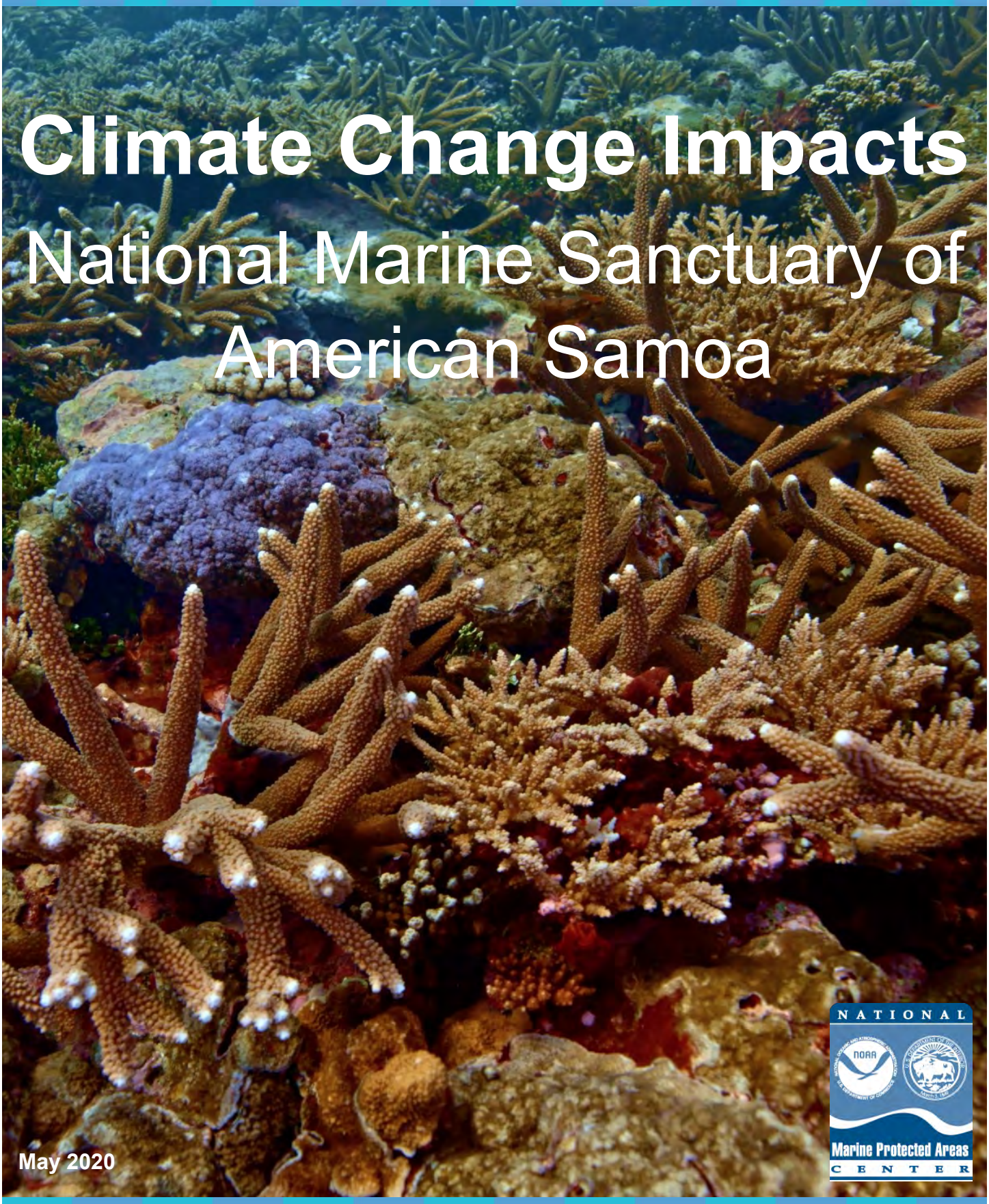
Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration



Climate Change Impacts

National Marine Sanctuary of American Samoa

May 2020

NATIONAL Marine Protected Areas CENTER

National Marine Sanctuary of American Samoa provides protection for hundreds of species. Photo: Wendy Cover/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.

National Marine Sanctuary of American Samoa

National Marine Sanctuary of American Samoa was originally designated by NOAA in 1986. Expanded in 2012 to become the United States' largest national marine sanctuary, the sanctuary is composed of six protected areas covering 13,581 square miles of healthy coral reefs and offshore ocean across the Samoan islands. The vibrant reefs of the sanctuary support hundreds of ecologically, economically, and culturally important species, including over 250 species of coral, hundreds of fishes, endangered species such as green and hawksbill sea turtles, and culturally important giant clams.

