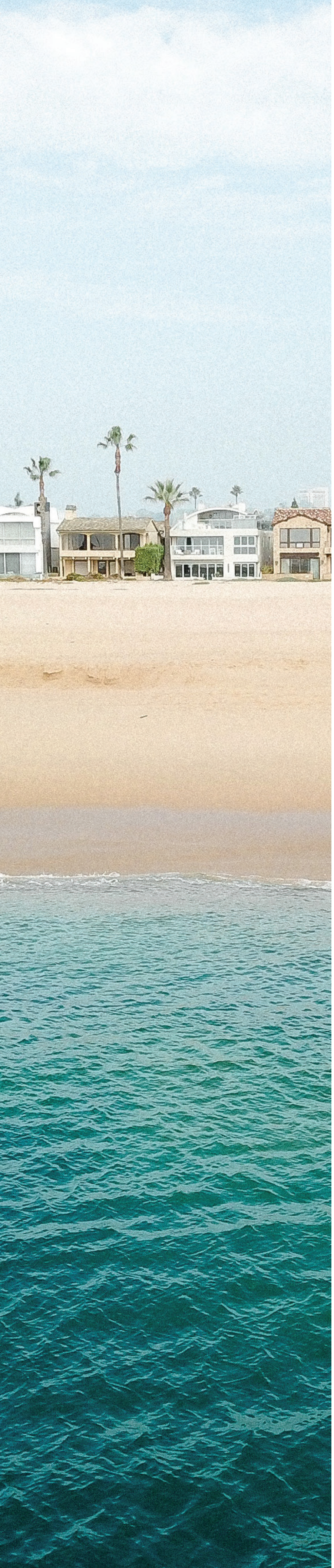
State of California Sea-Level Rise Guidance

2018 UPDATE



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CALIFORNIA natural resources AGENCY

CALIFORNIA OCEAN PROTECTION COUNCIL

Executive Summary

THE CLIMATE ACROSS CALIFORNIA is changing, and the effects, such as rising average temperatures, shrinking mountain snowpack, more intense storms, and higher sea levels are expected to continue and worsen in the coming decades. Sea-level rise is caused by the thermal expansion of warming ocean water and melting of land ice as the Earth warms. It is one of the most obvious manifestations of the trend of climate change and is an immediate and real threat to lives, livelihoods, transportation, economies, and the environment in California.

In April 2017, catalyzed by direction from Governor Brown and the need to ensure that best available science was informing sea-level rise planning decisions in California, a Working Group of the California Ocean Protection Council's Science Advisory Team (OPC-SAT) released a report, entitled "Rising Seas in California: An Update on Sea-Level Rise." The Rising Seas Report was prepared and peer-reviewed by some of the nation's foremost experts in coastal processes, climate and sea-level rise science, observational and modeling science, the science of extremes, and decision-making under uncertainty. The report synthesized the current state of sea-level rise science, including advances in modeling and improved understanding of the processes that could drive extreme global sea-level rise as a result of ice loss from the Greenland and Antarctic ice sheets. The report found that:

- Scientific understanding of sea-level rise is advancing at a rapid pace.
- The direction of sea-level change is clear; sea levels are rising.
- The rate of ice loss from the Greenland and Antarctic ice sheets is increasing, and California is particularly vulnerable to sea-level rise caused by ice loss from West Antarctica.
- New scientific evidence has highlighted the potential for extreme sea-level rise.
- Probabilities of specific sea-level increases can inform decisions.
- Current policy decisions are shaping our coastal future.
- Waiting for scientific certainty is neither a safe nor prudent option.

The increased understanding of sea-level rise projections and polar ice sheet loss warranted an update to the State's sea-level rise guidance document to ensure decisions were based on the best available science. Additionally, an increased policy focus requiring state and local governments to incorporate climate change into decision making merited an update to address the needs of both state and local audiences.

This updated document, the "State of California Sea-Level Rise Guidance" (Guidance), provides a bold, science-based methodology for state and local governments to analyze and assess the risks associated with sea-level rise, and to incorporate sea-level rise into their planning, permitting, and investment decisions. This Guidance provides:

1. A synthesis of the best available science on sea-level rise projections and rates for California;
2. A step-by-step approach for state agencies and local governments to evaluate those projections and related hazard information in decision making; and
3. Preferred coastal adaptation approaches.

What Has Changed Since the 2013 Update to the Guidance?

New policy context and expanded audience

State agencies were the target audience for the earlier versions of this Guidance, which was initially developed in 2010 and updated in 2013. However, over the past five years, there has been a multitude of policy and legislative directives and mandates focused on improving climate adaptation and resiliency in California at both the state and local level, including:

- Governor Brown's Executive Order B-30-15 directing state agencies to factor climate change into their planning and investment decisions;
- Senate Bill 379 (Jackson) requiring local governments to incorporate climate adaptation and resiliency strategies into their General Plans; and
- Senate Bill 246 (Wieckowski), which established the Governor's Office of Planning and Research's Integrated Climate Adaptation and Resiliency Program to coordinate local and state climate adaptation strategies.

With this increased policy direction and improved understanding of possible impacts, the 2018 Guidance aims to respond to the needs for guidance that can help cities, counties and the State prepare for, and adapt to, sea-level rise.

Significant advances in the scientific understanding of sea-level rise.

- Scenario-based versus probabilistic sea-level rise projections. The 2013 version of the State's sea-level rise guidance provided scenario-based sea-level rise projections based on a 2012 National Research Council report; these scenario-based projections were partially but not fully tied to specific emissions scenarios presented in the Intergovernmental Panel on Climate Change's Fourth Assessment Report and do not include a likelihood of occurrence. Since the 2013 Guidance, the scientific community has made significant progress in producing probabilistic projections of future sea level rise, and the team of scientists advising the Ocean Protection Council (OPC) on this Guidance strongly recommended that decision-makers use probabilistic projections to understand and address potential sea-level rise impacts and consequences. This updated Guidance thus incorporates probabilistic sea-level rise projections, which associate a likelihood of occurrence (or probability) with sea-level rise heights and rates, and are directly tied to a range of emissions scenarios.
- H++ scenario. The probabilistic projections may underestimate the likelihood of extreme sea-level rise (resulting from loss of the West Antarctic ice sheet), particularly under high emissions scenarios. Therefore, the 2018 update to the Guidance also includes an extreme scenario called the H++ scenario. The probability of this scenario is currently unknown, but its consideration is important, particularly for high-stakes, long-term decisions.

The science on sea-level rise will continue to evolve, possibly significantly, in coming years. Continual updates to our scientific understanding must be expected as observations and models improve, and as the environment continues to change. Planners should remain cognizant of this evolving picture, while at the same time beginning to plan today under this uncertainty. This Guidance is based on the recognition that it is no longer appropriate to assume a static environment in planning and decision making and that communities can nonetheless effectively plan and take action in such changing conditions.

Extended stakeholder engagement in Guidance development.

The 2018 update to the Guidance was developed by OPC, in close coordination with a Policy Advisory Committee with representation from the California Natural Resources Agency, the Governor's Office of Planning and Research, and the California Energy Commission. To improve coordination and consistency in sea-level rise planning, OPC also collaborated closely with state coastal management agencies and other member agencies of the State's Coastal and Ocean Working Group of California's Climate Action Team (CO-CAT). In addition, OPC, with assistance from the Ocean Science Trust and engagement experts, solicited input from coastal stakeholders including local governments, regional agencies, federal agencies, coastal consultants, environmental groups, Tribes, and others to better understand the needs and concerns related to planning for sea-level rise and related risks across the state.

Sea-level rise risk analysis and decision framework.

This Guidance provides a step-wise approach to help decision makers assess risk by evaluating a range of sea-level rise projections and the impacts or consequences associated with these projections. Depending on the finite factors of a proposed project's location and lifespan, decision makers can evaluate the potential impacts and adaptive capacity of the project across a spectrum of sea-level rise projections. This analysis will enable state agencies and local governments to incorporate the latest sea-level rise projections and related hazard information to consider in different types of decisions across California.

The following steps, outlined in the figure and in more detail below, provide a decision framework to evaluate the consequences and risk tolerance of various planning decisions. This framework should be used to guide selection of appropriate sea-level rise projections, and, if necessary, develop adaptation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded or prematurely reached:

>> **STEP 1:** *Identify the nearest tide gauge.*

>> **STEP 2:** *Evaluate project lifespan.*

>> **STEP 3:** *For the nearest tide gauge and project lifespan, identify range of sea-level rise projections.*

>> **STEP 4:** *Evaluate potential impacts and adaptive capacity across a range of sea-level rise projections and emissions scenarios.*

>> **STEP 5:** *Select sea-level rise projections based on risk tolerance and, if necessary, develop adapation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded.*

Preferred Coastal Adaptation Planning Approaches.

This Guidance expands the preferred coastal adaptation planning approaches identified in OPC's previous guidance, incorporating existing law, expressed policy preferences by the Governor and Legislature, and the goal of fostering consistency across coastal and ocean government agencies. The following is a summary of the new recommendations:

- Adaptation strategies should prioritize protection of vulnerable communities and take into consideration social equity and environmental justice.
- Coastal habitats and public access should be protected and preserved.
- Adaptation strategies should consider the unique characteristics, constraints and values of water-dependent infrastructure, ports and Public Trust uses.
- Acute increases in sea-level rise caused by storm surges, El Niño events, king tides, or large waves should be considered. These events could produce significantly higher water levels than sea-level rise alone and will likely be the drivers of the strongest impacts to coastal communities, ecosystems, and infrastructure.
- Cross-jurisdictional coordination and consistency among permitting entities should be sought in selecting sea-level rise projections. These entities should also prioritize implementation of consistent or complementary adaptation strategies.
- Local conditions, including the diversity of shoreline types, natural conditions, and community characteristics, should be evaluated to inform risk tolerance and adaptation decisions.
- Adaptive capacity should be built into project design and planning.
- Risk assessment and adaptation planning efforts should be conducted at community and regional levels, when possible.

Mapping Tools.

This Guidance also describes and provides links to a variety of geospatial and visualization tools to assist decision makers in understanding the impacts of sea-level rise. The document is accompanied by a library and database of additional resources – hosted on the State Adaptation Clearinghouse and OPC's website – to help visualize change, access funding opportunities, gather policy and scientific background related to specific jurisdictions, and provide additional support to address a challenge of this nature and magnitude. This library and database will be released in mid-2018 when the State Adaptation Clearinghouse is publicly launched.

How Often Will the State of California Sea-Level Rise Guidance be Updated?

Based on recommendations from OPC's Scientific Working Group, OPC anticipates updating the Guidance periodically, and at a minimum of every five years, to reflect the latest scientific understanding of climate change sea-level rise in California. Rapid advances in sea-level rise and climate science, and subsequent release of relevant, peer-reviewed studies from the Intergovernmental Panel on Climate Change (IPCC), state and national climate assessments, and equivalently recognized sources may generate the need for more frequent updates. By incorporating periodic updates at least every five years, this Guidance attempts to establish a strong foundation for sea-level rise planning and decision making at both local, regional, and statewide scales that can be perpetuated in future updates to sea-level rise projections.

In developing this Guidance, the State took intentional action to engage users and decision makers to ensure that the scientific information and policy direction was understandable and useful for sea-level rise planning and adaptation efforts. Going forward, OPC will continue to prioritize opportunities for co-production of future decision-support products by scientists, practitioners, and policy and decision makers to further improve the translation of sea-level rise science into action.

Introduction

The climate across California is changing, and the effects, such as rising average temperatures, shrinking mountain snowpack, more intense storms, and higher sea levels are expected to continue and worsen in the coming decades. Sea-level rise, caused by the thermal expansion of warming ocean and melting of land ice as the Earth warms, is one of the most obvious manifestations of the trend of climate change and is an immediate and real threat to lives, livelihoods, transportation, economies, and the environment in California.

The impacts of sea-level rise on California are significant. The vast majority of California's population lives in coastal counties and will directly experience the effects of sea-level rise on homes, roads, public services, and infrastructure. More frequent and chronic flooding and erosion are inevitable. Inland populations are not immune. For example, Sacramento-San Joaquin River Delta communities can expect to see inundation, saltwater intrusion, and transportation disruptions (for people and goods); and even further from the San Francisco Bay and California coast, communities will experience the far-reaching ripple effects of coastal changes on lives and livelihoods. California's ocean economy – including tourism, recreation and marine transportation – is the nation's largest, valued at over $44 billion per year.[1] This important and lucrative sector will be directly disrupted by the effects of sea-level rise.Many of the facilities and much of the infrastructure that support California's

1. Kildow, Judith, Colgan, Charles, and Johnston, Pat. "Coastal and Ocean Economic Summaries of the Coastal States - Update 2016" National Ocean Economics Program, Center for the Blue Economy, Middlebury Institute of International Studies at Monterey. 2016. http://centerfortheblueeconomy.org/2016-noep-report

ocean economy, as well as the state's many miles of public beaches, lie within a few feet of the present high-tide line and therefore are at risk from future sea-level rise and coastal storm events as a result of a changing climate.

Because the threats cascade beyond the immediate coastline, a proper and coordinated response and clear guidance about how to plan and prepare for change is crucial. California has exhibited strong and global leadership across both climate adaptation and mitigation. This Guidance seeks to build upon that leadership by providing a bold science-based methodology for state and local governments to analyze and assess the risks associated with sea-level rise. Catalyzed by direction from Governor Brown in 2016, this Guidance document reflects advances in sea-level rise science and addresses the needs of state agencies and local governments as they incorporate sea-level rise into their planning, permitting, and investment decisions.

State agencies were the target audience for the earlier versions of this Guidance, which was initially developed in 2010 and updated in 2013. However, over the past five years, there has been a multitude of policy and legislative directives and mandates focused on improving climate adaptation and resiliency in California at both the state and local level, including: Governor Brown's Executive Order B- 30-15 directing state agencies to factor climate change into their planning and investment decisions; Senate Bill 379 (Jackson) requiring local governments to incorporate climate adaptation and resiliency strategies into their General Plans; and Senate Bill 246 (Wieckowski), which established the Governor's Office of Planning and Research's Integrated Climate Adaptation and Resiliency Program (ICARP) to coordinate local and state climate adaptation strategies.[2] Increased policy direction and improved understanding of possible impacts are driving the need for guidance that can help cities, counties, and the State prepare for, and adapt to, sea-level rise.

In parallel with California's leadership across the climate change policy landscape, advances in scientific understanding warranted an update to the Guidance to ensure decisions were based on the best available science.[3] These advances include improved sea-level rise modeling (namely, improved methods for estimating probabilities of local sea-level change) and better understanding of potential ice loss from the Greenland and Antarctic ice sheets – and the implications of this loss for both global average sea-level rise and sea-level rise off the West Coast of the United States.

The 2018 update to the Guidance was developed by OPC, in coordination with the California Natural Resources Agency, the Governor's Office of Planning and Research, and the California Energy Commission. To ensure that the updated Guidance was understandable and useful for local and state decision making, the update process included extensive public outreach, with interviews, listening sessions and public workshops to solicit input from local, regional, state and federal stakeholders. To improve coordination and consistency in sea-level rise planning, OPC also collaborated closely with state coastal management agencies and other member agencies of the State's Coastal and Ocean Working Group of California's Climate Action Team (CO-CAT). See Appendix 1 for a full summary on the Guidance development.

Purpose and Intended Use

The purpose of this Guidance is to assist decision makers at state and local levels in planning for, and making decisions about, sea-level rise and related coastal hazards in light of the current state of the science.

This Guidance aims to:

1. Synthesize – at a high level – the key findings of the science report solicited in preparation for this Guidance update, thereby establishing what constitutes "the best available science," and outlining sea level projections and rates for

2. Executive Order B-30-15 (2015): https://www.gov.ca.gov/news.php?id=18938; SB 379 (Jackson), Land use: general plan: safety element: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB379; SB 264 (Wieckowski), Integrated Climate Adaptation and Resiliency Program: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB246

3. The 2013 document incorporated the sea-level rise projections from the 2012 National Research Council report on sea-level rise along the West Coast titled: "Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future": https://www.nap.edu/read/13389/chapter/1

California, for purposes of planning and decision making by state and local governments;

2. Provide a step-by-step approach for state agencies and local governments to incorporate and adapt to the latest sea-level rise projections and related hazard information in different types of decisions across California; and
3. Articulate OPC's preferred coastal adaptation planning approaches in the context of existing law, expressed policy preferences by the Governor and the Legislature, and OPC's goal to foster consistency across coastal and ocean government agencies.

This Guidance is consistent with OPC's commitments to use the best available science in the management of ocean resources, to employ a precautionary approach in the face of scientific uncertainty and the potential for significant harm, and to improve coordination across government agencies in addressing the complex challenges of climate change.[4]

This statewide policy document is necessarily a high-level framework that allows state agencies, local authorities and other users to incorporate the essential principles and recommendations while accommodating the diversity of processes and decisions across agencies and authorities. It is not a "how-to" guide but rather a guiding framework. Thus, accompanying this policy Guidance is a library and database of resources to help visualize change, access funding opportunities, gather policy and scientific background related to specific jurisdictions, and in general provide additional support to address a challenge of this nature and magnitude. This database and library of resources will be available on the State Adaptation Clearinghouse[5] in mid-2018, as well as OPC's website. It draws on an extensive resource database developed pursuant to AB 2516,[6] as well as additional resources compiled in response to outreach conducted as part of the Guidance update process.

Planning, permitting, and investment decisions initiated after OPC's adoption of the 2018 Guidance should incorporate the updated analysis and adaptation measures described below. Recognizing the considerable time and resources necessary to incorporate sea-level rise into planning processes, planning or development projects currently underway at the time of Guidance adoption should complete those efforts while evaluating potential adaptation pathways to prepare for projected increases in sea-level rise contained herein. To the extent possible, and where applicable, projects in the scoping or early stages at the time of the Guidance adoption should adjust sea-level rise projections to incorporate the latest projections in order to maximize a project's lifetime and plan for a more resilient coastline.

Frequency of Future Updates

Based on recommendations from OPC's Scientific Working Group, OPC anticipates updating the Guidance periodically, and at a minimum of every five years, to reflect the latest scientific understanding of climate change driven sea-level rise in California. Rapid advances in science and subsequent release of relevant, peer-reviewed studies from the Intergovernmental Panel on Climate Change (IPCC), state and national climate assessments, and equivalently recognized sources may generate the need for more frequent updates. By incorporating periodic updates at least every five years, this Guidance attempts to establish a strong foundation for sea-level rise planning and decision making at both local, regional, and statewide scales that can be perpetuated in future updates to sea-level rise projections. Wherever possible, California is integrating and aligning updates to the Guidance with other State-mandated policy and assessment efforts, such as the Governor's Office of Planning and Research's (OPR) Integrated Climate Adaptation and Resiliency Program, the recommendations and next steps of the Safeguarding California Plan, California's Fourth Climate Change Assessment, the Climate-Safe Infrastructure Working Group, and various guidance documents issued by the California Coastal Commission and other regulatory agencies.

