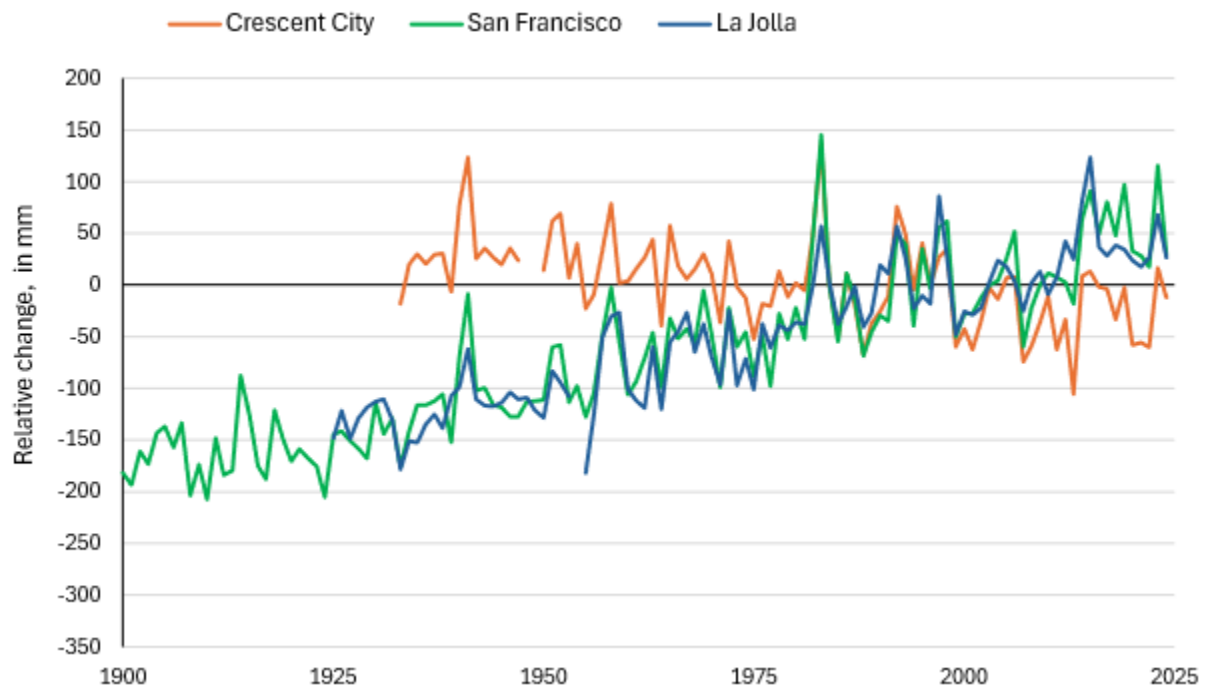


3.4 Sea Level Rise

Sea levels along most of California's coast have risen over the past century, except in the far north where tectonic uplift has caused a small relative drop in sea level. Driven by warming oceans and melting land ice, sea level rise amplifies flooding, coastal erosion, and storm impacts, threatening public safety, infrastructure, ecosystems, and cultural resources.

Figure 3.4.1. Annual Mean Sea Level (millimeters) from 1900-2025 for the California Coast.



The graph shows the relative change in sea level relative to the land surface for three California coastal locations. Source: NOAA (2026)

