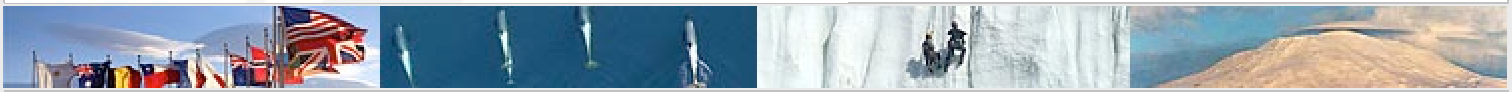

OCEAN AND CLIMATE SYSTEMS

A Long Duration Balloon lifts off near McMurdo Station, Antarctica, carrying a science payload. The balloon will circumnavigate the continent, following a high altitude wind current. Using the balloon to carry instruments to the edge of space is more cost efficient than using a satellite or the space shuttle. The balloon will expand at the edge of space to 11 million cubic meters. Once the balloon returns to the McMurdo area, a signal is sent to the module to release it from the balloon. A parachute activates to slow the payload's descent to the ground. A crew is then sent to retrieve the scientific instruments. (*NSF photo by Brien Barnett*)

On this page:

Overview

Though it borders the world's major oceans, the Southern Ocean system is like no other in the world, with 4 times more water than the Gulf Stream and 400 times more than the Mississippi River. It is a sea where average temperatures do not reach 2°C in the summer, where even the water itself is so distinctive that it can be identified thousands of miles away in currents that originated here. These Antarctic Bottom Waters provide the major source of cooling for the world's oceans. In fact, if the Earth is a heat engine, Antarctica should be viewed as its circulatory cooling component.

The climate in Antarctica is also unique, linked as it is to the extreme conditions of the land, ice, and sea below the troposphere (the inner region of the atmosphere, up to between 11 and 16 kilometers). This ocean/atmosphere environment defines and constrains the marine biosphere and in turn has a dynamic relationship with the global ocean and with weather all over the planet. Few major energy exchanges on Earth can be calculated without factoring in these essential antarctic phenomena. As such, they are both an indicator and a component of climate change.

The Ocean and Climate Systems Program supports research that will improve understanding of the high-latitude ocean environment, including the global exchange of heat, salt, water, and trace elements; there is also an emphasis on sea-ice dynamics, as well as the dynamic behavior and atmospheric chemistry of the troposphere. Major program elements include the following:

- **Physical oceanography:** the dynamics and kinematics of the polar oceans; the interaction of such forces as wind, solar radiation, and heat exchange; water-mass production and modification processes; ocean dynamics at the pack-ice edge; and the effect of polynyas on ventilation.

- **Chemical oceanography:** the chemical composition of sea water and its global differentiation; reactions among chemical elements and compounds in the ocean; fluxes of material, within ocean basins and at their boundaries; and the use of chemical tracers to map oceanic processes across a range of temporal and spatial scales.
- **Sea-ice dynamics:** the material characteristics of sea ice, from the level of the individual crystal to the large-scale patterns of freezing, deformation, and melting.
- **Meteorology:** atmospheric circulation systems and dynamics, including the energy budget; atmospheric chemistry; transport of atmospheric contaminants to the antarctic; and the role of large and mesoscale systems in the global exchange of heat, momentum, and trace constituents.

Antarctic Troposphere Chemistry Investigation (ANTCI).

Fred Eisele, Douglas Davis, Yuhang Wang, David Tan, and L. Greg Huey, Georgia Institute of Technology; Richard Arimoto, New Mexico State University; Detlev Helmig, University of Colorado–Boulder; Manuel Hutterli and Roger Bales, University of Arizona; Jack Dibb, University of New Hampshire; Donald Blake, University of California–Irvine; and Richard Shetter and Roy Mauldin, National Center for Atmospheric Research.

