Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

Climate Change Impacts

Flower Garden Banks National Marine Sanctuary

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Flower Garden Banks National Marine Sanctuary protects some of the healthiest coral reef communities in the Caribbean. Photo: G.P. Schmahl/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.

Flower Garden Banks National Marine Sanctuary

Flower Garden Banks National Marine Sanctuary includes three underwater mountains, called banks, located 70-115 miles off the coasts of Texas and Louisiana. The upper reaches of the banks support tropical reef communities while the deeper areas provide habitat for non-reef building corals, extensive beds of coralline algae dominated habitats, and associated communities. Both areas provide habitat for many ecologically and economically important species including snapper, grouper, and jacks. Designated by NOAA in 1992 to protect East and West Flower Garden Banks, and expanded by Congress in 1996 to include Stetson Bank, the sanctuary protects these vibrant ecosystems.

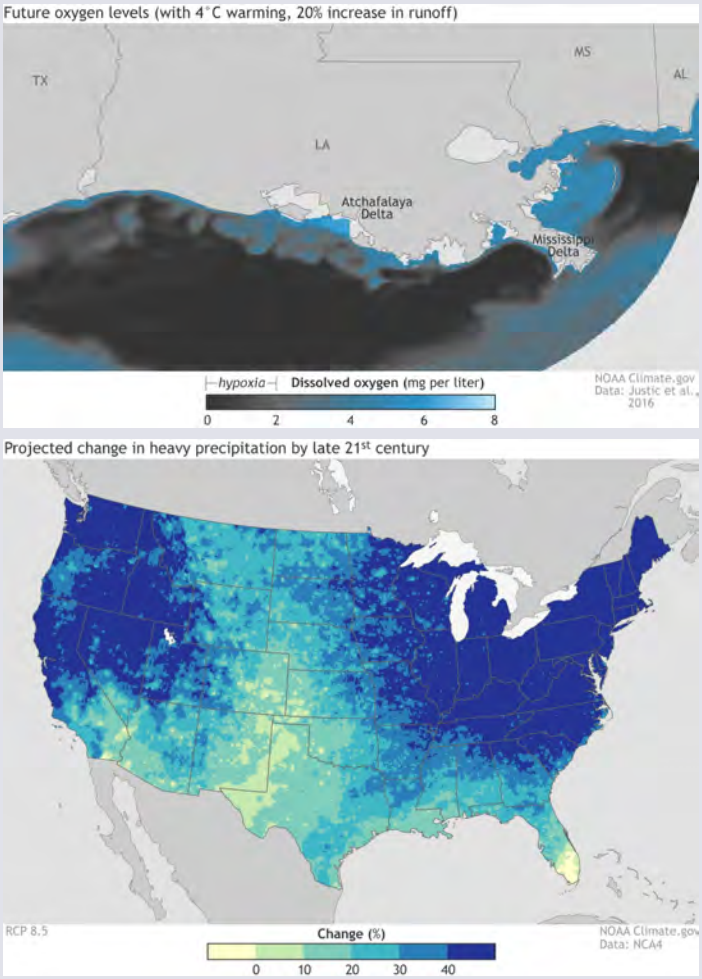
Rising Water Temperatures

As global temperatures rise, the ocean absorbs much of the heat, causing average seawater temperatures to rise worldwide.[1] In the Gulf of Mexico, where the sanctuary is located, water temperatures have been increasing since 1990[2] and are projected to warm by 0.7 °F per decade over the coming century.[3] Under some projections, by 2100 the yearly average water temperature in the Gulf of Mexico is expected to be higher than the warmest year currently on record.[3]

The sanctuary is home to hundreds of species, like goldentail moray eels, many of which may be impacted by climate change. Photo: Steve Miller

Extreme temperature events have also increased in frequency and intensity in past decades, a trend likely to continue in the coming century.[1] When combined with increasing average temperatures, these ocean heatwaves can cause corals to become stressed and expel the symbiotic algae living inside them that provide food and process waste. This phenomenon,

