U.S. Antarctic Program, 1996–1997

During the 1996–1997 austral summer and the 1997 winter, approximately 640 scientists and other specialists conducted 145 research projects in Antarctica under the auspices of the U.S. Antarctic Program. Supported by the National Science Foundation (NSF), they worked at McMurdo Station on Ross Island, at field camps in numerous locations, at Amundsen–Scott South Pole Station, aboard the ice-capable research ships Polar Duke and Nathaniel B. Palmer, and at Palmer Station on Anvers Island.

Although not every research grant is covered here, the projects described in this issue of the *Antarctic Journal* are intended to provide a representative overview of the U.S. Antarctic Research Program. In addition to the science teams working in Antarctica, researchers in the United States analyzed data acquired during fieldwork. This issue, comprised of 89 new papers prepared by program participants and seven articles that originally appeared in the 1997 monthly online issues of the journal, reflects the breadth of the U.S. program. Although final results typically will appear in peer-reviewed scientific journals, the *Antarctic Journal*, which is not peer-reviewed, is intended to provide initial reports. The assistance of all who contributed is gratefully acknowledged.

Aeronomy and astrophysics

Scientists added 216 more neutrino detectors to the Antarctic Muon and Neutrino Detector Array (AMANDA), completing the AMANDA-B portion of the array. AMANDA, a telescope constructed *inside* the ice sheet near Amundsen–Scott South Pole Station, consists of a series of optical modules (photomultiplier tubes) designed to use the ice itself to detect high-energy neutrinos, subatomic particles that pass through the Earth from distant sources. As neutrinos come up through the Earth, they collide with atoms of ice or rock and create muons, which emit Cherenkov light (or radiation) that can be measured and tracked by the array. Using AMANDA, astronomers hope to be able to "see" inside such celestial objects as the cores of galaxies, which are enshrouded with dust and gases that obstruct conventional observations.

Between November 1996 and February 1997, the AMANDA team installed six new strings of optical detectors, bringing the total for AMANDA-B to ten 2-kilometer-long strings. Each new string contains 36 optical modules, bringing the total number of modules to 302, at depths of 1.6 to 2 kilometers (about 1 to 1.25 miles). AMANDA-A, the upper part of the detector that was installed during the 1993–1994 austral summer, consists of four 1-kilometer-long strings, each with 20 optical modules. Even before the six new strings were added this season, AMANDA had demonstrated its effectiveness: it functioned as expected, and it detected neutrinos.

AMANDA is a collaboration of U.S., German, and Swedish scientists. Visit the AMANDA homepage on the Web at *http://amanda.berkeley.edu* for more information.

The Automatic Geophysical Observatory (AGO) network added a sixth unit. AGOs operate unattended for about a year at a time on the east antarctic plateau. These small, low-powered units transmit some operational and meteorological data via satellite, but most of the data they gather are stored on optical disk and retrieved annually. Originally, the AGO network was built to study the polar ionosphere and magnetosphere, but in recent years the functions have been expanded to include other Earth-related studies. When data collected by the U.S. AGOs are combined with data from several of the manned antarctic stations and from other nations' AGOs, the wealth of information gathered on the high geomagnetic latitude ionosphere provides a much better understanding of the Earth's response to solar activity.

During the 1996–1997 austral summer, scientists made operational the sixth and last of the U.S. AGO units. The AGO program is a collaboration of scientists from several nations. These Web sites contain more information about the U.S. AGOs:

- the University of Maryland page at *http://www.polar.umd.edu/ago.html*
- the Augsburg College page at *http://space.augsburg.edu/ago/index.html*

CARA, taking advantage of the unique astronomical location at the geographic South Pole and the unequaled clarity of the antarctic atmosphere, operated four major research projects at Amundsen–Scott South Pole Station. The Center for Astrophysical Research in Antarctica (CARA) is managed by the University of Chicago and involves researchers from eight U.S. institutions and one German institution. CARA researchers also conduct joint research with collaborators from the National Aeronautics and Space Administration (NASA), two U.S. universities, and Australian and French researchers. (See *http://astro.uchicago.edu/cara/home.html.*) The following are the four main research projects.

