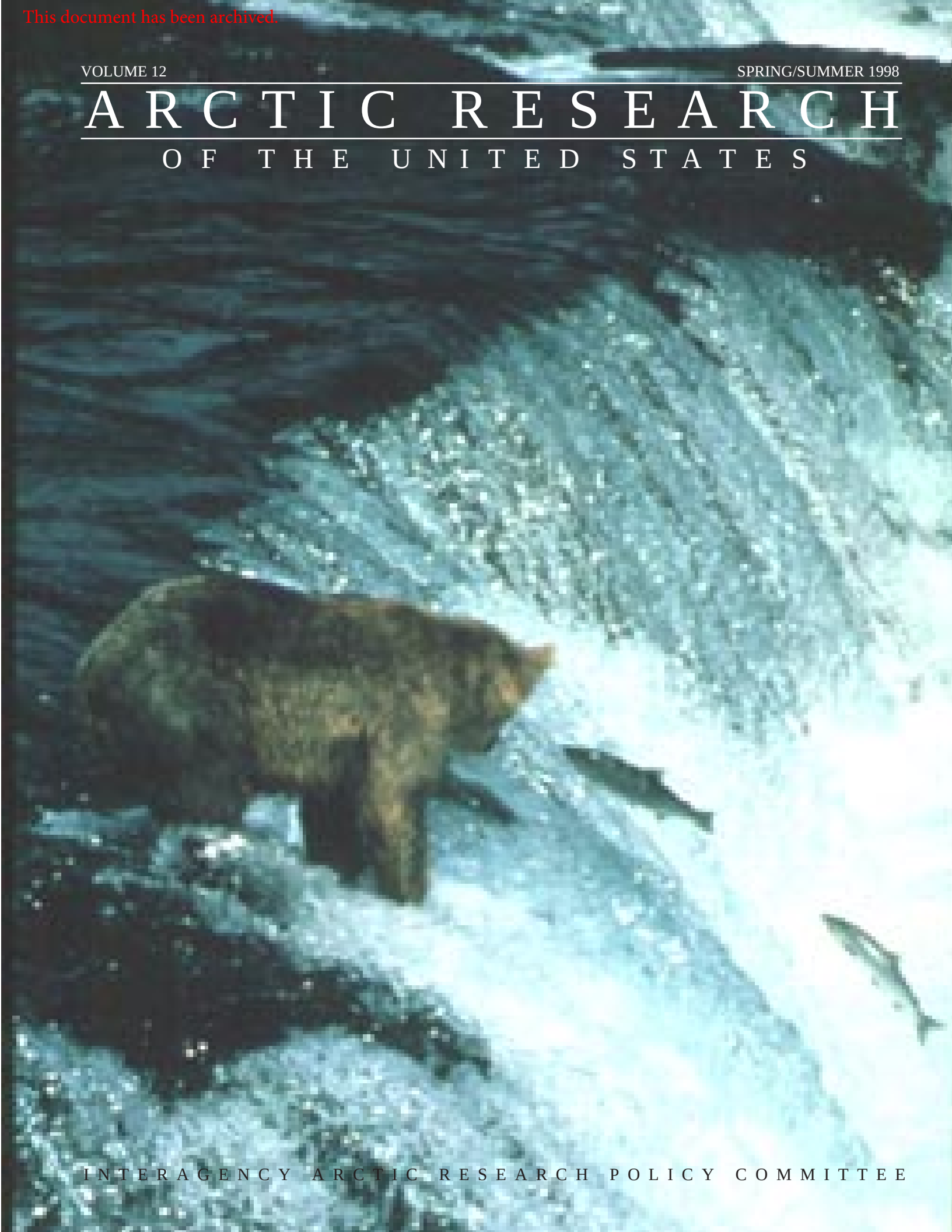
VOLUME 12 SPRING/SUMMER 1998

ARCTIC RESEARCH

OF THE UNITED STATES



INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

About the Journal

The journal *Arctic Research of the United States* is for people and organizations interested in learning about U.S. Government-financed Arctic research activities. It is published semi-annually (spring and fall) by the National Science Foundation on behalf of the Interagency Arctic Research Policy Committee and the Arctic Research Commission. Both the Interagency Committee and the Commission were authorized under the Arctic Research and Policy Act of 1984 (PL 98-373) and established by Executive Order 12501 (January 28, 1985). Publication of the journal has been approved by the Office of Management and Budget.

Arctic Research contains

- Reports on current and planned U.S. Government-sponsored research in the Arctic;
- Reports of ARC and IARPC meetings; and
- Summaries of other current and planned Arctic research, including that of the State of Alaska, local governments, the private sector and other nations; and

Arctic Research is aimed at national and international audiences of government officials, scientists, engineers, educators, private and public groups, and residents of the Arctic. The emphasis is on summary and survey articles covering U.S. Government-sponsored or -funded research rather than on technical reports, and the articles are intended to be comprehensible to a nontechnical audience. Although the articles go through the normal editorial process, manuscripts are not refereed for scientific content or merit since the journal is not intended as a means of reporting scientific research. Articles are generally invited and are reviewed by agency staffs and others as appropriate.

As indicated in the U.S. Arctic Research Plan, research is defined differently by different agencies. It may include basic and applied research, monitoring efforts, and other information-gathering activities. The definition of Arctic according to the ARPA is "all United States and foreign territory north of the Arctic Circle and all United States territory north and west of the boundary formed by the Porcupine, Yukon, and Kuskokwim Rivers; all contiguous seas, including the Arctic Ocean and the Beaufort, Bering, and Chukchi Seas; and the Aleutian chain." Areas outside of the boundary are discussed in the journal when considered relevant to the broader scope of Arctic research.

Issues of the journal will report on Arctic topics and activities. Included will be reports of conferences and workshops, university-based research and activities of state and local governments and public, private and resident organizations. Unsolicited nontechnical reports on research and related activities are welcome.

Address correspondence to Editor, *Arctic Research,* Arctic Research and Policy Staff, Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington VA 22203.

Cover

Brown bear catching sockeye salmon (also known as red salmon) at Brooks Falls, Katmai National Park and Preserve, Alaska.

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Editing and production: Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
Donna R. Valliere, Production Assistant

This issue of *Arctic Research of the United States* presents highlights and results of major fiscal year 1996 and 1997 Arctic research programs and selected projects of the Federal agenies. For more information, you may contact the agency staff representatives listed on page 152.

National Science Foundation

National Science Foundation research is concerned with the entire Arctic region, including Alaska, Canada, Greenland, Svalbard, the Arctic Ocean, and adjacent seas, the upper atmosphere and near space. Research falls principally within eight major scientific disciplines: atmosphere, ocean, biology, earth science, glaciology, social science, engineering and science education.

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The NSF supports a formal Arctic research program within the Office of Polar Programs (OPP). Other Divisions and programs throughout NSF, primarily in the Directorate for Geosciences and the Division of Environmental Biology in the Directorate for Biological Sciences, support research in and on the Arctic as part of their overall funding. Most research grants are awarded on the basis of unsolicited proposals and are merit reviewed.

In FY 97, NSF awarded funds for 358 Arctic research projects at 130 institutions in 38 states and the District of Columbia. NSF's support of Arctic research, including facilities support and field operations, over the past several years is shown below (in thousands of dollars).

	FY 92	FY 93	FY 94	FY 95	FY 96	FY 97
OPP	20,638	22,072	24,205	25,809	29,118	30,715
Other	14,308	13,779	16,279	19,386	16,959	18,674
Total	34,946	35,851	40,484	45,195	46,219	49,389

The following sections present highlights of several major programs and selected projects. A complete listing of NSF Arctic funded projects can be found in the publication *Arctic Science, Engineering, and Education Awards: FY 1997*, available from the Office of Polar Programs, National Science Foundation, Arlington, VA 22230.

Current information about the research supported by ARCSS can be found on the ARCSS home page: http://nsidc.colorado.edu/ARCSS/

	Funding (thousands)	
	FY 96	FY 97
Arctic Natural Science	10,382	10,316
Arctic System Science Prog	15,539	13,564
Arctic Social Sciences Prog	1,861	1,408
Arctic Research Support	639	415
Arctic Data/Info/Coord	339	364
Arctic Research Commission	500	500
Arctic Logistics/Instrumentation	0*	4,148
Other NSF Science Programs	16,959	18,674
Total	46,219	49,389

* Included with other programs in FY 96.

Arctic System Science

The National Science Foundation established the Arctic System Science (ARCSS) program in 1989. ARCSS is structured to be a regional component within the U.S. Global Change Research Program. Administration of the program uses review expertise and financial support from the Office of Polar Programs, the Divisions of the Geosciences Directorate and other components of NSF as appropriate. ARCSS is coordinated and managed by the Office of Polar Programs. Through a series of workshops and interactions with a broad scientific community, ARCSS has developed goals and priorities aimed at understanding the role of the Arctic in global change and how the Arctic will respond to global change. ARCSS is an interdisciplinary program that examines the interactions within and between the climatic, geologic, biologic and socio-economic subsystems of the Arctic. ARCSS is predicated on the knowledge that the Arctic system is sensitive to and important in global change.

ARCSS has six linked components. The original ARCSS program included the Greenland Ice Sheet Project (GISP2), Paleoclimates from Lakes

and Estuaries (PALE), Ocean/Atmosphere/Ice Interactions (OAII) and Land/Atmosphere/Ice Interactions (LAII). Two new programs, Synthesis, Integration and Modeling Studies (SIMS) and Human Dimensions of the Arctic System (HARC), were established in 1994 and 1996, respectively.

Science steering committees (SSCs) for each component facilitate and enhance the ARCSS program and provide a focal point for communication with the scientific community. Recommendations for overall coordination and integration of the ARCSS components and individual projects are provided by the ARCSS committee. The committee includes representatives from each SSC, as well as an investigator not supported by ARCSS with disciplinary interest in that component of ARCSS to enhance the scientific breadth and experience of the group.

NSF/ARCSS has been particularly successful at establishing partnerships with other Federal agencies. In 1996 and 1997 significant cost sharing on Arctic ocean science for ARCSS projects came from the Office of Naval Research (ONR). Considerable cost sharing with NASA, DOE, ONR and NOAA on current projects has occurred for projects dealing with Arctic climate and ocean processes and modeling research.

Paleoenvironmental Studies

Current information on scientific contributions from GISP2 may be found on the GISP2 home page: http://nsidc.colorado.edu/ARCSS/index.html

GISP2 and PALE both contribute to understanding the past climate, atmosphere and ecology of the Arctic. This historical information gives valuable insight into understanding system interactions. Starting in FY 98 the paleoenvironmental components of ARCSS were incorporated into the NSF program called Earth System History.

The overall goal of GISP2 was to obtain a history of global climate and atmospheric chemistry from the Greenland Ice Cap. This very successful program began in FY 86, completed its field phase in FY 93 and completed most of the laboratory analyses of the ice core in FY 97. GISP2 results provided evidence of global changes in atmospheric circulation, chemistry and temperature that have changed our perceptions of the intensity and rapidity of climate change during the most recent glacial–interglacial cycle.

The overall goal of PALE is to construct paleoclimatic history from the sediments of Arctic and sub-Arctic bogs, lakes and seas. A variety of proxy indicators (such as pollen, diatoms, sediment chemistry and grain size) in the sediments yield vital information on the responses of terrestrial and marine ecosystems to climate and land use change. PALE is complementary to GISP2 and provides information on local, regional and global changes. An Arctic circumpolar network of sampled sites has been established to describe the regional variation of climate over the past 18,000 years. PALE has joined an international program, Circumpolar Arctic Paleoclimate Experiment (CAPE), to produce a reconstruction of the circumarctic environment for three time slices: 2,000 years before the present (ybp), 6,000 ybp and 20,000 ybp. PALE has been accepted by PAGES (PAst Global changES) of the International Geological Biological Project (IGBP) as a core project.

Contemporary and Process Studies

Current information on OAII research may be found on the OAII home page: http://arcss-oaii.ccpo.odu.edu/

OAII and LAII are process oriented and rely more on experiment and less on description than GISP2 and PALE. An important goal of OAII is to investigate the effects of energy exchange on the structure of the Arctic Ocean and the interactions within the overlying atmosphere. Carbon sequestration, ecosystem dynamics, sedimentation and carbon deposition in the Arctic Ocean and its interactions with the surrounding land and river systems are also important topics of investigation. OAII currently is conducting the Surface Heat Budget of the Arctic Ocean (SHEBA) project from a ship frozen into the drifting ice pack in the Beaufort Sea. SHEBA is measuring the impact of clouds and albedo on sea ice for a full annual cycle.

An objective of the LAII-Flux study is to investigate feedback processes within the Arctic terrestrial system that modify global climate change, climate variability and fluxes of ice, fresh water, water-borne materials and greenhouse gases. LAII also assesses the effect of changing temperature and snow regimes on critical terrestrial organisms and their communities. LAII-Flux has discovered that the Alaskan tundra has shifted in the last 20 years from being a net sink of carbon dioxide to being a net source in winter. If this change is long term, it could lead to major positive reinforcing of global warming via the greenhouse effect. LAII-Flux has been accepted as a core project of IGBP. LAII has joined ITEX (International Tundra Experiment) of UNESCO's Man and the Biosphere (MAB) program, which is a study of the effects of climate warming on circumpolar plant species and community dynamics.

LAII-Flux is testing, among other things, the following three questions:

- Whether greenhouse-gas-induced changes in temperature and moisture are large enough to

trigger changes in trace gas fluxes from Arctic land areas;
- Whether climate change and the related oxidation of soil organic matter will increase the nutrient flux to streams, lakes and the Arctic Ocean; and
- Whether Arctic trace gas feedbacks will be sufficient to affect climate beyond the Arctic.

Synthesis, Integration, and Modeling Studies

SIMS is an integrative program that links all of the ARCSS components to provide a suite of model simulations for understanding the behavior, feedbacks, dynamics and function of the interactive Arctic system. Models are at all scales appropriate to building connections between LAII, OAII, PALE, GISP2 and HARC research, but those that provide a regional synthesis are emphasized. These models are essential to the ARCSS goal of developing a model that will predict the natural responses to global changes that affect the human condition.

Human Dimensions of the Arctic System

Human Dimensions of the Arctic System (HARC), the ARCSS component of the NSF Human Dimensions of Global Change program, is a collaborative effort with the Arctic Social Sciences Program to integrate natural and social sciences research that will demonstrate the interactions of climate and human development with the use of natural resources. Arctic Native peoples have sustained themselves through hunting, fishing, whaling and wage employment derived from petroleum revenues. The continued sustainability of that culture and regional development could be affected by global environmental changes that may affect vegetation and marine productivity, year-round sea ice maintenance, and construction/land use practices. In the next five years, interdisciplinary groups will focus on developing models that predict natural responses to global changes. Research at the natural sciences–human dimension interface will increase policy makers' understanding of regional natural and social systems and build linkages between communities in the Arctic. Those linkages will enhance the knowledge base necessary for examining policy choices and risk assessments within the context of global and regional climate changes.

Arctic Natural Sciences

The National Science Foundation established the Arctic Natural Sciences (ANS) program in 1995. The program is unique in NSF in the variety of disciplines supported. ANS supports research in space sciences, atmospheric sciences, geology, biology, glaciology and oceanography in the Arctic. Arctic Natural Sciences uses review expertise from the Office of Polar Programs, the Divisions of the Geosciences Directorate and other components of NSF as appropriate. The Office of Polar Programs coordinates ANS. A few science highlights follow.

Glaciology

Research in glaciology includes the study of all forms of naturally occurring ice and its history. Some examples are studies of past climates and atmospheric paleochemistry from ice cores, ice stream and valley glacier dynamics, glacial geology, glacial hydrology and the mass balance of mountain glaciers and ice sheets. The research takes place primarily in Alaska, Greenland, Arctic Canada, Svalbard, Arctic Russia and Sweden. In addition, some limited funding goes to support research in high-altitude and mid- and low-latitude regions of the Northern Hemisphere.

The program also supports research on new methods of studying glaciers and ice sheets, including the development of improved remote sensing capabilities, drilling methods and methods for analyzing ice cores. In addition a variety of theoretical, laboratory and data analysis projects are funded.

The U.S. National Ice Core Laboratory (NICL), located on the grounds of the Denver Federal Center in the same building as the U.S. Geological Survey's Core Research Center, is operated jointly by the University of Colorado and the U.S. Geological Survey. The NSF funding is from both the Arctic and Antarctic science programs.

The purpose of Arctic Glacier Studies projects is to increase understanding of the mechanisms responsible for the surge behavior of glaciers and the seasonal fluctuations of glacier flow. Work has focused on the role of subglacial water and basal water pressure, ice temperature, internal deformation, electrical conductivity and turbidity of meltwater. These parameters can be measured in boreholes in the ice at various places on the glacier. A multi-year study of the Greenland ice cover has shown that the ice-covered area around the Greenland periphery has decreased over the past decade.