We will study sulfur chemistry in the antarctic atmosphere to enhance our understanding of the processes that control tropospheric levels of reactive hydrogen radicals, reactive nitrogen, sulfur, and other trace species for the further purpose of improving the climatic interpretation of sulfur-based signals in antarctic ice-core records. Specifically, we will be making observations of reactive hydrogen radicals, sulfuric acid and its sulfur precursors, and the flux of ultraviolet radiation. The results we derive will lead to a more comprehensive understanding of antarctic atmospheric chemistry, as well as the factors that influence the levels and distributions of climate proxy species in antarctic ice cores.

Our major science objectives include

- evaluating the processes that control spring and summer levels of reactive radicals in the atmospheric surface layer at the South Pole,
- assessing how representative previously obtained South Pole and coastal measurements are in the larger context of polar plateau processes, and
- investigating the relative importance of the oxidative processes involved in the coast-to-plateau transport of reduced sulfur and determining the principal chemical transition regions.

Secondary objectives include investigating snow/firn chemical species that undergo extensive exchange with the atmosphere and assessing the different chemical forms of the trace elements and their relationships to levels of ozone and other oxidants.

Atmospheric sulfur chemistry is important in climate change because both naturally and anthropogenically emitted sulfur compounds form minute particles in the atmosphere (so-called aerosols) that reflect solar radiation, produce atmospheric haze and acid rain, and affect ozone depletion. These sulfate particles may also act as condensation nuclei for water vapor and enhance global cloudiness. The primary natural sources of sulfur are volcanic emissions and dimethylsulfide production by oceanic phytoplankton.

On the millennial time scale, the variability and background level of atmospheric aerosols can be reconstructed from ice cores. It is, however, necessary to understand how the physical and chemical environment of the process affects the relative concentrations of the oxidation products that become buried in the ice. (O–176–M/S; NSF/OPP 02–30246, NSF/OPP 02–29633, NSF/OPP 02–29605, NSF/OPP 02–30046, NSF/OPP 02–30051, NSF/OPP 02–30117, and NSF/OPP 02–30178)

Antarctic Meteorological Research Center (AMRC).

Charles R. Stearns, University of Wisconsin–Madison.

The Antarctic Meteorological Research Center (AMRC) was created in 1992 to improve access to meteorological data from the Antarctic. The AMRC's mission is to conduct research in observational meteorology and the stewardship of meteorological data, along with providing data and expert assistance to the antarctic community to support research and operations. The AMRC fulfills its mission by

- continuing to maintain and expand, as appropriate, the long-term record of all meteorological data on Antarctica and the adjacent Southern Ocean and make these data available to the scientific community for multidisciplinary use (special attention will be given to obtaining data not normally or readily available by other means);
- continuing to generate satellite products, specifically—but not limited to—antarctic composite imagery, and expand and improve on them as much as possible;
- conducting research in observational meteorology, especially with regard to climatological analyses and case studies; and
- continuing to conduct and expand, as appropriate, educational and public outreach activities associated with antarctic meteorology and related fields.

Using available meteorological interactive processing software and other standard computing tools, we will collect data from all available sources for processing, archiving, and distribution. The mission of the AMRC not only includes the opportunity to advance the knowledge of antarctic meteorology, but with the free availability of its data holdings, the AMRC gives others the opportunity to advance the frontiers of all antarctic science. Continuing educational outreach activities on meteorology and the Antarctic, an important component of this work, have the potential to raise the science literacy of the general public, as well as the level of K–12 science education. (O–202–M/P/S; NSF/OPP 01–26262)

Changes in atmospheric oxygen (O_2), carbon dioxide (CO_2), and argon (Ar) concentrations in relation to the carbon cycle and climate.

Ralph F. Keeling, University of California–San Diego, Scripps Institution of Oceanography.

