

Government Performance and Results Act (GPRA)

FY 2000 Performance Report



Office of Polar Programs

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A. INTRODUCTION: DIRECTORATE/OFFICE

Polar Programs is unique within the Foundation in both its geographic focus -- polar regions -- and in the breadth of the science it supports. Polar regions play a central role in environmental issues related to global climate and are vital to understanding past, present, and future responses of Earth systems to natural and man-made changes.

The Arctic and the Antarctic are premier natural laboratories whose extreme environments and geographically unique processes enable research not feasible elsewhere. For example, projects supported by Polar Programs employ ice sheets to detect high energy subatomic particles, establish environmental observatories to detect and monitor effects of climate change on terrestrial and marine ecosystems, analyze the chemistry of ice cores as a record of global climate history, utilize astrophysical observations made in cold dry polar conditions to determine the evolution and structure of the universe, examine the effects on terrestrial and marine life of increased ultraviolet light (UVB) from ozone depletion, and elucidate adaptation mechanisms of organisms and ecosystems to extreme living conditions.

NSF is one of twelve federal agencies supporting Arctic research and logistics. The Foundation provides interagency leadership for research planning as directed by the Arctic Research Policy Act of 1984. NSF also supports university research to increase our knowledge of the region, to improve understanding of Arctic phenomena, and to enhance stewardship of natural resources. Funding in the Arctic includes research and operational support for work conducted in that remote region.

NSF is charged with managing all U.S. activities in the Antarctic as a single, integrated program. The U.S. Antarctic Program (USAP) implements national policy to maintain Antarctica as an area of international cooperation reserved for peaceful purposes, to preserve and pursue unique opportunities for scientific research to understand Antarctica and its role in global environmental systems, to protect the relatively pristine environment and its associated ecosystems, and to assure the conservation and sustainable management of the living resources in the surrounding oceans. Funding for the USAP includes research and the science support directly linked to research projects, as well as support for the broader operations and logistics infrastructure that makes it possible to conduct science on the remote and otherwise uninhabited continent.

The Office of Polar Programs supports research and education, ranging from single investigator projects to large multi-investigator, multi-institutional, and sometimes international programs. The polar regions have special significance for studies of the environment and understanding processes related to global change and its possible effects. These regions are especially sensitive to climate change because of processes that are affected by low temperatures or by phase changes of water between the liquid and solid state.

Budget

The Office of Polar Programs' FY 2001 budget was \$276.57 million, of which approximately 73% is classified as "Tools," including research support, operations, and logistics. Over 26% is classified as "Ideas" -- direct research project support. The research supported and the facilities

and logistics that make the research possible support the NSF goal, “Discoveries at and across the frontier of science and engineering connected to learning, innovation and service to society.” About 1% of OPP’s funding is classified as “People” and contributes to the goal of a “Diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens.” The majority of these funds are for three Foundation-wide initiatives, Integrative Graduate Education and Research Training program (IGERT), Model Institutes of Excellence (MIE), and Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE). OPP contributes funds but does not manage any of these programs. OPP also supports Research Experiences for Undergraduates and contributes to GK-12 activities.

Outcome Goal	Ideas (Research) 25% of funding	Tools (Facilities) 74% of funding	People (Education) < 1% of funding
Discoveries at and across the frontier of science and engineering connected to learning, innovation and service to society			
Broadly accessible, state-of-the-art information-bases and shared research and education tools			
Diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens			

Shading of blocks indicates whether the funds contribute in a major way (darkest), a minor way (medium), or not at all (white).

How Report was Developed

Information for this report was developed by staff in OPP, from all three sections: Arctic Sciences Section, Antarctic Sciences Section, and Polar Research Support Section. This is particularly true for Section F of the report. Information from the FY 2001 COV of Antarctic research support was also used. Information for Section E of the report was developed primarily from NSF databases. Other data on facilities was developed in conjunction with OPP staff and contractors.

Sources of Information for Report

Primary information comes directly from the researchers through site visits, scientific meetings, annual progress reports, final project reports, and informal PI reports to program officers. Secondary sources of information include press releases and other publications as well as television and radio reports. When possible, specific award numbers have been provided.

FY 2001 HIGHLIGHTS

Highlights of OPP-supported activities are below. This is not intended to be all-inclusive. More complete descriptions of these activities can be found in Section E of this report.

Iron Isotopes as Biological Markers. This project, from MarsRock, developed a chemical method for fingerprinting biological activity in meteorites using the isotopic composition of iron (Fe), triggering new research in a field crossing geochemistry and biology and has attracted several other research groups.

Teachers Experiencing Antarctica and the Arctic (TEA). The TEA program promotes integration of research and education by allowing K-12 teachers to join a research team in Antarctica or the Arctic. The teachers post daily electronic journals for their students and develop teaching materials for classroom use. Fifteen teachers participated in the program this year

K-12 Teacher Training in Arctic Science. A partnership between the University of Texas at Austin Marine Science Institute and the Port Aransas Independent School District provides training for K-12 teachers on arctic science, including topics such as climate, sea ice, ozone depletion, and human adaptations.

Underrepresented Students Study Arctic DNA Samples. Students participated in Arctic DNA research in conjunction with the Center for Academic and Research Excellence (CARE), a program in which underrepresented students are trained in scientific techniques and participate in research projects.

Alaskan Fisheries Management Aided by Research on Lake Trout. In 2001, PIs met with the head of the Alaska Department of Fish and Game (ADF&G) for Fairbanks and the north to inform him of the slow growth and extreme longevity of lake trout in the region. As a result, ADF&G instigated a catch-and-release-only program for lake trout north of the Brooks Range.

Sea Ice and Native Whale Hunting in the Arctic. Two workshops brought together scientists and their instrumental data, anthropological records, and sea ice models with Native experts on sea ice conditions that have affected the whale hunt.

New Tool to Study Abrupt Climate Change. Researchers have developed and applied a new ice core 'paleothermometer' based on the principle of thermal diffusion, in which a mixture of gases separates into heavier and lighter components when subjected to a temperature gradient.

This technique allows direct comparison of the timing of atmospheric trace gas variations (for example, methane) relative to variations in surface temperature.

New Ribotype Discovered in Polar Plankton. PI compared the phylogenetic composition of Proteobacterial ammonia-oxidizing bacteria (AOB) assemblages in plankton samples collected in the Arctic and Antarctic, and found a novel 16S rDNA sequence distantly related to *Nitrosospira* in all samples that were positive for AOB. The widespread distribution of this ribotype in cold oceans suggests that it represents a dominant species of planktonic AOB. This is an important first-look at the genomic composition of polar bacteria.

Marine, Glacial and Environmental History of the Russian Arctic. A PI completed two field expeditions to the shores of the Kara Sea on the Yamal and Yugorski Peninsulas, areas that are parts of the little-studied Russian Arctic. The geologic record has yielded significant new information on the marine, glacial, and environmental history of the Russian Arctic, in some cases dramatically revising our understanding of past glacial extents and dynamics.

Geometry and Early Structure of the Universe. The array of sensors on the various telescopes at South Pole Station have continued to produce significant new insights into the structure of the cosmic microwave background radiation (CMBR). In particular, the Degree Angular Scale Interferometer (DASI) is currently providing measurements of the background radiation anisotropy over a range of scales that span the first three acoustic peaks in the CMBR power spectrum.

New Information About the Size of the Antarctic Ice Sheet During the Pliocene. By examining sediments recovered from sites on the Kerguelen Plateau and on Maude Rise, a PI has discovered important new information about the age of inception of the Antarctic ice sheets. This information will improve understanding of Antarctic environmental history and will be useful to polar paleoclimatology and paleobiology.

Thinning Arctic Sea Ice Cover. The cause of a rapid, decade-long thinning of Arctic Ocean sea ice in the 1990s, which has been widely reported in the press in the past two years, is largely attributed to changes in atmospheric circulation. The potential disappearance of the sea ice is critical to understanding future climates because of the role of surface reflectance from snow and sea ice in the Arctic in global climate change feedbacks.

New Model of Kinetic Theory. As part of a project on dynamic properties of plankton in polar lakes, PIs developed a new model of kinetic theory that could replace the 90 year-old Michaelis-Menten and 60 year-old Monod models to become the new standard for describing and understanding nutrient flux and transport into microorganisms and other cells.

New Diatom Fossil Species. A project analyzing drill cores recovered by the Cape Roberts Project discovered a new diatom species in Antarctic waters during the interval of 18-35 million years ago.

Oceanic Carbon Sequestration. Synthesis of oceanographic data obtained in the Southern Ocean Experiment of the Joint Global Ocean Flux Study has given a much more precise

understanding of the temporal and spatial variation in the effectiveness of the Southern Ocean as a sink for atmospheric carbon dioxide. The new data show that this region accounts for nearly a quarter of the global oceanic sequestering of atmospheric carbon dioxide.

Stream Size and Nutrient Transport. In a finding that could have important consequences for land-use policies in watersheds from the Chesapeake Bay to Puget Sound, researchers have discovered that small streams contribute more to removing nutrients such as nitrogen from water than do their larger counterparts.

Acquisition of Core Logging Equipment for the Antarctic Marine Geology Research Facility. The Multi-Sensor Core Logger has been used to analyze high-resolution mineralogical variations in marine sediment cores collected from four USAP cruises. The high-resolution MSCL data, among the first high-resolution core data from the USAP, contributes to interdisciplinary environmental change research.

The APOGEE vehicle. An Autonomous Underwater Vehicle (AUV) has been designed to work under ice-covered water, particularly in the Arctic Ocean Basin. A PI is developing a cost-effective experimental platform that can access all portions of the Arctic Ocean Basin.

For projects considered particularly high-risk, multidisciplinary and innovative, see section on FY 2001 Areas of Emphases, Ideas, page 39.

MANAGEMENT AND OPERATIONS

OPP manages and oversees operations and logistics in remote regions. Some OPP successes, therefore, do not readily fit into specific performance goals, but in very important ways provide the foundation for the successes reported. These are often the result of management decisions and can positively impact the entire program:

Improved Infrastructure for Support of Arctic Science. OPP improved infrastructure for Arctic science by means of a cooperative agreement with the University of Alaska, Fairbanks, for operation of the Toolik Lake field station (completed labs, upgraded power plant and wireless LAN); through upgrades of living conditions at Summit field camp in Greenland; through improved operations at Barrow Environmental Observatory; with a new mooring at the North Pole Environmental Observatory¹; with a new radar at Barrow for mesosphere and lower thermosphere observations; and with studies preparing for the Little Diomed Environmental Observatory.²

Provided and Supported Logistics Needs for 150 Projects and 600 Scientists. Approximately 50% of fieldwork was supported in Alaska, often via VECO Polar Resources,³

¹ OPP-9910305, Jamie Morrison

² OPP-9910319, Lee Cooper

³ OPP-0001041, www.veco.com/vpr

Barrow Arctic Science Consortium⁴, or the University of Alaska, Fairbanks (Toolik Lake)⁵. Support in Russia has been improved by means of new arrangements with a variety of providers. Expanded demand for air support and satellite communications in the past three years has been met.

Retrieved the Long-term Acoustic Tomography Array from the Arctic Ocean. In cooperation with the Office of Naval Research, OPP supported retrieval of the array located off Alert, Canada, which, upon analysis, will provide a continuous four-year record of ocean temperature and climate. This effort took advantage of logistics support of the synchronous emplacement of moorings at the North Pole Environmental Observatory.⁶

First science cruise of the USCG Cutter *Healy* to the Gakkel Ridge in the Arctic Ocean. NSF worked extensively with USCG, the science team and the polar oceanographic community to establish a new, effective research capability opening up new research possibilities in the Arctic. The cruise also utilized NASA's TILT communication system to provide high bandwidth at high latitudes.

First OPP-sponsored field safety training course held in the spring in Fairbanks, Alaska. This course will be offered again next year in several locations.

Expanded pool of satellite phones allocated to remote field parties in the Arctic.

Summit Station, Greenland operated year-round with a staff of 4 to support an international suite of experiments.

Light Vehicle Replacement. OPP recently completed replacement of the USAP light wheeled vehicles (pick-up trucks and vans), which will consolidate the fleet around a single vendor. This consolidation will result in reduced maintenance costs and reduced total inventory of spare parts

Commercial Helicopter Services in Antarctica. The first commercial contract for helicopter services has ended with marked success. Operational costs for USAP helicopters were reduced 50% from the Department of Defense with marked improvement in responsiveness to PI needs. OPP will continue to contract for commercial helicopter services.

New Science Support Aircraft for Antarctic Field Work. USAP contracted for a "medium lift" ski-equipped aircraft - Basler 67. The field test of this aircraft was successful, proving this aircraft can enhance USAP's ability to support deep field science.

CTBT Monitoring. USAP established and successfully installed the first Comprehensive Test Ban Treaty (CTBT) monitoring site in the Windless Bight, Antarctica. This was a combined effort involving NSF, the Department of Defense, and the University of Alaska.

