Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

Climate Change Impacts

Papahānaumokuākea Marine National Monument

May 2020

The coral reefs of Papahānaumokuākea provide homes for thousands of species, many found nowhere else on Earth. *Photo: Mark Sullivan/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.

Papahānaumokuākea Marine National Monument

Papahānaumokuākea Marine National Monument is the largest protected area in the U.S., encompassing 582,578 square miles of the Pacific Ocean around the Northwestern Hawaiian Islands. Created by presidential proclamation on June 15, 2006, and expanded in 2016, the monument includes islands, atolls, reefs, and seamounts that provide critical habitat for thousands of species including Hawaiian monk seals, sea turtles, and over 20 species of cetaceans. It is also the world's largest tropical seabird rookery hosting over 5.5 million breeding birds including the endangered short-tailed albatross and four land birds found only in the monument. The monument is administered jointly by four co-trustees – the U.S. Department of Commerce, the U.S. Department of the Interior, the State of Hawai'i, and the Office of Hawaiian Affairs.

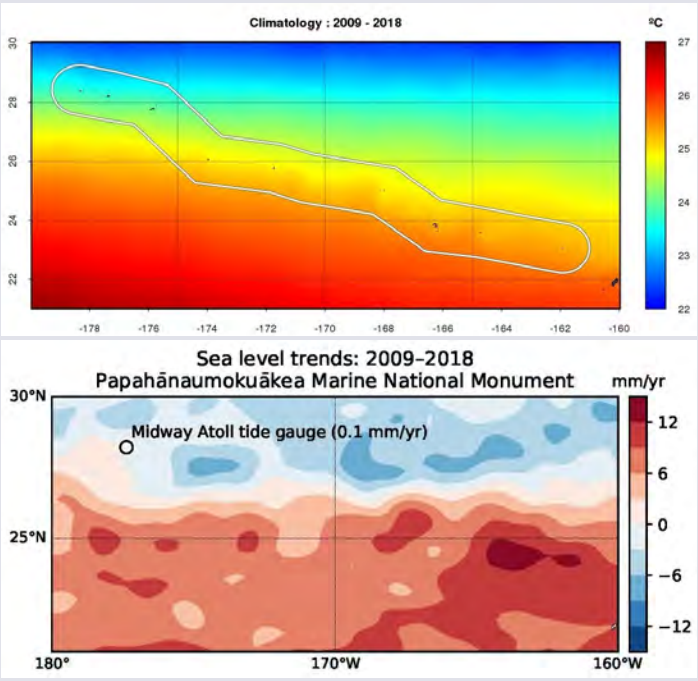
Rising Water Temperatures

As global temperatures rise, the ocean absorbs much of the heat. The average ocean temperature is rising worldwide,[1] and recent water temperatures in the region of Papahānaumokuākea are the highest on record.[1] In fact, the average water temperature in the monument is expected to increase by as much as 5°F by 2100.[2,3]

Extreme temperature events have also increased in frequency and intensity in past decades and are projected to continue to do so in the coming century.[1] When combined with increased average temperatures, ocean heat waves can cause corals to become stressed and expel the algae that provides their food. This phenomenon is known as "bleaching" since corals appear white due to the loss of algae and can lead to coral death. There were eight known mass bleaching

The Laysan duck is one of the endemic species of Papahānaumokuākea threatened by climate change. *Photo: Matthew Saunter/Hawai'i DLNR*

Case Study 1—Climate Variability in PMNM



Average sea surface temperature in the monument (outline) over a 10 year period (top) and the 10 year sea level trend in the region of the monument (bottom). *Photo: (top) Phillip Thompson/UH Sea Level Center using trends calculated from the UHSLC fast-delivery database and Ssalto/Duacs altimeter products produce and distributed by the E.U. Copernicus Marine and Environmental Monitoring Service (CMEMS); (bottom) Melanie Abecassis/NOAA*

While climate change is a global phenomenon, its impacts on the ocean can vary regionally or locally due to physical, chemical, or even gravitational factors. Papahānaumokuākea, which stretches across more than six degrees latitude and 16 degrees longitude, presents a unique challenge to monitoring, assessing, and managing the impacts of climate change. Its size means that the impacts of climate change, and the rate of those changes, can differ greatly across the monument. For example, average sea surface temperature in the monument varies by as much as 5°F. Further, while average sea level rise in the monument is expected to be higher than the global average,[1,11] between 2009 and 2018 it varied from 0.5 inches per year to falling at 0.25 inches per year depending on location. These local differences in climate change impacts are likely to result in differences in the responses of monument resources from location to location. However, this variability also provides hope. The wide range of climatic conditions within the monument increase the possibility that some portions may provide climate refugia that are vital to future adaptation and restoration. There is already some evidence of this as the reefs of the French Frigate Shoals are thought to be potentially resilient to a range of climate impacts.[2]