Oxygen, the most abundant element on Earth, comprises about a fifth of the atmosphere. But much of the Earth's oxygen resides in other chemical species (in water, rocks, and minerals) and, of course, in the flora and fauna that recycle it (both directly and as carbon dioxide) through photosynthesis and respiration. Thus, scientists are interested in measuring the concentration of molecular oxygen and carbon dioxide in air samples; our project includes a subset of collections (flask sampling of air) being made at a series of baseline sites around the world. The two antarctic sites are South Pole and Palmer Stations.

These data should help improve estimates of the processes whereby oxygen is cycled throughout the global ecosystem, specifically through photosynthesis and atmospheric mixing rates, and also improve predictions of the net exchange rates of carbon dioxide with biota, on land and in the oceans. An important part of the measurement program entails developing absolute standards for oxygen-in-air to ensure stable long-term calibration. In addition, we are conducting surveys of the oxidative oxygen/carbon ratios of both terrestrial- and marine-based organic carbon, hoping to improve the quantitative basis for linking the geochemical cycles of oxygen and carbon dioxide. The project will also entail continued measurements of changes in atmospheric argon concentrations, which provide constraints on the magnitude of air-sea heat exchange and on oceanic influences on atmospheric oxygen.

The data we gather will be of great use in modeling studies of ocean circulation and various carbon-related processes. Technology for making climate-relevant observations will be advanced and made available to the scientific community through publications and student training. This project will help enhance our understanding of the processes that regulate the buildup of carbon dioxide in the atmosphere and of the change processes, especially climate change, that regulate ecological functions on land and sea. (O–204–P/S; NSF/ATM 03–30096)

Processes driving spatial and temporal variability of surface pCO_2 in the Drake Passage.

Taro Takahashi, Columbia University, and Jorge Sarmiento, Princeton University.

The Southern Ocean provides an important component of the global carbon budget. Cold surface temperatures, with consequent low vertical stability, ice formation, and high winds, produce a very active environment in which the atmospheric and oceanic reservoirs readily exchange gaseous carbon. The Drake Passage is the narrowest point through which the Antarctic Circumpolar Current and its associated fronts must pass; this so-called chokepoint provides the most efficient site to measure the latitudinal gradients of gas exchange.

Working from the research ship *Laurence M. Gould*, we will use equipment designed to measure dissolved carbon dioxide gas, occasional total carbon dioxide, nutrients, and carbon-13 in the surface waters during transects of the Drake Passage. Two short cruises (4 to 5 days) will also be dedicated to providing a baseline for surface measurements with water column profiles.

This work extends similar measurements made aboard the research ship *Nathaniel B. Palmer* and complements other data collected on surface temperatures and currents. The objective is to test the hypothesis that the mean annual partial pressure of carbon dioxide (pCO_2) in the surface water of the Drake Passage is determined by the degree of winter mixing. This is of special significance in light of two scenarios that may be affecting the ventilation of deep water in the Southern Ocean now and in the future:

- a decrease in water column stratification with observations of higher zonal winds, or
- an increase in stratification due to higher precipitation and warming from climate change.

If winter mixing determines the mean annual pCO_2 in the Drake Passage, the increasing trend in atmospheric pCO_2 will have little effect on sea surface pCO_2.

The data sets we will gather, supplemented by satellite imagery, will enable scientists to estimate the net production and carbon export by the biological community, as well as the basic targets—a quantitative description of the sources of dissolved carbon dioxide variability and a calculation of carbon dioxide fluxes between the ocean and the atmosphere. These data will also help validate biogeochemical modeling efforts and provide a baseline data set for studies throughout the Southern Ocean. (O–214–L/N; NSF/OPP 03–38248 and NSF/OPP 03–38155)

South Pole monitoring for climatic change—U.S. Department of Commerce NOAA Earth System Research Laboratory, Global Monitoring Division.

David Hofmann, National Oceanic and Atmospheric Administration, Earth System Research laboratory, Global Monitoring Division.

