Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

Climate Change Impacts

Florida Keys

National Marine Sanctuary

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Florida Keys National Marine Sanctuary is home to vibrant, diverse habitats including coral reefs, seagrass meadows, and mangroves. *Photo: 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.

Florida Keys National Marine Sanctuary

Florida Keys National Marine Sanctuary protects more than 3,800 square miles of ocean and coastal habitats of the Florida Keys archipelago south of the Florida mainland. Established by Congress on November 16, 1990, the sanctuary is home to some of the most diverse and productive marine ecosystems in the country. The mangrove forests, seagrass meadows, hard bottom habitats, and coral reefs of the sanctuary are home to thousands of ecologically and economically important species such as sea turtles, spiny lobster, grouper, and stone crab. The blue economy of the Florida Keys thrives on the bounty and beauty of the sanctuary.

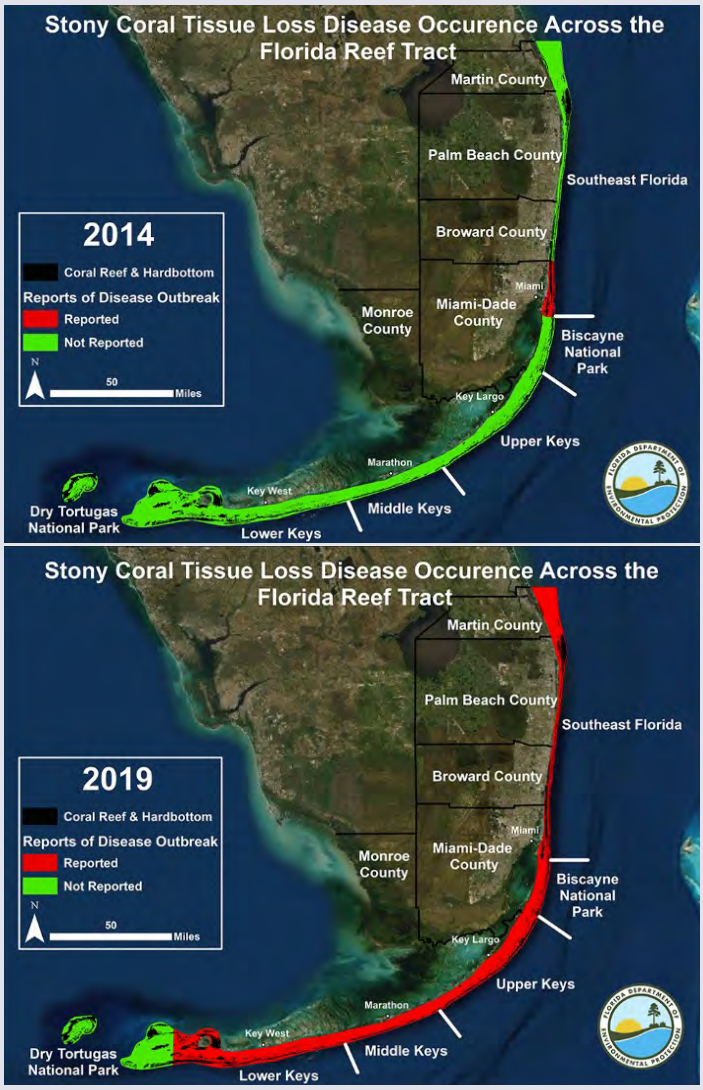
Changing Water Temperatures

As global atmospheric temperatures rise, the ocean absorbs much of the heat, causing average seawater temperature to rise worldwide.[1] In the Florida Keys, water temperatures have risen 1.4°F since 1970[2] and will likely continue to increase in coming decades.[1,3] Increasing temperatures combined with extreme hot and cold events, result in widespread impacts to living resources in the sanctuary.