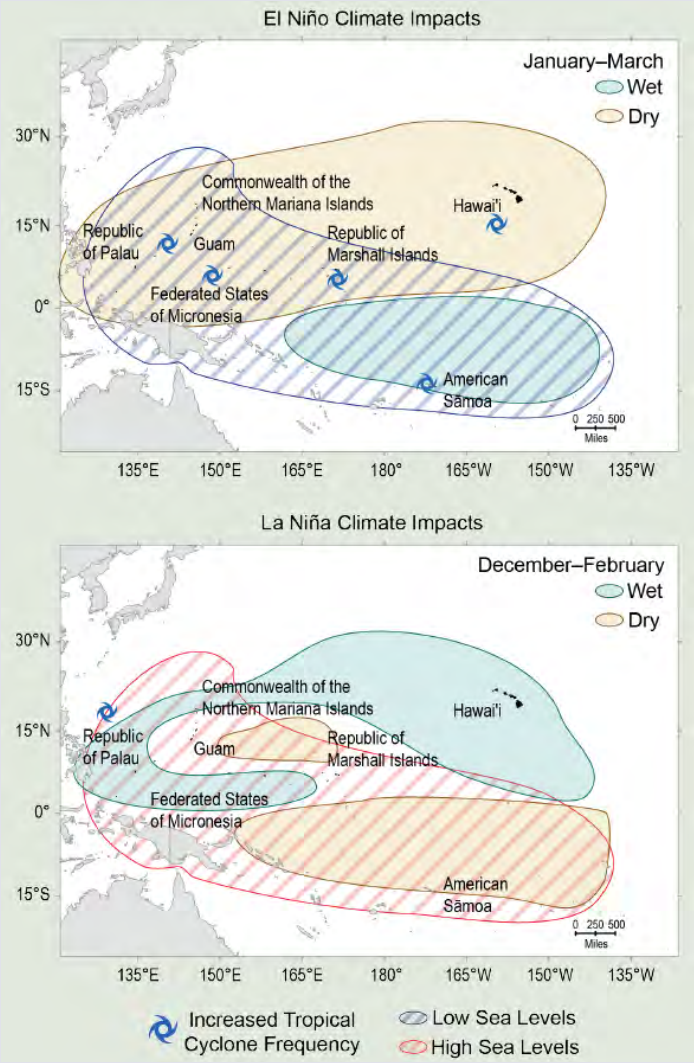
Rising Water Temperatures

As global temperatures rise, the ocean absorbs much of the heat, causing the average temperature of the ocean to rise worldwide.[1] In American Samoa, water temperatures have risen 1.8°F in the last 30 years[2,3] and may increase another 4.7°F by 2090.[4]

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, these ocean heatwaves can cause corals to become stressed and expel the algae living inside them that provide their food and process waste. This phenomenon, known as "bleaching" because corals appear white when they lose their algae, can lead to the coral's death. There have been five mass bleaching events in American Samoa between 1994 and the most recent event in 2017.[5] The 2015 bleaching event was

Waters that are too warm can cause corals to expel their symbiotic algae, a phenomenon known as bleaching. Photo: Wendy Cover/NOAA

Case Study 1— ENSO and Climate Change



Year-to-year climate patterns, as driven by El Niño-Southern Oscillation (ENSO) in American Samoa and the U.S. Affiliated Pacific Islands. Photo: Adapted from USGCRP 2018[1]

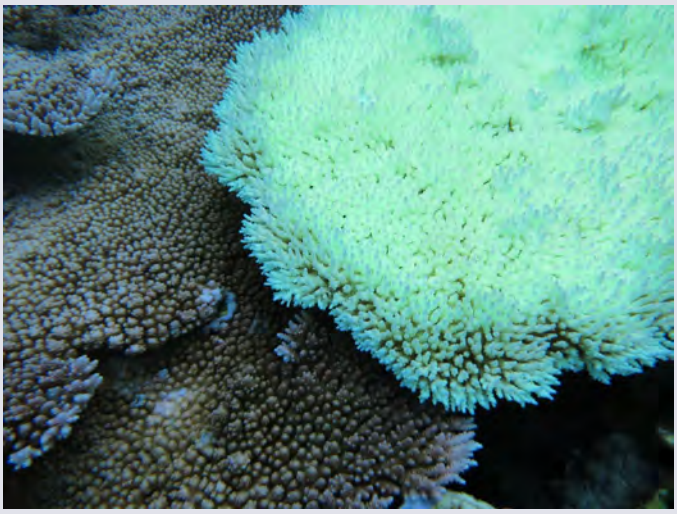
El Niño– Southern Oscillation (ENSO), which includes La Niña, often dominates the climate and weather of American Samoa, creating high inter-annual variability[5]. During El Niños, American Samoa experiences warm ocean temperatures and increased rainfall, conditions which are reversed during a La Niña.[1,10] However, climate change is also impacting ENSO with both El Niño and La Niña projected to become more intense and increase in frequency.[11,12] When combined with the long-term changes in climate factors such as ocean temperature and precipitation, increases in the intensity of El Niño and La Niña could enhance the impacts of climate change on sanctuary resources. In fact, with the exception of 2017, all mass bleaching events within the sanctuary[5] have occurred during El Niños. Further changes to ENSO could have large impacts on the sanctuary.