Case Study 1— Hypoxia in the Gulf of Mexico



Top: Modelled future hypoxia in the Gulf. Bottom: Projected future change in heavy rainfall. Photo: Climate.gov. Top adapted from Fennel et al. 2016[18] with data from Justić et al. Bottom adapted from NCA4[1]

Hypoxic, low-oxygen, conditions form every summer in the Gulf of Mexico.[18] At times, hypoxic conditions can also occur in the region of the sanctuary and have been implicated in the 2016 localized mortality event at East Flower Garden Bank.[2] Two of the major causes of hypoxia in the Gulf of Mexico are nutrient-laden river input and high temperatures, which reduce the ability of water to hold oxygen and prevent mixing with oxygen-rich surface waters.[1,18] Both of these causes of hypoxia are expected to become more intense in the future. In particular, heavy precipitation is projected to become more common in the majority of the Gulf's watershed, likely increasing riverine discharge into the Gulf.[1,19,20] This river discharge is laden with nutrients from the agricultural and urban areas within the watershed, driving algae blooms that reduce the oxygen content of the water as they decay. Climate change is expected to increase the extent and duration of hypoxic events within the Gulf, with potential consequences for the sanctuary.

known as "bleaching," because corals appear white when they lose their algae, can lead to the corals' death if the conditions causing the stress are prolonged. Since 1990, reefs in the sanctuary have bleached multiple times with extreme bleaching events in 2005 and 2016.[4]

As temperatures rise, species in many parts of the northern hemisphere are moving northward or deeper to cooler water.[5] This could lead to some temperate species, like Spanish mackerel, becoming less abundant in the sanctuary[6] and tropical species like elkhorn coral, becoming more common.[7,8] This gradual shift to a more tropical biological community in the Gulf of Mexico, called tropicalization, could alter the ecosystem functioning of the sanctuary.[9] There is also evidence that non-native tropical invasive and exotic species such as lionfish and orange cup coral may benefit from increased water temperatures,[10-14] allowing them to better compete with native species.

Increased water temperatures will also have indirect impacts on sanctuary resources. Higher temperatures are predicted to lead to larger, longer lasting harmful algal blooms (HABs), which can sicken or kill fish, birds, marine mammals, and people.[1,15-17] Further, higher water temperatures may increase the stratification of the water column leading to low-oxygen conditions, which likely contributed to a 2016 localized mortality event at East Flower Garden Bank,[2] to become more frequent, persistent, and widespread.[1]

Increasing water temperatures may allow invasive species, like the orange cup coral, to better compete with natives. Photo: Emma Hickerson/NOAA

Case Study 2— Coral Under Threat

As water temperatures continue to rise, corals in the sanctuary are projected to bleach more often. Photo: G.P. Schmahl/NOAA

The corals that form the foundation of the ecosystem and support much of the life at the Flower Garden Banks are under threat from rising water temperatures and other factor. When temperatures are too high, corals may bleach, which can lead to death. The 2016 bleaching event resulted in the most extensive bleaching ever witnessed in the sanctuary.[1,4] By some estimates, the corals of the sanctuary may bleach yearly by 2040.[21]

Other changes also impact corals. In 2016, low salinity and low oxygen may have led to a localized mortality event in a 14-acre area of East Flower Garden Bank.[2] Live coral cover dropped from approximately 50% to 20% in the localized area, and many corals, sponges, and other invertebrates died.[2,22] Globally, the ocean has also become more acidic in the past 150 years.[23,24] Under acidic conditions, corals have difficulty building stony skeletons, compromising growth and increasing their vulnerability to storm damage.[1,23-26] By 2100, nearly all reefs may be surrounded by water acidic enough to impair coral growth.[1,27]