Glacial Geological Studies

Among the largest uncertainties in ice volume changes during the late Quaternary are the areal and vertical extent of ice sheets over Franz Josef Land, Novaya Zemlya and the adjacent seas (Barents/

Kara). Deglaciation of Franz Josef Land and the northern Barents Sea occurred surprisingly early, according to glacial geologists funded by the Arctic Glaciology program. Deglaciation of the Barents/Kara Sea ice sheet may have been initiated by a rapid global sea-level rise 13 thousand years ago. This sea-level rise would have destabilized this marine-based ice sheet, particularly in the deep troughs bordering the Russian Arctic seas.

Studies on natural climate signals in ice cores have relied on the information preserved in the ice caps about past atmospheric conditions. Over 50 chemical species and physical properties have been measured in ice cores and are used to reveal past climatic conditions. Significant progress has also been made in characterizing the atmosphere-to-ice "transfer function." For example, it has been shown that the transfer function is nonlinear and depends on temperature, water accumulation and the abundance of other species.

American scientists have been invited by European researchers to participate in NGRIP, a Greenland ice sheet coring project that is being conducted from a site several kilometers north of where the two previous deep ice cores (GISP2 and GRIP) were recovered. The U.S. teams will measure stable isotope ratios of snow and ice to infer climate change in the last millennium and will analyze the dust recovered from the ice cores to infer the dominant wind regimes associated with paleoclimates.

Atmospheric Sciences

Several investigators studied climate change, how it is characterized, and its consequences for the Arctic. The program supports research aimed at the physical understanding of the processes responsible for climate change as well as the processes affected by climate change.

The past four winters have seen the largest ozone depletions ever recorded in the Arctic, and each year has seen more ozone depletion than the preceding one. Arctic ozone depletions have been far more dramatic than had been anticipated by most scientists. The program goals were to measure stratospheric constituents and understand the processes involved in ozone depletion and to study the effect of the increased UV radiation on biological systems. Ozone is depleted during extremely cold conditions, and ozone concentrations reach their minima in the late winter and early spring. Stratospheric measurements of ozone and studies of the ozone depletion processes have revealed the importance of natural effects such as volcanic eruptions in ozone depletion processes.

Conditions in the magnetosphere, ionosphere and thermosphere can influence the performance and reliability of both space-borne and ground-based technological systems. Arctic observations are essential to understanding the physical processes that govern space weather. NSF's program focuses on high-latitude observations aimed at understanding the coupling between the magnetosphere, ionosphere and upper atmosphere and predicting the weather in space. A specific emphasis of NSF programs is to understand Arctic and Antarctic conjugate phenomena. Conjugate studies provide a unique tool to trace time-varying magnetic field lines and determine large-scale current configurations in the magnetosphere.

Ocean Sciences

From 1995 through 1999 U.S. Navy submarines were and will be deployed to the Arctic Ocean (the SCICEX submarine cruises) for unprecedented missions to support unclassified oceanographic research conducted by and for researchers from academic institutions in the U.S., Canada and the United Kingdom. These missions are dedicated to providing an improved understanding of the Arctic Ocean and the nature of its seasonal variations.

The Arctic Ocean is the last frontier in oceanography. Important issues are related to the global carbon cycle and the distribution of biota, freshwater balance, circulation, heating, transport of sediments and pollutants, and spreading of the seafloor, as well as the volume, flow and properties of sea ice. Present emphasis is given to using Navy nuclear submarines as a platform. Future emphasis will involve the USCGC *Healy* research vessel under construction.

The SCICEX submarine cruises have provided a unique synoptic snapshot of the configuration of the Arctic Ocean. They have revealed changes in ice thickness distribution (which plays a major role in determining the overall heat and mass balance at the surface of the ocean). The front that separates Atlantic and Pacific waters appears to have moved from a position close to the Lomonosov Ridge to the Mendeleev and Alpha Ridges. This translates into a 20% increase of the area dominated by the Atlantic waters. In parallel the upper ocean temperature has increased greatly, by 1°C in some regions. These observed changes in Arctic Ocean circulation and temperature may be due to an increase in the temperature and volume of the incoming North Atlantic water.

Gakkel Ridge, the active spreading center in the Arctic Ocean, is the slowest spreading portion

of the mid-ocean ridge system. Gravity surveys carried out by the SCICEX program have revealed that the crust is very thin, probably less than 4 km.

Researchers have confirmed that a hot mud volcano on the seafloor between Greenland and Norway is oozing mud, seeping gas and spewing a gas-laden plume of warm water into the North Atlantic. Frozen methane hydrate caps the volcano, whose slopes are inhabited by a species of tubeworm most closely related to a group found in Antarctica.

Construction of a side-scan swath bathymetric sonar and a high-resolution sub-bottom profiler has started. This instrument, the Seafloor Characterization and Mapping Pod (SCAMP), will provide an unprecedented opportunity to map the deep Arctic Ocean. SCAMP will provide the data sets necessary for the accurate digital terrain mapping required for modeling ocean circulation. It will also provide detailed mapping of the Arctic Mid-Ocean Ridge and of periglacial features (such as iceberg plow marks on the continental shelves), which are needed to understand the Holocene history of the Arctic.

Biological Sciences

Research topics span a broad range of biological disciplines, with several projects multidisciplinary and interdisciplinary in design. The biological sciences component of the Arctic Natural Sciences Program supports research in all aspects of Arctic biology, including topics in biological oceanography and marine ecology as well as terrestrial and freshwater ecology.

The two largest projects are the ongoing Long-Term Ecological Research (LTER) projects on tundra, freshwater and taiga ecosystems in Alaska. The Arctic (Toolik Lake) and Bonanza Creek LTER projects continue the successful pursuit of their individual project objectives and their participation in the national network of LTER sites. The LTER network and individual LTER projects are actively developing research collaborations with scientists supported by other agencies and scientists in other countries who share research interests.

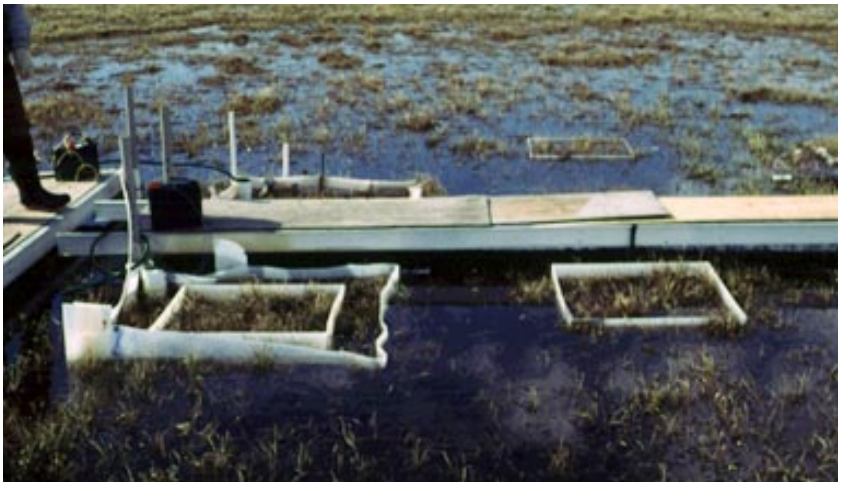
The Arctic LTER is a major interdisciplinary project located in the foothills of the Brooks Range on the North Slope of Alaska. Funding has supported a large group of biologists, ecologists, limnologists and hydrologists from major universities and research centers in the U.S. to study terrestrial and freshwater ecosystems. In conjunction with the LTER program, this project has developed a multidisciplinary team approach to ecosystem studies.

Four other ecosystem projects were supported during FY 96 and 97. One of these ecosystem projects was designed to test the importance of geomorphology in determining food web (trophic) structure. This research, termed the geomorphic–trophic hypothesis, postulates that landscape characteristics, including lake outflow gradient, lake depth and lake area, determine the distribution of fish species, which in turn controls the benthic and pelagic trophic structure. This proposed work has four major components:

- Assembling and interpreting a geographic information system database of lake area, lake depth and outflow gradient for lakes in the vicinity of the Toolik Lake LTER site;
- Sampling a subset of these lakes in an experiment designed to evaluate landscape control of fish distributions and their impact on benthic and plankton food webs;
- Sampling a group of experimental lakes, also in the context of the geomorphic–trophic hypothesis; and
- Constructing food web models to test whether the geomorphic–trophic hypothesis governs food web characteristics.

A second project was designed to improve the understanding of how carbon–nutrient interactions in soils might affect the responses of Arctic tundra ecosystems to global environmental change. This research was conceived in a global warming context that predicts that a global temperature increase would affect carbon–nutrient interactions at the ecosystem level. The central idea is that the primary production in Arctic ecosystems is often strongly nutrient limited, with virtually all of the nitrogen made available to vascular plants in tundra ecosystems coming from microbial mineralization of soil organic matter.

A third project, a Terrestrial Ecology and Global Change (TECO) research award, elucidated the short- and long-term responses of Arctic tundra ecosystems to climate change and associated changes in soil water content and active layer depth. Physical changes associated with an increase in average annual temperature in the northern latitudes (an increase in growing season length, a decrease in surface soil water content, and a decrease in the extent and distribution in snow and ice cover) have altered Arctic ecosystem function. This could result in a significant positive or negative feedback to global atmospheric carbon dioxide concentrations. This project will conduct net carbon



TECO water table manipulation experiment at the Prudhoe Bay oilfield.

dioxide exchange measurements over the annual cycle to determine both the warm- and cold-season contributions to annual net carbon dioxide exchange in Arctic tundra ecosystems.

A fourth project, another TECO award, was designed to develop a predictive understanding of the major classes of feedbacks from boreal fire to climate as a basis for improved understanding of the changing role of the boreal forests in the Earth's climate system. The goal of this project is to understand certain processes that remain outside of current general circulation models (GCMs). These processes reflect "surprises" that reduce the reliability of GCMs for predicting climate change because of limited understanding of the role of biotic and ecosystem feedbacks to regional and global dynamics. In addition to studies of paleoecological dynamics and fire and climate modeling, this project involves an integrative, large-scale field experiment in the boreal forest. Measurements of forest dynamics following burning, soil processes, trace gas fluxes and paleoecological reconstruction of vegetation and climate will be integrated in the project. This research will be conducted in association with the Bonanza Creek LTER program in Alaska. This project represents one of the few extensive and integrative assessments of the feedbacks between fire in boreal forest and global climate dynamics.

Environmental research

The purpose is to understand the relationship between physical and chemical processes as they relate to the unique character of the Arctic environment. Research projects in this area include the history, biology and dynamics of Arctic fauna and flora, the physical and biological geography of Beringia and the Arctic coastal regions, the microbial processes responsible for mineralization cycles such as carbon and nitrogen fluxes, biological adaptation to the Arctic environment, and the hydrography of freshwater drainages.

Climatic data obtained by Arctic Natural Sciences researchers studying changes in the permafrost indicate that Alaska is currently warming at a rate of about 2.4°C per century. Some of the discontinuous permafrost south of the Yukon River in Alaska has warmed by as much as 1.5°C.

The continental shelf break of the Bering Sea, which extends diagonally across the Bering Sea basin, is the site of some of the most productive water in the North Pacific. During the 1997 field season, researchers detected very anomalous conditions that included sea surface temperatures 3°C above normal, the first-ever-described phytoplankton blooms in the Bering Sea, unusually large numbers of whales and an unusually large die-off of short-tailed shearwaters ranging between hundreds of thousands to millions of birds. Researchers are now investigating the probable causes of these changes in the Bering Sea.

The flora and fauna of tundra soils are among the least known components of Arctic biodiversity. Tundra soils are unique because of the presence of permafrost, highly acid or alkaline conditions, and repeated cycles of freezing and thawing. The soil biota are generally small and difficult to identify or even detect, but recent evidence suggests that the bulk of the biological activity in the Arctic is due to these organisms. Researchers have developed a rapid and innovative molecular-based technique that promises to characterize bacteria and viruses by probing unique sequences of their DNA. Special probes are bonded to a microchip and buried in the soil for a short time; subsequent laboratory analysis enables comparisons between known microbial DNA and that of microbes that live in the tundra.

Earth Sciences

The Earth Sciences Program supports research in a wide range of fields of geology, including paleoclimatology, glaciomarine sedimentology, surficial processes, paleontology, petrology, tectonics and solid earth geophysics. These projects focus on unraveling the history of Arctic glaciation and understanding the past Arctic environments by examining the sedimentary and paleontological record of terrestrial coastal plain, continental shelf and deep marine sediments.

Arctic Social Sciences

In FY 96 and 97 the Arctic Social Sciences Program supported traditional social science fields such as anthropology, archaeology, linguistics and sociology, in addition to less traditional interdisciplinary studies. *The Chronicle of Higher Education* highlighted a project documenting the history and contemporary practices of Greenlandic sealing and whaling in its November 8, 1996, issue. This research shows the importance of local knowledge and resource use in the international context of conservation concerns. It also demonstrates the trend of establishing interdisciplinary linkages between social scientists and natural scientists to produce policy-relevant research results.

In another project the investigator accompanied Yup'ik elders to a Berlin museum to investigate and record the elders' comments on the Yup'ik artifacts collected from southwestern Alaska in 1882-83 by Johan Adrian Jacobsen. Transcripts of the elders' commentary will add immeasurably not only to the documentation of this extensive collection of artifacts but also to a broad understanding of Yup'ik knowledge and oral tradition.

The economic, political and spiritual ways of the Attuans, peoples who once inhabited the western Aleutian Islands, formed the subject of another study. This project combined oral histories of the last Attuans and their descendants with findings from archaeological excavations. During 1997, archaeologists on Buldir Island uncovered and excavated the only scientifically reported "house" built of whalebones found in the Aleutian chain. Radiocarbon dates suggest that the house was built in the mid-fifteenth century.

The Arctic Social Sciences Program has also cooperated with the ARCSS program to support social science components of multidisciplinary projects such as the study of changes in caribou populations and movements and the associated social changes in Alaskan and Canadian villages whose members depend on caribou harvests. An important aspect of this project is the exchange of knowledge between community experts and university-trained researchers. Indeed, a special feature of the Arctic Social Sciences Program has been the partnership between research and local communities established, for example, through the Alaska Native Science Commission. Additionally Arctic social scientists have fostered community involvement through educational activities and joint research efforts. These partnerships have not only strengthened the quality of research but also established the connection between new knowledge and its service to society.

Education

NSF has linked research and education through curriculum development, research experiences for undergraduates (REU) and teacher preparation and enhancement. In FY 97 NSF reached out to millions of students and teachers in preparation for National Science and Technology Week, April 1998, which focused on polar regions. Undergraduates at several REU sites have conducted remote-sensing studies of glaciers and ice sheets and environmental and ecological studies specific to high latitudes. An Arctic Research Consortium of the United States (ARCUS) workshop held in 1997 assembled 60 educators, curriculum specialists and scientists to integrate education and research and develop collaborative projects. Projects such as the Alaska Rural Systemic Initiative, Partners in Science, and Polaris integrate science and education by building partnerships among students, teachers and individual researchers. Finally the Alaska Native Science Commission (ANSC) has provided the primary link between the scientific community and Alaska Natives. In its first year the ANSC has organized and participated in workshops on traditional knowledge, science education and community involvement in science. These workshops have helped educate scientists about the needs and desires of Alaska Native communities and educated Native groups about the needs and conduct of science.

Arctic Research Coordination

NSF supported a program of polar information and advisory services, provided support for the Interagency Arctic Research Policy Committee, provided funds for the Arctic Research Commission, and supported conferences, workshops and studies to further develop and implement Arctic research planning and policy.

As required by the Arctic Research and Policy Act of 1984, a comprehensive Arctic Research Plan was prepared by the Interagency Arctic Research Policy Committee and submitted to the President, who transmitted it to Congress in July 1997. The fifth revision to the United States Arctic Research Plan included two major sections. The first of these presented the Integrated Interagency Research Plans:

- Assessment of risks to environments and people in the Arctic;
- Surface Heat Budget of the Arctic Ocean;
- Beringian systems studies; and
- Arctic data and information.

The second major section was Agency Programs, which represents the objectives of Federal agencies, focusing on the period covered by this revision (1998–2002). They were presented in seven major categories:

- Arctic Ocean and Marginal Seas
- Atmosphere and Climate
- Land and Offshore Resources
- Land–Atmosphere–Water Interactions
- Engineering and Technology
- Social Sciences
- Health.

The Interagency Committee also addressed issues related to logistics support for Arctic research. The biennial revision of the U.S. Arctic Research Plan serves as guidance for planning by individual agencies and for coordinating and implementing mutually beneficial national and international research programs.

NSF supports many other interagency planning and coordinating activities. Coordination with global change programs is an integral part of Arctic program development and implementation. Improved communication at all levels is encouraged through newsletters and journals.