- The Antarctic Submillimeter Telescope and Remote Observatory (AST/RO), a 1.7-meter-diameter submillimeter wave telescope, is used to survey the sky at submillimeter, far infrared, and millimeter wavelengths. Using AST/RO, researchers detected for the first time carbon in the Large Magellanic Cloud. (See *http://cfa-www.harvard.edu/~adair/AST_RO* for more information about AST/RO.)
- Cosmic Background Radiation Anisotropy (COBRA) tests cosmological models by measuring the anisotropy of relict radiation from the "Big Bang." The amplitude and spatial distribution of the anisotropy are directly related to conditions in the early Universe that led to the formation of the currently observed structure. The most sensitive measurements made to date of this small-scale anisotropy have been made by the COBRA project. (See *http://cmbr.phys.cmu.edu/pyth.html.*)
- The South Pole Infrared Explorer (SPIREX) studies galactic birth and evolution and the formation of stars

and planetary systems. (See *http://astro.uchicago.edu/home/web/nir/SPIREX/scope.html*.)

- The Advanced Telescope Project (ATP) consists of several telescopes mounted on top of the Martin A. Pomerantz Observatory. ATP, which collects information about the astronomical qualities of the South Pole, has done extensive site testing over the past few years. In 1996, NASA and CARA installed a 50-centimeter mid-infrared telescope to make further tests.

U.S. and French team successfully retrieved a $10-million Flare Genesis telescope. The second largest solar telescope, called Flare Genesis, circled Antarctica during the 1995–1996 summer suspended from a 29.4-million-cubic-foot, high-altitude helium balloon. Taking advantage of the 24-hour daylight, Flare Genesis acquired, during its 19-day flight, 14,000 solar images (including images of sunspots) and mapped associated magnetic fields, which are believed to cause solar flares.

Flare Genesis's 80-centimeter-diameter mirror can resolve features as small as 150 kilometers on the Sun. The principal objective of the Flare Genesis missions is to understand the origins of solar activity. Scientists hope to learn more about such key features as magnetic energy buildup and release on the Sun and, one day, to reliably forecast solar activity, which sends dangerous shocks and atomic particles to Earth.

In January 1996, the balloon came down south of the Adélie Coast, 1,400 kilometers from McMurdo Station. Hazardous weather permitted only the data recorder to be retrieved. During the 1996–1997 austral summer, the French Antarctic Program assisted U.S. researchers in a traverse to the site to recover the balloon payload, including the $10-million telescope. (See *http://www.jhuapl.edu/FlareGenesis/* for more information.)

Biology and medicine

Scientists find that archaea, one of the three branches of life, are surprisingly abundant in antarctic waters. Using DNA sequences and cell characteristics, biologists divide all life into three domains: prokaryotes (bacteria, viruses, and blue-green algae), eukaryotes (which include plants and animals), and archaea, which until quite recently were thought to be a type of prokaryote. Under the microscope, archaeans appear to be similar to bacteria and prokaryotes, but biochemically and genetically they are as different from prokaryotes as are eukaryotes. (See *http://www.ucmp.berkeley.edu/archaea/archaea.html*.)

Archaea have been found in extremely hot or saline environments such as hot springs, salt evaporation pans, and deep sea hydrothermal vents—places where no other life can survive. During the 1996–1997 research season, biologists working in the waters off Palmer Station discovered that a significant percentage of the planktonic microbes in cold (–1.5°C) southern ocean waters are archaea.

Archaea from hot and cold environments are closely related. They produce similar fatty acids and have similar genomic structures. The percentage of archaea found in the southern ocean sampling represents the highest rate measured to date in any of the world's oceans.

Icefish, whose bodies produce antifreeze glycopeptides to keep them from freezing, were found to possess an additional protective mechanism. Because of the high salt content, seawater surrounding Antarctica freezes at a temperature about 2°C below that of freshwater. Fish swimming in these waters theoretically should freeze, but their blood and tissues contain glycopeptides that prevent freezing. These compounds act by attaching to small ice crystals and preventing them from joining together to form larger crystals. Recently, investigators found another protective mechanism at work. Apparently, antibodies in the blood of these fishes seek out ice crystals and transport them to the spleen where they are expelled.

