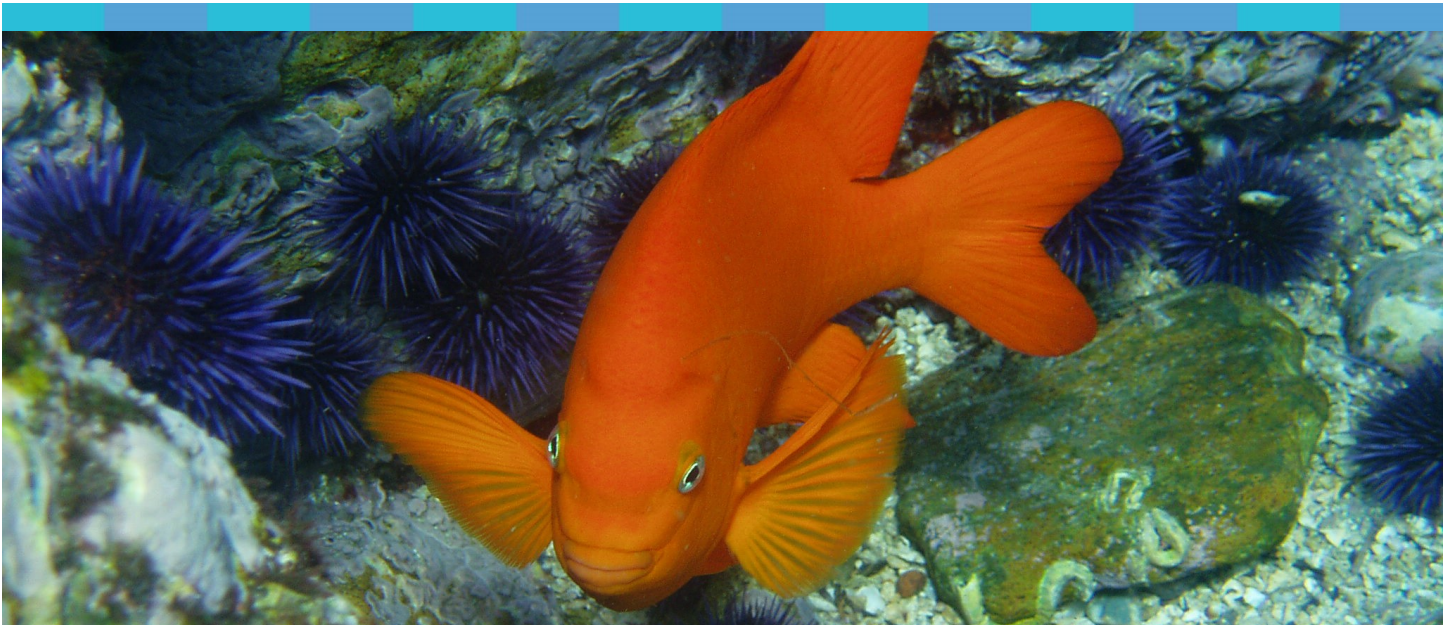


Climate Change Impacts Channel Islands National Marine Sanctuary

May 2020



Garibaldi, the state marine fish of California, is just one of the great diversity of species supported by the sanctuary *Photo: Claire Fackler/NOAA*

Our Changing Ocean

The impacts of [climate change](#) are intensifying both globally and locally, threatening America's physical, social, economic, and environmental [well-being](#)¹. [National marine sanctuaries and marine national monuments](#) must contend with [rising water temperatures](#) and [sea levels](#), water that is [more acidic](#) and [contains less oxygen](#), [shifting species](#), and [altered weather patterns and storms](#)¹. While all of our sanctuaries and national monuments must face these global effects of climate change, each is affected differently.

