Climate Change and the Oceans

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While some politicians claim that climate change is a hoax, and climate scientists try to refine their models and forecasts of how much warming will take place in the next few decades, marine scientists can see clearly the evidence of what has already happened.

One reason global warming has not been too bad as of yet is because the ocean absorbs over 90% of the Earth's excess heat, resulting in increasing ocean temperatures due to greenhouse gas emissions. According to the National Oceanic and Atmospheric Administration (NOAA), half of the increase in global ocean heat content since 1865 has occurred over the past two decades. Warmer water holds less oxygen, but the respiration rate of animals (except for marine mammals) goes up with temperature, so they need more oxygen at the same time that less is available. A warmer ocean has less turnover (vertical water movements), which normally brings nutrient-rich water up from deep

water to the plankton that photosynthesize near the surface. Without the nutrients, they photosynthesize less and animals don't get enough food.

Many species are moving north to find more suitable environments, including species of commercial importance. Lobsters are disappearing from Long Island and southern New England but increasing in the Gulf of Maine and Canada. Commercial catches are regulated by regional management agencies, but now these animals are fewer where they used to be and are increasing in places where they weren't important before.

The most dramatic and tragic responses to warming oceans are in corals, which are very sensitive. A rise of a few degrees can lead to illness, and eventually, death. The average ocean temperature has risen by more than one degree Fahrenheit. When stressed, corals eject the single-celled symbiotic algae that live in their tissues, which normally photosynthesize and provide the coral with most of its nutrition. When they are ejected, the coral is "bleached" and appears white. While they can still get some nutrition by catching plankton with their tentacles, most species get less than half of their nutrition this way, so if the stress persists and zooxanthellae do not return, corals die. About 30% of the Great Barrier Reef of Australia died between2016 and 2017. This die-off is devastating not only for the corals but also for the thousands of other species that depend on the reef, including humans, who depend on it for $6 billion in tourism revenue annually. An excellent documentary about this tragedy, called "Chasing Coral," is available on *Netflix*.

Major changes are occurring in polar regions where the extent of sea ice is diminishing rapidly.

July 12, 2017, *The New York Times*: "A chunk of floating ice that weighs more than a trillion metric tons broke away from the Antarctic Peninsula, producing one of the largest icebergs ever recorded and providing a glimpse of how the Antarctic ice sheet might ultimately start to fall apart."

As ice melts, the water gets fresher and normal algal blooms diminish, providing less food at the bottom of the food chain on which the rest of the ecosystem depends. Some species that depend on sea ice, like Adelie penguins in Antarctica and polar bears in the Arctic, are in trouble.

Closer to home, sea level rise (SLR) is one effect of warming that is apparent in coastal regions. SLR results from water expanding when it warms plus the addition of new water from melting glaciers, and it is happening faster than was predicted. Increased flooding from storms is common, and many areas (e.g. South Florida) have flooded streets even on sunny days. Flooding from storms becomes more damaging and expensive with SLR. Since much of the world's population lives in coastal areas, threats to human lives and well-being are becoming apparent. In Bristol Bay Alaska, the ability of local communities to access subsistence resources is being impaired. Changes in the timing of ice freeze and melt are affecting safety, making it difficult to travel to neighboring villages and in some cases causing loss of life. Residents of some small low-lying Pacific islands have already moved elsewhere, and such "climate refugees" are expected to increase in the future, which can cause political and social problems.

It is not only human communities but also natural communities that are at risk. Coastal salt marshes in the intertidal zone are very important ecosystems that take the edge off storm surge and winds, absorb pollutants, and provide habitat for a variety of crabs, shrimp, fishes, birds, mammals, etc. In the face of SLR, marshes must either increase their elevation or move inland. The increase in elevation is due to new sediments being deposited and organic matter accumulation from marsh plants. Many marshes in the Northeast do not have adequate input of new sediments to increase their elevation, so moving back is the only option. The marshes in the Accabonac Harbor, for

instance, are increasing sediments but not organic matter from plants, and do not appear to be keeping up with SLR over the past decade. In developed regions, there are roads, sidewalks, etc., immediately inland, so there is no place for the marshes to go. Subject to “coastal squeeze”, many marshes will disappear.

Another component of forecasted climate change is increased rainfall in the northeast. This will intensify the nitrogen problem in many estuaries since more rain means more runoff and more nitrogen going into the water. Thus, the dramatic increase in algal blooms in our ponds and harbors in recent years. Warmer water in the future will also accelerate algal blooms.

Ocean Acidification: About 1/3 of the CO2 we put into the atmosphere dissolves in the ocean, thereby reducing the amount of atmospheric warming, which is “good.” However, CO2 in the ocean combines with water to form carbonic acid and increases the acidity of the water. In recent decades, the oceans have become 30% more acidic. This affects marine animals; the most severe is impairing shell formation in animals with calcium carbonate shells, such as clams, mussels, corals. This has already occurred: in the Pacific Northwest, oyster larvae in hatcheries are unable to make their shells properly. Tiny planktonic snails are showing eroded shells. This water poses an additional stress to corals already suffering from rising temperatures. A less publicized effect is on behavior. Acidified waters impair the sense of smell of fish, causing them to be unable to find their home reef, and to move toward, rather than away from, the odor of a predator. While wetlands can remove carbon from the atmosphere and store it for hundreds of years and thus combat acidification, their extent is diminishing.

What can be done to save our threatened marine environment? We need rapid decreases in emissions of greenhouse gases, especially carbon dioxide. While governmental and international actions are vita, it is also important to keep up the pressure on all your elected officials to do more—collectively, individuals can make a difference. Examine your “carbon footprint.” Does your car use a lot of gas? Next time, buy a hybrid or electric. Do you drive short distances that you could walk? Or take public transportation? How high is your electric bill? Could you keep your house a bit warmer in the summer and a bit cooler in the winter to save energy? How about using solar power to offset your electricity usage? Could you eat less meat and more vegetables? Animal agriculture, especially beef, creates a huge amount of greenhouse gases. Together, these actions will make the quality of life better for everyone.

Image credit: NOAA