Because the fish antifreeze proteins are effective in inhibiting ice growth, researchers believe that the proteins could be used to prevent freezing and freezing injury in other applications. They have successfully cloned and characterized the genes of antifreeze proteins, producing two of the four different types of fish antifreeze proteins in yeast and bacteria through recombinant DNA technology. Using these cloned genes and molecular technology, researchers can produce large quantities of antifreeze proteins through large-scale fermentation.

Additionally, researchers believe that by transferring the antifreeze protein genes into the systems of selected plants and animals, they may be able to enhance cold or freeze tolerance. They are assessing the potential application of these proteins in cryomedical preservation, protection of frozen foods from recrystallization, enhancement of freeze or cold resistance, and use as nonpolluting de-icing agents. (See *http://www.life.uiuc.edu/physiology/faculty/devries.html* to learn more about the work of Arthur DeVries, a leading researcher in this field, and *http://www.oc.uiuc.edu/NB/97.05/9705fishtip.html* for related information.)

Scientists gathered samples of sea life from beneath the pack ice. Although the growth and retreat of the sea ice around Antarctica is one of the world's great seasonal events, little is known about how changes in the ice cover affect zooplankton and other animals in the ocean's upper 100 meters (the epipelagic zone), where light penetrates the water or ice enough to allow photosynthesis to occur.

During three cruises to the Weddell Sea in April and May 1996 and in November and December 1996, investigators collected samples by trawling and tracked the seasonal variations in the life cycle of these tiny animals by comparing the results from their trawls with the earlier findings of other investigators. Results indicated substantial differences in community composition from season to season. Trawls from April and May 1996 contained up to 100 times more biomass than samples from September and October 1995. Collections from November and December 1996 were intermediate in size between the other two sampling periods.

Analyzing the data from these three cruises and comparing the results from periods having different degrees of ice cover should give researchers greater insight into the role that the seasonal ice cover plays in structuring antarctic epipelagic communities.

Read more about this research on pages 88–90, "Epipelagic communities in the northwestern Weddell Sea: Results from high-resolution trawl surveys" by R.S. Kaufmann and K.L. Smith, Jr.

Geology and geophysics

The Support Office for Aerogeophysical Research (SOAR) made possible new studies of the west antarctic ice sheet. SOAR supports researchers needing an array of high-precision geophysical data about the west antarctic ice sheet and its underlying lithosphere. Geophysical systems include laser altimetry, magnetics, gravity, and ice-penetrating radar measurements—all supported by high-precision navigation information supplied by differential global positioning system (GPS) techniques. During 1996–1997, SOAR supported a new study of the west antarctic ice sheet in the Siple Dome area. Over the next several years, researchers, flying from a camp at Siple Dome in a specially instrumented Twin Otter airplane, are attempting to detect short-term (2- to 3-year) variations in the elevation of the west antarctic ice sheet. The data are used to create maps of the surface and the bed of the ice sheet as well as maps of the gravity and magnetic fields of the region, a clue to geologic structure, including volcanism of continental crust beneath the ice sheet.

Glaciologists and geologists believe the information being collected by SOAR will be crucial to understanding the behavior of the massive ice sheet and determining to what extent the ice sheet is affected by the geologic rift on which it formed. (See *http://www.ig.utexas.edu/research/projects/soar/soar.html.)*

Global positioning system (GPS) based tectonics research provided a new means to study the Earth's crust. Several projects used GPS technology to measure tectonic plate and vertical crust movements beneath the ice of Antarctica. The weight of glacial ice has a tremendous effect on the Earth's surface beneath it. Researchers believe that the vertical velocities they measured this season will reflect the Earth's viscous, elastic response to changes in the size and extent of Antarctica's ice sheets and will help them understand how periods of glaciation and warming in the past deformed the Earth's surface.

During the 1996–1997 season, a real-time differential GPS station was tested at McMurdo; a more permanent station was installed during the 1997–1998 austral summer. The high-precision differential positioning technology enables new antarctic geophysical investigations that could yield globally significant results before the turn of the century. The system provides accurate, real-time readings from handheld receivers and far more precise readings using station equipment at McMurdo. Differential GPS simplifies many survey tasks that would otherwise require time-consuming collection and post-processing of data. (See the University NAVSTAR Consortium Web site at *http://www.unavco.ucar.edu/polar* for more information.)