4. http://www.opc.ca.gov/about/
5. https://www.opr.ca.gov/s_icarpclearinghouse.php
6. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2516

Guidance Implementation

This high-level Guidance was developed to help state and local governments analyze the risks associated with sea-level rise, and develop precautionary adaptation pathways and strategies that ensure community, regional, and statewide resilience in the face of rising seas. The updated projections and recommendations, which fit within a larger body of work assessing sea-level rise vulnerabilities and preparing for future conditions, may be incorporated by state agencies into planning and investment decisions. The Guidance may also be integrated into local government planning and adaptation efforts through statutory, regulatory, and policy mechanisms including, but not limited to: the Coastal Commission's Local Coastal Programs, the San Francisco Bay Conservation and Development Commission's permitting process, and General Plans updates that must include climate change adaptation and resiliency strategies pursuant to Senate Bill 379. OPC is committed to continued outreach and collaboration with stakeholders and agencies to ensure effective implementation of this Guidance.

Best Available Science to Support Planning for Sea-Level Rise in California

Rising Seas In California: An Update On Sea-Level Rise Science

In April 2017, at the request of OPC, a Working Group of OPC's Science Advisory Team (OPC-SAT) released a report synthesizing the state of sea-level rise science entitled "Rising Seas in California: An Update on Sea-Level Science" (Rising Seas Report).[7] The Rising Seas Report was prepared and peer-reviewed by some of the nation's foremost experts in coastal processes, climate and sea-level rise science, observational and modeling science, the science of extremes, and decision-making under uncertainty. The Rising Seas Report, which provides the scientific foundation for this update to the Guidance, included advances in sea-level rise modeling and improved understanding of the processes that could drive extreme global sea-level rise from ice loss from the Greenland and Antarctic ice sheets. This work, along with other authoritative peer-reviewed science (as long as not less precautionary than the foundation set forth by the Rising Seas Report) serve as the best available science on which to base future planning and investing decisions in California.

Key findings from *Rising Seas in California: An Update on Sea-Level Rise Science*

There are seven key findings from the Rising Seas Report that provide a succinct summary statement of the latest understanding of and advancements in sea-level rise science. The report provides the foundation for state and local governments to make decisions associated with sea-level rise utilizing timely, well-vetted scientific analysis. Its fundamental

7. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

messages, which are relied on throughout this Guidance, are as follows:

1. **Scientific understanding of sea-level rise is advancing at a rapid pace.**
   Projections of future sea-level rise, especially under high emissions scenarios, have increased substantially over the last few years, primarily due to new and improved understanding of mass loss from continental ice sheets. These sea-level rise projections will continue to change as scientific understanding increases and as the impacts of local, state, national and global policy choices become manifest. New processes that allow for rapid incorporation of new scientific data and results into policy will enable state and local agencies to proactively prepare.

2. **The direction of sea-level change is clear.**
   Coastal California is already experiencing the early impacts of a rising sea level, including more extensive coastal flooding during storms, periodic tidal flooding, and increased coastal erosion.

3. **The rate of ice loss from the Greenland and Antarctic Ice Sheets is increasing.**
   These ice sheets will soon become the primary contributor to global sea-level rise, overtaking the contributions from ocean thermal expansion and melting mountain glaciers and ice caps. Ice loss from Antarctica, and especially from West Antarctica, causes higher sea-level rise in California than the global average: for example, if the loss of West Antarctic ice were to cause global sea-level to rise by 1 foot, the associated sea-level rise in California would be about 1.25 feet.

4. **New scientific evidence has highlighted the potential for extreme sea-level rise.**
   If greenhouse gas emissions continue unabated, key glaciological processes could cross thresholds that lead to rapidly accelerating and effectively irreversible ice loss. Aggressive reductions in greenhouse gas emissions may substantially reduce but do not eliminate the risk to California of extreme sea-level rise from Antarctic ice loss. Moreover, current observations of Antarctic melt rates cannot rule out the potential for extreme sea-level rise in the future, because the processes that could drive extreme Antarctic Ice Sheet retreat later in the century are different from the processes driving loss now.

5. **Probabilities of specific sea-level increases can inform decisions.**
   A probabilistic approach to sea-level rise projections, combined with a clear articulation of the implications of uncertainty and the decision support needs of affected stakeholders, is the most appropriate approach for use in a policy setting. This report employs the framework of Kopp et al. 2014 to project sea-level rise for three representative tide gauge locations along the Pacific coastline: Crescent City in Northern California, San Francisco in the Bay Area, and La Jolla in Southern California. These projections may underestimate the likelihood of extreme sea-level rise, particularly under high-emissions scenarios, so this report also includes an extreme scenario called the H++ scenario. The probability of this scenario is currently unknown, but its consideration is important, particularly for high-stakes, long-term decisions.

6. **Current policy decisions are shaping our coastal future.**
   Before 2050, differences in sea-level rise projections under different emissions scenarios are minor but they diverge significantly past mid-century. After 2050, sea-level rise projections increasingly depend on the trajectory of greenhouse gas emissions. For example, under the extreme H++ scenario rapid ice sheet loss on Antarctica could drive rates of sea-level rise in California above 50 mm/year (2 inches/year) by the end of the century, leading to potential sea-level rise exceeding 10 feet. This rate of sea-level rise would be about 30-40 times faster than the sea-level rise experienced over the last century.

7. **Waiting for scientific certainty is neither a safe nor prudent option.**
   High confidence in projections of sea-level rise over the next three decades can inform preparedness efforts, adaptation actions and hazard mitigation undertaken today, and prevent much greater losses than will occur if action is not taken. Consideration of high and even extreme sea levels in decisions with implications past 2050 is needed to safeguard the people and resources of coastal California.

Global Greenhouse Gas Emissions Scenarios

The pace and severity of sea-level rise will depend on several factors, including – most importantly – the pace and scale of global greenhouse gas (GHG) emissions and the success of subsequent reduction measures over this century. During the past five years, the atmospheric greenhouse gas concentrations have continued to increase. Since late 2015, measurements of the atmospheric CO_2 concentration have consistently exceeded 400 parts per million (PPM). Recent concentrations are approximately 45% higher than the pre-industrial level, and about 2.5% higher than in 2012. Increases in CO_2 and other greenhouse gases have resulted in the Earth's climate system absorbing more energy than it is emitting back to space. More than 90% of this excess heat is being captured by the global ocean, leading to a subsequent increase in sea surface temperatures and ocean heat content. Rising temperatures are melting glaciers and ice sheets. Combined with the expansion of seawater as it warms, these changes are causing sea levels to rise.

For this Guidance, the emissions scenarios included are the same as those used by the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC Fifth Assessment) and are called Representative Concentration Pathways or RCPs. There are four RCPs, named for the associated radiative forcing level, in watts per square meter, in 2100: RCP 8.5, 6.0, 4.5 and 2.6. Each RCP represents a family of possible underlying socioeconomic conditions, policy options and technological considerations, spanning from a low-end scenario (RCP 2.6) that requires significant emissions reductions to a high-end, "business-as-usual," fossil-fuel-intensive emission scenario (RCP 8.5). For this Guidance, we focus on RCP 2.6 and RCP 8.5 to bound a range of potential sea level futures based on GHG emissions trajectories.

RCP 8.5, often referred to as a "business-as-usual" scenario, is consistent with a future where there are few global efforts to limit or reduce emissions. Under RCP 8.5, global CO_2 emissions nearly double between years 2015 and 2050. At the other end of the spectrum, RCP 2.6 is an aggressive emissions reduction scenario that assumes global greenhouse gas emissions will be significantly curtailed. Under this scenario, global CO_2 emissions decline by about 70% between 2015 and 2050, to zero by 2080, and below zero thereafter. Though more aggressive, RCP 2.6 most closely corresponds to the aspirational goals of the United Nations Framework Convention on Climate Change (UNFCCC) 2015 Paris Agreement, which calls for limiting global mean warming to less than 2°C and achieving net-zero greenhouse gas emissions in the second half of this century.

We include RCP 8.5 as an upper bound for California's sea-level response projections because thus far, our greenhouse gas emissions worldwide have continued to follow the business-as-usual trajectory. Without a significant and timely commitment to reducing emissions across the globe, we will remain on this dangerous trajectory. We include RCP 2.6 as a lower bound because, although it will be challenging to achieve, it is important that we align with California's ambitious greenhouse gas reduction efforts. California has established emission reduction targets through efforts such as Assembly Bill 32 (Global Warming Solutions Act of 2006, which requires California to reduce its GHG emissions to 1990 levels by 2020),[8] Senate Bill 32 (which codifies a 2030 emissions reduction target of 40% below 1990 levels),[9] and the Under2 Coalition.[10] Throughout this Guidance, we refer to RCP 8.5 and RCP 2.6 as "high-emissions" and "low-emissions" scenarios, respectively.

8. http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf
9. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB32
10. Under2 Coalition: Subnational Global Climate Leadership Memorandum of Understanding: http://under2mou.org/

Advances in Sea-Level Rise Modeling

The OPC Scientific Working Group extensively analyzed different scientific approaches to modeling sea-level rise. They ultimately concluded that the best available approach today is the comprehensive probability approach based on Kopp et al. 2014, described below. Recognizing that the comprehensive probability approach may underestimate the likelihood of extreme sea-level rise, particularly under high emission scenarios, the Scientific Working Group also concluded that the H++ extreme sea-level rise scenario in the Fourth National Climate Assessment should be considered as well. A brief description of the scientific approaches is described in part here, and in significant detail in Rising Seas.

One approach, commonly referred to as scenario-based projections, focuses on providing scenarios that span a range of possible futures, without assessing the relative likelihood or probability of those scenarios. Another approach, called probabilistic projections, focuses on estimating the probability of different levels of future sea-level change, either by estimating a central projection with an associated range or by attempting to estimate a comprehensive probability distribution that also estimates the likelihood of extreme 'tail' outcomes. Probabilistic projections provide estimates of probability distributions of possible future sea-level rise outcomes, whereas scenario-based projections do not forecast future changes, but describe plausible conditions that support decision making under uncertainty.

DISCUSSION OF PROBABILISTIC PROJECTIONS

Probabilistic projections of sea-level rise included in this Guidance, based on Kopp et al. 2014 and the Rising Seas Report, represent the best available science. However, it is important to understand how these projections are developed and recognize that they serve as a guide for decision makers to understand current knowledge rather than as precise predictions of future conditions. As with all climate change projections, methodologies will continue to evolve over time as scientific knowledge and modeling capabilities improve.

Bayesian Probabilities:
Scientific statements about the probability or likelihood of different future pathways, such as those made by probabilistic sea-level rise projections or by the Intergovernmental Panel on Climate Change, are examples of Bayesian probabilities. Bayesian probabilities are based upon a synthesis of multiple lines of evidence and represent an assessment of the strength of the observational, modeling, and theoretical evidence supporting different future outcomes. Probabilistic projections differ from frequentist probabilities, as described below.

Frequentist Probabilities:
Frequentist probabilities are based on the historical frequency of occurrence, such as those commonly seen in estimating disease rates or determining flood risk. For example, the 1% annual exceedance probability flood (or the 100-year flood) is a flood of a level that historically occurred in about 1 in 100 years.

A Bayesian probabilistic framework can support improved decision making and easily integrate new lines of scientific evidence but may under- or overestimate sea-level rise contributions beyond 2050 and could lead to confusion if decision makers are unclear about the difference between Bayesian and frequentist probabilities.[11] Nonetheless, probabilistic projections represent consensus on the best available science for sea-level rise projections through 2150. With continued advances in sea-level rise science, it is expected that probabilistic projections will change in the future. However, the evolving nature of sea-level rise projections does not merit taking a 'wait and see' approach. Acting now is critical to safeguard the people and resources of California.

11. D. Behar, R.Kopp, R. DeConto, C. Weaver, K. White, K. May, R. Bindschadler. Planning for Sea Level Rise: An AGU Talk in the Form of a Co-Production Experiment Exploring Recent Science. December 2017. https://www.wucaonline.org/assets/pdf/pubs-agu-consensus-statement.pdf

Importantly, the scenario-based and probabilistic approaches differ in how they represent the dependence of future sea-level change on specific greenhouse gas emission scenarios (RCPs). Scenario-based projections are often informed by greenhouse gas emissions scenarios but may not be tied to specific RCPs and do not include a measure of likelihood of occurrence. In contrast, probabilistic projections estimate probability distributions regarding sea-level rise under the various RCPs. It is important to note that probabilistic projections do not provide actual probabilities of occurrence of sea-level rise but provide probabilities that the ensemble of climate models used to estimate contributions of sea-level rise (from processes such as thermal expansion, glacier and ice sheet mass balance, and oceanographic conditions, among others) will predict a certain amount of sea-level rise. As climate science continues to evolve and models are updated in the future, the probability distribution of model results - and the associated probabilities - are also likely to change.

The 2013 OPC Guidance was based on scenario-based sea-level rise projections from the 2012 National Research Council report, which produced a set of three scenarios (low, central, and high), with greater weight given to the central scenario. Subsequently, in 2013, the IPCC Fifth Assessment Report adopted a probabilistic approach and produced estimates of the likely range of global sea-level rise under different emission scenarios, where 'likely' covers the central 66% of the probability distribution (i.e., the sea levels that fall within the range created by the value that is 17% likely to occur and the value that is 83% likely to occur). The IPCC Fifth Assessment Report did not estimate sea-level rise outside these central 66% probability ranges or produce local projections for California.[11]

The IPCC Fifth Assessment served as a starting point for further probabilistic modeling and represented a shift away from scenario-based approaches. However, the absence of local projections and the failure to account for estimated probabilities outside the 66% range led Kopp et al. 2014 to synthesize

12. See Rising Seas Report, page 19

several lines of evidence to estimate comprehensive probability distributions for global mean sea level and local relative sea level changes under different emissions scenarios. In this approach, outputs from process-based models are combined with estimates of contributions from the polar ice sheets derived from an expert elicitation process.[13]

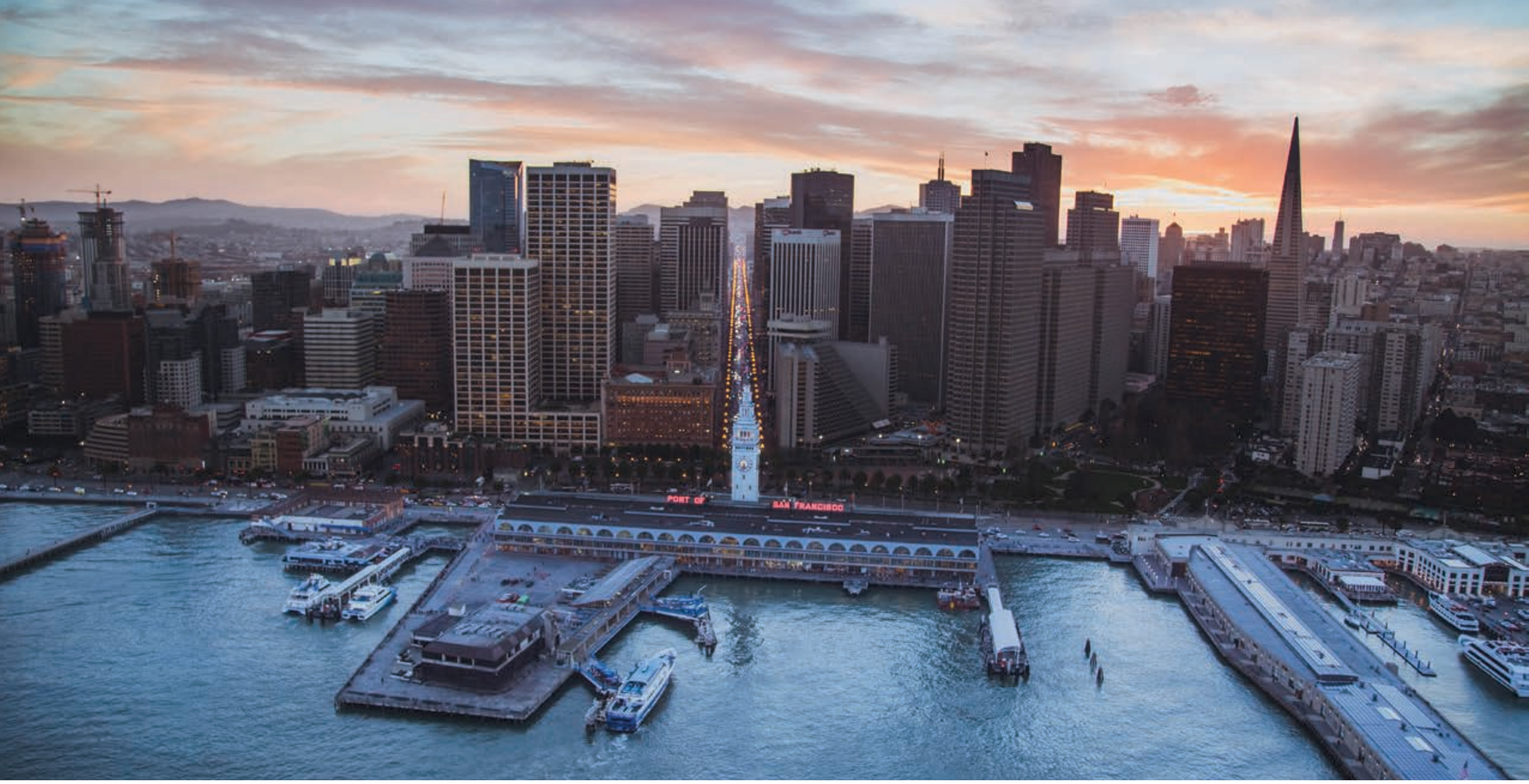
After considering a range of approaches, the OPC-SAT Scientific Working Group concluded in the Rising Seas Report that the comprehensive probabilistic approach employed by Kopp et al. 2014 was most appropriate for use in a policy setting in California. Consequently, for projections of sea-level rise other than that associated with the West Antarctic ice melt scenario, this Guidance adopts the comprehensive probabilistic approach. Similar modeling methods and frameworks have been utilized in other states and regions, including New York City[14], New Jersey[15], Oregon[16], regional groups in Washington State[17], and Boston[18]. It is important to note that the comprehensive probabilistic approach may underestimate the likelihood of extreme sea-level rise in the second half of this century and beyond, particularly under high-emissions scenarios.[19]

To address the potential for extreme sea-level rise as a result of ice loss from the West Antarctic Ice Sheet, this Guidance adopts the scientific approach in the Rising Seas Report by incorporating an extreme scenario—without an assigned probability—that is based on more recent understanding of Antarctic marine ice instability. Ice loss from the West Antarctic Ice Sheet has the potential to be a key contributor to sea-level rise in California in the coming decades. The OPC-SAT Scientific Working Group concluded that the H++ extreme sea-level rise scenario developed by Sweet et al. 2017 for the Fourth National Climate Assessment should be considered alongside the Kopp et al. 2014 comprehensive probability distributions for the RCPs. Sweet et al. 2017 maintained a scenario-based approach, but drew upon the Kopp et al. 2014 framework to localize projections and to discuss the likelihood of scenarios under different emissions pathways. Sweet et al. 2017 also developed an "extreme" scenario, leading to 8.2 feet of global mean sea-level rise in 2100 that is based on considerations derived from recent ice-sheet observations and new model simulations from Deconto and Pollard 2016[20] and also other attempts in the literature to estimate 'maximum physically plausible' sea-level rise.