events in the monument between 1982 and 2018.[4] During the 2014 event, ocean temperatures were particularly high in the monument, which caused extensive bleaching and coral death.[4] Bleaching events have widespread ecosystem impacts and are expected to become more common and more extreme in the future.[1,4,5] By some estimates, reefs in the monument may experience yearly bleaching by 2050.[6] As this may be up to 20 years later than the projected yearly bleaching of reefs on the Main Hawaiian Islands,[6] corals in the monument may have more time to adapt to bleaching conditions. Thus, the monument protects resilient coral reefs that may be important refugia and provide corals and larvae for other reefs in the future.

Increasing water temperatures will also impact many other species in Papahānaumokuākea. Rising temperatures cause more sea turtles to hatch as female, which could lead to fewer males in the population and reduced reproductive success in these endangered species.[7,8] Further, under extreme warming, water temperatures on reefs in the monument may be too warm for most of the current resident species by 2115.[9] While species often move when exposed to temperatures that are too warm, the isolation of the Hawaiian Islands means that many of these species may be unable to move elsewhere.[2] This is particularly problematic for endemic species, which make up 25% of the marine species in the monument.[10] As these species are found nowhere else on Earth, an inability to move elsewhere if exposed to inhospitable future conditions could increase their risk of extinction if they are unable to adapt.[2]

Rising temperatures could lead to more sea turtles hatching as females, leading to fewer males in the population. *Photo: Mark Sullivan/NOAA*

Case Study 2—Corals Under Threat

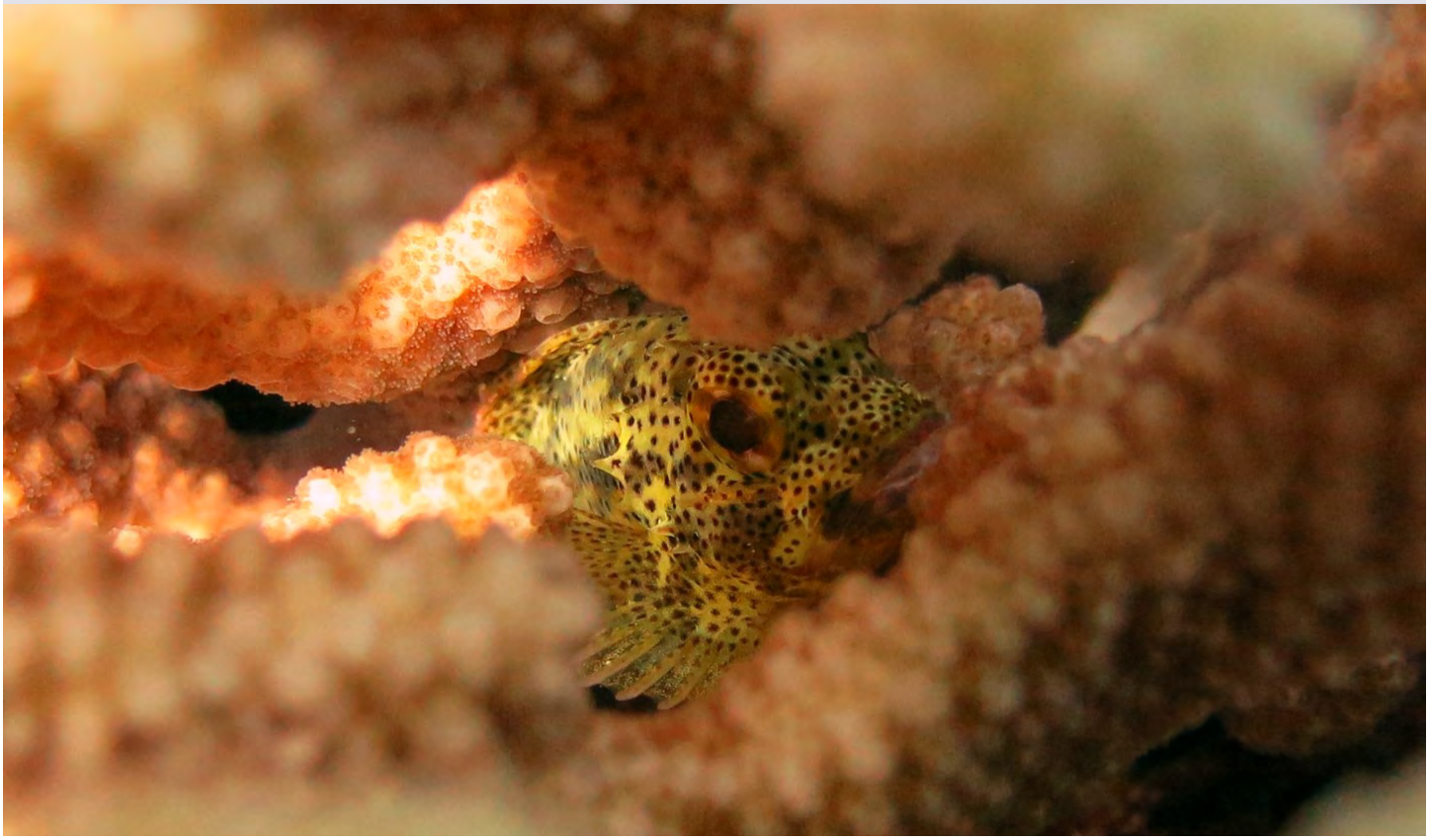
Many corals in Papahānaumokuākea bleached in 2014 as a result of high water temperatures. *Photo: NOAA and Courtney Couch*

