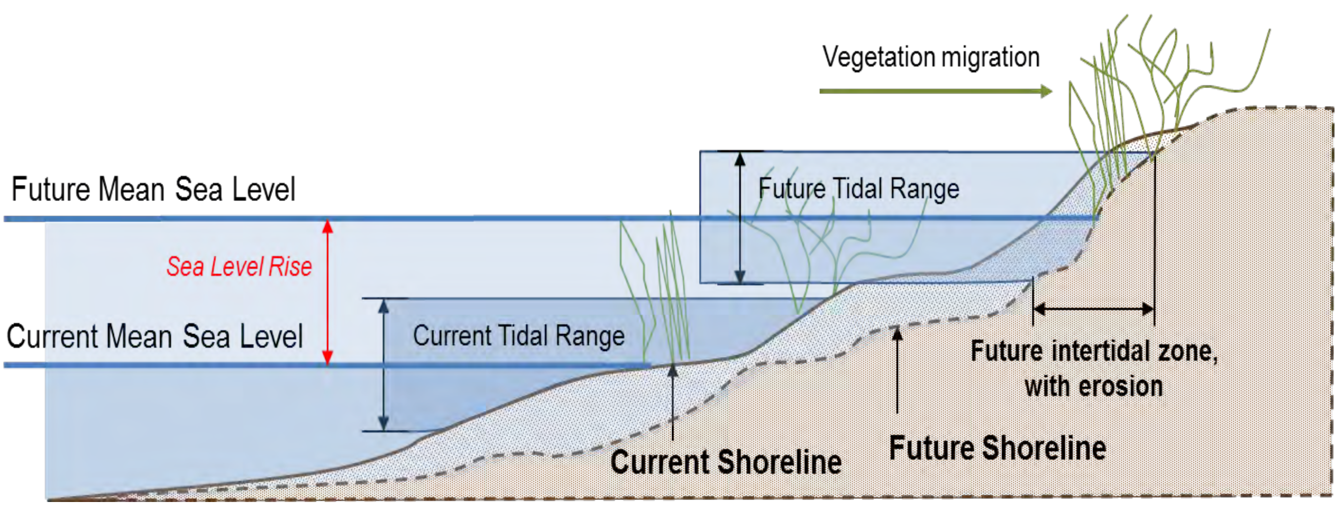


Figure B-2. Changes to the intertidal zone with sea level rise and erosion, without wave impacts. (Source: L. Ewing, 2013).

The simplest approach to evaluating coastal wetland change is to assume landforms remain the same and habitats will re-equilibrate to changing sea levels. In some wetlands, landform change can be dramatic even over short time periods (**Fig.** B-3). As mentioned previously, coastal wetlands are very sensitive to water levels and their distribution is largely controlled by the elevation of land relative to the local tide range. While sea level rise may change the range of the tides in certain areas, it is often simpler and sufficiently accurate to assume this change will not be significant and simply shift the existing tide range vertically by the amount of sea level rise being analyzed.

Figure B-3. Photo series documenting rapid bank and wetland erosion in Elkhorn Slough (adapted from California Department of Fish and Wildlife, 2021 with additional photo from B. Ammen, 2023)

More complex approaches would include creating a hydrodynamic model that simulates the water levels and currents that can then be used to model the movement of sediment and vertical erosion or accretion that may change landforms in an estuarine system. These kinds of models often require significant effort to develop, calibrate, and validate but can be used to answer specific management questions such as which coastal wetland areas may have sufficient natural sediment supplies to be able to keep pace with sea level rise and which areas may need more significant management actions to preserve ecosystem functions.

When deciding how to estimate coastal wetland change considering sea level rise, an initial assessment should consider how stable landforms have been within recent history, why landforms have or have not changed (for example, considering if existing marshes are in equilibrium with current sediment supply or tidal currents), and then evaluate whether it is reasonable to assume those factors would continue unchanged into the future with sea level rise.

COASTAL FLOODING

Extreme water levels are caused by a combination of high tides, storm surge, oceanographic forcing, and waves. Along the open coast of California, waves are typically, if not always, a major factor in driving extreme water levels and coastal flooding. The biggest storm waves often come from "swell" which originates far out in the Pacific Ocean. In sheltered areas where there is sufficient "fetch," wind waves can become sizeable enough to warrant consideration in analyses.

The deeper the water close to shore, the larger the size of waves that can reach the shore becomes. Waves will eventually break when the depth is shallow enough and runup on or over land. When analyzing wave hazards along beaches, an eroded beach condition should be evaluated as this often results in the most hazardous conditions. Furthermore, large waves also occur during large coastal storms which tend to occur most frequently in winter months, when beaches are typically at their narrowest.

There are multiple ways to evaluate coastal flooding that consider sea level rise with ranging levels of complexity as well as data, effort, and skill required. Another important factor when analyzing flooding is the resolution and accuracy of available topographic data. Small changes in topography can result in vastly different results.

Certain low-lying coastal areas may not be exposed to either swell or significant wind waves and, in these areas, coastal flooding is likely dominated by extremely high ocean water levels that can occur during a combination of high tides, atmospheric influences like storm surge, and oceanographic influences like El Niño. This section will generally progress through methods for evaluating coastal flooding where increasing attention is given to the influence of wave hazards starting with a discussion on "bathtub" approaches and moving to site specific wave hazard analyses.

"Bathtub" Approach

One of the simplest approaches to analyzing flood risk is to compare ground elevations to current or future flood levels. A "bathtub" approach, as it's commonly called, takes a flood elevation, e.g., 10 ft above mean sea level, and then assumes all elevations in the area of interest below that flood elevation will be flooded. This approach can easily consider sea level rise by simply increasing the flood elevation by the amount of sea level rise being analyzed e.g., 10 ft + 1 ft of sea level rise = 11 ft. The most important factors for this kind of analysis are determining the appropriate flood elevations and finding appropriate topographic data.

Bathtub approaches are extremely simplistic, which makes them very easy to implement. However, they may not be appropriate in some cases. Bathtub approaches can make sense for areas where flooding is expected to increase linearly with sea level rise; this is often the case for low-lying areas along partially enclosed bays or inlets that experience flooding as result of extreme still water levels and where significant erosion and shoreline change is not expected. It is not appropriate for areas where water is expected to be dynamic such as areas exposed to large waves or fast-moving flow down rivers or creeks. Bathtub approaches to projecting future flooding also rely on estimates for existing floodwater elevations which could come from previous studies such as FEMA studies or estimates of extreme coastal water levels for NOAA tide stations.

Hydrodynamic Models

Another approach for evaluating coastal flood risk is through the development or use of hydrodynamic models. Hydrodynamic models simulate the water levels and currents that occur during storm conditions and can take considerable effort to develop, calibrate, and validate. Hydrodynamic models can also simulate waves, including wave runup and overtopping, in great detail. Generally, it only makes sense to develop site-specific hydrodynamic models for a larger areas on the order of miles since the models need to consider appropriate boundaries that capture relevant features, such as the entirety of a coastal lagoon, to avoid undue modeling errors. To consider sea level rise, hydrodynamic models are essentially re-run with the sea level rise incorporated in the input conditions.

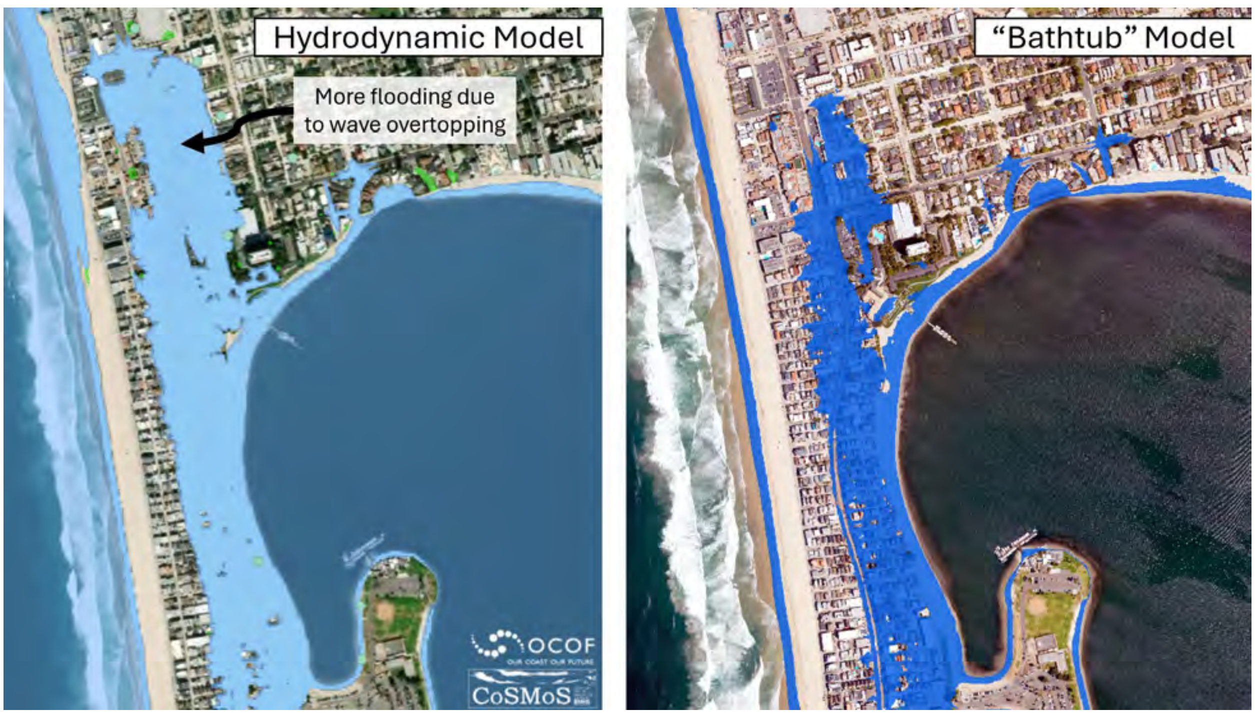


Figure B-4. Illustration of differences between a hydrodynamic model (CoSMoS; 100-year flooding 0 ft SLR) and a "bathtub" model (all areas below 8 feet, NAVD88 shaded blue)

The USGS has developed flood models and published hydrodynamic flood modeling results statewide for increments of sea level rise ranging from 0.25 meters to 5 meters, providing a useful tool for evaluating both existing coastal flood risk and future flood risk as worsened by sea level rise. Importantly, CoSMoS models were developed on large scales and, while a great tool for screening and high-level planning analysis, require sound technical judgement when interpreting results for uses that might require higher levels of detail. When evaluating the results from any model, it is generally good practice to examine the results for similar conditions from separate models or, if possible, validate with observations (e.g., flooded areas) for real events with similar storm conditions. When a higher degree of confidence and resolution might be desired such as for evaluating the potential performance of a proposed tide gate or pump system, developing a site-specific model would provide results more appropriate for use in design.

FEMA Flood Zones

FEMA develops and maps flood zones including for areas subject to coastal flooding from both waves and extreme static water levels. These flood zones do not consider future sea level rise and generally represent areas that could be impacted by flooding from events with a 1% probability of occurring in a year. In coastal areas, "VE" Zones generally represent areas of high wave hazards, while "A" and "AE" Zones generally represent areas of moderate to minimal wave hazards. Zones VE and AE will specify a base flood elevation (BFE) which is meant to represent the elevation of the 1% annual exceedance probability total water level. Total water level combines all contributions to the water level at a given time, including mean sea level, tides, seasonal and storm effects, wave runup and other factors (**Fig.** B-5).