Including consideration of this rapidly developing science is critical given the important role of the Antarctic Ice Sheet in both local and global sea-level rise projections. However, at this point, it is difficult to estimate the probability that the H++ scenario will occur, and when the world may shift to the H++ trajectory. Although sea-level rise is not following the H++ scenario at this moment, this scenario cannot be excluded for the second half of this century given the potential for non-linear acceleration of sea-level rise driven by positive feedbacks of ice-sheet dynamics and the significant consequences to California's coastline.

The approach to sea-level rise projections for the Guidance update is slightly more conservative than California's Fourth Climate Assessment, which is currently underway and due out in fall 2018. California's Fourth Climate Assessment directly adopted the Antarctic projections of Deconto and Pollard 2016, replacing in full the Antarctic projections of Kopp et al., 2014. For the purposes of use in policy guidance, the authors of the Rising Seas Report chose to include the H++ projections as a stand-alone scenario rather than incorporating ice sheet dynamics associated with this extreme into the model ensemble used to generate probabilistic projections. Because of the high level of uncertainty associated with physical processes that would trigger the H++ scenario and the emerging nature of the science, the authors felt the stand-alone scenario application was more appropriate for planning and permitting decisions at this time.

13. See Rising Seas Report, page 20
14. https://www.nyclimatescience.org/catalog/doc?DocId=vitroIndividual:http://www.nyclimatescience.org/individual/n8040
15. http://njadapt.rutgers.edu/docman-lister/conference-materials/167-njcaa-stap-final-october-2016/file
16. http://www.occri.net/media/1042/ocar3_final_125_web.pdf
17. http://docs.wixstatic.com/ugd/a3bdcc_1c4b6b33caf54836a2cac641b7ebe53b.pdf
18. https://www.boston.gov/sites/default/files/03_climate_ready_boston_digital_climateprojectionconsensus.pdf
19. See Rising Seas Report, page 22
20. http://www.nature.com/nature/journal/v531/n7596/full/nature17145.html?foxtrotcallback=true



Sea-Level Rise Projections for California

THE RISING SEAS REPORT PRESENTED a range of sea-level rise projections for a subset of the active tide gauges in California based on emission trajectories, acknowledging that projected sea-level rise has a significant range of variation as a result of uncertainty in future greenhouse gas emissions and their geophysical effects, such as the rate of land ice melt. Below are tables that build on those included in the Rising Seas Report for projections over different time frames and emission scenarios at the San Francisco tide gauge. The same details included for the San Francisco tide gauge below can also be found for all 12 active tide gauges along the California coast[21] in Appendix 3.

The baseline for the sea-level rise projections presented in the Rising Seas Report and this Guidance is the year 2000[22]. Projections begin at 2030, consistent with the 2013 Guidance; however, the maximum planning horizon has been extended to 2150 to support precautionary planning and decision making for projects with longer lifespans.

21. Active tide gauges locations include: Crescent City, North Spit (Eureka), Arena Cove, Point Reyes, San Francisco, Monterey, Port San Luis, Santa Barbara, Santa Monica, Los Angeles, San Diego and La Jolla; see Appendix 2 for map.

22. The year 2000 baseline is based on the average relative sea-level rise from 1991-2009.

How much sea-level rise will California experience over this century?

The following table provides probabilistic projections for the height of sea-level rise over various timescales for RCP 2.6 (low emissions) and RCP 8.5 (high emissions), along with the extreme H++ scenario (which is a single scenario and not a probabilistic projection). These numbers do not include impacts of El Niño, storms or other acute additions to sea-level rise. As discussed in more detail below, before 2050, differences in sea-level rise projections under different emissions scenarios are minor, and currently the world is on the RCP 8.5 emission trajectory. However, beyond 2050, different emissions pathways will result in significantly different levels of sea-level rise. Therefore, this Guidance includes projections only for a high greenhouse gas emissions scenario through 2050, and includes projections for both high and low emissions scenarios from 2050 through 2150.

TABLE 1: Projected Sea-Level Rise (in feet) for San Francisco

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	5.7	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

When is sea-level rise going to exceed a particular height in California?

In addition to understanding the potential range of sea-level rise projections as presented in the table above, it may be helpful for decision makers to understand when a particular level is projected to occur. The following table provides information on the likelihood that sea-level rise will meet or exceed a specific height over various timescales. However, the H++ scenario is not included in this table. Again, this information is presented for a high-emissions scenario through 2050 and both low- and high-emissions scenarios post-2050. It is important to note that episodic events, such as king tides, storms, El Niños, and waves may cause acute increases in sea level heights sooner than is shown in Table 2 below.

TABLE 2: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in San Francisco

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

SAN FRANCISCO - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	3.3%									
2050	31%	0.4%								
2060	65%	3%	0.2%	0.1%						
2070	84%	13%	1.2%	0.2%	0.1%					
2080	93%	34%	5%	0.9%	0.3%	0.1%	0.1%			
2090	96%	55%	14%	3%	0.9%	0.3%	0.2%	0.1%	0.1%	
2100	96%	70%	28%	8%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	96%	79%	52%	28%	15%	8%	4%	3%	2%

SAN FRANCISCO - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	43%	1.4%	0.2%							
2070	62%	4%	0.6%	0.2%	0%					
2080	74%	11%	2%	0.4%	0.2%	0.1%				
2090	80%	20%	3%	1.0%	0.4%	0.2%	0.1%	0.1%		
2100	84%	31%	7%	2%	0.8%	0.4%	0.2%	0.1%	0.1%	
2150	93%	62%	31%	14%	7%	4%	2%	2%	1%	1%

What will the rate of sea-level rise be in California?

The rate at which sea levels will rise can help inform the planning and implementation timelines of state and local adaptation efforts. Rates of sea-level rise are also important to consider when evaluating the ability of natural and restored coastal habitats to adapt to rising seas. In some cases, sea-level rise may exceed the rate at which habitats, such as coastal wetlands, can accrete sediment, migrate inland or to adjacent neighboring low-lying areas, resulting in flooding and loss and destruction of these important ecological systems. Understanding the speed at which sea level is rising can provide context for planning decisions and establish thresholds for action to better protect habitats and their ecological and resiliency benefits. The information in the table listed below is presented for a high-emissions scenario through 2050 and both low- and high-emissions scenarios post-2050.

TABLE 3: Projected Average Rate of Sea-Level Rise (mm/year) for San Francisco

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column). Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
			Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030-2050	6.7	4.5 - 9.3	12	17	26
Low emissions	2060-2080	5.3	3.1 - 8.2	12	22	
High emissions	2060-2080	9.5	6.4 - 13	17	28	42
Low emissions	2080-2100	5.2	2.3 - 9.1	14	28	
High emissions	2080-2100	11	6.0 - 16	22	37	55

Guidance on How to Select Sea-Level Rise Projections

SELECT SEA-LEVEL RISE PROJECTIONS BY TAKING A STEP-WISE APPROACH AND CONSIDERING A SUITE OF FACTORS AND CONDITIONS.

This Guidance summarizes the best available sea-level rise science, which includes probabilistic projections, an extreme scenario, and a recognition that these projections may change in the future. Although sea-level projections may change in the future, when used as part of the risk management process outlined in this Guidance, they provide vital information for adaptation actions and hazard mitigation undertaken today. Decisions about which sea-level rise projections to select - and the necessary adaptation pathways and contingency plans to ensure resilience - will be based on factors including location, lifespan of the given project or asset, sea-level rise exposure and associated impacts, adaptive capacity, and risk tolerance/aversion.

An adaptation pathway is a planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures, and allows analysis of the robustness and flexibility of various options across those multiple futures.[23]

Adaptive capacity is the ability of a system or community to evolve in response to, or cope with the impacts of sea-level rise.[24] Assets or natural resources with high adaptive capacity will likely have greater flexibility and potential to withstand rising sea levels. Adaptive capacity may be inherent to the asset, or can be improved through forward-looking planning or design (for example, including sufficient physical space to allow for buffering effects or inland

23. South West Climate Change Portal: Catchment Planning - Using Adaptation Pathway: http://www.swclimatechange.com.au/cb_pages/adaptation_pathways.php
24. Willows RI, RK Connell (eds.). 2003. Climate Adaptation: Risk, Uncertainty and Decisionmaking. UKCIP Technical Report. Oxford: UKCIP. 154 pp. http://www.ukcip.org.uk/wordpress/wp-content/PDFs/UKCIP-Risk-framework.pdf

migration of habitats, or designing a structure that can be easily relocated). Adaptive capacity is also a function of the innate characteristics of a system; e.g., a community that is chronically under-resourced may develop effective adaptation strategies but will likely still be at a disadvantage compared to communities with more resources for advanced planning and implementation.

Risk tolerance is the level of comfort associated with the consequences of sea-level rise and associated hazards in project planning and design.[25] Risk aversion is the strong inclination to avoid taking risks in the face of uncertainty. State and local governments should consider the risks associated with various sea-level rise projections and determine their tolerance for, or aversion to, those risks

Assessing risk requires evaluation of two dimensions: 1) uncertainty, which can be analyzed and assessed using a range of sea-level rise projections, and 2) impacts or consequences, which may require a combination of quantitative and qualitative assessments. The step-wise approach we provide guides decision makers through both dimensions of the risk analysis. Depending on the finite factors of location and project lifespan, decision makers will evaluate the potential impacts and adaptive capacity of the project across a spectrum of sea-level rise projections. This analysis will enable the decision maker to select the appropriate projection for the particular project while building in adaptation pathways and contingency plans should that projection be exceeded. These steps complement other State guidance documents that provide a step-wise approach to the analysis needed to incorporate sea-level rise into planning and decision making, such as the California Coastal Commission's Sea Level Rise Policy Guidance[26] and Draft Residential Adaptation Policy Guidance.[27]

25. 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
26. https://documents.coastal.ca.gov/assets/slr/guidance/August2015/0_Full_Adopted_Sea_Level_Rise_Policy_Guidance.pdf
27. https://documents.coastal.ca.gov/reports/2017/8/w6h/w6h-8-2017-exhibits.pdf#page=2

The following steps, outlined in the figure and in more detail below, provide a decision framework to evaluate the consequences and risk tolerance of various planning decisions, and should be used to guide selection of appropriate sea-level rise projections, and, if necessary, develop adaptation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded:

>> **STEP 1:** *Identify the nearest tide gauge.*

>> **STEP 2:** *Evaluate project lifespan.*

>> **STEP 3:** *For the nearest tide gauge and project lifespan, identify range of sea-level rise projections.*

>> **STEP 4:** *Evaluate potential impacts and adaptive capacity across a range of sea-level rise projections and emissions scenarios.*

>> **STEP 5:** *Select sea-level rise projections based on risk tolerance and, if necessary, develop adapation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded.*

>> STEP 1: *Identify the nearest tide gauge.*

Sea levels and rates of sea-level rise will vary along the California coast due to variable land elevations resulting from factors such as tectonic activity and subsidence. This difference between the height of the sea surface and the height of the land is called relative sea level, and the National Oceanic and Atmospheric Administration (NOAA) provides a summary of the trends in the measured relative sea level at 12 active tide gauges (water level recorders) in California that have been operating for at least 39 years and up to 162 years.[28,29] For localized sea-level rise projections, relative trends in sea level from changes in land elevation should be factored into the analysis. Therefore, of the 12 tide gauges across California, start by identifying the tide gauge nearest to the project location, in Appendix 2. This step will orient the user to the appropriate projection table. If the project is located in an area between two tide gauges, refer to Appendix 2 to determine which tide gauge is closest to your location. If the project is nearly equidistant between two tide gauges, it is appropriate to interpolate between or average the two tide gauges. The 12 active tide gauges along the California coast cannot account for specific local variation across the entire shoreline of the state; however, data driven projections using information from these tide gauges provides the most scientifically rigorous approach to estimating localized sea-level rise projections. If additional scientific data is available, it may be evaluated and considered in local planning decisions.

28. https://tidesandcurrents.noaa.gov/water_level_info.html
29. See Rising Seas Report, Box 2, page 23

>> STEP 2: *Evaluate project lifespan.*

Prior to 2050, differences in sea-level rise projections under different emissions scenarios are minor. This is because near-term sea-level rise has been locked in by past greenhouse gas emissions and the slow response times of the ocean and land ice to warming. The long-lived nature of most greenhouse gases means that their impacts on the environment are felt and experienced long after being emitted. Comparatively, after 2050, sea-level rise projections increasingly depend on the pathway of future greenhouse gas emissions. Therefore, this Guidance only includes sea-level rise projections based on a high scenario of greenhouse gas emissions (RCP 8.5; "high emissions") through 2050, and includes projections for both the RCP 2.6 "low-emissions" scenario as well as the RCP 8.5, "high-emissions" scenario after 2050 through 2150. The Guidance also includes an extreme sea-level rise scenario, the H++ scenario, which is not tied to a specific emissions trajectory but should be considered for projects with a lifespan beyond 2050 that have a low tolerance for risk, such as large power plants, major airports and roads, wastewater treatment plants, and hazardous waste and toxic storage sites. The H++ scenario may also be relevant to communities considering regional or general plans, climate action plans, local hazard mitigation plans, regional transportation plans, and other planning efforts, due to the interrelated nature of critical infrastructure, homes, businesses, etc. Determining project lifespan will guide whether to evaluate sea-level rise projections for the high-emissions scenario only (in the case of projects with a lifespan that ends before 2050) or across the range of high- and low-emissions scenarios for projects with a lifespan beyond 2050.

JUSTIFICATION FOR RECOMMENDED LOW, MEDIUM-HIGH AND EXTREME RISK AVERSION PROJECTIONS

This guidance document will inform a breadth of planning and adaptation decisions at both the state and local level. As such, it provides high-level guidance on the appropriate range of sea-level rise projections to be considered in project planning and design, while providing enough flexibility to allow for local priorities and trade-offs to determine final decisions. To ensure that consideration of sea-level rise is precautionary enough to safeguard the people and resources of California and that sufficient adaptation pathways and contingency plans are developed, we recommend that decisions evaluate a range of projections based on low, medium-high and extreme levels of risk aversion:

Projection for decisions with low risk aversion: Use the upper value of the "likely range" for the appropriate timeframe. This recommendation is fairly risk tolerant, as it represents an approximately 17% chance of being overtopped, and as such, provides an appropriate projection for adaptive, lower consequence decisions (e.g. unpaved coastal trail) but will not adequately address high impact, low probability events. Additionally, it is important to note that the probabilistic projections may underestimate the likelihood of extreme sea-level rise, particularly under high-emissions scenarios.

Projection for decisions with medium – high risk aversion: Use the 1-in-200 chance for the appropriate timeframe. The likelihood that sea-level rise will meet or exceed this value is low, providing a precautionary projection that can be used for less adaptive, more vulnerable projects or populations that will experience medium to high consequences as a result of underestimating sea-level rise (e.g. coastal housing development). Again, this value may underestimate the potential for extreme sea-level rise.

Projection for decisions with extreme risk aversion: Use the H++ scenario for the appropriate timeframe. For high consequence projects with a design life beyond 2050 that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to relocate/repair, or would have considerable public health, public safety, or environmental impacts should this level of sea-level rise occur, the H++ extreme scenario should be included in planning and adaptation strategies (e.g. coastal power plant). Although estimating the likelihood of the H++ scenario is not possible at this time (due to advancing science and the uncertainty of future emissions trajectory), the extreme sea-level rise projection is physically plausible and will provide an understanding of the implications of a worst-case scenario.

>> STEP 3: *For the nearest tide gauge and project lifespan, identify range of sea level rise projections.*

Considering a range of different sea-level rise projections allows decision makers to evaluate the vulnerability of people, natural resources and infrastructure under various future flooding conditions, as well as their level of comfort with over- or underestimating sea-level rise. Because future projections of sea-level rise along California's coastline are uncertain (due to uncertainty associated with modeling and the trajectory of global emissions), it is critical to consider a range of projections to understand the consequences of various decisions, determine the tolerance for risk associated with those decisions, and to inform adaptation strategies necessary to prepare for change in the face of uncertainty. We recommend using a set of projections appropriate for low, medium-high and extreme levels of risk aversion to evaluate a spectrum of potential impacts, consequences and responses. (See adjacent call-out box for justification on the recommended projections.)

For the low risk aversion sea-level rise projection, use the upper end in the "likely range" as shown in Table 1 above or in Appendix 3. For the medium-high risk aversion sea-level rise projection, use the 1-in-200 chance projection. For highly vulnerable or critical assets that have a lifespan beyond 2050 and would result in significant consequences if damaged, the H++ scenario (extreme risk aversion projection) should also be included in planning analyses. For example, for a project in San Francisco with a lifespan to 2050 under a high-emissions scenario (RCP 8.5), the recommended range of projections from Table 1 are:

Low risk aversion projection:	1.1 feet
Medium-high risk aversion projection:	1.9 feet
Extreme risk aversion projection:	2.7 feet

For projects with a lifespan beyond 2050, the range of low, medium-high and extreme risk aversion projections should be evaluated across the range of high and low emissions scenarios (RCP 8.5 and RCP 2.6, respectively). For example, for a project with a lifespan to 2100, the recommended range of projections from Table 1 are:

Low risk aversion projection:	2.4 - 3.4 feet
Medium-high risk aversion projection:	5.7- 6.9 feet
Extreme risk aversion projection:	10.2 feet

>> STEP 4: *Evaluate potential impacts and adaptive capacity across a range of sea level rise projections and emissions scenarios.*

After the appropriate low, medium-high, and extreme risk aversion projections have been identified based on location and timespan, the next step is to conduct a vulnerability assessment to evaluate the potential impacts of sea-level rise on the project and the project's adaptive capacity. This can be done using the sea-level rise mapping tools discussed later in this Guidance. In analyzing impacts and adaptive capacity, consider the following questions for each identified sea-level rise projection, which mirror components outlined in OPR's risk management approach of the Governor's Office of Planning and Research's "Planning and Investing for a Resilient California: A Guidebook for State Agencies[30]":

Consequence of potential impacts: If sea-level rise is not addressed adequately, will the consequences of the project on equity, environment, economy and governance (both to the development itself and to the surrounding environment and community) be minimal, moderate, or catastrophic?

What is at stake: Will vulnerable communities, coastal habitats, or critical infrastructure be significantly impacted?

Adaptive capacity: Can people, natural systems, and infrastructure readily respond or adapt to rising sea levels?

Economic impacts: Will failure to adequately plan for sea-level rise create significant economic burden now or in the future?