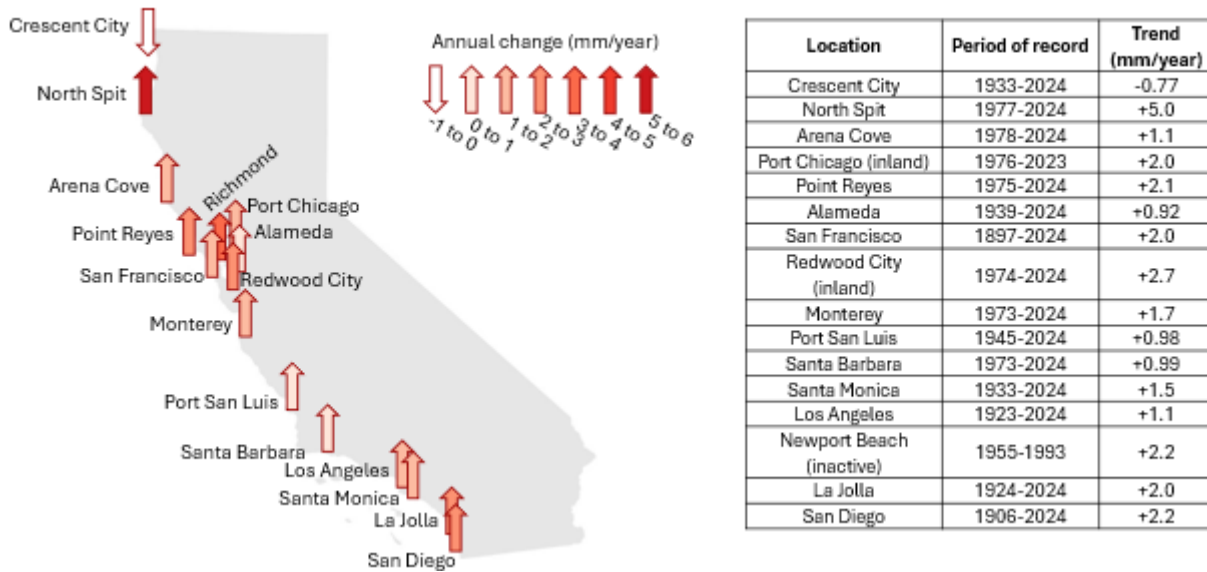


What does the indicator show?

Sea levels are rising along much of California's coastline, with significant year-to-year (interannual) variability. **Figure 3.4.1** shows changes in relative sea levels measured at NOAA tide gauges along California's coast. Relative (local) sea levels reflect both changes in absolute sea level and vertical land motion (how fast the coast is sinking or rising). Trends at 16 tide stations in California are presented from north to south (NOAA, 2026). As illustrated in **Figure 3.4.2**, a negative trend (as shown by the downward arrow in the figure) indicates the land is rising faster than the ocean at that location. Trends close to zero indicate that the land is rising at essentially the same rate as the ocean although there are other factors at play also (such as ocean dynamics and gravitational effects) that affect regional sea level rise in addition to vertical land motion. For most of the state's coastline, local sea level rise rates (shown by upward arrows in **Figure 3.4.2**) over the period of record range from approximately 1 millimeter per year (mm/year) to nearly 3 mm/year. Relative sea levels are rising the fastest at Eureka's North Spit (5.0 mm/year), Redwood City (2.7 mm/year), and San Diego (2.2 mm/year). The high rates are due in part to land subsidence, which is the sinking of land caused by a combination of tectonics, sediment compaction, and groundwater withdrawal and subsequent subsidence. Relative sea levels have declined at Crescent City since records began in 1933, due to regional land uplift driven by the movement of the Earth's tectonic plates.



Figure 3.4.2. Annual Mean Sea Level Trends for California.



The map shows annual mean sea level trends at selected stations along the California coast. Records span different time periods depending on data availability, with observations extending from 1897 to 2024. Source: NOAA (2026)

The trend towards higher sea levels in California is consistent with global observations (IPCC, 2023; Griggs et al., 2017). Global (absolute) sea level rise is accelerating — the current rate is triple the 20th century rate (OPC, 2024a). In the last 100 years, average sea levels off California's coast rose by up to 6-8 inches, comparable to global trends. By 2050, average statewide sea levels are expected to rise another 0.5 feet (ft) to 1.2 ft relative to 2000 levels. By 2100, the midpoint of sea level rise projections is 3.1 ft, but higher amounts are possible. The range of plausible sea level rise becomes increasingly large towards 2100 and beyond due to uncertainties associated with physical processes that drive sea level, such as ice sheet loss from Greenland and Antarctica. Sea levels may rise by 2.6 ft to 11.9 ft by 2150, and even higher amounts cannot be ruled out (OPC, 2024a).



