Effects of global warming on the coral reefs of Florida, USA

Project Director: Catherine Laroche
Team Leader: Vanessa Santiago
Team: Daniel Acosta, Eliott Alamo, Julian Alarcon, Christian Lopez, John Marinelli, Albert Plasencia, Max Rosario

Problem Statement: How is ocean acidification affecting the health of the coral reefs of southern Florida?

Abstract

Global warming is impacting the oceans. As carbon dioxide increases in the atmosphere, it is absorbed by the oceans making the oceans acidic. This ocean acidification negatively influences coral reefs. The growth of coral reefs is slowed. Coral reefs also experience "coral bleaching" which can ultimately result in the death of the corals. As the corals die, the reef is no longer able to support the fish that rely on the it. The fish either die or move on to a different location. For areas like Florida that rely on ocean recreation tourism, the death of coral reefs can have an economic impact.

Global Warming

Global warming is the rise in the average temperature of the earth which presents serious challenges that could be harmful for various parts of earth's ecosystems. Excessive use of fossil fuels causes the production of greenhouse gases. The buildup of greenhouse gases like carbon dioxide from cars and factories that use fossil fuels affects the atmosphere. The carbon dioxide in the air eventually impacts the weather, climate, and oceans. These gases are absorbed into our oceans and result in making the water acidic. Even a slight increase in the water acidity affects ocean plants and animals, including coral reefs.

Ocean Acidification

Everyone knows that the ocean is contains water, but there is a lot more than just water - there are also salts. The chemistry of the seas is important to maintain the processes that control ocean dynamics and to support life. The ocean environment supports the beginning of the earth's food web the greatest abundance of life on earth. Interestingly, although not surprising, this life is mostly composed of the same chemicals that comprise the ocean: water and salts.

Change in the ocean chemistry is occurring. Since the start of the industrial revolution, carbon dioxide (CO_2), mostly from factories but also from increased agricultural activities, has been released into the air. The amount of CO_2 has steadily increased since the 1800's. About 25% of the CO_2 in the atmosphere is absorbed by oceans every year. Therefore, as atmospheric CO_2 levels increase, so does the level of CO_2 in the oceans. Although the air may benefit from the ocean removing CO_2 from the atmosphere, it is not so good for the oceans themselves. The CO_2 absorbed by

the oceans is changing the water chemistry in a process called ocean acidification.

Ocean acidification is the process where the ocean's pH decreases. The pH scale, is from 0 to 14, where numbers below 7 are considered acidic and numbers above 7 are considered basic, and 7 is considered neutral. Therefore, when the pH of the oceans decreases it means the oceans are becoming more acidic. When CO_2 is absorbed by the oceans, it becomes dissolved in the water. This forms carbonic acid (H_2CO_3). This process occurs mainly near the surface, as that is where the CO_2 from the atmosphere is being absorbed. Therefore, the surface of the oceans is more acidic than the bottom of the oceans.