particularly damaging causing widespread bleaching of the threatened coral *Isopora crateriformis* within Fagatele Bay and mass mortalities of staghorn coral in Airport Pool on Tutuila.[5] Bleaching events have widespread impacts on the ecosystem of the sanctuary and are likely to become more common and more extreme in the future.[1,6] By some estimates, the reefs of American Samoa could experience yearly bleaching as early as 2040.[6]

Increasing water temperatures in the region are also likely to directly impact other species in the sanctuary. Warming waters are predicted to decrease the larval survival of culturally important giant clams,[7] which may hinder the recovery of these species. Further, under extreme warming, by 2115 water temperatures on Samoan coral reefs may be too warm for many of the species currently found on coral reefs in the sanctuary.[8] While some species may be able to shift to new ranges as temperatures rise, the isolation of the Samoan islands means that many species may be unable to move elsewhere and that natural repopulation of the reefs by new species from other sources is difficult. High water temperatures may also lead to larger and longer lasting algal blooms which can negatively impact corals and other reef species.[5,9] Some of these blooms can even be toxic, known as harmful algal blooms (HABs), and can kill fish, seabirds, marine mammals, and other wildlife with direct impacts on the ecology, economy, and culture of American Samoa.

Culturally important giant clams may suffer increased larval mortality in the future due to warming water temperatures. Photo: Greg McFall/NOAA

Case Study 2— Coral Under Threat



The bleaching of corals, is expected to become more common and more extreme as waters warm further. Photo: Wendy Cover/NOAA

Corals are the foundation of the reef ecosystem that is vital to the marine life, economy, and culture of American Samoa. These vibrant ecosystems provide habitat and prey for thousands of species including giant clams and hawksbill sea turtles. However, Samoan corals face many threats. The reefs of Fagatele Bay alone have been subjected to six cyclones, three bleaching events, and a crown-of-thorns sea star outbreak since 1985.[5]

Rising water temperatures are the greatest climate threat to corals. When temperatures are too high, corals may bleach, which can lead to death. Since 1994, reefs in the sanctuary have been increasingly exposed to bleaching temperatures.[1,5] Yet some corals appear resilient to bleaching and impacts such as storm damage. The reef in Fagatele Bay has shown a remarkable ability to recover from extreme events[5] and may provide a refuge for corals vital to future restoration and repopulation.

The ocean has also become more acidic in the past 250 years.[13,14] Corals have difficulty building their stony skeletons under acidic conditions.[15] This may compromise their growth and increases their vulnerability to damage by storms and waves.[1,14-16] It is possible that by 2100 nearly all coral reefs may be surrounded by water that is acidic enough to impair coral growth.[1,17]

Samoan corals are also threatened by outbreaks of crown-of-thorns sea stars, which feed on coral. These outbreaks have been linked to human and climate impacts.[5,18,19]