Why is this indicator important?

Understanding relative (local) sea level rise is important to recognizing how low-lying coastal communities and ecosystems will be affected by flooding, habitat loss, and damage to infrastructure (Blackwell et al., 2020). Millions of residents, infrastructure, housing, natural resources, and economies along California's coast face serious and costly threats from rising sea levels (OPC, 2024a).

Rising sea levels coincide with more frequent and extreme storms, which are drowning beaches, eroding bluffs, flooding homes and businesses, and damaging roads and other essential public infrastructure (OPC, 2024a; see the *Coastal Flooding* chapter). As sea level rise continues to accelerate throughout this century and beyond, coastal flooding, beach erosion, bluff retreat, loss of ecosystems, salinization of soils, shallower groundwater, and impeded drainage will further increase along low-lying coasts worldwide without adequate adaptation efforts (IPCC, 2019). Coastal erosion (**Figure 3.4.3**) poses an increasing threat to public safety, infrastructure, and property (Vitousek et al., 2017; Limber et al., 2018; USGS, 2019), while **Figure 3.4.4** shows what the impacts of coastal floods and storms can look like. And although tsunamis are rare in California, rising sea levels are expected to gradually increase their destructive potential in the long term, with near term impacts dependent on coastal water levels (e.g., tides) at the time of tsunami arrival (Dura et al., 2021; Griggs, 2024; Sepúlveda and Mosqueda, 2025).



Figure 3.4.3. Coastal Cliff Erosion Hazards and Impacts.

A) Isla Vista



B) Capitola



C) Big Sur coast



D) Pacifica



A) Cliff retreat threatening coastal homes in Isla Vista. B) Cliff failure on Depot Hill in Capitola along the northern Monterey Bay coastline. C) The Mud Creek Slide along the Big Sur coast closed State Highway One for months. D) The weak bluff materials in Pacifica have continued to erode during major storm events in recent years, and these three apartment buildings were eventually demolished. Source: Patrick Barnard (photo top left) and Gary Griggs

Nearly 50% of California's beaches could disappear under a 1-meter sea level rise scenario (Vitousek et al., 2023). In Southern California, 31 to 67% of beaches are predicted to become completely eroded by 2100 (Vitousek et al., 2017). The magnitude of beach loss varies regionally, with the greatest projected losses occurring along Southern and Central California, where narrow beaches, coastal armoring, and limited



sediment supply constrain landward migration. Northern California beaches are generally wider and less armored, which may allow for greater persistence under some sea level rise scenarios (Vitousek et al., 2017 and 2023). Sea level rise and coastal flooding also threaten beach and dune species such as the western snowy plover and other shorebirds that nest in low-lying coastal areas. Many of the state's tidal wetlands are also projected to be nearly or entirely lost by the end of the century under moderate to high sea level rise scenarios. Subtidal habitats like California's giant kelp forests (*Macrocystis pyrifera*) and seagrass beds—critical for species including the endangered Southern sea otter (*Enhydra lutris nereis*) and red abalone (*Haliotis rufescens*)—are expected to be affected as sea level rise alters water depth, light availability, and wave energy, potentially forcing communities to shift shoreward or experience localized losses, rather than disappear entirely. In addition, small changes in flooding, inundation, salinity, temperature, and other abiotic factors can trigger abrupt change in structure and function. For example, storm events can have substantial impacts on kelp, seagrass, and macroalgal communities, from changes in the relative abundance of species within a community to total habitat loss. The combined stress of increasing sea levels and other climate-driven disturbances threaten the sustainability of aquatic and terrestrial plant species and benthic and fish communities (Thorne et al., 2024).