Coral Reefs

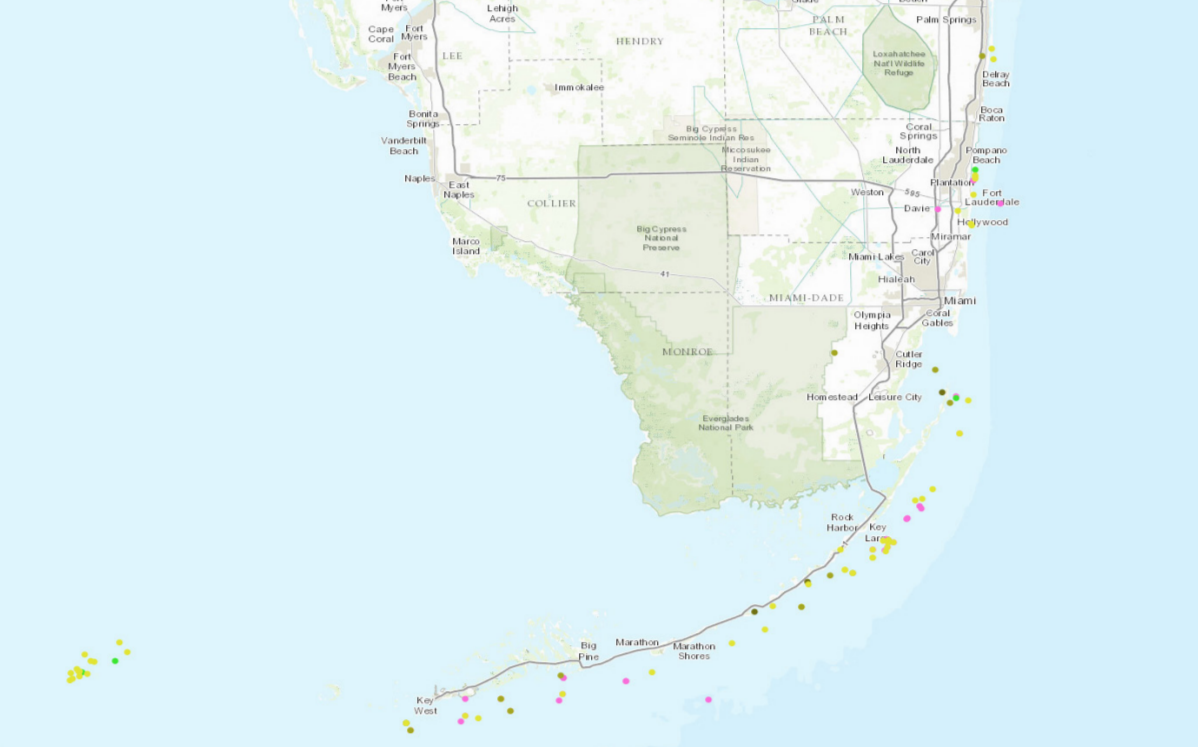
Coral reefs may look like rocks piled up on a shallow ocean floor but they are really a collection, or colony, of tiny living organisms. There are many different types of coral, but all coral are tiny animals that build protective calcium carbonate skeletons. They form skeletons by using dissolved calcium and carbon dioxide from the sea and mix it with water. They secrete a calcium carbonate mixture and build their skeletons. The living animals build their skeletons on the remains of dead coral and over time as skeletons are built on top of older dead skeletons, a large mass of calcium carbonate develops. This is called a coral reef. Only the outside portion of the reef is alive with living coral sitting on top of the remains of dead coral skeletons.

Coral reefs are considered the "rainforests of the sea". A coral reef is home to many creatures. Its inhabitants include plants that undergo photosynthesis to give off nutrients which in turn give food and shelter to animals. Reefs also filter the ocean helping to provide clean, fresh water to its occupants. The characteristics of corals, such as color and texture, depend on the organisms that created and live in the reef. Below is a picture of a reef with a variety of different types of coral.

Florida's Coral Reefs

Coral reefs require a very specific set of conditions to form. They grow only in oceans that have a solid structure to attach to, warm water that is low in phosphate and nitrogen, and moderate waves to wash away wastes and can bring in oxygen and plankton to the reef. The near coastal water of south Florida meets these conditions. In fact Florida is the only state in the continental United States to have shallow coral reef near its coastline. Being near the coastline means the reefs are also near cities, towns and highways, allowing visitors and residents easy access to visit the reefs.

One of Florida's industries is tourism and much of the tourism cen-



MyCOE ArcGIS map of coral reefs in Florida

ters around south Florida's beach activities. Many people come to Florida to scuba and snorkel around the coral reefs. Biscayne National Park is mostly underwater and attracts tourists by offering easy access to reefs. In the Florida Keys, John Pennekamp Coral Reef State park also offers visitors the chance to view coral reefs up close. Florida is one of the world's leading areas for sports fishing, and most of Florida's sport fish species live around the reefs of south Florida. Above is a map that shows the locations of coral reefs around Florida.