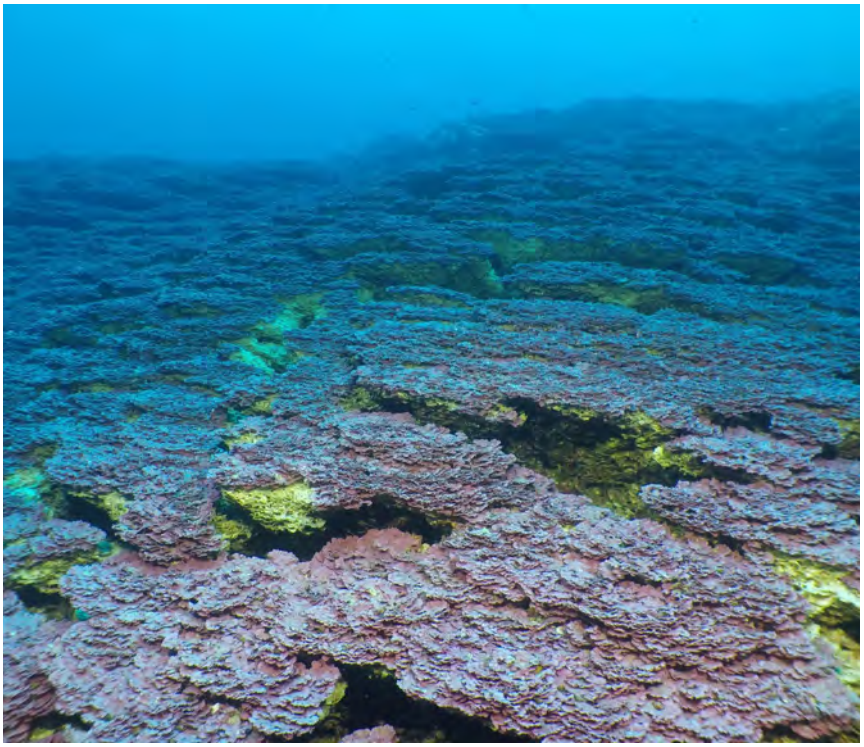
Despite the threats, corals in the sanctuary have shown remarkable resilience. Unlike most reefs, live coral cover has remained high (40-70%) on the reef cap and bleaching mortality is low.[2] Thus, the sanctuary may provide refuge for Caribbean corals and a source of resilient corals vital to future restoration and repopulation.

A ruby brittle star gathers gamete bundles from a spawning star coral during the annual mass spawning spectacle. Photo: Emma Hickerson/NOAA

Ocean Acidification

About 30% of the carbon dioxide (CO_2) released into the atmosphere is absorbed by the ocean,[28] causing a chemical reaction that leads to ocean waters becoming more acidic. The ocean has become 30% more acidic since the beginning of the industrial revolution[23,24] and the waters in the region of the Flower Garden Banks have acidified even faster than the open ocean, especially since 2007.[29] The large discharges of the Mississippi and Atchafalaya rivers, combined with many smaller Texas rivers, also make the sanctuary susceptible to pulses of freshwater that is more acidic than the ocean. Increasingly acidic waters make it difficult for coral, crustose coralline algae, and shellfish to make and maintain their skeletons and shells. The already slow-growing corals of the ecologically important mesophotic (mid-depth) reefs of the sanctuary could also be impacted if acidification further slows coral growth, as has been shown to occur in shallow coral reefs.[30] However, the impacts of ocean acidification, and climate change more broadly, on mesophotic reefs are poorly understood.[31] Acidification can also impact fish, making it difficult for their larvae to grow, survive, and find their way back to the reef.[32-34]

Crustose coralline algae (an algae that makes a stony skeleton) play an important role in cementing reefs and provide surfaces in shallow habitats on which corals can settle and grow.[35-37] They also cover large portions of the substrate in deeper areas of the sanctuary, creating an important habitat called the "coralline algae zone".[37] However, these algae are highly susceptible to acidification.[35] Their loss would cause degradation of ecosystems in the sanctuary.