Higher sea levels can also contribute to rising groundwater tables, increasing saltwater intrusion into freshwater aquifers, increasing corrosion of underground infrastructure, undermine structural foundations, mobilizing subsurface contaminants, and leading to surface pooling of water. These effects are most pronounced in low-lying coastal and deltaic regions, where elevated ocean levels reduce groundwater drainage to the coast and increase hydraulic pressure inland. In particular, the Sacramento-San Joaquin Delta that supplies fresh water to two-thirds of the state's population and millions of acres of farmland is particularly vulnerable to groundwater aquifer saltwater intrusion due to its low elevation, extensive levee system, and strong surface water–groundwater connectivity. The extent of intrusion varies by location and sea level rise scenario making it difficult to define a single intrusion boundary statewide (OPC, 2024a).



Figure 3.4.4. Storm and flood damage in Santa Cruz in January 2023.



Damage to a public roadway and pedestrian path (left) and flooding of a coastal road (right) due to the simultaneous arrival of very large waves and high tides. Source: Gary Griggs

Tribal Connection 3.4.1

The Wiyot Tribe lives around Humboldt Bay or *Wigi* and nearby coastal and upland areas. They are experiencing a loss of spiritual, archaeological, and biological cultural sites as sea level rises. They write: *“Inundation of cultural sites such as Tuluwat [Island] is a major concern of the Tribe for the next century. Located in the center of Wigi, Tuluwat is the center of the universe for the Wiyot people. Since time immemorial, the Wiyot people have served as stewards of Tuluwat, performing an annual World Renewal Ceremony to bring balance to the land and its people. Tuluwat is home to sacred village and gathering sites, as well as a historic shell midden. [...]. Sea level rise and larger storm surges contribute to gradual beach loss and acute scarping, or the erosion of front dunes by waves. These processes are destroying the habitat of bulb species that the Wiyot Tribe depends on, such as various Indian potatoes (*Brodiaea* and *Dichelostemma congestum*), native lilies (*Fritillaria affinis*), and more.”* (Wiyot Tribe, 2026).



Coastal erosion and sea level rise, along with warming ocean temperatures and ocean acidification, collectively threaten cultural sites and resources along the shoreline for the Amah Mutsun and Chumash Tribes. Coastal erosion has damaged cultural sites, and as sea levels rise, sites previously used for gathering are no longer accessible (SCTLS, 2021; see Amah Mutsun and Santa Ynez Chumash Tribal reports). For example, traditional areas for the Chumash Tribe to gather Olivella shells (**Figure 3.4.5**), used in shell money, jewelry, and regalia, are often no longer accessible. Without access to traditional sites, knowledge can be disrupted, and the weight of that loss is felt by generations of tribal members (PBMI and SYBCI, 2021).

Figure 3.4.5. Olivella Shells Carved by the Chumash.



Source: Science News (2021)

Multiple efforts across California are underway to plan for, prepare for, and adapt to rising sea levels to protect coastal ecosystems, infrastructure and communities (OPC, 2024b). Nature-based solutions such as wetland restoration can help attenuate the impacts of waves and storm surges and provide additional ecological benefits including habitat creation and enhancement, carbon sequestration, improved water quality, and increased biodiversity (Nederhoff et al., 2025; Taylor-Burns et al., 2025). To support local adaptation strategies, online coastal flooding hazard maps using data by the scientific and research community in California may be accessed at: [CalAdapt](#), [Our Coast Our Future](#), [Hazard Exposure and Reporting Analytics \(HERA\)](#), and [CoSMoS](#). These maps include predicted flooding for the San Francisco Bay and California coast resulting from storm events for different sea level rise scenarios.



What factors influence this indicator?