Antarctic Search for Meteorites (ANSMET) teams recovered 390 meteorites. The news in mid-1996 that ALH84001, a meteorite from Mars found in Antarctica's Allan Hills in 1984, may contain fossil evidence of early life called attention to the work of ANSMET, led by Ralph P. Harvey, Case Western Reserve University. Each year, Harvey's field teams retrieve hundreds of meteorites. Since the project began in 1976, ANSMET has brought more than 7,800 specimens, including samples from the Moon and Mars, to the United States for study.

During 1996–1997, ANSMET traveled to the Elephant Moraine–Reckling Moraine region, which had already yielded over 2,000 specimens. Of the 390 recovered this year, several were initially identified as being unusual, although detailed characterization remained to be completed.

Antarctica is unequaled as a location for finding meteorites. Although meteorites fall all over the globe, the likelihood of finding them is increased in Antarctica where the ice background provides stark contrast to the dark rocks. Close to half of the total meteorites found on Earth have been found in Antarctica.

See *http://www.cwru.edu/affil/ansmet/index.html* and *http://www-curator.jsc.nasa.gov/curator/antmet/marsmets/contents.htm*. In this issue, refer to "Meteorite studies: Terrestrial and extra-terrestrial applications, 1997" by M.E. Lipschutz (pages 23–25) and "Meteorite recovery and reconnaissance in the Allan Hills–David Glacier and Darwin Glacier regions, 1996–1997" by R.P. Harvey and J.W. Schutt (pages 25–27).

Glaciology

At Vostok Station, scientists determined the depth of the ice sheet's base. In an international collaboration, about 30 investigators from the United States, France, and Russia continued drilling a core from the east antarctic ice sheet near Vostok Station, reaching a depth of 3,520 meters. The Vostok core contains the deepest, oldest ice ever recovered by coring operations. Studies of it have shown a close link between climate over the past 200,000 years and changing concentrations of greenhouse gases.

Geophysicists determined this field season that the base of this ice sheet is 3,750±20 meters below its surface. Below the ice-sheet base lies a subglacial lake, named Lake Vostok by researchers, a huge freshwater body believed to be the size of Lake Ontario. The lake and any life it may harbor have been sealed off from the atmosphere for hundreds of thousands and perhaps many millions of years. To avoid contaminating the lake, researchers currently plan to halt the drilling at about 3,700 meters. (For more information about the Vostok core, see *http://www.agu.org/sci_soc/vostok.html* and about Lake Vostok, see *http://www.nerc-bas.ac.uk/public/press/vostok.html*.)

Researchers prepared for deep coring at Siple Dome to be done during the 1997–1998 season. As part of the West Antarctic Ice Sheet Initiative, researchers are undertaking a multi-year effort to retrieve a deep core from Siple Dome, an ice rise located between two ice streams that feed into the Ross Ice Shelf. Glaciologists believe that Siple Dome is a critical location for studying the dynamics of the west antarctic ice sheet.

During the 1996–1997 austral summer, a field camp was established, and shallow cores were retrieved from a number of sites surrounding the main drill site. These shallow cores were shipped to the National Ice Core Laboratory in Denver for processing and examination.

At the main site, workers drilled to 60 meters, and the drill hole was cased in preparation for the deep drilling to be done during the 1997–1998 field season, when investigators hope to reach bedrock, 1,000 meters below the ice surface. The core's record is expected to span 80,000 years and should reveal much about climate changes as well as the movement of the west antarctic ice sheet from the last glaciation to the present day. Glaciologists want to compare the data gathered from this core with similar data gathered from a deep core drilled in Greenland to see if climate changes recorded there represent local or global phenomena.

Two articles in this issue describe the season's work at Siple Dome:

- "Visible examination of Siple Dome, West Antarctica, shallow cores" by R.B. Alley, M.K. Spencer, and D.E. Voigt (pages 44–45) and
- "Glaciochemical studies at Siple Dome, West Antarctica, during the 1996–1997 season" by K.J. Kreutz, P.A. Mayewski, M.S. Twickler, S.L. Whitlow, and L.D. Meeker (pages 46–48).

Ocean and climate systems

Investigators in two ocean sciences projects studied the carbon cycle in the southern ocean. During the 1996–1997 field season, two multiyear studies continued to make physical and chemical measurements in the Ross Sea, examining how living organisms use carbon.

