Climate Change Impacts
Gray’s Reef
National Marine Sanctuary

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Gray’s Reef provides habitat for a diverse ecological community of temperate and tropical species. Photo: Greg McFall/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. 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. While all of our sanctuaries and national monuments must face these global effects of climate change, each is affected differently.

Gray’s Reef National Marine Sanctuary

Gray’s Reef National Marine Sanctuary protects 22 square miles of ocean 19 miles off the coast of Georgia. Designated in 1981, the sanctuary protects Gray’s Reef, one of the largest live bottom reefs in U.S. waters. Gray’s Reef is the only protected natural reef on Georgia’s continental shelf and sits at the transition of the tropical and temperate seas, making it important to many species. The reef’s diverse assemblage of sponges and soft corals provide habitat for economically and ecologically important species such as lobsters, shrimp, black sea bass, snappers, and groupers. The sanctuary also protects habitat used year-round by threatened loggerhead sea turtles and is near the only known calving ground of endangered North Atlantic right whales.

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. In the region of the sanctuary, the frequency of extreme rainfall events has increased in recent years and is expected to continue to increase in the coming century.

Runoff associated with increasingly frequent extreme rain events can have a number of impacts on the living resources of the sanctuary. Runoff from rivers is more acidic than ocean water, exacerbating the effects of ocean acidification. Pulses of sediment can clog the pores of sponges, important habitat-builders within the sanctuary, and the increased turbidity can reduce light levels, further impacting photosynthetic sponges and corals. The high level of nutrients often found...
Tropical cyclones (tropical storms and hurricanes) are expected to be altered by climate change. In the Atlantic Ocean, higher ocean temperatures are projected to result in stronger storms while warmer, moister air is expected to cause these storms to produce more rainfall. Further, the frequency of the most intense storms, category 4 and 5 hurricanes, is expected to increase. However, climate change could also cause changes that discourage the initial formation of Atlantic hurricanes. Projected increases in vertical wind shear (the change in the wind’s speed and direction with height) and warming atmospheric temperatures could make it more difficult for hurricanes to form. Ultimately, the combination of these climate change impacts is expected to result in fewer Atlantic hurricanes. However, those storms that do form are projected to be stronger and produce more rainfall.

In addition to rainfall, tropical storms and hurricanes are expected to be altered by climate change. Over the past 500 years, the tracks of these storms have slowly shifted northward towards the sanctuary. In fact, 47 tropical storms and hurricanes have passed within 25 miles of the sanctuary since 1853, with three doing so in 2016 alone. The wind, waves, and storm surge driven by these storms can directly damage sponges, corals, and other habitat-forming invertebrates while the rainfall they produce can result in extreme runoff events that further impact these animals. Moreover, warming water temperatures are projected to result in an increase in the number of the strongest tropical storms and hurricanes and to cause these storms to intensify more rapidly. In addition, the rainfall associated with Atlantic hurricanes is expected to increase by 10-15%, further exacerbating the impacts of associated runoff events. While the storms that do form are expected to be stronger and produce more rainfall, the overall number of tropical storms and hurricanes in the region of the sanctuary is projected to decrease due to changes in wind, currents, and atmospheric circulation.
**Case Study 2—Climate Change and Habitat-Forming Invertebrates**

Sponges and non-reef building corals provide complex habitat for hundreds of species in the sanctuary. Climate change may impact these habitat-forming invertebrates. While bleaching (the loss of algae that provide food to some corals and sponges) due to high temperatures is a danger, it is not expected to impact the survival of sponges and corals at Gray’s Reef due to their relatively low dependence on photosynthesis.\(^4,14\)

The ocean has become more acidic in the past 250 years.\(^15,16\) Under acidic conditions, corals and some sponges can have difficulty building stony skeletons, compromising their growth and increasing their vulnerability to storms.\(^1,16-19\) Separately, sponges could be impacted by sediment runoff associated with increases in extreme rainfall.\(^1,4,6\) Sediment can decrease sponge growth by clogging pores and reducing the light available for photosynthesis.\(^4,6\) **Nutrients** in runoff have also been associated with coral and sponge bleaching and disease\(^20\) and can lead to **low-oxygen conditions**\(^1,7,8\) that can stress or kill bottom-dwelling invertebrates.