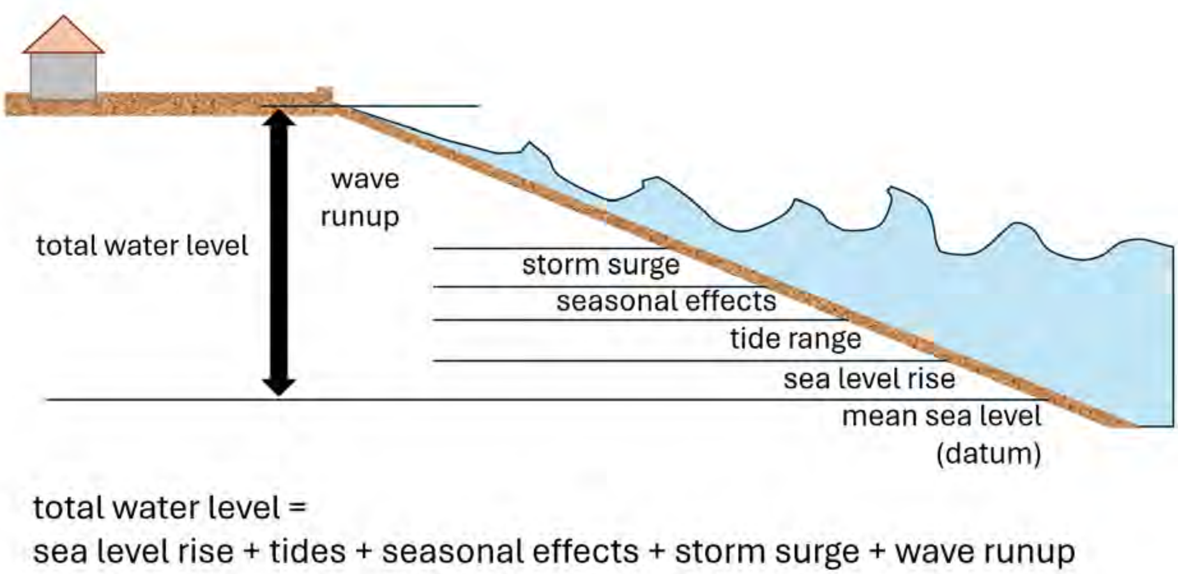


Figure B-5. Illustration of components of coastal total water levels (adapted and simplified figure 1 of Barnard *et al.*, 2019)

There are several relatively simple analytical approaches that relate current FEMA flood zones to future coastal conditions considering sea level rise. These approaches often don't require the level of data and effort as developing new hydrodynamic models and can provide reasonable, rough estimates for future flood risk that leverage the detailed studies conducted by FEMA. One example of this kind of an approach is detailed in a Technical Methods Manual by Battalio *et al*., 2016 and involves determining the portion of the total water level (or Base Flood

Elevation) due to wave runup, increasing the wave runup based on a “morphology function” determined by the erodibility of the backshore, and calculating a new total water level by adding both sea level rise and the increase in wave runup. This method is relatively simple when the information on the wave runup estimates used to determine the FEMA total water levels is available and accounts for the compounding effects of sea level rise on total water levels illustrated in Figure B-6 below. Translating current FEMA flood zones to future coastal conditions may make sense for jurisdictions looking to create hazard maps that consider sea level rise but are also familiar in form to existing flood zones, which may aid with the application of existing flood ordinances.

Site Specific Wave Hazard Analyses

In some cases, site-specific wave hazards analyses that consider the effects of sea level rise may be needed to adequately assess risks to new development along the coastline. This often requires consideration of the potential wave runup elevations that consider higher static water levels, sea level rise induced beach change, and expected 100-year storm conditions. There is a diversity of methods for estimating wave runup and overtopping. Because of the dynamic nature of extreme wave events, empirical equations can be an important tool for simplifying analyses while maintaining appropriate consideration of engineering uncertainty. These empirical equations typically relate inputs such as wave conditions (wave height and period), beach slope, a structure’s (such as a revetment's or seawall’s) roughness, and a structure’s slope.

In general, hazards analyses should consider risk from extreme conditions (often the 1% annual exceedance probability or “100-year” event). Because coastal flood events typically involve a combination of several partially related factors such as storm surge, wave conditions, and acute erosion, it can be challenging to determine exact probabilities. To address this complexity, deterministic approaches attempt to estimate the conditions of a 100-year event, generally assuming reasonable conservative estimates for things like wave height, period, and event-based beach erosion often through professional experience or judgment. Other more probabilistic approaches leverage existing datasets for things like observed water levels and wave conditions to create a hindcast of wave runup elevations that can inform a statistical analysis to estimate a range of extreme events.

Notably, while the field of coastal engineering has developed a range of methods for predicting wave hazards across the globe, different methods have been shown to be more or less appropriate for California’s (and the Pacific North American coast more broadly) oceanographic context. In California, much of coastal wave hazard is influenced by the large swell which creates large fluctuations in water levels at the shore through what are called infragravity waves. This dynamic setup, as it is also called, can create deeper waters long enough for larger waves to break closer to shore where there is less space for their energy to be dissipated. This dynamic is notably different than the Gulf and Atlantic coasts where extreme wave hazard is typically dominated by large storm surge from strong storm systems like hurricanes. FEMA, as part of its update for coastal hazard mapping on California's open coast, developed guidelines to this end that can be found here.[121]

Proper consideration should be given to selecting an appropriate method for estimating wave hazards including how sea level rise will be included in the inputs used for such an analysis. Most notably, sea level rise will increase static water elevations which not only increases the baseline from which wave runup is calculated but also increases the size of waves able to reach the shore. Similarly, where wave hazards are being analyzed on coastal structures, sea level rise induced beach retreat should be considered such that the depth of water at the toe of structures will increase. In shorelines where the backshore is armored or otherwise resistant to erosion, this leads to a compounding effect from sea level rise where one foot of sea level rise could lead to a two to four foot increase in total water level (Battalio *et al.*, 2016). These compounding effects are illustrated below (**Fig.** B-6).

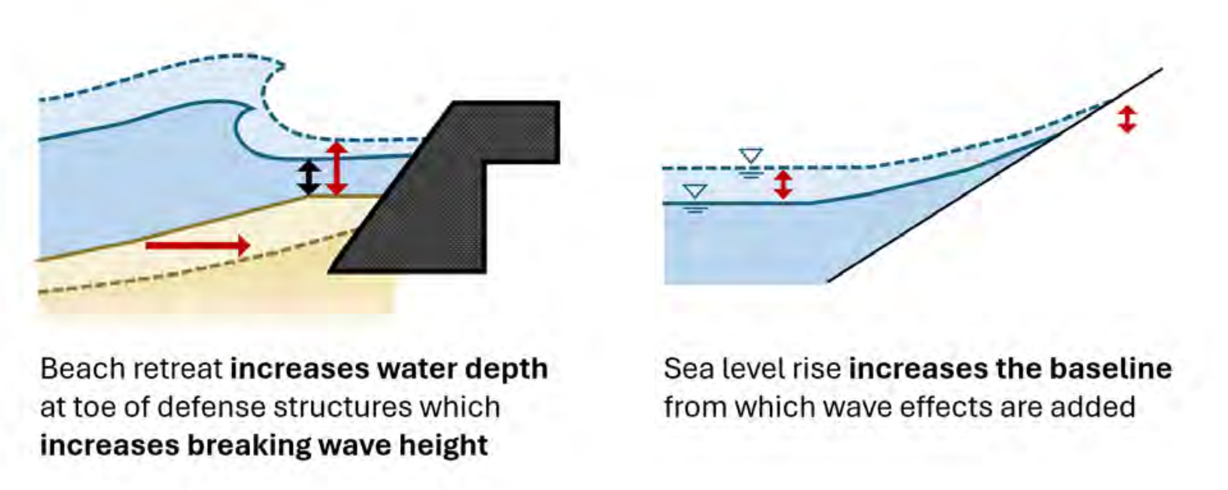


Figure B-6. Diagram illustrating the compounding effects of sea level rise on coastal wave hazards (Source: J. Smith, 2024)

Summary

In summary, coastal flooding events can be influenced by a variety of factors but in simple terms can be grouped in two categories: flooding strongly influenced by waves and coastal flooding not-strongly influenced by waves. While there is a variety of approaches to estimating future coastal flood risk as worsened by sea level rise, selecting the appropriate approach should be based on the levels of uncertainty and precaution desired by the relevant decision makers.

[121] Note that while the document linked here has been superseded by the FEMA Policy for Flood Risk Analysis and Mapping, the document contains useful guidance to support implementation of the new standards

FLUVIAL/RIVERINE FLOODING

Where rivers, creeks, and drainage channels meet the ocean, high water levels can "back up" upstream. Sea level rise will increase water levels at the downstream end of watersheds and so can increase fluvial flood risk even on days when coastal flooding may not be a concern (**Fig.** B-7). Most fluvial flood risk in the State has been assessed as part of FEMA flood insurance rate maps which generally map flood zones for the 100-year recurrence interval or 1% annual exceedance probability event, which reflect historical observations and do not capture the effects of future sea level rise. These zones have been developed over decades from a multitude of FEMA-commissioned studies.

Fluvial flood risk is generally reassessed when there are proposed changes to topography within or near floodplains, when bridges are being constructed, retrofitted, or replaced, and as part of flood control improvement projects. Generally, fluvial flood risk is assessed through the use of hydraulic models of varying levels of complexity.

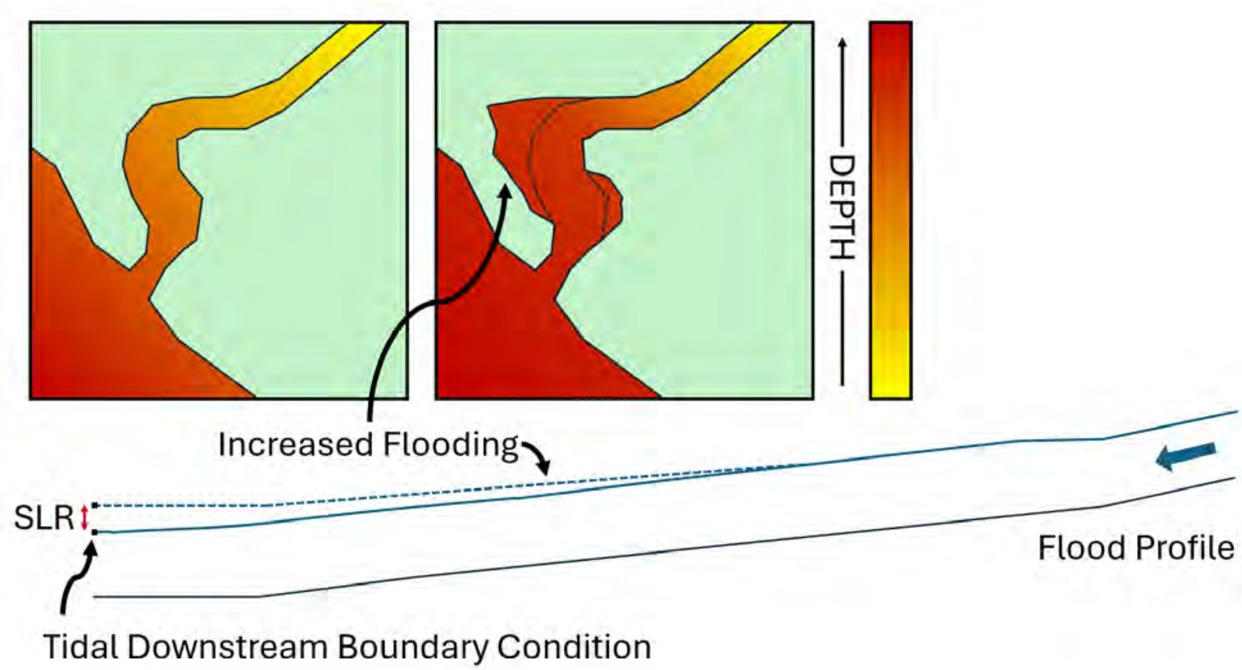


Figure B-7. Diagram illustrating how sea level rise can influence fluvial flooding upstream (Source: J. Smith, 2024).