Corals are the foundation of the reef ecosystem that supports much of the life in Papahānaumokuākea Marine National Monument. These vibrant ecosystems provide complex habitats for thousands of species including the prey that support Hawaiian monk seals, sea turtles, and large fish. Coral reefs are home to many species found only in Hawai‘i, which make up 25% of marine species in the monument.[10] More frequent extreme climate conditions threaten corals.

Rising water temperatures are the greatest immediate threat to corals. When temperatures are too high, corals may bleach, which can lead to coral death. The 2014 bleaching event led to coral death and lower coral cover in the monument, including a 68% loss at Lisianski Island, resulting in reduced habitat complexity.[2,4] Some reefs in the monument experienced complete coral mortality.[4]

The ocean has also become more acidic over the past 200 years.[12,13] Under acidic conditions, corals have difficulty building stony skeletons, compromising growth, and are more vulnerable to storm and wave damage.[1,13-15] By 2100, nearly all reefs may be surrounded by water acidic enough to impair coral growth.[1,15] Slow-growing deep sea corals are particularly vulnerable as acidification is more pronounced in the deep, cool waters where they live.[17]

Increasingly strong storms threaten coral reefs. In 2018, Hurricane Walaka greatly damaged one of the most diverse reefs of French Frigate Shoals. Strong storms have occurred before, but climate stressors such as ocean acidification and heat stress may make corals more vulnerable to their effects and less able to recover.



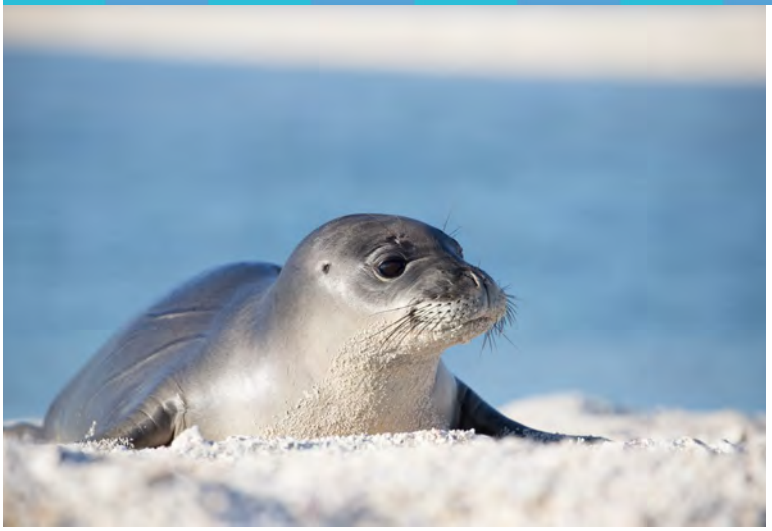
The corals of Papahānaumokuākea provide habitat for thousands of species, including speckled scorpionfish. *Photo: Tate Wester/UH Mānoa*

Ocean Acidification

About 30% of the carbon dioxide (CO_2) released into the atmosphere is absorbed by the ocean[18] 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.[12,13] Due to its chemistry, such as particularly low levels of dissolved minerals like calcium, the ocean waters of Papahānaumokuākea may be more vulnerable to acidification than other parts of the Pacific.[19] Increasingly acidic waters make it difficult for organisms like coral, shellfish, and culturally important ʻopihi (a limpet) to make and maintain their stony skeletons and shells.[2,20] Acidic waters can even degrade the sand of the monument's beaches, which are largely derived from ground coral, urchin spines, calcifying algae, and shells.[21,22] Increased acidification also makes it difficult for the larvae of coral reef fish to grow, survive, and find their way back to the reef.[23-25]

The effects of ocean acidification on crustose coralline algae may be one of the greatest climate change vulnerabilities of reefs in Papahānaumokuākea.[2] These pink and purple-colored algae, which make a stony skeleton, play an important role in cementing reefs, are an important component of the sand that makes up the beaches in the monument,[27] provide usable surfaces for coral to settle and grow, and can be a large part of the reef structure.[2,26] However, these algae are highly vulnerable to acidification.[2,28] Losses of crustose coralline algae could have widespread and dramatic effects, from the degradation of coral reefs to the reduction of important coastal habitat for Hawaiian monk seals, sea turtles, and seabirds.