The impacts of lionfish, an invasive species in the sanctuary, may increase due to warmer water temperatures. Photo: Greg McFall/NOAA

As temperatures rise, many species in the northern hemisphere are moving north or deeper to cooler water[4]. This could have ecosystem-level impacts. Heat-tolerant species may benefit from warmer waters while others that are not adapted to high temperatures may be negatively affected.[5,6] Warmer waters are also expected to negatively impact the larvae of Florida stone crab,[7] with potential consequences for the $30 million fishery this species supports.[7,8] Higher temperatures may increase the impact of invasive

Case Study 1— Climate and coral disease



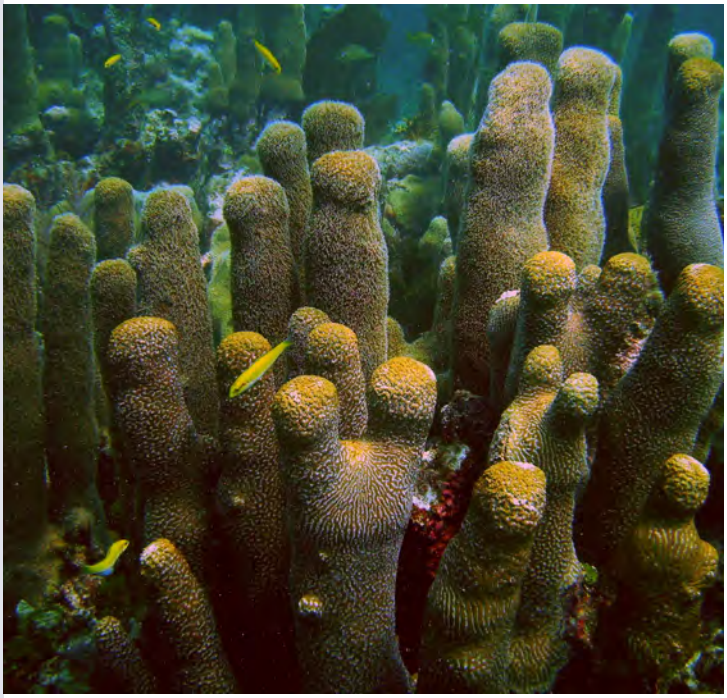
Progression of SCTLD in the Florida reef tract. Photo: floirdakeys.noaa.gov

In 2014, stony coral tissue loss disease (SCTLD) emerged off the coast of Miami and has since spread throughout the Florida Keys.[21] In recent decades, SCTLD and other coral diseases have caused widespread damage to corals in the Keys. While coral diseases are not directly caused by climate change, there is evidence that it is worsening their effects.[22] Warmer waters can accelerate disease by increasing the virulence of pathogens and disease prevalence while thermal stress decreases the effectiveness of coral immune responses.[17,22,23] High nutrient runoff from extreme rainfall events, which are expected to become more common, have also been tied to coral disease.[17,24] Thus, while not the ultimate causes, the combination of climate change and human stressors make corals more susceptible to coral disease. Reduced human impacts, as found in the sanctuary, could be critical to the ability of corals to survive climate change and disease.

lionfish by causing them to eat more native species.[9] Under extreme scenarios, by 2115 the waters of the Keys may even be too warm for up to 90% of the species currently found there.[10] Higher temperatures will likely also increase the size and duration of harmful algal blooms[11-13] such as the red tides and blue-green algae that have killed fish, birds, and marine mammals in Florida in recent years and led to millions of dollars in economic losses.[14,15]

Extreme temperature events have increased in both frequency and intensity in past decades, a trend likely to continue.[1] Ocean heat waves, when combined with increasing average temperatures, can cause corals to become stressed and expel the algae living inside them that provide 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. Corals in the Keys were first reported to bleach in 1973[2,16] and have experienced mass bleaching several times since, most notably in 1987, 1997, and 2014. Even when corals do not bleach, high water temperatures can stress corals, increasing their susceptibility to disease and reducing growth.[17,18]