The inland geographic extent of where sea level rise is expected to affect fluvial flooding levels varies. Generally, channels with flatter slopes will see a greater extent where higher sea levels affect fluvial flood levels. Channels where flow is constricted due to a narrowing in the channel or a flow control structure will generally not see effects from higher sea levels upstream of those constricted areas because the flow is controlled by that constriction rather than downstream water levels.

To evaluate the effects of sea level rise on fluvial flood risk, hydraulic models should use conservative downstream boundary conditions increased with the amount of sea level rise being analyzed.

> For most situations, the 100-year event should be used as the design event for hazards like coastal or fluvial flooding. The term “100-year” is equivalent to saying a storm or flow event has a 1% annual probability of exceedance. There is a 22% probability that a 100-year storm event or greater will occur during a 25-year period and over 53% probability that a 100-year storm or greater will occur at least once during a 75-year period. Even so, the 100-year event, like the 100-year flood event, is often used as a design standard for development. However, for structures with a very long projected life or for which storm protection is very critical, a larger, 200-year or 500-year event might be appropriate.

PLUVIAL/STORMWATER FLOODING

Pluvial flooding (also called “urban” flooding) is flooding that occurs as a result of runoff from rainstorms. While pluvial flooding can happen in natural watersheds its often most severe in altered watersheds. Examples include ponding in depressions, along the edges of topographic barriers, or around constrained stormwater infrastructure. Ponding can occur in depressions when runoff exceeds the capacity of stormwater infrastructure like drains or pumps such as underpasses (see an example in **Fig.** B-8 below). Any areas where stormwater is controlled and drained to coastal waters could potentially see worsened flooding as a result of sea level rise. This is because stormwater drainage capacity can be reduced by higher coastal water levels (including as increased by sea level rise) causing a “backing up” of stormwater drainage systems.

It can be difficult to initially identify areas where stormwater drainage systems could be significantly impacted by higher sea levels. Generally, the areas with the greatest potential vulnerability are areas that are close to or below the elevation of daily highest tides (mean higher high water). Some drainage systems already require special infrastructure for their drainage to coastal areas, such as drainage systems that rely on pumps or tide gates. These areas are an example where the effects of sea level rise on the function of the stormwater systems should be assessed.

Stormwater systems are often evaluated through hydrology and hydraulics (or H+H) modeling which can have varying levels of complexity but which ultimately simplifies drainage systems as a network of drainage infrastructure (stormwater pipes, inlets, pumps, etc.) and drainage areas (e.g., small watersheds) which, with rainfall estimates and information about the drainage area such as the slopes, surface types, etc., are used to determine the flow of water into the drainage system.

Sea level rise can be considered in these modeling efforts by increasing downstream water level conditions, altering pump capacities by evaluating the effects of higher water levels on pump curves, and increasing assumed baseloads to the drainage system from increased groundwater inputs from groundwater rise.

Figure B-8. Photo of pluvial flooding at an undercrossing in San Mateo, CA (Source: B. Washburn, www.flicker.com/btwashburn; CCA 2.0)

GROUNDWATER RISE

Where surficial groundwater is hydraulically connected to the ocean, sea level rise can cause an increase in groundwater tables (decreasing depths from surface to groundwater), increased salinity of groundwater, and/or increased groundwater flow (Rotzoll & Fletcher, 2013).

Higher groundwater elevations can cause a variety of problems ranging from increased liquefaction risk, damage to roads and buried structures (e.g., basements, pipes, and utilities), decreased capacity for infiltration of rainfall, mobilization of contaminants in soil, and in some cases, temporary or permanent emergence of groundwater onto the surface (Hill *et al.*, 2023).

Saline intrusion into groundwater used for irrigation or potable water uses can be a major issue where such groundwater is the only or a major source of fresh water. When saline ocean water interacts with fresh water in the ground, it typically forms what is referred to as a saline groundwater wedge with boundary between fresh and saline groundwater decreasing in elevation with distance away from coastal waterbodies. This wedge is expected to move inland with sea level rise (Glover, 1959) which will increase the geographic extent of saline intrusion into shallow groundwater wells landward. This concept is illustrated in Figure B-9 below.

In some areas, groundwater infiltrates buried stormwater or wastewater pipes which can both influence groundwater elevations around them. The leaking of groundwater into pipes can increase “baseloads” at stormwater or wastewater treatment facilities, limiting capacity and increasing operating costs (May *et al.,* 2022).

Changes to groundwater as a result of sea level rise can be modeled but are often limited in the availability of critical information such as existing or historic groundwater levels and local geology, which are needed for calibration and validation. There are several approaches where groundwater change could be considered in analyses using more conceptual or qualitative approaches as well.

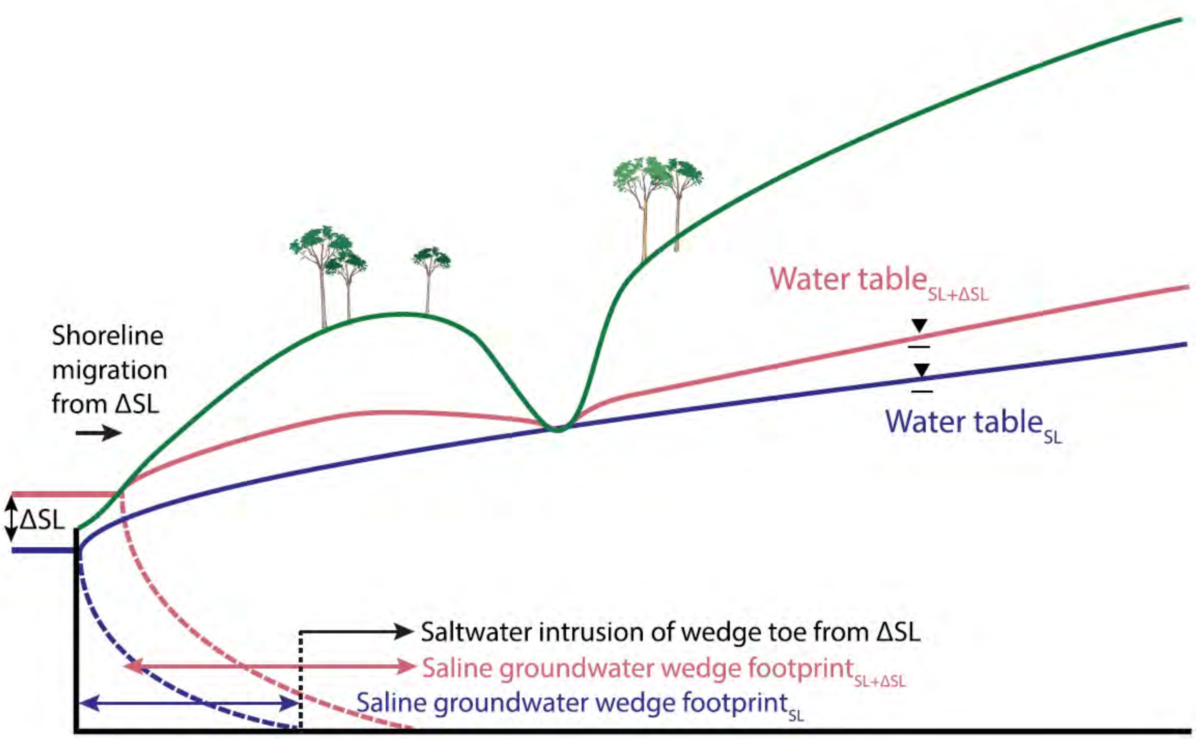


Figure B-9. Diagram from Befus *et al.* 2020 illustrating current groundwater table and saline groundwater wedge in blue and future groundwater table and saline groundwater wedge in pink. Note groundwater table is limited controlled by local topography in this example.

As part of CoSMoS, USGS partnered with groundwater modeling experts to create a statewide dataset of modeled equilibrium groundwater depths for both present sea level and increments of sea level rise (Befus *et al*., 2020, **Fig.** B-9). The modeled equilibrium groundwater surface represents the long-term average elevation of groundwater flowing along the coast for the tidal datums considered (local mean sea level and mean high water) and can be viewed as a baseline that seasonal, tidal or shorter-term influences such as storms would start from. The model results are largely a function of topography, distance from coastal water bodies, and how readily water moves through the ground (via pore spaces, fracture networks, etc.), a property known as hydraulic conductivity. The USGS model produced projections for three different hydraulic conductivity values ranging across three orders of magnitude due to a lack of detailed information on hydraulic conductivity at both fine scales and available statewide. These three hydraulic conductivity results help demonstrate the range in uncertainty, and users can focus on the dataset associated with the hydraulic connectivity value they know to be representative of their local geology. While the CoSMoS-GW results are helpful for high level analyses and screening for where groundwater rise may be an issue in local hazard planning, site-specific groundwater models developed with higher resolution topographic and geologic data would provide results appropriate for use in planning stormwater and flood control systems, or in designing individual projects.

TSUNAMIS

Tsunamis are large, long-period waves that can be generated by submarine landslides, subaerial landslides (slope failures from land into a water body), large submarine earthquakes, meteors, or volcanic eruptions. They are rare events but can be extremely destructive when they occur. The extent of tsunami damage will increase as rising water levels allow tsunami waves to extend farther inland. Thus, the tsunami inundation zone will expand inland with rising sea level. There has been no research that suggests that climate change will increase the intensity or frequency of seismically-generated tsunamis. However, the number and size of coastal subaerial landslides may increase because of increased coastal erosion due to sea level rise, which in turn may increase the potential for tsunamigenic landslides along the California coast (Highland 2004; Walder *et al*. 2003).

Figure B-10. Screenshot of ASCE Tsunami Hazard Tool showing results for the Venice-Marina del Rey area for the 2,475-year probabilistic tsunami hazard analysis

Recent advancements by the California Geological Survey (CGS) have significantly improved the availability of high quality tsunami data statewide for use in hazard analyses and planning. These data including the maps of California Tsunami Hazard Area (which was created for use in disaster preparedness and evacuation planning) are available on the CGS website. Several third party websites are also available as tools or viewers to access products that utilize the statewide probabilistic tsunami hazard analysis results such as the American Society of Civil Engineers (ASCE) Tsunami Design Geodatabase which is used to determine tsunami loads for critical facilities as part of the building code (**Fig.** B-10). There are currently no statewide datasets for tsunami inundation areas that consider sea level rise, though these are in progress. A rough estimate of how to adjust existing available tsunami inundation data to consider sea level rise is by assuming a 1:1 increase in tsunami flow depths with sea level rise i.e., if any area is shown to have a 4 ft tsunami flow depth, with 1 ft of sea level rise, it could have 5 ft of tsunami flow depth.

SUMMARY

Sea level rise will worsen many of today's hazards. Incorporating the effects of sea level rise into estimates of hazard conditions is not always simple. This appendix can serve as a resource that outlines the variety of ways sea level rise can be considered for different hazards as well as some of the tradeoffs in difficulty or level of detail that come from the diversity of methods.

As this appendix has outlined, sea level rise will be a persistent increase to baseline sea levels from which a variety of more dynamic factors such as storm surge and coastal wave storms will be increase, sometimes non-linearly with each foot of additional sea level rise. The approximate magnitudes and timescales of these factors are outlined in Table B-1 below.

When developing local hazard conditions for use in coastal planning and analyzing coastal development, there is a wide array of available tools, some of which have already been mentioned, available to aid in analysis of future hazards. These range from viewers of detailed modeling efforts to technical datasets and guidance that will aid in the development of localized or site-specific hazard analyses. These tools and resources are outlined in Table B-2 below.