Engineering and Technology

The Engineering, Geosciences, and Mathematical and Physical Sciences Directorates support research in engineering, material sciences and permafrost. Research includes studies of the mechanical properties of ice, the hydraulic conductivity of frozen soils, metamorphism of dry snowpacks, three-dimensional analyses of ice, and permafrost.

NSF also sponsors a program for science-based and high-technology small business firms, the Small Business Innovative Research Program (SBIR) in the Engineering Directorate. SBIR is interested in research on advanced concepts in scientific or engineering areas, particularly where the research may serve as a base for technological innovation.

Department of the Interior

The Department of the Interior performs biological and physical research; conducts mapping, monitoring and assessment programs throughout Alaska and its offshore regions; and manages Department lands in Alaska. These activities are performed by services or bureaus, each with administrative and technical offices located in Alaska.

Minerals Management Service

The Minerals Management Service (MMS) has the statutory responsibilities to manage the mineral resources located on the U.S. Outer Continental Shelf (OCS) in an environmentally sound and safe manner and to collect, verify and distribute mineral revenues from Federal and Indian lands.

In support of these responsibilities, MMS conducts two major programs of research that are relevant to activities in the Arctic. One, the Technology Assessment and Research (TA&R) program, focuses on engineering and technology issues. The other, the Environmental Studies (ES) program, focuses on issues related to assessing and predicting potential environmental and socioeconomic impacts.

Technology Assessment and Research Program

The MMS supports an active research program to understand the engineering constraints for offshore operations, especially as related to the structural integrity of structures and pipelines, the prevention of pollution, and the technologies necessary to clean up an oil spill should one occur. In essence, the program provides an independent assessment of the status of OCS technologies and, where deemed necessary, investigates technology gaps and provides leadership in reaching solutions. The program also facilitates a dialogue among engineers in the industry, the research community and MMS in dealing with the many complex issues associated with offshore oil and gas operations.

	Funding (thousands)	
	FY 96	FY 97
Technology Assessment/Research	3,320	3,270
Environmental Studies	1,810	3,700
Total	4,130	6,970

The TA&R program, which includes both Safety and Pollution Prevention Research, and Oil Spill Response Research, continues as an essential and integral element of the MMS regulatory program. The TA&R program does not address the economics of operations, which are in the purview of industry. On the contrary, it specifically addresses the functional needs of the MMS to provide for a sound technology base for regulatory decisions to ensure safe and pollution-free operations.

In the past the program was motivated by the need to acquire basic engineering information necessary to oversee the general development of offshore operations. As a direct result of research funded by the TA&R program, regulatory changes were initiated on the design and operation of diverter systems, well control procedures and training requirements, the need for periodic platform inspections, methodologies for assessing the integrity of older or damaged platforms, the reduction of exhaust pollution offshore, and the development of oil pollution plans to ensure that the proper equipment, personnel and procedures were available to respond to an offshore oil spill, should one occur.

However, the future has provided new goals and directions for offshore oil and gas research initiatives. This new emphasis is a result of past technology developments, economic constraints within the industry and a continuing need to ensure that offshore oil and gas operations can be conducted in a safe manner without harm to the environment.

With a sound appreciation for the current state of offshore technology, the TA&R program will

continue to focus its research efforts in the following four areas:

- Frontier areas of operations (both deep water and the Arctic), including safety issues as well as the integrity of structures and pipelines;
- Human and organization factors and how they can be addressed to mitigate accidents;
- The aging offshore infrastructure, including platforms and pipelines; and
- Spill mitigation measures, including cleanup and containment technologies for an oil spill, should one occur.

The TA&R program is a contract research program; that is, the research is not performed within the agency but is conducted by academic institutions, private industry and government laboratories. Studies are performed in cooperation with the offshore industry or with other agencies or governments. This aspect of the program provided an important multiplier of funding support, but probably of equal importance is the discourse it provides with the industry.

The ability to work together to assess a particular technology or the rationale for future technical developments helps both industry and government. Such cooperation and dialogue allow us to understand each other's needs and eliminate possible conflicts or misunderstandings concerning the engineering feasibility of an operational decision. As a result of this dialogue, a valuable exchange of information is provided between MMS and the industry.

Safety and Pollution Prevention Research

Arctic offshore operations have been hampered more by the lack of commercially economic discoveries than by technology. The industry has tended to develop onshore resources in the Arctic with just minimal exploration and development offshore. However, recently there has been an increased interest by the oil and gas industry in Arctic offshore resources.

Sea ice is still the most severe environmental hazard posed by the Arctic relative to future offshore development. Such hazards include forces that moving sea ice may exert against offshore structures, icing of structures resulting from freezing spray, gouging of the sea floor by sea ice (which could interfere with buried pipelines), and interference with locating or cleaning up a potential oil spill. Engineering data for these hazards will become increasingly important as operations move from an exploration mode to a production mode and as structures are considered for deeper water, especially within the shear zone or pack ice.

The TA&R program has funded a variety of projects and major international workshops to develop a better understanding of the engineering constraints for operating in the harsh Arctic environment:

- International Workshop on Ice Scour and Arctic Marine Pipelines;
- International Workshop on Human Factors in Offshore Operations;
- International Workshop on Composite Materials for Offshore Operations;
- Pressure Ridge Ice Scour Experiment;
- Risk Assessment for Ice Damage to Seabed Facilities;
- Methodology for Risk-Based Optimization of Pipeline Integrity Maintenance Activities; and
- Safety and Integrity of Arctic Marine Pipelines.

The International Workshop on Ice Scour and Arctic Marine Pipelines was held in February 1998 in Mombetsu, Hokkaido, Japan, in association with the 13th International Symposium on Okhotsk Sea and Sea Ice. It was a joint project between the MMS, the Centre for Cold Ocean Resources Engineering (C-CORE) from Memorial University of Newfoundland, and Sakhalin Oil and Gas from Okha, Russia. The general aim of the workshop was to review the current understanding of the mechanics of ice keel scour, the ability to model the scouring process, and the application of models to the issue of pipeline burial and protection. The workshop attracted scientists and engineers from Canada, Russia, the U.S., Japan, the U.K. and Norway.

Most attendees agreed that the 1996 International Workshop on Human Factors in Offshore Operations held in New Orleans, Louisiana, was long overdue. They felt it was time for professionals representing industry, government and academic institutions to discuss the status of human factors offshore. The need was to review what was done in the past, what we are doing now, and what we can do in the future to lower the risk and the number of human factors related to possible incidents in offshore operations. The supportive remarks, keynote addresses and theme papers presented by government leaders, representatives from regulatory and certification agencies, and management of several international oil companies clearly demonstrated the importance of human factors issues to both industry and government. Six topics were selected to establish the status of human factors spanning the life cycle of an offshore facility: design, fabrication and installa

tion, field operations, management system, standards and regulations, and science and application. Each group was successful in capturing the state of the art utilized in offshore facilities from preliminary design to decommissioning. The issues discussed by each working group during the course of the workshop brought out the use and benefits of human factors established in other industries, advances in human factors offshore, and barriers blocking further progress.

In the First International Workshop on Composite Materials for Offshore Operations held in 1993 in Houston, Texas, important recommendations were made by the participants. As a result of these recommendations and with the strong support of the MMS and Department of Energy, U.S. petroleum companies formed an alliance with the domestic manufacturing industry, material suppliers, engineering service companies, and the University of Houston to develop major technological initiatives to accelerate the utilization and deployment of advanced composite materials and structures for future deep-water offshore developments. One of the initiatives was the establishment of the Composites Engineering and Applications Center (CEAC) for Petroleum Exploration and Production at the University of Houston.

In view of the recent and current composite activities, and their potential impact and implications for future offshore exploration, construction and production operations, especially in the Gulf of Mexico and the North Sea, CEAC and the MMS organized the Second International Conference on Composite Materials for Offshore Operations, which was held in October 1997 in Houston, Texas.

Several critical topics were covered in the conference, including various state-of-the-art developments and applications as well as recent advances in the fundamental science and engineering of offshore composites. A series of opening and keynote lectures were given by internationally recognized experts to review the current state of developments and to assess the future opportunities of composites offshore. On the first day of the meeting, major current industrial developments were discussed, ranging from composite production and drilling risers, mooring systems, platform structures, drill pipe and equipment for extended reach and deviated drilling, tanks and high-pressure vessels, and other advanced applications. On the second day, critical issues addressed included new materials, jet-fire resistance, composite durability, advanced design and reliability, nondestructive evaluation and sensor technology, and standards and codes for offshore composite components. The important regulatory and certification concerns were discussed on the third day, followed by summaries and reports from the individual session chairmen before the conclusion of the conference.

The Pressure Ridge Ice Scour Experiment (PRISE) is also being conducted by C-CORE and addresses the most likely transportation mode for commercial development of oil and gas prospects in the Arctic—a product pipeline laid on or under the seabed. Marine pipelines in areas frequented by ice will be threatened by grounded or scouring ice masses, which occur periodically throughout the ice season. Pipelines must therefore be protected by trenching or burial to a safe, yet manageable and economical depth below the seabed. The major question facing industry planners and regulatory and design engineers concerns the depth of burial required or trenching and trench backfill requirements. This question arises due to an incomplete understanding of the ice below the incision scour depth. PRISE is designed to increase knowledge of the scouring process and specifically of subscour deformation processes. This integrated, multidisciplinary approach progresses from the selection and development of theoretical and numerical models to corroboration of these models with results of small-scale, high-gravity centrifuge modeling and validation of model results with full-scale observations. The result of the program will be an industry-accepted design tool (a field-verified finite-element model) complete with a set of specific design guidelines.

In offshore environments where ice is present, damage to subsea facilities from icebergs or pressure ridge keels may limit the application of these emerging technologies. Ice damage of seabed facilities typically does not present a direct threat to human health and safety, but it can have severe environmental consequences, as well as economic consequences in terms of both repair costs and downtime. To determine the feasibility of pipelines, wellheads and other structures on the seabed, risk assessment for ice damage must be performed.

Unlike risk assessments for waves, winds and other relatively well understood environmental parameters, approaches to assessing risk for ice loading are not well established. There can also be severe data limitations. With such limited information, risk itself is a random variable. The variance of this random variable (expressing the degree of uncertainty of assessed risk) strongly affects the results of risk analysis and therefore can have

important economic impacts. This variance can be reduced by increasing the amount and quality of information, for example, new field investigations, data from other sites with similar conditions, or improved numerical models. Both the proponents of offshore hydrocarbon developments and the regulatory agencies have a vested interest in maximizing the accuracy of risk estimates and understanding and quantifying the uncertainty in risk assessments.

Uncertainty in risk assessment has two main sources. First, there is uncertainty in environmental data. Some environmental parameters such as soil type may be well known or easily quantified through a sampling program. Other parameters, such as pressure ridge keel depths, may be poorly known. Because these types of parameters vary seasonally and annually, short-term sampling programs cannot completely define the phenomenon. Other information such as ice scour frequency may be unknown and not easily measured. Data of this type must be estimated. Each parameter has a different level of importance in a risk analysis and a different degree of uncertainty associated with it. Knowing the existence of these uncertainties, MMS initiated a research project to establish a framework for assessing risks associated with ice damage to Arctic seabed facilities. Phases 1 and 2 of the PRISE project included phenomenological (field) studies, theoretical studies and physical experiments.

Continuing industry interest, partly because of the potential offshore hydrocarbon developments around Sakhalin Island, Russia, prompted Phase 3 of PRISE to extend the database of physical experimentation and to adapt an existing commercially available engineering model to the design of pipelines.

The MMS is part of a joint industry program (JIP), through the Center for Engineering Research in Canada, directed at optimizing pipeline integrity maintenance activities using a risk-based approach. The goal of the JIP is to develop models and software tools for estimating the risk levels associated with individual pipelines or individual segments within a pipeline system. The models and tools developed will allow risk reductions associated with various inspection and maintenance activities to be quantified, providing a basis for comparing alternatives. The overall framework will include an approach to evaluate potential risk-reduction benefits against the associated costs, allowing optimal decisions to be made regarding the choice of an integrity maintenance strategy. Integrity maintenance decisions have traditionally been based on subjective assessments of pipeline inspection data. More recently, engineering analysis of the data has provided a more rational basis for technical decisions.

Risk analysis can transform inspection data into information that is directly related to the operator's objective, namely to reduce the probability of failure of individual segments within a pipeline system in a balanced manner that acknowledges the potential difference in the consequences of failure associated with different line segments.

The potential economic benefits to pipeline operators of using a risk-based approach are significant. On one hand, any small reduction in failure rates resulting from better maintenance planning would reduce the potentially high cost of failure. On the other hand, if excessive conservatism in repair strategies can be identified and eliminated, costly premature maintenance activities may be avoided.

Post-scour examination of the Phase 3 PRISE centrifuge model tests show that surface and subsurface scour-induced deformation structures observed from the Phase 2 full-size scour marks in the field could be reliably modeled in the centrifuge. Sub-scour soil deformation empirical relationships for the ice–soil interaction at steady state were developed from examination of the physical centrifuge model test data. The observed extent and magnitude of sub-scour deformations for mean scour events were much larger than previously anticipated.

These PRISE tests provided data for scour depths and widths as large as 1.49 and 30 m, respectively, in clay and 2.14 and 30 m in sand. However, extreme events on the order of a 5-m depth and/or a 100-m width might be expected in areas with development potential. The current Phase 3 program is determining the forces and soil deformation effects of extreme full-scale ice keel scour events in medium-dense sand and stiff clay through the use of centrifuge modeling. These new experimental data are being used to expand the empirical relationship to include extreme scour events. However, the Phase 3 tests have also indicated large and extensive normalized sub-scour deformations for extreme ice scour events. This test series has been extended to simulate both the ice-scour conditions expected for the pipeline development for Northstar, Alaska, in silt, and for Sakhalin I, Russia, in sand. The new tests conducted in a dilatant silt have also shown large and extensive normalized sub-scour deformations.

These normalized deformations are apparently larger than those observed in compressible materials. It is this observation from centrifuge model tests that needs confirmation from further field evidence and numerical simulations. In this regard the TA&R program funded an effort to conduct a field study to allow for direct observation of sub-scour deformation.

The principle objective of this proposal is to confirm the magnitude and extent of sub-scour (zone 2) deformations in a dilatant soil, such as a compact silt. This confirmation is essential to achieve the PRISE goal—developing the capability to design pipelines and other seabed installations in regions gouged by ice, taking into account the soil deformations and stress changes that may be caused during a gouge event. The objective will be achieved by three activities:

- Direct field observation of sub-scour deformations under fresh ice scours in compact silt in a tidal estuary;
- Simulation of these field ice scour events by centrifuge modeling; and
- Development of the existing numerical model to predict sub-scour deformation profiles in dilatant materials, such as compact silt.

Although the above projects address critical areas for Arctic offshore facilities, additional research is still required to demonstrate fully that the technology is available to design, construct and operate facilities in this ice-laden region. In addition to the development of numerical models, actual field programs are needed to improve the understanding of sea ice and the ice–structure interaction process. Research is also needed to improve probabilistic models for estimating year-round ice loads for permanent production structures. There are added load uncertainties due to the extended exposure periods of production structures, and these uncertainties must be considered in the design process. These areas will be addressed by the TA&R program in the near future.

Alaskan Arctic offshore oil and gas deposits may be one of the major undeveloped petroleum resources remaining in the U.S. The capability to drill exploratory wells in water depths up to 200 feet in the Arctic has been proven. As noted previously, production in these areas has been negated more by the lack of commercial, economic discoveries than by the lack of technology. The information gained as activities are extended into deep water and more hostile ice conditions, combined with extensive research, should provide a solid technological base for future operations.

Oil Spill Response Research

For the last several years the MMS has been the principal U.S. agency sponsoring offshore oil spill response research. Since the late 1970s the MMS has managed a comprehensive international Oil Spill Response Research Program (OSRRP) to improve oil spill response technologies and procedures as part of the TA&R program. The OSRRP has improved existing capabilities to respond to open-ocean oil spills. The OSRRP was expanded in 1986 by coordinating and cooperative funding of research within the purview of both Environment Canada and the U.S. National Institute of Standards and Technology. This partnership is continuing, and many of MMS's oil spill research projects are JIPs where MMS leverages its money by as much as 6:1. The OSRRP complies with Title VII of the Oil Pollution Act (OPA) of 1990 and participates in the Interagency Coordinating Committee for Oil Pollution Research. The OSRRP receives its funding through the OPA.

The OSRRP research objectives are to:

- Develop oil spill detection technologies and improve the efficiency and effectiveness of response and cleanup equipment to handle oil spills at sea;
- Improve the ability of response organizations to burn oil in situ;
- Increase our knowledge of the properties and behavior of oil spilled at sea;
- Develop new and innovative shoreline cleanup strategies;
- Continue operation and maintenance of Ohmsett, the National Oil Spill Response Test Facility.

