



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

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

SEA LEVEL RISE ADAPTATION PLANNING AND ENVIRONMENTAL JUSTICE

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

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

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

Protection Council’s [State Sea Level Rise Guidance](#) recommends prioritizing social equity, environmental justice, and the needs of vulnerable communities in adaptation planning.

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

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

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

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

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

The Coastal Act’s broad concern for all the people is highlighted in its public access policies, which require the maximum provision and protection of the public’s rights of access to and along the shoreline (Sections 30210-30214). These policies reflect the judgement of the people of California in passing Proposition 20 in 1972 that public access and recreation along our coast

is a fundamental environmental benefit to be protected for and enjoyed by all, not just by those with the good fortune or means to live along the shoreline. Public access to the coast is important to the health and well-being of the public, and promoting public access for all citizens provides low-cost, outdoor recreation that can improve the overall quality of life of the public, including low-income and underserved communities, no matter whether they live near or far from the coast.

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

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

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

California increase due to climate change. The utility of coastal areas as a respite from inland urban heat islands is especially important for environmental justice communities who often reside in these high heat areas (Hoffman *et al.*, 2020).

Relatedly, the Commission’s prior authority to require affordable housing in the coastal zone was stripped in the early 1980s. The lack of extensive affordable and low-cost overnight accommodations on the coast disproportionately affects low-income communities from accessing the coast.³² And many of the remaining lower-cost rental units and homes in coastal areas that are threatened by sea level rise could potentially displace communities, further exacerbating California’s housing crisis. Compounding this challenge, these populations are less likely to be able to take proactive steps to adapt to sea level rise due to resource constraints and procedural inequities. This loss affects not only those directly displaced but also contributes to broader community destabilization, such as limiting access to affordable living near coastal habitats.

The environmental justice movement is inclusive of tribal and indigenous communities due to their disproportionate exposure to environmental burdens, lack of access to environmental benefits, and overall systemic oppression. However, it is imperative to recognize both the overlap and distinct challenges that tribal communities face in relation to sea level rise. Tribal communities will be uniquely impacted and vulnerable to sea level rise. Many tribes hold a historical and cultural connection to specific regions and locations. The loss of coastal habitats like beaches, dunes, and wetlands signifies more than an environmental catastrophe for these communities — it is a loss of access to cultural and ancestral lands, eroding ties to heritage and traditional practices essential to their identity and way of life. For more information on the challenges and consequences that tribal communities face in relation to sea level rise in California, see the section below, “Sea Level Rise Consequences Unique to Tribal Communities”.

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

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

³² The topic of housing inequities within the coastal zone is further examined in a 2022 Commission staff report, [“Historical Roots of Housing Inequity and Impacts on Coastal Zone Demographic Patterns.”](#)

this Guidance to avoid and mitigate the potential impacts to coastal resources from hazard responses. This is particularly true for recommendations to consider alternatives to shoreline armoring and, where armoring must be approved, for recommendations to fully mitigate the impacts of such structures on coastal resources.

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

The potential impacts of adaptation responses on public shoreline resources, and thus the potential environmental justice impacts of such actions, will need to be considered for all resources protected under the Coastal Act. It is also true that due to current development patterns along the coast, sea level rise hazards may affect various sections of the population differently, as could the implementation and effectiveness of various adaptation measures. The number of people living along the open coast in areas exposed to flooding from a 100-year flood would increase to 210,000 with a 4.6 ft (1.4 m) increase in sea level; approximately 27% or 56,000 of these are lower income people (those earning less than \$30,000 annually); 45,000 are renters; and 4,700 are linguistically isolated and less likely to understand flood warnings (Heberger *et al.* 2009). According to Heberger *et al.* (2009), the greatest increases in the number of people vulnerable to flooding will occur in Los Angeles, San Diego, Ventura, Humboldt, and San Luis Obispo counties. Sea level rise will likely result in the loss of key infrastructure, intrusion of saltwater into water sources, and the creation of additional coastal hazards. Hazards in vulnerable areas will have disproportionate impacts on communities with the least capacity to adapt, which could deepen and expand existing environmental injustices if adaptation responses are not managed appropriately.