The projected increase in the intensity of La Niña events[19] may, in some instances, lead to more extreme cold events. In 2010, such an event caused catastrophic mortality of many fish, mangroves, and corals, killing up to 17% of the corals on some Keys reefs.[20]



Endangered pillar coral is just one coral species threatened by warming water temperatures. Photo: Bill Precht/NOAA

Case Study 2— Coral Reefs Under Threat

Corals in the sanctuary are expected to be exposed to bleaching conditions more often in the future. Photo: NOAA

Coral reefs are the foundation that supports much of the marine life and economy of the Florida Keys. These vibrant ecosystems provide habitat and food for hundreds of species including lobster, grouper, and snapper. However, coral mortality has accelerated in recent decades due to human and climate-related impacts.

Changing water temperatures are the greatest immediate climate threat to corals. When temperatures are too high, corals may bleach, which can lead to death. Since the 1970s, corals in the Keys have increasingly experienced bleaching temperatures.[1,2,25] By some estimates, Keys reefs could soon bleach annually.[25,26] Some corals and sites may resist or be resilient to bleaching. The reefs of Cheeca Rocks appear especially resilient and may be a refuge for corals vital to future restoration and repopulation.[27]

The ocean has also become more acidic in the past 250 years,[28,29] threatening stony corals. Under acidic conditions, corals have difficulty building stony skeletons, compromising their growth and increasing their vulnerability to damage by storms and waves.[1,29-31] It is possible that as early as 2100 nearly all coral reefs may be surrounded by water acidic enough to impair coral growth.[1,32]

Corals in the Keys are also threatened by stony coral tissue loss disease, which began in 2014 and is causing widespread death of nearly half of coral species found in Florida, including many that form the framework (or foundation) of the reefs.[21] High temperatures, combined with other climate and human-induced stressors, reduce the ability of corals to fight disease and could contribute to sustained or recurrent outbreaks.[17,22-24]

The corals of the Florida Keys face a number of climate change and human-induced threats. Photo: Greg McFall/NOAA

Ocean Acidification

About 30% of the carbon dioxide (CO_2) released into the atmosphere by humans has been absorbed by the ocean,[33] 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,[24,25] and some areas of the Florida Keys are acidifying at three times the global rate.[34,35] Increasingly acidic waters make it difficult for coral, crustose coralline algae, and shellfish to make and maintain their skeletons and shells. There is evidence that some Keys reefs are already experiencing conditions that inhibit coral growth and that some reefs are even actively dissolving during the fall and winter months.[36] Acidification also damages reefs through impacts on crustose coralline algae. These pink and purple-colored algae have a stony skeleton and play an important role in cementing reefs while also providing surfaces for larval corals to settle, grow, and contribute to the critical structure of the reef.[37,38] However, crustose coralline algae are highly susceptible to acidification.[39] Given their many important roles on coral reefs, losses of crustose coralline algae could lead to dramatic and widespread degradation of sanctuary reefs.

Acidification also directly impacts economically important species like scallop, spiny lobster, and stone crab. In combination with increased water temperatures, increased acidification could reduce the survival of larval lobsters[39] and stone crabs,[7,35] which together support Florida fisheries worth $80 million.[40] In fact, the average annual catch of stone crab declined 2.7 to 3.5 million pounds of claws per year from 1998-2016,[7] likely due, in part, to climate change.

Many species in the Florida Keys are likely to be impacted by ocean acidification and other climate change impacts. Species IDs (top to bottom): hermit crab, Christmas tree worms, spiny lobster. Photos: NOAA; James Guttuso/NOAA; NOAA

Strong storms and hurricanes can damage seagrasses, coral reefs, mangroves, and other ecosystems. Photo: NOAA

Changes to Weather and Storms

Weather patterns around the world are being altered by climate change.[1] Changes to wind and evaporation impact rainfall while rising ocean temperatures fuel stronger storms.[1,41] The number of factors affecting weather in the Keys make changes difficult to predict. Some projections call for less rainfall while others predict more.[1,42] Climate change may also be increasing the frequency and intensity of El Niños[43] which could lead to greater variability and intensity of rainfall and other extreme weather and storm events.[1,43]