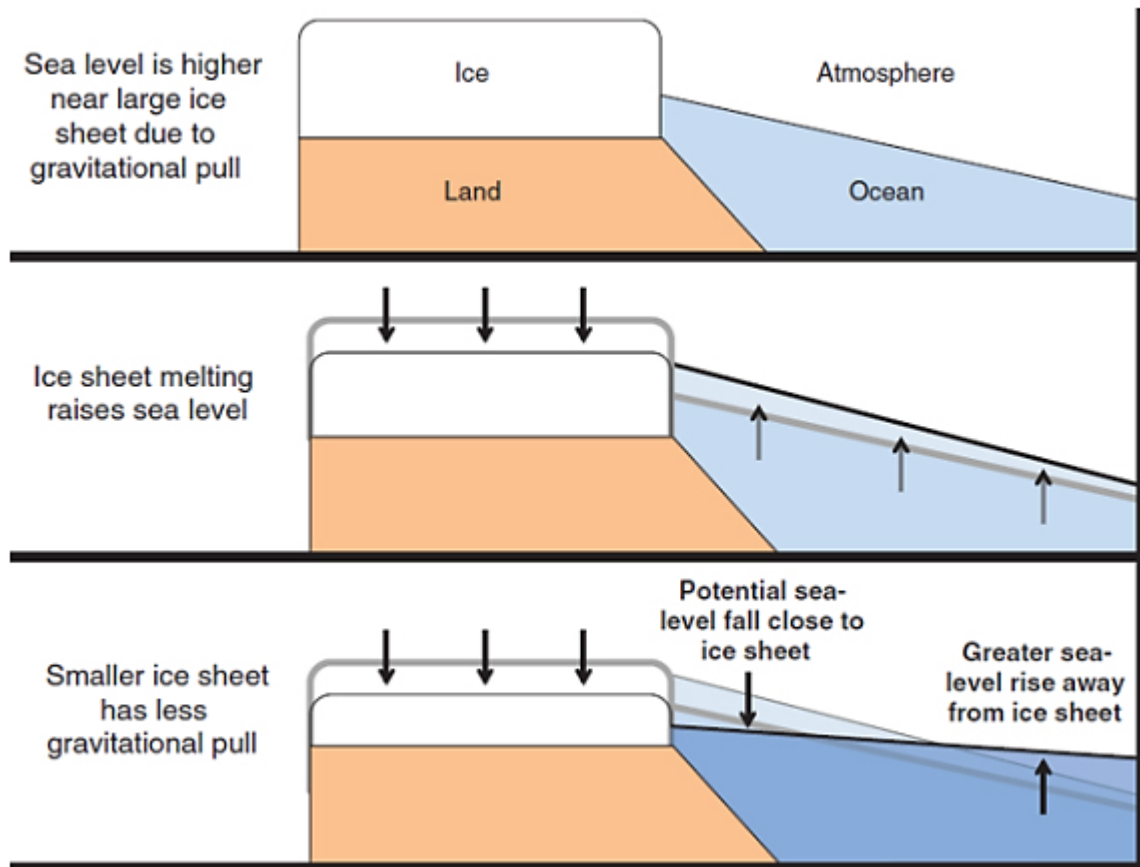
The main contributors to sea level rise on a global scale are thermal expansion of ocean water as it continues to warm and the input of freshwater from melting ice sheets and glaciers. The warming oceans and melting ice are both consequences of our warming climate — human influence on the climate has likely been the main driver of global sea level rise since at least 1971 (IPCC, 2023). Relative sea level rise (the rise of the ocean relative to land) at any specific location is driven by a combination of these global processes plus steric sea level change (combined effect of changes in temperature, salinity, winds, and currents), ice-mass loss, and vertical land motion. Episodically, the local sea level is modulated by processes that produce higher-than-normal coastal water levels, such as storm surges, wave runup, and extreme (King) tides. Factors affecting sea level rise along California’s coast are described in further detail below.