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

consider the potential impacts of hazard mitigation actions to protect development that may only benefit a few, on the public access and shoreline resources that are available for all Californians to enjoy.

Meaningful Engagement and Environmental Justice

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

Meaningful engagement recognizes the historic exclusion of community input and attempts to uplift community voices and perspectives. Meaningful engagement is the intentional outreach, inclusion, and consideration of the voices and perspectives from presently and historically underserved and marginalized communities in the design, development, implementation, and policies that may impact the health, environment, and livelihood of their communities. It is essential to environmental justice and relies on communicating directly with potentially impacted communities and providing an opportunity for their input to inform decision outcomes (EPA, 2024). Essentially, meaningful engagement is the foundation upon which all subsequent policy and decision making depends. When engaging with communities, it is imperative to remind ourselves that members of the public are partners and collaborators, not a “checked box” for outreach. There is ongoing concern that community consultations can feel like a procedural step, with predetermined outcomes already in place. To counter this, it is essential that engagement is coupled with genuine opportunities for communities to influence project decisions.

Further, many communities, including environmental justice and tribal communities, have experienced land dispossession, displacement, discrimination, and other forms of state-sanctioned violence; therefore, trust, especially as government representatives, must be earned. It is important to recognize that trust will not always be easily granted, but it is our duty to try our best as decision-makers. Adopting outreach practices such as early notification, avoiding overpromising, and timeliness are just a few examples of how trust can be built over time. Additionally, coordinating with trusted community partners, such as local environmental justice and/or community-based organizations can help bolster outreach and engagement efforts.

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

SEA LEVEL RISE CONSEQUENCES UNIQUE TO TRIBAL COMMUNITIES

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

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

The persistence of tribal communities highlights an unwavering ability to adapt to a variety of changes. Historically, indigenous peoples depended on a wide variety of natural resources for food, water, medicine, ceremonies, and shelter. Coastal tribal communities, in particular, harnessed their deep ancestral and traditional ecological knowledge of the land to adapt to tidal fluctuations, saltwater intrusion, and other coastal stressors (Lynn *et al.*, 2021; Leonard, 2021). For example, the Yurok and Chumash tribes continue to employ methods like sustainable fishing, gathering, and land stewardship, which have been honed over centuries and are increasingly seen as models for climate resilience (USGS, 2015). The resurgence of these practices is not only a means of survival but also a reaffirmation of cultural identity and sovereignty. It will be important to increase opportunities for tribes to help manage these areas using traditional ecological knowledge that enhances biodiversity and promotes sustainability.

However, tribal communities are uniquely vulnerable to climate change stressors because of their connection to, and reliance on, the environment, including through traditional fishing, hunting, and gathering practices. In the Tribal Leaders Summit on Climate Change report, the Yurok Tribe of the Yurok Reservation located in northern California along the Klamath River highlighted their main concern in relation to climate change as hydrologic impacts to surface waters and aquatic resources on which they depend for sustenance (Black *et al.*, 2015). Sea level rise threatens coastal tribal resources, including coastal access, recreation, and sustenance. Sea level rise also endangers coastal tribal cultural resources such as traditional dwellings, ancestral sites, and sacred places, and poses a significant threat to adjacent ecosystems, local water quality, traditional food systems, and harvesting practices. Although indigenous stewardship has been shown to mitigate climate impacts, including those caused by sea level rise, past sea level rise adaptation planning efforts carried out by local and state governments have not sufficiently included the interests of tribal communities (Harvard Ash Center, 2022).