Table B-1. Factors that Influence Local Water Level Conditions

Factors Affecting Water Level	Typical Range for CA Coast (ft)	Typical Range for CA Coast (m)	Period of Influence	Frequency
Tides	3 – 10	1 – 3	Hours	Twice daily
Low pressure	1.5	0.5	Days	Many times a year
Storm Surge	2 – 3	0.6 – 1.0	Days	Several times a year
Storm Waves	3 – 15	1 – 5	Hours	Several times a year
El Niño events (within the ENSO cycle)	<1.5	< 0.5	Months - Years	2 – 7 years
Tsunami waves	20 – 50 (max) 3 – 10 (typical)	6 – 15 (max) 1 – 3 (typical)	Minutes, Hours, Days	Infrequent but unpredictable
Historical Sea Level, over 100 years	0.7	0.2	Ongoing	Persistent
OPC Sea Level Projections 2000 – 2050 (SF tide gauge; see also App. F)	0.5 – 1.3	0.15 – 0.4	Ongoing	Persistent
OPC Sea Level Projections 2000 – 2100 (SF tide gauge; see also App. F)	1.0 – 6.5	0.3 – 2.0	Ongoing	Persistent

Note that all values are approximations. The conversions between feet and meters have been rounded to maintain the general ranges and they are not exact conversions. *Sources*: Flick 1998; OPC 2018; Personal communications from Dr. Robert Guza (Scripps Institution of Oceanography), Dr. William O'Reilly (Scripps Institution of Oceanography and University of California, Berkeley), and Rick Wilson, California Geological Survey; and professional judgment of staff.

Table B-2. General Resources for Developing Local Hazard Conditions

Resource	Description	Link
California Coastal Records Project	Oblique photograph time series; useful for general information on shore type, trends in beach or bluff retreat.	www.californiacoastline.org
UCSB FrameFinder	Historic aerial imagery spanning 20th and 21st centuries.	https://mil.library.ucsb.edu/ap_indexes/FrameFinder/
U.S. Coast Survey Maps "T-Sheets" (Southern California)	Historic surveys from mid-19th century; detail geomorphic and shoreline features; have been adapted to identify historic habitats.	https://www.caltsheets.org/socal/index.html https://scwrp.databasin.org/maps/new/#datasets=159884c34c9848949d76ef1f72d468b4

NOAA Data Access Viewer	Land cover, elevation (LiDAR datasets and digital elevation models), aerial imagery (including pre- and post-storm events).	https://coast.noaa.gov/dataviewer/#/
Regional Sediment Management Studies	Range of studies covering oceanographic conditions, beach and bluff change data, flooding and wave impacts, and historic conditions.	https://dbw.parks.ca.gov/?page_id=29239
CoastSat	Viewer to explore global shoreline change trends and information on the open-source CoastSat tool for extracting shoreline data from satellite imagery.	http://coastsat.wrl.unsw.edu.au/
USGS Coastal Change Hazards Portal	Viewer to explore a range of USGS datasets on extreme storms, shoreline change, historical shoreline positions.	https://marine.usgs.gov/coastalchangehazardsportal/
California Coastal Cliff Erosion Viewer	Viewer to explore cliff erosion rates observed from 1998 to 2011 and 2009 to 2016.	https://siocpg.ucsd.edu/data-products/ca-cliff-viewer/
Coastal Storm Modeling System (CoSMoS)	Detailed predictions of storm-induced coastal flooding, erosion, and groundwater rise over large geographic scales.	https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos#overview
Our Coast Our Future (OCOF)	Viewer with hazard map to explore range of data from USGS CoSMoS.	https://ourcoastourfuture.org/
FEMA California Coastal Analysis and Mapping Project | Open Pacific Coast Study	Statewide effort commissioned by FEMA to update open Pacific Coast coastal hazard maps for Flood Rate Insurance Maps. Intermediate Data Submittals include range of wave hazards information.	Not easily available online. Reports and studies conducted at the county level and may be available from county hazard offices or FEMA Region 9 https://www.fema.gov/locations/contact/california
Coastal Data Information Program (CDIP)	Current and historical information on wind, waves, and water temperature, wave and swell models and forecasting. Localized nearshore wave data available at "MOP" lines.	https://cdip.ucsd.edu/ https://cdip.ucsd.edu/mops/
FEMA National Flood Hazard Layer	Viewer includes Flood Rate Insurance Maps (FIRMs). Note that FIRMs do not consider sea level rise or other effects of climate change.	https://www.fema.gov/flood-maps/national-flood-hazard-layer
USACE Wave Information Study (WIS)	National resource with long-term wave climate and multi-decade hindcasts of wave conditions.	https://wis.erdc.dren.mil/

FEMA Guidelines for Flood Risk Analysis and Mapping Activities	Extensive range of guidance and standards including focused guidance on coastal wave hazard analysis.	https://www.fema.gov/flood-maps/guidance-reports/guidelines-standards
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	"Bathtub" model showing areas below mean higher high water with a range of 1-foot increments of sea level rise.	https://coast.noaa.gov/slr/
Cal-Adapt Climate Tools	Range of tools and datasets for considering the effects of climate change including sea level rise and projected changes in intensity and frequency of extreme precipitation events.	https://cal-adapt.org/tools/
California Geological Survey Tsunami Page	Includes information on tsunami hazards, preparedness and evacuation resources, and data and reports for statewide probabilistic tsunami hazard analysis.	https://www.conservation.ca.gov/cgs/tsunami
ASCE Tsunami Design Geodatabase	Mapped runup extents and runup elevations used in ASCE 7 Standards.	https://asce7tsunami.online/

REFERENCES: APPENDIX B

Barnard, P. L., Erikson, L. H., Foxgrover, A. C., Hart, J. A. F., Limber, P., O'Neill, A. C., ... & Jones, J. M. (2019). Dynamic flood modeling essential to assess the coastal impacts of climate change. Scientific reports, 9(1), 4309.

Bascom W. 1979. *Waves and Beaches: The Dynamics of the Ocean Surface.* Garden City, NY: Anchor Books. 366pp.

Battalio, R. T., Bromirski, P. D., Cayan, D. R., & White, L. A. (2016). Relating Future Coastal Conditions to Existing FEMA Flood Hazard Maps: Technical Methods Manual.

Befus, K. M., Barnard, P. L., Hoover, D. J., Finzi Hart, J. A., & Voss, C. I. (2020). Increasing threat of coastal groundwater hazards from sea-level rise in California. *Nature Climate Change*, *10*(10), 946-952.

Bromirski PD, AJ Miller, RE Flick, G Auad. 2011. Dynamical suppression of sea level rise along the Pacific Coast of North America: Indications for imminent acceleration. *Journal of Geophysical Research-Oceans* 116: C07005. doi:10.1029/2010JC006759.

Bromirski PD, DR Cayan, N Graham, RE Flick, M Tyree. 2012. White Paper from the California Energy Commission. Prepared by Scripps Institution of Oceanography, CEC-500-2012-011. http://iodlabs.ucsd.edu/peter/pdfs/Bromirski_Flooding_Potential_PIER_CVAS_2012.pdf

Cayan DR, PD Bromirski, K Hayhoe, M Tyree, MD Dettinger, RE Flick. 2008. Climate change projections of sea level extremes along the California coast. *Climatic Change* 87(Suppl 1): S57-S73. doi:10.1007/s10584-007-9376-7.

Cushing L.J., Ju, Y., Kulp, S., Depsky, N., Karasaki, S., Jaeger, J., Raval, A., Strauss, B., & Morello-Frosch, R. (2023). Toxic Tides and Environmental Injustice: Social Vulnerability to Sea Level Rise and Flooding of Hazardous Sites in Coastal California. Environ. Sci. Technol. 2023, 57, 19, 7370–7381. https://doi.org/10.1021/acs.est.2c07481.

Flick RE. 1998. Comparison of California tides, storm surges, and mean sea level during the El Niño winters of 1982–1983 and 1997–1998. *Shore & Beach* 66(3): 7-11.

Flick R, J Murray, L Ewing. 2003. Trends in U.S. Tidal Datum Statistics and Tide Range. *ASCE Journal of Waterway, Port, Coast and Ocean Engineering* 129(4): 155-164. http://dsp.ucsd.edu/~jfmurray/publications/Flick2003.pdf.

Gallien TW, PL Barnard, M van Ormondt, AC Foxgrover, BF Sanders. 2012. A parcel-scale coastal flood forecasting prototype for a southern California urbanized embayment. *Journal of Coastal Research* 29(3): 642-656. doi: 10.2112/JCOASTRES-D-12-00114.1.

Governor's Office of Planning and Research. (2018). Defining Vulnerable Communities in The Context of Climate Adaptation. https://opr.ca.gov/docs/20180723-

Vulnerable_Communities.pdf.

Gallien TW, JE Schubert, BF Sanders. 2011. Predicting tidal flooding of urbanized embayments: A modeling framework and data requirements. *Coastal Engineering* 58(6): 567-577. doi:10.1016/j.coastaleng.2011.01.011.

Glover, R. E. (1959). The pattern of fresh-water flow in a coastal aquifer. *Journal of Geophysical Research*, *64*(4), 457-459.

Griggs G, K Patsch, L Savoy (Eds.). 2005. *Living with the Changing California Coast*. Berkeley and LA, CA: University of California Press. 551 pp.

Grinsted A, J Moore, S Jevrejeva. 2009. Reconstructing sea level from paleo and projected temperatures 200 to 2100 AD. *Climate Dynamics* 34: 461-472. doi:10.1007/s00382008-0507-2.

Hapke CJ, D Reid, BM Richmond, P Ruggiero, J List. 2006. *National Assessment of Shoreline Change Part 3: Historical Shore Change and Associated Coastal Land Loss Along Sandy Shorelines of the California Coast*. USGS Open File Report 2006-1219.

Hapke, C. J., & Reid, D. (2007). National assessment of shoreline change, Part 4: Historical coastal cliff retreat along the California coast (No. 2007-1133). US Geological Survey.

Highland L. 2004. *Landslide Types and Processes*. US Geological Survey Fact Sheet 2004-3072: 1-4, Reston, VA.

Hill, K., Hirschfeld, D., Lindquist, C., Cook, F., & Warner, S. (2023). Rising Coastal Groundwater as a Result of Sea-Level Rise Will Influence Contaminated Coastal Sites and Underground Infrastructure. *Earth's Future*, *11*(9), e2023EF003825.

Hummel, M.A., Berry, M.S., & Stacey M.T. (2018). Sea Level Rise Impacts on Wastewater Treatment Systems Along the U.S. Coasts. *Earth’s Future*. 6:4, 622-633. https://doi.org/10.1002/2017EF000805.

Komar PD. 1998. *Beach Processes and Sedimentation*. 2nd Ed. Upper Saddle River, NJ: Prentice Hall. 544pp.

Limber, P. W., Barnard, P. L., Vitousek, S., & Erikson, L. H. (2018). A model ensemble for projecting multidecadal coastal cliff retreat during the 21st century. Journal of Geophysical Research: Earth Surface, 123(7), 1566-1589.

May, C. L.; Mohan, A.; Plane, E.; Ramirez-Lopez, D.; Mak, M.; Luchinsky, L.; Hale, T.; Hill, K. 2022. *Shallow Groundwater Response to Sea-Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties*. Pathways Climate Institute and San Francisco Estuary Institute.

Merrifield MA. 2011. A shift in western tropical Pacific sea level trends during the 1990s. *Journal of Climate* 24(15): 4126-4138. doi:10.1175/2011JCLI3932.1.

FEMA, 2005. Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States. https://www.fema.gov/sites/default/files/nepa/Guidelines_for_Coastal_Flood_Hazard_Analysis_and_Mapping_for_the_Pacific_Coast_of_the_United_States__Jan_2005__SUPERSEDED.pdf

Ocean Protection Council (OPC). 2018. *State of California Sea-Level Rise Guidance: 2018 Update. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf*

Pfeffer WT, JT Harper, S O'Neel. 2008. Kinematic constraints on glacier contributions to 21st century sea-level rise. *Science* 321(5894): 1340 -1343. doi:10.1126/science.1159099.