In any given year, there is a 20-25% chance that a tropical storm or hurricane will pass within 75 miles of the Florida Keys and an 8-10% chance that a hurricane will do so.[44,45] These probabilities are among the highest on Earth. While the effect of climate change on the number of tropical storms and hurricanes that occur in the region of the sanctuary is uncertain, the strength of these storms is projected to increase in the coming century.[1,41] Rapid intensification of storms, such as witnessed during Hurricane Michael in 2018, is also expected to occur more often.[1,46] Strong storms like Hurricane Irma in 2017, which made landfall in the lower Keys as a Category 4 storm, can cause extensive damage to infrastructure and the ecosystem. Such storms drive winds, waves, and storm surge, damaging coral, mangroves, seagrasses, and nesting habitat for sea turtles and birds. Rain and flooding brought by strong storms, tropical or otherwise, can lead to the runoff of nutrients and sediment from land into nearshore waters, increasing coral disease,[31,47] leading to algae blooms,[48,49] smothering corals and other bottom-dwelling species,[50,51] and causing coral bleaching.[32]

Rising Ocean Waters

Many factors contribute to rising global sea levels, including melting glaciers and thermal expansion of sea water. Differences in factors such as currents cause sea levels to rise at different rates in different locations. Due to variations in the Gulf Stream and the Florida Current, the Florida Keys are projected to experience up to 8.6 feet of sea level rise in the next century, outpacing the global average.[45,52]

Mangroves, which are threatened by sea level rise, provide coastal protection and habitat for many ecologically and economical important species. Photo: David J. Ruck/NOAA

The low-lying islands of the Keys make the sanctuary particularly susceptible to rising waters. Species such as sea turtles and seabirds may lose important beach nesting habitat.[53] The extraordinary rate of expected sea level rise could outpace the ability of coastal ecosystems to keep up, leading to a reduction in mangroves that provide coastal protection and nursery habitat for ecologically and economically important species and their prey.[45,54] While the Keys' coral reefs are unlikely to drown in the near term, the rate of sea level rise, in combination with reduced coral growth due to acidification, could increase water depths over reefs up to 2.5 feet by 2100.[55] This would greatly reduce the coastline protection that the reefs now provide.[56]

What Is Being Done?

While it may not be possible to control the large scale effects of climate change, Florida Keys National Marine Sanctuary is addressing impacts to the sanctuary and surrounding region. Sanctuary scientists partner with Bleach Watch, a group of trained recreational divers, and the Florida Reef Resilience Program, whose climate change strategy includes surveys and monitoring, to monitor and respond to bleaching events and track Stony Coral Tissue Loss Disease. These quantitative surveys provide much of the detailed information in response to these impacts. The sanctuary also partners with other NOAA offices and the University of Miami to study ocean acidification at Cheeca Rocks using a buoy deployed in 2011.

The sanctuary is working with scientists to identify corals that are resilient to stressors such as disease, high temperature, and acidification. Determining what makes corals resilient may help restore reefs by using corals adapted to an altered environment. The sanctuary also works with partners to grow corals in nurseries and out-plant them to restore reefs throughout the Keys. These efforts are vital to the restoration of reefs damaged by climate and human-induced impacts, a necessary step in restoring and maintaining reef ecosystem functions.

The sanctuary works with the community, its partners from other agencies, and through the Water Quality Protection Program to improve water quality and reduce stressors such as impacts from vessels and divers, land-based pollution, overfishing, invasive species, and marine debris. It is vital to create and maintain an environment that minimizes all stressors to give organisms their best chance to resist climate change impacts.

The sanctuary is involved in growing coral in nurseries to replenish reefs damaged by climate and other impacts. Photo: Mitchell Tartt/NOAA

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