⁴ OPP-0004401, Glenn Sheehan, <http://www.sfos.uaf.edu/basc/>

⁵ OPP-9981914, Brian Barnes, <http://www.uaf.edu/toolik/>

⁶ OPP-9910305, Jamie Morrison

LC-130 Maintenance. Contracted with Air New Zealand for maintenance of Air National Guard LC-130 aircraft, saving the Air National Guard approximately \$300,000 per aircraft.

Medical Equipment for Antarctica. Installed, tested, and used ultrasound diagnostic capabilities for use at McMurdo and South Pole stations.

Antarctic Remediation. A joint U.S. and New Zealand team has completed an environmental survey of a former Antarctic research station at Cape Hallett. This station was operated jointly by New Zealand and the United States from the International Geophysical Year in 1957 to February 1973 on the eastern side of Cape Hallett. It was operated as a year-round research station until 1964, when the main scientific laboratory was destroyed by fire. Steps have been recommended to safeguard penguin chicks at a nearby rookery from melt pools contaminated with oil from an unknown source.

Successful Winter Evacuation from the South Pole. A twin-engine plane successfully completed an historic 1,300-mile Antarctic flight to the Amundsen-Scott South Pole Station, bringing a new physician to replace the ailing doctor who recently suffered a bout of gallstones and associated pancreatitis. NSF officials along with the Air Force and the Department of Interior had analyzed options and concluded that the Twin Otter airframe offered the best chance of getting to and from the Pole in the near-dark with temperatures around -75 Celsius (-103 Fahrenheit). Two Twin Otters (one for backup) flew from Canada to South America and then on to Britain's Rothera research station located on the Antarctic Peninsula. When weather conditions made it possible, one of the planes made the 10-hour flight to the South Pole carrying two pilots, an engineer, a replacement physician and a nurse. After landing at the Pole, the crew shut down the aircraft and rested for 10 hours before restarting the engines and successfully evacuating the station physician, who had been suffering from gallstones and associated pancreatitis.

Cost-Saving Retrograde. Waste products returned from Antarctica formerly processed in Washington state were processed in California, reducing per diem costs for the cargo vessel by approximately \$200,000 and decreasing by several days the time it takes to return samples and cargo to investigators.

South Pole Communications. Improvements in communication at the South include: installation of a 9-meter satellite earth station; acquisition and inauguration of significant bandwidth available to South Pole via the MARISAT satellite; and transmission of an aggregate 1.1 terabytes of science data via the South Pole NSF/NASA TDRSS high speed service. This is the largest amount of science data ever transmitted from Antarctica by the USAP in one year.

Flight Communications Improvements. The final installation of the modernization program for the McMurdo Station HF radio communications infrastructure was successfully completed. This infrastructure is used for aircraft flight following, search and rescue, and deep field science operations and safety.

B. CROSSCUTTING AND COORDINATION ACTIVITIES

OPP's geographic focus on the poles lends itself to interdisciplinary research, interagency, and international activities, and OPP encourages these types of activities.

NSF-WIDE ACTIVITIES

Crosscutting activities include the following:

- Surface Heat Budget of the Arctic (SHEBA) - cooperative with GEO/OCE and Office of Naval Research (ONR).
- Shelf Basin Interactions (SBI) – cooperative with GEO/OCE and ONR.
- Graduate Teaching Fellows in K-12 Education (GK-12) (Lead: DGE/EHR): OPP co-funds one GK-12 award: San Diego State University, Nancy Taylor and Walt Oechel, in collaboration with Barrow schools.
- CAREER: OPP participates on the coordinating committee.
- IGERT: OPP participates on the coordinating committee.
- Biocomplexity: OPP is represented on the environmental research and education working group) which advises senior management on NSF's environmental portfolio and on the Biocomplexity special competitions.
- Partnerships for Innovation (Lead: EHR): OPP co-funds an award to Ilisagvik College and partners to develop, test, and refine distance education model for isolated rural communities.
- EPSCoR (lead: EHR): OPP works with the EPSCoR office on outreach travel to EPSCoR states.
- ADVANCE: OPP participates on the agency-wide working group
- National Center for Atmospheric Research (NCAR): Works with GEO's Division of Atmospheric Sciences and NCAR to refine atmospheric modelling of Antarctic meteorology to assist in flight forecasting; will lead to integration of forecasters, modellers, and research scientists in understanding dynamics affecting weather in Antarctica.
- Worked with EHR's Division of Elementary, Secondary, and Informal Education to support Teachers Experiencing the Arctic and Antarctica (TEA), a program that puts teachers in polar regions with NSF-funded research teams to bring polar science into classrooms.
- Worked with the NSF's Office of Legislative and Public Affairs to select media events to bring Arctic and Antarctic science to the general public.
- MRI: OPP participates as a member of the coordinating committee for this agency wide program.

INTERAGENCY ACTIVITIES

OPP has long-term collaborative ventures with other agencies in support of research including the Long Duration Balloon Program (with NASA), the Antarctic Mapping and Geodesy Program (with USGS), the National Ice Core Laboratory (with USGS), the Antarctic Meteorite Program (with NASA and the Smithsonian Institution), SCICEX (with ONR), Greenland climate change (with NASA), gas flux measurements (with DOE, NASA, and NOAA), the Cold Regions Bibliography Project (with Army Cold Regions Research and Engineering Laboratory), and the Arctic Climate Impact Assessment (with NOAA).

OPP also actively works with the Interagency Arctic Research Policy Committee (IARPC), for which NSF is the lead agency. This past year IARPC, at the urging of Neal Lane, Assistant to the President for Science and Technology, authorized the establishment of a working group on the Study of Environmental Change (SEARCH) and authorized the working group to develop a multi-agency research project and a coordinated approach to implementation. The working group completed a report recommending a coordinated research program, and IARPC staff representatives currently are implementing the report. There is increased agency attention on SEARCH because the Arctic is in the midst of a major change involving impacts on the atmosphere, oceans, land, ecosystems and society. Arctic change is connected to changes in the atmospheric circulation of the Northern Hemisphere. The future course of the change is unknown, but change in the Arctic may be a fingerprint of global warming. To study these changes, long-term programs in observation, analysis and modeling will be required.

Other interagency activities included:

- Participation in the Department of State Interagency Arctic Policy Group, which meets monthly, addressing a wide range of Arctic-related issues.
- Cooperating with the DoD in the installation and operating of infrasound, and seismic instruments to monitor for nuclear weapons tests under the Comprehensive Test Ban Treaty.
- Work with NASA and U.S. Air Force in the establishment of a Joint Spacecraft Operations Center in McMurdo station for the downlink of remote sensing satellite imagery, tracking first orbit polar satellite trajectory parameters, and station communication functions.
- Continued support of NOAA Climate Modeling and Diagnostics Laboratory at the South Pole for continuous monitoring of atmospheric chemistry including green house gases and ozone and cooperative measurement of UV at Barrow, Alaska..
- The following Antarctic projects are cooperative efforts with NASA:
 - Long Duration Ballooning Program - near space balloon borne experiments to assist in the measurement of mass of the universe and investigate the composition and energy spectra of galactic cosmic rays.
 - Antarctic Miniature Lidar/Antarctic Weather Station Lidar - to establish a long-term data record of evolution of polar stratospheric clouds; and establish long-term near surface to 30 kilometer backscatter and transmission.
- In cooperation with the U.S. Geological Survey assist in the conduct of geodetic surveying, aerial photography, remote sensing and mapping to support research objectives primarily in geological, geophysical, and glaciologic sciences.
- Continued cooperative efforts with the U.S. Army Cold Regions Research and Engineering Laboratory for assistance in polar engineering of the modernization of South Pole Station, airfields, and snow and ice roadways.
- Work with the U.S. Coast Guard for the emplacement of instruments to measure the dynamics surrounding the major ice bergs that have broken from the Ross Ice Shelf. The U.S. Coast Guard also breaks the channel to McMurdo Station each year for resupply ships.
- Work with CIA, NIMA, and USGS to release images of the Barrow, Alaska, area for use in environmental studies.
- Work with the Advisory Committee on Antarctic Names with USGS. This is a subcommittee of the Department of Interior's Board on Geographic Names.

- OPP represents NSF on the Civil Applications Committee and on the Global Fiducials Working Group.

INTERNATIONAL ACTIVITIES

OPP also works extensively with the Department of State on Antarctic issues, particularly those that relate to the Antarctic Treaty. International cooperation in the U.S. Antarctic Program is extensive in both research and operations. It usually involves in-kind contribution of national strengths to the realization of research goals beyond the capability of a single nation. These goals generally are achieved by (1) performing similar work in different places (collecting weather data, for example) and sharing the results as required by the Antarctic Treaty or (2) performing an intensive project in one place (an example is the 1996–1998 Cape Roberts project, which will drill an ocean-bottom sedimentary core from a platform on coastal sea ice) in which each participating nation delivers a negotiated component of the project. Opportunities for international cooperation are explored and implemented regularly. Formal mechanisms include the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (nongovernmental), the annual Antarctic Treaty consultative meetings (government-to-government policy decisions), the Council of Managers of National Antarctic Programs (COMNAP, a U.S. initiative), the Council's Standing Committee on Antarctic Logistics and Operations (SCALOP) and its Antarctic Managers' Electronic Network (AMEN: electronic mail and data exchange and a home page on the World Wide Web).

Other international work includes:

- Member of Forum of Arctic Research Operators (FARO) Executive Committee
- Memorandum of Understanding with Norway (Norsk Polarinstitut for research on Svalbard (Norway))
- U.S. representative to Arctic Ocean Studies Board.
- U.S. representative to Regional Board of the International Arctic Science Committee.
- Steering Committee of Arctic Climate Impact Assessment under Arctic Council.
- Cape Roberts drilling was completed in FY 2000, but science cooperation is ongoing and continued through FY 2001). This project is interdisciplinary -- earth science - paleontology, paleoceanography, geophysics, tectonics – and includes the cooperation of 7 nations: U.S., New Zealand, Italy, the United Kingdom, Germany, Australia, and the Netherlands.
- The Antarctic Meteorite program is a key element that facilitates research conducted by an international community of planetary materials researchers. Samples are provided on a regular basis to researchers in the U.S. and many other countries. The meteorite program is also an interagency activity that bears on a wide range of planetary science issues.
- Cooperative efforts with Russia in the remote aerogeophysical, and seismic survey of Lake Vostok and on a variety of projects in the Russian Arctic.
- Workshop on Antarctic weather forecasting with participants from Canada, Australia, United Kingdom, and Italy.
- Continued logistics cooperative arrangements with Italy and New Zealand for support to the Ross Sea Region of the Antarctica.
- International Trans-Antarctic Scientific Expedition an international effort to collect and interpret a continental wide array of environmental parameters including transfer functions

between the atmosphere and snow/ice interface; verify atmospheric models, and interpolate spatial and time-series from satellite remote sensing. The U.S. component is, collecting surface and near surface snow and ice samples and conducting radar studies to determine the internal stratigraphy and bedrock topography of the terrain along a traverse in West Antarctica.

- Discussions are being held with the British Antarctic program to plan a joint field program in West Antarctica in the Amundsen Sea Embayment section (Pine Island/Thwaites Glacier area).
- Continued cooperation with New Zealand on joint topographic mapping projects as a research support activity. This activity is implemented through the NSF/OPP partnership with the USGS for Antarctic Mapping and Geodesy Program.
- Cold Regions Bibliography Project collaboration with the world's most complete polar research library at the Scott Polar Research Institute, University of Cambridge, UK.
- International teacher exchange with the Swedish Polar Research Secretariat.

OPP/NSF has been extensively involved in Arctic Council activities, at the request of the U.S. Department of State. This high level intergovernmental forum addresses environmental protection and sustainable development in the Arctic region. Members of the forum include 8 Arctic nations, Arctic indigenous representatives and a wide range of governmental and organizational observers. OPP's major involvement includes participation in a comprehensive study of the impact of climate change in the Arctic. This Arctic Climate Impact Assessment (ACIA) is an international multi-year program that will assess the impact and effects of climate change, including environmental, human health, social and economic impacts. This project was initiated in FY 2000 and received official ministerial endorsement by the Arctic Council in FY 2001.

C. FY 2001 COV RESULTS AND FY 2002-2004 COV SCHEDULE

FY 2001 COV: POLAR (ANTARCTIC) RESEARCH SUPPORT

The COV for Polar Research Support was held September 6-7, 2001. Although the NSF Committee of Visitors structure requires COVs to address GPRA goals and results, this standard structure is intended for NSF's primary business: awarding research grants. The standard structure of the COV reports does not lend itself to identifying results or successes of an operational program. Those successes have been included in this GPRA report in Section A under "Management and Operations." That being said, however, the COV did realize that is a direct link between the performance of the Polar Research Support Section and the research results of the Antarctic Sciences Section. The Executive Summary of the COV Report includes the following statement:

``The performance of the National Science Foundation's Polar Research Support Section (PRSS) is most directly judged by assessing the effectiveness of the Office of Polar Programs (OPP) in accomplishing its primary mission ~ conducting science in Antarctica. While research support operations can and will be judged on metrics of efficiency, productivity, on-time

performance, and cost effectiveness, it is the more intangible measures related to the quality, impact, and relevance of Antarctic science that the success of PRSS should ultimately be judged against. In all measures of performance, it is the Committee of Visitors' assessment that Antarctic science is strong, it is relevant, it is cutting edge, and it is by far the best being performed in the world today. The Committee, therefore, concludes that PRSS is accomplishing its major objectives as reflected in the state and health of U.S. Antarctic science. Given the challenging environment, the complex network of stations and facilities, the fleets of vehicles of all kinds, the extensive infrastructure, supply lines that extend virtually around the world, and not least of all, the human resources provided by PRSS, it is even more impressive that their presence is often taken for granted by the ultimate end users - the National Science Foundation-supported scientists. The question must be asked; could the accomplishments of the scientists be achieved if PRSS were not there ~ the answer is clearly no. . . .