Rahmstorf S. 2007. A semi-empirical approach to projecting future sea-level rise. *Science* 315(5810): 368-370. doi:10.1126/science.1135456.

Revell DL, R Battalio, B Spear, P Ruggiero, J Vandever. 2011. A methodology for predicting future coastal hazards due to sea-level rise on the California Coast. *Climatic Change* 109(Suppl 1): 251-276. doi:10.1007/s10584-011-0315-2.

Rohling E, K Grant, C Hemleben, M Siddall, B Hoogakker, M Bolshaw, M Kucera. 2008. High rates of sea-level rise during the last interglacial period. *Nature Geoscience* 1: 38-42. doi:10.1038/ngeo.2007.28.

Rotzoll, K., & Fletcher, C. H. (2013). Assessment of groundwater inundation as a consequence of sea-level rise. Nature Climate Change, 3(5), 477-481.

Scarborough, C., Welch, Z.S., Wilson, J., Gleason, M.G., Saccomanno, V.R., & Halpern, B.S. (2022). “The Historical Ecology of Coastal California.” Ocean & Coastal Management 230: 106352. https://www.sciencedirect.com/science/article/pii/S0964569122003283

Schaeffer M, W Hare, S Rahmstorf, M Vermeer. 2012. Long-term sea-level rise implied by 1.5˚C and 2˚C warming levels. *Nature Climate Change* 2: 867-870. doi:10.1038/nclimate1584.

Schubert JE, BF Sanders. 2012. Building treatments for urban flood inundation models and implications for predictive skill and modeling efficiency. *Advances in Water Resources* 41: 49-64. doi:10.1016/j.advwatres.2012.02.012.

Spencer, T., Schuerch, M., Nicholls, R. J., Hinkel, J., Lincke, D., Vafeidis, A. T., ... & Brown, S. (2016). Global coastal wetland change under sea-level rise and related stresses: The DIVA Wetland Change Model. *Global and Planetary Change, 139*, 15-30.

Swirad, Z. M., & Young, A. P. (2022). Spatial and temporal trends in California coastal cliff retreat. *Geomorphology, 412*, 108318.

Thio, HK. (2019). *Probabilistic Tsunami Hazard Maps for the State of California (Phase 2)*. Report prepared by AECOM for the California Geological Survey.

Vellinga P, C Katsman, A Sterl, J Beersma, W Hazeleger, J Church, R Kopp, D Kroon, M Oppenheimer, H Plag, S Rahmstorf, J Lowe, J Ridley, H von Storch, D Vaughan, R van de Wal, R Weisse, J Kwadijk, R Lammersen, N Marinova. 2009. *Exploring high-end climate change scenarios for flood protection of the Netherlands. International Scientific Assessment*, Prepared for the Delta Committee. Scientific Report WR-2009-05. KNMI, Alterra, The Netherlands. 150pp. http://edepot.wur.nl/191831.

Vermeer M, S Rahmstorf. 2009. Global sea level linked to global temperature. *Proceedings of the National Academy of Science* 108: 21527-21532. doi:10.1073/pnas.0907765106.

Vitousek, S., Barnard, P. L., Limber, P., Erikson, L., & Cole, B. (2017). A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. *Journal of Geophysical Research: Earth Surface*, 122(4), 782-806.

Walder JS, P Watts, OE Sorensen, K Janssen. 2003. Tsunamis generated by subaerial mass flows. *Journal of Geophysical Research: Solid Earth (1978–2012)* 108: B5. doi: 10.1029/2001JB000707.

Appendix C. Resources for Addressing Sea Level Rise

This section contains lists of sea level rise viewers, guidance documents, and state agency-produced resources and data clearing houses related to sea level rise. These resources will be particularly relevant for informing Steps 1-7 of the LCP planning process (Chapter 5). This section also provides a summary of the Commission's Environmental Justice and LCP Toolkit that is a resource for local jurisdictions to consider and incorporate environmental justice into their LCP planning process.

Resource	Description	Link
Key State Guidance and Research		
California State Sea Level Rise Guidance (OPC 2024)	The Ocean Protection Council's *State of California Sea-Level Rise Guidance* (Guidance) provides a synthesis of the best available science on sea level rise scenarios for California, a stepwise approach for state agencies and local governments to evaluate those scenarios and related hazard information in decision-making and preferred coastal adaptation approaches. This Coastal Commission SLR Policy Guidance includes the same sea level rise scenarios. It also includes recommendations about the application of the best available science that are aligned with those in the *State Sea Level Rise Guidance* but most specific to the Coastal Commission context.	https://opc.ca.gov/wp-content/uploads/2024/05/Item-4-Exhibit-A-Final-Draft-Sea-Level-Rise-Guidance-Update-2024-508.pdf
California Climate Assessments **Fourth California Climate Assessment (2018)** **Fifth California Climate Assessment (2023-2025)**	Senate Bill 1320 (Stern, 2020) called on the State to advance action-based science by developing California Climate Change Assessments at least every five years. Previous Assessments (2006, 2009, 2012, 2018) contributed to a growing understanding about the impacts of climate change in California and offer communities and decision makers the tools to take action, including a technical report that provides sea level rise projections. The Fifth Assessment is currently underway.	Home page: https://www.climateassessment.ca.gov/ Access 4th Assessment SLR projections here. Fifth Assessment data products are available via Cal-Adapt Analytics Engine
California Climate Adaptation Strategy (2021)	The *California Climate Adaptation Strategy*, mandated by Assembly Bill 1482 (Gordon, 2015), links together the state's existing and planned climate adaptation efforts, showing how they collectively achieve	https://climateresilience.ca.gov/

	California's six climate resilience priorities. Its goal is to enable a coordinated, integrated approach to building climate resilience.	
Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action (2020)	Adopted by California state agencies with coastal, bay, and shoreline climate resilience responsibilities, these principles guide unified action toward sea level rise resilience for California's coastal communities, ecosystems, and economies. The principles relate to the following subjects: Best Available Science, Partnerships, Alignment, Communications, Local Support, Coastal Resilience Projects, and Equity.	https://opc.ca.gov/wp-content/uploads/2021/01/State-SLR-Principles-Doc_Oct2020.pdf
State Agency Sea-Level Rise Action Plan for California (2022)	This Action Plan is a statewide, collaborative document designed to carry out a preceding document, *Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action.* It identifies proposed new and ongoing work for 2022-2027 and includes over 80 trackable actions, covering both a regional and statewide scope.	https://www.opc.ca.gov/webmaster/_media_library/2022/02/Item-7_Exhibit-A_SLR-Action-Plan-Final.pdf
Coastal Hazard Resilience Plan Alignment Guide (2023)	The Coastal Resilience Compass is a planning guide that helps planners along the California coast align their planning efforts to address climate change and manage future risks. It discusses how to align Local Coastal Programs (LCPs), Local Hazard Mitigation Plans (LHMPs), General plans (with a specific focus on safety and Housing Elements), climate adaptation plans, and implementation plans.	https://resilientca.org/plan-alignment/coastal-resilience-compass/
Other Coastal Commission Guidance Documents		
Critical Infrastructure at Risk: Sea Level Rise Adaptation Planning for California's Coastal Zone (CCC 2021)	This guidance promotes resilient coastal infrastructure and protection of coastal resources by providing recommendations for stakeholders on how to plan effectively for the impacts of sea level rise on coastal infrastructure, a description of the regulatory framework that applies to adaptation planning for infrastructure, and model policies that can be used by local governments as a tool for updating LCPs. It addresses two main types of infrastructure – transportation and water – and presents six key considerations for successful adaptation planning.	https://www.coastal.ca.gov/climate/slr/vulnerability-adaptation/infrastructure/
Public Trust Guiding Principles and	This Commission-adopted document describes how the public trust doctrine relates to the Coastal Commission's and local governments' work on sea level rise planning under the Coastal Act. It presents a	https://www.coastal.ca.gov/public-trust/

Action Plan (CCC 2023)	series of principles to guide the Commission's and local governments' work on this subject as well as a set of next steps and research priorities for the Commission.	
California Coastal Commission Sustainability Principles: A Framework for Reducing Greenhouse Gas Emissions in the Coastal Zone (CCC 2023)	This set of Commission-adopted principles aim to improve climate resiliency and minimize the effects of climate change throughout the coastal zone. The principles align with and help carry out the Commission's 2021 to 2025 Strategic Plan, particularly with respect to Objective 4.5 to facilitate greenhouse gas reductions in LCPs, CDPs, and other efforts. The principles also align with the state's goal of carbon neutrality by 2045 and related statewide climate strategies.	https://documents.coastal.ca.gov/assets/lcp/LUPUpdate/Sustainability%20Principles_Adopted%20August%209%202023%20Final.pdf
Progress in California: status of adaptation planning, LCPs, and case studies		
Coastal Commission website	The Coastal Commission's LCP Local Assistance Grant Program webpage provides a "Status of Grantees" chart that links to various local governments' sea level rise vulnerability assessments, adaptation plans, and LCP updates. This chart is a good resource for those looking for examples of recently completed studies and plans related to SLR.	https://www.coastal.ca.gov/lcp/grants/
California Coastal Adaptation Planning Inventory	This online Storymap summarizes the status of coastal adaptation planning in California's 76 coastal jurisdictions along the outer coast, including community vulnerability assessments, adaptation strategies, and local coastal planning under the Coastal Act. The inventory was developed by the research team at UCSB's Ocean and Coastal Policy Center, with major funding from the California Ocean Protection Council (OPC) under Proposition 68, and will be periodically updated.	https://storymaps.arcgis.com/stories/5c3ec4198b564750886cc75b95a8e492
California Adaptation Clearinghouse	Hosted by the OPR Integrated Climate Adaptation and Resiliency Program (ICARP), the *California Adaptation Clearinghouse* is a searchable database of adaptation and resilience resources organized by climate impact, topic, and region. Types of resources in the Clearinghouse include assessments, plans, or strategies; communication and educational materials; planning and policy guidance; data, tools, and research; and case studies, projects, and example planning documents.	https://resilientca.org/

Funding		
Coastal Commission LCP Local Assistance Grant Program	The Coastal Commission's LCP Local Assistance Grant Program provides funds to support local governments in completing or updating Local Coastal Programs (LCP) consistent with the California Coastal Act, with special emphasis on planning for sea level rise and climate change. Grant-funded work has included the sea level rise vulnerability assessments, technical studies, economic analyses, adaptation planning and reports, public outreach and engagement, and LCP policy development. Additional program details, including eligibility information and evaluation criteria, are provided on the program website.	https://www.coastal.ca.gov/lcp/grants/
Ocean Protection Council SB1 Grant Program	OPC's SB 1 SLR Adaptation Planning Grant Program (SB 1 Grant Program) aims to provide funding for coastal communities to develop consistent sea level rise adaptation plans and projects to build resilience to sea level rise along the entire coast of California and San Francisco Bay. One track funds projects in the pre-planning, data collection, and planning phases, and another funds projects in the implementation phase.	https://www.opc.ca.gov/sb-1-funding/
State Coastal Conservancy	The California State Coastal Conservancy has a variety of grant programs to support increased public access to and along the coast, protection and restoration of natural lands and wildlife habitat, preservation of working lands, and increased community resilience to climate change. Funding can support a variety of project stages including feasibility studies, property acquisition, community engagement, environmental review, and monitoring. More information on Conservancy grants can be found on their website.	https://scc.ca.gov/grants/
Grants.ca.gov	The California Grants Portal, a project by the California State Library, is a search engine for all grants and loans offered on a competitive or first-come basis by California state agencies. Agencies that have historically funded projects related to SLR adaptation include: the Federal Emergency Management Agency (FEMA), California Governor's Office of Emergency Services (CalOES), Ocean Protection Council (OPC), Office of Planning and Research (OPR), Strategic Growth Council (SGC), State Coastal Conservancy (SCC), and California Coastal Commission (CCC).	Grants.ca.gov