Channel Islands National Marine Sanctuary

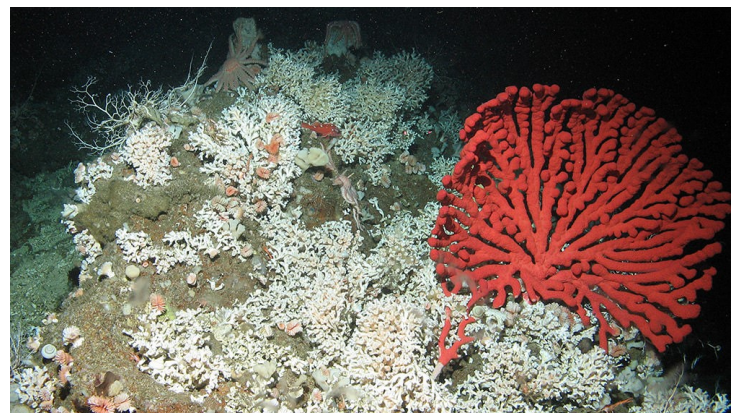
[Channel Islands National Marine Sanctuary](#) protects 1,470 square miles of ocean around five of southern California's Channel Islands, surrounding and partially overlapping Channel Islands National Park. Established in 1980, the sanctuary protects vibrant ecosystems from kelp forests to deep sea coral gardens. These waters provide habitat for ecologically, economically, and culturally important species like market squid and rock crab, while hosting a number of endangered species from abalone to whales. The sanctuary supports a variety of recreational uses, supports prime commercial fishing grounds, and is a place of important cultural heritage, protecting over 150 historic shipwrecks and containing waters of immeasurable value to the Chumash people.



Ocean Acidification

About [30%](#) of the carbon dioxide (CO₂) released into the atmosphere by humans is absorbed by the ocean,² causing a chemical reaction that leads to ocean waters becoming [more acidic](#). Globally, the ocean has become 30% more acidic since the beginning of the industrial revolution.^{3,4} In many areas of California, acidification is exacerbated by [upwelling](#). Cool, nutrient-rich upwelled water fertilizes the region's ecosystems but is more acidic than surface waters. Due in part to the influence of upwelling, which is expected to increase in intensity in the coming century,^{5,6} the acidity of California's waters has increased by up to 60% since 1895 and will continue to rise.^{7,8}

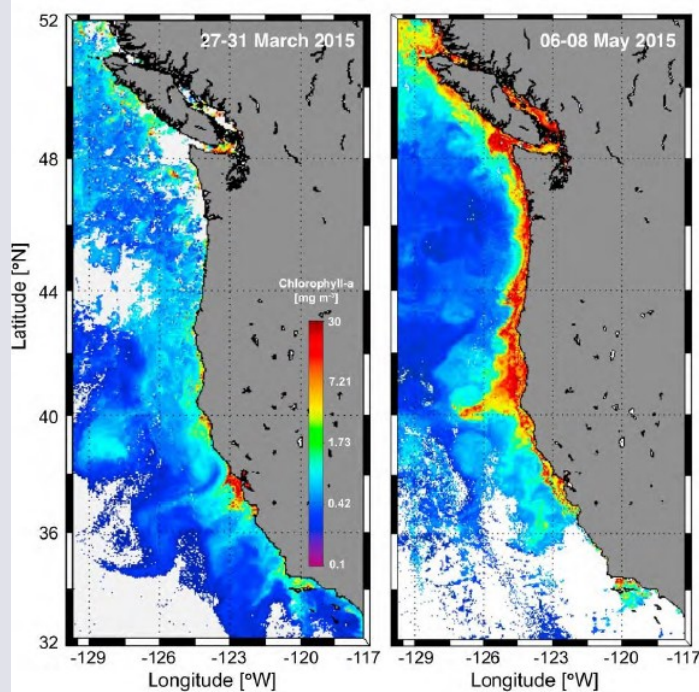
Increasingly acidic waters make it difficult for organisms like rock crab and [deep water coral](#) to make and maintain stony skeletons and shells. Deep water corals, which provide important habitat for many



Deep sea coral communities in the sanctuary are threatened by ocean acidification. *Photo: NOAA*