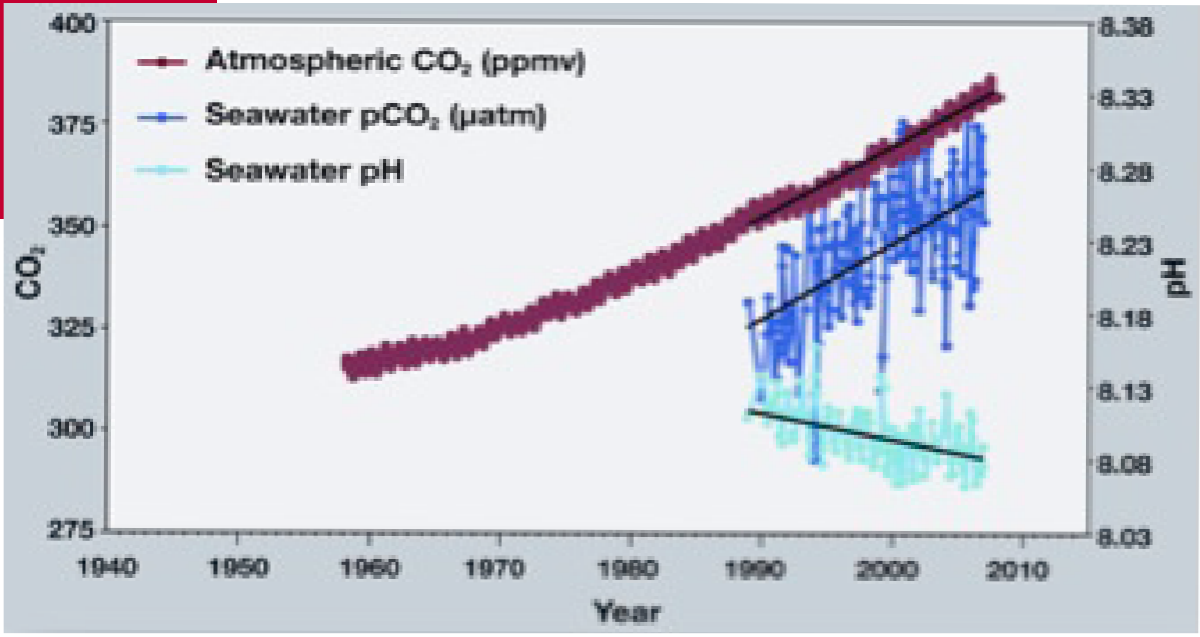
Impact of Acidification on Florida's Reefs

Research has shown the ocean's pH in the past to have been slightly basic, averaging about 8.2. However, today, it is has decreased to be about 8.1. This may seem small but it is a drop of 0.1 pH units, which is a 25% increase in acidity over the past two centuries. The graph below shows the change in pH of the oceans as CO_2 is increased in the atmosphere.

South Florida's coral reefs have been taking damage from global warming as a result of ocean acidification. Ocean acidification occurs mostly near the surface of the ocean, Most of the life in the oceans is near the surface, and south Florida's beaches are very shallow, therefore the change in the pH of the oceans has badly affected the reefs and ocean life in south Florida.

Coral undergoes different stages in development, one of them being the formation of their skeleton. As the oceans become more acidic it slows down how quickly coral can grow its carbonate skeleton. This results in a decrease in the growth rate of the entire reef. This has a domino effect which then causes a weaker structural support for the coral and the reef, which in turn makes erosion by waves possible.

Changes in the pH of water can also cause problems for corals through a process called coral bleaching. Stress on ocean water such as a change in the chemistry, or a change in temperature such as being too hot or too cold can cause corals to expel algae they live with symbiotically. The algae are called "zo-



A decrease in pH (and increase in acidity) of ocean water as CO2 increases in the atmosphere

oxanthellae" and live in the tissue of coral. When the algae leaves the coral it causes the coral to turn completely white. Although coral bleaching does not immediately kill coral, it can put the coral under more stress which may eventually lead to the death of the reef. Below is a picture showing coral bleaching.