For more than 30 years, the National Oceanic and Atmospheric Administration has been conducting studies to determine and assess the long-term buildup of trace atmospheric constituents that influence climate change and the ozone layer. Time-series analyses of long-term data provide insight into several phenomena of particular interest, including

- seasonal and temporal variations in greenhouse gases,
- the depletion of stratospheric ozone,
- transantarctic transport and deposition,
- the interplay of trace gases and aerosols with solar and terrestrial radiation fluxes that occur on the polar plateau, and
- the development of polar stratospheric clouds over Antarctica.

Project scientists measure carbon dioxide, methane, carbon monoxide, stable isotopic ratios of carbon dioxide and methane, aerosols, halocarbons, and other trace constituents. Flask samples are collected and returned for analysis, while concurrent *in situ* measurements of carbon dioxide, nitrous oxide, selected halocarbons, aerosols, solar and terrestrial radiation, water vapor, surface and stratospheric ozone, wind, pressure, air and snow temperatures, and atmospheric moisture are made. Air samples are also collected at Palmer Station.

These measurements allow us to determine the rates at which concentrations of these atmospheric constituents change; they also point to likely sources, sinks, and budgets. We collaborate with climate modelers and diagnosticians to explore how the rates of change for these parameters affect climate. (O–257–S; NSF/NOAA agreement)

The Drake Passage High-Density XBT/XCTD Program.

Janet Sprintall, University of California–San Diego, Scripps Institution of Oceanography.

At the latitude of the Drake Passage, which is off the tip of South America, there are no continental boundaries to impede the flow of the Antarctic Circumpolar Current. The continual circumpolar flow therefore provides an effective mechanism for water-property exchanges and the transfer of climate anomalies throughout the world's oceans. The region experiences the strongest winds in the world, driving the current and enhancing the large heat and momentum exchanges between the ocean and the atmosphere. Recent studies have shown that large fluctuations can occur from weekly to interannual time scales in response to regional and remote forcing.

The dynamics and heat exchange within the Southern Ocean are further complicated by the prevalence of eddy variability: Eddy heat flux probably plays a strong role in heat balance, with a more uncertain role in providing an effective mechanism for dissipating the energy input of the wind. We will attempt to determine the significance of the eddy fluxes to the heat and momentum balance of the current and their relationship to the forcing fields.

During each crossing of the research ship *Laurence M. Gould*, we intend to launch expendable bathythermographs (XBTs), supplemented by expendable conductivity- temperature-depth (XCTD) probes, to obtain high-density sections from which to study the seasonal variability and long-term change in the upper ocean structure of the Drake Passage. Whenever the distance between Antarctica and neighboring land is narrow, as in the Drake Passage, the Antarctic Circumpolar Current, which drives the waters in the Southern Ocean, is extremely strong.

The information we gather will lead to the establishment of a high-quality database that can be used to study the magnitude and depth of penetration of the seasonal signals, the connections to atmospheric forcing, and the effects of interannual variations such as those associated with the Antarctic Circumpolar Wave. The sections obtained during these voyages will supplement the approximately 20 sections that we have been gathering and studying since September 1996. Our data analysis will continue to be carried out in cooperation with the Instituto Antártico Argentino in Buenos Aires. (O–260–L; NSF/OPP 03–37998)

Collection of atmospheric air for the U.S. Department of Commerce NOAA Earth System Research Laboratory, Global Monitoring Division, worldwide flask-sampling network.

David Hofmann, National Oceanic and Atmospheric Administration, Earth System Research Laboratory, Global Monitoring Division.

The National Oceanic and Atmospheric Administration has been conducting studies to determine and assess the long-term buildup of trace atmospheric constituents that influence climate change and the ozone layer. Time-series analyses of long-term data provide insight into several phenomena of particular interest, including

- seasonal and temporal variations in greenhouse gases,
- the depletion of stratospheric ozone,
- transantarctic transport and deposition,
- the interplay of trace gases and aerosols with solar and terrestrial radiation fluxes that occur on the polar plateau, and
- the development of polar stratospheric clouds over Antarctica.