Case Study 1—Harmful Algal Blooms



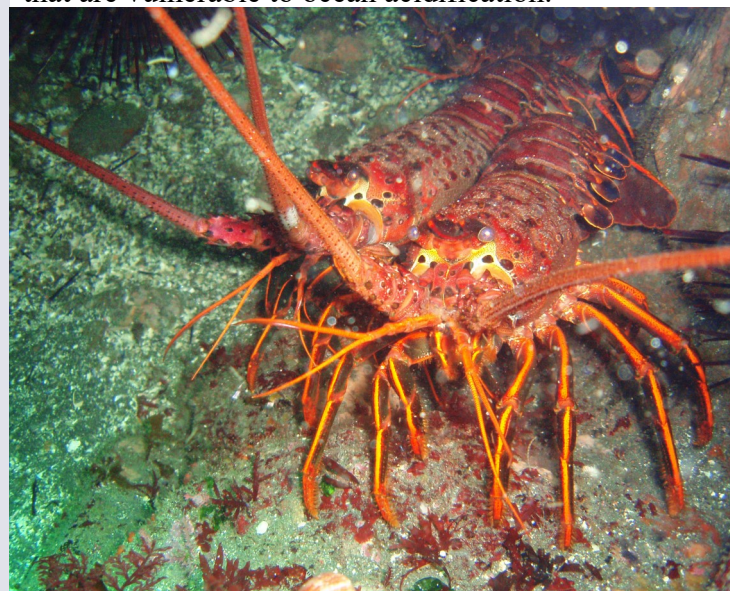
Chlorophyll levels, a measure of algae growth, along the U.S. west coast before (left) and during (right) the 2015 harmful algal bloom. Photo: ONMS 2019,²⁷ adapted from McCabe et al. 2016.²²

Harmful algal blooms (HABs) produce toxins that can harm animals and humans. These toxins are produced by **phytoplankton** that are eaten by zooplankton and small fish, which are in turn prey for larger animals. In this way, toxins work their way up the food web and can sicken or kill animals and poison seafood. In recent decades, HABs on the west coast of North America have been responsible for **mass mortalities** of seabirds,²² whales,²²⁻²⁴ and other marine mammals,^{22,24,25} as well as closures and delays of valuable fisheries such as Dungeness crab and rock crab.^{22,26,27} Climate change is altering the frequency and intensity of these natural disasters along the entire west coast. The Santa Barbara Channel has been a known hot spot for HABs since 1998.²⁷ Increasing water and air temperatures create conditions that may favor larger, longer lasting HABs,^{28,29} and ocean acidification may cause phytoplankton to produce more toxins, leading to blooms that are more toxic.³⁰ Further, projected increases in storm intensity and extreme rainfall events could lead to increases in coastal runoff events that introduce **large loads of nutrients** into the ocean, sustaining blooms and potentially increasing their toxicity.^{31,32} As climate change progresses, HABs are likely to increase in size, intensity, and frequency with widespread potential impacts for the ecology and economy of the west coast.

species,⁹ are particularly vulnerable as deeper habitats are naturally more acidic than surface waters.⁹ The low oxygen and high acidity conditions of the sanctuary's deep waters are at the edge of suitable conditions for some corals to grow and survive.^{9,10} Some areas are already acidic enough to slow coral growth and cause their skeletons to dissolve.⁹

Acidification also affects other species. Increasing acidity could reduce breeding habitat for **market squid**¹¹ while increasing stress and decreasing larval survival in rockfish and other species.¹²⁻¹⁶ The prey of fish, seabirds, and marine mammals may also be impacted.¹⁷⁻¹⁹ More acidic waters could affect zooplankton with consequences for the entire food web from corals and rock crabs to seabirds and whales. For example, past decreases in zooplankton have reduced the number of fish in the sanctuary.²⁰

Preliminary research suggests that the northern shores of the northern Channel Islands may **provide some partial refuge** from acidification because they experience high-acidity conditions less frequently.²¹ The east-west orientation of the coast in this area and shallower depths of the Santa Barbara Channel reduce local upwelling compared to elsewhere in California.²¹ As water upwelled north of Point Conception flows south, it becomes less acidic while bathing the islands with nutrients, allowing them to receive the benefits of upwelling without as much increased acidity.²¹ Therefore, some portions of the sanctuary experience relatively lower acidity within a rapidly acidifying region, and may provide a local refuge to organisms that are vulnerable to ocean acidification.²¹