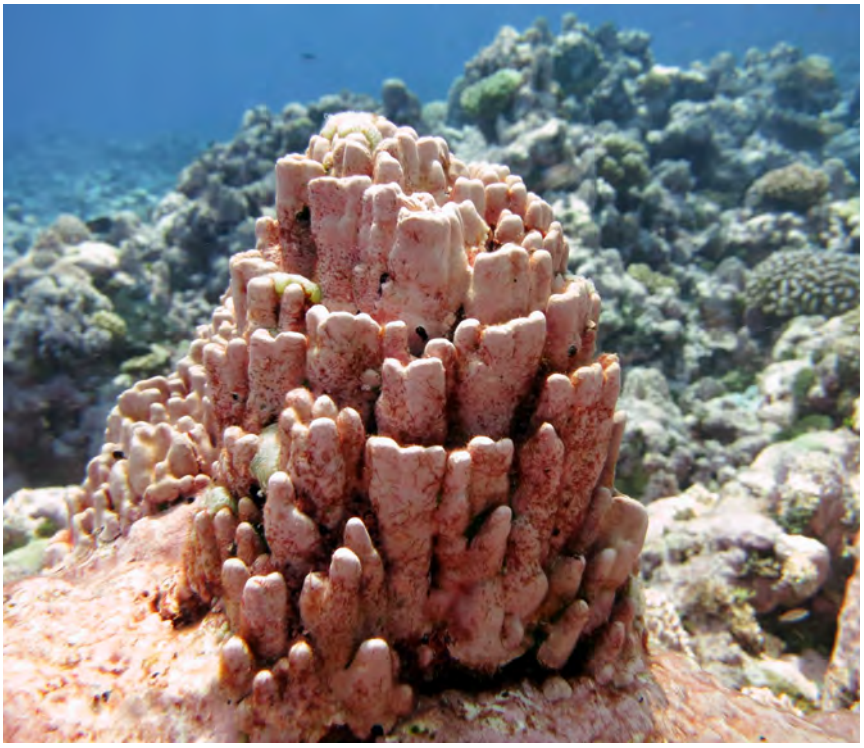
The corals of American Samoa provide habitat for thousands of species, including this guard crab. Photo: NOAA

Ocean Acidification

About 30% of the carbon dioxide (CO_2) released into the atmosphere by humans has been absorbed by the ocean[20] causing a chemical reaction that leads to ocean waters becoming more acidic. Globally, the ocean has become 30% more acidic since 1750, the beginning of the industrial revolution.[13,14] Increasingly acidic waters make it difficult for organisms like coral, crustose coralline algae, shellfish, and culturally important giant clams to make and maintain their skeletons and shells. In fact, chemical conditions in the waters in the region of the sanctuary may fall below the threshold for ideal coral growth by 2065.[4] Acidification also damages reefs through impacts on crustose coralline algae (an algae that makes a pink or purple colored encrusting stony skeleton). These algae play an important role in cementing reefs, provide surfaces for corals to settle and grow, and even dominate many of the reefs in American Samoa.[21-23] However, crustose coralline algae are highly susceptible to acidification.[24] Given their many important roles on coral reefs, losses of crustose coralline algae could lead to dramatic degradation of sanctuary reefs.

Culturally important giant clams are also impacted by acidification. Increased acidification is likely to reduce the survival of larval clams and make it more difficult for clams of all life stages to grow their shells.[7,25] These impacts could slow the recovery of those species that have been overharvested in much of the region.

Ocean acidification can also affect organisms that do not have shells. In fact, increased acidification makes it difficult for the larvae of coral reef fish to grow, survive, and even find their way back to the reef.[26-28]



Many species in American Samoa are likely to be affected by ocean acidification. Species IDs (top to bottom): Brittle star on an octocoral, anemone fish, crustose coralline algae. Photos: NOAA, Greg McFall/NOAA, Wendy Cover/NOAA

A diver injects ox bile into a crown-of-thorns sea star as part of the sanctuary's effort to control an outbreak of this coral predator. Photo: Greg McFall/NOAA

Changes to Weather and Storms

Weather patterns throughout the world are being altered by climate change.[1] In American Samoa, rainfall is projected to increase by up to 10% by 2100[1,29] and extreme rainfall events are predicted to become more common.[4,23] Extreme rain events may also be worsened by predicted increases in the frequency and intensity of El Niño and La Niña.[1,11,12] Extreme rain events cause large amounts of sediment and other material to run off of the land and onto reefs, which can smother and kill corals.[30,31] There is also evidence that land based pollution may be one factor leading to crown-of-thorns sea star outbreaks.[5,18,19] Further, sediments in the runoff create cloudy water which may reduce photosynthesis in the algae living in corals and giant clams, reducing growth rates in these animals.[25,32] This runoff can also contain high levels of nutrients, especially when the water has run through populated areas. High levels of nutrients such as nitrogen, a common ingredient in fertilizer, can increase coral disease[33,34] and cause coral bleaching.[35]

Tropical cyclones are also a danger to sanctuary resources. These storms drive winds, waves, and surge that can damage ecosystems such as beaches, mangroves, and coral reefs. Past cyclones in 1990, 1991, 2004, and 2005 caused widespread damage to coral reefs in American Samoa, leading to long-lasting decreases in coral cover.[5,36,37] While the intensity of tropical storms is expected to increase,[1,38] the number of storms in the region of American Samoa is projected to decrease due to changes in wind, currents, and atmospheric circulation.[39-41]