Coastal Quest Coastal Funding Database	This database provides current funding opportunities that support coastal resilience programs and coastal multi-benefit nature-based solutions, including disaster resilience, 30×30 protection, conservation, and restoration. The database is updated weekly.	https://www.coastal-quest.org/our-programs/coastal-funding-database/
SLR Mapping & Scenario Tools		
Our Coast Our Future (CoSMoS)	The USGS's Coastal Storm Modeling System (CoSMoS) provides maps of various sea level rise-related hazards under half-meter incremental sea level rise scenarios. CoSMoS provides more detailed predictions of coastal flooding due to both future sea level rise and storms integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat) over large geographic areas (100s of kilometers). While projections of groundwater rise and shoreline change are available statewide, other hazards are available from Point Arena to the Mexico border and will be available statewide in the coming years.	Access the online viewer at ourcoastourfuture.org Download GIS data layers at https://www.sciencebase.gov/catalog/item/5633fea2e4b048076347f1cf and view them on Cal Adapt at Cal-Adapt.org (Data is also hosted on the 30x30 California Climate Explorer)
Hazard Exposure Reporting and Analytics (HERA) (CoSMoS data)	The USGS's CoSMoS data is hosted on both ourcoastourfuture.org (above) and on HERA, the Hazard Exposure Reporting and Analytics website. HERA allows users to overlay the hazard data layers of CoSMoS with a host of different spatial datasets on communities, residents, employees, land types, habitats, parcels, and various types of critical infrastructure and facilities. It provides users with statistics regarding the number of people and assets within any give hazard zone.	https://www.usgs.gov/apps/hera/
NOAA Sea Level Rise Viewer	An example of a "bathtub model," this viewer shows areas that are hydrologically connected to the ocean and are located at 1-foot increments of elevation above mean sea level rise, representing the geographic areas that would become inundated with sea level rise up to 10 feet. Storms, waves, erosion, and other coastal processes are not represented.	https://coast.noaa.gov/digitalcoast/tools/slr.html

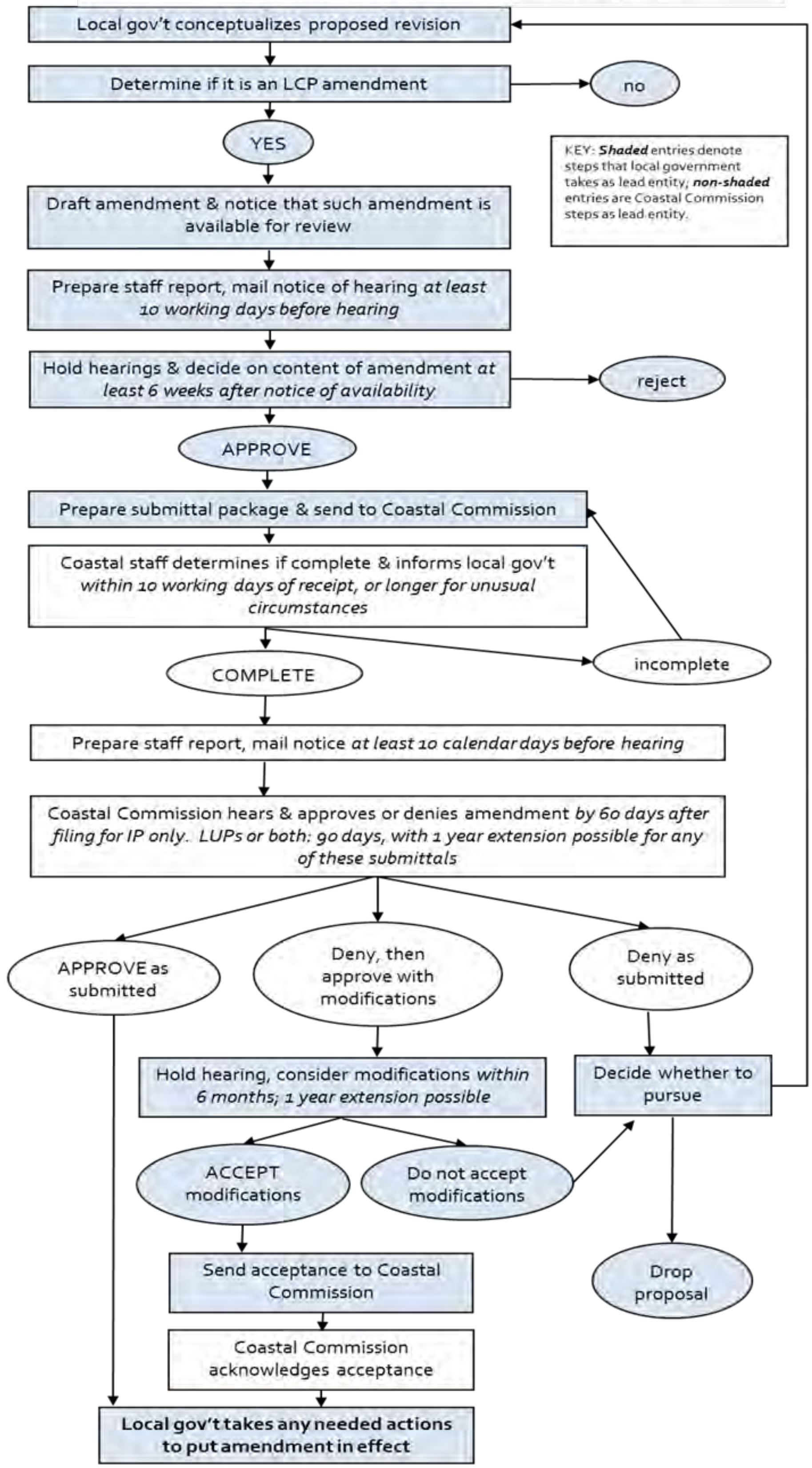
NASA Flooding Analysis Tool	This tool describes the frequency of high-tide flooding will change under various sea level rise scenarios. Users can view sea-level observations and assess past high-tide flooding frequency, view future changes in high-tide flooding frequency under various sea level rise scenarios, and view statistics and inflection points that support decision making. The tool was developed with funding from the NASA Sea Level Change Team by scientists at the University of Hawaii Sea Level Center and is based on the methods of Thompson *et al*., 2021.	https://sealevel.nasa.gov/data_tools/15/
Cal-Adapt – Exploring California's Climate	Cal-Adapt hosts two datasets on sea level rise hazards: CoSMoS data and CalFloD3D-TFS. The CoSMoS data is the same as the dataset described above. The CalFloD3D-TFS assesses potential coastal flooding exposure to areas of interest to the Transportation Fuel Sector (TFS) over five 20-year planning horizons and the Fourth Assessment scenarios using a 3Di hydrodynamic model during extremely high sea level events (72 hour storm event). Due to the inclusion of aboveground objects such as buildings and levees, CalFloD-3D depicts detailed land surface details. Details are described in Radke *et al*., 2018. Cal-Adapt Analytics Engine provides the foundational climate and environmental data that underpins the California Climate Change Assessment, including sea level rise information.	http://cal-adapt.org/tools/slr-calflod-3d/ https://analytics.cal-adapt.org/
NASA Interagency Sea Level Rise Scenario Tool	The NASA Interagency Sea Level Rise Scenario Tool provides graphs of the sea level rise scenarios in the report, *Global and Regional Sea Level Rise Scenarios for the United States* (Sweet *et al*., 2022). Scenarios are available for all U.S. states and territories, out to the year 2150.	https://sealevel.nasa.gov/task-force-scenario-tool?psmsl_id=1352
NASA & IPCC Sea Level Rise Projection Tool	The NASA Sea Level Projection Tool allows users to visualize and download the sea level projections from the IPCC *Sixth Assessment Report* (AR6). Along with global mean sea level rise projections, projections are available for various regions and tide gauge locations around the globe.	https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?type=global

The Coastal Commission has developed a resource guide to assist local governments in integrating environmental justice into their LCPs. This guide is a direct response to the Commission's Environmental Justice Policy, which encourages local authorities to include environmental justice considerations in their coastal management efforts, particularly in addressing sea level rise and ensuring community involvement. The guide is enriched with extensive research, best practices, and examples from jurisdictions like Morro Bay and Half Moon Bay, which have successfully incorporated environmental justice measures into their LCPs. It offers practical advice on amending LCPs to reflect environmental justice concerns, building meaningful relationships with affected communities, and ensuring that these communities' perspectives and needs are central to the planning process. This resource is designed to be a comprehensive tool for local governments to enhance their coastal management strategies and protect vulnerable populations while managing coastal resources effectively. For more detailed information and guidance on how to integrate environmental justice into Local Coastal Programs, you can access the full Resources for Addressing Environmental Justice Through Local Coastal Programs guide on the Commission's webpage.

Appendix D. General LCP Amendment Processing Steps and Best Practices

Sea level rise is one of many topics that should be addressed in a Local Coastal Program (LCP) or LCP amendment. The Coastal Commission offers a Local Coastal Program (LCP) Update Guide that outlines the broad process for amending or certifying an LCP, including guidance for both Land Use Plans and Implementation Plans. It addresses major Coastal Act concerns, including public access, recreation and visitor serving facilities, water quality protection, ESHA and natural resources, agricultural resources, new development, archaeological and cultural resources, scenic and visual resources, coastal hazards, shoreline erosion and protective devices, energy and industrial development, and timberlands. Therefore, this *Sea Level Rise Policy Guidance* should be used in conjunction with the LCP Update Guide to perform complete LCP amendments or certifications. The following figure depicts the general LCP amendment process.

Figure I: General LCP Amendment Processing Steps



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Appendix E. Primary Coastal Act Policies Related to Sea Level Rise and Coastal Hazards

Legislative Findings Relating to Sea Level Rise

Section 30006.5 of the Coastal Act states (Legislative findings and declarations; technical advice and recommendations) states (emphasis added):

> The Legislature further finds and declares that sound and timely scientific recommendations are necessary for many coastal planning, conservation, and development decisions and that the commission should, in addition to developing its own expertise in significant applicable fields of science, interact with members of the scientific and academic communities in the social, physical, and natural sciences so that the commission may receive technical advice and recommendations with regard to its decision-making, especially with regard to issues such as coastal erosion and geology, marine biodiversity, wetland restoration, the question of sea level rise, desalination plants, and the cumulative impact of coastal zone developments.

Environmental Justice

Section 30013 of the Coastal Act (Environmental Justice) states:

> The Legislature further finds and declares that in order to advance the principles of environmental justice and equality, subdivision (a) of Section 11135 of the Government Code and subdivision (e) of Section 65040.12 of the Government Code apply to the commission and all public agencies implementing the provisions of this division. As required by Section 11135 of the Government Code, no person in the State of California, on the basis of race, national origin, ethnic group identification, religion, age, sex, sexual orientation, color, genetic information, or disability, shall be unlawfully denied full and equal access to the benefits of, or be unlawfully subjected to discrimination, under any program or activity that is conducted, operated, or administered pursuant to this division, is funded directly by the state for purposes of this division, or receives any financial assistance from the state pursuant to this division. (Added by Ch. 578, Stats. 2016.)

Public Access and Recreation

Section 30210 of the Coastal Act (Access; recreational opportunities; posting) states:

> In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.

Section 30211 of the Coastal Act (Development not to interfere with access) states:

> Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use

> of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.

Section 30212 of the Coastal Act (New development projects) states:

> (a) Public access from the nearest public roadway to the shoreline and along the coast shall be provided in new development projects except where: (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or (3) agriculture would be adversely affected. Dedicated accessway shall not be required to be opened to public use until a public agency or private association agrees to accept responsibility for maintenance and liability of the accessway.