Melting of glaciers and ice sheets

Water from melting mountain glaciers and ice sheets is the main source of global mean sea level rise today (IPCC, 2019; Slater et al., 2020). The ice sheets in Greenland and Antarctica, while not expected to melt completely even on millennial time scales, contain enough ice to raise the global mean sea level by 24 feet and 187 feet, respectively. Observations show that ice mass loss from these ice sheets has accelerated substantially over recent decades, with loss rates increasing by a factor of two to three since the 1990s, driven by rising air and ocean temperatures (Griggs et al., 2017). Additionally, as an ice sheet loses mass to the ocean, its gravitational pull on the surrounding ocean is reduced. The reduced gravitational pull on the ocean causes sea levels near the ice sheet to fall, but farther away (including off the coast of California), relative sea levels will rise (**Figure 3.4.6**; OPC, 2024a).



Figure 3.4.6. Gravitational Effects of Ice Sheet Melting.



The visual shows how sea level is higher than the global average near large ice sheets due to gravitational pull. When the ice melts, global sea level rises. The reduced gravitational pull from the smaller ice sheet causes sea level near the ice to fall and rise farther away. Source: NAS (2013)

Heat-driven expansion

As the ocean warms, seawater expands, contributing to rising sea levels (IPCC, 2019). This heat-driven expansion, also known as the steric effect, was the single greatest contributor to global mean sea level rise over the past century, accounting for approximately half of the observed sea level rise (Griggs, et al., 2017). The ocean has absorbed more than 90% of the excess energy associated with anthropogenic greenhouse gas emissions, resulting in sustained ocean warming and continued sea level rise.



Sterodynamic sea level change

Sterodynamic sea level change refers to the combined effect of steric (temperature and salinity) changes and changes in ocean dynamics (winds and currents). Temperature and salinity are expected to be the primary drivers of sterodynamic sea level rise along the California coast, with ocean circulation and wind patterns influencing regional variability (OPC, 2024a). Globally, sterodynamic processes account for a substantial fraction of observed sea level rise—on the order of one-third to one-half over the 20th century—although the relative contribution varies by region and over time (IPCC, 2019; OPC, 2024a).

Land subsidence and upliftTribal Connection 3.4.2

Less than 100 miles south of Crescent City, where relative sea level is dropping, is Humboldt Bay, where relative sea level is rising the fastest. This juxtaposition of greatest drop and greatest rise is due to the tectonic plate phenomenon known as the Triple Junction. The Wiyot Tribe live in some of the lowest lying areas most vulnerable to sea level change. They write, “*Relative sea level is rising 2–3 times faster in the southern portion of Wigi [Humboldt Bay] than anywhere else on the California coast. Analysis of temporary tide gages around Wigi suggests that the rate is as high as 6.2 millimeters per year around Hookton Slough in the southern part of Wigi near Table Bluff Reservation [of the Wiyot Tribe] (Anderson, 2018; Patton et al., 2023). [...] The Tribe has experienced an increasing number of high tide flood events over the past 40 years.*” (Wiyot Tribe, 2026).