Spiny lobsters are vulnerable to ocean acidification but may find refuge within the sanctuary. Photo: Claire Fackler/NOAA



Case Study 2—Kelp Forests and Climate Change



Blue and olive rockfish are some of the more than 1,000 species found in Channel Island kelp forests. Photo: Yasmeen Smalley/NPS

The vibrant [kelp forests](#) of the sanctuary are home to [over 1,000](#) ecologically, economically, and culturally important species including sheephead, spiny lobster, and abalone. Kelp forests also act as “[blue carbon](#)” ecosystems. As kelp grows, it stores carbon in its structures and as pieces break off, they can float up to 150 miles offshore.³³ Tens of thousands of tons of kelp is transported through [offshore canyons](#) to the deep sea each year, where it can be buried for millennia.^{34,35} Globally, kelp and other [macroalgae](#) could sequester up to 200 million tons of carbon annually,³⁴ 13% more than the annual emissions of Los Angeles.³⁶

Warming waters can reduce kelp survival and reproduction,^{37,38} and kelp can be removed by the strong waves and currents associated with [El Niño](#) and extreme weather events,³⁷ which are both projected to increase in frequency and intensity.³⁹ Kelp can also be impacted by ecological changes that may be triggered by climate change, like sea urchin population booms.⁴⁰

Despite these threats, when compared to kelp elsewhere in California, the kelp forests of the Channel Islands appear more resilient to climate change. The reproduction of kelp in the sanctuary is more resilient to high temperatures³⁸ and while kelp forests in the sanctuary did show some die-off during the [warm water anomalies](#) of 2013-2016, they regrew more quickly and more completely than those to the north and south.³⁷ The ability of Channel Islands kelp to better survive, recover from, and reproduce in high temperatures could increase the adaptation of kelp throughout California through the spread of resilient kelp from the sanctuary.³⁸ Given their apparent resilience to climate change, kelp forests in the sanctuary are an important habitat not only for the ecology and economy of the region, but for mitigating the impacts of climate change on the California coast.



The vibrant kelp forests of the Channel Islands are particularly resilient to climate change. Photo: Robert Schwemmer/NOAA



Increasing Water Temperatures

Average ocean temperature is [rising world-wide](#).¹ Water temperatures in the sanctuary increased slightly over the past century,^{1,41} and could warm up to 7°F by 2100.⁴² In addition to rising average temperatures, warm water anomalies are expected to increase in frequency and intensity.⁴³

Rising temperatures and warm water anomalies can cause mortality events of intertidal species, and could create conditions that are too warm for some [deep water corals](#).⁴⁴ Higher temperatures are also expected to lead to more frequent and intense [HABS](#),^{26,29} and have caused changes in nutrients and zooplankton that alter the food web.⁴⁵⁻⁴⁸ Warmer waters also hold [less oxygen](#). Oxygen in California marine waters has decreased 20% since 1980^{49,50} and may fall below the range of natural variability by 2030.^{1,51} Lower oxygen could decrease rockfish habitat in the sanctuary by 50%,¹² reduce breeding habitat for [market squid](#),¹¹ and impact deep water corals.⁵²

Warming waters also encourage species to move north or deeper to cooler waters.⁵³ Southern species, like Humboldt squid and brown booby, could become more common in the sanctuary while others, like market squid, may become less abundant.^{34,42,54} These shifts are particularly relevant to the sanctuary as the confluence of warm and cool currents results in the western islands hosting a community of cool water species while the eastern islands host warm water species.^{55,56} The transition point between these communities is sensitive to changes in temperature. In the 1970s, warming waters caused a change in the marine community of Santa Cruz Island along with a decrease in the number of fish due to reduced zooplankton prey.²⁰ A similar shift towards a warm water community occurred during the [2013-2016 warm water anomalies](#).⁵⁷ Such changes to ecological communities are expected to continue as waters warm.⁵⁷



The sanctuary protects a great diversity of life, much of which could be affected by climate change. Species IDs (top to bottom): Black and yellow rockfish, Spanish shawl nudibranch, blue whales. Photo: Claire Fackler/NOAA; Claire Fackler/NOAA; Jessica Merten/NOAA



Changing Oceanographic Processes

Globally, climate change is altering large scale oceanographic processes such as ocean currents, atmospheric circulation, and [El Niño](#).^{39,58,59} These changes can have direct impacts on the sanctuary.