Through MMS funding, scientists and engineers from the public and private sectors worldwide are working to address gaps in information and develop technology for cleaning up oil spills. This, in turn, will reduce the impact and environmental damage caused by oil spills. Promising results have been obtained in many areas, such as burning of spilled oil, mechanical containment/cleanup devices and techniques, understanding the behavior of spilled oil, airborne and satellite remote sensing of oil spills, and evaluating oil spill chemical treating agents such as dispersants.

In-Situ Burning. Research results from the meso-scale burns in Mobile, Alabama (1991–1994), the Newfoundland Offshore Burn Experiment, and more recently, the Alaska Clean Seas, Emulsion Burn Experiments, indicate that burning is a rapid, effective and environmentally safe means for removing large quantities of oil from

the surface of the water. In public and government forums, burning has become accepted as a first response method. However, questions remain about the effects of in-situ burning on both water and air quality. In addition, improvements are needed in equipment to conduct in-situ burns, such as durable fire-resistant booms, as well as research to extend the "window of opportunity" for use of in-situ burning as oil weathers and emulsifies. The following research projects address public and technical concerns about in-situ burning through experiments in the laboratory, in meso-scale tests and in full-scale tests at sea.

A recent project called Meso-Scale In-Situ Burn Testing of Alaskan Crude Oils studied the ignition and burning characteristics of five Alaskan oils during Phases 1 and 2. Phase 3 involved approximately 54 meso-scale (7-ft-diameter) burns with fresh, weathered and emulsified Alaska North Slope and Milne Point crude oils in 6- to 12-in.-high waves at the ARCO Fire Training Ground wave tank at Prudhoe Bay. The tests, conducted in August and September 1997, provided the information necessary to design appropriate large-scale tests offshore. Future large-scale tests will assess the capabilities and limitations of using emulsion breakers to extend the window of opportunity for in-situ burning operations.

The U.S. National Institute of Standards and Technology (NIST) ALOFT (A Large Outdoor Fire Plume Trajectory) model is widely recognized as a tool for computing and displaying smoke plume trajectories from in-situ burning. In the event of a burn, responders can rapidly access ALOFT predictions and other in-situ burning data to predict the trajectory and concentrations of soot and other combustion products. The ALOFT model of smoke transport is capable of predicting time-averaged downwind concentrations of particulate matter from a large fire. Model assumptions include a uniform ambient wind blowing over relatively flat terrain. The model has been expanded to include the effect of varying wind velocity with altitude and the ability to calculate smoke plume concentrations as a function of time. The model has also been expanded to calculate the soot production from multiple smoke plumes over flat terrain.

Two model versions now exist: ALOFT-FT for flat terrain and ALOFT-CT for complex terrain (mountainous regions, for example). Both the flat terrain and three-dimensional complex terrain versions are operational on work stations, and both versions can accommodate multiple fire sources. Development work on the computational portions of the models has been completed. ALOFT-FT for personal computers has undergone two rounds of beta testing. Based on input from users, several significant new features have been added, including multiple fire sources, a fuel properties database that can be modified by the user, optional user-specified emission factors, and the ability to specify different wind fluctuations over water and land. This version is being prepared for general distribution to the response community.

Work will continue on installing the ALOFT-FT and ALOFT-CT versions of the model on personal computers on a routine basis. In this next phase, NIST will add a three-dimensional graphical animation of a smoke plume to the flat terrain model to aid in visualizing the model output. In addition, a beta version of the ALOFT-CT model for personal computers will be developed. ALOFT-CT requires input data on the terrain and a wind field and requires substantially greater execution time than ALOFT-FT. ALOFT-FT is adequate in most areas except where smoke is expected to move into mountainous terrain. Large mountains, such as those found along the coast of Alaska, can have a substantial impact on the smoke plume trajectory and require ALOFT-CT.

In a study of fire-resistant booms, six commercially available offshore fire booms produced by five manufacturers were tested at Ohmsett between July and October 1996. The objectives of this first phase of the tests were to examine the sea-keeping and oil-containing ability of the booms. The booms were tested to determine first-loss tow speed, oil loss rate, critical tow speed and wave conformance. No burning performance was measured during these tests. Four of the booms performed within speed and oil loss rates that have been measured for regular commercial booms. One boom was found to be superior in wave conformance and critical tow speed, but this boom was at the lower part of the range for first-loss tow speed. A prototype boom with a unique paddle-wheel operating system was found in need of further development.

Phase 2 evaluated five of the booms tested in Phase 1 for thermal stress and mechanical performance when exposed to a liquid-fuel fire in waves. The Phase 2 test series was conducted in September and October 1997 at the U.S. Coast Guard Fire and Safety Test Detachment in Mobile, Alabama. The test pan is 100 feet long by 30 feet wide by 5 feet deep and contains a wave maker and an artificial beach. These tests were conducted using a test plan developed from the ASTM *F-20*

Draft Standard Guide for In Situ Burning of Oil Spills On Water: Fire Resistant Containment Boom. The fire was burning diesel fuel floating on water. These experiments provided additional data on the heat flux to the boom from a liquid-fuel fire.

Another project involves redesigning an existing large stainless steel boom to reduce its size, weight and cost. The stainless steel boom was first designed, constructed and tested in the early 1980s. It was built to survive for extended periods in steep Arctic waves, carry high loads, withstand impacts from ice, and operate in flames for long periods. Because of the rigorous performance criteria in the original design, the boom is expensive, heavy and cumbersome to deploy manually. This project will be completed in four phases:

- Redesigning the existing stainless steel boom to reduce cost, size, weight and handling problems and to make it compatible with existing fire boom systems;
- Constructing a 15-m (50-ft) prototype section of redesigned boom for testing purposes;
- Testing the boom with and without fire at appropriate testing facilities; and
- Refining the design of the boom and producing detailed engineering drawings.

A recent literature review on soot production during in-situ burning of oil attempted to determine the range of soot yield generated by in-situ burning of petroleum oils on water, and the effects of the size of the fire and the type of fuel used. The natural variability of fires and the difficulty in measuring soot yield precludes highly accurate, repeatable measurements. However, very general conclusions can be drawn from the data. It appears that the soot yield from in-situ petroleum fires range from approximately 1 to 10% for fires less than 10 cm in diameter; 5 to 15% for fires in the 10- to 100-cm range; and 10 to 25% for fires greater than 1 m.

Remote Sensing/Surveillance. A project to develop a scanning laser environmental airborne fluorosensor (SLEAF) has the following objectives:

- Develop laser fluorosensing technology for detecting oil on water, shorelines, debris, ice or weeds;
- Develop and test prototype instruments; and
- Develop a new-generation instrument that provides scanning capability.

The SLEAF development is nearing completion, with delivery and aircraft installation set for February 1998. The SLEAF system will employ a state-of-the-art laser optimized for fast deployment and the detection of oil contamination on shorelines, land, snow and ice and at sea. It will have an adjustable scanning capability that will allow for selection of the optimum swath to respond to various spill conditions. This capability will maximize coverage on shorelines, broken ice conditions on water, and other complicated surfaces.

The SLEAF has been designed to provide a real-time annotated map. This geo-referenced map will be faxed or otherwise transmitted to oil spill response personnel. The timely information provided by the SLEAF sensor will help mitigate the harmful effects of an oil spill by ensuring a fast and effective response. The SLEAF will detect and classify oil in real time. Geo-referenced oil contamination locations will be easily visible on the hard-copy map output. Once the SLEAF has been installed in Environment Canada's aircraft, it will undergo a period of flight testing to verify the proper operation of the system under airborne conditions and ensure that the system complies with all design specifications.

Physical Behavior of Oil. The objective of these projects is to improve our understanding of the behavior and fate of spilled oil and to develop models to predict oil behavior. They also include measuring the physical and chemical properties of oils and including the results in a database. Elements to be addressed include oil weathering, evaporation, water-in-oil emulsification, dispersion, dissolution and photo-oxidation.

A catalog of oil properties was first compiled by Environment Canada (EC) in 1984. The MMS has jointly funded the catalog program since 1989. The catalog was started to provide a single reference on the physical and chemical data relevant to oil spills. The current edition (December 1996) of the catalog contains information on over 380 types of crude oils and petroleum products, including many Outer Continental Shelf (OCS) crude oils. The catalog is available in electronic format and has been distributed to all MMS OCS regions and other Federal agencies. The data are also available on a public bulletin board maintained by EC as well as online at the EC home page.

The catalog contains many new items such as adhesion measurements, evaporation equations, a new form of distillation data, BTEX and C3 analysis. It is now possible to obtain over 800 pieces of information for each oil. A new report format has been created that is more attractive and easier to use. EC is currently negotiating with Elsevier regarding printing of the December 1996 edition. This year the main catalog will include some new oils, and the project will continue measuring properties of oils and petroleum products for future updates

to the catalog. In addition, a "mini-catalog" was prepared for the Gulf of Mexico crude oils, and a similar document will be prepared relating to oils imported into the Pacific coast.

The Behavior of Oil Spills (BOSS) project is designed to provide a comprehensive review of information concerning the behavior of spilled oil. The emphasis is on the behavior of oil spilled at sea but will also include information on oil spilled on land, in fresh water and in the ground. The final report will combine the literature on oil spill behavior and findings from previous jointly funded research projects with MMS. Over 5500 papers have been collected and initially reviewed to date. This project will result in a series of volumes combining the review of the literature with data tables and unpublished results. The oil-in-ice review has been completed. Work is continuing on the sections on solubility, evaporation and emulsification.

The current *Basics of Oil Spill Cleanup* manual was published in 1983 by EC and is in the process of being updated. The manual explains what happens to oil when it is accidentally spilled on water or land and the specific cleanup strategies that are possible under varying environmental conditions. The draft chapters of the updated manual are undergoing final review. Over 200 high-quality photographs have been collected and the line graphics are complete. Negotiations with Lewis Publishers to publish the manual have taken place.

Shoreline Cleanup. The Svalbard Shoreline Project is part of a series of studies to better understand the behavior of oil on shorelines and determine the most appropriate response options. Shoreline cleanup operations following a spill in a remote area are limited by the constraints of available equipment and personnel and by the desire to minimize waste materials that require transport and disposal. In such cases the preferred option is to treat the oil on site so that natural environmental recovery is accelerated without a labor-intensive effort. The Svalbard Shoreline Project, along with the related Oil and Fines Interaction Basin Project, will investigate the effectiveness of traditional shoreline cleanup techniques as well as the natural processes that remove oil from shorelines. Special emphasis will be placed on oil and fine particle interaction.

The Svalbard Shoreline Project is evaluating the cleanup techniques of surf washing, tilling, and tilling combined with bioremediation at an experimentally oiled shoreline. These techniques have been used frequently, but only qualitative data are available on the relative efficiencies of the various techniques. To date, only post-spill studies have been conducted, while these projects will evaluate cleanup techniques with basin-scale and field-scale trials on experimentally oiled sites after pre-oiling conditions at the beaches have been studied.

In July and August 1997 near Sveagruva, Svalbard, Norway, experimental plots were established for cleanup operations at three sites along a continuously oiled stretch of shoreline. A total of about 6000 L of oil was applied along a 3-m-wide swath in the upper intertidal zone of the shoreline. Early results indicate that the surf washing technique was effective, with obvious removal of oil. Also encouraging was the use of fertilizers, in both slow release and soluble forms. The nutrients stimulated microbial activity and may enhance the effectiveness of mechanical removal techniques.

The University of New Hampshire is in the second year of an effort to develop fast-current oil barriers having substantially better performance characteristics than the standard, single-vertical-barrier oil boom. These improvements include increased tow speeds and more effective oil retention in the new boom design. First-year work resulted in the two-dimensional submerged plane concept that was tested in a laboratory flume using oils with a wide range of properties. Second-year accomplishments include the design, construction and testing of flexible, three-dimensional submerged plane systems that improved on the first cross-sectional design. The goal is to fabricate one or more prototypes for full-scale testing.

In addition to further developing the submerged plane technology in a new boom design, there is a companion effort at the University of Rhode Island to develop a computer model that evaluates and predicts the causes of boom failure and oil loss. The computer model now operates in only two dimensions. The model will be validated at the Ohmsett facility by comparing its predictions with actual boom performance under controlled conditions. Eventually this model may be used to evaluate and suggest improvements to boom designs.

The fast-current boom prototype will be tested by JPS/Oiltrol, a manufacturer of oil spill response equipment. Field testing will include participation in harbor response exercises conducted by the Piscataqua River Cooperative, which is a consortium of four petroleum product terminals on the fast-moving, tidally influenced Piscataqua River in New Hampshire. Final product evaluations will be conducted at Ohmsett. If the tests are successful, JPS/Oiltrol intends to make the fast-current boom into a commercially viable product.

Ohmsett. The national oil spill response test facility known as Ohmsett is located in Leonardo, New Jersey, on the grounds of Naval Weapons Station Earle. Ohmsett is the only facility in the world where clients can test and evaluate full-scale oil spill response equipment with a variety of crude oils and refined petroleum products. Equipment tests are conducted under controlled, reproducible conditions, and the Ohmsett test tank has a variable artificial wave maker. Ohmsett is also a unique facility to do research and development on new devices and techniques to detect, map, contain and clean up oil spills.

The Environmental Protection Agency built Ohmsett in 1973 and operated it until 1988, when MMS assumed management responsibility. MMS directed its refurbishment between 1990 and 1992 at a cost of over $1.5 million, extending the life of the facility by an estimated 15–20 years.

The primary feature of the facility is a pile-supported, concrete tank with a water surface 203 m long by 20 m wide with a water depth of 2.4 m. The tank is filled with 9.84 million liters of brackish water from nearby Sandy Hook Bay. The tank has a movable, cable-drawn towing bridge capable of towing floating test equipment at graduated speeds up to 3.3 m/s for at least 40 s. The towing bridge is equipped to lay oil on the surface of the water several meters ahead of the equipment being tested, so that reproducible thicknesses and widths of test oils are achievable with minimal wind interference. The principal operating systems of the tank include a wave generator, a beach and a filter system. The wave generator and absorber beach have the capability to produce regular waves up to 0.6 m high and up to 45 m long, as well as a series of 0.7-m-high reflected waves.

Because of improved marketing efforts, the usage of Ohmsett has increased dramatically, from a total of only 32 days of testing at Ohmsett in FY 93 out a possible maximum of 150 test days per year to 114 test days in FY 96. The client base has increased to include academic research organizations and commercial firms in addition to the traditional U.S. and Canadian government agencies. Even with a major program of maintenance, refurbishment and upgrades to Ohmsett over the winter of 1997, which delayed the start of testing until June, there were still over 100 test days in FY 97. In addition to testing and equipment development, FY 97 saw Ohmsett being used as a “hands on” training facility for the first time by the U.S. Navy and the U.S. Coast Guard.

Alaska Environmental Studies Program

As the managing agency for the OCS leasing program in Alaska, the MMS Alaska Outer Continental Shelf (OCS) Region has conducted environmental studies to obtain information needed to make sound leasing decisions and to monitor the human, marine and coastal environments. In Alaska more than $250 million has been spent on studies in 15 OCS planning areas in the Arctic, Bering Sea and Gulf of Alaska subregions. These studies cover a range of disciplines such as endangered species, living resources, fate and effects, and socioeconomics.

Regional government leaders, traditional knowledge sources, environmental groups, oil and fishing industry personnel, studies contractors and other scientists, and Federal, state and local agencies help the MMS to identify environmental issues and information needs. Information transfer meetings and workshops are convened to bring together information from these key sources. The overlap of shared knowledge results in a synthesis of information that identifies studies needed to meet the current focus on postlease and monitoring information requirements.

In 1993 the MMS established a Coastal Marine Institute (CMI) at the University of Alaska Fairbanks (UAF) to take advantage of environmental scientific expertise at local levels. Under a recently extended cooperative agreement, the MMS committed $1 million per year for studies to be conducted by the CMI if matching state funds were available. The institute conducts research focused on environmental, social and economic studies relevant to both Federal and state offshore oil and gas and mineral resource management issues. The UAF School of Fisheries and Ocean Science, nationally renowned for its coastal/marine expertise, manages the CMI. The institute creates an opportunity for the MMS and the state to accomplish research programs that could not otherwise be carried out.