Personnel at Palmer Station collect air samples to be analyzed for carbon dioxide, methane, carbon monoxide, and stable isotopic ratios of carbon dioxide and methane. Flasks are also collected for analysis of halocarbons, nitrous oxide, and other trace constituents.

These measurements allow us to determine the rates at which concentrations of these atmospheric constituents change; they also point to likely sources, sinks, and budgets. We collaborate with climate modelers and diagnosticians to explore how the rates of change for these parameters affect climate. (O–264–P; NSF/NOAA agreement)

Operation of an aerosol sampling system at Palmer Station.

Colin G. Sanderson, U.S. Department of Energy, Environmental Measurements Laboratory.

Radionuclides, some of which occur naturally in the surface air, are atoms emitting radioactive energy. It is these, as well as nuclear fallout and any accidental releases of radioactivity, that the Environmental Measurements Laboratory's (EML's) Remote Atmospheric Measurements Program (RAMP) is designed to detect and monitor.

Since 1963, EML, which is part of the U.S. Department of Energy, has run the Global Sampling Network to monitor surface air. The RAMP system provides on-site analysis in 13 different locations around the world, including Palmer Station. Using a high-volume aerosol sampler installed in 1990, a gamma ray spectrometer, and a link to the National Oceanic and Atmospheric Administration's ARGOS satellite system, we will continue to sample the air at Palmer Station for anthropogenic radionuclides. Our data are analyzed and archived at EML and contribute significantly to its database on radionuclides. (O–275–P; NSF/DOE agreement)

Antarctic automatic weather station program: 2004–2007.

Charles R. Stearns and George A. Weidner, University of Wisconsin–Madison.

A network of nearly 50 automatic weather stations (AWS) has been established on the antarctic continent and several surrounding islands. These facilities were built to measure surface wind, pressure, temperature, and humidity. Some of them also track other atmospheric variables, such as snow accumulation and incident solar radiation.

The data they collect are transmitted via satellite to a number of ground stations and put to several uses, including operational weather forecasting, accumulation of climatological records, general research, and specific support of the U.S. Antarctic Program, especially the Long-Term Ecological Research Program at McMurdo and Palmer Stations. The AWS network has grown from a small-scale program in 1980 into a significant, extremely reliable data retrieval system that has proven indispensable for both forecasting and research. This project maintains and augments the AWS as necessary. (O–283–M; NSF/OPP 03–38147)

Solar/wind-powered instrumentation module development for polar environmental research.

Anthony D. Hansen, Magee Scientific Company.

We will develop and test a self-contained, transportable module that will provide a sheltered, temperature-controlled interior environment for standard, rack-mounted equipment. Electric power will be provided by solar panels and a wind generator, backed up by batteries with several days' capacity. The module will offer both alternating and direct current for internal and external use and will include data logging and communications capability for practical application in a polar environment.

At South Pole Station, McMurdo Station, and almost all other inhabited camps in Antarctica, aircraft, helicopters, ground vehicles, diesel generators, and other sources release exhaust, which can affect the environment. The collection of real-time pollution data at downwind locations can be used to assess the amount of pollution and the effectiveness of efforts to improve air quality. At this time, optimal placement of measuring instruments is severely limited by the availability of power and shelter, a limitation that this module is intended to overcome.

Although designed to facilitate measurements at the South Pole, the module will be helpful in a variety of other situations where remotely located equipment is to be used for long-term monitoring of environmental phenomena. The module will have no emissions at all and therefore will not affect the environment that it is designed to study. Also, it can be placed anywhere it is needed. (O–314–S; NSF/DBI 01–19793)

Shipboard acoustic Doppler current profiling on the *Nathaniel B. Palmer* and *Laurence M. Gould*.

Eric Firing, University of Hawaii–Manoa, and Teresa K. Chereskin, University of California–San Diego.