''Discoveries include enhancing our understanding of the behavior of the earth system, providing cosmological insights into the origins of the universe, and documenting ecosystem responses to climate change. Specific important discoveries include: measurement of cosmic microwaves generated at the time of the creation of the universe, recognition of recent major fluctuations in sea ice cover, revision of our understanding of atmospheric sulfur chemistry, recognition of ancient volcanic eruptions in the Ross Sea, and the mapping of sub-glacial lakes under more than four kilometers of the East Antarctic ice sheet. The creation of new knowledge and techniques within and across traditional boundaries as a result of OPP awards and PRSS support include: descriptions of global scale primary productivity, definition of the role of clouds in atmospheric warming and melting of sea ice, discovery of fish anti-freeze genes that link evolution with climate history, and the use of Antarctic ice as a detector of high energy particles. It is clear that these discoveries required substantial and complex logistical support from PRSS and the excellence of the science produced says volumes about the effectiveness of PRSS.''

The specific recommendations made by the COV are unrelated to GPRA outcome goals.

COV SCHEDULE FY 2001-2004

FY 2001	Antarctic Research Support
FY 2002	none
FY 2003	Polar Sciences (Arctic and Antarctic)
FY 2004	Antarctic Research Support

D. SUMMARY OF FY 2001 ACHIEVEMENTS

OPP's results for each goal and indicator is summarized in the tables below:

OPP RESULTS FOR OUTCOME GOALS

Goal: Development of "a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens."	Overall Rating for Goal: Successful
Indicators	Rating for Each Indicator:
Improved mathematics, science, and technology skills for U.S. students at the K-12 level and for citizens of all ages.	Successful
A science and technology and instructional workforce that reflects America's diversity.	Successful
Globally engaged science and engineering professionals who are among the best in the world.	Successful
A public that is provided access to the benefits of science and engineering research and education.	Successful
Goal: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society."	Overall Rating for Goal: Successful
Indicators	Rating for Each Indicator:
A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning.	Successful
Discoveries that advance the frontiers of science, engineering and technology.	Successful
Partnerships connecting discovery to innovation, learning, and societal advancement.	Successful
Research and education processes that are synergistic.	Successful
Goal: Providing "broadly accessible, state-of-the-art information-bases and shared research and education tools."	Overall Rating for Goal: Successful
Indicators	Rating for Each Indicator:
Shared-use platforms, facilities, instruments, and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce.	Successful
Networking and connectivity that take full advantage of the Internet and make science, mathematics, engineering and technology information available to all citizens	Successful
Information and policy analyses that contribute to the effective use of science and engineering resources.	N/A

OPP RESULTS FOR MANAGEMENT AND INVESTMENT PROCESS GOALS

Management Goals	OPP Result Goal met/not met
Diversity - NSF will show an increase over 1997 in the total number of hires to S&E positions from underrepresented groups.	Goal not met OPP 2001 - 1 hire: 1 woman OPP 1997 – 1 hire: 1 woman
INVESTMENT PROCESS GOALS	
Implementation of Merit Review Criteria – Reviewers address both criteria	60% of reviewers address both (up from 34% in FY 1999)
Implementation of Merit Review Criteria – Program Officers address both criteria	73% of program officers address both (up from 47% in FY 1999)
Time to Prepare Proposals – 95% of program announcements available at least 90 days prior to deadline	Goal met . 2 out of 2.
Time to Decision – 70% of proposals acted on within 6 months	Goal not met 59% acted on within 6 months.
Award Size – average annualized awards size at least \$110,000	Goal met \$111,902
Award Duration – average duration at least 3 years	Goal not met 2.7 months
Maintaining Openness in System – 30% of research grants awarded to new investigators	Goal not met 17% to new investigators
Construction and Upgrade of Facilities Annual expenditures do not exceed 110% of plan Annual scheduled milestones met.	Goal met for SPSM. Goal not met for LC-130's.
Operation and Management of Facilities Operating time lost less than 10% of scheduled operating time.	Goal met .

DISCUSSION OF GOALS NOT MET

Time to Prepare Proposals

The relatively long planning time required for fielding projects in Antarctica makes it extremely difficult to make informed decisions on proposals within six months. Proposals undergo a merit review of the scientific quality of the work proposed as well as a fairly lengthy analysis to determine the logistics and support required. This results in a longer-than-average time for decisions to be made.

OPP will be reviewing the entire review process to determine whether changes could reasonably be made to speed processing time without impacting the quality of decisions made.

Award Duration

The average duration of research awards in OPP is 2.7 years, somewhat short of the goal of 3 years. Increasing duration as a general goal makes sense, but cannot be applied across the board. Many awards are naturally short, including workshops. However, OPP understands that longer duration is an NSF goal and makes efforts, when possible and when prudent, to increase duration.

New Principal Investigators

The percentage of new investigators who submit proposals to OPP is perennially low. Recognizing that fact, OPP held a two-day new investigators workshop in FY 2001, attended by about 90 people, to introduce new investigators to polar research. It will be difficult to judge the success of the workshop in terms of increasing new researchers until FY 2002, but proposals were received in June from workshop attendees – first time proposers.

Construction and Upgrade of Facilities – Annual Milestones

Three NSF-owned LC-130s are being upgraded to conform to Air Force safety and operability standards. Completion of the three aircraft was originally scheduled for FY01. Modifications were complete on one aircraft in FY01. The other two are scheduled to be complete November 2001 and January 2002. The original schedule for completion did not realistically account for complexity of modification or the difficulty in obtaining certain critical parts.

Lack of Information

Most of the Investment Goals have quantitative data used for measuring success. Assessing whether the goals on use of both merit review criterion have been met continues to be problematic. The NSF Performance Plan indicates “Reviewer data will be collected on FastLane to establish a baseline,” but there is no systematic method for making this assessment. Since measurement depends on individuals reading samples of reviews and program recommendations, the process is subjective and the results almost surely vary depending on who is reading the information. The goals themselves are somewhat subjective since “reviewers address the

elements of both generic review criteria” gives no indication of how many reviewers would need to address the criteria for it to be a success. In addition, the solution of having separate blocks in FastLane for the two review criteria and then using as a measure of success how many people enter something in both blocks may not be valid. There appears to be some confusion, still, on what criterion 2 is intended to cover. Reviewers say they are addressing criterion 2, but they often are not.

E. REPORTING EXAMPLES FOR RELEVANT OUTCOME GOALS AND AREAS OF EMPHASIS

NSF has three broadly stated GPRA outcome goals covering a wide variety of supported activities. The three areas covered are referred to simply as People, Ideas, and Tools. Each of the three goals is further subdivided into types of activities called “indicators.” This section of the report contains examples of OPP results for each GPRA goal and indicator, as appropriate. The following research results have been broadly organized under the GPRA People, Ideas and Tools outcome goals. However, most address more than one of the performance indicators for the three outcome goals. (See Attachment 1 for a summary table of goals and indicators.) Therefore, each result is followed by a classification of all of the performance indicators it addresses. For instance, if a result addresses the first indicator of the GPRA People outcome goal and the third indicator of the GPRA Ideas outcome goal, it will be followed by the notation “*People 1, Ideas 3*”.

People—Development of “a diverse, internationally competitive and globally-engaged workforce of scientists, engineers, and well-prepared citizens.”

People Indicator 1—Improved mathematics, science, and technology skills for U.S. students at the K-12 level and for citizens of all ages, so that they can be competitive in a technological society.

Teachers Experiencing Antarctica and the Arctic (TEA). The TEA program promotes integration of research and education by allowing K-12 teachers to join a research team in Antarctica or the Arctic. The teachers post daily electronic journals for their students and develop teaching materials for classroom use. Fifteen teachers participated in the program this year⁷, including:

- Kolene Krysl, Spacing and Group Dynamics of Weddell Seal Colonies (PI Donald B. Siniff, University of Minnesota)⁸
- Karina Leppik, The Antarctic Submillimeter Telescope/Remote Observatory (AST/RO) at Amundsen-Scott South Pole Station. (PIs Chris Martin and Anthony Stark, Harvard-Smithsonian Center for Astrophysics.)⁹
- Robert Schlichting, Investigation of Englacial Conduit Formation and Evolution (PI Andrew Fountain, Portland St.)¹⁰

⁷ For a complete list of participants and their activities, see http://tea.rice.edu/tea_meetteachers.html

⁸ OPP-9725820, http://tea.rice.edu/tea_kryslfrontpage.html

⁹ OPP-0002473, http://tea.rice.edu/tea_leppikfrontpage.html

¹⁰ OPP-9812973; http://tea.rice.edu/tea_rslichtingfrontpage.html

- Elizabeth Youngman, Snowpack and Atmospheric Photochemistry (PI Roger Bales, U. Arizona)¹¹

People 1, 3, 4, Ideas 3, 4

K-12 Teacher Training in Arctic Science. A partnership between the University of Texas at Austin Marine Science Institute and the Port Aransas Independent School District provides training for K-12 teachers on arctic science, including topics such as climate, sea ice, ozone depletion, and human adaptations.¹² *People 1, Ideas 3*

U.S. Component of the International Trans-Antarctic Expedition During the last two U.S. ITASE field seasons, team members (including several students) participated in a variety of outreach activities. These included: a Sunday lecture in McMurdo, a news article for the *Antarctic Sun*, biweekly live telephone interviews with the Boston Museum of Science, and e-mail/web site updates. Numerous visits have been made to elementary schools that were following the project as part of their curriculum in New Hampshire, Maine, Vermont, Maryland and Ohio. Several local newspaper articles have written about the project. One team member developed laboratory exercises for grade schoolers, which have been presented at teacher workshops. Video footage is available from the field season and outreach websites are maintained. US ITASE posters have been developed for distribution at teacher workshops. Data collected as part of this program will be used as an integral part of a senior/graduate level course in Paleoclimate Analysis.¹³ *People 1, 4, Ideas 3, 4, Tools 2*

People Indicator 2—A science and technology and instructional workforce that reflects America's diversity.

Underrepresented Students Study Arctic DNA Samples. Students participated in Arctic DNA research in conjunction with the Center for Academic and Research Excellence (CARE), a program in which underrepresented students are trained in scientific techniques and participate in research projects. Reliable techniques were developed for extracting and amplifying DNA from ancient samples preserved in the permafrost of the Arctic. As a result, over 100,000 samples of vertebrates housed in the American Museum of Natural History can now undergo genetic analysis.¹⁴ *People 2, Ideas 2, 4*

Continued Outreach and Interaction with Alaska Native Organizations. Activities this year include a new Cooperative Agreement with the Alaska Native Science Commission, continued research support and community outreach via the Barrow Arctic Science Consortium, community support of the Little Diomed Environmental Observatory and a long-term program with the Calista Elders Council.¹⁵ *People 2, 4, Ideas 3*

¹¹ OPP-9813311; http://tea.rice.edu/tea_youngmanfrontpage.html

¹² OPP-9815808, www.utmsi.utexas.edu/staff/dunton/k12/mywebs/index.htm

¹³ OPP-0096338, Paul Mayewski, University of Maine

¹⁴ OPP-9817937, Wayne

¹⁵ OPP-0003072, Caulfield; OPP-9906692, Webber; OPP-9818837, Elias; OPP-9910319, Cooper; OPP-9909945, John

People Indicator 3—Globally engaged science and engineering professionals who are among the best in the world.