Changing Ocean Dynamics and Communities

Changes to global currents can have direct impacts on the sanctuary. Some of the ocean currents that flow through the Samoan islands are expected to weaken under climate change.[39] This includes the South Equatorial Current,[42] which plays an important role in transporting larvae of coral and reef organisms between islands.[43] The isolation of the Samoan islands means that reefs in the sanctuary are dependent on nearby islands to provide larvae after disturbances such as storms, bleaching events, and disease.[43] Weakening of currents could decrease the ability of reefs to receive the larvae they need to recover from such extreme events.[43]

Many organisms, like this sea cucumber, rely on currents to transport larvae between reefs and islands of the Samoan archipelago. Photo: Greg McFall/NOAA

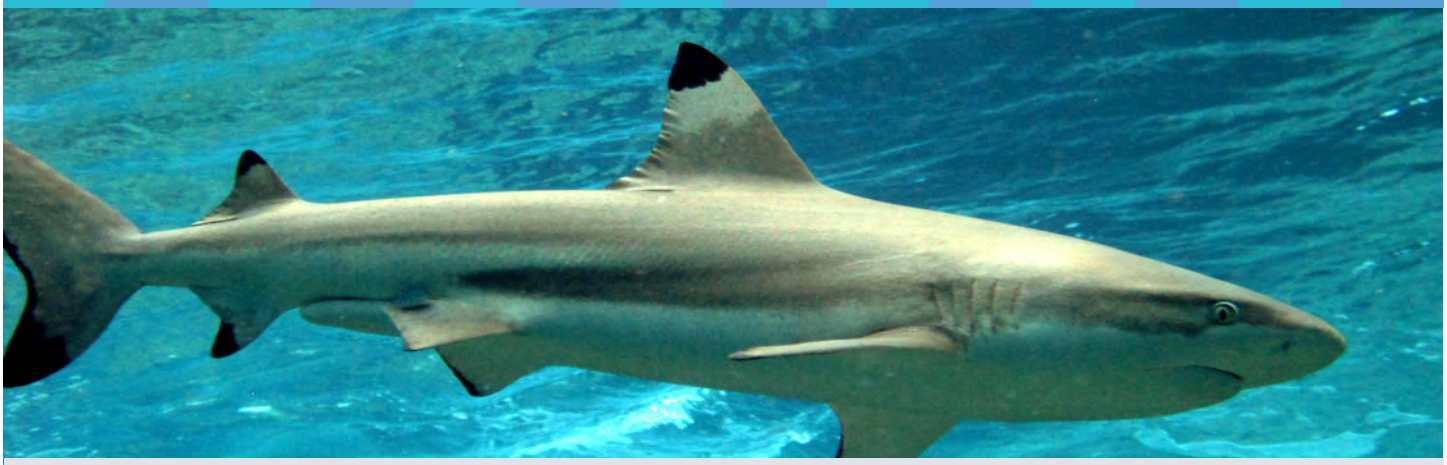
Climate change is also altering ecological communities. Warming waters cause species to move out of historic areas in search of cooler conditions and may favor invasive species.[23,44,45] Changing conditions such as warming water and rain-induced runoff have also worsened coral diseases[33,34,46,47] and outbreaks of crown-of-thorns sea stars.[5,18,19] These impacts can reduce coral cover, leading to changes in the reef community that supports the ecology, economy, and culture of American Samoa.

What Is Being Done?

National Marine Sanctuary of American Samoa is addressing climate change impacts to the sanctuary and the Samoan islands. Managers monitor climate impacts to better understand and prepare for future changes. In partnership with the sanctuary and local resource agencies, the NOAA Ocean Acidification Program deployed a state-of-the-art buoy in Fagatele Bay in May 2019. This buoy takes real-time ocean measurements, including water temperature and acidity, allowing managers to observe and analyze trends and changes.

NOAA is also acting to reduce non-climate stressors on corals, which can increase their resilience to climate change. One example is crown-of-thorns sea star population control. While this species is native to American Samoa, human and climate impacts can lead to outbreaks that can devastate coral. Managers control populations by injecting sea stars with ox bile, a natural substance that kills the animal but does not harm the reef. NOAA is also developing a coral nursery program by piloting a project in 2020. This pilot project will test which nursery designs and coral species perform best. The eventual goal is to establish a successful, full-scale coral nursery. While the reefs of the sanctuary are currently very healthy, corals grown in the nursery could be used for restoration after future disasters or to restore other reefs in the Samoan islands.

White spotted surgeonfish are just one of the thousands of species supported by the ecosystem of the sanctuary. Photo: Kevin Lino/NOAA



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