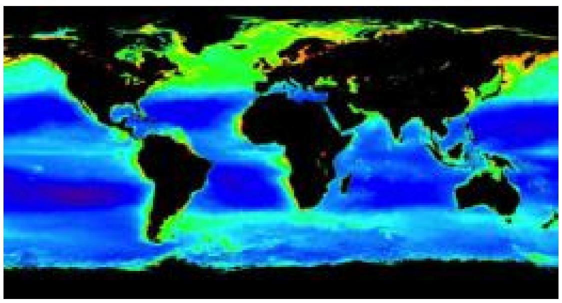
# The breathing ocean: Reducing the effects of climate change

June 20 2013



Worldwide view of plankton from NASA's Sea-viewing Wide Field-of-view Sensor. Credit: NASA

(Phys.org) —Each year, between the burning of fossil fuels and the clearing of old growth forests, humans put about 10 petagrams of carbon dioxide (CO2) into the atmosphere. A petagram is one quadrillion grams. Ten petagrams is equivalent to the mass of Halley's comet, to put it in perspective.

Having a steady amount of CO2 in the atmosphere is necessary to ensure stable average temperatures across the globe. Ideally, carbon output and uptake would balance out, as it has for centuries. But since the industrial revolution, human activities have disturbed that equilibrium, resulting in excess atmospheric CO2. As a greenhouse gas, CO2 prevents heat from escaping Earth's surface through the atmosphere. Most of the scientificMassive Open Online CoursesMassive Open Online Courses community believes this is the primary cause of global climate change.

Fortunately, the ocean helps mitigate the effects of that excess CO2, absorbing anywhere from a quarter to a third of our carbon emissions. Some of the CO2 dissolves into the cold waters of the polar seas. But a large portion is removed from the atmosphere by tiny organisms most people know nothing about.

Those organisms are phytoplankton – microscopic algae that are the basis for the entire food web in the ocean. Phytoplankton are like the grass of the sea. They can be found in virtually any body of water that is exposed to sunlight. They photosynthesize, turning carbon dioxide into sugar in order to grow, and simultaneously produce oxygen. In fact, half the oxygen in our atmosphere was made by phytoplankton.

These microscopic algae are also the main food source for a variety of grazing ocean animals, such as small crustaceans and fish. Once the animals digest the phytoplankton, they produce fecal pellets that sink deep into the ocean. Some of this organic material feeds the animals and bacteria of the deep sea, but some of it actually reaches the ocean floor and gets buried.

Scientists call this process the biological carbon pump, and it takes place all over the world. It's important because when fecal pellets containing phytoplankton sink, the CO2 within them is removed from contact with the atmosphere.

"It's the only mechanism that can actually permanently bury organic carbon," says Susanne Neuer, a plankton ecologist in ASU 's School of Life Sciences. "The carbon is buried on geological time scales, so that's gone for a very long time."

According to a 2008 study led by NASA, the upper safety limit for atmospheric $CO_2$ is 350 parts per million (ppm). But that amount was surpassed years ago, and current data suggests a continued upward trend.

"Earth's current atmospheric $CO_2$ concentration is almost 400 ppm. Without the ocean, it would be close to 480 ppm," Neuer says. One ppm is equal to about 2 petagrams of carbon, or the amount that humans put into Earth's atmosphere in a little over two and a half months.

Essentially, the ocean has bought us time – maybe 40 or 50 more years – to figure out how to reduce our $CO_2$ emissions on a global scale. Meanwhile, phytoplankton will continue to quietly remove massive amounts of $CO_2$ from the atmosphere. But for how vital these tiny organisms are to the health of our planet, there is still much left unknown about them.

In her lab at ASU, Neuer has been studying the biological carbon pump in the Sargasso Sea. Located entirely within the subtropical Atlantic Ocean, it is the only sea defined not by land but rather by ocean currents. Neuer has also investigated the oceans north of the Canary Islands, finding that the carbon pump in this area is much less efficient, taking in less carbon than that of the Sargasso Sea.

"That's a huge thing, because we don't really understand why," Neuer says. "One of the hypotheses that we still have to study is the role of the phytoplankton."

In order to do that, Neuer's team is collecting samples of ocean water from different depths. They have innovated a method of trapping and analyzing phytoplankton particles as they sink in the ocean. Team members stationed out at sea deploy cylinders, about 12 centimeters wide, from a ship designated for research. The cylinders are cast out at various depths, the shallowest of which is 150 meters. After a day or two of catching particles, the whole array of cylinders is brought back to the ship and samples are sent to Neuer's lab at ASU.

That's where undergraduate student researcher Demetra Hamill comes in. Using an epifluorescence microscope, she analyses DNA of the sample particles to find out which types of phytoplankton are present in the traps. She then compares samples from the sunlit ocean surface to samples from other depths to see how the community of phytoplankton and grazers changes deeper in the ocean.

"It's an oil immersion microscope, which uses auto fluorescence from the organisms. You can see the colors as they fluoresce, and that allows you to determine what type of organism it is," Hamill says. "For example, chlorophyll will fluoresce red under blue light, so you can tell that organism can do photosynthesis. Heterotrophic organisms, which cannot perform photosynthesis, will fluoresce a greenish color."

Hamill's analysis helps determine how much phytoplankton is being grazed, and by what types of creatures. Ultimately, Neuer's team is interested in deciphering the food web interaction among organisms in the water column.

"We're trying to categorize the whole interaction in the ocean and the sinking carbon and the moving carbon, but it takes a lot to figure out what all the little parts do. What I'm doing is just a small part of the overall big picture," Hamill says.

As a recent graduate of Barrett, The Honors College, Hamill was required to complete some type of undergraduate research for her Genetics, Cellular and Developmental Biology degree. However, the world of marine biology was at first unfamiliar territory.

"I had no idea what I was really getting into," Hamill says. But Neuer acted as a mentor from the beginning, eventually serving as director for

Hamill's honors thesis committee.

Hamill graduated in May after working for nearly a year in Neuer's lab, an experience she says prepared her for future research and made her education at ASU feel more hands-on. While she plans eventually to attend graduate school, Hamill is still deciding which program to pursue. Like many recent graduates, she faces the daunting task of selecting one area of study from a sea of potential options.

But for Neuer, the choice to be a plankton ecologist was always clear. Even before she knew the importance of phytoplankton in mediating the effects of global climate change, Neuer loved the ocean and the organisms living within it. As a young girl growing up in Germany, she spent summers snorkeling in the Mediterranean. By the age of 13, she had earned enough money to buy her first microscope, which she used to examine the contents of lakes and ponds near her home.

"I guess there are a few people who know early on what they want to be. That was the case for me," Neuer says.

Now, as part of her research grant from the National Science Foundation, Neuer is inspiring other young minds to take interest in marine biology. She has partnered with ASU's Ask-a-Biologist initiative, which is geared toward a K-12 audience, to produce articles and podcasts about her research with plankton and the oceans.

After having a conversation with Neuer about her work, it's clear she still has all the passion and curiosity of that 13-year-old explorer.

"Something that is so close to my heart is that plankton is so important. And it's not only in the ocean, it's in any freshwater body that you go to. Most people don't know much about it because it's so small, yet they are amazingly important organisms that we can't see."

Provided by Arizona State University

Citation: The breathing ocean: Reducing the effects of climate change (2013, June 20) retrieved 20 April 2024 from https://phys.org/news/2013-06-ocean-effects-climate.html

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