While climate change may have some impacts on the habitat-forming invertebrates of Gray’s Reef, sponges, which dominate the community, are often beneficiaries of climate change.\(^21\) Sponges are generally more tolerant of warming waters and ocean acidification than other habitat-forming invertebrates.\(^21,22\) In some photosynthetic sponges, acidification may even counter the effects of warming by increasing the ability of the symbiotic algae to provide food.\(^21,22\) The ultimate response to climate change impacts will differ from species to species\(^21,22\) but, in general, sponges are thought to be resilient to many of the impacts of climate change.\(^21\)

This could allow the sanctuary, as a healthy reef, to be a source of climate-tolerant sponges in the future.
**Warming Waters**

As global temperatures rise, the ocean absorbs much of the heat, causing the average ocean temperature to rise world-wide.\(^1\) In the sanctuary, average sea surface temperature has risen 2°F since 1824\(^4,23\) and could increase another 5.4°F by 2100.\(^4,24\) 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 heatwaves can cause photosynthetic sponges and corals to become stressed and expel the algae that provide their food. This phenomenon, known as “bleaching” because sponges and corals appear white due to the loss of algae, can decrease their growth and reproduction.\(^4,25\) However, unlike on tropical reefs, bleaching is unlikely to kill the invertebrates of Gray’s Reef as they can sustain themselves on zooplankton prey alone.\(^4,14\) Warming waters can still impact sponges and corals in other ways, such as increasing disease.\(^6,26,27\)

Increasing temperatures can also impact sanctuary resources indirectly. As temperatures rise, many species are moving northward or deeper to cooler waters.\(^1,28\) This could cause southern species, like red snapper,\(^4,29\) to become more common in the sanctuary while species like black sea bass may become less abundant.\(^4,29,30\) Separately, warm water, which holds less oxygen, is one contributor to a projected 1% decline in dissolved oxygen content within the sanctuary by 2050.\(^31\) While low-oxygen conditions can stress and kill bottom-dwelling invertebrates, it is unlikely that oxygen will drop to harmful levels in the sanctuary.\(^4\) Higher temperatures will likely also increase the size and duration of harmful algal blooms (HABs).\(^32-34\) These blooms release toxins that can be damaging to invertebrates, fish, mammals, and even humans.
Ocean Acidification

About 30% of the carbon dioxide (CO₂) released into the atmosphere by humans is absorbed by the ocean, 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, and the waters of the sanctuary could become another 26% more acidic by 2050. Increasingly acidic waters decrease the concentration of carbonate, the mineral animals use to make shells, making it difficult for coral, shellfish, and some sponges to make and maintain their shells and stony skeletons. In the sanctuary, carbonate concentrations are projected to decrease up to 40% by 2100. This decrease is expected to be exacerbated by an influx of low-carbonate water due to changing currents and increased bursts of high-acidity river water from extreme rainfall events.

Increased acidification and lower carbonate concentrations could reduce the growth of corals and shellfish, such as shrimp and lobsters, by making it more difficult to make and maintain their shells. Acidification also impacts the larvae of economically and ecologically important species, including lobsters and fish, by decreasing growth, survival, and their ability to find their way back to the reef. Some corals in the sanctuary show resilience to acidification but could show decreased growth by the end of the century. While sponges are generally more resistant to ocean acidification than other invertebrates, they could experience reductions in their zooplankton prey, which are directly affected by acidification, decreasing growth and reproduction.

Changing Ecological Communities

Together, exotic species and climate change are creating communities in many places that are ecologically different from those that existed in the past, altering ecosystem functions and services. Sitting at the transition of the temperate and tropical oceans, Gray’s Reef typically hosts a temperate community in winter and a tropical community in summer. As winter temperatures increase, tropical species may become established year-round while temperate species like black sea bass and sheepshead could become less common. This shift to a more tropical community could have unexpected consequences.

Invasive species can also alter ecological communities. While the presence of invasive species is not necessarily a direct result of climate change, climate impacts such as warming waters, can allow invasion of new areas or give invaders advantages over native species. The lionfish has been documented at Gray’s Reef since 2003 and is an invasive species of particular concern. Lionfish prey heavily on native species, competing with native predators, and are expected to become more established in the sanctuary as its waters warm. While invasive species and other changes to ecological communities are difficult to predict, they are likely to continue as climate change progresses.
What Is Being Done?

Climate change is an issue that cuts across all aspects of the sanctuary’s work. NOAA uses research, monitoring, education, and outreach to understand and address the impacts of climate change. In collaboration with numerous partners, NOAA seeks to better understand the impacts of climate change, the first step in addressing its effects. A scientific buoy stationed at Gray’s Reef measures and records data such as water temperature, pH, oxygen concentration, and CO₂ concentration to track and better understand how these values are being altered by climate change. In partnership with NOAA’s Pacific Marine Environmental Laboratory, Gray’s Reef National Marine Sanctuary managers are using data from this buoy to examine differences in CO₂ concentration at the surface and bottom of the sanctuary, as well as long-term trends. Gray’s Reef National Marine Sanctuary managers are also studying ancient scallop beds to better understand how Earth’s climate has changed in the past. All of this research will help scientists and sanctuary managers better forecast and understand how the bottom-dwelling community of the Atlantic Ocean will adapt to climate change.

In addition to research, NOAA actively participates in outreach and education with students, teachers, and the public throughout the region. This outreach is critical to increase understanding of climate change and begin to address its effects.
Citations

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