Evaluating these factors will help decision makers understand the vulnerabilities of people, assets and the natural environment under a range of sea-level rise possibilities and determine their tolerance for the risks associated with the consequences of over- or underestimating sea-level rise. This approach aligns with ongoing efforts throughout the state to complete vulnerability assessments, including the California Coastal Commission's Statewide Sea Level Rise Vulnerability Synthesis.[31] OPC recognizes that that the social, economic and environmental impacts of sea-level rise at different levels of exposure may be difficult to quantify and qualify, and ultimate decisions will require a balance of tradeoffs and priorities that may not be consistent across communities or jurisdictions.

30. https://opr.ca.gov/planning/icarp/resilient-ca.html
31. https://documents.coastal.ca.gov/assets/climate/slr/vulnerability/FINAL_Statewide_Report.pdf

>> STEP 5: *Select sea-level rise projections based on risk tolerance and, if necessary, develop adapation pathways that increase resiliency to sea-level rise and include contingency plans if projections are exceeded.*

OPC recommends utilizing a decision framework to assist in evaluating tradeoffs and determining the appropriate sea-level rise projections for the condition and characteristics of the shoreline being evaluated. The decision framework in Appendix 4 builds on the work of OPR in response to Governor Brown's Executive Order B-30-15, as well as the U.S. Climate Resilience Toolkit's guidance.[32] In general, decision makers may have a higher tolerance for risk (or lower risk aversion) when considering projects with a shorter lifespan, minimal consequences, flexibility to adapt, or low economic burden as a result of sea-level rise. In this decision context, it may be appropriate to select low sea-level rise projections across the range of RCP 2.6 and 8.5. However, for longer lasting projects with less adaptive capacity and medium to high consequences should sea-level rise be underestimated, we suggest that decision makers take the more precautionary, more risk-averse approach of using the medium-high sea-level rise projections across the range of emissions scenarios. We further recommend incorporating the H++ scenario in planning and adaptation strategies for projects that could result in threats to public health and safety, natural resources and critical infrastructure, should extreme sea-level rise occur.

In addition to selecting sea-level rise projections, coastal communities should consider phasing in short and long-term adaptation strategies over time when planning for sea-level rise. This concept of adaptation pathways considers the challenges of planning for uncertain timing and extent of rising sea levels while providing a structure for sequencing adaptation measures using the time horizon of projected hazards from a changing climate. The adaptation pathway approach links the choice of near-term adaptation actions with identification of pre-determined threshold events. Observation of such threshold events would trigger subsequent actions in the planning or implementation stages of adaptation strategies. Often an adaptation pathway includes low-regret, near-term actions that preserve future options to adjust if necessary. Observable events that might trigger new phases of adaptation might include the extent of flooding, frequency of damage, or the extent of economic development along the coast. These triggers should reflect a community's risk tolerance, local conditions, and adaptation vision.

Communities should look for signs that some adaptation options have run their course and plan adaptation pathways to transition actions as needed. Analyzing a worst-case "high" projection for the planning horizon of the project provides a conservative upper bound for planning pathways based on current information. Following this approach, which is used in other recent sea-level rise guidance documents[33,34] and cited in more recent policy writing,[35,36] a community or project might consider an adaptive plan, which includes contingency responses if climate hazards occurs more quickly than expected. The adaptive plan need not choose between future options now, but would include steps to keep future options open. For instance, the plan could include identifying a future inland site and zoning the land so that it would be available in the future if needed. This trigger-based adaptation planning is discussed further in Recommendation 7 below.

32. https://toolkit.climate.gov/topics/coastal/sea-level-rise

33. Coastal Hazards and Climate Change. Guidance for Local Government. New Zealand Government, Ministry for the Environment. http://www.mfe.govt.nz/publications/climate-change/coastal-hazards-and-climate-change-guidance-local-government

34. California Coastal Commission Draft Residential Adaptation Policy Guidance. July 2017. https://documents.coastal.ca.gov/reports/2017/8/w6h/w6h-8-2017-exhibits.pdf#page=2

35. Haasnoot, M., J. Kwakkel, W. Walker, J. Maat. Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change. 2013. 485-498. https://documents.coastal.ca.gov/assets/slr/guidance/August2015/0_Full_Adopted_Sea_Level_Rise_Policy_Guidance.pdf

36. Center for Ocean Solutions. Coastal Adaptation Policy Brief. December 2017. http://centerforoceansolutions.org/sites/default/files/Triggers%20WEB.pdf

Recommendations for Sea-Level Rise Planning and Adaptation

The step-wise approach above provides guidance on how to select sea-level rise projections by evaluating risk and vulnerability. The following recommendations provide guidance on preferred sea-level rise planning and adaptation approaches, with an understanding that the diversity of communities, uses, and natural resources along California's coastline, as well as planning for new development versus existing structures, may merit different approaches to building resilience.

1. Adaptation planning and strategies should prioritize social equity, environmental justice and the needs of vulnerable communities.

Communities of color, low-income communities, and Native Nations have been, and will continue to be, disproportionately overburdened by pollution and climate change. Sea-level rise will add to those burdens. Impacts such as increased flooding, damage to homes and roads, disruption to public transportation, elevated exposure to toxic materials, and destruction of coastal sacred places and cultural sites will unduly affect vulnerable communities. These impacts can manifest as complete community displacement, loss of places of ancient and contemporary cultural and historic significance, loss of personal property, worsened health, reduced or lost wages, and loss of free or affordable public access to the coast. Vulnerable communities may lack financial or other resources to plan for sea-level rise as well as the ability to adequately respond to impacts once they occur.

Sea-level rise planning that prioritizes social equity, environmental justice and protection of the lives and property of vulnerable communities should include early public engagement of those who will be directly or indirectly affected by rising sea levels, a focused characterization of impacts on exposed populations and communities dependent on critical assets threatened by sea-level rise, and identification of specific adaptation strategies to minimize or mitigate these impacts. Engaging communities that face existing inequalities already (or will face unequal distribution of sea-level rise impacts) early in the planning process will ensure that vulnerability assessments and adaptation strategies accurately reflect their risk, needs and priorities. State and local governments should also prioritize technical support and funding opportunities for planning and adaptation efforts of vulnerable and Native communities. Incorporating social equity and environmental justice in sea-level rise planning and adaptation strategies should:

- ***Address environmental contamination risks for coastal communities adjacent to industry or toxic sites.*** Coastal environmental justice communities tend to have fewer beachfront homes at risk of inundation, but are often separated from the coast by strips of industrial facilities, ports and military installations. Sea-level rise threatens job sites for local residents, risks spreading contamination from cleanup sites, and can damage critical energy, transportation or other infrastructure. Prioritizing cleanup of sites threatened by sea-level rise can prevent toxic contamination from spreading into nearby communities.

- ***Preserve access to and along the beach.*** Protecting natural coastlines preserves affordable outdoor recreation access for communities that often lack parks or other sources of green space and face existing health disparities. While many coastal cities in California include expensive beachfront homes, the coast is used regularly for recreation by thousands of working class residents who are visiting or live nearby. Sea-level rise planning and adaptation strategies should protect public access to and along the beach to maximize free or affordable use of the coast for the benefit of all Californians.

- ***Prevent displacement by ensuring that investments in coastal resilience protect local jobs and housing costs.*** In climate adaptation policies, it is important to understand the economic ties between vulnerable communities and polluting industries along their coasts, and how to build environmentally healthy and economically vibrant communities. Deindustrialization of coastal areas and restoration of natural coastal habitats can result in major environmental benefits, but also job losses and rent increases for the very same communities who are intended to be protected by these natural buffers. Coastal resilience investments should provide economic benefits for adjacent working-class communities, including anti-displacement housing policies and local jobs programs.

- ***Address economic impacts on agriculture.*** California has major agricultural regions along the Central Coast - such as the Oxnard Plain, Santa Maria Valley and Salinas Valley - where tens of thousands of farmworkers are employed in the fields and whose livelihoods are threatened by seawater intrusion into groundwater aquifers. Focused monitoring of seawater intrusion in coastal agricultural areas, restoration of coastal wetlands buffers, and effective groundwater management to prevent excessive pumping and restore groundwater could help prevent major long-term economic damage to agriculture and farmworkers.

- ***Address emergency services and response to natural disasters.*** Low-income, immigrant communities and other vulnerable populations are often left behind in access to information and resources in the chaos of disaster response. Proactive, deliberate planning in partnership with marginalized communities can prevent this type of systemic failure in the event of a flooding disaster. Emergency services agencies should be prepared to translate print and online communications and create a more comprehensive vulnerable communities emergency response plan through stakeholder engagement. Known information about future flooding risks should be made easily available in all commonly-spoken local languages and in visual form.

- ***Evaluate the social and economic implications of various adaptation strategies.*** Planning and investment decisions that will increase risk to vulnerable communities should be avoided, and actions to bolster resilience and social equity should be prioritized.

2. Adaptation strategies should prioritize protection of coastal habitats and public access.

- ***Implement natural solutions for shoreline protection, including managed retreat.*** Strategies to protect shoreline development from sea-level rise impacts should prioritize the use of natural infrastructure where feasible or appropriate and minimize shoreline armoring and flood barriers. While hard structures or gray solutions provide temporary protection against the threat of sea-level rise, they disrupt natural shoreline processes, accelerate long-term erosion, may increase wave and storm run-up, and can prevent coastal habitats from migrating inland, causing loss of beaches and other critical habitats that provide ecosystem benefits for both wildlife and people; therefore, they should only be used in appropriate locations and situations. There is a breadth of resources available to guide the implementation of natural solutions including a recently released report, "Case Studies of Natural Shoreline Infrastructure in Coastal California"[37] as part of California's Fourth Climate Change Assessment.

  Natural shoreline infrastructure means utilizing the natural function of ecological systems or processes to reduce vulnerability to specific environmental hazards and increase resilience of the shoreline in order to perpetuate or restore its ecosystem services.[38] Natural infrastructure includes preservation or restoration of dunes, wetlands and other coastal habitats and leverages natural processes to reduce risk to human lives, property and infrastructure by providing a buffer against storm surge and increased wave action, thus reducing shoreline impacts and coastal erosion. These solutions have been shown in many cases to be low maintenance, cost-effective and adaptive to changing conditions. Additionally, natural infrastructure provides multiple benefits beyond flood protection including public access, habitat for wildlife and improved water quality, thereby building resilience while improving overall ecological function of coastal systems.

  In addition to prioritizing natural infrastructure, managed retreat should be considered as a possible adaptation strategy to address rising sea levels. Managed retreat refers to varying approaches to managing coastal hazard risk by structure relocation and/or abandonment of land.[39] These strategies can result in a landward redevelopment pattern and a managed realignment of development along the coast so that natural erosion and other coastal processes, including beach formation and creation, can continue. Managed retreat allows shorelines to migrate inland naturally, rather than using seawalls, flood barriers, or rock revetments to anchor them in a specific location. This strategy may involve removal or relocation of residential, commercial, or industrial development and restoration of natural areas to enhance ecosystem services, make sound infrastructure investments, and provide additional protection and safety against flooding through buffering effects, as described above.

37. http://scc.ca.gov/files/2017/11/tnc_Natural-Shoreline-Case-Study_hi.pdf

38. Newkirk, S, S. Veloz, M. Hayden, W. Heady, K. Leo, J. Judge, R. Battalio, T. Cheng, T. Ursell, and M. Small. (The Nature Conservancy and Point Blue Conservation Science). 2018. Toward Natural Infrastructure to Manage Shoreline Change in California. California's Fourth Climate Change Assessment, California Natural Resources Agency. Publication number: CNRA-CCC4A-2018-3B. Expected release August 2018.

39. Hino, M., Field, C.B. and Mach, K.J., 2017. Managed retreat as a response to natural hazard risk. Nature Climate Change. https://www.nature.com/articles/nclimate3252.

Managed retreat will also provide added protection for wetlands, marshes and other important coastal habitats that will face inundation or erosion if restricted from moving landward by existing development or shoreline armoring. Decision makers should prioritize conservation, restoration and land acquisition of properties that can provide needed open space to accommodate inland migration in order to preserve the natural function of wetlands and other coastal ecosystems.

Restoration of wetlands and other coastal habitats should remain a priority in California even in the face of rising seas; even if present-day restored wetlands transition to subtidal habitat sometime in the future, there will still be continued ecosystem benefits for wildlife and people over the long term. In addition, wetland restoration and other adaptation strategies that provide greenhouse gas reduction benefits by storing and sequestering carbon should be prioritized.

- ***Preserve public access, including beaches and coastal parks, while protecting natural resources.*** Public access along California's coast is already being affected by sea-level rise, coastal flooding, and erosion. Coastal trails, public beaches, park infrastructure, and other state and public assets that are of high value to Californians will increasingly be under threat from higher sea levels, intensified wave action, and accelerated coastal erosion.

  Decision makers, including state and local agencies that manage state- or locally-owned coastal assets, should assess the vulnerability of public access and prioritize its protection for the invaluable benefits it provides to residents and visitors. Every effort should be made to ensure that protection of public access or park infrastructure does not degrade coastal habitats. Beaches backed by development or shoreline armoring will not be able to migrate inland as sea levels rise, resulting in permanent inundation over time and loss of public access. Consideration should be given to allowing for natural shoreline retreat and relocation of public access and park infrastructure to preserve beach access and protect wetlands, dunes and other coastal habitats. Using natural infrastructure to safeguard public access facilities, parks, and trails or planning ahead to relocate these resources will help ensure that both public access and coastal habitats are preserved for the long-term.

3. Adaptation strategies should consider the unique characteristics, constraints and values of existing water-dependent infrastructure, ports and Public Trust uses.

Existing water-dependent infrastructure and ports support Public Trust uses vital to the State (such as commerce, navigation, fisheries, and recreation) and have unique characteristics and constraints for adaptation to sea-level rise. They are often located in densely developed coastal areas where managed retreat, natural infrastructure solutions, and other space-dependent strategies may not be feasible. Planners should continue to collaborate regionally and with the State to develop adaptation strategies for water-dependent infrastructure that will be protected in place, as well as address strategies to adapt existing infrastructure into the future. Existing shoreline protective structures may need to be repaired and retrofitted to adapt to rising sea levels. Negative impacts to other Public Trust values, including coastal habitats and public access, should be minimized in all existing and future use of shoreline protective structures. Innovative and resilient design alternatives to conventional grey infrastructure should be explored when retrofitting existing protective structures or contemplating future protective structures.

4. Consider episodic increases in sea-level rise caused by storms and other extreme events.

Future sea-level rise projections presented in this Guidance do not include acute increases in water level associated with El Niño events, king tides, storm surges or large waves. Alone or in combination, these events will produce significantly higher water levels than sea-level rise alone, and will likely be the drivers of the strongest impacts to coastal ecosystems, development and public access over the next several decades. Water levels reached during these large, acute events have already caused significant damage along California's coast. For example, a strong El Niño combined with a series of storms during high-tide events caused more than $200 million in damage (in 2010 dollars) to the California coast during the winter of 1982-83. Additionally, in areas where rivers meet the ocean, the combined effects of sea-level rise, storm conditions and higher riverine water levels could further exacerbate flooding conditions in these locations.

Furthermore, climate change may result in increased frequency or intensity of coastal storms and extreme events, posing even greater risks for California's coastline from flooding, erosion and wave damage. To adequately protect coastal communities, infrastructure and natural resources, decision makers should consider extreme oceanographic conditions in conjunction with sea-level rise over the expected life of a project. A range of existing mapping tools is available to help evaluate storm-related coastal flooding, sea-level rise and shoreline change and to evaluate impacts and change into the future; these mapping tools are described in detail below. In addition to these tools, the San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) Program has developed robust and locally-relevant for the San Francisco Bay to understand current and future flood risk.[40] It is important to note that current Federal Emergency Management Agency (FEMA) flood maps are based on existing shoreline characteristics and wave and storm climatology at the time of the flood study and historic storm data; therefore, these maps will not reflect flood hazards based on anticipated future sea levels or increased storms associated with climate change.[41]

40. www.adaptingtorisingtides.org

41. https://www.fema.gov/coastal-frequently-asked-questions#How is FEMA accounting for sea level rise and climate change on the FIRMs? Does sea level rise/climate change affect the FIRMs?

5. Coordinate and collaborate with local, state and federal agencies when selecting sea-level rise projections; where feasible, use consistent sea-level rise projections across multi-agency planning and regulatory decisions.

Project planning and design along the coast often requires approval by multiple agencies across local, regional, state and federal levels. To increase efficiency and standardize risk evaluation, efforts led by or under the regulatory authority of multiple agencies should use the same sea-level rise projections to achieve consistency across specific projects and regions. Cross-jurisdictional decisions should also prioritize implementation of consistent or complementary adaptation strategies.

6. Consider local conditions to inform decision making.

Local circumstances and associated sea-level rise impacts should be assessed to inform adaptation decisions that will protect communities and the environment. The interplay between sea-level rise and conditions such as contaminated soil, groundwater, or stormwater systems as well as beach and cliff erosion can vary significantly along the coast and should be evaluated at a local level. The diversity of shoreline types, natural conditions, community characteristics, services, assets, land ownership, and local priorities may warrant different approaches to planning and adaptation, particularly when making decisions for new development versus maintenance or replacement of existing assets necessary for public health and safety. Adaptation pathways with a phased approach can invoke the precautionary principle while maintaining protection of community well-being, the environment, and critical assets.

7. Include adaptive capacity in design and planning.

Uncertainty around the magnitude and timing of future sea-level rise, coupled with the potential impacts of rising seas on California's coastline, warrant a proactive approach that builds adaptive capacity into project design and planning. Projects or resources that can more easily adapt to sea-level rise will experience fewer consequences and will be more resilient against risks associated with sea-level rise and other coastal climate-related impacts.

If designing a project to accommodate high or extreme sea-level rise is not critical in the near term, but the likelihood of impacts is expected to increase with rising sea level, adaptive capacity should be built into project design or planning using triggers and phased adaptation measures or adaptation pathways, as described in Step 5 above. Triggers are predetermined thresholds that, when crossed, prompt implementation of identified adaptation measures. For example, one trigger mechanism could require that, when sea-level rise reaches a certain level, identified adaptive measures must be taken. Alternatively, the occurrence of a specific impact such as the flooding of a highway could act as a trigger. An increase in the frequency of a specific sea-level rise-associated impact, such as the flooding of a coastal trail ten times in a year rather than a historically traditional three times a year, also could be a trigger.

Adaptation measures may include, but are not limited to, removal of threatened structures (including identification of parties responsible for removal) or relocation of public access. Trigger-based adaptation planning may also include the following approaches: 1) a no-regrets response, involving prohibition or restriction of development in the most vulnerable areas; 2) a tempered response, involving restriction or changing conditions for redevelopment after an event; and 3) a proactive response, involving investigation of opportunities to relocate vulnerable communities, critical infrastructure or coastal habitats.

Providing adaptive capacity for higher sea-level rise will allow projects to be designed for a more moderate level of sea-level rise but planned with enough flexibility that adaptation measures to minimize impacts can be implemented if the amount of sea-level rise is higher than anticipated in the original design. In other words, projects should be scoped (planned and designed) with the potential to be updated or changed if lower-probability, higher-impact sea level rise projections come to occur. Design and planning efforts that include a trigger-based adaptation pathways approach should include a monitoring component to ensure timely implementation of adaptation or contingency measures once impact or risk thresholds are crossed.