- In 13 cruises aboard two ships over the 1996–1997 and 1997–1998 research seasons, the Joint Global Ocean Flux Study (JGOFS) Southern Ocean Experiment is examining the complex organic and inorganic pathways carbon takes from the dissolving of gaseous atmospheric carbon dioxide at the surface to the burial of carbon detritus on the ocean bottom. (See pages 61–63, "Global modeling of particle-reactive chemical species in the oceans: Thorium-230 advection and flux to sediment" by G.M. Henderson, C. Heinze, and R.F. Anderson for a sample of the research done on this project during 1996–1997.)
- The Research on Ocean–Atmosphere Variability and Ecosystem Response in the Ross Sea (ROAVERRS), an interdisciplinary team, started a 3-year study to examine atmospheric, oceanic, and sea-ice factors that initiate and control organic carbon production in the Ross Sea.

By studying the role of the southern ocean in the global cycle of carbon, scientists hope to be able to predict the ocean's response to climate change.

The Weddell Polynya Quick Response program sought to predict polynya recurrence. The Weddell polynya is a large area of open water, about a third of a million square kilometers, within the winter ice cover. It is caused by the upwelling of relatively warm water that melts the ice. The Weddell polynya was observed by satellite from 1974 to 1976. Although it has not recurred since, several precursors to the development of the polynya have occurred recently. Scientists who developed the Weddell Polynya Quick Response program during the 1996–1997 season hope that by studying and tracking the Weddell ocean dynamics that lead to the formation of a polynya, they can place a ship into a forming polynya and gather new information about this sea-ice phenomenon.

Antarctic automatic weather stations provided reliable, accurate data for another year. Approximately 50 automatic weather stations transmitted data throughout the 1996–1997 season. These rugged instruments, developed for the U.S. Antarctic Program, have performed well in some of the most rigorous climatic conditions on Earth. Measurements of surface temperature, pressure, wind, and humidity are transmitted to polar-orbiting satellites and delivered electronically for weather forecasting and research purposes to users in Antarctica and in the United States. The automatic weather stations are the primary direct data source for much of the antarctic continent and represent a valuable data set for validating satellite imagery.

Records of the antarctic automatic weather stations for the past two research seasons can be found in two articles in this issue, and a third article describes the work of the Antarctic Meteorological Research Center:

- "Antarctic automatic weather stations: 1995–1996" by R.E. Holmes, C.R. Stearns, and G.A. Weidner (pages 171–174);
- "Antarctic automatic weather stations: 1996–1997" by C.R. Stearns, R.E. Holmes, and G.A. Weidner (pages 174–178); and
- "The Antarctic Meteorological Research Center: 1997" by C.R. Stearns and J.T. Young (pages 207–209).

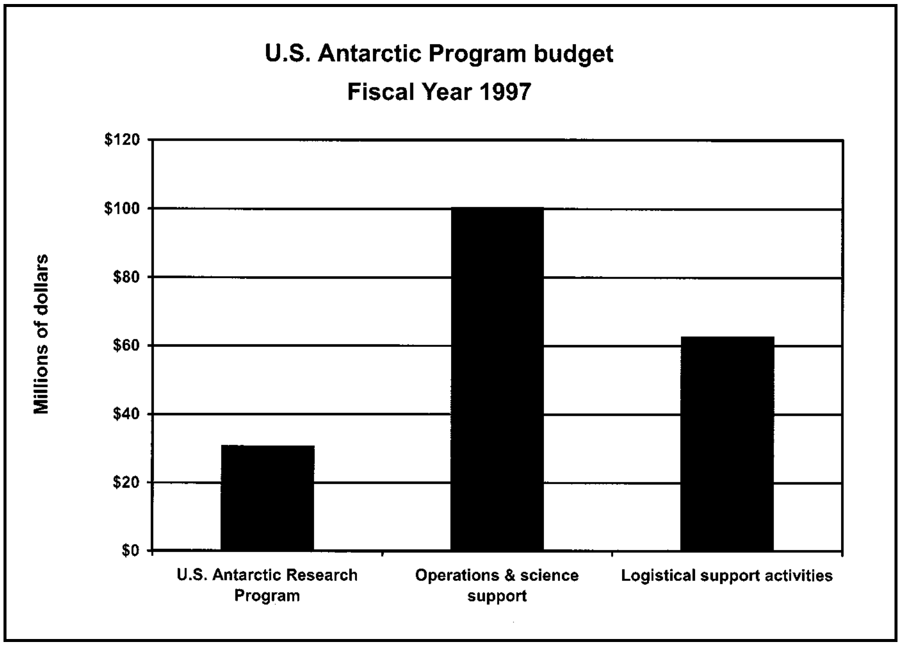
See also the University of Wisconsin's Antarctic Meteorology Research Center Web site at *http://uwamrc.ssec.wisc.edu/amrchome.html* and the Antarctic Weather Station site at *http://uwamrc.ssec.wisc.edu/aw/sawsproj.html*.