International Science at Summit, Greenland. In an effort to broaden international funding of a year-round program at Summit, a German microwave radar study¹⁶ was added to the Swiss boundary layer meteorology program¹⁷ and the on-going U.S. study of atmosphere-ice transfer processes at the Environmental Observatory¹⁸ (site of the Greenland Ice Sheet Project-2 core).
People 3, Ideas 2

International Workshops. OPP organizes, provides resources for and participates in a wide variety of workshops that facilitate collaboration with international colleagues. These workshops are a useful mechanism for ensuring that the US scientific community is globally engaged and among the best in the world. During the past year, OPP contributed to over twenty workshops. These included:

- **Workshop Report: Life in Ancient Ice.** This symposium brought together an international group of researchers in diverse disciplines that work with ancient ice and permafrost. The group assessed current and future research that would extend knowledge of life in ancient frozen matrices. Topics included: contamination and decontamination; methods to detect and identify microorganisms and their nucleic acids; and methods on ice coring, transport, processing and culturing.¹⁹
- **Social Science Workshop and Field Course in the Arctic.** The Arctic Social Sciences Program supported an interdisciplinary workshop and field course in Alaska for graduate students through the Circumpolar Arctic Social Science (CASS) Ph.D. Network. The workshop promoted connections among graduate students across the entire circumpolar north, and between scholars and indigenous communities. The students and faculty participating in the workshop and field course published a book of proceedings, Northern Communities and the Global Economy.²⁰
- **West Antarctic Ice Sheet (WAIS) Workshop.** This workshop focused a broad cross-section of the Antarctic research community on two urgent global issues: future sea level and rapid climate changes. It promoted international, interdisciplinary collaboration, while providing an opportunity for scientists to exchange and present research results.²¹
- **Antarctic Acoustic Stratigraphy program (ANTOSTRAT) Symposium.** This international coordination encouraged and facilitated data sharing and research collaboration related to marine sedimentary records from the Antarctic continental margins. Much of the work focused on paleoenvironmental issues, including

¹⁶ <http://www.ram.uni-bremen.de>, funded by the EU; Klaus Kuenzi, Institute of Environmental Physics, Institute of Remote Sensing, University of Bremen/FB1

¹⁷ Atsumo Ohmura, Institute of Climate Change Research, Swiss Federal Institute of Technology. Funded by the Swiss Science Foundation.

¹⁸ www.hwr.arizona.edu/GEOsummit/

¹⁹ OPP-0003804, OPP-0196481Rogers and Castello

²⁰ OPP-0003072, Caulfield; Northern Communities and the Global Economy, edited by Richard A. Caulfield and Mie Kojima (Department of Alaska Native & Rural Development, College of Rural Alaska, University of Alaska Fairbanks, 2001).

²¹ OPP-0000515, Bindschadler; <http://igloo.gsfc.nasa.gov/wais>

paleoceanography and ice sheet fluctuations in the past. The ultimate ANTOSTRAT goal has been to generate successful proposals to the Ocean Drilling Program.²²

- **Antarctic Drilling - ANDRILL.** Scientists from several nations met at Oxford to prepare a science implementation plan for geological drilling in Antarctica. Most of the scientific goals for drilling are related to paleoclimate issues. Participating nations included the US, UK, Italy, New Zealand and Germany.²³
- **Paleoecology and Quaternary Geology Arctic Workshop.** Graduate students from the US, Canada, and several European countries attended the Arctic Workshop, to present and discuss results of paleoecology and quaternary geology research.²⁴

People 3, Ideas 3, 4

Integrating Research and Education Globally. The Arctic Social Sciences Program Director convened and chaired a special session at the International Congress of Arctic Social Sciences in Quebec (May 16-20, 2001) on integrating research and education across international boundaries.²⁵ *People 3, Ideas 4*

People Indicator 4—A public that is provided access to the benefits of science and engineering research and education.

Arctic Contaminants and Their Relevance to Arctic Communities. PIs met in the field with delegates from the U.S. Department of the Interior, several state and federal congressional staff, the NSF liaison to Congress, and numerous local governmental officials to provide a special briefing on arctic contaminants and their relevance to Arctic communities. The research project on airborne contaminants contributes significantly to our understanding of how environmental issues affect Inupiat people. The scientists worked directly with village elders and other members of the community in planning, experimental design and fieldwork. In this way, the two groups not only benefited from their collective wisdom, but also were able to ensure that the project would contribute significantly to their scientific and societal needs.²⁶ *People 4, Ideas 3*

Alaskan Fisheries Management Aided by Research on Lake Trout. In 2001, PIs met with the head of the Alaska Department of Fish and Game (ADF&G) for Fairbanks and the north. After the scientists informed the ADF&G of the slow growth and extreme longevity (more than 50 years) of lake trout in the region, ADF&G instigated a catch-and-release-only program for lake trout north of the Brooks Range. Each year, PIs brief representatives of the ADF&G on the results of their research underway at Toolik Lake, Alaska.²⁷ *People 4, Ideas 3*

Evolution of Alaskan Brown Bears and Gray Wolves. Prior to the last glaciation 20,000 years ago, North American bears and wolves showed a wide diversity of distinctive DNA sequences. When the land bridge with Asia opened, they were replaced by sequences of Old World origin. The Old World sequences carried through to the present with minor modifications.

²² OPP-0111665, Dunbar and Cooper

²³ OPP-0118665, Harwood.

²⁴ OPP-9614129, Andrews, University of Colorado.

²⁵ <http://www.fss.ulaval.ca/iassa/icass4.HTML>

²⁶ OPP-9979689, Allen-Gil; OPP-9979695, Ford

²⁷ DEB-9810222; DEB-9211775; OPP-9911278; OPP-9400722, Hobbie

The fact that pre-glacial population of bears and wolves were genetically more diverse than post-glacial ones suggests a natural, rather than anthropogenic, cause of limited genetic diversity in large North American carnivores. If supported by further study on other species, these findings would have substantial importance for theories of faunal change in the late Pleistocene. This work is featured in the first show of the recent television series *EVOLUTION*, by WGBH and Clear Blue Skies Productions.²⁸ *People 1, 4, Ideas 1, 2*

Sea Ice and Native Whale Hunting in the Arctic. Changes in sea ice dynamics for the past few decades have affected both the size of the whale harvest and the ability of Arctic Natives in Alaska and Chukota to implement safe hunting practices. Two workshops, “Native Whaling in the Western Arctic: Development, Spread and Responses to a Changing Environment” and “The Barrow Symposium on Sea Ice, 2000,” brought together scientists and their instrumental data, anthropological records, and sea ice models with Native experts on sea ice conditions that have affected the whale hunt. The symposia revealed a wealth of knowledge from the scientific approach and Traditional Ecological Knowledge (TEK) that when utilized together enhances the understanding of environmental change impacts on subsistence and cultural hunting practices.²⁹ *People 4, Ideas 1, 2, 3*

Ideas—Enabling “discovery across the frontier of science and engineering, connected to learning, innovation, and service to society.”

Ideas Indicator 1—A robust and growing fundamental knowledge base that enhances progress in all science and engineering areas including the science of learning.

New Tool to Study Abrupt Climate Change. Abrupt climate events, occurring in less than decades, are now widely recognized in paleoclimatic records spanning the last 100,000 years. The aim of the funded research was to better quantify the events' magnitude and scope, and to address their fundamental cause. Researchers have developed and applied a new ice core 'paleothermometer' based on the principle of thermal diffusion, in which a mixture of gases separates into heavier and lighter components when subjected to a temperature gradient. This technique allows direct comparison of the timing of atmospheric trace gas variations (for example, methane) relative to variations in surface temperature. With these methods, PIs identified a 20-30 year lag of atmospheric methane concentration change following Greenland temperature change during the abrupt warming at the end of the last ice age (known as the Bolling Transition). This lag is thought to be significant because it suggests that the tropical climate changed at least 20 years after the Greenland climate. A second major finding concerns the magnitude of the Greenland temperature change, which was up to 9 degrees Celsius in as little as a decade. Work is ongoing on Antarctic cores to look for similar results. These findings reinforce the emerging view that abrupt events are important to the evolution of the earth system.³⁰ *Ideas 1, 2*

²⁸ OPP-9817937, Wayne

²⁹ OPP-9807051, McCartney; OPP-9908682, Norton

³⁰ OPP-9725305, Jeffrey P Severinghaus, U of Cal SD Scripps Inst , California.

New Ribotype Discovered in Polar Plankton. PI compared the phylogenetic composition of Proteobacterial ammonia-oxidizing bacteria (AOB) assemblages in plankton samples collected in the Arctic and Antarctic, and found a novel 16S rDNA sequence distantly related to *Nitrosospira* in all samples that were positive for AOB. The widespread distribution of this ribotype in cold oceans suggests that it represents a dominant species of planktonic AOB. Its trans-polar distribution contrasts with that of another group of polar prokaryotes, the gas vacuolate bacteria, which display polar endemism. These differences in distribution can be related to the influence of the adaptive strategies of these two groups of organisms on their potential for trans-global dispersal. This is an important first-look at the genomic composition of polar bacteria.³¹ *Ideas 1, 2*

Modeling Paleozoic Glaciations. Coupled modeling of the oceans and atmosphere shows important aspects of the effects of atmospheric CO₂ on global climate. This project is simulating paleoenvironmental conditions that are derived from geological records and is demonstrating the value of plate tectonic reconstructions to paleoclimate models. The paper published in *Nature* (May, v405, p425-429) is an outstanding contribution toward understanding glacial intervals in Earth's early history and thus understanding of Earth's evolution as a whole. An additional aspect of this project is that it is teaching people how to more fully integrate boundary conditions into global simulations. This work also has important ramifications for understanding how life could survive on Earth during periods of global glaciation.³² *Ideas 1, 2*

Marine, Glacial and Environmental History of the Russian Arctic. A PI completed two field expeditions to the shores of the Kara Sea on the Yamal and Yugorski Peninsulas, areas that are parts of the little-studied Russian Arctic. The geologic record has yielded significant new information on the marine, glacial, and environmental history of the Russian Arctic, in some cases dramatically revising our understanding of past glacial extents and dynamics. For example, radiocarbon and luminescence age estimates coupled with lithostratigraphic and paleoenvironmental proxies indicate that the eastern Kara Sea was not glaciated during the last glacial maximum, but remained cold and dry. This is currently a part of the boundary conditions for testing global circulation model simulations of climate. A major focus of the project was to develop and apply a new technique for amino acid dating and paleothermometry (reverse-phase chromatography for higher resolution with D/L Aspartic Acid in fossil molluscs).³³ *People 3, Ideas 1, 2*

Hydrologic Change. The Arctic Ocean receives 11% of the world's freshwater runoff while containing only 1% of the global volume of seawater. The largest volume of that runoff flows onto the shallow Russian shelves, where access to hydrologic data has been sparse. A compilation of existing data for the entire Arctic drainage basin is revealing seasonal changes on a decadal time scale that may be related to natural or anthropogenic climate change. Those changes are critical to understanding the role of continental scale hydrologic changes on terrestrial and marine productivity, sea ice formation, and ocean circulation.³⁴ *Ideas 1, 2*

³¹ OPP-9809971, Hollibaugh

³² OPP-9615011, Crowley (CF "Snowball Earth", OPP-9817244)

³³ OPP-9529350, Gifford Miller, University of Colorado

³⁴ OPP-9524740 (Peterson), OPP-0041225 (Vorosmarty) - Lammers et al., *J. Geophys. Res.*, 2001

Genetic Variation Among Ancient Arctic Populations. Researchers studying genetics and northern human history have discovered a high level of genetic variance among the ancient populations of North Asia, especially those groups adapted to boreal climates in the northernmost regions of human habitation. This discovery has important implications for understanding the historic peopling of North America.³⁵ *Ideas 1, 2*

Geometry and Early Structure of the Universe. The array of sensors on the various telescopes at South Pole Station have continued to produce significant new insights into the structure of the cosmic microwave background radiation (CMBR). In particular, the Degree Angular Scale Interferometer (DASI) is currently providing measurements of the background radiation anisotropy over a range of scales that span the first three acoustic peaks in the CMBR power spectrum. The shape of the power spectrum, in particular the spacing of the peaks, provides a potentially clean measure of the geometry of the universe. An extension to measure the polarization of the CMBR anisotropy will provide a critical test of the early structure of the universe.³⁶ *Ideas 1, 2*

Cold Halocline Layer. The cold halocline (salinity gradient) insulates sea ice from warmer ocean water below. Without it, more warm water would come in contact with the ice, creating a positive feedback loop for melting. In a modeling and data analysis effort, PIs discovered a partial recovery of the Cold Halocline Layer (CHL) in the Eurasian Basin of the Arctic Ocean. As of 2000, conditions were similar to those seen in 1991 by the icebreaker Oden. These conditions are still somewhere between the historical mean and the extreme CHL retreat seen by the mid-1990's, in keeping with the behavior of the Arctic Oscillation index. The PIs have begun to examine the circulation and heat content variability of summertime Pacific waters that flow into the Arctic Ocean. This will assist in an examination of the so-called 'cool halocline' of the western arctic, where waters of up to a degree above freezing reside just below the mixed layer. Surprisingly, they also found that within Fram Strait, the gridded data from the Environmental Working Group were of lower quality than those from the National Oceanographic Data Center (NODC). The reason is a fortuitous blending of summertime data into the winter time frame, which preserves the exchanges of water masses in this region in the NODC data. The PIs engaged in extensive outreach, and have given lectures on Arctic change, sea ice and the polar oceans to the Washington Science Teachers Association annual meeting, an undergraduate class at the University of Washington, and classes at elementary schools in Seattle. In addition, they have written an article for *Discover* magazine and two chapters of the upcoming *Encyclopedia of the Arctic*.³⁷ *People 1, 4, Ideas 1, 2, 3*

³⁵ OPP-9806759; Hammer, M.F., et al. (2001) "Hierarchical Patterns of Global Human Y-chromosome Diversity." *Molecular Biology and Evolution* 18: 189-203; Karafet, T.M. et al. (2001) "Paternal population history of East Asia: Sources, patterns and microevolutionary processes." *American Journal of Human Genetics* 69: 615-628; Karafet, T.M. et al (2001) "A history of Siberian Native people from the perspective of male lineages." *American Journal of Physical Anthropology* 32 (suppl): 88 (abstract).