The Commission acknowledges tribal sovereignty and understands that California's tribes and their members have long served as stewards of the state's important coastal resources, and possess unique and valuable knowledge and practices for conserving and managing these resources in a sustainable manner, and in a manner consistent with the spirit and intent of the Coastal Act. In 2018, after multiple public hearings and extensive coordination with California Native American Tribes and other interested groups, the Coastal Commission adopted its [Tribal Consultation Policy](#). This document sets out procedures for consultation and meaningful engagement between Commission staff and tribes, provides for the designation of agency tribal liaisons, and requires consideration of tribal cultural resources (not just archaeological resources) in planning and permitting decisions. While there are complexities surrounding the distinction between federally and state-recognized tribes, the Commission's Tribal Consultation Policy applies to both groups, and directs Commission staff to communicate with and engage tribes at the earliest possible stage in the review and decision-making process. Throughout this process, respect for tribal interests is essential, ensuring that tribes have a meaningful role in decisions affecting their cultural resources. Local governments are encouraged to consult the Tribal Consultation Policy and work with Commission staff for assistance with conducting outreach with tribal communities regarding Local Coastal Programs and Coastal Development

Permits that have a sea level rise component. Addressing tribal interests in sea level rise adaptation planning will help prioritize the significance of these vulnerable sacred sites to tribal communities.

CONSEQUENCES OF SEA LEVEL RISE FOR COASTAL ACT RESOURCES

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

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

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



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

- **Ports (Coastal Act Sections 30703 – 30708):** Sea level rise could cause a variety of impacts to ports, including flooding and inundation of port infrastructure and damage to piers and marina facilities from wave action and higher water levels. A possible benefit could be a decreased need for dredging. But, unless facilities have already included accommodations for larger ships than they currently service, higher water levels could increase the difficulty for cargo handling facilities due to the higher vessel position (CCC 2001; CNRA 2014). Increased water heights could reduce bridge clearance, reducing the size of ships that can access ports or restricting movement of ships to low tides, and potentially increasing throughput times for cargo delivered to ports. Heberger *et al.* (2009) found that significant flooding from sea level rise is possible at the Ports of Los Angeles and Long Beach, a finding also reflected in each Port’s AB 691 Sea Level Rise Assessment (State Lands Commission, 2022). Given that these two ports handle 45-50% of the containers shipped into the United States, and 77% of goods that leave the state, sea level rise could affect the efficiency of goods movement, and have serious economic implications for California and the nation (Heberger *et al.* 2009). These hazards emphasize the need to upgrade port infrastructure to withstand sea level rise, which should include upgrades to address environmental justice concerns such as reducing air pollution and improving water quality to protect nearby communities from adverse health impacts.
- **Industrial development, refineries, and petrochemical facilities (Coastal Act Sections 30260-30266.5):** Sea level rise could reduce areas available for siting or expansion of industrial development. Inundation of contaminated lands near industrial development could negatively impact water quality and result in polluted runoff. Sea level rise could lead to an increase in flooding damage of refineries or petrochemical facilities, and impacts from sea level rise could be an issue when locating or expanding refineries or petrochemical facilities, or when mitigating any adverse environmental effects. Notably, the University of

California, Berkeley's [Toxic Tides Project](#) found that over 400 hazardous sites in coastal areas that are at risk of flooding and inundation are also located near environmental justice communities. Facilities that store hazardous waste, such as those associated with industrial development, may experience a decreased ability to contain these materials with sea level rise, thereby exposing surrounding populations and structures to detrimental health hazards or forcing temporary or permanent relocation of these communities if these materials are particularly harmful.