Environmental research

Two devices were installed at Amundsen–Scott South Pole Station to monitor station pollution. In February 1997, investigators installed two Aethalometer™ instruments, devices designed to measure black carbon, or soot, in combustion emissions, at South Pole Station. One instrument, installed at the Atmospheric Research Observatory about 457 meters (1,500 feet) upwind of the main part of the station, will provide a background reading representing the very small amount of soot that is brought over the thousands of kilometers from the nearest population area to the pole. The second instrument, which was installed at the balloon inflation facility about 183 meters (600 feet) downwind from the station, will measure the general emissions from station equipment, such as small building heaters and vehicles, as well as the plume from the main power generators. The instruments are automatic, and approximately every 2 weeks the data files from each instrument are transmitted by e-mail to researchers in the United States, assembled into spreadsheets, and merged with the station's meteorology data.

Preliminary results from the first season of operation indicated the following.

- The upwind concentrations of soot were about 3 nanograms per cubic meter at the end of the austral summer and about 0.1 nanogram per cubic meter during the middle of the winter. The reduction in winter



For Fiscal Year 1997, the National Science Foundation received $193.52 million for the U.S. Antarctic Program. With these funds, NSF funded scientists working in Antarctica and at facilities in the United States and operations in Antarctica in support of the U.S. research effort. The funds fall into three major categories:

U.S. Antarctic Research Program - - - - - - $30.63
Operations and science support - - - - - - - $100.29
Logistical support activities - - - - - - - - - $62.60
(Funds provided for Department of Defense support)

occurs because the polar vortex creates a barrier in the antarctic atmosphere and prevents incursions of polluted air from off the continent.

- The downwind concentrations (recorded every 10 minutes) ranged from hundreds to thousands of nanograms per cubic meter, depending on what equipment was being operated at the time and the direction of the related exhaust plume.

Researchers predict that concentrations during the peak summer months, when airplane pollution is factored in, could be much greater than estimates made before the monitoring equipment was installed.

The data gathered by the two devices will help investigators assess the atmospheric pollution impact that human activities at the South Pole have on the antarctic environment. The article by A.D.A. Hansen, "Measurement of combustion effluent aerosols from Amundsen–Scott South Pole Station" (pages 163–164 in this issue), discusses this project in greater detail.

Policy

The last required ratification to the Protocol on Environmental Protection to the Antarctic Treaty was submitted to the U.S. Department of State on 15 December 1997. The Protocol entered into force 30 days later on 14 January 1998.

In October 1991, the United States and 25 other nations signed the Protocol on Environmental Protection, which builds on the Antarctic Treaty to provide a comprehensive system to protect the antarctic environment and its associated and dependent ecosystems. For the Protocol to become a legally binding agreement, the 26 consultative nations that signed the agreement in 1991 needed to ratify it in accordance with their own constitutional processes. The United States completed its ratification with passage of the Antarctic Science, Tourism and Conservation Act of 1996, which President Clinton signed into law on 2 October 1996.

By affirming the principles of the Antarctic Treaty, the protocol helps to ensure that Antarctica will continue to be a natural reserve, devoted to peace and science. Among the provisions of the protocol is a ban on all activities related to mineral resources except for scientific research. The protocol also commits parties to environmental impact assessment procedures for planned activities, both governmental and private. It enhances the protective measures accorded to fauna and flora and imposes strict limitations on the disposal of wastes and discharge of pollutants, both land based and shipboard. Changes to the terms used for designating protected areas are included in one of the annexes to the protocol, though adoption of those changes must be made separately by the Treaty parties.