We will build on a successful 5-year collaboration that developed the capability to routinely acquire, process, and archive ocean current measurements from hull-mounted shipboard acoustic Doppler current profilers (ADCPs) on board the research ships *Nathaniel B. Palmer* and *Laurence M. Gould*. We will enhance the technical capabilities of the program through new software developments and hardware acquisition. Also, we will continue the collection and dissemination of a quality-controlled data set of upper-ocean current velocities and acoustic backscatter in the sparsely sampled and remote Southern Ocean, an area that plays an important role in global ocean circulation. In addition, we will perform scientific analyses of upper-ocean current structure in the Drake Passage.

One of our short-term objectives is to develop the ongoing data collection program so it can be maintained with a minimum of personnel and resources and so the observations become publicly available in a timely manner.

Our long-term objectives are to

- measure the seasonal and interannual variability of upper-ocean currents in the Drake Passage,
- combine this information with similar temperature observations to study the variability in the heat exchange, and
- characterize the velocity and acoustic backscatter structure in the Southern Ocean on a variety of time and space scales.

With new dual-frequency ADCP capability gained through the acquisition and installation of 38 kilohertz (kHz) phased-array Doppler sonars, in addition to the existing 150 kHz ADCP capability, the maximum profiling range will increase to about 1,000 meters (m) under good sea and scattering conditions while maintaining higher vertical resolution in the upper 300 m. New software developments will improve the ability to measure currents while the ships are in ice. The collection, quality control, real-time processing, and dissemination of this high-quality data set allow these observations to be used to support ongoing antarctic science programs and make the data easily accessible for conducting retrospective analyses, planning future observations, and validating numerical models.

Finally, after the ship leaves dry dock, we will replace the current logging computer with a newer one and upgrade the acquisition and processing software to accommodate the new system. (O–315–N and O–317–L; NSF/OPP 03–37375 and NSF/OPP 03–38103)

Physics and mechanics of the breakup of warm antarctic sea ice: In-situ experiments and modeling.

John P. Dempsey, Clarkson University.

We will study how the antarctic sea ice cover responds to stresses applied by wind and ocean waves and how the temperature distribution within the sea ice affects these responses. We will investigate the breakup of antarctic sea ice in light of recent findings indicating that the fracture strength of first-year ice is strongly size dependent, that the deformation and fracture on the scale of tens of meters is influenced by microstructural anisotropy, and that the characteristic flaws of sea ice (such as brine drainage features) give rise to length scales relevant to transitions in fracture behavior. Given the importance of warm McMurdo Sound sea ice for research and tourism at McMurdo Station, there is an urgent need to understand its fracture behavior. We will therefore investigate the following topics:

- coupled deformation-diffusion influences (due to fluid transport within the ice matrix),
- the influence of loading rate versus specimen size over a significant size range,
- fractal descriptions of the failure surfaces, and
- a new cyclic loading geometry (independent of the fracture testing).

Our findings will provide insight into the underlying mechanisms of ice breakup and will significantly improve the accuracy and reliability of models.

Each fracture test will have several parts that will allow us to make quantitative comparisons between deformation and fracture energy and the fractal dimension. Few such comparisons are available for any geologic material. We will examine, both theoretically and experimentally, the ability of sea water and brine to be transported within the ice matrix, and we will also make quantitative assessments of permeability. We have timed our work to coincide with significant warming of the sea ice.

Two graduate students will be involved in this project and in the teaching and outreach associated with it, and every effort will be made to recruit them from underrepresented groups. Moreover, a different K–12 teacher will be invited for each of the three trips we will take. To more broadly disseminate our material, we will produce CDs and maintain a Web page. (O–316–M; NSF/OPP 03–38226)

Maud Rise Nonlinear Equation-of-State Study (MaudNESS).

Miles McPhee, McPhee Research Company; David Holland, New York University; Laurence Padman, Earth and Space Research; Eric D'Asaro, University of Washington; and Timothy Stanton, Naval Postgraduate School.