8. Assessment of risk and adaptation planning should be conducted at community and regional levels, when possible.

Sea-level rise planning decisions made for one municipality, or even one landowner, have the potential to impact the resiliency of nearby properties and coastal habitats. A jurisdiction that chooses to implement natural infrastructure may lose some of the benefits and protection from this adaptation strategy if an adjacent community decides to construct a seawall. Decision makers should identify opportunities to coordinate regional adaptation planning efforts by: conducting regional vulnerability assessments to evaluate common risks; leveraging technical and financial resources; and implementing consistent regional adaptation strategies. BCDC's ART Program and the San Diego Regional Climate Collaborative[42] are examples of regional planning efforts that can serve as models for other regional planning efforts throughout the state.

42. https://www.sdclimatecollaborative.org

Tools Available to Visualize Sea-Level Rise Spatially

THERE ARE SUITES OF EXISTING GEOSPATIAL AND VISUALIZATION TOOLS that can be readily paired with the latest and best available sea-level rise projections. These include CoSMoS/Our Coast Our Future,[43,44] the NOAA Sea-Level Rise Viewer,[45] Cal-Adapt,[46] The Nature Conservancy (TNC) Coastal Resilience Toolkit[47] and Surging Seas Risk Finder.[48] Each viewer serves a unique niche, target audience and role, has strengths and limitations, and requires varying levels of skill to use. More information on these tools can be found on Sea the Future[49] (formerly known as Lifting the Fog) and on the State Adaptation Clearinghouse. In addition to assisting in the visualization and analysis of sea-level rise, these tools are also helpful aids in communicating about sea-level rise across local, state, and regional communities and planning and decision-making venues. In general, we recommend that the most detailed tool available for a particular area be used for planning, though in some cases a suite of tools should be evaluated to get a better picture of the possible risks.

- **CoSMoS** is a model that has been developed by the United States Geological Survey (USGS) in order to allow for 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. CoSMoS models the relevant physics of a coastal storm (e.g., tides, waves, and

43. https://walrus.wr.usgs.gov/coastal_processes/cosmos/
44. http://data.pointblue.org/apps/ocof/cms/
45. https://coast.noaa.gov/digitalcoast/tools/slr
46. http://cal-adapt.org/
47. http://coastalresilience.org/
48. https://riskfinder.climatecentral.org/
49. http://sealevel.climatecentral.org/matrix/CA.html?v=1

storm surge), which are then scaled down to local flood projections for use in community-level coastal planning and decision-making. Rather than relying on historic storm records, CoSMoS uses wind and pressure from global climate models to project coastal storms under changing climatic conditions during the 21st century. CoSMoS projections are currently available for the north-central coast, San Francisco Bay, and Southern California. Modeling is underway for the Central Coast, to be completed in summer 2018. The North Coast of California is expected to be complete by the end of 2019. CoSMoS information can also be accessed, viewed, and downloaded through the Our Coast, Our Future (OCOF) flood mapper, which provides a user-friendly web-based tool for viewing results. OCOF provides resources and guidance for helping communities navigate the information provided by CoSMoS.

- The NOAA Sea-Level Rise Viewer is a visualization tool for coastal communities showing the potential impacts from sea-level rise and coastal flooding. The NOAA Viewer allows users to select the nearest NOAA tide gauge and identify relative sea-level rise scenarios based on the NOAA 2017 Technical Report[50], which includes the federal government's most updated scenarios that will inform the Fourth National Climate Assessment. These scenarios are similar to the probabilistic ranges for California. The tool allows users to visualize inundation by scenario or year and explore thresholds for levee overtopping. It also includes the ability to look at flood frequency, marsh migration, socio-economic impacts, and uncertainty. The maps consider static sea-level rise on top of mean higher high water[51] (MHHW) and are created using a "modified" bathtub approach that includes a hydrologic connectivity assessment. This means that areas are only shown as inundated if there is a feasible pathway for water to flow. The viewer is a screening-level, planning tool that uses nationally consistent data sets and analyses. Data and maps can be downloaded directly from the tool to enable users to develop their own visualizations to gauge trends and prioritize actions.

- Cal-Adapt makes scientific projections and analyses available as a basis for understanding local climate risks and resilience options. To date, development has been supported by the California Energy Commission and has targeted resilience needs of the energy sector. Released in 2017, Cal-Adapt 2.0 dramatically expands the capacities of the initial (2011) version of Cal-Adapt in five main ways, providing new climate projections, more powerful and flexible visualizations, improved access to data, a public applications programming interface (API) platform that enables external development of custom tools, and connection with supporting resources such as OPR's Integrated Climate Adaptation and Resiliency Program (ICARP). Forthcoming enhancements to Cal-Adapt will expand its sea-level rise tool to include selected results from USGS's CoSMoS model (portrayed in detail by the Our Coast, Our Future tool) as well as an expanded range of sea-level rise projections for which UC Berkeley has modeled inundation associated with an extreme storm event for the Delta, San Francisco Bay, and the entire California coast.

- The Nature Conservancy Coastal Resilience tool is a visualization and decision support platform where ecological, social, and economic information can be viewed alongside sea-level rise and storm surge scenarios to develop risk reduction and restoration solutions. The decision support tool was first created in 2008 and now covers multiple regions including: 10 U.S. States (Alabama, California, Connecticut, Florida, Louisiana, Mississippi, New Jersey, New York, Texas, Washington), four countries in Latin America (Mexico, Belize, Guatemala, Honduras) and three island nations in the

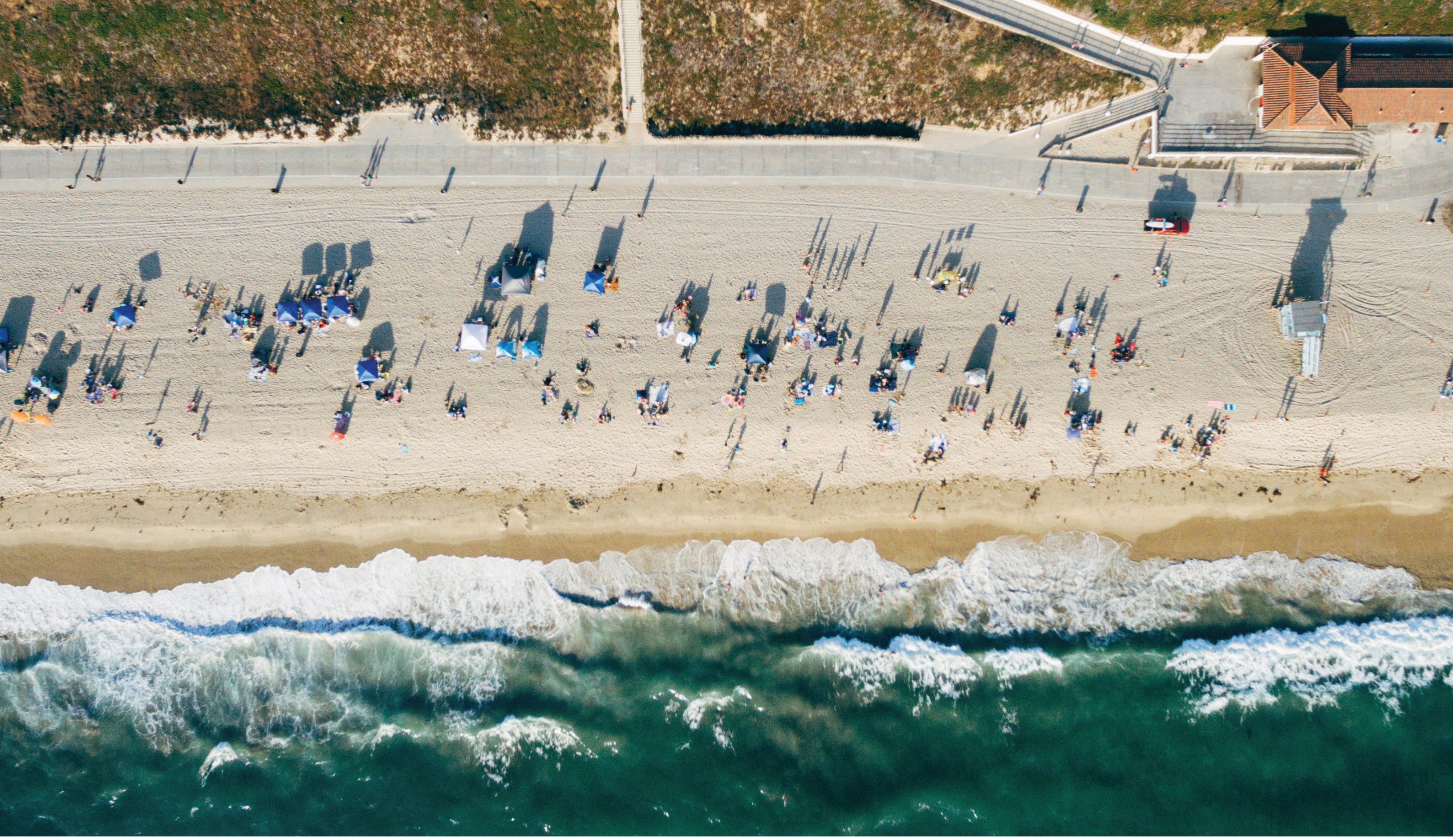
50. https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

51. California experiences semidiurnal tides, with two high tides and two low tides each day. One of the two high tides is higher than the other and one of the two low tides is lower than the other. Mean higher high water is the average of the higher high tides over the National Tidal Data Epoch. https://tidesandcurrents.noaa.gov/datum_options.html

Caribbean (Grenada, St. Vincent and the Grenadines, U.S Virgin Islands). There also is a U.S. national and global application. Coastal Resilience 2.0 was released in October 2013 to better enable decision makers to assess risk and identify nature-based solutions to reduce socio-economic vulnerability to coastal hazards. The purpose of the tool is to inform county hazard mitigation planning. Its intended uses are to: 1) raise awareness of coastal hazards issues; 2) examine local flood risk; and 3) identify potential adaptation solutions.

- Surging Seas Risk Finder is a multi-part public web tool that provides local sea-level rise and flood risk projections, interactive maps, and exposure tabulations from zip codes and up. Projections integrate extreme flood statistics with dozens of sea-level rise models and scenarios to choose from. Maps are based on the same modified bathtub model used by NOAA's Sea-Level Rise Viewer and consider static sea-level rise up to 10 feet above mean higher high water (MHHW). Maps illustrate which areas are or are not hydrologically connected to the ocean at each one-foot increment, and have layers for population, social vulnerability, property value, point features and more. Exposure assessments tabulate over 100 demographic, economic, infrastructure and environmental variables for every zip code and municipality, as well as planning, legislative and other districts. Additional features include heat maps showing wide-area exposure comparisons, and extensive data downloads including localized fact sheets, reports, and PowerPoint slides. Tutorial videos and step-by-step guides are also available.[52]

52. http://sealevel.climatecentral.org/ssrf/help-page



Conclusion

EXACT RATES AND MAGNITUDE OF SEA-LEVEL RISE IN CALIFORNIA over the next century are uncertain, though the direction of change is not. California has an immediate opportunity to make smart, informed, and risk-based decisions that prepare our coastal and inland communities for change while ingraining sustainability, longevity, and resiliency into our planning, permitting, investment, development, transportation, and recreational decisions. This Guidance document serves as a precautionary, though realistic and scientifically rigorous, recommendation on how best to approach sea-level rise in California no matter the decision at hand. The Guidance should be considered and cited throughout local, regional, and statewide sea-level rise discussions and decisions. And while sea-level rise science is rapidly evolving, the Guidance was prepared so that it can be a living document and swiftly updated as needed and recommended.

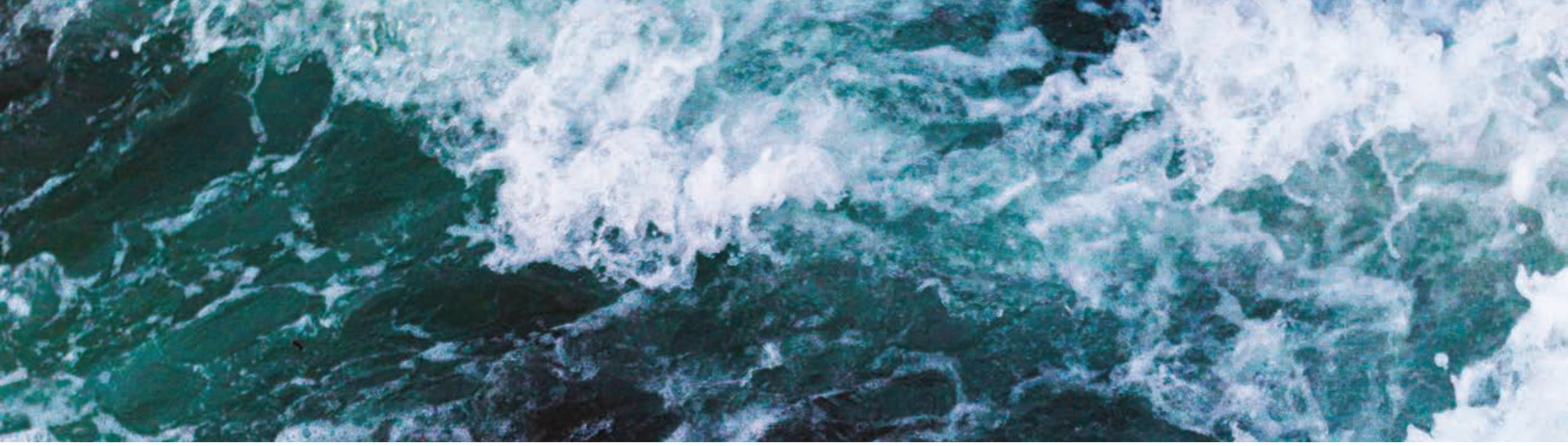
Depending on the time or planning horizon being considered, different sources of uncertainty (i.e., emission scenario or model uncertainty) play smaller or bigger roles in projections of sea-level rise. For example, as we consider the more distant future and our ability to predict what society will do lessens, different models will be more or less dependable, and the processes generating or driving the extreme sea-level rise scenarios will unfold. This uncertainty is why the State included the extreme sea-level rise scenario but did not assign a likelihood or probability to this scenario. Similarly, it is worth explicitly noting that probabilistic projections need to be taken as an evolving representation of the scientific field, open to updates and modifications. In this context of continued and unquantifiable uncertainties, incorporating long-range planning for sea-level rise in decisions is increasingly urgent. We know we will experience significant increases in sea-level rise, though it remains a challenge to say when this will occur and with what level of confidence it will occur in the given timeframe. This is precisely why it is critical to plan now for a range of possibilities, and integrate these possible futures in planning and preparing across specific communities.

This risk-based approach outlined in the Guidance, with consideration of the full range of outcomes including potentially consequential outcomes with low probability of occurrence, is consistent with standard practice across risk-centered fields.

California's state agencies and local jurisdictions along the coast and inland Delta are taking action to assess the risks and reduce the anticipated short and long-term impacts of climate change. Steps to incorporate sea-level rise in planning and investment decisions must be taken at the local and State levels to be appropriately relevant, precautionary, agile and progressive. This Guidance serves to increase our understanding of risks as they relate to sea-level rise and apply a set of principles so we are as adaptive and responsive as possible. While the Guidance currently pertains mostly to the coast, it is critical that we consider inland impacts of sea-level rise for long-term planning and follow the same set of recommendations and principles beyond the immediate coastal zone. For future updates to the Guidance, we will incorporate inland sea-level rise modelling and projections to the extent they are available and based on rigorous and peer-reviewed science.

This Guidance, accompanied by a set of resources provided on the State's Adaptation Clearinghouse and OPC's website, serves to be a living tool and resource for state and local planners, decision makers, and stakeholders. It is deliberately structured to be both precautionary and flexible with a core set of recommendations and principles that can readily infuse new scientific approaches and methods to sea-level rise projections as they arise. This adaptability and commitment to actionable science is what will ensure that California is prepared and responsive to the host of changes to come.

Finally, in developing this Guidance, the State took intentional action to engage users and decision makers to ensure that the scientific information and policy direction was understandable and useful for sea-level rise planning and adaptation efforts. There is a continued need for ongoing coordination and collaboration across state, regional and local entities to guarantee effective implementation this Guidance. Going forward, OPC will continue to prioritize opportunities for co-production of future decision-support products by scientists, practitioners, and policy and decision makers to further improve the translation of sea-level rise science into action.



Glossary

ADAPTATION (climate change): Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.[53]

ADAPTATION PATHWAY: An adaptation pathway is 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.[54]

ADAPTIVE MANAGEMENT: A process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.[55]

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.[56]

53. Glossary of Climate Change Terms. Office of Air and Radiation/Office of Atmospheric Programs/Climate Change Division. September 9, 2013: https://19january2017snapshot.epa.gov/climatechange_.html
54. South West Climate Change Portal: Catchment Planning - Using Adaptation Pathway: http://www.swclimatechange.com.au/cb_pages/adaptation_pathways.php
55. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-AnnexII_FINAL.pdf
56. Willows RI, RK Connell (eds.). 2003. Climate Adaptation: Risk, Uncertainty and Decisionmaking. UKCIP Technical Report. Oxford: UKCIP. 154 pp. http://www.ukcip.org.uk/wordpress/wp-content/PDFs/UKCIP-Risk-framework.pdf

CLIMATE CHANGE: Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use.[57]

COMMUNITY RESILIENCE: Community resilience is the ability of communities to withstand, recover, and learn from past disasters to strengthen future response and recovery efforts. This can include but is not limited to physical and psychological health of the population, social and economic equity and well-being of the community, effective risk communication, integration of organizations (governmental and nongovernmental) in planning, response, and recovery, and social connectedness for resource exchange, cohesion, response, and recovery.[58]

DISADVANTAGED COMMUNITIES: Areas disproportionately affected by environmental pollution and other hazards that can lead to negative public health effects, exposure, or environmental degradation, or with concentrations of people that are of low income, high unemployment, low levels of homeownership, high-rent burden, sensitive populations, or low levels of educational attainment.[59]

57. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability https://www.ipcc.ch/report/ar5/wg2/
58. Los Angeles County Community Disaster Resilience: http://www.laresilience.org/resources/glossary.php
59. California Health and Safety Code Section 39711: http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0501-0550/sb_535_bill_20120910_enrolled.html

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.[60]

ENVIRONMENTAL JUSTICE: The structures, policies, practices, and norms resulting in differential access to the goods, services, and opportunities of society by "race." It is normative, sometimes legalized, and often manifests as inherited disadvantage. Examples include differential access to quality education, sound housing, gainful employment, appropriate medical facilities, and a clean environment (Gov. Code §65040.12[e]).