- **Construction altering natural shorelines (Coastal Act Section 30235):** Sea level rise may lead to an increase in demand for construction of shoreline protection for existing development, public access, and coastal-dependent uses in danger of erosion. Shoreline protection devices alter natural shorelines and also generally have negative impacts on beaches, near-shore marine habitat, and scenic and visual qualities of coastal areas.
- **Public access and recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221):** One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding, or erosion of beaches, recreational areas, or trails. As sea levels rise, many areas along the coast that are developed with infrastructure and/or shoreline protective devices will impede the natural inland migration of the shoreline, resulting in a “coastal squeeze,” or the narrowing and eventual loss of the fronting beach, wetland, or other valuable habitat as well as public accessways. “Coastal squeeze” may have far-reaching effects on California’s economy and quality of life (Lester and Matella, 2016). The loss of public coastal spaces due to sea level rise will impact not only coastal communities, but also inland communities that rely on the coast for recreation and a respite from higher inland temperatures. Access to, and functionality of, water-oriented activities may also be affected. For instance, by increasing water levels and altering sediment patterns, sea level rise could lead to a change in surfing conditions. If water becomes deeper over known surf spots, only larger waves would be able to break at the same location, and smaller waves would break in shallower water, likely altering the surfing opportunities (Reineman *et al.*, 2017; Sadrpour and Reineman, 2023). Likewise, sea level rise could affect the safety of harbors and marinas (Kornell 2012).
- **Coastal habitats (Coastal Act Sections 30230, 30231, 30233, 30240):** Coastal habitat areas likely to be affected by sea level rise include bluffs and cliffs, rocky intertidal areas, beaches, dunes, wetlands, estuaries, lagoons and tidal marshes, tidal flats, eelgrass beds, and tidally-influenced streams and rivers. Importantly, there are many endemic and endangered species in California that are dependent on these coastal environments. For example, grunion need a sandy beach environment in order to reproduce and survive, the California clapper rail is dependent on marshes and wetlands, and the black abalone requires rocky intertidal habitat. Nesting habitat,

nursery areas, and haul-out sites important for birds, fish, marine mammals and other animals could also disappear as sea levels rise (Funayama *et al.* 2012).

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

- **Beaches, dunes, and intertidal areas:** Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Sea level rise will cause landward migration of beaches over the long term, and could lead to a rapid increase in the retreat rate of dunes. Beaches with seawalls or other barriers will not be able to migrate landward and the sandy beach areas will gradually become inundated (NRC 2012). For example, without changes in coastal management, 30 to 67% of Southern California beaches may be completely lost due to rising sea level (Vitousek *et al.* 2017). A case study from Santa Barbara County found a tipping point at just 0.25 meters of sea level rise at which over 50% of beaches and wetland habitat would be lost (Barnard *et al.*, 2019). A loss of beach and dune areas will have significant consequences for beach and adjacent inland ecosystems. Beaches and dunes provide critical habitat for species and act as buffers to interior agricultural lands and habitat during storms (CNRA 2009).
- **Wetlands:** Sea level rise will lead to wetland habitat conversion and loss as the intertidal zone shifts inland. Of particular concern is the loss of saltwater marshes from sea level rise, which have already decreased by about 90% from their historical levels in California (CNRA 2010). California's 550 square miles (885 km) of critical coastal wetland habitat (Heberger *et al.* 2009, including wetlands in San Francisco Bay) could be converted to open water by 4.6 ft (1.4 m) rise of sea level if they are not able accrete upward or to migrate inland due to natural or anthropogenic barriers. Although barriers are plentiful, inland migration of these wetlands is possible for over 50% of the potentially inundated wetland area based on land use compatibility alone (Heberger *et al.* 2009). Consideration of adequate sediment supply and additional barriers to inland migration would further constrain wetland migration potential. A 4.6 ft (1.4 m) increase in sea level would flood 150 square miles (241 km) of land immediately adjacent to wetlands, which could become future wetlands if that land remains undeveloped. Loss or reduction of wetland habitat would impact many plant and animal species, including migratory birds that depend on these habitats as part of the Pacific Flyway. Species that are salt-tolerant may have an advantage as sea level rise occurs and exposes new areas to salt water, while species that have narrow salinity and temperature tolerances may have difficulty adapting to changing conditions.
- **Biological productivity of coastal waters (Coastal Act Sections 30230, 30231):** Sea level rise could affect biological productivity of coastal waters by changing the types of habitats that are available. This change could alter species composition, and could potentially result in cascading effects through the coastal food chain. Changes in water