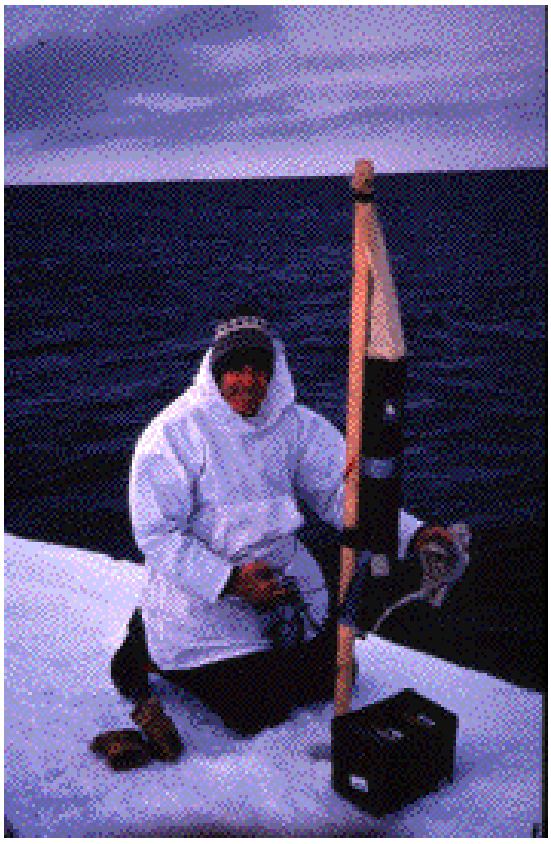
Endangered Species

The bowhead whale, an endangered marine mammal of high importance to Native cultures in the Arctic, migrates through areas in which oil and gas have been discovered. Efforts to define the migration corridors of bowhead whales and their responses to offshore operations continued through 1997 under the ongoing in-house Bowhead Whale Aerial Survey Project (BWASP). Annual reports of

the fall bowhead migration are available through fall 1996.

The BWASP provides real-time data on each fall migration of bowhead whales across the Alaskan Beaufort Sea for implementing overall limitations on seasonal drilling and geological/geophysical exploration. The fall 1996 report showed that the cumulative median water depth at which whales were observed is 37 m, with a high level of significance between the 1983 median water depth (347 m) and the median value for other years (1982–1996). There also was a high level of significance between the 1989 median value (18 m) and the median values for other years. Between-year differences in the median water depth at which whales were spotted appear to be correlated to the general severity of sea ice during the fall migration. During the fall 1997 survey, observers spotted record numbers of bowheads feeding near shore in the Beaufort Sea.

A recently completed study, Effects of Production Activities on Arctic Whales, documented the effects of underwater noise on bowhead whales. Experimental playbacks of operational sounds caused statistically significant alterations in the migration paths of individual whales, but the overall biological significance was considered to be negligible. Under an ongoing extension of this study, the researcher is drafting nine journal articles about the main conclusions of this multi-year study.



Scientist deploying a hydrophone to study the effects of production noise on marine mammals.

A recently awarded multi-year study called Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information will augment scientific and traditional knowledge about bowhead whale feeding in the eastern Alaskan Beaufort Sea. The researcher will coordinate with area whale hunters and other key stakeholders to develop hypotheses that scientists and subsistence hunters concur can be scientifically tested. Based on these hypotheses and a summary of available scientific and traditional information, the researcher will design and propose appropriate research options for determining the importance of the area to feeding bowheads, characterizing the ambient acoustic environment in the study area, and predicting sound levels of oil and gas industry activity received by feeding whales.

The 1997 MMS-sponsored Arctic Seismic Synthesis and Mitigating Measures Workshop provided subsistence whaling captains and representatives from the MMS, other agencies and industry with opportunities to discuss their concerns about the effects of offshore seismic operations on bowhead whales. Recommendations for improved communications, technological improvements and research needs were identified. The main conclusions and recommendations have been incorporated into National Environmental Protection Act (NEPA) analyses and planning documents.

Living Resources

An ongoing international cooperative study called the Beluga Satellite Tagging Project involves the coordinated efforts of the MMS, the Canadian Fisheries Joint Management Committee (Inuvik, NWT), the United Kingdom Sea Mammal Research Unit, and Inuvialuit hunters to capture and track the fall migration of beluga whales through Alaskan Beaufort Sea OCS areas. Satellite tags were placed on the belugas in the summer of 1997 by capture teams from the Canadian Beaufort Sea villages of Inuvik, Aklavik and Tuktoyaktuk. The teams relied on their local traditional knowledge to identify the best shallow-water capture sites in Canadian Beaufort estuaries and the latest time window for capture prior to the fall migration. Satellite-linked time/depth recorders and transmitter tags obtained detailed information on beluga migration routes through oil and gas

lease areas in the Beaufort Sea to determine detailed beluga migration routes to overwintering areas of concentration, population estimates based on aerial surveys, and habitat preferences as they relate to sea ice and continental shelf geomorphology.

A nearly completed CMI study called Testing Conceptual Models of Marine Mammal Trophic Dynamics Using Carbon and Nitrogen Stable Isotope Ratios found that there may be a split in trophic status between populations of Steller sea lions. Harbor seals also have moved upwards by approximately half a trophic level. This finding is not incompatible with observed regime shifts in fisheries from an ecosystem dominated by crab, capelin, herring and shrimp to one dominated in recent years by pollock and flatfish. The study also produced ocean maps of carbon and nitrogen isotope ratios in zooplankton taxa that are key to the support of commercially and ecologically important top consumers. The database for the maps is large enough to confidently assess year-to-year and geographic differences in productivity regimes.

A nearly completed project with the U.S. Fish and Wildlife Service has found that sea otters between Cape Hinchinbrook and Cape Spencer in the Gulf of Alaska have increased in abundance and expanded in range since the last survey of the area in 1987.

The MMS initiated a study in 1997 that is investigating linkages between forage fish and their physical and biological environment in lower Cook Inlet and Shelikof Strait. The study is exploring the status of forage fishes by multi-year sampling to determine their relative biomass, nutritional status and exposure to organic contaminants. The first sampling, conducted in the Tuxedni Bay/Chisik Island area of Cook Inlet in August 1997, netted large numbers of Pacific herring, several species of smelt, Dolly Varden char, Pacific tomcod, many shrimp juveniles, mysids, many euphausids and other fish species. The forage fish are currently undergoing analyses of proximate composition, stomach contents and cytochrome P450. The resulting data will provide a basis for decisions regarding mitigations and for future damage assessment, if necessary. This study will provide useful information for exploration monitoring and postlease environmental assessments for historical, current and future offshore operations in lower Cook Inlet.

Defining Habitats for Juvenile Flatfishes in South Central Alaska is a multi-year CMI study that is examining seasonal changes in the abundance and distribution of juvenile flatfishes by identifying and quantifying species-specific habitat preferences for the most abundant flatfish species in southcentral Alaska. The study identifies biologically sensitive areas and is critical to understanding the linkages between physical and ecological processes in the Gulf of Alaska and Cook Inlet for use in analyzing potential oil and gas leasing activities. Among the preliminary findings of this ongoing study are that:

- In Kodiak Island bays, Kachemak Bay and Izhut Bay, rock sole and either flathead sole or Pacific halibut are the dominant species in August;
- Depth and sediment are key factors for defining Age-0 rock sole, Age-1 yellowfin sole, Age-0 flathead sole and Age-0 Pacific halibut distribution; and
- Kodiak Island bays, Izhut Bay and Kachemak Bay have similar distributions of rock sole based on depth and sediment in August; flathead sole in Chiniak and Kachemak Bays also have similar summer distributions.

The sampled fish stomachs from this habitat study will be used in another CMI study funded in 1997: The Relationship of Diet to Habitat Preferences of Juvenile Flatfishes in Kachemak Bay, Alaska. A subsample of 80 juvenile flathead sole stomachs will be examined to determine fish diets indexed by prey biomass. In Phase 1 of two phases the researcher will determine what hypotheses are testable, what power the statistical analysis will have, and what sample size will be necessary to bring the power of the statistical tests to the appropriate level prior to the Phase 2 analysis of more than 1500 flathead and rock sole stomachs.

A recently completed CMI fish study, North Slope Amphidromy Assessment, concluded that stable isotopes are effective indicators of fish feeding habits and life history patterns.

Fate and Effects

In the first of two modeling studies begun in 1997, Sintef Applied Chemistry of Trondheim, Norway, will re-evaluate the oil-weathering model currently used by the MMS Gulf of Mexico and Alaska OCS Regions. The model shows how a specific oil would weather after a spill as a function of physical conditions and oil characteristics, and it calculates a mass balance, how much oil evaporates, how much disperses into the water, and how much remains in the slick. The study will evaluate the weaknesses and strengths of the OCS Oil Weathering Model and recommend improved or alternative algorithms.

In the second modeling study the University of Alaska's Institute of Marine Science (IMS) is examining the differences in wind field representations from two meteorological models—one used by the European Center for Medium Weather Range Forecasting, the other by the U.S. Navy Fleet Numerical Oceanography Center. The study also examines how differences in the two models affect modeled oceanographic circulation in two-dimensional and three-dimensional baroclinic shelf-circulation models.

The MMS also initiated studies of sediment quality in the Gulf of Alaska and the Beaufort Sea. Scientists from A.D. Little, Inc., are conducting the sediment-quality study of depositional areas in lower Cook Inlet and Shelikof Strait. During the summer of 1997, bottomfish, surface sediments and sediment cores were collected for chemical analyses (petroleum hydrocarbons and trace metals) and source fingerprinting, toxicity bioassays and biomarker analyses. Also during the summer of 1997 the IMS collected surface sediment samples and sediment cores in the nearshore Beaufort Sea between the Colville River and Barter Island for petroleum hydrocarbon and trace metal analyses.

In addition, a final report on the adsorption of aromatic hydrocarbons by marine sediments was completed by scientists at the UAF Institute of Arctic Biology. This study examined adsorption and desorption of benzene, naphthalene and phenanthrene on and from Cook Inlet sediments.

Socioeconomics

Several new social and economic studies were initiated in 1997. Economic and Social Effects of Diminishing Oil and Gas Industry Activity on Alaskan Communities will document the expansion, decline and recovery of the Alaska economy in the 1975–1995 period, which was driven largely by oil sector activity. This study will document fluctuations in state oil and local government revenues with related effects on local governments and economies, oil company support of community institutions with related effects on those institutions, and employment associated with (and not associated with) fluctuations in the oil industry with related effects on individuals and households. Based on this analysis of economic history, the researcher will formulate options that the MMS and relevant public bodies can implement to mitigate the effects of similar economic fluctuations.

A CMI study, An Economic Assessment of the Marine Sport Fisheries in Lower Cook Inlet, will collect data from sportfishing-guide outfitters and related businesses and from their clients. These data will be used to:

- Update IMPLAN (an economic model) input/output coefficients;
- Hold focus group meetings in Kenai Peninsula communities;
- Ground-truth the Kenai Peninsula component of the IMPLAN model and database;
- Extract information from IMPLAN for use in the Fisheries Economic Assessment model;
- Analyze effects; and
- Evaluate scenarios.

The *Exxon Valdez* oil spill is likely the world's most studied spill; in addition to published reports, there is an enormous amount of "grey literature." *Exxon Valdez* Oil Spill Cleanup and Litigation: A Collection of Social-Impact Information and Analysis will collect, organize and synthesize all the information about the oil spill, cleanup and associated litigation. It also will identify key social factors for analyzing this information to determine related effects on the human environment in local communities. Examples of social factors are social organization, cultural values, social health, access to subsistence resources, subsistence hunting and use of subsistence resources. The major product will be a CD-ROM containing an annotated bibliography with abstracts, key social factors and analytical findings.

Traditional knowledge is information possessed primarily by Native American residents and gained from experience in living on the land and water. The Inupiat of the Alaskan North Slope have lived in the Arctic for countless generations and have much knowledge of the biological and physical environment of both the marine and terrestrial ecosystems. However, because most of this knowledge, which has adapted to changes in technology and social/economic conditions, has been passed on orally from one generation to the next, little of it is in published form and even less is indexed. Some traditional knowledge has been written down, recorded, archived and, in some cases, published, but because this knowledge has not been indexed, it is often not available to Western scientists. MMS has initiated an effort that will collect, catalogue and organize appropriate information identified by Inupiat community elders, North Slope Borough subsistence coordinators, Inupiaq Language and Cultural Center personnel, and members of the North Slope Scientific Committee. The information will be attributed, abstracted, key-worded and geographically refer-

enced in a database. The resulting information will be indexed and abstracted on a CD-ROM, and copies will be provided to Alaskan Native communities and Federal, state and local government agencies involved in environmental research and assessment.

Information Transfer

The MMS organized a major Information Transfer Meeting during 1997. When industry announced a nearby oil discovery, the Federal and state governments proposed to re-offer portions of the National Petroleum Reserve–Alaska (NPRA) for exploration. Recently the Alaska staffs of the Bureau of Land Management and the MMS were requested to jointly prepare an environmental assessment of the NPRA. In order to quickly prepare NEPA documents with high-quality science, a 1997 NPRA Symposium was coordinated by the Alaska OCS Region. The symposium, attended by over 100 people, effectively demonstrated the large quantity of new environmental, social and cultural information that has been collected since the last leasing and exploration of the NPRA in the mid-1980s.

Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) conducts research, including inventories and monitoring, in the Arctic to generate information that will help meet its resource management responsibilities. These responsibilities include conservation of migratory birds, certain marine mammals, endangered species, anadromous fishes and all biota inhabiting national wildlife refuges and other FWS lands.

In November 1993, FWS research programs were transferred to the National Biological Survey (NBS), a new bureau that was formed by combining the biological research functions of a number of Interior Department bureaus. In 1996, NBS was reorganized as the Biological Resources Division under the U.S. Geological Survey. The FWS continues to conduct inventory and monitoring programs of biota in the Arctic at both the national and international levels.

Migratory Birds

The FWS in Alaska is responsible for a variety of population monitoring and research efforts in both the Waterfowl Management and Nongame Branches. The Waterfowl Management Branch is primarily responsible for long-term monitoring of waterfowl populations. As a result, activities were virtually identical for 1996 and 1997. Activities in northern Alaska included aerial population monitoring surveys of threatened spectacled and Steller's eiders, an annual survey of breeding waterfowl, and continued monitoring of molting goose populations in the vicinity of Teshekpuk Lake, one of the world's largest known goose molting areas. Activities in interior Alaska included aerial surveys of breeding waterfowl, banding of mid-continent populations of greater white-fronted geese, dabbling duck banding in support of Pacific flyway objectives, trumpeter swan productivity surveys, and trumpeter swan egg collection in support of the continental restoration program. Western Alaska/Bering Sea activities included breeding population and nesting surveys of three species of geese with diminished populations, waterfowl breeding population surveys, Bering Sea winter spectacled eider surveys, emperor goose productivity and spring population surveys, spring staging Steller's eider population surveys, banding of cackling Canada geese in support of Pacific flyway objectives, radio-tracking flights of king eiders in support of an Ecological Services project, and an aerial inventory of the extensive 1997 die-off of marine birds washing up on the shores of Bristol Bay and the Alaska Peninsula. In south-central Alaska and Prince William Sound areas, the Waterfowl Management Branch conducted aerial surveys of Copper River Delta nesting trumpeter swans and breeding bald eagles in the Susitna Valley, cooperative surveys of waterfowl use of a phosphorus-contaminated military firing range, a dusky Canada goose breeding pairs survey, and an aerial survey of waterbirds in Seward Bay in support of an Ecological Services office. Southeast Alaska activities included an aerial survey of wintering waterbirds (1997 only), a Chilkat Valley trumpeter swan survey, and a summer waterbird survey of 20% of southeast Alaska.

Snow geese flying over the coastal plain of the Arctic National Wildlife Refuge in northern Alaska, with the Brooks mountain range in the background.

The Nongame Branch of Migratory Bird Management (MBM) continued to investigate the recovery of species negatively affected by the *Exxon Valdez* oil spill. MBM continued biannual surveys to monitor population trends of marine birds in Prince William Sound. Other projects were focused on the interactions of seabird predators and their forage fish in Prince William Sound: seabird surveys concurrent with hydroacoustic fish sampling, reproductive biology and foraging ecology of black-legged kittiwakes, and breeding and feeding ecology of pigeon guillemots. The abundance, productivity index and prey selection of marbled murrelets were also investigated in the Sound. MBM conducted surveys of seabirds on Saint Lawrence Island, in cooperation with the villages of Gambel and Savoonga, and continued surveys of seabird colonies in Prince William Sound and on Kodiak Island.

Biologists with MBM conducted surveys on the Yakutat Forelands to assess their importance to migrating shorebirds during the springs of 1996 and 1997. Other landbird and shorebird survey projects included breeding bird inventories of Alaska Army National Guard Training Areas and a breeding bird atlas of the Fort Richardson Army base. A major effort was undertaken to assess bird habitat along Breeding Bird Survey routes in Alaska. MBM continued a fall migration banding station for passerines at Yakutat and collected information on weather patterns and habitat use. Biologists also conducted breeding bird surveys and measured vegetation features on Research Natural Areas on the Tongass National Forest.