Section 30214 of the Coastal Act (Implementation of public access policies; legislative intent) states:

> (a) The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances in each case including, but not limited to, the following:
>
> (1) Topographic and geologic site characteristics.
>
> (2) The capacity of the site to sustain use and at what level of intensity.
>
> (3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area and the proximity of the access area to adjacent residential uses.
>
> (4) The need to provide for the management of access areas so as to protect the privacy of adjacent property owners and to protect the aesthetic values of the area by providing for the collection of litter.
>
> (b) It is the intent of the Legislature that the public access policies of this article be carried out in a reasonable manner that considers the equities and that balances the rights of the individual property owner with the public's constitutional right of access pursuant to Section 4 of Article X of the California Constitution. Nothing in this section or any amendment thereto shall be construed as a limitation on the rights guaranteed to the public under Section 4 of Article X of the California Constitution.
>
> (c) In carrying out the public access policies of this article, the commission and any other responsible public agency shall consider and encourage the utilization of innovative access management techniques, including, but not limited to, agreements with private organizations which would minimize management costs and encourage the use of volunteer programs.

Section 30220 of the Coastal Act (Protection of certain water-oriented activities) states:

> Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

Section 30221 of the Coastal Act (Oceanfront land; protection for recreational use and development) states:

> Oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area.

Section 30223 of the Coastal Act (Upland areas) states:

> Upland areas necessary to support coastal recreational uses shall be reserved for such uses, where feasible.

Wetlands and Environmentally Sensitive Resources

Section 30231 of the Coastal Act (Biological productivity; water quality) states in part:

> The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored…

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

> (a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:

Section 30240 of the Coastal Act (Environmentally sensitive habitat areas; adjacent developments) states:

> (a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.
>
> (b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.

Coastal Act Section 30121 defines "Wetland" as follows:

> "Wetland" means lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens.

The California Code of Regulations Section 13577(b) of Title 14, Division 5.5, Article 18 defines "Wetland" as follows:

> (1) Measure 100 feet landward from the upland limit of the wetland. Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats. For purposes of this section, the upland limit of a wetland shall be defined as:
>
> (A) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover;
>
> (B) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or
>
> (C) in the case of wetlands without vegetation or soils, the boundary between land that is flooded or saturated at some time during years of normal precipitation, and land that is not.
>
> (2) For the purposes of this section, the term "wetland" shall not include wetland habitat created by the presence of and associated with agricultural ponds and reservoirs where:
>
> (A) the pond or reservoir was in fact constructed by a farmer or rancher for agricultural purposes; and
>
> (B) there is no evidence (e.g., aerial photographs, historical survey, etc.) showing that wetland habitat pre-dated the existence of the pond or reservoir. Areas with drained hydric soils that are no longer capable of supporting hydrophytes shall not be considered wetlands.

In addition, Coastal Act Section 30107.5 defines "Environmentally sensitive area" as follows:

> "Environmentally sensitive area" means any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

Agricultural and Timber Lands

Section 30241 of the Coastal Act (Prime agricultural land; maintenance in agricultural production) states:

> The maximum amount of prime agricultural land shall be maintained in agricultural production to assure the protection of the areas' agricultural economy, and conflicts shall be minimized between agricultural and urban land uses…

Section 30242 of the Coastal Act (Lands suitable for agricultural use; conversion) states:

> All other lands suitable for agricultural use shall not be converted to nonagricultural uses unless (1) continued or renewed agriculture use is not feasible, or (2) such conversion would preserve prime agricultural land or concentrate development consistent with Section 30250. Any such permitted conversion shall be compatible with continue agricultural use on surrounding lands.

Section 30243 of the Coastal Act (Productivity of soils and timberlands; conversions) states:

> The long-term productivity of soils and timberlands shall be protected, and conversions of coastal commercial timberlands in units of commercial size to other uses or their division into units of noncommercial size shall be limited to providing for necessary timber processing and related facilities.

Archaeological and Paleontological Resources

Section 30244 of the Coastal Act (Archaeological or paleontological resources) states:

> Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Marine Resources

Section 30230 of the Coastal Act (Marine resources; maintenance) states:

> Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

Section 30231 of the Coastal Act (Biological productivity; water quality) states:

> The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms

> and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

> (a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects…
>
> (d) Erosion control and flood control facilities constructed on watercourses can impede the movement of sediment and nutrients that would otherwise be carried by storm runoff into coastal waters. To facilitate the continued delivery of these sediments to the littoral zone, whenever feasible, the material removed from these facilities may be placed at appropriate points on the shoreline in accordance with other applicable provisions of this division, where feasible mitigation measures have been provided to minimize adverse environmental effects. Aspects that shall be considered before issuing a Coastal Development Permit for these purposes are the method of placement, time of year of placement, and sensitivity of the placement area.

Section 30234 of the Coastal Act (Commercial fishing and recreational boating facilities) states:

> Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.

Section 30234.5 of the Coastal Act (Economic, commercial, and recreational importance of fishing) states:

> The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.

Coastal Development

Section 30250 of the Coastal Act (Location; existing developed area) states:

> (a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able

> to accommodate it, in other areas with adequate public services and where it will not have significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.
>
> (b) Where feasible, new hazardous industrial development shall be located away from existing developed areas.
>
> (c) Visitor-serving facilities that cannot feasibly be located in existing developed areas shall be located in existing isolated developments or at selected points of attraction for visitors.

Section 30251 of the Coastal Act (Scenic and visual qualities) states:

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas...

Section 30253 the Coastal Act (Minimization of adverse impacts) states in part:

> New development shall do all of the following:
>
> (a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.
>
> (b) 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 that would substantially alter natural landforms along bluffs and cliffs...

Section 30235 of the Coastal Act (Construction altering natural shoreline) states:

> Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible.

Section 30236 of the Coastal Act (Water supply and flood control) states:

> Channelizations, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (l) necessary water

> supply projects, (2) flood control projects where no other method for protecting existing structures in the flood plain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.

Sea Level Rise

Section 30270 of the Coastal Act (Sea level rise) states:

> The Commission shall take into account the effects of sea level rise in coastal resources planning and management policies and activities in order to identify, assess, and, to the extent feasible, avoid and mitigate the adverse effects of sea level rise.

Ports

Section 30705 of the Coastal Act (Diking, filling or dredging water areas) states:

> (a) Water areas may be diked, filled, or dredged when consistent with a certified port master plan only for the following: …
>
> (b) The design and location of new or expanded facilities shall, to the extent practicable, take advantage of existing water depths, water circulation, siltation patterns, and means available to reduce controllable sedimentation so as to diminish the need for future dredging.
>
> (c) Dredging shall be planned, scheduled, and carried out to minimize disruption to fish and bird breeding and migrations, marine habitats, and water circulation. Bottom sediments or sediment elutriate shall be analyzed for toxicants prior to dredging or mining, and where water quality standards are met, dredge spoils may be deposited in open coastal water sites designated to minimize potential adverse impacts on marine organisms, or in confined coastal waters designated as fill sites by the master plan where such spoil can be isolated and contained, or in fill basins on upland sites. Dredge material shall not be transported from coastal waters into estuarine or fresh water areas for disposal.

Section 30706 of the Coastal Act (Fill) states:

> In addition to the other provisions of this chapter, the policies contained in this section shall govern filling seaward of the mean high tide line within the jurisdiction of ports:
>
>> (a) The water area to be filled shall be the minimum necessary to achieve the purpose of the fill.
>>
>> (b) The nature, location, and extent of any fill, including the disposal of dredge spoils within an area designated for fill, shall minimize harmful effects to coastal resources, such as water quality, fish or wildlife resources, recreational

resources, or sand transport systems, and shall minimize reductions of the volume, surface area, or circulation of water.

(c) The fill is constructed in accordance with sound safety standards which will afford reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters.

(d) The fill is consistent with navigational safety.

Section 30708 of the Coastal Act (Location, design and construction of port related developments) states:

All port-related developments shall be located, designed, and constructed so as to:

(a) Minimize substantial adverse environmental impacts.

(b) Minimize potential traffic conflicts between vessels.

(c) Give highest priority to the use of existing land space within harbors for port purposes, including, but not limited to, navigational facilities, shipping industries, and necessary support and access facilities.

(d) Provide for other beneficial uses consistent with the public trust, including, but not limited to, recreation and wildlife habitat uses, to the extent feasible.

(e) Encourage rail service to port areas and multicompany use of facilities.

Public Works Facilities

According to Coastal Act Section 30114, public works facilities include:

(a) All production, storage, transmission, and recovery facilities for water, sewerage, telephone, and other similar utilities owned or operated by any public agency or by any utility subject to the jurisdiction of the Public Utilities Commission, except for energy facilities.

(b) All public transportation facilities, including streets, roads, highways, public parking lots and structures, ports, harbors, airports, railroads, and mass transit facilities and stations, bridges, trolley wires, and other related facilities. For purposes of this division, neither the Ports of Hueneme, Long Beach, Los Angeles, nor San Diego Unified Port District nor any of the developments within these ports shall be considered public works.

(c) All publicly financed recreational facilities, all projects of the State Coastal Conservancy, and any development by a special district.

(d) All community college facilities.

Greenhouse Gas Emissions Reduction

Section 30250(a) of the Coastal Act (Location, existing developed areas states) in part:

> (a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able to accommodate it, in other areas with adequate public services and where it will not have significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.

Section 30252 of the Coastal Act (Maintenance and enhancement of public access) states:

> The location and amount of new development should maintain and enhance public access to the coast by (1) facilitating the provision or extension of transit service, (2) providing commercial facilities within or adjoining residential development or in other areas that will minimize the use of coastal access roads, (3) providing nonautomobile circulation within the development, (4) providing adequate parking facilities or providing substitute means of serving the development with public transportation, (5) assuring the potential for public transit for high intensity uses such as high-rise office buildings, and by (6) assuring that the recreational needs of new residents will not overload nearby coastal recreation areas by correlating the amount of development with local park acquisition and development plans with the provision of onsite recreational facilities to serve the new development.

Section 30253(d) of the Coastal Act (Minimization of adverse impacts) states in part:

> New Development shall:
>
> > (d) Minimize energy consumption and vehicle miles traveled….