The United States, through regulations that were issued under the Antarctic Conservation Act, has been complying with most of the protocol even before the U.S. Congress ratified the international agreement. The passage of H.R. 3060 and its signing by the President bring the force of law to antarctic environmental protection and designate specific responsibilities for federal agencies to enforce the protocol. (Read the complete text of the protocol at this Web site: *http://www.icair.iac.org.nz/treaty/protocol/protocol.html.*)

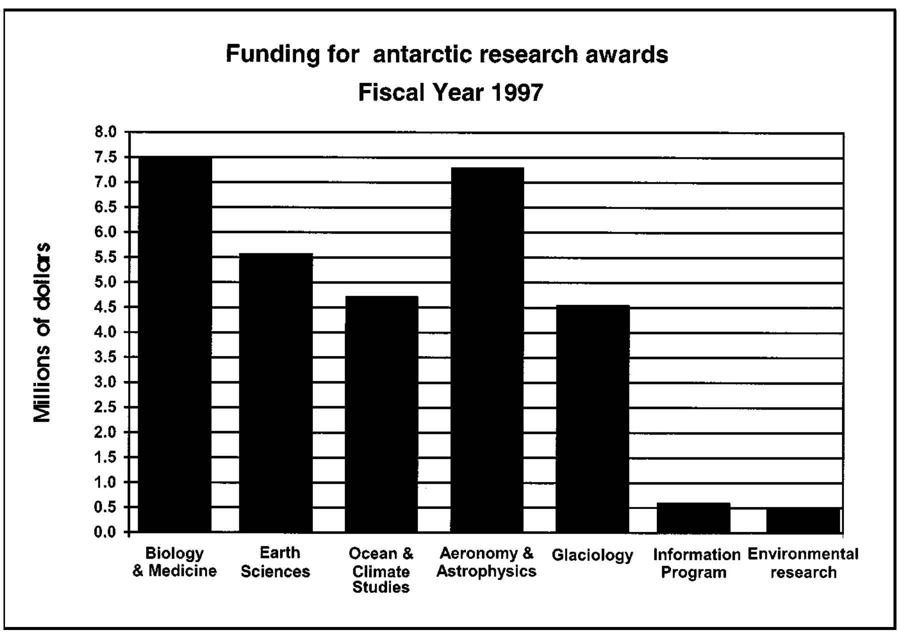
The External Panel studying U.S. presence in Antarctica made 12 recommendations to NSF. On 12 March 1997, Norman R. Augustine, Chairman of the U.S. Antarctic Program External Panel, presented to the House Committee on Science the committee's recommendations that resulted from the panel's 9-month examination of infrastructure, management, and scientific options. Their findings and recommendations were developed to help maintain a high-quality research program and U.S. policy to provide an active and influential presence in Antarctica, while operating within a realistic budget. The panel's review emphasized the high geopolitical, scientific, and environmental value of the antarctic program.

In response to a Congressional mandate, Dr. Neal Lane, Director of the NSF, had established the U.S. Antarctic Program External Panel in August 1996. The charge given to the 11-member panel by Dr. Lane was to "examine and make recommendations concerning the stations and logistics systems that support the science while maintaining appropriate environmental, safety, and health standards; the efficiency and appropriateness of the management of these support systems; and how and at what level the science programs are implemented." The panel members were also asked to consider the eventual replacement of Amundsen–Scott South Pole Station and other infrastructures.

In his testimony to the House Committee on Science, Mr. Augustine summarized the External Panel's findings and recommendations and answered questions. The panel's complete report, *The United States in Antarctica—Report of the U.S. Antarctic Program External Panel* (April 1997), is online at *http://www.nsf.gov/cgi-bin/getpub?antpanel.* (Printed copies are available from the Antarctic Sciences Section of NSF, room 755, phone 703/306-1031.) Highlights of Mr. Augustine's testimony follow.

- Overall, the panel concluded that the geopolitical importance assigned to a permanent U.S. presence in Antarctica, particularly at the South Pole, is warranted and that this justifies a year-round presence at several locations, including the South Pole.
- The panel emphasized that, by working in cooperation with many nations, the United States is playing an important role in preserving a fragile and nearly pristine ecological system that serves as an indicator of potential global environmental trends.
- The panel determined that the research being performed in Antarctica is of the same high quality and relevance as that being supported elsewhere by the NSF and that it uses the unique antarctic environment well and addresses significant scientific issues that have important human consequences.
- The panel recommended that Amundsen–Scott South Pole Station be replaced soon for economic, safety, and operational reasons and that modest upgrades be made at Palmer and McMurdo Stations.