Marine Mammals

The FWS in Alaska is responsible for managing three species of marine mammals: polar bears, Pacific walruses and northern sea otters. Of these three species, polar bears and walruses are characteristic of Arctic regions. Populations of both species are shared with Russia, and polar bear populations are also shared with Canada. A major focus of research on these populations relates to international actions that are necessary to conserve populations. The issue of harvest is important because both species have been subject to legal or subsistence harvest or both, and research seeks to develop methods of defining and monitoring populations so that local or region-wide populations will not become depleted. Another issue addressed by research is the identification of important habitat areas and the potential impact of human activities on areas that may be essential for the stability of populations.

Polar Bears

The Polar Bear Specialist Group (PBSG) was established in 1968 in response to concern for overharvest of polar bears. The PBSG comprises scientists and resource managers from the five Arctic nations that manage polar bears. A major function of the PBSG is to oversee research and management activities to ensure their consistency with the 1973 international Agreement on the Conservation of Polar Bears, signed by all five nations. Between 1989 and 1993 the FWS participated in a study coordinated through the PBSG that was designed to determine the levels of chlorinated hydrocarbons in polar bears from eastern Russia, North America, Greenland and Svalbard, Norway. Findings were finalized in 1996 and have been submitted for publication. Knowledge of the distribution and trends in concentrations of organochlorine contaminants is important in determining the effects on all components of the Arctic ecosystem.

In 1996 and 1997 the FWS continued to collect information regarding polar bears harvested by Native hunters in coastal villages for subsistence purposes. The majority of polar bears are killed during the winter, when advancing pack ice brings bears into contact with coastal Alaska Natives. Harvest numbers are therefore reported on a harvest year basis, which runs from July 1 through June 30. The Alaska harvests during the 1995-96 and 1996-97 harvest years totaled 43 and 86 bears,

Female polar bear with cubs on pack ice in the spring near Prudhoe Bay, Alaska.

respectively. The recent harvest trend continues to be approximately 33% below the long-term average.

Tissue specimens (skull muscle, kidney, liver and skin) were also collected to assess the accuracy of sex reported for polar bears harvested during subsistence activities. Samples from harvested animals were collected by FWS biologists and Alaska Native taggers between 1985 and 1995 and submitted for genetic analysis. Specimens were collected from polar bears of the southern Beaufort Sea population and from the Chukchi–Bering Seas population. The results indicate that some misidentification of sex and age does occur in the field. Findings from this study are in preparation for publication.

In 1996 the FWS, in cooperation with the Alaska Nanuuq Commission and the National Fish and Wildlife Foundation, initiated a polar bear contaminant sampling program. Polar bears are ideally suited for monitoring the level and distribution of heavy metal and organochlorine levels in the Arctic ecosystem because of their position at the top of the Arctic marine food chain and their wide distribution. Alaska Native hunters and taggers were trained in the collection of biological specimens from male polar bears harvested for subsistence purposes. Samples from polar bear liver, kidney, fat and muscle tissue are analyzed for heavy metal and organochlorine concentrations. To date, tissue samples from 12 bears have been collected and submitted for analysis. Collection activities will continue until 60 samples are received.

The Incidental Take Program is another ongoing monitoring effort in Alaska. The purpose of the program is to monitor the activities of industrial development in polar bear habitat and help minimize impacts to polar bears, their habitat and their availability for subsistence use. As part of the incidental take regulations, the FWS was tasked with developing a Habitat Conservation Strategy for Polar Bears in Alaska. Completed in 1995, the strategy identified important habitat areas for polar bears; threats to polar bears and their habitat; land ownership, treaties, laws and agreements that affect habitat management; options for conserving habitat; and research needs. In August 1997 the FWS completed the report *Collection of Local Knowledge Regarding Polar Bear Habitat Use in Alaska*. This report summarizes information collected during the development of the strategy from Alaska Native polar bear hunters regarding areas used by polar bears for denning, feeding and seasonal movements. A database of den locations was developed that includes all known locations of dens based on traditional knowledge, radiotelemetry and other anecdotal sources of information. This information is used for land use planning activities with the oil and gas industry and other ongoing activities in the Arctic. Local knowledge of polar bear use of coastal beaches and barrier islands alerted scientists to the importance of marine mammal carcasses as a food source for polar bears. Marine mammal carcasses represent tons of potential food for polar bears and may be particularly important for the survival of females with cubs and younger bears during the fall. To document the distribution and abundance of marine mammal carcasses, aerial surveys were conducted in 1995–1997 along the Alaska coast from Nome to the Canadian border. A summary report is in preparation.

Walruses

In 1996 and 1997 the FWS, in cooperation with the Eskimo Walrus Commission, continued to monitor the spring subsistence harvest of walruses in the Native villages of Gambell, Savoonga, Diomede and Wales. FWS technicians and village residents worked together to collect information on the size and demographics of the spring harvest by conducting hunter interviews and obtaining biological samples. This information is used to assess the size and composition of the harvest and to study aspects of walrus population dynamics and life history.

In 1996 and 1997 the FWS, the Alaska Department of Fish and Game and the Bristol Bay Native Association teamed up to monitor walrus numbers

For more information on FWS marine mammal research, please contact David McGillivary at (907) 786-3800.

and human disturbances at terrestrial walrus haulouts in Bristol Bay. Each summer, thousands of male walruses migrate to Bristol Bay to rest, molt and replenish body reserves lost during the breeding season. Bristol Bay, Alaska, represents critical habitat for the largest aggregation of Pacific walruses in North America. Daily count data collected by haulout monitors have been incorporated into a database to monitor trends in walrus numbers and habitat use patterns within Bristol Bay. Monitors also participated in a study to identify the effects of anthropogenic disturbances on haulout use and collaborated with Native hunters in the development and implementation of a harvest monitoring and biosampling program centered on a subsistence walrus hunt at Round Island.

Between 1975 and 1990 information on the size of the Pacific walrus population was collected through a series of aerial surveys conducted jointly by the U.S. and Russia. The last aerial survey flown in 1990 produced a population estimate of approximately 200,000 animals. Range-wide surveys were suspended in 1995 because of budgetary constraints. Although there are no immediate plans to conduct another survey, future cooperative work to evaluate the size and trend of the Pacific walrus population is considered a high priority by both nations. In 1996 and 1997 the FWS began investigating the feasibility of using satellite imagery to count walruses. This technology may prove to be cheaper and safer than flying aerial surveys.

Fisheries

FWS fishery research in the Arctic focuses on Yukon River salmon, an anadromous resource shared by the U.S. and Canada. Allocation of the harvest has been an international issue. Research objectives by the FWS have been to use state-of-the-art enumeration techniques to quantify salmon abundance and monitor resource health and to employ genetic stock identification (GSI) techniques to quantify genetic diversity and determine what portions of harvested populations are of U.S. and Canadian origin. The Alaska Region of the FWS has participated in U.S.–Canada Yukon River Treaty negotiations under the Pacific Salmon Treaty and has been instrumental in providing technical guidance in support of the international negotiations. As part of that effort the Fairbanks Fishery Resource Office, in cooperation with the National Marine Fisheries Service, is conducting a combined mark–recapture (mass marking) and radiotelemetry study on fall chum salmon to provide fishery managers with information on total and stock-specific abundance, stock composition, run timing and locations of undocumented spawning areas in the upper Yukon Basin. Some Yukon River fall chum salmon travel more than 3500 km before spawning, the longest freshwater salmon spawning migration in the world. Fishwheels operated in the mainstem Yukon River, upstream of the Tanana River, are used to capture chum salmon for both the marking and recapture events. Mark–recapture population estimates from 1996 and 1997 compare favorably with independent estimates derived from up-river harvests and escapement monitoring. In 1997, remote tracking stations for radiotelemetry were installed at sites on the U.S.–Canada border, and additional sites were located on major spawning tributaries within the upper drainage.

In 1997 the FWS enumerated salmon escapements on four Yukon River tributaries, including the Chandalar, South Fork Koyukuk, Gisasa and East Fork Andreafsky Rivers. To maintain biodiversity and resource health an adequate number of salmon in any particular stock must be permitted to return to their natal stream of origin. The number that returns to spawn is called escapement. Escapement information is used to schedule fishery openings and to ensure stock conservation, so it is crucial that fisheries managers have accurate and timely information. The FWS has operated floating resistance board weirs and split-beam sonar to ensure adequate escapement of salmon stocks on National Wildlife Refuges. Floating weirs spanning 100 m have been used to count over 500,000 salmon in Yukon River tributaries. The FWS has also pioneered the development of split-beam sonar technology to enumerate riverine populations of adult salmon.

The FWS Fish Genetics Laboratory initiated two genetic stock identification projects in 1997. In a continuing effort to improve the utility of the GSI methods for stock discrimination, the Fish Genetics Laboratory has initiated a three-year project to improve stock discrimination of Yukon River fall chum salmon. This project supports interjurisdictional efforts to rebuild fall chum salmon stocks and improve the ability of managers to better allocate the catch among users. Molecular genetic methods are being used to evaluate the suitability of several classes of genetic markers for stock discrimination, with special emphasis being placed on separating U.S.- and Canadian-origin

For more information on FWS fisheries research, please contact Steve Klein at (907) 786-3548.

fall chum stocks. Genetic profiles of representative spawning stocks from throughout the Yukon River drainage will be established using the new genetic markers. The discriminatory performance of the new markers will then be evaluated.

The second genetic study initiated in 1997 is a three-year project to develop a genetic baseline for coho salmon. The new baseline will provide fisheries biologists and managers a tool to achieve biological diversity, conservation and harvest goals. The project is phased to include collections from spawning stocks in various regions of the state (including the Yukon River), testing and development of genetic markers, and development of genetic profiles for the spawning stocks. The molecular genetic methods being used permit the application of nonlethal sampling methods for collections, greatly simplifying the field logistics and resulting in more collections in a shorter period. The results of this project will have application not only in Alaska but also throughout the entire geographic range of coho salmon.

On the Selawik National Wildlife Refuge and Kobuk Valley National Park, sheefish support substantial subsistence fisheries that are of great practical and cultural importance to the residents of the region. In cooperation with the Alaska Department of Fish and Game, the FWS initiated a study in 1994 to quantify the distribution, abundance, genetics and life history characteristics of Selawik and Kobuk River sheefish populations. Distribution and abundance were assessed with mark–recapture techniques. To locate spawning grounds, adult sheefish were surgically implanted with radio transmitters to permit biologists to track their movements from airplanes and boats. The Fish Genetics Laboratory characterized the genetic substructuring of the population using nonlethal tissue sampling and new molecular genetics methods. Several FWS technical publications are in preparation that will help guide managers in conserving this unique stock.

In 1997 the FWS conducted research on sheefish in the upper Yukon River. Sheefish are known to be highly migratory within many Arctic river systems and exhibit both anadromous and freshwater resident life history forms. The sheefish at the FWS research site were suspected to be anadromous and to spawn in various areas throughout the upper river, including the Yukon Flats National Wildlife Refuge. Through radiotelemetry, the FWS confirmed that spawning areas occur on the Yukon Flats NWR. Anadromous behavior was verified by using a complex microchemical technique on sheefish otoliths, which retain a chemical record of passage into salt water. The distance between the spawning areas and salt water exceeds 2000 km, one of the longest recorded migrations for this species. Continuing work next year may further expand our knowledge of the migratory range of these Arctic fish.

International Circumpolar Activities– Area V

Since 1972 the U.S. and Russia have been involved in international negotiations regarding the protection of nature and the organization of reserves. In 1994 the U.S.–Russia Environmental Agreement was signed (renegotiated from the 1972 U.S.–U.S.S.R. Environmental Agreement). Under this agreement, conservation agencies and other organizations in both countries actively sponsor exchanges of American and Russian specialists in rare and endangered fauna and flora, refuges and reserves, migratory birds, marine mammals, fish husbandry and terrestrial/marine ecosystem biodiversity. Joint projects have made significant contributions to the protection and management of shared species.

The FWS is involved in a number of Area V initiatives. The Conservation of Wild Species of Fauna and Flora and the Protection of Natural Areas project's primary goal is to promote conservation of individual species or groups of species (especially migratory) and their habitats. Biologists from both countries continually exchange expertise and collaborate in field studies to contribute to scientific knowledge and foster a more effective management approach. Six activities comprise the work of this project:

- Implementation of the 1976 U.S.–Russia Convention Concerning the Conservation of Migratory Birds and their Environment, which monitors and promotes the study and protection of more than 200 bird species;
- Study and conservation of cranes, raptors and other rare birds, including the establishment and maintenance of stable, reproducing populations of rare and endangered species of birds, both in the wild and in captivity;
- Study and conservation of rare and endangered mammals;
- Study and conservation of protected natural areas, including military–civilian cooperation in land management, and a small grants program where the U.S. awards small grants

for technical assistance to nature reserves, parks and other protected areas of Russia;
- Cooperation among zoos in captive breeding of rare and endangered animals; and
- Conservation and management of marine birds.

Another Area V initiative that FWS leads is the Aleutian Chain Biodiversity Project, which focuses on joint studies of the species occurring in national wildlife refuges of southeastern Alaska, the Alaska Peninsula and the Aleutian Islands and the nature reserves of northeastern Russia, the Kamchatka Peninsula and the Commander Islands of Russia. The establishment of a Sister Refuge program was proposed for 1996 where scientists and information will be exchanged regarding inventory and monitoring of brown bears, migrating raptors and coastal plant communities.

Over the years the Area V Environmental Protection Agreement between the United States and Russia has provided a conduit for the exchange of information. Cooperative studies of the biology, ecology and population dynamics of marine mammals species are also underway. FWS species studied under the Area V initiatives include polar bears, Pacific walruses and sea otters.

The Polar Bear Specialist Group recognized the need for unified conservation efforts between the U.S. and Alaska for the shared Bering–Chukchi Seas population of polar bears. After several years of negotiations and public review, a draft government-to-government agreement and companion Alaska–Chukotka Native-to-Native agreement was completed in 1997. These agreements would provide a basis for developing unified and comprehensive management programs, including provisions for conducting joint research. The U.S. Department of State has granted negotiating authority for the development of this agreement. A negotiating meeting was scheduled for February 1998.

The routine exchange of publications and harvest data between the U.S. and Russia has advanced understanding of walrus biology and helped the FWS track the status of the population. In 1997 both sides began working to develop a database that will consolidate data from aerial surveys, haulout counts, harvest data, disturbance studies, biological collections and habitat studies. When completed, this database will be made available to researchers and managers in both countries. In November 1997 the sixth U.S.–Russia workshop on sea otters was held in the state of Washington. Scientists representing Canada, Japan, the Russian Federation and the U.S. attended. Research efforts and information regarding population estimates of sea otters in their ranges bordering these countries were summarized. The results of studies were presented in areas such as sea otter food consumption and foraging including ecosystem effects, contaminant exposure monitoring, and reproductive and genetic studies involving captive or rehabilitated sea otters. Several U.S.–Russia collaborative projects were proposed in the area of genetics, contaminant research, population monitoring and research into general sea otter biology and life history. The next joint workshop is planned for 1999 in Russia.

The Animal and Plant Ecology Project focuses on cooperative research into the ecology of single species and communities of fauna and flora in the U.S. and Russia. Activities include studies of:
- Rare and endangered species of plants and the introduction of exotic species in both countries;
- Northern migratory waterfowl, specifically snow geese, Aleutian Canada geese, and spectacled and Steller's eiders;
- Holarctic mammals;
- Chemical senses and communication in animals;
- Application of contemporary technology, such as sea ice mapping distribution, in studies of large mammals such as polar bears; and
- Wildlife health and disease, such as the effects of lead poisoning in waterfowl.

The Area V Ichthyology and Aquaculture Project seeks to improve fisheries management, increase productivity through intensive fish culture, restore fishery resources, and exchange information on the physiology, nutrition, diseases, genetics and reproductive biotechnology of mutual fish species.

The FWS also leads the effort to facilitate cooperation in wildlife trade and law enforcement activities to provide technical assistance and training for the conservation of endangered species in the Russian Far East. In addition, conservation education efforts are underway to enhance public awareness of and commitment to the need to conserve wild species of flora and fauna, as well as their habitats.

Conservation of Arctic Flora and Fauna

The FWS Alaska is the lead agency for Conservation of Arctic Flora and Fauna (CAFF), an inter-

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national initiative that falls under the umbrella formerly known as the Arctic Environmental Protection Strategy (AEPS), recently reorganized as the Arctic Council. CAFF is one of four programs formed under AEPS, which was adopted by Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden and the U.S. in 1991. The FWS participates on the CAFF International Working Group, which was established in 1992 and consists of scientists, conservation managers and indigenous peoples of the Arctic. CAFF provides a circumpolar forum in which a wide range of Arctic conservation issues can be discussed.

CAFF's focus is biodiversity, habitat conservation, species conservation within an ecosystem approach and the integration of indigenous peoples and their knowledge into the work of CAFF. In 1996 and 1997 FWS work under CAFF focused on inventory and mapping of Arctic vegetation, development of conservation strategies for murres and eiders, and development of a strategy and action plan for the Circumpolar Protected Areas Network (CPAN). Future work of CAFF will be directed by the Strategy for the Conservation of Biological Diversity in the Arctic Region.