³⁶ OPP-9980654, Ruhl

³⁷ OPP-0083108, Martinson; OPP-0082770, Steele. Invited lecture 'Arctic Change' at the Washington Science Teachers Association annual meeting in Vancouver, WA, October, 2000; Invited lecture 'Big Changes in the Polar Oceans' to an undergraduate class at the Univ. of WA, 'Forestry and Society' taught by Prof. R. Gara, November, 2000; Ongoing talks to elementary school classes around Seattle about the arctic and sea ice; 'How The Ocean Freezes', an installment of the 'Ask the Wizard' column for Discover Magazine, expected publication date in fall,

Cape Roberts Project (CRP). The CRP is a major program within the international Antarctic earth science community which collected over 1700 meters of drill core offshore of Cape Roberts, McMurdo Sound, Antarctica, having sediment of Pleistocene, Pliocene, Miocene and Oligocene age. This provides a physical record of environmental changes over periods of history which had not been previously available. Analysis of these records has significance for all areas of Antarctic geosciences, including glacial, tectonic, stratigraphic, paleobiologic and paleoceanographic disciplines. For example, sedimentological studies show some depositional cycles that appear to be related to the 100 thousand year orbital cycle, providing important evidence that the orbital variations did affect earth's environment over 30 million years ago. The CRP is an excellent example of a large coordinated international project that provided professional interactions and development activities for all participants, from professors to students. Over fifty people from seven countries participated in the project.³⁸ *People 3, Ideas 1, 2, 3, 4*

Arctic Bird Adaptations. Researchers are currently studying the physiological and behavioral adaptations of birds to the extreme conditions that prevail in Arctic environments. Recent field studies in Barrow revealed that Arctic breeding birds are resistant to the well-known effects of stress hormones that are typical of breeding birds at lower latitudes. There are three possible receptor types for corticosteroids in the brain of a passerine bird, one of which appears to be different from the mammalian type. Additionally, mRNA can be measured for androgen receptor gene expression in the passerine brain. Finally, the studies found that snow buntings and redpolls are polyandrous (i.e. each nesting female has from 1-5 males attending her and the nest), a condition that appears unique in arctic passerines.³⁹ *Ideas 1, 2*

American Zoologist . The entire contents of Volume 41 of this journal issue consisted of nine papers resulting from the symposium *Antarctic Marine Biology*, organized by James McClintock, Charles Amsler, and Bill Baker, and held at the Annual Meeting of the Society for Comparative and Integrative Biology, January 4-8, 2000. All authors were OPP PIs who reported on research topics ranging from the effects of increased ultraviolet radiation on marine organisms, global climate change and the origin of modern benthic communities, chemical ecology of marine organisms, sea ice algae production, primary production in marine ecosystems, biology of krill, habitat use by seal and penguins in the Ross Sea, trophic relationships between fauna and benthic macroalgae, and adaptive evolution of gene expression in Antarctic fishes.⁴⁰ *Ideas 1, 2, 3*

High Metabolism of Sea Urchin Embryos at Low Temperatures. Assessing the energy costs of development in extreme environments is important for understanding how organisms can exist

2001; 'The Cold Halocline' and 'Thermohaline Circulation,' two chapters in the upcoming *Encyclopedia of the Arctic*, Fitzroy Dearborn Publishers.

³⁸ OPP-9527481, Powell; 9527013, Askin; 9527075 Wrenn; OPP-9527329; OPP-9317979; OPP-9527394; OPP-9527008; OPP-9420062; OPP-9418429; OPP-9419770; OPP-9422893; OPP-9526889; OPP-9527070; OPP-9420475

³⁹ OPP-9911333, Wingfield

⁴⁰ OPP-9820698; OPP-9815381; OPP-9632763; OPP-9019812; OPP-9420678; OPP-9529569; OPP-9632733; OPP-9908856; OPP-9413295; OPP-9901076; OPP-9814538; OPP-9528241; OPP-9814794.

at the margins of the biosphere. Macromolecular turnover rates of RNA and protein were measured at -1.5°C during early development of an Antarctic sea urchin. Contrary to expectations of low synthesis with low metabolism at low temperatures, protein and RNA synthesis rates exhibited temperature compensation and were equivalent to rates in temperate sea urchin embryos. High protein metabolism with a low metabolic rate is energetically possible in this Antarctic sea urchin because the energy cost of protein turnover is 1/25th the values reported for other animals.⁴¹ *Ideas 1, 2*

Needle Retention and Tree Growth Variance in Alaska. A PI discovered that the needle retention of forest white spruce in the Chugach Mountains in the south of Alaska was about half of that in the White Mountains of interior Alaska, and the Brooks Range of northern Alaska. The trees above the forest limit (i.e. in the treeline zone) showed premature needle loss and thus lower needle retention than forest trees. This difference in needle retention between forest and treeline is greatest in the southern-most mountain Range (the Chugach Mountains) and least in the northernmost mountain range (the Brooks Range). Tree growth decreases northwards and at higher elevations, and the greatest difference between elevations is in the southernmost Chugach Mountains where climatic differences between treeline and forest sites are most extreme. These results have implications for vegetation in a global warming scenario.⁴² *Ideas 1, 2*

Stability of the West Antarctic Ice Sheet. Glacial geologists have developed a history of grounding line retreat for the West Antarctic ice sheet in the Ross Sea. Interpretation and analysis of the data through flow modeling, constrained by field measurements, has enabled the scientists to determine when the grounding line retreated past Roosevelt Island. Results concerning the retreat of the West Antarctic ice sheet have been of widespread interest, particularly for those who are studying past and present changes in sea level, ocean circulation, and atmospheric circulation. This information was widely disseminated to the public through press and radio reports, and also at seminars and meetings.⁴³ *Ideas 1, 2*

New Information About the Size of the Antarctic Ice Sheet During the Pliocene. By examining sediments recovered from sites on the Kerguelen Plateau and on Maude Rise, a PI has discovered important new information about the age of inception of the Antarctic ice sheets. This research supports the "stabilists" view in the debate over the Sirius Formation deposits and their paleoenvironmental significance. In other words, it refutes the notion that there was a significant reduction in Antarctic ice sheet volume during the Pliocene. This information will improve understanding of Antarctic environmental history and will be useful to polar paleoclimatology and paleobiology.⁴⁴ *Ideas 1, 2*

Snowball Earth. The "snowball earth" hypothesis postulates that a stratigraphic record of global glaciations should be apparent in well-preserved Neoproterozoic sections worldwide, even where no glacial deposits are preserved. Thus, an important way of understanding how these extreme ice ages began is to examine the sedimentary record leading up to glaciation.

⁴¹ OPP-9420803; *Science* 291: 1950-1952. Adam G. Marsh, Robert E. Maxson Jr., and Donal T. Manahan.

⁴² OPP-9978143, Sveinbjornsson

⁴³ OPP-9615347, Howard Conway, University of Washington

⁴⁴ OPP-9527067, Rea

Isotope profiles in carbonates immediately below glacial deposits are proxies for marine chemistry leading into the ice age and may help to elucidate their ultimate cause. Researchers studying stratigraphic cores along with two glacial deposits in Svalbard have recorded firm documentation of a large decline in isotopic Carbon-13 preceding deposition of the older of the two glacial deposits. Large declines in isotopic Carbon-13 prior to Neoproterozoic glaciation have also been identified in Namibia and the Adelaide Rift complex of Australia.⁴⁵ *Ideas 1, 2*

Sources of Radionuclides in Sea Ice Sediments. A study using natural and anthropogenic radionuclides in sea-ice sediments characterizes the source(s) of these sediments and possible modifications as they are transported across the Arctic in the Transpolar Drift. The PI found that samples of sea-ice sediment recovered from sea ice floes around Svalbard all had detectable Cs-137 activity. Measurements of plutonium isotope ratios (Pu-240/Pu-239) on these samples show that the source of the plutonium is fallout from the atmospheric testing of atomic weapons. There was no evidence in the sea-ice sediment samples of a source of plutonium from Russian nuclear facilities in the Siberian Arctic. However, measurement of the Pu-240/Pu-239 isotope ratio in bottom sediments from the Fram Strait and Northeast Water Polynya show that non-fallout plutonium may have been added to these areas in the past.⁴⁶ *Ideas 1, 2*

Thinning Arctic Sea Ice Cover. The cause of a rapid, decade-long thinning of Arctic Ocean sea ice in the 1990s, which has been widely reported in the press in the past two years, is largely attributed to changes in atmospheric circulation. The thinning is due to a natural long-term cycle of atmospheric variability that is difficult to separate from the additional influence of anthropogenic forcing on sea ice thickness variability without more measurements of the natural system.⁴⁷ The potential disappearance of the sea ice is critical to understanding future climates because of the role of surface reflectance from snow and sea ice in the Arctic in global climate change feedbacks. The physical factors controlling the seasonal and interannual sea ice thinning have been the subject of the SHEBA project, which has shown the importance of how increasing cloudiness plays a role in enhanced melting rates.⁴⁸ *Ideas 1, 2*

Vegetation and Climate Change. Warming of the Alaskan Arctic has accelerated over the past three decades and is expected to increase vegetation productivity in tundra though increased abundance of shrubs. Comparison of aerial photographs taken over fifty years ago with current photographs taken at the same locations reveals that the expansion of shrubs has already begun. Shrub expansion affects both the amount of carbon absorbed from the atmosphere and soils as well as the trapping and distribution of snow, which affects hydrologic runoff and surface reflectivity. The study of complex climate feedbacks from shrub expansion reveals how climate is changing the environment in northern Alaska.⁴⁹ *Ideas 1, 2*

⁴⁵ OPP-9817244, Paul Hoffman, Harvard University. (CF “Modeling Paleozoic Glaciations”, OPP-9615011, Crowley)

⁴⁶ OPP-9979684, Cochran

⁴⁷ OPP-9806296, (Johnson) - Polyakov and Johnson, *Geophys. Res. Ltrs*, December, 2000; OPP-9634513 (Tucker) - Tucker et al., *Geophys. Res. Ltrs.*, July, 2001

⁴⁸ OPP-9703127, Curry

⁴⁹ OPP-0084345, Sturm; Sturm et al., *Nature*, 2001

Arctic Freshwater Crustacean Genetics and Distribution. A PI produced the first genetic characterization of the major lineages of an ecologically important freshwater crustacean group (Bosmina). Using the 16S reference sequences he developed, researchers can now determine the major group to which their study populations belong. This is an important contribution to the comparative biology of Arctic freshwater organisms. The PI also found the first strong evidence for the origin of an Arctic polyploid animal. Newly collected nuclear phylogeography and mtDNA evidence suggest that the most successful zooplankter in glacial lakes (*Daphnia galeata mendotae*) resulted from hybridization between two species that hid out in Beringia during the last glaciation. The phylogeographic patterns emerging from freshwater microcrustaceans suggest a close association of Eastern Canadian Arctic to European Arctic species, and a close association of western North American Arctic species with Asian Arctic species (Beringia). This challenges the argument that Greenland acts as a dispersal barrier between North American and Eurasian freshwater species in the Arctic.⁵⁰ *Ideas 1, 2*

Ideas Indicator 2—discoveries that advance the frontiers of science, engineering and technology.