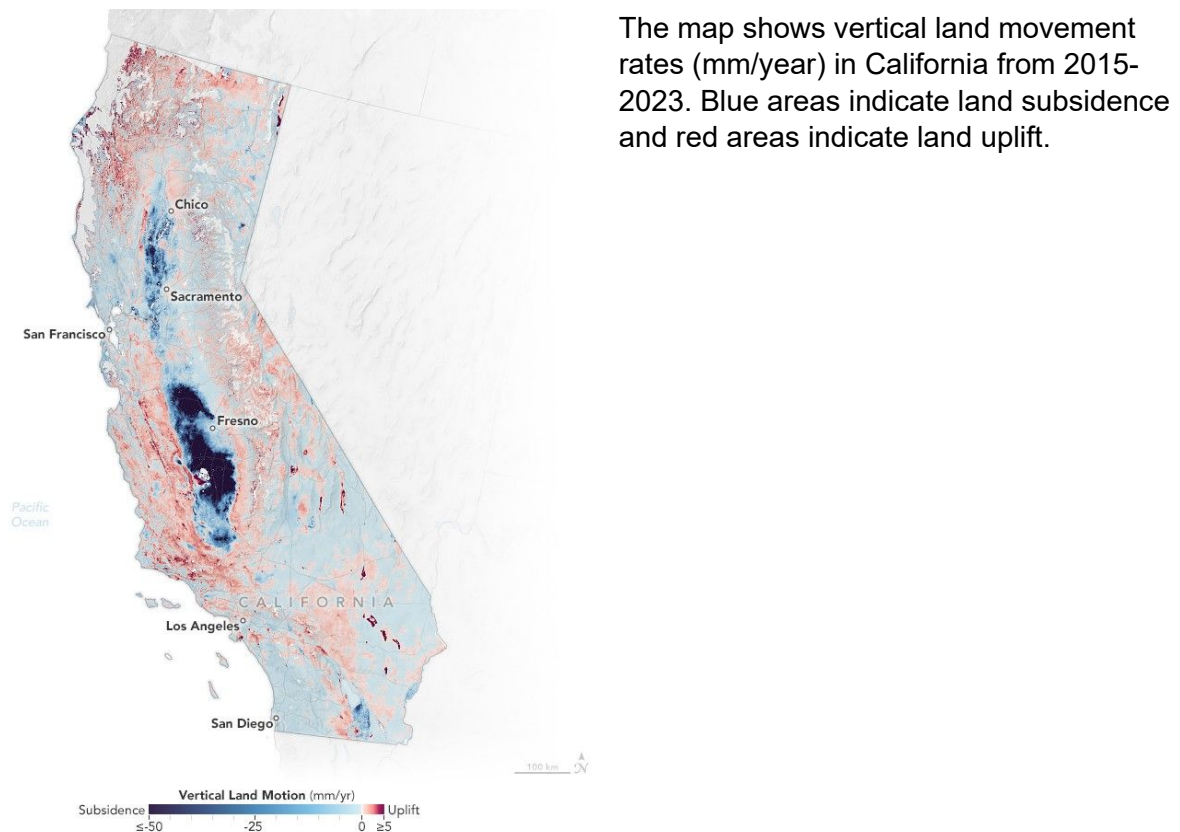
Vertical land motion is the primary driver of local variations in sea level rise along the state’s coastline. As previously mentioned, vertical land motion is due to a combination of tectonics, sediment compaction, and groundwater withdrawal and subsequent subsidence (OPC, 2024a). Groundwater pumping and other fluid withdrawals from the subsurface, as well as sediment compaction, can lead to high rates of local subsidence, as in the California Bay-Delta, and along the San Francisco Bay shoreline. Much of California’s coast is subsiding due to regional changes in land levels (Blackwell et al., 2020). A radar study of an approximately 100 kilometer (km) wide swath of land along



California's coast during the years 2007-2018 estimated that between 4.3 million and 8.7 million people in California's coastal communities live on areas of subsiding land (**Figure 3.4.7**; Blackwell et al., 2020).

Many of the islands in the California Bay-Delta have dropped below sea level. Drainage to allow for farming has resulted in extensive subsidence, as well as exposed the Delta's organic soils to microbial activity that converts much of the soil matter into carbon dioxide and nitrous oxide – both of which are greenhouse gases that contribute to climate change (Delta Stewardship Council, 2025; NASA, 2017). Conversely, plate tectonics can cause land uplift along the coast to outpace relative sea level rise, as is happening in Crescent City in northern California, where NOAA's records show a drop in relative sea level over time. The far north coast is the only area along California where the sea level is dropping relative to the land surface (Russell and Griggs, 2012).

Figure 3.4.7. Land Subsidence Along the Coast of California.