Oceanic currents are of particular importance to the Channel Islands ecosystem. The interaction of the warm Davidson Current and cool California Current creates a high-diversity ecological transition in the sanctuary.^{55,56} While it is uncertain if climate change will alter these currents, changes could have impacts on sanctuary ecosystems.

During El Niño events, the region of the sanctuary experiences large waves, wet conditions, reduced

upwelling, and warmer water.^{60,61} These effects could intensify in the future as the frequency and intensity of El Niño events are expected to increase.³⁹ Climate change is also projected to cause increases in the winds that drive [upwelling](#).⁶ Overall, despite periodic decreases during El Niño, this is expected to increase the frequency and intensity of upwelling in the coming century, which could exacerbate the impacts of ocean acidification.^{5,6}

Changes to atmospheric circulation also affect the sanctuary. In 2013, an area of unusually high pressure south of the Gulf of Alaska led to the formation of a coast-wide [marine heatwave](#).^{62,63} In the sanctuary, this led to the 2013-2016 warm water event with ocean temperatures up to 11°F above normal,⁶⁴ causing many species, like market squid, to move northward,^{45,46,54} fueling a large [HAB](#),⁴⁶ and reducing zooplankton prey.^{45,46}



The diverse ecological communities of the sanctuary could be impacted by changes to ocean currents. *Photo: NOAA*

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Rising Ocean Waters

Numerous factors contribute to [rising global sea levels](#) including melting glaciers and [thermal expansion](#) of seawater. Factors such as currents and [changing land height](#) cause sea level to rise at different rates in different locations.^{1,65} Along the mainland shoreline in the region of the sanctuary, sea level has been rising at about 1.2 inches per decade⁶⁶ and could rise another 2 feet in the next 50 years.⁶⁷

Although it's unclear how this projection will affect the Channel Islands, sea level rise could drown

beaches and rocky intertidal habitats. This could inundate critical nesting, pupping, and haul-out habitat for mammals, such as [northern elephant seals](#) and [California sea lions](#), and sea birds like the [western snowy plover](#).⁶⁸ However, the lack of development on the islands will likely allow many of these habitats to move up shore. Rising sea level also reduces intertidal habitat for mussels, oysters, and other intertidal species by exposing them to more predation from oceanic predators at the same time that warming air temperatures limit their ability to move higher in the intertidal zone. Further, deeper waters could “drown” [eelgrass](#) meadows, by reducing available light, shrinking this ecologically important habitat that [sequesters carbon](#).⁶⁹ Rising waters could also increase [coastal erosion](#) in combination with projected increases in storm and wave intensity.^{70,71}



The habitats of many species in the sanctuary, such as northern elephant seals, could be degraded by sea level rise. *Photo: Robert Schwemmer/NOAA*

What is Being Done?

To gain a better understanding of how conditions are changing, NOAA scientists track climate indicators such as water temperature and acidity. They have also developed indicators to track changes in ecological communities, such as monitoring of deep sea corals. Sanctuary staff have also established and enhanced partnerships with other researchers at NOAA, the University of California Santa Barbara, the U.S. National Park Service, and others to research and address the impacts of climate change in the region. Detecting, assessing, and tracking the impacts of climate change was also a clear theme throughout the sanctuary's [2016 Condition Report](#). Building on that report, in 2020 NOAA staff began developing an [updated sanctuary management plan](#). As supported by the condition report, public comments, and advisory council input, the new plan is expected to include a climate change action plan.

Recognizing the importance of sharing this important information, NOAA has also developed a regional educational website that teachers can use to help students gain a better understanding of ocean acidification. Through this website, teacher workshops, volunteer trainings, and outreach demonstrations, NOAA is increasing public understanding and awareness of the impacts of climate change.



Teacher workshops are an integral part of the sanctuary's climate change outreach and education activities. Photo: Laura Francis/NOAA

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