The consequences of ocean acidification on coral and reef communities may be worse than previously thought. As the reefs become impacted, the fish that rely on the reefs move out from the devastation. Below is a map showing the areas of reefs thought to be in greatest danger from global warming and ocean acidification.

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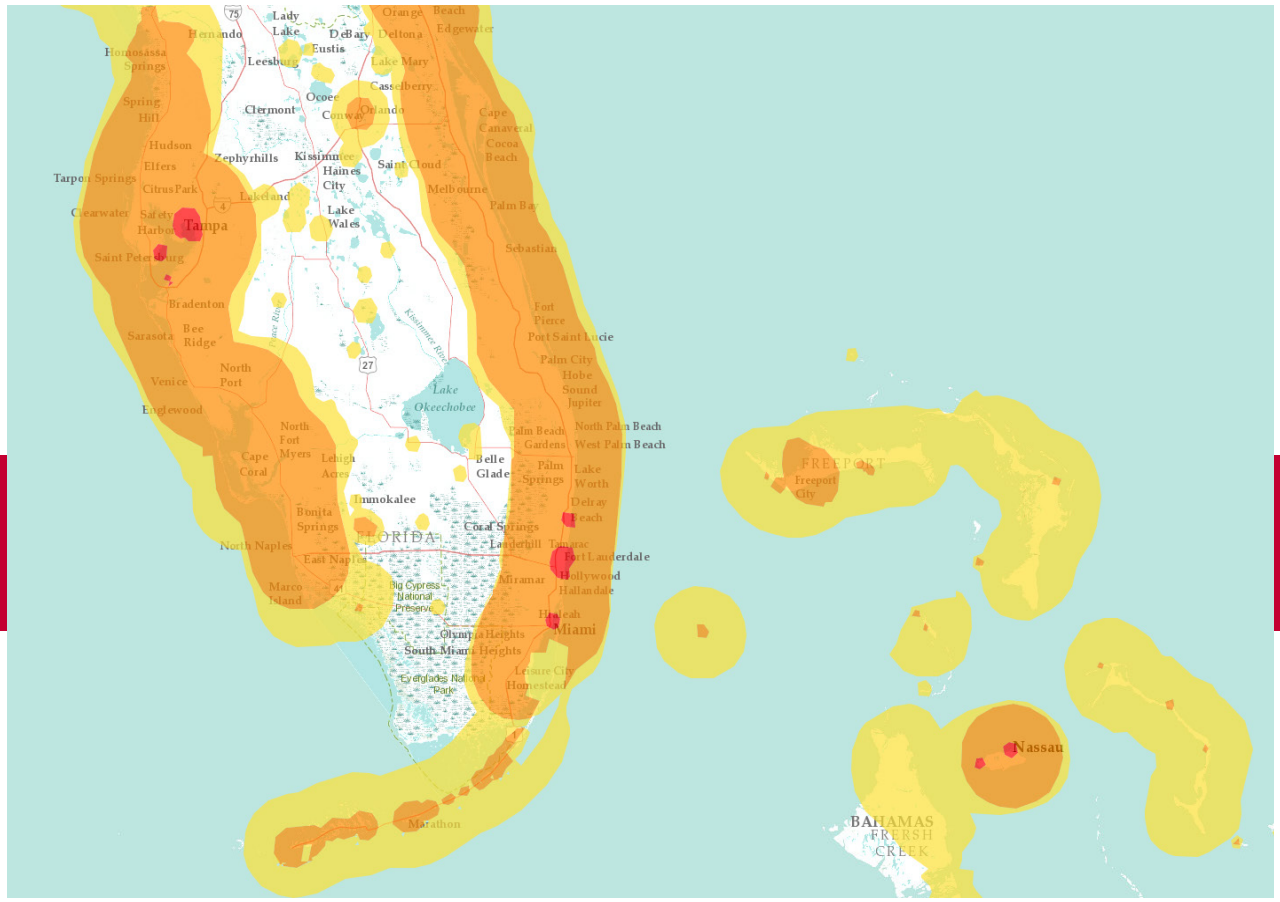
Coral reef threat levels, red = highest



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