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Phytoplankton and Polynyas [1]

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Climate link to primary productivity in the Ross Sea is investigated.

- About National Snow and Ice Data Center DAAC (NSIDC DAAC) [2]

The Ross Sea is home to Antarctica's largest polynya (an area of open water surrounded by ice). It was first spotted by explorers in the early 19th century, and then by satellite imagery in the 1970s. Since 1975, scientists have monitored the polynya closely to determine its role in global primary production and carbon cycling in the Ross Sea.

The Ross Sea is an ideal location for research on climate changes and carbon cycling in high-latitude environments because it represents a typical Antarctic coastal region, has well-defined boundaries and current circulation, and exhibits large biogenic production in the form of plankton. In combination, these factors also result in a fairly simple model representative of a polar ocean. Polynyas are significant because they allow light and nutrient conditions in which seasonal, very dense blooms flourish, creating a significant carbon sink.

In late November each year, the polynya in the Ross Sea opens, reaching its fullest extent in January (Antarctica's brief summer). During this time, researchers observe enormous phytoplankton blooms, particularly around the receding ice edge. Phytoplankton absorb atmospheric carbon, and with such a large annual bloom in the polynya, researchers realized that the Ross Sea might play a greater role in global carbon cycling than was previously thought.

"What ultimately lead to this study is that models for climate change predict larger changes at the poles, so the Ross Sea is a place where small changes may show up first," says Rob Dunbar of Rice University, who has done field work in Antarctica since 1982. By using a variety of methods and tools, such as weather stations, ocean moorings, and satellite imagery, Dunbar and other researchers can begin to piece together a more accurate view of the role of polar regions in climate change.

During field programs in 1991 and 1992, researchers collected water samples, temperature-depth readings, sediment cores, and biogenic particles. Throughout the study, three ocean moorings were used to obtain a time-series of information on organic particulates in the ocean below and around the sea ice. Each had two particle traps attached, one about 250 meters below the surface, and another about 50 meters above the sea floor.

Placed in locations that exhibit differing sea ice conditions, the moorings were used to measure variations in primary production as well as distribution of biogenic forms and organic matter. The sediment traps featured 14 cups that rotated into place every few weeks, gathering plankton, silica, and diatoms over a two-year period.

Throughout the study, passive microwave brightness temperature data from the National Snow and Ice Data Center DAAC provided information on sea ice concentration and ice edge growth and recession. Researchers used averaged ice concentrations to estimate sea ice cover during years in which they performed field work, and used satellite imagery from 1978 to 1994 to analyze longer term variations in sea ice extent and concentration.

Though the investigators encountered technical problems with cup rotation and mooring retrieval, they still obtained sufficient information to determine biogenic populations in different parts of the Ross Sea. They also developed a time series of plankton bloom and dissolution, and determined spatial and temporal variations in primary production.

As witnessed in the annual polynya blooms, productivity reaches a peak in mid to late December along the receding ice edges, and then declines steadily into January and February as the ice freezes and closes the polynya. "If you look at sea ice data archives, December is a key time for phytoplankton." Dunbar says, "Algae need to have open water." In years that the polynya did not open to such a large extent, phytoplankton blooms were minimal, and primary productivity was consequently lower.

The annual event of the Ross Sea polynya provides insight into how polar regions interact with and potentially influence larger climate systems. Whether or not the polynya opens each year depends on several factors. The distribution and condition of sea ice reflects changes in wind speed and direction, changes in atmospheric and ocean temperature, and changes in weather patterns.

Carbon cycling in the Ross Sea is more than a modeling scheme component. Primary productivity is vital to marine life. Algae require open water to bloom, so when the polynya does not open, the marine food chain is interrupted.

"If you're part of the food chain," Dunbar explains, "this is it." During years when the Ross Sea polynya did not open, "there was a lot of seal mortality because the base of the food chain was perturbed -- everything there is marine-based, delicately in balance with physical conditions."

Dunbar plans to continue studying Antarctic carbon cycling using similar techniques, and will continue to rely on sea ice data from the National Snow and Ice Data Center. Carbon uptake in Antarctic phytoplankton blooms may seem a small factor in global carbon cycling, but Dunbar insists that it is necessary to understand as many components in the process as possible in order to come up with a complete picture of climate change.

Reference(s)

Dunbar, R. B., A. R. Leventer, and D. A. Mucciarone. 1996. Water column sediment fluxes in the Ross Sea, Antarctica (I): Atmospheric and sea ice forcing. Submitted to Journal of Geophysical Research.

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