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Gail Gallessich

Marine Researchers Fertilize Southern Ocean with Iron to Study Past and Future Climate Change

Scientists are learning about the history and possibly the future of climate change by fertilizing the ocean with iron to create blooms of microscopic plants.

These microscopic marine plants in the Southern Ocean may have played a pivotal role in the Earth's climate during past ice ages, explained Mark Brzezinski, professor of biology and deputy director of the Marine Science Institute at the University of California, Santa Barbara.

He took part in a major ocean fertilization study involving many institutions that began 12 years ago. The research is funded by the National Science Foundation and the Department of Energy. The results of the research project are described in the April 16 cover story of the journal Science, in a three-part description of the findings.

There are three major areas of the ocean where iron is a limiting factor in the growth of these plants: the sub-Arctic Pacific, the Equatorial Pacific, and the Southern Ocean. By adding iron to the ocean's surface, the tiny plants, called phytoplankton, increase in number in these locations. The plants need carbon dioxide -- an important greenhouse gas -- to live. The source of their carbon dioxide is the atmosphere, and more plants means more carbon dioxide is taken from the atmosphere. By enriching the plants with iron, carbon dioxide is transferred from the atmosphere to the ocean.

Iron was more plentiful in the atmosphere during the ice ages because the Earth was drier at that time. The dryness caused more dust to be picked up by the wind, and the dust contained iron, which then fertilized the ocean. More plant productivity in the ocean meant a reduction in carbon dioxide in the atmosphere.

Brzezinski, one of 17 principal investigators, took part in a major expedition to the Southern Ocean to test the theory. He spent 42 days at sea. With technician Janice Jones and graduate student Mark Demarest, both from UCSB, he took part in the dropping of a yellowish powder of iron sulfate, mixed with ocean water, into two areas of the Southern Ocean. The goal was to observe the growth and fate of the marine plants under such enriched conditions.

In order to simulate ice-age conditions, the scientists added iron to surface waters in two patches, each 15 kilometers on a side, so that the concentration of this micronutrient reached about 50 parts per trillion -- a 100-fold increase over ambient concentrations. Even at this low concentration, massive blooms of phytoplankton occurred at both locations. These blooms covered thousands of square kilometers, and were visible in satellite images of the area.

Each of these blooms consumed over 30,000 tons of carbon dioxide. Of particular interest to the scientists was whether this carbon dioxide would be returned to the atmosphere, or would sink into deep waters as the phytoplankton died or were consumed by grazing marine organisms.

Certain plants, like diatoms, are heavy and sink to the deep ocean. "If they are eaten, or decomposed by bacteria, and if that occurs at depth, then the carbon dioxide is retained in the deep sea where it is sequestered for at least 1,000 or more years," said Brzezinski.

Some of the findings from the study suggest that, when extrapolated over large regions, iron fertilization could cause billions of tons of carbon to be removed from the atmosphere each year. Removal of this much carbon dioxide from the atmosphere could have helped cool the Earth during ice ages.

Similarly, some people have proposed that a massive iron fertilization program could help mitigate the current trend toward global warming. Brzezinski, however, does not hold out much hope for the prevention of global warming through fertilization of the ocean. He said that his measurements did not show a strong enough result to expect that fertilization could reverse global warming. "It's still an open question as to whether or not this is a viable way to export carbon to the deep sea," he said.

Brzezinski is particularly interested in the availability of silicon to phytoplankton, another limiting factor like iron. The southern part of the Southern Ocean has plenty of silicon, and the northern part has low levels. Diatoms, for example, need silicon. They are heavy and sink rapidly to the deep ocean when fertilized with iron. Brzezinski's studies showed that the lack of silicon in the northern part of the Southern Ocean severely restricted the growth of diatoms after iron was added.

Yet there are other forms of phytoplankton that do not require silicon for growth. These forms bloomed in the northern region, still consuming vast amounts of carbon dioxide.

This finding has doubled the area of the Southern Ocean that scientists believe could be important for carbon cycling.

The study was headed by Kenneth Coale of Moss Landing Marine Laboratories and Ken Johnson of Monterey Bay Aquarium.

The research, known as SOFeX, for Southern Ocean Iron Enrichment Experiments, was carried out in 2002 after a decade of planning and preparation.