Many species in the sanctuary may be impacted by climate change. Species IDs (top to bottom): Manta ray, ruby brittle star, crustose coralline algae. Photos: G.P. Schmahl/ NOAA; G.P. Schmahl/NOAA; GFOE/NOAA, NOAA awarded funding to GFOE

Lionfish invaded the sanctuary in 2011. Some invasive species could cause changes in the ecological community in the sanctuary. Photo: A. Sterne/NOAA

Changing Ecological Communities

Together, non-native species and climate change are creating communities in many places that are different from those that existed in the past. Some non-native species, called invasive species, cause community changes that negatively alter ecosystem functions and services.[38,39] While invasive species are not a direct result of climate change, climate impacts, such as warming waters, can lead to the invasion of new areas or give invaders advantages over native species.[10-14] Lionfish, which have been established in the sanctuary since 2011,[2] are an invasive species of particular concern. Lionfish are expected to benefit from warming waters and prey heavily on native species, many of which are food for native predators like grouper.[13,14] Another non-native fish, the regal demoiselle, was first sighted in the sanctuary in 2018. This small fish forms large schools and could displace native species like brown chromis. Orange cup coral, an invasive non-reef building coral, has been found in the sanctuary since 2002 and competes with native species for space.[2,40] Orange cup coral may be more resistant to acidification than native corals, giving it an advantage as waters become more acidic.[41,42]

Climate change stressors are already contributing to changes in sanctuary ecosystems. A 2005 bleaching event, combined with coastal runoff from Hurricane Rita, caused a community switch at Stetson Bank from a fire coral and sponge dominated community to an algae-dominated habitat.[43] Invasive species and warming temperatures may also alter the fish community of the sanctuary.[9,44] While changes to ecological communities are difficult to predict, they are likely to continue as the climate continues to change.

Changes to Weather and Storms

Weather patterns around the world are being affected by climate change.[1] Extreme rainfall events are projected to become more common in the Gulf of Mexico watershed,[1,19,20] leading to higher river discharge, some of which could reach the sanctuary. The higher acidity and nutrient loads of river water can increase coral disease,[45,46] cause bleaching,[47] fuel algae blooms,[48] and produce low-oxygen conditions.[49,50] High river discharge may have been partially responsible for the 2016 localized mortality event in the sanctuary.[2]

The diversity of life supported by the sanctuary could be threatened by changes to storms and other climate change impacts. Photo: G.P. Schmahl/NOAA

Tropical storms and hurricanes cause extreme rainfall and increase river discharge. In the Gulf of Mexico, the heaviest rainfall from these storms is already 5-7% higher than a century ago and could increase an additional 30-40%.[51] These storms also produce waves that can damage coral reefs by scouring and moving coral. Hurricanes Rita (2005) and Ike (2008) caused this kind of damage to sanctuary reefs and future high-intensity storms are predicted to be more powerful and intensify more rapidly.[52,53] However, the overall number of tropical storms in the Gulf of Mexico is projected to decrease due to changes in wind, currents, and atmospheric circulation.[51]

What is Being Done?

Regular monitoring cruises allow NOAA to track the impacts of climate change, helping Flower Garden Banks National Marine Sanctuary managers better understand and prepare for future changes. Towards this goal, sanctuary managers are working with NOAA's Ocean Acidification Program and researchers at Texas A&M University and Texas A&M University-Corpus Christi to study ocean acidification in the sanctuary. This includes NOAA's long-term monitoring of key ocean chemistry measurements. NOAA is also working to curb the success of invasive species through removal events such as Lionfish Invitationals. While some teams of divers remove as many lionfish as possible during these events, others gather data on populations of both native species and lionfish. The removal of invasive species like lionfish can reduce biological stresses on the local ecosystem and make it more resilient to climate impacts.

In addition, sanctuary staff and managers actively participate in outreach and education with students, teachers, and the public throughout the region. The sanctuary also works with local partners on outreach activities such as workshops to help teachers and community members learn to effectively communicate about climate change and how it is affecting Flower Garden Banks National Marine Sanctuary

A spotted scorpionfish at Stetson Bank makes a meal of an unlucky rockhind. Photo: Emma Hickerson/NOAA

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