National Park Service

	Funding (thousands)	
	FY 96	FY 97
Cultural Resources	790	1,338
Natural Ecology	1,650	2,431
Total	2,440	3,769

The central mission of the National Park Service (NPS) in Alaska is no different than for the rest of the U.S. The NPS preserves, unimpaired, the natural and cultural resources under its stewardship for the enjoyment, education and inspiration of present and future generations. As an adjunct to this central mission, the NPS is also charged with cooperating with partners to extend the benefits of natural and cultural resources conservation and outdoor recreation throughout the U.S. and the world.

The unique aspect of the NPS's mission in Alaska is provided by the Alaska National Interest Lands Conservation Act (ANILCA). Among other things, ANILCA ensures the continuation of traditional subsistence pursuits in most of the park areas and allows sport hunting in the national preserves. The vast size of the Alaska parks, combined with their ecological complexity, presents great management challenges. As recently demonstrated by the *Exxon Valdez* oil spill, they are not free of threat and degradation from the impacts generated by the modern industrial world. They remain vulnerable, and the wise management of these lands depends on the knowledge and information that can only be supplied by solid and well-thought-out research and monitoring programs.

Recent organizational restructuring within the agency, coupled with the creation of the National Biological Service (now the Biological Resources Division of the U.S. Geological Survey), has changed the way research is accomplished within the NPS. Today, in the more decentralized NPS, park staffs have assumed significantly greater responsibilities for charting and carrying out its research activities. And in keeping with current Department of the Interior policy, the NPS has turned to the USGS for assistance with the larger and more complex biological research issues that face the parks. Moreover, in step with the intent of the Arctic Research and Policy Act, the NPS has actively sought the involvement and partnership of other Federal agencies, the State of Alaska, adjacent northern nations, Native groups, educational institutions and other interested parties in cooperative research endeavors.

The research objectives in the NPS are driven and guided by its major mission goals. These goals were reaffirmed by the NPS's National Leadership Council in the just-published *1997 National Park Service Strategic Plan*. The specific goals that give general direction to its natural and cultural resource programs in the North are as follows:

- Natural and cultural resources and associated values are protected, restored and maintained in good condition and managed with their broader ecosystem and cultural context.
- The National Park Service contributes to knowledge about natural and cultural resources and associated values; management decisions about resources and visitors are based on adequate scholarly and scientific information.
- Park visitors and the general public understand and appreciate the preservation of parks and their resources for this and future generations.

Shared Beringian Heritage Program

The Shared Beringian Heritage Program of the NPS has expanded its outreach and partnership activities during the 1996-97 fiscal years. In addition to its cooperation with universities throughout the nation, the NPS has agreements in place with state and Native organizations, both at the regional and village level.

The Beringia Panel continues to convene several times a year to prioritize research proposals and to hear first-hand reports on current projects that are presented at the annual Beringia Days symposium in the fall in Anchorage. This panel has been successful in bringing the interests of the NPS and the Native corporations of western Alaska together in the areas of conservation and research in Beringia. Its members include management from the NPS and the Native corporations of western Alaska (Bering Straits, NANA and Arctic Slope Regional Corporations).

During this period, new Russian partners have been developed and a working relationship established with the regional government of Chukotka. The NPS's goal is to facilitate the exchange of scientists and data across the frontier and to encourage a strong link between villages on both sides of the Bering Strait. More and more Russian scientists and resource managers are attending Beringia Days, and increasing numbers of Beringia research projects have a Russian partner or Russian component to their study.

In the summer of 1997 an archeological reconnaissance was conducted by researchers from the University of Washington in the upper headwaters of the Killik River within Gates of the Arctic National Park and Preserve (GAAR). This is in the general neighborhood of the now-famous Mesa Site being excavated by the Bureau of Land Management. The object of the work was to discover traces of the earliest inhabitants of Arctic Alaska. Little evidence of early use of this area was discovered, and researchers will address the implications of these findings in making future predictions of likely locations where evidence of Alaska's earliest people might be found.

The NPS funded the translation and publication of Nikolai N. Dikov's seminal work on the prehistory of Beringia, *Asia at the Juncture with America in Antiquity*. This book summarizes the results of Dikov's research between 1979 and 1986 in Chukotka and reports on the data gleaned from 170 archeological sites. It was the NPS's purpose to make this important volume available in English translation to the world community of scholars.

A joint project of the Shishmaref IRA (Indian Reorganization Act) Council and the NPS has provided detailed documentation of traditional place names and connections to the land in the coastal zone of the Bering Land Bridge National Preserve (BELA). A report on the study has been completed and is scheduled for publication in 1998 or 1999.

Kawerak Incorporated, in partnership with the NPS, is engaged in transcribing and cataloging 500 interview tapes with Eskimo people of the Seward Peninsula. These tapes represent an invaluable record of traditional life in the area.

The purpose of a University of Alaska project is to better define and understand the geomorphic and hydrological processes that govern the formation of vegetation and waterfowl habitat in the Cape Espenberg wetlands of BELA. Research results demonstrate that these dynamic and complex wetlands form one of the most important "biological engines" in the region.

The purpose of a cooperative venture with local elders, Native language teachers and the University of Alaska Native Language Center is to record local Inupiaq folk tales in their original dialects and settings and integrate them with a workbook on Inupiaq orthography. The products will be used to preserve and teach the Inupiaq language in the context of local oral history.

In cooperation with the King Island Native community the NPS is sponsoring a study of the Wolf Dance, one of the most important ceremonies of the King Island Eskimos. The research is being conducted by Deanna Kingston, a Native King Islander and anthropologist. Since the Wolf Dance was originally performed within the context of the Messenger Feast, where one community hosted another, the study will illuminate relationships with other Eskimo groups in the Bering Strait region.

The NPS, in cooperation with the Northwest Arctic Borough School District, has updated and will soon publish *Kuuvangmiut Subsistence: Traditional Eskimo Life in the Latter Twentieth Century*. A revised version of this invaluable record of traditional subsistence lifestyle will be published for the first time, and the book will be made widely available to bilingual school programs in eleven villages in northwest Alaska and to scholars around the world.

Researchers from the University of Alaska Fairbanks are using a variety of scientific approaches to decipher the key natural processes responsible for the creation and maintenance of the Kobuk

Sand Dunes in Kobuk National Park. Because the dunes appear to also be a sensitive environmental sentinel for the region, a better understanding of the dunes will also shed important light on the larger landscape and climatic history of Beringia.

A multi-year collaborative research effort involving the University of Alaska Fairbanks, the University of Massachusetts, the National Science Foundation and several research institutions affiliated with the Russian Academy of Sciences is attempting to determine the extent of Cenozoic glaciation in the Bering Strait and also characterize the changing character of the paleoceanography of the region during the same time span.

A project developed in partnership with indigenous people on both sides of the Bering Strait was designed to promote the continuation of traditional intercontinental links and the revitalization of cultural traditions associated with these cross-continental exchanges. This project specifically funded the attendance of regional dance groups and video documentation of their performances at the 1997 Northwest Alaska Native Trade Fair in Kotzebue, Alaska.

Ernest Burch is comparing and documenting the social, political and economic institutions and forces that characterized the traditional Inupiaq nations of the nineteenth century. As with his earlier-funded study on "international relations" among the Inupiaq nations, which has been completed, the product will be a published book.

Research by the University of Alaska Fairbanks on multiple exposures of an ancient ground surface buried under the 17,500-year-old Devil Mountain ash fall in BELA continued in 1996 and 1997. Studies include plant and insect identification, pollen analysis and the estimation of paleo-biomass and productivity. The results to date support the concept of a steppe–tundra environment during the late Pleistocene, but a newly found surface points to the existence of a shrub tundra more similar to today's environment at around 35,000 years ago.

In cooperation with the Eskimo Society of Chukotka, the Naukan Native Company, the Provideniya Municipal Museum and the North Slope Borough, the NPS is supporting the development of increased awareness of the values of the subsistence lifestyle and the potential benefits of the creation of an international park to the continuation of this traditional lifestyle. Local participation is critical to this project because it sponsors a variety of local efforts and studies ranging from marine mammal harvest counts to skin boat construction.

In close cooperation with the U.S. Fish and Wildlife Service as well as the communities of Savoonga and Gambell, Native Alaskan researcher Caleb Pungowiyi is directing a three-year study of seabirds and seabird subsistence harvests on St. Lawrence Island. The study involves strong participation by the local islanders in making direct bird colony observations and in sharing traditional knowledge on bird management strategies.

Researchers from the Russian Academy of Sciences, St. Petersburg, and the University of Alaska Fairbanks continued to explore the nature and extent of twentieth-century cultural exchanges across the Bering Strait. Recent work centered on the roles of the Chukchi, King Islander and Diomede Eskimos in these contacts. The intensity of economic and social relations across the waters of the Bering Strait are much greater than originally expected, and new linguistic evidence has emerged that suggests that the Yupik spoken in the village of Naukanski on the Russian side had its origins in Alaska.

Cultural Resources

Multi-Park Studies

In its fifth and sixth years, the Gulf of Alaska Coastal Archeological Survey Project, funded by the Systemwide Archeological Inventory Program (SAIP), resulted in the completion of surveys of coastal areas within Lake Clark National Park and Preserve (LACL) and within Wrangell–St. Elias National Park and Preserve (WRST). The project continues to be interdisciplinary, placing emphasis on the construction of a regional model of prehistoric settlement patterns relative to Holocene sea-level changes, glacial action and the distribution of subsistence resources along the coast. The research is led by investigators from the Arctic Studies Center, National Museum of Natural History, Smithsonian Institution, and University of Alaska Fairbanks through the U.S. Geological Service (USGS), Biological Resources Division, Cooperative Research Unit. The FY 96 investigations at WRST, on the north shore of Yakutat Bay, demonstrated at least 800 years of prehistoric occupation where no archeological sites had previously been recorded. The sites provide a possible tangible link to Tlingit oral history, which mentions migrations into Yakutat Bay from the north. The FY 96 investigations at LACL demonstrated a high-density late-prehistoric Dena'ina occupation on the north shore of Chinitna Bay in an area

where few definite archeological sites had been previously reported. In Tuxedni Bay the project recorded a 3500-year-old site, the first site of that time period recorded on the north shore of Cook Inlet, and it extends the known geographical range of the early maritime Ocean Bay culture. In FY 97 project work shifted to laboratory analysis and preparation of final reports. The final reports for the work in Kenai Fjords National Park (KEFJ) and Katmai National Park and Preserve (KATM) should be published in 1998. The final reports for the work in GLBA, LACL and WRST will be published in 1999.

Archeological overviews and assessments were completed for WRST and LACL, and four others were initiated in Glacier Bay National Park (GLBA), Sitka National Historical Park (SITK), Gates of the Arctic National Park and Preserve (GAAR) and Klondike Gold Rush National Historical Park (KLGO). The one at KLGO involved the Chilkoot Trail and White Pass Units and is being accomplished through a cooperative agreement with the University of Idaho. The outcome of these projects is the publication of synthesis documents that compile, review and evaluate all existing archeological data for a park and its immediate vicinity. The results include an up-to-date park resource information base and directions for future research and management of the resources.

Alagnak Wild River

Another first systematic archeological survey was conducted in 1997 at the headwaters of the Alagnak River and along the Nonvianuk River to its confluence with the Alagnak River. Twenty-four previously unrecorded archeological sites were identified. They document human occupation of the area from about 8000 years ago to historic times and include a large multi-component village with 69 features, two of which were large multi-room houses. A previously recorded site was also visited and mapped. This site has 38 house depressions, 25–35 cache depressions, Russian Orthodox church ruins and a cemetery.

Aniakchak National Monument and Preserve

The first-ever systematic archeological survey of this remote and poorly known region was conducted in 1997. Twenty-one new archeological sites (11 prehistoric and 10 historic) were found and documented. The sites included several sizable villages, one with more than 35 house pits. Lithic and faunal data from these sites will help in developing a picture of the culture and economy of this region, and the charcoal and tephra samples will help to develop a chronological framework for the cultural occupation and major volcanic events in the monument and preserve.

Cultural resource staff also began work on an ethnographic overview and assessment. The study will define relevant neighboring groups with ties to park lands, identify traditional use areas and determine future ethnographic research directions. Archival research will be combined with the collection of oral histories, and a comprehensive GIS cultural database will be developed to aid in evaluating information and designing future investigations.

Denali National Park and Preserve

In cooperation with the State of Alaska, Division of Subsistence, work was initiated on an ethnographic overview and assessment of the park and preserve as a whole. This is a two-year project that will involve not only the NPS and the State of Alaska but also several neighboring tribal groups and Alaska Native villages.

Gates of the Arctic National Park and Preserve

Archeological surveys in 1996 of two parcels of land to be affected by the Anaktuvuk Pass land exchange resulted in identifying and recording seven new sites that range in age from approximately 5000 years old to historic Nunamiut. This project also initiated a monitoring program for previously recorded sites around Agiak Lake.

A Native American Graves Protection and Repatriation Act (NAGPRA) study in the park seeks to determine culturally affiliated traditional burial practices of the Native people associated with park lands. This study will use published references, unpublished field data and interviews with community members to identify distinguishing surface features of gravesites. This information will be used by park management to protect sites from disturbance and to identify affiliated groups for future consultation.

Glacier Bay National Park and Preserve

In association with the Hoonah Indian Association, the NPS undertook in 1997 an effort to use the recently compiled Tlingit place name map as a guide for locating and documenting former habitations and sacred sites in the park and preserve. The survey resulted in the discovery of eight archeological sites, including three fort sites. Two of the forts are in Glacier Bay proper and are likely the earliest sites thus far recognized in the bay. The

forts are particularly significant because they allow a heretofore unrecognized glimpse of the tumultuous human environment in the mid- to late 1800s.

Katmai National Park and Preserve

In addition to revisiting and monitoring the condition of 50 previously recorded sites along the coast of the park in 1996, the park undertook data recovery excavations at the Mink Island archeological site within the Takli Island Archeological District. This work was undertaken in cooperation and consultation with the Council of Katmai Descendants, a group representing all Natives who have traditional ties with Katmai lands. Natural weathering, wave erosion and recent vandalism have contributed to the partial destruction of this site. The excavations included units in both the upper component of the site, which dates from 2500 to 500 years ago, and the lower component, which dates from 7000 to 4000 years ago. Work will be completed in 1998.

Lake Clark National Park and Preserve

In 1997 the first year of a three-year project to map, analyze and interpret the Kijik National Historic Landmark was initiated. This year involved taking low-altitude aerial photographs of the 14-square-mile project area and producing detailed topographic maps. Included within Kijik are the remains of 12 Dena'ina settlements and approximately 200 dwellings. The sites date at least from the late prehistoric period, approximately AD 1600, until the abandonment of historic Kijik Village in the early 1900s.

Western Arctic National Parklands

Responding to an impending severe decline in the Western Arctic Caribou Herd, the NPS has joined with other Federal, state, regional and community partners in northwest Alaska to form a proactive cooperative management initiative. Melding both Western management models and traditional ecological knowledge, this initiative concludes that the overall objectives of agency and community members and the conservation of healthy resource populations is best met by negotiating co-management regimes that integrate agency and local perspectives into a legitimate self-regulating system.

Screening for artifacts at Kaiyak Lake in Noatak National Preserve.

Archeological surveys were performed in Kobuk Valley National Park (KOVA) and Noatak National Preserve (NOAT) in 1996, and an additional survey was conducted in KOVA in 1997. The work in KOVA, done in collaboration with Brown University, identified 14 new sites that ranged from paleoarctic to the historic 1898 gold rush in age and resulted in three major prehistoric village sites being mapped. The work at NOAT resulted in architectural maps of stone qarigis at three late-prehistoric village sites (Feniak, Desperation and Burial Lakes) and initiated an ethnographic cultural landscape study at Desperation Lake. This study represents the first attempt at assessing the scope and problems associated with looking at archeological sites in the Arctic as part of a larger ethnographic landscape.

In 1996 at Cape Krusenstern National Monument (CAKR), in a collaborative effort with the Smithsonian Institution, the NPS began the process of re-locating the more-than-500 archeological sites located by J. Louis Giddings and Douglas D. Anderson, both of Brown University, in the 1960s. Rebar monuments were established at each site, and global positioning system (GPS) fixes were obtained for each. In 1997 new aerial photography of the CAKR beaches was acquired to build detailed photogrammetric maps to be used to monitor beach erosion, to locate archeological sites and other resources, and to inform future archeologists of areas not examined by Giddings and Anderson.