On behalf of the panel, Mr. Augustine commended NSF's management of the logistics and research programs.



Funds ($30.63 million) provided for the U.S. Antarctic Research Program were awarded for research and related grants in the following categories:

Biology and medicine	7.47
Geology and geophysics	5.56
Ocean and climate studies	4.71
Aeronomy and astrophysics	7.29
Glaciology	4.54
Information program	0.59
Environmental research	0.46

Support

A civilian helicopter contractor replaced Navy helicopters and pilots. With the start of the 1996–1997 research season, a commercial operator, Petroleum Helicopters Inc. (PHI), was awarded an NSF contract to provide all helicopter services for the U.S. Antarctic Program (except those operations associated with the U.S. Coast Guard icebreakers) over the next 5 years. In Antarctica, PHI flies one Bell 212 helicopter, the commercial equivalent to the Navy's UH-1N or "Huey," and three smaller A-Star helicopters. The Bell 212 carries one crew member (two at night) and has room for nine passengers and 990 kilograms (2,200 pounds) of cargo; its range is 560 kilometers (350 miles). The smaller A-Stars carry one crew member, five passengers, and 495 kilograms (1,100 pounds) of cargo; their range is 480 kilometers (300 miles).

With nearly 50 years of experience, PHI, a Louisiana-based company, is one of the world's largest and most experienced commercial helicopter operators. The firm's clients include national and international offshore oil, land-based mining, and aeromedical companies. In addition to providing services to North American companies, PHI has operated in 38 foreign countries worldwide. During the 1996–1997 season, seven pilots and five mechanics flew and maintained the four helicopters, which are based at McMurdo Station. (For more information, see the PHI Web site at *http://www.phihelico.com/*.)

The research ship Polar Duke retired from antarctic duty at the end of the 1996–1997 season. In June 1997, the Polar Duke headed north, leaving Antarctica after serving antarctic science for 13 years. Designed and built for research and supply work in the north polar seas, Polar Duke was christened in Kyrksæterøra, Norway, in 1983 by Rieber Shipping A/S of Bergen, Norway. When North Sea oil exploration waned, Rieber chartered the ice-strengthened ship to the U.S. Antarctic Program for research and support work. In January 1985, the Duke replaced the NSF-owned wooden research ship Hero, which was retired from south polar duty after 17 years of service.

Initially, *Polar Duke* was chartered to do what the *Hero* had done: perform austral summer research and resupply. In its first season, which lasted from January to April 1985, the *Duke* made three cruises between Punta Arenas, Chile, and the Antarctic Peninsula. The next year, however, Langdon Quetin of the University of California–Santa Barbara proposed a rare winter cruise. The success of this cruise, and one that followed during the austral winter of 1987, established *Polar Duke* as a year-round vessel. From the 1988–1989 austral summer season until its 1997 contract completion, the ship logged 275 to 300 days at sea per year in support of U.S. Antarctic Program science.

Polar Duke made possible countless landmark projects in the disciplines of physiology, microbiology, and oceanography and, in support of science and scientists, navigated some of the roughest waters in the world, including the Drake Passage between South America and the Antarctic Peninsula. In addition to serving as a research laboratory, *Polar Duke* also transported people, equipment, food, construction supplies, and other materials from Tierra del Fuego to Palmer Station and to seasonal field camps and other outposts. During the 1989–1990 operating year, *Polar Duke* made its first ever call at McMurdo Station. From the time of its charter in 1985 until it headed north in retirement in 1997, the *Duke* left the Southern Hemisphere only once: in 1995, the vessel carried a shipment of hazardous waste to the U.S. mainland for final processing and disposal.

A new ice-strengthened research vessel, *Laurence M. Gould*, was to replace *Polar Duke* in Antarctica next season. (For more information, visit Antarctic Support Associate's page for the *Gould* at *http://adelie.asa.org/marine/lmg/lmgtofc.htm*.)