EQUITY: Equity is just and fair inclusion into a society in which all can participate, prosper, and reach their full potential.[61]

EQUITY (climate): The central equity challenges for climate change policy involve several core issues: addressing the impacts of climate change, which are felt unequally; identifying who is responsible for causing climate change and for actions to limit its effects; and understanding the ways in which climate policy intersects with other dimensions of human development, both globally and domestically.[62]

EXTREME (climate) EVENTS: The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.[63]

GLOBAL CLIMATE MODELS: A numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties.[64]

60. Bedsworth L, E Hanak. 2008. Preparing California for a Changing Climate. PPIC Research Report. Public Policy Institute of California. San Francisco, USA. http://www.ppic.org/content/pubs/report/R_1108LBR.pdf
61. PolicyLink: http://www.policylink.org/
62. World Resources Institute. Building Climate Equity: Creating a New Approach from the Ground Up. July 2014. https://www.wri.org/sites/default/files/building-climate-equity-072014.pdf
63. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. IPCC, 2012. http://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf
64. IPCC, 2012: Glossary of terms. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. https://www.ipcc.ch/pdf/special-reports/srex/SREX-Annex_Glossary.pdf

INTEGRATED CLIMATE ACTIONS: Program, plans, or policies that simultaneously reduce greenhouse gas emissions and decrease the risks posed by climate change on the system where the action is implemented.

MITIGATION (climate change): A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.[65]

MITIGATION (of disaster risk and disaster): The lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability.[66]

NATURAL & GREEN INFRASTRUCTURE: Natural infrastructure means utilizing the natural function of ecological systems or processes to reduce vulnerability to specific environmental hazards and increase resilience of the shoreline in order to perpetuate or restore its ecosystem services.[67]

REPRESENTATIVE CONCENTRATION PATHWAYS: Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report in 2014. The Representative Concentration Pathways (RCPs), which are used for making projections based on these factors, describe four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high GHG emissions (RCP8.5).[68]

65. Glossary of Climate Change Terms. Office of Air and Radiation/Office of Atmospheric Programs/Climate Change Division. September 9, 2013. https://www.epa.gov/climatechange
66. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability. https://www.ipcc.ch/report/ar5/wg2/
67. Newkirk, S, S. Veloz, M. Hayden, W. Heady, K. Leo, J. Judge, R. Battalio, T. Cheng, T. Ursell, and M. Small. (The Nature Conservancy and Point Blue Conservation Science). 2018. Toward Natural Infrastructure to Manage Shoreline Change in California. California's Fourth Climate Change Assessment, California Natural Resources Agency. Publication number: CNRA-CCC4A-2018-3B. Expected release August 2018.
68. IPCC, 2014: Climate Change 2014: Synthesis Report. https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf

RESILIENCE (climate): Resilience is the capacity of any entity – an individual, a community, an organization, or a natural system – to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience.[69]

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 by the consequences a given system may experience.[70]

RISK AVERSION: The strong inclination to avoid taking risks in the face of uncertainty.

RISK TOLERANCE: A community's or decision maker's willingness to accept a higher or lower probability of impacts.[71]

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.[72]

SEA-LEVEL RISE: The worldwide average rise in mean sea level, which may be due to a number of different causes, such as the thermal expansion of sea water and the addition of water to the oceans from the melting of glaciers, ice caps, and ice sheets; contrast with relative sea-level rise.[73]

69. Rodin, Judith. 2014. The Resilience Dividend: Being Strong in a World Where Things Go Wrong. Philadelphia: Perseus Books Group (pages 3-4).
70. Burton I, E Malone, S Huq. 2004. Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. [B Lim, E Spanger-Siegfried (eds.)]. United Nations Development Programme. Cambridge University Press: Cambridge, New York, Melbourne, Madrid. 258 pp. https://www.preventionweb.net/files/7995_APF.pdf
71. 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
72. National Oceanic and Atmospheric Administration (NOAA). 2010. Adapting to Climate Change: A Planning Guide for State Coastal Managers. NOAA Office of Ocean and Coastal Resource Management. 138pp. http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf
73. Glossary of Climate Change Terms. Office of Air and Radiation/Office of Atmospheric Programs/Climate Change Division. September 9, 2013. https://19january2017snapshot.epa.gov/climatechange_.html

VULNERABILITY: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.[74]

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, etc.[75]

VULNERABLE POPULATIONS: Vulnerable populations include, but are not limited to women; racial or ethnic groups; low-income individuals and families; individuals who are incarcerated or have been incarcerated; individuals with disabilities; individuals with mental health conditions; children; youth and young adults; seniors; immigrants and refugees; individuals who are limited English proficient (LEP); and Lesbian, Gay, Bisexual, Transgender, Queer, and Questioning (LGBTQQ) communities, or combinations of these populations.[76]

74. IPCC Climate Change 2014: Impacts, Adaptation, and Vulnerability. https://www.ipcc.ch/report/ar5/wg2/
75. Tompkins, E, S. Nicholson-Cole, L. Hurlston, E. Boyd, G. Hodge, J. Clarke , G. Gray, N. Trotz, L. Varlack. 2005. Surviving Climate Change in Small Islands – A guidebook. https://www.preventionweb.net/files/734_10365.pdf
76. California Health and Safety Code Section 131019.5 https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Health_and_Safety_Code_131019.5.pdf

APPENDIX 1:

Guidance Document Development

THE PURPOSE OF THE 2018 UPDATE TO THE STATE'S SEA-LEVEL RISE GUIDANCE (Guidance) was to reflect recent advances in ice loss science and projections of sea-level rise and focus on the needs of state agencies and local governments as they incorporate sea-level rise into their planning, permitting and investment decisions. The development of the Guidance update included three components: 1) a science synthesis to reflect the latest advances in sea-level rise science; 2) a robust public outreach and engagement effort to ensure the updated Guidance is understandable and useful for decision making; 3) and integration of components 1 and 2 to create a science-based, user-informed policy document.

Updating the Science.

Ocean Science Trust (OST), with support from the Ocean Protection Council (OPC), led the scientific component of the update and convened an OPC Science Advisory Team (OPC-SAT) Working Group. The Working Group members, who have subject-matter experts in coastal processes, risk assessment, climatic change, ice loss and ice sheet behavior, and statistical modeling, included: Gary Griggs, University of California Santa Cruz, OPC-SAT (Working Group Chair); Dan Cayan, Scripps Institution of Oceanography, OPC-SAT; Robert Kopp, Rutgers University; Claudia Tebaldi, National Center for Atmospheric Research; Helen Fricker, Scripps Institution of Oceanography; Joe Arvai, University of Michigan; and Rob DeConto, University of Massachusetts.

To ensure that the science synthesis could provide a foundation for policy decisions made in the updated Guidance, a Policy Advisory Committee (PAC) comprised of OPC, the California Natural Resources Agency, the Governor's Office of Planning and Research, and the California Energy Commission developed a list of questions to elicit information about the current estimates of SLR for California and how to understand the scientific context around those estimates. The full list of PAC questions can be found in Appendix 5.

Using the PAC questions as a guide, the working group compiled and reviewed the latest climate research, including the implications of recent scientific advances on ice loss dynamics for updating sea-level rise projections and provided a summary of key findings along with updated projections for three representative tide gauges in California. This science summary, entitled "Rising Seas in California: An Update on Sea-Level Rise Science," was presented to the California Ocean Protection Council at its April 2017 meeting, where the Council then adopted a resolution[77] acknowledging the report as the best available science on which the updated Guidance should be based and directing OPC staff to engage in an inclusive public engagement process to share the scientific findings and solicit feedback on how the updated guidance document will be used.

Public Outreach and Engagement.

Input from users of the guidance document was solicited at multiple points throughout the update process. In February, March and April 2017, an engagement team led by Susanne Moser Research & Consulting and Climate Access, a not-for-profit organization, conducted interviews[78] and five listening sessions to better understand the needs of those who will use the guidance document. In addition, throughout the summer 2017, the OPC and OST, with support from the engagement team, convened four public workshops with state, regional, and local stakeholders in Eureka, San

77. Resolution of the California Ocean Protection Council on Updating the State of California Sea-level Rise Guidance Document, Adopted on April 26, 2017: http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20170426/ADOPTED-SLR-Resolution-20170426.pdf

78. Interviews were conducted with representatives from local, state and federal governments including: U.S. Geological Survey, San Francisco Bay Conservation and Development Commission, California Coastal Commission, California Coastal Conservancy, Delta Stewardship Council, California Department of Public Health, Department of Water Resources, State Lands Commission, California State Parks, Strategic Growth Council, State Water Resources Control Board, LA Regional Water Quality Control Board, Governor's Office of Planning and Research, Governor's Office of Emergency Services, Caltrans; the cities of Eureka, Arcata,Seaside, Santa Monica, Long Beach; Marin and San Mateo counties, and the San Diego Regional Collaborative. Several consulting firms were also interviewed.

Francisco, Los Angeles and San Diego. The purpose of these workshops was to share the science findings and to solicit feedback on how stakeholders will utilize the guidance document. Close to 400 coastal stakeholders from city, county, and regional government entities, consulting groups, non-profits, state and federal agencies and tribal representatives provided input that helped shape the framework for the Guidance update and associated web resources.

OPC also coordinated closely with the Sea-Level Rise Coastal Leadership Team (California Coastal Commission, San Francisco Bay Conservation and Development Commission, State Lands Commission, California State Parks, State Coastal Conservancy) and the Coastal and Ocean working group of the State's Climate Action Team (CO-CAT), an entity comprised of senior level staff from California state agencies with ocean and coastal resource management responsibilities.

Update to Policy Guidance.

Using the Rising Seas Report and the input from public engagement efforts, OPC staff drafted a science-based, user-informed updated Guidance document in coordination with the PAC and Sea-Level Rise Coastal Leadership Team. The draft will be circulated for formal public comment in the fall of 2017, with final adoption by the Ocean Protection Council scheduled for March 2018.

In response to user needs, the policy Guidance will be supported by a library and database of resources to help visualize change, access funding opportunities, gather policy and scientific background related to specific jurisdictions, and in general provide additional support to address a challenge of this nature and magnitude. This database and library of resources will be available on the State Adaptation Clearinghouse in mid-2018, as well as OPC's website.

APPENDIX 2:

Map of Tide Gauge Locations

APPENDIX 3:

Sea-Level Rise Projections For All 12 Tide Gauges

TABLE 1: Projected Sea-Level Rise (in feet) for Crescent City

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.1	0.0	-	0.3	0.4	0.5	0.8
	2040	0.3	0.1	-	0.4	0.6	0.9	1.4
	2050	0.4	0.2	-	0.7	0.9	1.5	2.3
Low emissions	2060	0.4	0.1	-	0.7	1.0	1.8	
High emissions	2060	0.6	0.2	-	0.9	1.3	2.1	3.3
Low emissions	2070	0.5	0.1	-	0.9	1.3	2.4	
High emissions	2070	0.8	0.4	-	1.2	1.7	2.8	4.5
Low emissions	2080	0.6	0.1	-	1.1	1.6	3.1	
High emissions	2080	1.0	0.5	-	1.6	2.2	3.7	5.9
Low emissions	2090	0.7	0.1	-	1.3	1.9	3.9	
High emissions	2090	1.2	0.6	-	2.0	2.8	4.7	7.4
Low emissions	2100	0.7	0.1	-	1.5	2.3	4.8	
High emissions	2100	1.5	0.7	-	2.5	3.4	5.9	9.3
Low emissions	2110*	0.8	0.2	-	1.5	2.4	5.3	
High emissions	2110*	1.5	0.9	-	2.5	3.4	6.2	11.0
Low emissions	2120	0.8	0.1	-	1.7	2.8	6.3	
High emissions	2120	1.8	1.0	-	3.0	4.1	7.4	13.1
Low emissions	2130	0.9	0.1	-	1.9	3.2	7.3	
High emissions	2130	2.1	1.1	-	3.4	4.8	8.7	15.3
Low emissions	2140	1.0	0.1	-	2.2	3.6	8.4	
High emissions	2140	2.3	1.2	-	3.9	5.5	10.1	17.8
Low emissions	2150	1.0	0.0	-	2.4	4.2	9.6	
High emissions	2150	2.6	1.3	-	4.4	6.2	11.6	20.6

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 2: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Crescent City

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

CRESCENT CITY - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030										
2040	0.3%									
2050	3%	0.1%								
2060	13%	1%	0.1%							
2070	31%	2%	0.4%	0.1%	0.1%					
2080	49%	8%	1%	0.4%	0.2%	0.1%				
2090	63%	17%	4%	1%	0.4%	0.2%	0.1%	0.1%		
2100	72%	30%	9%	3%	1%	1%	0.3%	0.2%	0.1%	0.1%
2150	90%	67%	40%	21%	11%	6%	3%	2%	1%	1%

CRESCENT CITY - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	6%	0.3%	0.1%							
2070	13%	1%	0.2%	0.1%						
2080	20%	2%	1%	0.2%	0.1%	0.1%				
2090	28%	5%	1%	0.4%	0.2%	0.1%	0.1%			
2100	36%	8%	2%	1%	0.4%	0.2%	0.1%	0.1%	0.1%	
2150	52%	23%	11%	6%	3%	2%	1%	1%	1%	1%

TABLE 3: Projected Average Rate of Sea-Level Rise (mm/year) for Crescent City

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	3.8	1.6 - 6.4	8.6	14	23
Low emissions	2060 - 2080	2.5	0.2 - 5.5	8.9	20	
High emissions	2060 - 2080	6.6	3.4 - 11	15	26	40
Low emissions	2080 – 2100	2.6	-0.2 - 6.4	11	25	
High emissions	2080 – 2100	7.7	3.4 - 13	19	34	51

TABLE 4: Projected Sea-Level Rise (in feet) for North Spit

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...			5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.6	0.5	-	0.7	0.8	1	1.2
	2040	0.9	0.7	-	1.1	1.2	1.6	2.0
	2050	1.2	0.9	-	1.5	1.7	2.3	3.1
Low emissions	2060	1.3	1.0	-	1.7	2	2.8	
High emissions	2060	1.5	1.2	-	1.9	2.2	3.1	4.3
Low emissions	2070	1.6	1.2	-	2	2.4	3.5	
High emissions	2070	1.9	1.4	-	2.4	2.9	4	5.6
Low emissions	2080	1.8	1.4	-	2.4	2.9	4.4	
High emissions	2080	2.3	1.7	-	2.9	3.5	5.1	7.2
Low emissions	2090	2.1	1.5	-	2.7	3.4	5.3	
High emissions	2090	2.7	2.0	-	3.5	4.3	6.2	8.9
Low emissions	2100	2.3	1.7	-	3.1	3.9	6.3	
High emissions	2100	3.1	2.3	-	4.1	5.1	7.6	10.9
Low emissions	2110*	2.5	1.9	-	3.3	4.2	7.1	
High emissions	2110*	3.3	2.6	-	4.3	5.2	8	12.7
Low emissions	2120	2.7	2.0	-	3.7	4.8	8.2	
High emissions	2120	3.7	2.9	-	4.9	6.1	9.4	15.0
Low emissions	2130	3	2.1	-	4	5.3	9.4	
High emissions	2130	4.2	3.1	-	5.5	6.9	10.9	17.4
Low emissions	2140	3.2	2.3	-	4.4	5.9	10.7	
High emissions	2140	4.6	3.4	-	6.2	7.8	12.5	20.1
Low emissions	2150	3.4	2.3	-	4.8	6.6	12.1	
High emissions	2150	5	3.7	-	6.8	8.7	14.1	23.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 5: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in North Spit

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

NORTH SPIT - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.5%									
2040	27.2%	0.1%								
2050	76%	1.4%	0.1%							
2060	94%	12%	0.6%	0.1%						
2070	98%	40%	3.4%	0.5%	0.1%	0.1%				
2080	99%	68%	14%	2.1%	0.5%	0.2%	0.1%			
2090	100%	83%	33%	7%	1.8%	0.6%	0.3%	0.1%	0.1%	
2100	100%	90%	54%	19%	6%	2%	0.8%	0.4%	0.2%	0.1%
2150	100%	100%	94%	76%	50%	28%	15%	8%	4%	3%

NORTH SPIT - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	86%	5.2%	0.3%							
2070	94%	18%	1.4%	0.3%						
2080	97%	37%	4%	0.8%	0.3%	0.1%				
2090	98%	55%	10%	2.0%	0.7%	0.3%	0.2%	0.1%	0.1%	
2100	98%	68%	20%	4%	1.5%	0.6%	0.3%	0.2%	0.1%	
2150	100%	91%	63%	32%	15%	7%	4%	2%	2%	1%

TABLE 6: Projected Average Rate of Sea-Level Rise (mm/year) for North Spit

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	8.7	6.4	-	11	14	19	28
Low emissions	2060 - 2080	7.4	5.1	-	10	14	24	
High emissions	2060 - 2080	11	8.2	-	16	20	31	44
Low emissions	2080 – 2100	7.4	4.5	-	11	16	29	
High emissions	2080 – 2100	13	8.1	-	18	24	39	56

TABLE 7: Projected Sea-Level Rise (in feet) for Arena Cove

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2	-	0.5	0.5	0.7	1.0
	2040	0.5	0.3	-	0.7	0.9	1.2	1.6
	2050	0.7	0.5	-	1.0	1.2	1.8	2.6
Low emissions	2060	0.8	0.5	-	1.1	1.4	2.2	
High emissions	2060	1.0	0.6	-	1.3	1.7	2.5	3.7
Low emissions	2070	0.9	0.5	-	1.3	1.8	2.9	
High emissions	2070	1.2	0.8	-	1.7	2.2	3.3	5.0
Low emissions	2080	1.0	0.6	-	1.6	2.1	3.6	
High emissions	2080	1.5	1.0	-	2.2	2.8	4.3	6.4
Low emissions	2090	1.2	0.7	-	1.8	2.5	4.5	
High emissions	2090	1.8	1.1	-	2.6	3.4	5.4	8.0
Low emissions	2100	1.3	0.7	-	2.1	3.0	5.4	
High emissions	2100	2.1	1.3	-	3.1	4.1	6.7	9.9
Low emissions	2110*	1.4	0.8	-	2.2	3.1	6.0	
High emissions	2110*	2.3	1.5	-	3.2	4.2	7.0	11.6
Low emissions	2120	1.5	0.9	-	2.5	3.6	7.1	
High emissions	2120	2.6	1.8	-	3.8	5.0	8.2	13.9
Low emissions	2130	1.7	0.9	-	2.8	4.1	8.1	
High emissions	2130	2.9	1.9	-	4.3	5.7	9.7	16.2
Low emissions	2140	1.8	0.9	-	3.1	4.6	9.4	
High emissions	2140	3.2	2.1	-	4.8	6.5	11.1	18.7
Low emissions	2150	1.9	0.9	-	3.4	5.1	10.7	
High emissions	2150	3.6	2.3	-	5.4	7.3	12.6	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 8: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Arena Cove

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

ARENA COVE - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030										
2040	1.5%									
2050	17%	0.3%								
2060	44%	2%	0.2%							
2070	68%	8%	0.8%	0.2%	0.1%					
2080	82%	22%	3%	0.7%	0.2%	0.1%	0.1%			
2090	89%	40%	9%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2100	91%	56%	20%	6%	2%	1%	0.4%	0.2%	0.1%	0.1%
2150	99%	89%	66%	40%	22%	12%	6%	4%	2%	1%