Iron Isotopes as Biological Markers. This project, from MarsRock, developed a chemical method for fingerprinting biological activity in meteorites using the isotopic composition of iron (Fe). Meanwhile, it has triggered new research in a field crossing geochemistry and biology and has attracted several other research groups. For the first time, it was shown that biological activity can produce detectable isotopic fractionation of iron. The results were key to advancing knowledge about the natural variability of Fe isotopes. Mass dependent isotope variation of the light stable isotopes (e.g., H, C, N, O, S) is a widely used tool in nearly every branch of the physical sciences. This research contribution, development of the Fe isotope system, adds a new element to the list of potential tools that a scientist can use for tracing the pathways and conditions as an element is cycled through different reservoirs.⁵¹ *Ideas 1, 2*

Ice Pre-Melting at Freezing Temperatures. Pre-melting of ice is the formation of a thin layer of liquid water at the interfaces between individual ice crystals at temperatures colder than the nominal melting point of ice. Interfacial pre-melting is important in many macroscopic applications ranging from the migration of impurities through sea ice, the sliding of glaciers on bedrock, and permafrost heaving, to the uptake of particles on polar stratospheric clouds, and speed skating. A newly developed theory of the effect of soluble impurities on the magnitude of a pre-melted water layer has ordered the molecular dispersion forces and short and long-range intermolecular forces, and for the first time has provided a foundation for organizing the microscale processes that give rise to the distinctive fabrics of fresh water ice, sea ice, and permafrost.⁵² *Ideas 1, 2*

Ultra-Violet Radiation and Photosynthesis. A PI found that the presence of humic materials (partially decomposed organic materials) in arctic Norwegian coastal waters results in rapid attenuation of ultra-violet radiation as compared to extinction coefficients obtained in Antarctic

⁵⁰ OPP-9984901, Taylor

⁵¹ OPP-9713968, Beard and Johnson

⁵² OPP-9908945, Wettlaufer and Dash

waters. As this will minimize the loss of integrated primary production due to ultra-violet radiation in the euphotic zone, contributes to our understanding of the seasonal aspects of humic materials in coastal waters, timing of atmospheric ozone depletion, and the timing of the spring phytoplankton bloom which is important for fish larvae.⁵³ *Ideas 1, 2*

Shelf/Basin Interactions (SBI) Program. A new five-year interdisciplinary effort has been developed to understand the biogeochemical fluxes on the continental shelves of the western Arctic. The competition was run in 2001 and fieldwork will begin in 2002.⁵⁴ *Ideas 2*

New Model of Kinetic Theory. As part of a project on dynamic properties of plankton in polar lakes, PIs developed a new model of kinetic theory that could replace the 90 year-old Michaelis Menten and 60 year-old Monod models to become the new standard for describing and understanding nutrient flux and transport into microorganisms and other cells. The new model predicts the various cellular components relevant to transport and growth, such as permease distributions, metabolic pool concentrations, and enzyme concentrations and ratios from first principals according to kinetic theory. Thus, it provides a powerful tool for designing experiments that may probe nutrient dynamics on both a system and a cellular level.⁵⁵ *Ideas 1, 2, Tools 3*

Oceanic Crust Formation at Gakkel Ridge. Four Principal Investigators have been funded to sample basalts, peridotites, and related rocks along 600 km of the Gakkel Ridge. Detailed geochemical study of these rocks along with geophysical estimates of crustal and lithospheric thickness will be combined to generate quantitative models of oceanic crust formation under ultra-slow spreading conditions. A hydrothermal survey is being done with a MAPR device, which measured the temperature, pressure and optical properties of seawater. This is the maiden scientific voyage of the USCGC *Healy* and a jointly operated cruise with the Germans on the Polarstern icebreaker. The Gakkel Ridge has been a prime target for sampling by scientists for many years, but its inaccessibility due to the perennial Arctic ice cover has discouraged a systematic study.⁵⁶ *People 3, Ideas 1, 2*

New Diatom Fossil Species. A project analyzing drill cores recovered by the Cape Roberts Project discovered a new diatom species in Antarctic waters during the interval of 18-35 million years ago. Diatoms offer the greatest potential for age resolution based on fossils for the Miocene and Oligocene of the Antarctic continental shelf. The basic data of biostratigraphic ranges of taxa will be used in the future to establish a biostratigraphic scheme for correlation within and outside the Antarctic realm. This is important for linking Antarctic events into a global chronology of climate and paleoenvironmental change. In addition, there is significance to the general study of diatom evolution, classification and paleobiogeography. At the McMurdo Station, the PI was in email contact with fifth grade students on a weekly basis. Upon returning

⁵³ OPP-9907692, Holm-Hansen

⁵⁴ NSF 01-78; <http://utk-biogw.bio.utk.edu/SBI.nsf>

⁵⁵ OPP-9907776, Button, et.al.

⁵⁶ OPP-9911795, Peter Michael, Chief Scientist, University of Tulsa; OPP-0000389, Charles Langmuir, Lamont; OPP-9912162, Henry Dick, Woods Hole Oceanographic Institution; OPP-9912156, David Graham, Oregon State

to Nebraska, the PI visited the school both in 2000 and again in 2001.⁵⁷ *People 1, Ideas 1, 2, 4, Tools 2*

Ocean Productivity During the Last Ice Age. Researchers estimate that the productivity of Earth's biosphere during the last ice age was 15-25% less than today. If the productivity of the land biosphere is known, it is possible to calculate ocean productivity. With existing land biosphere productivity data, researchers have calculated that ocean productivity during the last ice age was 70-160% of present. Although this estimate includes a high level of uncertainty, once land productivity data improve, it will be possible to calculate the fertility of the ocean biosphere with useful accuracy. Eventually, this data will help to characterize the nature of the ice age biosphere and contribute to our understanding of its role in climate change. The latter is fundamental because it is increasingly recognized that the biosphere introduces climate feedbacks that play a major role in glacial/interglacial climate change.⁵⁸

Understanding How Life Survives in Glacial Ice. Research on the effects of impurities on the flow of polycrystalline ice may prove to be important for future understanding of how life survives in glacial ice. The PI is one of the few scientists studying impurity concentration (sulfuric and nitric acid) in grain boundaries of ice. Filaments and an extraordinary leaf-like structure (probably magnesium sulfate) were observed in grain boundaries of Vostok accretion ice. A first year undergraduate was supported by an REU supplement to this project.⁵⁹ *Ideas 2, 4*

Stratospheric Cloud Composition. Polar stratospheric clouds are critical to understanding the details of ozone depletion, particularly in the Arctic. Measurements completed this year provide the most complete characterization of a polar stratospheric cloud yet obtained. They are the first direct measurements of the size and concentration of polar stratospheric cloud particles that are definitely composed of nitric acid trihydrate. The measurements are being used to test our understanding of the formation of polar stratospheric clouds, by comparing these measurements with microphysical models.⁶⁰ *Ideas 1, 2*

Oceanic Carbon Sequestration. Synthesis of oceanographic data obtained in the Southern Ocean Experiment of the Joint Global Ocean Flux Study has given us a much more precise understanding of the temporal and spatial variation in the effectiveness of the Southern Ocean as a sink for atmospheric carbon dioxide. Quantitative data using an undulating towed vehicle to continuously sample sea water on nine cruises of the research vessels *Nathaniel B. Palmer* and *Roger Revelle* shows that the uptake of atmospheric CO₂ is regulated by mesoscale eddies of ocean water. For the first time, coupling of the distribution of biogeochemical properties with flow dynamics of the ocean water has been demonstrated, and for the first time a complete seasonal cycle of sea-air carbon dioxide transfer has been documented across the Southern Ocean. The new data show that this region accounts for nearly a quarter of the global oceanic sequestering of atmospheric carbon dioxide.⁶¹ *Ideas 1, 2*

⁵⁷ OPP-9420062, Harwood

⁵⁸ OPP-9814634, Michael Bender, Princeton University

⁵⁹ OPP-9980379, Ian Baker, Dartmouth College.

⁶⁰ OPP-9707520, Deshler; Voigt, C., J. et al. December, 2000. Nitric acid trihydrate (NAT) in polar stratospheric cloud particles, *Science*, 290, 1756-1758.

⁶¹ OPP-9530609, Goyet and Peltzer; OPP-9530677, Nelson; OPP-9531982, Brzezinski

Small Grants for Exploratory Research (SGER). NSF supports small-scale, high risk exploratory work through the SGER program. OPP has sponsored many of these cutting-edge projects. This year, they included:

- **Ione Hunt von Herbing**, University of Maine – a study of hemoglobin gelation and fish adaptation to cold water.⁶²
- **Gerald Kooyman**, University of California, San Diego – high-resolution satellite imagery to census Emperor penguin colonies.⁶³
- **Peter Michael**, University of Tulsa –developing new sampling and measurement methods and tools that can be deployed under the Arctic Ocean ice cap on the Gakkel Ridge.⁶⁴
- **Tad Pfeffer**, University of Colorado – study to document the continuing retreat of the Columbia Glacier, Alaska, which is presently retreating at a rate of approximately 1.67 km year. This rapid retreat has been accompanied by flow speeds up to 34 m/day, making it the world's fastest-moving glacier.⁶⁵
- **Rudolf Scheltema**, Woods Hole Institution – survey to determine whether or not larvae of benthic invertebrates can be found in Antarctic plankton during the early winter months.⁶⁶

Ideas 1, 2

Ideas Indicator 3—partnerships connecting discovery to innovation, learning and societal advancement

Stream Size and Nutrient Transport. In a finding that could have important consequences for land-use policies in watersheds from the Chesapeake Bay to Puget Sound, researchers have discovered that small streams contribute more to removing nutrients such as nitrogen from water than do their larger counterparts. There is a very strong correlation between the size of a stream and how rapidly that stream removes nutrients: the smaller the stream, the more quickly nitrogen can be removed and the less distance it will be transported down the stream. The findings are based on data collected initially from streams in NSF's Arctic Tundra Long-Term Ecological Research site in Alaska and subsequently from 12 sites across the country.⁶⁷ *Ideas 1, 2, 3*

Fisheries and Climate Change. The social impacts of climate change have been demonstrated in historical and geological records from Iceland and Greenland. The geologic and early Norse record indicate large incursions of sea ice into the North Atlantic that have had a major influence on climate feedbacks affecting ocean currents and productivity that, in turn, affect fisheries.⁶⁸ The human consequences of climate variability are seen in the effect of sea ice concentration on

⁶² OPP-0118372

⁶³ OPP-0001450

⁶⁴ OPP-9911795

⁶⁵ OPP-9614493

⁶⁶ OPP-9910164

⁶⁷ OPP-9911278, Hobbie et al; NSF press release on Peterson et al *Science*, vol 292, 6 April, 2001.

⁶⁸ ATM-9809795 (Miller) - EOS, Trans. American Geophysical Union, February, 2001; OPP-9726510 (Ogilvie) - Andrews et al., *J. Quaternary Sci.*, 2001.

cod fisheries even in the twentieth century, as dynamic changes between fishing practices and climate change resulted in increased resource use and dwindling supplies.⁶⁹ *Ideas 1, 2, 3*

Space Weather Disturbances to Earth's Magnetic Field. The Antarctic network of surface magnetometers has produced new insights into the triggering of plasma instabilities by ultra-low frequency waves in the Earth's magnetic field. Disturbances in the solar wind that arrive at the Earth within minutes to days after a violent event on the Sun are referred to as space weather. The largest space weather disturbances are produced by coronal mass ejections and fast solar wind streams emanating from coronal holes, which distort the Earth's magnetic field and inject energy into the magnetosphere. This produces the aurora but also relativistic electrons, a source of radio and television interference, hazards to orbiting spacecraft, and current surges in power lines.⁷⁰ *Ideas 1, 2, 3*

Implementation Plan for the Interagency Study of Environmental Arctic Change Program (SEARCH). Working with the Science Steering Committee and its Science Plan, OPP developed the interagency implementation plan for SEARCH and received approval from the agency principals at the Interagency Arctic Research Policy Committee (IARPC).⁷¹ *Ideas 3*

Ideas Indicator 4—research and education processes that are synergistic.

Reconstructing the Retreat History of the West Antarctic Ice Sheet. Researchers are working with students to reconstruct the retreat history of the West Antarctic ice sheet along a flowline through the Ford Ranges in Marie Byrd Land, from the last ice age to the present. The research results will contribute to our understanding of the history and dynamics of the West Antarctic ice sheet and will help forecast its future stability. Several undergraduate students have worked as lab assistants on samples connected with the project, learning techniques of analytical chemistry. Another undergraduate is using research results for a senior thesis, while a graduate student is conducting research for his PhD thesis. PIs have visited four elementary schools in Seattle to teach children about research and life in Antarctica, and plan to visit more schools next year.⁷²

El Niño Southern Oscillation (ENSO). Isotopic measurements on the West Antarctic Ice Sheet/Siple Dome ice cores have shown that stable isotopes in ice cores can be used to reconstruct past behavior of the ENSO system that dominates climate variability in the Pacific as well as many other parts of the world. ENSO affects food production and hurricane frequency and intensity, two of the socially relevant impacts of ENSO. Ice cores can be dated annually, and contain thousands of years of record. Comparing core records of ENSO with those from tree rings and corals, as well as with modern observations, should improve our understanding of this key feature of the climate system. The project has involved four undergraduate students (two are women). Two of the technicians (including one woman) who have worked on the project were inspired to go on to graduate school. Results have been incorporated into undergraduate courses and are being used in an undergraduate honors thesis. They will also be used in a PhD. thesis. At

⁶⁹ OPP-9515380 (Hamilton) - Hamilton et al., *Climatic Change*, 2000

⁷⁰ OPP-9909212, Engebretson and Arnoldy

⁷¹ OPP-0076298; <http://psc.apl.washington.edu/search/>

⁷² OPP-9909778, John Stone, University of Washington

the University of Colorado, several political science faculty have discussed climate change policy with the PI.⁷³ *People 2, 4, Ideas 2, 3, 4*

Biology Training Course In Antarctica (third year). An international graduate-level training course, "Integrative Biology and Adaptation of Antarctic Marine Organisms", was taught in Antarctica for one month during the austral summer. There were 22 participants from six countries (18 graduate students and 4 post-doctoral researchers). The goals for the course were to introduce students to the diversity of biological organisms in Antarctica, to study the unique aspects of biology that permit life in such an extreme environment, and to give students firsthand experience in dealing with the unique problems inherent in Antarctic field sampling. The research emphasis of the course was on experimental Antarctic biology and a number of aspects of evolution, physiology and ecology were considered. These included investigations on bacteria, algae, invertebrates and fish to study molecular phylogeny, ultraviolet radiation effects, energy metabolism and biochemical adaptations to cold temperature. The course attracted an extremely competitive group of young scientists, introduced new researchers to Antarctica, and provided participants the opportunity to use the most modern research methods to study the mechanisms that are unique to Antarctic biology. A number of course participants attended the 2001 SCAR Biology Symposium in Amsterdam to present results from course projects. The course also fostered collaborations between participants that will further influence their future research activities. *People 3, Ideas 1, 2, 3, 4*

Influence of Seasonal Ice Cover on Pelagic and Benthic Communities. These long time-series studies focused on the distribution and abundance of macrozooplankton and micronekton in the water column and benthos with respect to seasonal ice cover over an annual cycle at Deception Island, Antarctic Peninsula region. Three graduate students were supported on this award and REU support allowed 16 undergraduates from universities in the San Diego area to participate on the five cruises to Deception Island. Additionally, a writer/photographer participated in one cruise and published an article in the Scripps publication *Explorations* (vol. 6, No. 4, 2000). A website describing the study and findings can be found at <http://smithlab.ucsd.edu>⁷⁴ *People 4, Ideas 4, Tools 2*

Marine Sediment Records of Global Change. Results from this project provided new information that allowed ice core records to be tied to paleoenvironmental signals in marine sediments, which can be used to help constrain global climate change models. This research has significantly advanced our knowledge of paleoenvironmental conditions in the Antarctic Peninsula and offers promise of correlating records between high southern and high northern latitude sites. In addition, researchers discovered a new type of glacial marine deposit - a sediment drift on the continental shelf region. Predominantly current controlled, it represents a possible sedimentary organic carbon sink for the area. Seven undergraduate students participated in the project, and many have gone on to environmental positions, teaching posts, marine technical positions, and post-graduate research in earth sciences. Many of these students were supported with REU funds. The research results were also used to develop two courses at

⁷³ OPP-9526979, James W White, U of Colorado Boulder, Colorado.