Source: NASA (2025)



Groundwater pumping

Groundwater that is pumped for agriculture, industry, and domestic use transfers more water to the ocean, thereby contributing to sea level rise along the California coast (Griggs, et al., 2017). In addition, groundwater extraction can cause the drawdown of aquifers to cause subsurface compaction (land sinking), accelerating local or relative sea level rise. In California, this effect is most pronounced in heavily pumped regions, including the Sacramento–San Joaquin Delta, San Francisco Bay shoreline, and parts of Southern California, where subsidence rates of several millimeters per year have been observed and can locally exceed rates of global mean sea level rise (Blackwell et al., 2020; Griggs et al., 2017).

Technical considerations

Data characteristics

Sea level measurements came from federally operated tide gages located along the California coast which are managed by the National Water Level Observation Network, within NOAA, as well as from satellite altimetry operated by NASA. Data are available online at [NOAA's Tides and Currents webpage](#) and [NASA's sea level webpage](#).

Tide stations measure sea level relative to specific locations on land where the gauges are mounted. Short-term changes in sea level (e.g., monthly mean sea level or yearly mean sea level) are determined relative to a location's Mean Sea Level, the arithmetic mean of hourly heights observed over a specific 19-year period called the “National Tidal Datum Epoch” (NTDE) established by NOAA's National Ocean Service. The NTDE accounts for the effect of the 18.6-year lunar nodal cycle on variations in the tidal range. The current NTDE is 1983-2001 (previous NTDEs were for the periods 1924-1942, 1941-1959, and 1960-1978); NTDEs are updated about every 20 years (NOAA, 2000; Szabados, 2008). This epoch is now undergoing revision and will be replaced by the fifth iteration of the NTDE, spanning the years 2002-2020. The proposed release date for new NTDE products is after 2027.

The U.S. federal government began collecting sea level measurements in the mid-19th century to support accurate navigation and marine boundary determinations. Data from these early observation efforts, along with continued monitoring, are used to assess



long-term changes in sea level at multiple locations in California. Monitoring efforts have expanded over the years to include more locations with tidal stations, allowing for analysis of sea level trends at more regions, although for shorter time scales (NOAA, 2006).

Strengths and limitations of the data

Monthly mean sea levels along the California Coast tend to be highest in the fall when the ocean temperatures are warmest and lowest in the spring, when the waters are coolest, with seasonal differences of approximately 6 inches (15 centimeters (cm)). Local warming or cooling driven by offshore shifts in water masses and changes in wind-driven coastal circulation patterns also seasonally alter the average sea level by 8.4 inches (21 cm; Flick, 1998). For day-to-day activities, the tidal range and elevations of the high and low tides are often far more important than the elevation of mean sea level.

As noted above, vertical land motion complicates regional estimates of sea level rise. Much of the California coast is experiencing elevation changes due to tectonic activity and glacial isostatic adjustment. Mean sea level is measured at tide gauges with respect to a tide gauge benchmark on land, which traditionally was assumed to be stable. This only allows local changes to be observed relative to that benchmark. Additional data from global positioning systems (GPS) are useful to record vertical land movement at the tide gauge benchmark sites to correct for tectonic activity. Satellite altimetry has been used since the 1990s to track sea level rise at the global scale with uniform coverage and provide an additional check on sea level rise rates derived from tide gauges alone (Abdalla et al., 2021; NOAA, 2020).



OEHHA acknowledges the expert contribution of the following to this report:



Patrick Barnard, Ph.D.
Research Director
Center for Coastal Climate Resilience
UC Santa Cruz
pbarnard1@ucsc.edu



Gary Griggs, Ph.D.
Distinguished Professor of Earth and Planetary Sciences
Institute of Marine Sciences
UC Santa Cruz
griggs@ucsc.edu



Reviewers:

Ella McDougall, M.A.
Senior Coastal Resilience Program Manager
California Ocean Protection Council
Ella.McDougall@resources.ca.gov

Paige Thionnet
California Ocean Protection Council

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