In many parts of the Weddell Sea, modest ice growth and heat loss to the atmosphere could eliminate the density contrast between the cold, relatively fresh surface mixed layer and the underlying Weddell Deep Water, thereby setting the stage for deep convection. However, as soon as warm water mixed from below melts the ice, a strong negative feedback occurs. This process re-verses buoyancy flux at the surface and stabilizes the upper ocean, thus reducing turbulent heat flux from below and preserving the ice-pack. Yet the ice cover has often disap-peared over significant areas during the winter, and the large Weddell polynya (area of open water in sea ice), which persisted for several years, had profound effects on the Weddell Sea and areas farther north. These events seem to be linked to circulation patterns around the Maud Rise seamount.

How can turbulent mixing overcome the stabilizing effect of ice melt long enough to remove the ice cover? The answer may lie in the nonlinear equation-of-state (NES) properties of seawater. When layers of water with similar densities but strong temperature and salinity contrasts interact, a number of possible NES instabilities can convert the potential energy of the unstable temperature stratification to the tur-bulent energy needed to counteract the buoyancy sink from melting. In the Weddell Sea, the cold surface mixed layer is often separated from the underlying warm, more saline water by a thin layer (pycnocline), making the water column particularly susceptible to an instability associated with the pressure dependence of the thermal expansion coefficient.

Our objectives are as follows:

- to use measurements and high-resolution modeling to investi-gate the role of NES instabilities in breaking down stratification, and
- to use longer-term measurements and regional-scale modeling to determine how the circulation around Maud Rise preconditions convection.

The Southern Ocean produces much of the deep water of the global oceans and is a major conduit by which the abyssal ocean communicates with the global climate. Deep-ocean convection in the Antarctic thus represents an important component in the quest for climate simulation and prediction, and our research will contribute to understanding this phenomenon. (O–325–N; NSF/OPP 03–37159, NSF/OPP 03–37073, NSF/OPP 03–37301, NSF/OPP 03–37751, and NSF/OPP 03–38020)

Interactions between cobalt, cadmium, and zinc biogeochemistry and phytoplankton dynamics in the Ross Sea.

Mak A. Saito, Woods Hole Oceanographic Institution.

We will apply voltammetric speciation techniques to water column samples and bottle incubations to investigate the biogeochemistry of cobalt, cadmium, and zinc in the Ross Sea. The CORSACS (Controls on Ross Sea Algal Community Structure) project already planned for the 2006 season (see B–258–N) involves cruises of the research ship *Nathaniel B. Palmer* in the Ross Sea. CORSACS aims to use novel trace metal chemostat culture methods to study the interactions between iron limitation and carbon dioxide use and limitation. Because carbon acquisition by marine phytoplankton depends on the zinc, cadmium, or cobalt metalloenzyme carbonic anhydrase, our adding these trace metal analyses to the CORSACS project should prove highly complementary and yield valuable data.

We will measure total dissolved concentrations and chemical speciation analyses in field samples (to ascertain the ambient geochemical conditions) and in bottle incubation samples (to measure chemical transformations and the drawdown of these micronutrients). We will analyze cobalt by using cathodic stripping voltammetry with dioxime electroactive ligands and cadmium and zinc by using anodic stripping voltammetry.

Ferric reductases have been shown to be involved in the acquisition of ferric iron, including organically chelated forms, but molecular analyses of marine phytoplankton ferric reductases have barely begun. Therefore, we will also collect DNA samples from the Ross Sea and amplify them for genes homologous to these enzymes. We will use polymerase chain reaction and degenerate primers to amplify gene sequences and then screen clone libraries for sequences of interest. This study of ferric reductases will also complement the CORSACS research focusing on iron limitation and is an important first step in the future analysis of ferric reductase gene expression in environmental samples.

This work will contribute to our understanding of how trace metals influence marine primary productivity and carbon biogeochemical cycling in a region of major importance for the marine carbon cycle. (O–398–N; NSF/OPP 04–40840)