quality can have differing impacts on biological productivity. For instance, decreased water quality due to increased nutrient pollution has been found to increase biological productivity at the base of the food chain to undesirable levels, and has been linked to harmful algal blooms which result in hypoxic conditions for other marine species (Kudela *et al.* 2010; Ryan *et al.* 2010; Caldwell *et al.* 2013). Furthermore, adverse impacts to biological productivity can result in the loss of subsistence fishing opportunities, which presents a significant challenge to communities that depend on these resources. This not only impacts the economic stability of these communities but could also erode cultural traditions tied to fishing practices.

- **Water quality (Coastal Act Section 30231):** Sea level rise could lead to declines in coastal water quality in several ways. First, coastal water quality could be degraded due to mobilization of contaminants in shallow soils from both overland inundation and rising groundwater as well as due to an increase in nonpoint source pollution from flooding. In particular, the presence of facilities or land containing hazardous materials in coastal areas susceptible to flooding or permanent inundation presents toxic exposure risks for people and ecosystems (Hill *et al.*, 2023). Sea level rise can push contaminated groundwater upwards, potentially introducing volatile organic compounds (VOCs) into communities situated in proximity to polluted sites. As established earlier, low-income households and people of color are most vulnerable due to the discriminatory siting of hazardous facilities in environmental justice communities or the tendency to place new low-income housing projects near degraded lands and contaminated sites. Second, rising seas could impact wastewater facility infrastructure and other methods and structures designed to protect water quality near the coast. In addition to damaging equipment and blocking discharge from coastal outfall structures, floods could force facilities to release untreated wastewater, threatening nearby water quality (Heberger *et al.* 2009). Saltwater draining into sewer lines as part of extreme weather flooding might also damage biological systems at wastewater facilities if the organisms present in these systems are not salt-tolerant. Third, sea level rise could lead to saltwater intrusion into valuable groundwater aquifers, potentially rendering some existing wells unusable and decreasing the total groundwater supply in coastal areas. The extent of saltwater intrusion will likely vary based upon local hydrogeological conditions, with the worst impacts occurring in unconfined aquifers along low-lying coastal areas that have already experienced overdraft and saline intrusion. This change could force affected communities to turn to more costly water sources such as surface water transfers or desalination, which can exacerbate burdens to low-income communities. Finally, loss of wetlands could decrease water quality given that wetlands act to improve water quality by slowing and filtering water that flows through them. Coordination with the State and Regional Water Boards, the Department of Toxic Substances Control, and other agencies with water quality management roles will be critical for addressing these risks.
- **Coastal agriculture (Coastal Act Sections 30241- 30243):** Sea level rise could lead to an increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and a decrease in the amount of freshwater available

for agricultural uses. Flooding of agricultural lands can cause major impacts on local businesses, national food supplies, and the state's economy. This may result in displacement of farmworkers through loss of wages, health coverage, and housing, which may exacerbate the burdens they already experience.

- **Archaeological and paleontological resources (Coastal Act Section 30244):** Archaeological, tribal cultural, or paleontological resources could be put at risk by inundation, flooding, or by an increase in erosion due to sea level rise. Areas of traditional cultural significance to California Native American tribes, including villages, religious and ceremonial locations, middens, burial sites, and other areas, could be at risk from sea level rise. For example, the Santa Barbara Channel area has thousands of archaeological sites dating over 13,000 years that are at risk of being destroyed or altered from small amounts of sea level rise (Reeder *et al.*, 2010).