⁷⁴ OPP-9727077, Kenneth Smith, Scripps Institution of Oceanography, UC San Diego.

Hamilton College, “Wilderness and Global Environmental Change” (an introductory course) and “Antarctica and Global Change” (an upper level elective).⁷⁵ *Ideas 1, 2, 4*

Research Experiences for Undergraduates (REU). OPP encourages undergraduate students from underrepresented groups to participate in scientific research projects. This year, OPP supported students from over thirty universities through the REU program. In addition, OPP supported two REU sites:

- Augustana College administers an REU site on the Matanuska Glacier, a large valley glacier in south central Alaska. For six weeks, students stay at the Matanuska Glacier Research Camp, about two kilometers from the glacier’s terminus. They engage in research and fieldwork that involves collecting water samples, maintaining equipment, downloading data, filtering water for suspended sediment, and tabulating data. Students complete their undergraduate thesis projects at their home institutions and are encouraged to present the results at a national meeting.⁷⁶
- The City University of New York collaborates with the Archaeological Institute of Iceland, Edinburgh University, Stirling University, and the University of Oslo in an interdisciplinary, international field school on human settlement and environmental impact in Northern Iceland. The REU site is one of the most important Viking age settlements in the North Atlantic region. Students learn about the geology, settlement history, and traditional agriculture of the area. They are required to take related courses before and after the field season and to complete a research project incorporating the fieldwork and laboratory methods.⁷⁷

Ideas 4

Tools—Providing “broadly accessible, state-of-the-art information-bases and shared research and education tools.”

Tools Indicator 1—Shared-use platforms, facilities, instruments and databases that enable discovery and enhance the productivity and effectiveness of the science and engineering workforce.

Acquisition of Core Logging Equipment for the Antarctic Marine Geology Research Facility. The Multi-Sensor Core Logger has been used to analyze high-resolution mineralogical variations in marine sediment cores collected from four USAP cruises. The high-resolution MSCL data, among the first high-resolution core data from the USAP, contributes to interdisciplinary environmental change research. The instrument has also been used to analyze cores that have been raised from lakes in Guatemala and Peru, which has been instrumental in helping decipher the climate history of the region. Students from a variety of colleges and universities have been trained to use the MSCL. They come from institutions such as Rice

⁷⁵ OPP-9615053, Domack; OPP-9615670, Manley; OPP-9714371, Leventer; OPP-9615695, Banerjee; OPP-9615669, Ishman

⁷⁶ OPP-9802446, Jeffrey Strasser

⁷⁷ OPP-9912332, Perdikaris and McGovern

University, Ohio State University, Hamilton College, Colgate University, and Middlebury College.⁷⁸ *People 3, Ideas 4, Tools 1*

The APOGEE vehicle. An Autonomous Underwater Vehicle (AUV) has been designed to work under ice-covered water, particularly in the Arctic Ocean Basin. A PI is developing a cost-effective experimental platform that can access all portions of the Arctic Ocean Basin. The first stage was completed in the summer of 2001. A critical aspect was the development of an acoustic homing system that allows the vehicle to find and latch itself to a trawl wire lowered through a hole in the ice. The payload section can be reconfigured in a few hours, allowing researchers to respond to discoveries in real-time and the science mission to evolve during the course of a single expedition. Potential sensor types include acoustic imaging (e.g., sidescan sonar, multibeam bathymetry), hydrographic (e.g., Conductivity-Temperature-Depth, Acoustic Doppler Current Profiler), optical (e.g., nephelometer), and chemical (e.g., methane snifter, etc.). This program adds a new dimension to AUV operations by remaining motionless on the sea bottom for long periods of time, during which a data acquisition system will be running to acquire seismological data.⁷⁹ *Tools 1*

Continued Development of Robotic Vehicles. Through sponsorship of efforts at Monterey Bay Aquarium Research Institute and tests to be conducted on the U.S. Coast Guard Cutter *Healy* in October 2001, OPP continued efforts to obtain better all-season ocean data (while reducing cost and “footprint”) by developing the first autonomous underwater vehicle with the endurance to work under ice in the Arctic. Strategically related efforts continued to develop robotic samplers for the atmosphere (aerosondes) at the University of Colorado and to develop an autonomous, under-ice ocean bottom seismometer (the APOGEE vehicle) at Woods Hole Oceanographic Institution.⁸⁰ *Tools 1*

U.S. Coast Guard Cutter *Healy*. Based on 5 years of planning and cooperation with the science community and the Coast Guard (primarily through the Arctic Icebreaker Coordinating Committee of the University-National Oceanographic Laboratory System), OPP worked with the Coast Guard to have the U.S. Coast Guard Cutter *Healy* modified while under construction so that it could more effectively support science, conducted the first known use of science trials as part of a Navy ship-acceptance procedure and is now completing the first year of operation of the *Healy*.⁸¹ *Tools 1*

Support Office for Aerogeophysical Research (SOAR). Many experimental techniques for acquiring, managing, and analyzing high quality aerogeophysical data over ice sheets were developed over the course of this project. The data collected by SOAR provide an unprecedented view of the ice sheet and the underlying continental crust that allow crustal boundaries to be identified and geological controls of ice stream locations to be understood. This project employed and provided research experience to a range of personnel from high school seniors and college undergraduates through senior scientists. The SOAR project was an excellent mechanism

⁷⁸ OPP-9871166, Janecek

⁷⁹ OPP-9910290, Bellingham

⁸⁰ OPP-9910290, Bellingham; OPP-9910297, Curry, See also www.aerosonde.com/barrow_2000.htm; OPP-0001392, Sohn

⁸¹ OCE-9988593, Prince

for training a large number of people in airborne remote sensing research - from data collection through interpretation of data. Almost all SOAR personnel deployed to Antarctica, many of them for the first time. There, they gained experience with remote field operations and acquisition of high quality geophysics data under such conditions. The major technical skills developed by SOAR personnel were operation of geophysical instrumentation, use of computer based data acquisition systems and airborne research platforms.⁸² *People 1, Ideas 1, 2, 3, 4, Tools 1*

Upgrading Ice Core Processing and Analytical Equipment. Paleoclimatology, ice core geochemistry, and analytical chemistry have all been aided by the acquisition of new equipment and upgrades of old equipment that are used to process and analyze ice cores. This has been accomplished in three major areas: the design and construction of an ice core lathe, development of a continuous melting system, and new ion chromatographs. The lathe is a unique ice core processing tool that operates similar to a wood lathe. The lathe will reduce or eliminate the need for the cores to be hand scraped, the first cleaning step of core preparation. The continuous melting system has been modified to allow analysis of discrete samples of both cations and anions. The new ion chromatographs are state of the art with conductivity detectors that provide high sensitivity and associated autosamplers that support high sample throughput. Graduate and undergraduate courses, graduate research projects, and teacher workshops all benefit from the new equipment.⁸³ *Tools 1, Ideas 3, 4*

U.S. Antarctic Stations. In addition to the above, OPP is responsible for managing and operating the three U.S. stations in Antarctica. These stations provide the necessary facilities for any U.S. scientist, including those from other federal agencies, to do research in Antarctica in widely divergent disciplines.

Tools Indicator 2—Networking and connectivity that take full advantage of the internet and make science, mathematics, engineering and technology information available to all citizens.

The Antarctic Glaciological Data Center (AGDC). The AGDC provides data management for the U.S. Antarctic Glaciological Program and related cryospheric science investigations. The AGDC is tasked with the development and implementation of a web-based archival and distribution capability for well documented physical and geochemical data derived from ice cores, ice surface elevations, ice thickness, and bedrock topography, snow accumulation data and 10-meter temperatures, ice velocity measurements from remote sensing imagery and field survey data. This award provides a mechanism to help the Antarctic Glaciology Program implement and enforce the OPP Data Policy.⁸⁴ *Tools 1, 2*

⁸² OPP-Blankenship

⁸³ OPP-0096291, Paul Mayewski, University of Maine

⁸⁴ NSF 98-2, OPP-9814550, Gregory R Scharfen, University of Colorado Boulder, Colorado. The Office of Polar Programs, in conformance with NSF policy (see Grant Proposal Guide - GPG, Section VII-H), expects investigators to share with other researchers, at no more than incremental cost and within a reasonable time, the data, derived data products, samples, physical collections and other supported materials gathered or created in the course of the research project. The purpose of this policy is to facilitate full and open access to data and materials for polar research from projects supported by OPP.

Improving the Antarctic Geologic Database. Efforts are underway to refine and support the Antarctic Geologic Database, an on-line database for geologic specimens collected in Antarctica by members of the U.S. geologic community. The database allows search, retrieval and loading of collection and analytic data via the Internet. Some of the most important refinements and improvements to this database completed or in progress are: the addition of an Antarctic map to aid in geographic searches, capability for users to edit and add to their database entries, and the capability for users to directly input their own database/spreadsheet information. These improvements will greatly expedite research opportunities, proposal preparation, and additional analyses on previously collected material as new ideas, research directions and technologies become available. Another objective is to continue with the rescue of at-risk Antarctic geologic collections and data, which includes entering all pertinent information into the database. A prototype of the Antarctic Geologic Database was designed as part of a Small Grant for Exploratory Research.⁸⁵ *Tools 1, 2*

New Instrumentation for Antarctic Borehole Research. Several new instruments have been developed that contribute valuable physical resources for glaciology: hot water ice-drilling equipment, ice-coring equipment, and borehole video equipment and methodology. The ice borehole video probe, built by the Jet Propulsion Laboratory with guidance from this project, is an instrument that enables visual observation of ice rock material at depth in glaciers and ice sheets, accessed in water-filled boreholes drilled by the hot-water-jet ice drilling method. Borehole video will probably be of much importance in the exploration of Lake Vostok. Data recovered by these instruments has improved understanding of mechanisms of ice stream formation, implications for possible collapse of the West Antarctic ice sheet, and potential effects on sea level. The data is shared with the public on a web site. Funds for this project came from the SGER program.⁸⁶ *People 4, Tools 1, 2*

Tools Indicator 3—Information and policy analyses that contribute to the effective use of science and engineering resources.

Review of Intergovernmental Panel on Climate Change (IPCC) Report. Two members of the OPP staff participated in the U.S. government review of the IPCC Working Group 2 Report. One staff member was invited by the Department of State to be part of the U.S. delegation in Geneva that negotiated final language for the Summary for Policymakers. *Tools 3*

F. FY 2001 AREAS OF EMPHASIS

NSF has identified specific areas of emphasis for FY 2001. Some of these areas are clearly outside the purview of OPP and when that is the case it has been indicated below. We have been asked to address our activities in each area – identifying those that are not relevant for OPP.

⁸⁵ OPP-9727155, Rosemary Askin, Ohio State University; The database can be accessed at URL agd.mps.ohio-state.edu, or via the Byrd Polar Research Center homepage at www-bprc.mps.ohio-state.edu.

⁸⁶ NSF 99-2, OPP-9910838, Barclay Kamb, California Institute of Technology

PEOPLE GOALS

- **K-12 systemic activities**
(see section on People Indicator 1 in this report)

- **Enhancing Instructional Workforce**
 - Centers for Learning and Teaching – N/A (EHR program)

 - Graduate Teaching Fellows in K-12 Education
OPP supports Graduate Teaching Fellows in K-12 Education (GK-12) (Lead: DGE/EHR): OPP co-funds one GK-12 award: San Diego State University, Nancy Taylor and Walt Oechel, in collaboration with Barrow schools.