The monument protects a great diversity of life, much of which is impacted by climate change. Species IDs (top to bottom): ʻopihi, octopus, Laysan albatross. *Photo: Hoku Johnson/NOAA; Paola Ayotte/NOAA; Kittipong Janthasang*



Species like Hawaiian monk seals are in danger of losing important beaches in Papahānaumokuākea to rising ocean waters. *Photo: Koa Matsuoka*

Rising Ocean Waters

Numerous factors contribute to rising global sea levels including melting glaciers and thermal expansion of seawater. Differences in factors such as currents and the Earth's gravitational field cause sea levels to rise at different rates in different locations.[1,29] In the next century, Papahānaumokuākea is expected to experience extraordinarily large changes in sea level with a potential rise of 3.2 ft by 2060 and 8 ft by 2100.[1,11]

The numerous low-lying islands and atolls of Papahānaumokuākea, many less than 6.5 ft above sea level, are very vulnerable to sea level rise with many expected to be submerged in the next 50-100 years.[2,30] These islands provide critical breeding and haul-out habitat for seabirds, sea turtles, and Hawaiian monk seals. Even modest sea level rise could result in the loss of much of this important habitat from storm surge and waves.[1,2,31] In fact, it has been predicted that sea level rise of 6 ft could lead to a reduction of habitat resulting in the yearly loss of approximately 60% of albatross nests in Papahānaumokuākea.[31]

The impacts of sea level rise are already being felt within the monument, particularly at French Frigate Shoals. Sea level rise, together with dynamic weather and geological processes, contributed to the complete erosion of Whale-Skate Island in the 1990s and Trig Island in 2018. As sea levels continue to rise, the low-lying islands and atolls of the monument, and the wildlife that depend on them, will continue to be threatened.

Changing Weather and Storms

Weather patterns around the world are being altered by climate change. Changes to wind and evaporation impact rainfall while rising ocean temperatures fuel stronger storms.[1,32] While the number of factors impacting weather in Hawai'i make changes difficult to predict, there is evidence that rainfall will decrease.[1,33,34] Reduced rainfall could decrease the freshwater lenses and seeps of islands, critical sources of water for plants, insects, and birds, many of which, such as Laysan duck, are found nowhere else on Earth.[2,35]

The result of loss of habitat from sea level rise will impact species, like green sea turtles, that depend on low lying islands in the monument. *Photo: Koa Matsuoka*

Papahānaumokuākea is also expected to experience stronger tropical storms that will track closer to the monument.[1,36,37] Storms damage corals and compound the effects of rising sea levels to erode the ecologically important beaches of low-lying islands and atolls.[2] In 2018, six hurricanes approached Hawai'i, with one impacting the monument. On October 18, 2018, Hurricane Walaka devastated coral reefs and caused East Island to lose over 95% of its emergent land overnight. The near loss of East Island represented the destruction of important reproductive habitat for many species including Hawaiian monk seals and over 95% of green sea turtles in the monument.

What is Being Done?

Monument managers are working with scientists to monitor Lisianski Island, where reefs experienced mass bleaching in 2014. This effort includes 3D analyses to examine changes to the ecological community and physical reef structures. Scientists are also using remote sensing to monitor the processes that are reshaping East Island. Other efforts include relocating seabirds to the higher Main Hawaiian Islands to increase species resilience and exploring the impacts of increasing temperatures and reduced reproductive habitat on sea turtles. These efforts help managers understand how resources respond to climate change and better prepare for future impacts. Monument managers are interested in working with scientists researching the impacts of climate change.

At the Mokupāpapa Discovery Center in Hilo and across Hawai‘i, monument staff engage in outreach and education including lessons on reducing greenhouse gases, the ultimate cause of climate change, and other impacts through recycling, reducing waste, and removing marine debris. By reducing non-climate stressors, the resources of Papahānaumokuākea may be better able to adapt to climate change. Further, NOAA is taking action to minimize its own impact by reducing emissions and single-use plastics at all facilities and events.

Banded coral shrimp is just one of the thousands of species that represent the diversity of life in Papahānaumokuākea. *Photo: Greg McFall/NOAA*

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