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

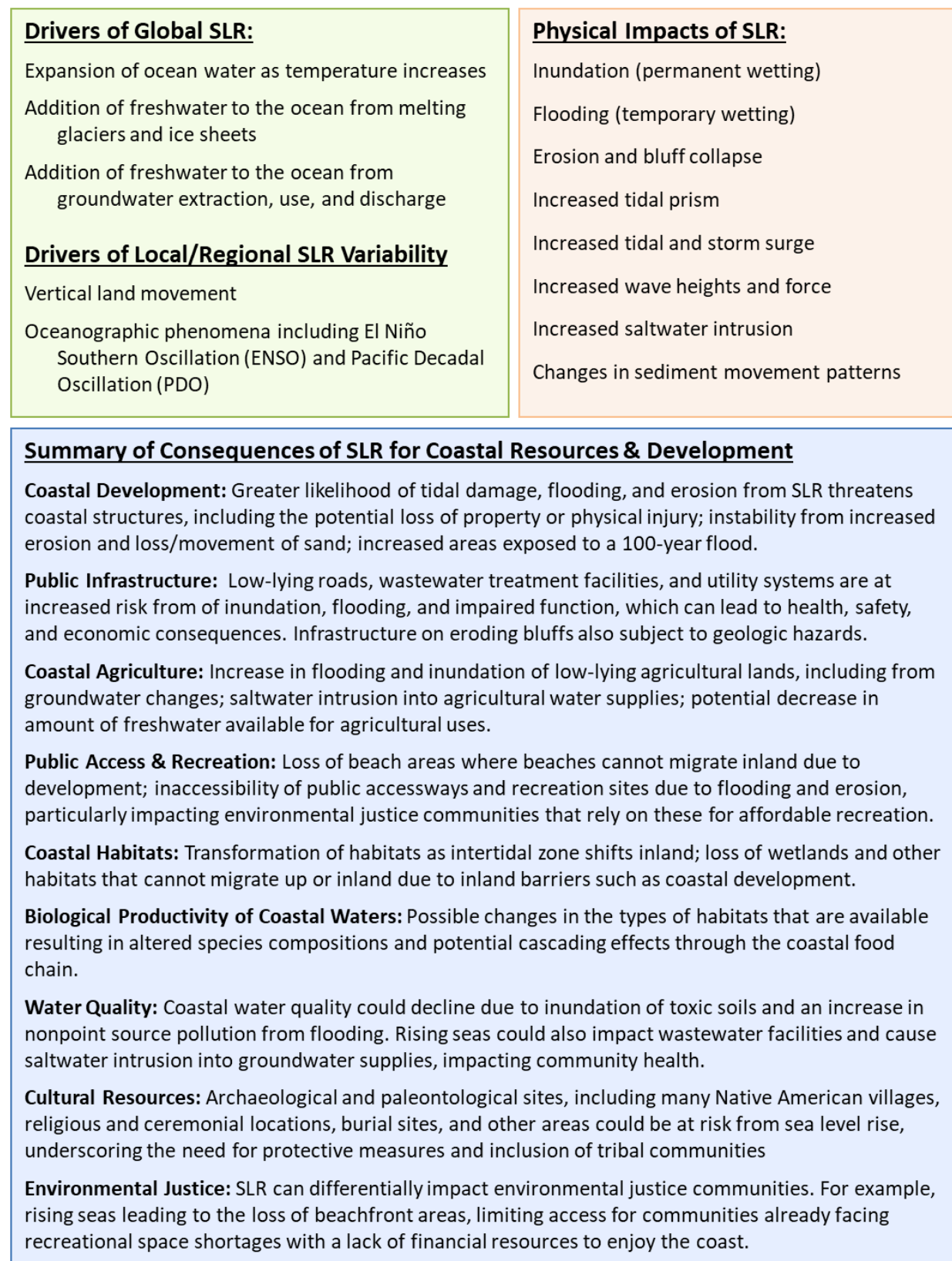


Figure 10. Summary of sea level rise impacts and consequences