- **Broadening Participation**
 - Tribal Colleges
OPP helped coordinate and encourage grants by the EHR tribal college program to two Alaska Native groups, --
 - the College of Rural Alaska for a 5-year project to increase Alaska Native participation and success in science, mathematics, engineering and technology (SMET), including developing SMET knowledgeable Alaska Native engineers and develop SMET knowledgeable Alaska Native leaders who will participate in making decisions about tribal lands; and
 - Ilisagvik College for a planning grant for assessment and improvement of the college's Science, Mathematics, Engineering and Technology Programs.

 - Partnerships for Innovation – N/A (EHR program)

- **Addressing near-term workforce needs**
 - Advanced Technological Education – N/A (EHR program)

IDEAS GOALS

- **Appropriate balance of high risk, multidisciplinary or innovative research across all NSF programs.**

Because OPP supports research on the “cutting edge,” investments are made which are risky – either because the technology used is new or the research situation presents risk. There is an inherent risk in funding field programs in the polar regions – weather and field conditions can be hard to predict and even in optimum conditions the extreme cold makes work, both for people and instruments, challenging. Examples of field locations which present an element of risk -- which is mitigated to the extent possible by extensive planning – include Summit, Greenland; North Pole; South Pole; and remote Antarctic field camps. In addition, examples of awards considered high risk include the following activities:

Cape Roberts Project. The international Antarctic earth science community has collected over 1700 meters of drill core with sediment of Pleistocene, Pliocene, Miocene and Oligocene age. These records have significance for all areas of Antarctic geosciences, including glacial, tectonic, stratigraphic, paleobiologic and paleoceanographic disciplines.⁸⁷

Iron Isotopes as Biological Markers. This project, from MarsRock, developed a chemical method for fingerprinting biological activity in meteorites using the isotopic composition of iron (Fe). Meanwhile, it has triggered new research in a field crossing geochemistry and biology and has attracted several other research groups.⁸⁸

Modeling Paleozoic Glaciations. Coupled modeling of the oceans and atmosphere is simulating paleoenvironmental conditions that are derived from geological records and is demonstrating the value of plate tectonic reconstructions to paleoclimate models. The research an outstanding contribution toward understanding glacial intervals in Earth's early history and thus understanding of Earth's evolution as a whole.⁸⁹

Oceanic Crust Formation at Gakkel Ridge. Basalts, peridotites, and related rocks are being collected along 600 km of the Gakkel Ridge, which for many years has been inaccessible due to Arctic ice cover. Data will be combined to generate quantitative models of oceanic crust formation under ultra-slow spreading conditions.⁹⁰

Small Grants for Exploratory Research (SGER). NSF supports small-scale, high risk exploratory work through the SGER program. OPP has sponsored many of these cutting-edge projects. This year, they included:

- *Gerald Kooyman*, University of California, San Diego – high resolution satellite imagery to census Emperor penguin colonies.⁹¹
- *Peter Michael*, University of Tulsa –developing new sampling and measurement methods and tools to be deployed under the Arctic Ocean ice cap on the Gakkel Ridge.⁹²

Snowball Earth. The “snowball earth” hypothesis postulates that a stratigraphic record of global glaciations should be apparent in well-preserved Neoproterozoic sections worldwide, even where no glacial deposits are preserved. Researchers are studying stratigraphic cores along with two glacial deposits in Svalbard to better understand how these extreme ice ages began.⁹³

⁸⁷ OPP-9527481, Powell; 9527013, Askin; 9527075 Wrenn; OPP-9527329; OPP-9317979; OPP-9527394; OPP-9527008; OPP-9420062; OPP-9418429; OPP-9419770; OPP-9422893; OPP-9526889; OPP-9527070; OPP-9420475

⁸⁸ OPP-9713968, Beard and Johnson

⁸⁹ OPP-9615011, Crowley (CF “Snowball Earth”, OPP-9817244)

⁹⁰ OPP-9911795, Peter Michael, Chief Scientist, University of Tulsa; OPP-0000389, Charles Langmuir, Lamont; OPP-9912162, Henry Dick, Woods Hole Oceanographic Institution; OPP-9912156, David Graham, Oregon State

⁹¹ OPP-0001450

⁹² OPP-9911795

⁹³ OPP-9817244, Paul Hoffman, Harvard University. (CF “Modeling Paleozoic Glaciations”, OPP-9615011, Crowley)

- **Investments in NSF's Three Initiatives:**

- Information Technology Research (ITR)
Intelligent Radar Sensors Conducting Glaciological Investigations. OPP supported one ITR award for the development and deployment of intelligent radar sensors for measuring key glaciological parameters. Radar instrumentation will consist of a synthetic aperture radar (SAR) that can operate in bistatic or monostatic mode. A tracked vehicle and an automated snowmobile will be used to test and demonstrate the utility of an intelligent radar in glaciological investigations. The system will be developed to collect, process and analyze data in real time and in conjunction with *a priori* information derived from archived sources. The combined real time and archived information will be used onboard the vehicles to select and generate an optimum sensor configuration. This project involves innovative research in intelligent systems, sounding radars and ice sheet modeling. In addition it has a very strong public outreach and education program, which includes near-real-time image broadcasts via the world wide web.
- Nanoscale Science and Engineering – N/A
- Biocomplexity in the Environment

OPP contributed \$1.41 million to the Biocomplexity in the Environment initiative in FY 2001. Awards made in FY 2001 competition included:

Microbes and Biomolecules in Glacial Ice. PIs are constructing a biospectrologger, which will enable them to study microbes and biomolecules in an ice borehole in Antarctica. This is the first time that scientists will be able to search for living bacteria in liquid veins of polar ice. Chemical, physical and biological arguments indicate that as many as 10³ microbes/cm³ can extract enough energy from acids confined in narrow liquid veins in otherwise solid ice to survive for a few thousand years (or a smaller population for a correspondingly longer time).⁹⁴

Workshop: Human Dimensions of the Arctic System. The Arctic offers a unique opportunity to study close linkages between people and the environment, the great variability in both human and natural systems, and the impacts of global change in polar regions. For this reason, a PI has organized a workshop that will bring together researchers, graduate students, junior faculty and indigenous groups to study the dynamics of coupled natural and human systems.⁹⁵

In addition, OPP supports a wide range of research that is BE-related although it is not part of the formal BE competition.

- **Investments in NSF's High Priority Non-Initiative Fundamental Research:**

⁹⁴ OPP-0119988, Price

⁹⁵ OPP-0119798, Huntington

- Mathematical Sciences Research – N/A. Although not currently involved in this activity, OPP out-year planning will likely include activities associated with this area – specifically, modeling for polar research.
- Functional Genomics

Examples of OPP-supported research in functional genomics include the following:

Antifreeze Proteins in Antarctic Fishes. The Southern Ocean represents the world's coldest marine environment and its near-shore waters are perennially at the freezing point of seawater and replete with ice crystals. A number of polar and subpolar fish evolved special biological antifreeze proteins to avoid freezing in their frigid habitats. The impact of the evolution of the antifreeze function on organismal success is particularly clear in the Antarctic notothenioids. PIs are now studying the role of antifreeze glycopeptides, antifreeze proteins involved in freezing avoidance of Antarctic fishes. Research specific to antifreeze glycopeptides includes determining the specific location of the gene family on chromosomes, and its protease progenitor gene, calibration of the rate of evolution of nuclear protein coding sequences and the temporal aspects of antifreeze glycopeptides during embryogenesis and early larval stages. The multidisciplinary approach will lead to major advances in the molecular biology and evolution of the antifreeze systems and will be applicable to a wide range of disciplines.⁹⁶

Adapted Cellular Functions of Antarctic Fishes. As the Southern Ocean cooled during the past 25 million years, the fishes of Antarctic coastal waters evolved biochemical and physiological adaptations that maintain essential cellular processes such as cytoskeletal function and gene transcription at low temperatures. Their microtubules, for example, assemble and function at body temperatures (-1.8 to +1 degree C) well below those of warm-blooded and temperate cold-blooded organisms. Over the long-term, researchers will seek to determine, at the molecular level, the adaptations that enhance the assembly and movement of microtubules, and the expression of related genes. In the broadest sense, this research program should advance the molecular understanding of the survival of cold-blooded organisms.⁹⁷

Genomic Study of Antarctic Microorganisms. One of the most interesting aspects of life in extreme environments is understanding the unique adaptations required for survival. The Antarctic marine psychrophiles (organisms that like the cold) provide an excellent model group of extreme microorganisms, since very little is known about their biological and functional diversity, or specific metabolic adaptations to life at -1.8 degree C. PIs expect to develop genomic approaches for studying microorganisms sampled directly from extreme environments and thus, circumventing the requirement for cultivation. The application of DNA microarray technology to studies of life in

⁹⁶ OPP-9909841, DeVries and Cheng, University of Illinois, Urbana-Champaign

⁹⁷ OPP-0089451, Detrich, Northeastern University

extreme environments offers an outstanding opportunity for identifying new genes for biotechnological use. Discovering specific adaptations to extreme environments by detecting genes that are uniquely expressed in the natural environment is an ultimate goal of this research.⁹⁸

- Cognitive Neuroscience – N/A

TOOLS GOALS

- **Investments in Major Research Equipment**

OPP has two MRE projects currently ongoing – South Pole Station Modernization and Polar Support Aircraft (LC-130) Upgrades.

One MRE project, jointly proposed by OPP and the Directorate for Mathematics and Physical Sciences, which is under consideration by NSF for future funding requests is IceCube. IceCube is a device to detect high energy neutrinos using the 2-mile deep ice cap at the South Pole as the detector medium. The project builds on the success of the recently completed Antarctic Muon and Neutrino Detector (AMANDA), which the same team initiated in 1994. With AMANDA, the investigators have demonstrated the requisite detector and drilling technologies and have installed detector modules up to 2500 meters deep in the ice. The ice itself has proven to be an excellent detector medium.

- **Continue investments in:**

- Terascale Computing System – N/A

- Major Research Instrumentation

Two MRI awards in FY 2001 were in polar research:

- An award to University of Arizona (Bales)⁹⁹ to develop a state-of-the-art continuous flow analysis system that will be used for measuring concentrations of eight soluble chemical species (calcium, hydrogen peroxide, ammonium, formaldehyde, nitrate, sodium, chloride, and sulfate) plus electrical conductivity in polar ice cores. This system, which will be designed for use in either the laboratory or the field, will enable U.S. ice core scientists to remain at the forefront of technology and will increase the quality and rate at which new ice core records can be produced. This in turn could result in a better understanding of climate and atmospheric chemistry.
- An award to New Mexico Institute of Mining and Technology (Kyle)¹⁰⁰ for development of an integrated instrument package for surveillance of volcanic gas, seismic activity, and elevation change. Seismic and geodetic methods are

⁹⁸ OPP-0085435, Murray, University of Nevada

⁹⁹ OPP-0116674

¹⁰⁰ OPP-0116577

the principal tools used to monitor volcanoes, as these have been shown to be the most useful means of forecasting volcanic eruptions through the remote sensing of deviatoric stress release and intruding and withdrawing mass fluxes of magma. This collaborative project involving NM Tech researchers, staff from UNAVCO, and Guralp Systems will develop and deploy a low-power cost-effective real-time integrated instrument package of seismic, geodetic and environmental sensors primarily for monitoring the activity at active volcanoes and in tectonically active areas. The instrumentation developed should have wide application in both applied and basic earth science projects with the potential to contribute significantly to societal goals of better predicting volcanic and seismic natural hazards.

The most recent MRI COV (June 2000) made the following observation: “The real excitement of the program seems to arise from the development proposals; therefore, program staff should devise methods to attract greater numbers of such proposals.” It is worth noting that OPP has a high percentage of development (versus acquisition) proposals.

The same COV gave the following – an OPP MRI proposal -- as its first example of results that lead to “discovery across the frontier of science and engineering”:

The detection of neutrinos through a large volume of natural ice in Antarctica as a Cherenkov detection medium. Fifteen institutions and several countries use it. It has public interest because of the Antarctic environment and astronomy outcomes that boost the interest of the public in science. It has fostered the development of remote distance analysis and reporting of data as well as the development of power supplies that are highly reliable (Polar Programs 9512578). The AMANDA project is an excellent example.

The AMANDA project continues to yield results and publications. A recent article in *Nature*¹⁰¹ reported the detection of upwardly propagating atmospheric neutrinos by AMANDA. The results establish a technology with which to build a kilometer-scale neutrino observatory necessary for astrophysical observations. As the authors conclude, “the observation of neutrinos by a neutrino telescope deep in the Antarctic ice cap, a goal that was once thought difficult if not impossible, represents an important step toward establishing the field of high-energy neutrino astronomy first envisioned over 40 years ago.”

- S&E information/reports/databases – N/A
- New types of scientific databases & tools for using them – N/A

¹⁰¹ *Nature*, Vol. 410, 3/22/01