ARENA COVE - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	25%	0.9%	0.1%							
2070	42%	3%	0.4%	0.1%						
2080	55%	7%	1%	0.3%	0.2%	0.1%				
2090	63%	13%	3%	0.8%	0.3%	0.2%	0.1%	0.1%		
2100	69%	20%	5%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2150	81%	48%	22%	11%	5%	3%	2%	1%	1%	1%

TABLE 9: Projected Average Rate of Sea-Level Rise (mm/year) for Arena Cove

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	5.8	3.5 - 8.4	11	17	25
Low emissions	2060 - 2080	4.4	2.1 - 7.4	11	22	
High emissions	2060 - 2080	8.6	5.4 - 13	17	28	42
Low emissions	2080 – 2100	4.4	1.4 - 8.4	13	27	
High emissions	2080 – 2100	9.6	5.0 - 15	21	36	54

TABLE 10: Projected Sea-Level Rise (in feet) for Point Reyes

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…		5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.6	0.6	0.8	1
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	2.0	2.8
Low emissions	2060	1.0	0.7 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.9	2.7	3.9
Low emissions	2070	1.1	0.8 -	1.6	2.0	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.4	3.9	
High emissions	2080	1.8	1.2 -	2.4	3.0	4.6	6.7
Low emissions	2090	1.5	1.0 -	2.1	2.8	4.8	
High emissions	2090	2.1	1.4 -	2.9	3.7	5.6	8.3
Low emissions	2100	1.7	1.0 -	2.5	3.3	5.7	
High emissions	2100	2.5	1.6 -	3.5	4.5	7.0	10.3
Low emissions	2110*	1.8	1.2 -	2.6	3.5	6.4	
High emissions	2110*	2.6	1.9 -	3.6	4.6	7.3	12.0
Low emissions	2120	1.9	1.2 -	2.9	4.0	7.5	
High emissions	2120	3.0	2.2 -	4.2	5.3	8.6	14.3
Low emissions	2130	2.1	1.3 -	3.2	4.5	8.6	
High emissions	2130	3.4	2.4 -	4.7	6.1	10.1	16.6
Low emissions	2140	2.3	1.3 -	3.5	5.0	9.8	
High emissions	2140	3.7	2.6 -	5.3	6.9	11.5	19.2
Low emissions	2150	2.4	1.3 -	3.8	5.6	11.2	
High emissions	2150	4.1	2.8 -	5.9	7.8	13.1	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 11: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Point Reyes

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

POINT REYES - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	4.0%									
2050	34%	0.4%								
2060	66%	3%	0.3%	0.1%						
2070	84%	15%	1.3%	0.3%	0.1%					
2080	93%	36%	5%	1.0%	0.3%	0.1%	0.1%			
2090	96%	56%	15%	3%	0.9%	0.3%	0.2%	0.1%	0.1%	
2100	96%	70%	30%	9%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	96%	79%	53%	30%	16%	8%	5%	3%	2%

POINT REYES - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	45%	1.5%	0.2%							
2070	64%	5%	0.6%	0.2%						
2080	75%	12%	2%	0.4%	0.2%	0.1%				
2090	81%	21%	4%	1.1%	0.4%	0.2%	0.1%	0.1%		
2100	84%	33%	8%	2%	0.9%	0.4%	0.2%	0.1%	0.1%	
2150	93%	63%	32%	15%	7%	4%	2%	2%	1%	1%

TABLE 12: Projected Average Rate of Sea-Level Rise (mm/year) for Point Reyes

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	6.8	4.5 - 9.4	12	18	26
Low emissions	2060 - 2080	5.4	3.1 - 8.4	12	23	
High emissions	2060 - 2080	9.6	6.4 - 14	18	29	43
Low emissions	2080 – 2100	5.3	2.4 - 9.3	14	28	
High emissions	2080 – 2100	11	6.0 - 16	22	38	55

TABLE 13: Projected Sea-Level Rise (in feet) for San Francisco

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	7.7	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 14: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in San Francisco

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

SAN FRANCISCO - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	3.3%									
2050	31%	0.4%								
2060	65%	3%	0.2%	0.1%						
2070	84%	13%	1.2%	0.2%	0.1%					
2080	93%	34%	5%	0.9%	0.3%	0.1%	0.1%			
2090	96%	55%	14%	3%	0.9%	0.3%	0.2%	0.1%	0.1%	
2100	96%	70%	28%	8%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	96%	79%	52%	28%	15%	8%	4%	3%	2%

SAN FRANCISCO - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	43%	1.4%	0.2%							
2070	62%	4%	0.6%	0.2%						
2080	74%	11%	2%	0.4%	0.2%	0.1%				
2090	80%	20%	3%	1.0%	0.4%	0.2%	0.1%	0.1%		
2100	84%	31%	7%	2%	0.8%	0.4%	0.2%	0.1%	0.1%	
2150	93%	62%	31%	14%	7%	4%	2%	2%	1%	1%

TABLE 15: Projected Average Rate of Sea-Level Rise (mm/year) for San Francisco

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	6.7	4.5 - 9.3	12	17	26
Low emissions	2060 - 2080	5.3	3.1 - 8.2	12	22	
High emissions	2060 - 2080	9.5	6.4 - 13	17	28	42
Low emissions	2080 – 2100	5.2	2.3 - 9.1	14	28	
High emissions	2080 – 2100	11	6.0 - 16	22	37	55

TABLE 16: Projected Sea-Level Rise (in feet) for Monterey

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…		5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.4 -	0.8	0.9	1.2	1.7
	2050	0.8	0.5 -	1.1	1.3	1.9	2.7
Low emissions	2060	0.9	0.5 -	1.2	1.5	2.3	
High emissions	2060	1.0	0.7 -	1.4	1.8	2.6	3.8
Low emissions	2070	1.0	0.6 -	1.4	1.9	3.0	
High emissions	2070	1.3	0.9 -	1.8	2.3	3.4	5.1
Low emissions	2080	1.2	0.7 -	1.7	2.3	3.8	
High emissions	2080	1.6	1.1 -	2.3	2.9	4.4	6.6
Low emissions	2090	1.3	0.8 -	2.0	2.7	4.6	
High emissions	2090	2.0	1.3 -	2.8	3.5	5.5	8.2
Low emissions	2100	1.5	0.9 -	2.3	3.1	5.5	
High emissions	2100	2.3	1.5 -	3.3	4.3	6.9	10.1
Low emissions	2110*	1.6	1.0 -	2.4	3.3	6.1	
High emissions	2110*	2.5	1.7 -	3.4	4.4	7.2	11.8
Low emissions	2120	1.7	1.0 -	2.7	3.8	7.3	
High emissions	2120	2.8	2.0 -	4.0	5.2	8.5	14.0
Low emissions	2130	1.9	1.1 -	3.0	4.2	8.3	
High emissions	2130	3.1	2.2 -	4.5	5.9	9.9	16.4
Low emissions	2140	2.0	1.1 -	3.2	4.7	9.5	
High emissions	2140	3.5	2.4 -	5.1	6.7	11.3	18.9
Low emissions	2150	2.1	1.1 -	3.6	5.3	10.8	
High emissions	2150	3.8	2.6 -	5.7	7.6	12.9	21.8

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 17: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Monterey

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

MONTEREY - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	2.5%									
2050	24%	0.3%								
2060	55%	2%	0.2%	0.1%						
2070	77%	11%	1.1%	0.2%	0.1%					
2080	88%	29%	4%	0.8%	0.3%	0.1%	0.1%			
2090	93%	48%	12%	3%	0.8%	0.3%	0.2%	0.1%	0.1%	
2100	94%	63%	25%	7%	2%	1%	0.4%	0.2%	0.1%	0.1%
2150	100%	93%	73%	46%	25%	14%	7%	4%	2%	2%

MONTEREY - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	34%	1.2%	0.1%							
2070	52%	4%	0.5%	0.1%						
2080	64%	9%	1%	0.4%	0.2%	0.1%				
2090	72%	16%	3%	0.9%	0.3%	0.2%	0.1%	0.1%		
2100	77%	25%	6%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2150	87%	55%	26%	12%	6%	4%	2%	1%	1%	1%

TABLE 18: Projected Average Rate of Sea-Level Rise (mm/year) for Monterey

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	6.3	4.0 - 9.0	11	17	25
Low emissions	2060 - 2080	4.9	2.6 - 7.8	11	22	
High emissions	2060 - 2080	9.1	5.9 - 13	17	28	43
Low emissions	2080 – 2100	4.7	1.8 - 8.7	13	27	
High emissions	2080 – 2100	10	5.5 - 16	22	37	54

TABLE 19: Projected Sea-Level Rise (in feet) for Port San Luis

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…		5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2 -	0.5	0.5	0.7	1.0
	2040	0.5	0.3 -	0.7	0.8	1.2	1.6
	2050	0.7	0.5 -	1.0	1.2	1.8	2.6
Low emissions	2060	0.8	0.4 -	1.1	1.4	2.2	
High emissions	2060	1.0	0.6 -	1.3	1.7	2.5	3.7
Low emissions	2070	0.9	0.5 -	1.3	1.7	2.9	
High emissions	2070	1.2	0.8 -	1.7	2.2	3.3	5.0
Low emissions	2080	1.0	0.6 -	1.6	2.1	3.6	
High emissions	2080	1.5	1.0 -	2.1	2.8	4.3	6.4
Low emissions	2090	1.1	0.6 -	1.8	2.5	4.5	
High emissions	2090	1.8	1.1 -	2.6	3.4	5.3	8.0
Low emissions	2100	1.3	0.7 -	2.1	2.9	5.4	
High emissions	2100	2.1	1.3 -	3.1	4.1	6.7	9.9
Low emissions	2110*	1.4	0.8 -	2.2	3.1	5.9	
High emissions	2110*	2.3	1.5 -	3.2	4.2	7.0	11.6
Low emissions	2120	1.5	0.8 -	2.4	3.5	7.0	
High emissions	2120	2.6	1.8 -	3.7	4.9	8.2	13.8
Low emissions	2130	1.6	0.9 -	2.7	4.0	8.0	
High emissions	2130	2.9	2.0 -	4.3	5.7	9.6	16.2
Low emissions	2140	1.7	0.9 -	3.0	4.5	9.2	
High emissions	2140	3.2	2.1 -	4.8	6.4	11.1	18.7
Low emissions	2150	1.9	0.8 -	3.3	5.1	10.5	
High emissions	2150	3.6	2.3 -	5.4	7.3	12.6	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 20: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Port San Luis

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

PORT SAN LUIS - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030										
2040	1.5%									
2050	16%	0.3%								
2060	44%	2%	0.2%	0.1%						
2070	68%	8%	0.8%	0.2%	0.1%					
2080	82%	22%	3%	0.7%	0.2%	0.1%	0.1%			
2090	89%	40%	9%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2100	91%	56%	20%	6%	2%	1%	0.4%	0.2%	0.1%	0.1%
2150	99%	89%	66%	40%	21%	11%	6%	4%	2%	1%

PORT SAN LUIS - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	24%	0.9%	0.1%							
2070	40%	3%	0.4%	0.1%						
2080	52%	6%	1%	0.3%	0.2%	0.1%				
2090	61%	12%	2%	0.7%	0.3%	0.2%	0.1%	0.1%		
2100	67%	19%	4%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2150	80%	46%	21%	10%	5%	3%	2%	1%	1%	1%

TABLE 21: Projected Average Rate of Sea-Level Rise (mm/year) for Port San Luis

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	5.8	3.5 - 8.4	11	17	24
Low emissions	2060 - 2080	4.3	2.1 - 7.2	11	21	
High emissions	2060 - 2080	8.5	5.4 - 13	17	27	42
Low emissions	2080 – 2100	4.1	1.2 - 8.0	13	27	
High emissions	2080 – 2100	9.6	5.0 - 15	21	37	54

TABLE 22: Projected Sea-Level Rise (in feet) for Santa Barbara

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2	-	0.4	0.5	0.7	1.0
	2040	0.5	0.3	-	0.7	0.8	1.1	1.6
	2050	0.7	0.4	-	1.0	1.2	1.8	2.5
Low emissions	2060	0.7	0.4	-	1.0	1.4	2.2	
High emissions	2060	0.9	0.6	-	1.3	1.6	2.5	3.6
Low emissions	2070	0.9	0.5	-	1.3	1.7	2.8	
High emissions	2070	1.1	0.7	-	1.7	2.1	3.3	4.9
Low emissions	2080	1.0	0.5	-	1.5	2.0	3.6	
High emissions	2080	1.4	0.9	-	2.1	2.7	4.3	6.3
Low emissions	2090	1.1	0.6	-	1.8	2.4	4.4	
High emissions	2090	1.7	1.1	-	2.6	3.3	5.3	7.9
Low emissions	2100	1.2	0.6	-	2.0	2.9	5.3	
High emissions	2100	2.1	1.2	-	3.1	4.1	6.6	9.8
Low emissions	2110*	1.3	0.7	-	2.1	3.0	5.9	
High emissions	2110*	2.2	1.4	-	3.2	4.2	6.9	11.5
Low emissions	2120	1.4	0.7	-	2.4	3.5	7.0	
High emissions	2120	2.5	1.7	-	3.7	4.9	8.2	13.7
Low emissions	2130	1.5	0.8	-	2.6	3.9	8.0	
High emissions	2130	2.9	1.8	-	4.2	5.6	9.5	16.0
Low emissions	2140	1.6	0.8	-	2.9	4.4	9.1	
High emissions	2140	3.1	2.0	-	4.8	6.4	11.0	18.6
Low emissions	2150	1.8	0.7	-	3.2	5.0	10.5	
High emissions	2150	3.5	2.2	-	5.3	7.2	12.6	21.4

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 23: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Santa Barbara

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

SANTA BARBARA - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030										
2040	1.3%									
2050	14%	0.2%								
2060	40%	2%	0.2%							
2070	64%	7%	0.8%	0.2%	0.1%					
2080	78%	20%	3%	0.7%	0.2%	0.1%	0.1%			
2090	86%	37%	8%	2%	0.7%	0.3%	0.1%	0.1%	0.1%	
2100	89%	53%	19%	6%	2%	1%	0.3%	0.2%	0.1%	0.1%
2150	98%	87%	63%	38%	20%	11%	6%	3%	2%	1%

SANTA BARBARA - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	21%	0.8%	0.1%							
2070	35%	2%	0.3%	0.1%						
2080	48%	6%	1%	0.3%	0.1%	0.1%				
2090	57%	11%	2%	0.7%	0.3%	0.2%	0.1%	0.1%		
2100	63%	17%	4%	1%	0.6%	0.3%	0.2%	0.1%	0.1%	
2150	76%	42%	19%	9%	5%	3%	2%	1%	1%	1%

TABLE 24: Projected Average Rate of Sea-Level Rise (mm/year) for Santa Barbara

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	5.6	3.3 - 8.2	11	16	24
Low emissions	2060 - 2080	4.1	1.9 - 7.0	10	21	
High emissions	2060 - 2080	8.3	5.1 - 12	16	27	41
Low emissions	2080 – 2100	3.9	0.91 - 7.8	12	27	
High emissions	2080 – 2100	9.4	4.8 - 15	21	36	53

TABLE 25: Projected Sea-Level Rise (in feet) for Santa Monica

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1
	2040	0.6	0.4	-	0.8	0.9	1.2	1.7
	2050	0.8	0.6	-	1.1	1.3	1.9	2.6
Low emissions	2060	0.9	0.6	-	1.2	1.5	2.3	
High emissions	2060	1.1	0.8	-	1.4	1.8	2.6	3.8
Low emissions	2070	1.0	0.7	-	1.4	1.9	3.0	
High emissions	2070	1.3	1.0	-	1.8	2.3	3.4	5.1
Low emissions	2080	1.2	0.8	-	1.7	2.3	3.8	
High emissions	2080	1.7	1.1	-	2.3	2.9	4.4	6.5
Low emissions	2090	1.3	0.8	-	2.0	2.7	4.6	
High emissions	2090	2.0	1.3	-	2.8	3.5	5.5	8.1
Low emissions	2100	1.5	0.9	-	2.3	3.1	5.5	
High emissions	2100	2.3	1.5	-	3.3	4.3	6.8	10.0
Low emissions	2110*	1.6	1.0	-	2.4	3.3	6.1	
High emissions	2110*	2.5	1.8	-	3.5	4.5	7.2	11.7
Low emissions	2120	1.7	1.0	-	2.7	3.8	7.3	
High emissions	2120	2.9	2.0	-	4.0	5.2	8.5	14.0
Low emissions	2130	1.9	1.1	-	3.0	4.2	8.3	
High emissions	2130	3.2	2.2	-	4.5	5.9	9.8	16.3
Low emissions	2140	2.0	1.1	-	3.2	4.7	9.4	
High emissions	2140	3.5	2.4	-	5.1	6.7	11.3	18.9
Low emissions	2150	2.2	1.1	-	3.6	5.3	10.8	
High emissions	2150	3.9	2.6	-	5.7	7.6	12.9	21.7

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 26: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Santa Monica

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

SANTA MONICA - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	2.5%									
2050	25%	0.3%								
2060	58%	2%	0.2%	0.1%						
2070	79%	11%	1.0%	0.2%	0.1%					
2080	89%	30%	4%	0.8%	0.3%	0.1%	0.1%			
2090	94%	50%	12%	3%	0.8%	0.3%	0.2%	0.1%	0.1%	
2100	95%	65%	25%	7%	2%	1%	0.4%	0.2%	0.1%	0.1%
2150	100%	94%	74%	47%	26%	14%	7%	4%	2%	2%

SANTA MONICA - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	35%	1.2%	0.1%							
2070	53%	4%	0.5%	0.1%						
2080	66%	9%	1%	0.4%	0.2%	0.1%				
2090	74%	16%	3%	0.9%	0.3%	0.2%	0.1%	0.1%		
2100	78%	25%	6%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2150	89%	56%	26%	12%	6%	4%	2%	1%	1%	1%

TABLE 27: Projected Average Rate of Sea-Level Rise (mm/year) for Santa Monica

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	6.4	4.3 - 8.9	11	17	24
Low emissions	2060 - 2080	4.9	2.8 - 7.8	11	22	
High emissions	2060 - 2080	9.2	6.0 - 13	17	28	42
Low emissions	2080 – 2100	4.6	1.6 - 8.5	13	27	
High emissions	2080 – 2100	10	5.6 - 16	22	37	54