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Appendix F. Sea Level Rise Scenarios for 14 California Tide Gauges

Map of Tide Gauge Locations

Figure F-1. Map of tide gauge locations (from OPC 2024)

Table F-1. Sea Level Scenarios for Crescent City

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.1	0.1	0.2	0.2	0.2
2040	0.1	0.2	0.2	0.3	0.4
2050	0.1	0.3	0.4	0.6	0.8
2060	0.1	0.4	0.6	1.0	1.5
2070	0.2	0.4	0.8	1.6	2.3
2080	0.2	0.6	1.2	2.3	3.4
2090	0.2	0.7	1.7	3.0	4.5
2100	0.2	0.8	2.3	3.9	5.6
2110	0.2	0.9	2.9	4.7	6.9
2120	0.2	1.0	3.4	5.3	7.9
2130	0.2	1.2	3.8	5.8	8.7
2140	0.2	1.3	4.2	6.3	9.6
2150	0.2	1.4	4.7	6.8	10.3

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-2. Sea Level Scenarios for North Spit, Humboldt Bay

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.5	0.6	0.6	0.6	0.7
2040	0.7	0.8	0.9	1	1.1
2050	0.9	1	1.2	1.4	1.6
2060	1.1	1.3	1.5	2	2.4
2070	1.3	1.5	1.9	2.7	3.5
2080	1.4	1.8	2.5	3.6	4.7
2090	1.6	2.1	3.1	4.5	6
2100	1.8	2.4	3.9	5.5	7.3
2110	1.9	2.7	4.6	6.5	8.7
2120	2.1	3	5.3	7.3	9.9
2130	2.3	3.3	5.9	8	10.8
2140	2.4	3.5	6.5	8.6	11.9
2150	2.6	3.8	7.1	9.3	12.8

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-3. Sea Level Scenarios for Arena Cove

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.4	0.4
2040	0.3	0.4	0.5	0.6	0.7
2050	0.4	0.5	0.7	0.9	1.1
2060	0.5	0.7	0.9	1.4	1.8
2070	0.5	0.8	1.2	2.1	2.8
2080	0.6	1.0	1.7	2.8	3.9
2090	0.7	1.2	2.2	3.6	5.1
2100	0.8	1.4	2.9	4.5	6.4
2110	0.8	1.6	3.6	5.4	7.6
2120	0.9	1.7	4.1	6.1	8.7
2130	0.9	1.9	4.6	6.7	9.6
2140	1.0	2.1	5.1	7.3	10.5
2150	1.0	2.3	5.6	7.8	11.4

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-4. Sea Level Scenarios for Point Reyes

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.5
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.7	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.6	2.0
2070	0.7	1.0	1.4	2.2	3.0
2080	0.8	1.2	1.9	3.0	4.1
2090	0.9	1.4	2.5	3.9	5.4
2100	1.0	1.6	3.1	4.8	6.6
2110	1.1	1.8	3.8	5.7	7.9
2120	1.2	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.5	7.6	10.9
2150	1.4	2.7	6.0	8.2	11.8

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-5. Sea Level Scenarios for San Francisco

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	2.9
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.8	5.3
2100	1.0	1.6	3.1	4.8	6.5
2110	1.0	1.8	3.8	5.6	7.8
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.4	7.6	10.8
2150	1.3	2.6	6.0	8.1	11.7

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-6. Sea Level Scenarios for Alameda

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.8	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.6	1.1	2.1	3.5	5.0
2100	0.6	1.2	2.8	4.4	6.2
2110	0.7	1.4	3.4	5.3	7.5
2120	0.7	1.6	4.0	5.9	8.5
2130	0.8	1.7	4.5	6.5	9.4
2140	0.8	1.9	4.9	7.1	10.3
2150	0.8	2.1	5.4	7.6	11.2

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-7. Sea Level Scenarios for Port Chicago

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.4
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.6	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.5	2.0
2070	0.7	1.0	1.4	2.2	2.9
2080	0.8	1.2	1.8	3.0	4.1
2090	0.9	1.4	2.4	3.8	5.3
2100	1.0	1.6	3.1	4.8	6.5
2110	1.0	1.8	3.8	5.6	7.8
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.0	9.9
2140	1.3	2.4	5.4	7.6	10.8
2150	1.4	2.6	6.0	8.1	11.7

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-8. Sea Level Scenarios for Monterey

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.4	0.4
2040	0.3	0.4	0.5	0.6	0.7
2050	0.4	0.6	0.7	0.9	1.2
2060	0.5	0.7	1.0	1.4	1.9
2070	0.6	0.9	1.3	2.1	2.8
2080	0.6	1.0	1.7	2.9	3.9
2090	0.7	1.2	2.3	3.7	5.2
2100	0.8	1.4	2.9	4.6	6.4
2110	0.8	1.6	3.6	5.5	7.7
2120	0.9	1.8	4.2	6.2	8.8
2130	0.9	1.9	4.7	6.8	9.7
2140	1.0	2.1	5.2	7.3	10.6
2150	1.1	2.3	5.7	7.9	11.5

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-9. Sea Level Scenarios for Port San Luis

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.7	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.5	1.1	2.1	3.5	5.0
2100	0.6	1.2	2.8	4.5	6.3
2110	0.6	1.4	3.4	5.3	7.5
2120	0.7	1.5	4.0	6.0	8.6
2130	0.7	1.7	4.4	6.6	9.5
2140	0.7	1.9	4.9	7.1	10.4
2150	0.8	2.0	5.5	7.6	11.3

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-10. Sea Level Scenarios for Santa Barbara

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.7	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.5	1.1	2.1	3.5	5.0
2100	0.6	1.2	2.8	4.5	6.3
2110	0.6	1.4	3.4	5.3	7.5
2120	0.7	1.5	4.0	6.0	8.6
2130	0.7	1.7	4.4	6.6	9.5
2140	0.7	1.9	4.9	7.1	10.4
2150	0.8	2.0	5.5	7.6	11.3

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-11. Sea Level Scenarios for Santa Monica

Projected SLR Amounts (in feet)					
	Low	Intermediate-Low	Intermediate	Intermediate-High	High
2030	0.3	0.3	0.4	0.4	0.4
2040	0.3	0.4	0.5	0.6	0.7
2050	0.4	0.6	0.7	0.9	1.2
2060	0.5	0.7	1.0	1.5	1.9
2070	0.6	0.9	1.3	2.1	2.8
2080	0.6	1.0	1.7	2.9	3.9
2090	0.7	1.2	2.3	3.7	5.2
2100	0.8	1.4	2.9	4.6	6.4
2110	0.8	1.6	3.6	5.5	7.7
2120	0.9	1.8	4.2	6.2	8.8
2130	0.9	1.9	4.7	6.8	9.7
2140	1.0	2.1	5.2	7.3	10.6
2150	1.1	2.3	5.7	7.9	11.5

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-12. Sea Level Scenarios for Los Angeles

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.2	0.3	0.3	0.4	0.4
2040	0.3	0.4	0.5	0.6	0.7
2050	0.4	0.5	0.7	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.8	1.2	2.1	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.6	1.1	2.2	3.6	5.0
2100	0.6	1.3	2.8	4.5	6.3
2110	0.7	1.4	3.5	5.3	7.6
2120	0.7	1.6	4.0	6.0	8.6
2130	0.8	1.8	4.5	6.6	9.5
2140	0.8	1.9	5.0	7.1	10.4
2150	0.8	2.1	5.5	7.7	11.3

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-13. Sea Level Scenarios for La Jolla

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.4	0.5
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.7	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.6	2.0
2070	0.7	1.0	1.4	2.3	3.0
2080	0.8	1.2	1.8	3.1	4.1
2090	0.9	1.4	2.4	3.9	5.3
2100	0.9	1.6	3.1	4.8	6.6
2110	1.0	1.8	3.8	5.7	7.9
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.1	9.9
2140	1.2	2.4	5.5	7.6	10.9
2150	1.3	2.6	6.0	8.2	11.8

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Table F-14. Sea Level Scenarios for San Diego

Projected SLR Amounts (in feet)					
	Low	**Intermediate-Low**	**Intermediate**	**Intermediate-High**	**High**
2030	0.3	0.4	0.4	0.5	0.5
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.7	0.8	1.1	1.3
2060	0.6	0.9	1.1	1.6	2.0
2070	0.7	1.0	1.4	2.3	3.0
2080	0.8	1.2	1.9	3.1	4.1
2090	0.9	1.4	2.5	3.9	5.4
2100	1.0	1.6	3.2	4.9	6.7
2110	1.1	1.8	3.9	5.7	8.0
2120	1.2	2.1	4.5	6.5	9.1
2130	1.3	2.3	5.0	7.1	10.0
2140	1.3	2.5	5.6	7.7	11.0
2150	1.4	2.7	6.1	8.3	11.9

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Appendix G. Coastal Commission Contact Information

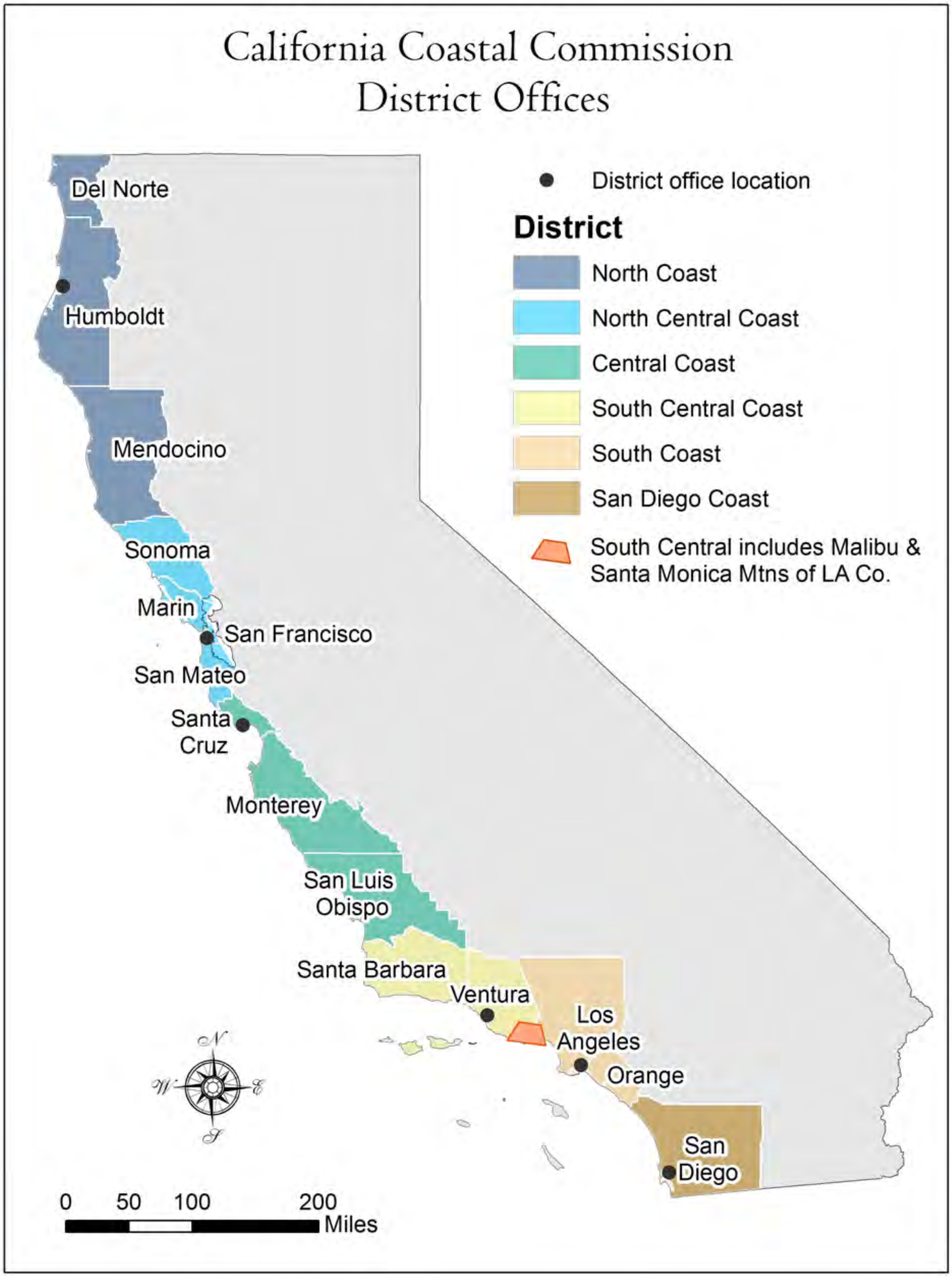

Figure G-1. Location of Coastal Commission Offices

Coastal Commission District Office Contact Information

North Coast (Del Norte, Humboldt, Mendocino Counties)
(707) 826-8950

North Central Coast (Sonoma, Marin, San Francisco, San Mateo Counties)
(415) 904-5260

Headquarters
(415)-904-5202

Central Coast (Santa Cruz, Monterey, San Luis Obispo Counties)
(831) 427-4863

South Central Coast (Santa Barbara and Ventura Counties, and the Malibu portion of Los Angeles County)
(805) 585-1800

South Coast (Los Angeles (except Malibu) and Orange Counties)
(562) 590-5071

San Diego (San Diego County)
(619) 767-2370