TABLE 28: Projected Sea-Level Rise (in feet) for Los Angeles

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.3	0.2	-	0.5	0.6	0.7	1.0
	2040	0.5	0.4	-	0.7	0.9	1.2	1.7
	2050	0.7	0.5	-	1.0	1.2	1.8	2.6
Low emissions	2060	0.8	0.5	-	1.1	1.4	2.2	
High emissions	2060	1.0	0.7	-	1.3	1.7	2.5	3.7
Low emissions	2070	0.9	0.6	-	1.3	1.8	2.9	
High emissions	2070	1.2	0.8	-	1.7	2.2	3.3	5.0
Low emissions	2080	1.0	0.6	-	1.6	2.1	3.6	
High emissions	2080	1.5	1.0	-	2.2	2.8	4.3	6.4
Low emissions	2090	1.2	0.7	-	1.8	2.5	4.5	
High emissions	2090	1.8	1.2	-	2.7	3.4	5.3	8.0
Low emissions	2100	1.3	0.7	-	2.1	3.0	5.4	
High emissions	2100	2.2	1.3	-	3.2	4.1	6.7	9.9
Low emissions	2110*	1.4	0.9	-	2.2	3.1	6.0	
High emissions	2110*	2.3	1.6	-	3.3	4.3	7.1	11.5
Low emissions	2120	1.5	0.9	-	2.5	3.6	7.1	
High emissions	2120	2.7	1.8	-	3.8	5.0	8.3	13.8
Low emissions	2130	1.7	0.9	-	2.8	4.0	8.1	
High emissions	2130	3.0	2.0	-	4.3	5.7	9.7	16.1
Low emissions	2140	1.8	0.9	-	3.0	4.5	9.2	
High emissions	2140	3.3	2.2	-	4.9	6.5	11.1	18.7
Low emissions	2150	1.9	0.9	-	3.3	5.1	10.6	
High emissions	2150	3.7	2.4	-	5.4	7.3	12.7	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 29: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in Los Angeles

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

LOS ANGELES - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030										
2040	1.6%									
2050	17%	0.3%								
2060	47%	2%	0.2%							
2070	71%	8%	0.8%	0.2%	0.1%					
2080	84%	23%	3%	0.7%	0.2%	0.1%	0.1%			
2090	90%	42%	9%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2100	92%	58%	21%	6%	2%	1%	0.4%	0.2%	0.1%	0.1%
2150	99%	90%	68%	42%	23%	12%	6%	4%	2%	1%

LOS ANGELES - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	25%	0.9%	0.1%							
2070	42%	3%	0.4%	0.1%						
2080	55%	7%	1%	0.3%	0.2%	0.1%				
2090	64%	13%	2%	0.7%	0.3%	0.2%	0.1%	0.1%		
2100	69%	20%	5%	2%	0.7%	0.3%	0.2%	0.1%	0.1%	
2150	82%	48%	22%	10%	5%	3%	2%	1%	1%	1%

TABLE 30: Projected Average Rate of Sea-Level Rise (mm/year) for Los Angeles

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	5.9	3.8	-	8.4	11	16	25
Low emissions	2060 - 2080	4.5	2.3	-	7.3	11	21	
High emissions	2060 - 2080	8.7	5.5	-	13	17	27	42
Low emissions	2080 – 2100	4.1	1.1	-	8.0	13	27	
High emissions	2080 – 2100	9.7	5.1	-	15	21	37	54

TABLE 31: Projected Sea-Level Rise (in feet) for La Jolla

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.5	0.4	-	0.6	0.7	0.9	1.1
	2040	0.7	0.5	-	0.9	1.0	1.3	1.8
	2050	0.9	0.7	-	1.2	1.4	2.0	2.8
Low emissions	2060	1.0	0.7	-	1.3	1.7	2.5	
High emissions	2060	1.2	0.9	-	1.6	1.9	2.7	3.9
Low emissions	2070	1.2	0.9	-	1.6	2.0	3.1	
High emissions	2070	1.5	1.1	-	2.0	2.5	3.6	5.2
Low emissions	2080	1.4	1.0	-	1.9	2.4	4.0	
High emissions	2080	1.9	1.3	-	2.5	3.1	4.6	6.7
Low emissions	2090	1.6	1.0	-	2.2	2.9	4.8	
High emissions	2090	2.2	1.6	-	3.0	3.8	5.7	8.3
Low emissions	2100	1.7	1.1	-	2.5	3.3	5.8	
High emissions	2100	2.6	1.8	-	3.6	4.6	7.1	10.2
Low emissions	2110*	1.9	1.3	-	2.7	3.5	6.4	
High emissions	2110*	2.8	2.0	-	3.7	4.7	7.5	12.0
Low emissions	2120	2.0	1.3	-	3.0	4.1	7.6	
High emissions	2120	3.1	2.3	-	4.3	5.5	8.8	14.3
Low emissions	2130	2.2	1.4	-	3.2	4.5	8.6	
High emissions	2130	3.5	2.5	-	4.9	6.3	10.2	16.6
Low emissions	2140	2.4	1.5	-	3.6	5.1	9.7	
High emissions	2140	3.9	2.8	-	5.4	7.1	11.7	19.2
Low emissions	2150	2.5	1.5	-	3.9	5.7	11.1	
High emissions	2150	4.3	3.0	-	6.1	7.9	13.3	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 32: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in La Jolla

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

LA JOLLA - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	5.5%									
2050	40%	0.5%								
2060	74%	4%	0.3%	0.1%						
2070	89%	17%	1.5%	0.3%	0.1%					
2080	95%	41%	6%	1.1%	0.3%	0.1%	0.1%			
2090	97%	62%	17%	4%	1.0%	0.4%	0.2%	0.1%	0.1%	
2100	98%	75%	33%	10%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	97%	83%	58%	33%	17%	9%	5%	3%	2%

LA JOLLA - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	52%	1.7%	0.2%							
2070	70%	6%	0.7%	0.2%						
2080	80%	14%	2%	0.4%	0.2%	0.1%				
2090	85%	24%	4%	1.1%	0.4%	0.2%	0.1%	0.1%		
2100	88%	36%	8%	2%	0.9%	0.4%	0.2%	0.1%	0.1%	
2150	96%	68%	35%	16%	8%	4%	3%	2%	1%	1%

TABLE 33: Projected Average Rate of Sea-Level Rise (mm/year) for Los Jolla

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column). Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…	5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
High emissions	2030 – 2050	7.2	5.1 - 9.6	12	18	26
Low emissions	2060 - 2080	5.7	3.5 - 8.6	12	22	
High emissions	2060 - 2080	9.9	6.7 - 14	18	29	43
Low emissions	2080 – 2100	5.3	3.4 - 9.2	14	28	
High emissions	2080 – 2100	11	6.5 - 17	22	38	54

TABLE 34: Projected Sea-Level Rise (in feet) for San Diego

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds…	66% probability sea-level rise is between…			5% probability sea-level rise meets or exceeds…	0.5% probability sea-level rise meets or exceeds…	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030		0.4	-	0.6	0.7	0.9	1.1
	2040	0.7	0.5	-	0.9	1.0	1.3	1.8
	2050	0.9	0.7	-	1.2	1.4	2.0	2.8
Low emissions	2060	1.0	0.7	-	1.3	1.7	2.5	
High emissions	2060	1.2	0.9	-	1.6	1.9	2.7	3.9
Low emissions	2070	1.2	0.9	-	1.6	2.0	3.1	
High emissions	2070	1.5	1.1	-	2.0	2.5	3.6	5.2
Low emissions	2080	1.4	1.0	-	1.9	2.4	3.9	
High emissions	2080	1.9	1.3	-	2.5	3.1	4.6	6.7
Low emissions	2090	1.6	1.0	-	2.2	2.9	4.8	
High emissions	2090	2.2	1.6	-	3.0	3.7	5.7	8.3
Low emissions	2100	1.7	1.1	-	2.5	3.3	5.8	
High emissions	2100	2.6	1.8	-	3.6	4.5	7.0	10.2
Low emissions	2110*	1.9	1.3	-	2.7	3.5	6.4	
High emissions	2110*	2.8	2.0	-	3.7	4.7	7.5	12.0
Low emissions	2120	2.0	1.3	-	3.0	4.1	7.6	
High emissions	2120	3.1	2.3	-	4.3	5.5	8.8	14.3
Low emissions	2130	2.2	1.4	-	3.3	4.6	8.6	
High emissions	2130	3.5	2.6	-	4.9	6.3	10.2	16.6
Low emissions	2140	2.4	1.5	-	3.6	5.1	9.8	
High emissions	2140	3.9	2.8	-	5.4	7.1	11.7	19.2
Low emissions	2150	2.5	1.5	-	3.9	5.7	11.1	
High emissions	2150	4.3	3.0	-	6.1	7.9	13.3	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 35: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in San Diego

*Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050;. **the H++ scenario is not included in this table.***

SAN DIEGO - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	5.4%									
2050	40%	0.5%								
2060	74%	4%	0.3%	0.1%						
2070	89%	17%	1.5%	0.3%	0.1%					
2080	95%	41%	6%	1.1%	0.3%	0.1%	0.1%			
2090	97%	62%	17%	3%	1.0%	0.4%	0.2%	0.1%	0.1%	
2100	98%	76%	33%	10%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	97%	83%	58%	33%	17%	9%	5%	3%	2%

SAN DIEGO - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed… (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	52%	1.7%	0.2%							
2070	70%	5%	0.6%	0.2%						
2080	80%	14%	2%	0.4%	0.2%	0.1%				
2090	86%	24%	4%	1.1%	0.4%	0.2%	0.1%	0.1%		
2100	88%	36%	8%	2%	0.9%	0.4%	0.2%	0.1%	0.1%	
2150	96%	68%	35%	16%	8%	4%	3%	2%	1%	1%

TABLE 36: Projected Average Rate of Sea-Level Rise (mm/year) for San Diego

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...			5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
High emissions	2030 – 2050	7.2	5.1	-	9.6	12	17	26
Low emissions	2060 - 2080	5.7	3.5	-	8.6	12	22	
High emissions	2060 - 2080	9.9	6.7	-	14	18	29	43
Low emissions	2080 – 2100	5.4	2.4	-	9.2	14	28	
High emissions	2080 – 2100	11	6.5	-	17	22	38	54

APPENDIX 4:

Risk Decision Framework

(Adapted from the Governor's Office of Planning and Research's "Planning and Investing for a Resilient California: A Guidebook for State Agencies")

This framework serves to help planners and decision makers evaluate sea-level rise impacts across a range of projections to inform appropriate design, adaptation pathways, and contingency plans that build resilience.

RISK CONSIDERATIONS & EVALUATION	**Consequences of Impact or Disruption**	**LOW** *Minimum Disruption, Limited Scale and Scope*	**MEDIUM TO HIGH** *Inconvenience, but Limited in Scope and Scale*	**EXTREME** *Unacceptable Risk and/or Extensive Scale and Scope*
RISK CONSIDERATIONS & EVALUATION	**Adaptive Capacity**	• Future flexibility maintained • People or systems readily able to respond or adapt	• Limited future flexibility	• Irreversible • Threat to public health and safety
RISK CONSIDERATIONS & EVALUATION	**Who or What is Affected?**	• Low impact on communities, infrastructure, or natural systems	• Communities, systems, or infrastructure readily able to adapt or respond to change	• Vulnerable populations • Critical infrastructure • Critical natural systems • Areas of economic, historic, or cultural significance
RISK CONSIDERATIONS & EVALUATION	**Economic Impacts**	**LOW**	**MEDIUM**	**HIGH**
EMISSIONS SCENARIO EVALUATION	**Pre-2050**	**RCP 8.5** *(high emissions)*	**RCP 8.5** *(high emissions)*	**RCP 8.5** *(high emissions)*
EMISSIONS SCENARIO EVALUATION	**Post-2050**	**EVALUATE RCP 2.6 AND RCP 8.5** *(low emissions and high emissions)*		
SLR PROJECTIONS SELECTION		**LOW RISK AVERSION**	**MEDIUM-HIGH RISK AVERSION**	**EXTREME RISK AVERSION**

APPENDIX 5:

Questions from the Policy Advisory Committee to the OPC-SAT Working Group

THE QUESTIONS BELOW were developed by the Policy Advisory Committee to the OPC-SAT Working Group to elicit information about the current estimates of sea-level rise for the California coast and how to understand the scientific context around those estimates, including the state of the science (e.g., areas of uncertainty, emerging science), the importance of each contributor to sea-level rise, and sensitivity of the estimates to policy actions. Sections noted in parentheses reference locations in the Rising Seas Report where these questions were addressed.

Estimates of Sea-level Rise

1. What is the current range of estimates of sea level rise for the California coast? *(Section 3)*
    - **a.** What probabilities can be assigned to those estimates given the current state of science? *(Section 3.1)*
    - **b.** Should more weight be given to certain parts of the range, and if so, why? *(Section 3.2)*
2. Across the physically plausible range of sea-level rise projections, is it possible to say which scenario(s) are more likely than others? *(Section 3.1.2)*
    - **a.** What progress has been made since the existing State Sea-level Rise Guidance Document was published in 2013 on assigning probabilities to different emissions, warming and sea-level rise scenarios? *(Section 3.1.2)*
    - **b.** Which contributors to sea-level rise (e.g., thermal expansion, ice loss) are currently included in developing probabilistic sea-level rise scenarios? *(Section 3.1.2)*
    - **c.** What is the OPC-SAT Working Group's recommendation on how to estimate the likelihood of certain amounts of sea-level rise occurring at future dates for a given global emissions scenario? *(Section 3.1.2)*
    - **d.** What other approaches is the OPC-SAT Working Group aware of, or could the Working Group recommend, for presenting uncertain sea-level rise projections? *(Section 3.1.2)*
    - **e.** Is it possible to identify and characterize the degree of uncertainty in different contributors to sea-level rise? Where do the biggest uncertainties lie and what causes these uncertainties? *(Box 3)*

State of the Science

These questions are designed to elicit information on the state of sea-level rise science, including emerging issues and the treatment of ice loss in Antarctica.

3. What are the significant and notable emerging insights in sea-level rise science since the current State Sea-Level Rise Policy Guidance was issued? Why do they warrant attention? *(Section 2.2)*
    - **a.** Have there been any notable changes in understanding how thermal expansion of ocean water contributes to sea-level rise? *(Section 2.1.1 and Section 2.2)*
    - **b.** Have there been any notable changes in understanding of the role of ice loss from inland glaciers and major ice sheets? *(Section 2.1 and 2.2)*

   - **c.** Have there been any notable changes in understanding of steric or dynamic ocean current changes that affect regional sea-level rise projections? *(Section 3.1.2)*
   - **d.** Have there been any notable changes in understanding of local or regional land movement that could affect projections of relative sea level change? *(Section 2.2)*

4. Does the OPC-SAT Working Group consider the emerging science important and significant enough to warrant consideration in the current update to the State Sea-level Rise Guidance Document? If yes, why? If no, why? Please comment on the current confidence in new scientific insights or advances. *(Section 2.2, Section 3.1.1, Appendix 2)*

5. Existing models, including Kopp et al. (2014) and Cayan et al. (2016), project very different sea-level rise estimates under different emissions scenarios. However, some scientists suggest that sea levels in 2100 are determined by events in Antarctica, regardless of future GHG emission levels and trajectories. What is your scientific opinion about this issue? *(Section 2.1, Section 3.2)*

6. What are the scientific advances in best approaches to project sea-level rise since the publication of the existing State Sea-level Rise Guidance Document (2013)? What makes some modeling approaches better than others; in what way? *(Section 3.1)*

   - **a.** What are the strengths and weaknesses of the different approaches for projecting global sea-level rise? *(Section 3.1)*
   - **b.** Which approach or combination of approaches would the OPC-SAT Working Group recommend for estimating future global sea levels? *(Section 3.1.2)*

7. What are the best/most reliable approaches for translating global projections into regional projections? *(Section 3.1.2)*

8. What are the factors that cause sea-level rise projections to differ among locations? *(Section 2.1.2, Box 2)*

9. How are these factors considered in regional projections? *(Section 3.1.2)*

10. Is the OPC-SAT Working Group aware of additional research/modeling efforts, etc., presently underway that should inform the update to the State Sea-level Rise Guidance Document? *(Section 4.1)*

   - **a.** How soon does the OPC-SAT Working Group expect major breakthroughs in understanding of sea-level changes? What would constitute a major breakthrough? How might these breakthroughs affect sea-level rise projections? Given current uncertainties in scientific understanding, and the anticipated rate of accumulation of new knowledge or observations, can the Working Group provide a recommended frequency for reviewing the latest available science to update guidance for state and local decision-makers? *(Section 1.4, Section 4.1, Appendix 2)*
   - **b.** Similarly, can the Working Group provide recommendations, from a scientific perspective, on how this science could be considered in a policy setting (e.g., establishing an appropriate frequency for policy updates, establishing a scientific body to provide regular updates)? *(Section 1.4)*

Understanding the Contributors to Local Sea-Level Rise

11. In addition to projecting future sea levels, other factors may also be important.

   - **a.** What is the state of science on identifying future (a) tidal amplitude and/or phase, and (b) frequency and intensity of extreme events (e.g., high water due to storm surges, ENSO events)? *(Box 1)*

b. What are the pros and cons of different approaches of arriving at total water level? *(Box 4)*

c. What is the OPC-SAT Working Group's recommendation on how to integrate (global or regional) sea-level rise projections with expected changes in tidal and extreme events? *(Box 4)*

d. What is the OPC-SAT Working Group's assessment of the adequacy of superimposing historical extreme event departures from mean onto projected mean sea levels to estimate future values? *(Box 4)*

Policy Sensitivity of Sea-Level Rise Projections

12. How "policy dependent" are the different contributors to sea-level rise? *(Section 2.3)*

a. Are the different contributors to sea-level rise equally sensitive to changes in global emissions/temperature? *(Section 2.1)*

b. How much sea-level rise can be avoided or how much can it be slowed down by significant emission reductions (e.g., achieving the global commitments made at COP21 in Paris or 80% GHG emissions reductions by 2050)? *(Section 2.1, Section 3.2, and Section 3.3)*

c. What new implications for planning and decision making, if any, are introduced by including ice loss scenarios in sea-level rise projections (e.g., magnitude, timing, non-linear rates, nature of the impact)? *(Section 3.1.2. Appendix 2)*

13. Sea-level rise projections typically use emissions scenarios (e.g., IPCC emissions scenarios/ Representative Concentration Pathways (RCPs) as inputs into general circulation/sea-level rise models. The RCP 2.6 scenario (lowest IPCC emission scenario) appears out of reach, given current greenhouse gas emission trends, and the unlikely development of more ambitious emission reduction targets in the near future. Is there any physically plausible scenario under which it remains sensible to retain such low-end scenarios in the range of projections? If not, what is the lowest plausible sea-level rise scenario? *(Section 3.1.1)*

Sea-Level Rise Exposure vs. Risk-based Assessment

14. Risk (often defined as probability multiplied by consequence) is a critical input to planning and decision-making.?

a. What is the OPC-SAT Working Group's recommendation on whether and, if so, how to incorporate consideration of risk as part of the State Sea-level Rise Guidance Document to state and local decision-makers? *(Section 1.3, Section 4.2)*

b. How would this approach take account of the uncertainties in sea-level rise projections? *(Section 4.2, Box 3)*

15. What other questions should we be asking that we haven't asked? What other considerations should be brought to bear on this topic?

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