Also at CAKR, archeological excavations were conducted in 1997 at the erosion-threatened sites of Agiagruat and Aitiligauraq. The work at the former was done in association with Washington State University, and a preliminary assessment of the artifacts collected indicates a late-Western Thule occupation dating to the 14th or 15th centuries AD. The latter, which was undertaken as an archeological field school jointly with Brown University, involved two turn-of-the-century Inupiaq semi-subterranean houses. This time period was one of transition and trauma for the Inupiat, and the analysis of the material will focus on the juxta-

Partially excavated housepit in Cape Krusenstern National Monument. Note the fallen roof timbers inside the house.

position of items of traditional and Euro-American manufacture.

Yukon–Charley Rivers National Preserve

In cooperation with the Alaska Department of Fish and Game, Subsistence Division, the NPS conducted an ethnographic study of the Han Gwitch'in people. The purpose of the study was to produce an illustrated manuscript that would celebrate and document Han culture and history. The Han community of Eagle Village, the Tr'ondek Hwech'in First Nation in Yukon Territory, and Parks Canada were consultants on this study. Study topics included an overview of source materials; Han band territories and settlement patterns; traditional subsistence practices; social organization; expressive culture; changes in Han culture brought by contact with the fur trade, the gold rush and missionaries; and the Han people today.

Wrangell–St. Elias National Park and Preserve

In 1996 an archeological survey of the historic mining townsite of Chisana was completed. Although historic accounts mention 400–500 log cabins at Chisana in its heyday, the survey documented only 125 structures. Stream erosion and the construction of an airstrip and other facilities on adjacent private land account for the decimation of much of the original townsite.

In 1997 the first extensive archeological survey specifically targeted at identifying prehistoric sites was carried out in the Wiki Peak area near the Canadian border. An unexpectedly high density of prehistoric sites (65) was encountered and recorded. The discovery of a large concentration of sites, their relative chronology (from 2700 years ago to the protohistoric) before and after a significant volcanic eruption, the lithic technology represented, and its association with recently identified obsidian source material traded elsewhere in Alaska provided the park with invaluable resource data on the uncertain prehistory of the area.

Natural Resources

Denali National Park and Preserve

Scientific research in Denali National Park and Preserve is critical to understanding and documenting resource conditions, providing information for park management decisions, and resolving threats to natural conditions. The park provides a unique opportunity for comparative studies that look at environmental response in pristine areas versus intensively manipulated areas. Denali is a vast wilderness over six million acres in size; documentation of the presence and condition of resources is a massive task. To accomplish this task the NPS conducts and supports a substantial interdisciplinary natural resource inventory, monitoring and research program. This program is implemented through efforts by park scientific staff, cooperating state and Federal agencies, and various academic institutions. During any given year, there are nearly 100 individual studies or projects underway.

Wildlife research has been important in Denali since 1926, when the first thorough inventory of wildlife in the park was started. Examples of 1996 and 1997 projects include the ecology of moose (USFS), the nesting ecology of migratory golden eagles (NPS), the ecology of grizzly bears (USGS-BRD) and investigations into predator–prey (caribou–wolf) relationships (USGS-BRD). Information to deal with wolf management, one of the most controversial resource issues in the park, continued to be developed through an extensive monitoring program using radiotelemetry. Other studies continued in 1997 include documenting wildlife behavioral response to vehicular use along the park road. For example, the effects of such vehicular use on Dall sheep migratory routes were examined and identified.

Denali's Long-Term Ecological Monitoring (LTEM) program continues to be developed jointly by park staff and USGS-BRD. Studies from this program are contributing to a fundamental understanding of park resources. Watershed-based studies for this program are wide-ranging in scope and have focused on such resources as soils, water chemistry, small mammals, birds and vegetation. Other LTEM

studies parkwide were aimed at monitoring weather and determining the regional effects of climate on glaciers.

Recent studies have reflected a shift in interest to learning more about the park's abiotic resources. Examples of such projects include investigating the characteristics of the Cantwell formation volcanics unit. Paleontology studies were continued by the USGS. A study of the phenomena of surging glaciers continued on the Muldrow Glacier. Studies dealing with roadside impacts (trail development) and road dust were also continued. Closely related studies on the environmental fate and impact of dust palliatives were conducted. Air quality sampling efforts continued and were expanded in 1997 to include ultraviolet B monitoring. Investigations related to other park issues and threats included such things as assessing channel response to stream restoration, monitoring gravel extraction from alluvial floodplains, and documenting the freeze–thaw transition on a regional scale in boreal forests using satellite data (NASA).

Although the park is a vast and often forbidding area in which to conduct research and monitoring, this vastness has been made far more manageable by park staff through the application of global positioning systems and geographic information systems. ArcInfo and ArcView software are used by the park staff involved in research efforts; this program is supported by a full-time GIS specialist. Additionally, efforts are being directed at automating all resource data and information, as well as developing and cataloging traditional information such as specimens, maps and written records.

Katmai National Park and Preserve

Genetic analyses and color-banding programs are being used in cooperation with the U.S. Fish and Wildlife Service and USGS-Biological Resources Division to assess the degree of population differentiation and movements among geographically separate groups of harlequin ducks. The primary area of study encompasses areas affected by the *Exxon Valdez* oil spill on the northeast coast of the Alaska Peninsula (Katmai National Park) and the Kodiak Island Archipelago (Kodiak National Wildlife Refuge) along the Shelikof Straits and Prince William Sound. Harlequin ducks were captured in molting drives, genetic samples were collected, and legbands were applied with site-specific colors and individual alphanumeric codes before release.

An Alaskan brown bear study was conducted along the Kulik River corridor cooperatively with the USGS-BRD for purposes of detecting patterns of activity, distribution, behavior and human interaction. The intent of the study is to determine the level of bear and human activity, bear and human spatial and temporal use, and bear–human interactions along the Kulik River during periods of high and low seasonal use by commercial operators and guide services. The Kulik River is a representative site similar to other drainages within the park that are experiencing exponential growth in terms of visitation and bear–human contact.

Concerns have been raised about the health of a prized rainbow trout population in the Alagnak River and its upstream tributaries in Katmai National Park. In cooperation with the USGS-BRD and the Alaska Department of Fish and Game, questions regarding the rainbow trout population structure of the Alagnak drainage are being addressed. It is unknown whether the rainbow trout in various rivers, lakes and tributaries of the watershed are represented by a single, well-mixed population with readily mixed spawning aggregations or whether there are discrete populations having independent spawning groups. While it is generally believed that seasonal migrations occur, little is known about the detailed patterns of movement or population intermixing. Furthermore, little is known about the locations and relative importance of juvenile rearing areas. Because of limited knowledge of these basic life history characteristics, it is difficult to assess the relative impacts of the increasingly popular sport fisheries. Therefore, beginning in 1997 a five-year study was initiated to increase basic understanding of the population dynamics of Alagnak watershed trout and to improve technical capabilities for assessing the overall health of Alaska rainbow trout populations in general.

Lake Clark National Park and Preserve

The Johnson River watershed, located in the southeast part of Lake Clark National Park and Preserve, with glacial headwaters on the Mt. Iliamna volcano and draining east to Cook Inlet, has been the focus of a water resource and fisheries inventory from 1995 to 1997. A continuously recording stream gaging station was established on the river in 1995 in a cooperative effort between the NPS and the USGS. Water quality sampling, aquatic invertebrate sampling, fish trapping and stream sediment analyses were conducted on the mainstem and tributaries of the Johnson River and in Bear Creek, a neighboring small clear-water stream. In addition to baseline information gathered for the watershed in light of future development in the area, data collected on the Johnson River will

prove useful to the National Water Quality Assessment for Cook Inlet, part of a national water quality program administered by the USGS.

Kenai Fjords National Park

A multi-agency coastal lake and lagoon inventory and monitoring program began in 1996. Cloudy Cape Lagoon, adjacent to the western shore of Taroka Arm, was the first lake to be inventoried. Survey data collected included outflow stream and beach profiles, lake bathymetric profiles, and temperature and conductivity profiles through a range of depths and lake level recordings. Water, plankton, fish and invertebrate samples were collected. In 1996, 14 sockeye salmon spawners were counted in the shallow gravel bottom area of the lagoon; however, all juvenile salmonids captured were coho salmon. In 1997, many more sockeye spawners were observed in the lagoon, even though no surface flow was observed in the poorly defined stream channel linking the lagoon to Taroka Arm.

A second lake or lagoon will be surveyed in 1998, and Cloudy Cape Lagoon will be resampled. A recording rain gauge and lake level recorder will be deployed at Cloudy Cape Lagoon in an effort to determine how quickly the lake level responds to rainfall events. These data will help resource managers determine when salmon are entering the system and will be useful in developing models that predict the fate of salmon runs in this system.

The coastal bald eagle population has been monitored in the park since 1986. Results from the 1996 season and preliminary results from the 1997 monitoring season suggest a greater number of nest failures than expected. Final results are expected in early 1998.

In 1997, park resource managers, biologists from the National Marine Mammal Laboratory (Seattle, Washington), the Alaska Department of Fish and Game, and the University of Alaska Fairbanks (Institute of Marine Science), and a visiting Russian scientist collaborated for the first-ever live capture of harbor seals using floating glacier ice as a primary haulout. The team used a modified floating gill net to capture the seals. Once captured, the animals' condition was determined and vital statistics (sex, weight, etc.) recorded. Blood and tissue samples were collected from each animal, and a small radio transmitter was attached to the rear flipper. Collected data will help to provide an understanding of individual harbor seal condition and movements within the fjords and may be used to assess causes of a continued population decline.

Park staff assisted killer whale researchers from the University of British Columbia and the North Gulf Oceanic Society to identify individual killer whales and monitor resident and transient pod movements in waters adjacent to the park. These data may enable a better understanding of the effects of transient killer whale predation on the park's declining harbor seal populations. In 1998, park staff and scientists from the Alaska SeaLife Center and the North Gulf Oceanic Society will deploy a remote hydrophone close to the mouth of Resurrection Bay. Hydrophone data will determine cycles of occurrence of transient killer whales along portions of the park coastline.

Temperature dataloggers were deployed at three coastal locations and two Exit Glacier locations in 1997. A knowledge of seasonal temperature regimes will enable a better understanding of seasonal cycles of floral and faunal occurrence, distribution, condition and productivity. This program will be expanded in 1998.

Park staff also conducted the first cycle of campsite impact monitoring since an initial 1993 campsite impact inventory. To date, approximately 50 campsites have been identified and monitored. Preliminary results suggest that approximately 90% of the sites showed little increased impact due to human disturbance. However, some sites located in more sensitive environments exhibited a marked increase in size. Other less-utilized sites exhibited some degree of recovery. The final results of the 1997 monitoring are anticipated in early 1998.

Bering Land Bridge National Preserve

The NPS is developing an assessment protocol for reindeer ranges in western Alaska. The preserve, located on the Seward Peninsula of Alaska, is the only NPS unit in the system with mandated reindeer grazing. Existing herd management practices that have evolved over the last century give more attention to acres of range than to quality of range. The NPS is hoping to change that focus. Donald Spalinger of the University of Alaska Anchorage, who is developing a monitoring protocol, completed a second field season in 1997, working with Keith Owen of Texas A&M University. The team is collecting specific information on range condition and diversity. The goal of this work is to produce a detailed guide to range assessment for reindeer ranges in western Alaska. After more field work and consultation in 1998, Dr. Spalinger and the NPS will produce a monitoring handbook for distribution to reindeer herders, land managers and other interested parties. The

goal is to have the handbook available to herders by the spring of 1999.

In 1977 Douglas and Diane Schamel returned to Cape Espenberg to study the nesting habits of red-necked phalaropes and other shorebirds. This fourth year of field work complements studies done in the late 1970s by the couple and provides excellent data on trends over an extended period. The Schamels have been able to re-locate their original study plots and use exactly the same locations and techniques. Collateral to their shorebird study the team is monitoring numbers, hatching success and predation on common eiders. Preliminary data indicate that numbers and breeding success are down for all species. Predation of eggs by jaegers, foxes and reindeer has reduced hatching success. The Schamels will return to the field in 1998 for a final season with hopes of gathering more specific data on common eiders.

Noatak National Preserve and Kobuk Valley National Park

The fifth year of moose population monitoring in Noatak National Preserve was completed with the cooperation of the Alaska Department of Fish and Game. The purposes of the study are to delineate census areas and document survival of radio-collared moose. Currently a radio-collared sample of 70 moose is monitored four times during the year to document survival and movements. During 1997 the project expanded its objectives to document calf production and survival using intensive monitoring of radio-collared cows during the calving period in June.

Annual monitoring of Noatak National Preserve sheep entered its eleventh year in 1997. Aerial minimum count surveys documented the third year of significant lamb production following a five-year absence of productivity. Adult numbers also increased in the Baird Mountains because of immigration of sheep from groups living east of the survey area.

The fourth year of a five-year program to monitor neotropical songbird populations within Noatak National Preserve and Kobuk Valley National Park was completed in late August. Over 1000 birds of 30 species have been banded since the program began in 1994 as part of the Monitoring Avian Productivity and Survivorship Program sponsored by the Institute for Bird Populations. Highlights of the program include a banding station on Native corporation land near Kotzebue where the public participates in banding activities.

Over 50 trapper-caught wolverine carcasses were collected as part of a cooperative project with the Selawik National Wildlife Refuge to document the harvest of wolverines on Federal lands within northwest Alaska. Carcasses will be necropsied to determine the sex and age of harvested wolverines, the reproductive characteristics of females, and the nutritional condition of each animal. In FY 98 the project will expand its objectives to determine the survival and productivity of wolverines using a radio-collared sample.

Gates of the Arctic National Park and Preserve

Using standard National Wetlands Inventory photointerpretation and cartographic conventions, wetlands identification, classification and mapping were completed on eleven USGS quadrangles covering the upper Kobuk River watershed.

A botanical reconnaissance was conducted in the Walker Lake National Natural Landmark (NNL) and parts of the adjacent Arrigetch Peaks NNL. A total of 350 species, including 214 vascular plants and 136 macrolichens, were inventoried. Thirty-one of the vascular plants represented additions to known park flora, and nine represented large range extensions. Thirty-seven of the lichen species were new to the park's flora, and 26 were new to the Brooks Range.

In FY 97 the NNL biological reconnaissance effort was expanded to provide baseline data on lichen flora and floristics for the entire park. More than half of the park's species are lichens and bryophytes, yet surprisingly little was known about their presence and distribution. Lichens were inventoried across two broad transects of the park, resulting in approximately 30 new records for the park and a clearer idea of the parkwide distribution of taxa. The project also provided training to botanists from other park units and agencies, published a guidebook to Alaskan genera of macrolichens, and produced a visitor center display. The park's lichen flora was incorporated into a database including records from an extensive literature search and current identifications. A sizable lichen collection of over 900 specimens was added to the park's holdings.

A project was initiated to determine the distribution and abundance of the rare plant *Aster yukonensis* in the park and preserve and to determine its vulnerability to human disturbance. The species is found in scattered populations in northern Alaska and in parts of the Yukon and Northwest Territories, Canada. Relatively few data are available to document the range and distribution of this plant.

Identifying lichens in Gates of the Arctic National Park and Preserve.

Baseline vegetation information was collected within the Anaktuvuk Pass all-terrain vehicle (ATV) access land exchange area of the park. Monitoring plots were established in different plant communities and associated soil types to evaluate how ATV use will affect those communities. These data will be used to determine changes in community structure and to establish thresholds of acceptable change.

Sheefish in the Kobuk and Selawik Rivers are the largest in Alaska and represent an important subsistence and sport fishing resource. A cooperative ADF&G/NPS project was conducted to describe the stock status of spawning sheefish in the upper Kobuk River and to measure the proportions of sheefish that return to spawn one and two years after a previous spawn. Spawning sheefish abundance, length and age composition were estimated in the upper Kobuk River. Subsistence and commercial harvests were estimated in Hotham Inlet, and sport harvest was estimated for the entire river.

The opening of the Dalton Highway (Haul Road) to the general public in 1995 caused concerns over increased fishing in lakes north of the Brooks Range. This motivated the State to initiate population studies of four lakes containing lake trout. As part of this effort a two-year cooperative ADF&G/NPS study began in 1997 on the lake trout of Itkillik Lake. The study objectives are to estimate lake trout abundance and length composition, and to estimate lake trout catch per unit effort using standardized gillnet sampling (index fishing).

A Dall sheep population survey was conducted in 1996 in park areas where the sheep are subject to sport or subsistence harvest. Approximately 2200 square miles were surveyed. The sheep population decreased by 30% to 80% since surveys were conducted in 1986 and 1982–1983.

Snowshoe hare track count transects were conducted through seven tundra vegetation types near the village of Wiseman. Long-term monitoring of the transects may reveal refugia where hare populations remain high, even during the low part of the population cycle.

Landbird species were monitored within the park and preserve as part of a statewide Boreal Partners in Flight effort. Three off-road point-count transects were monitored: tundra transects in Anaktuvuk Pass and in the upper Noatak River drainage, and a boreal forest transect in the Middle Fork of the Koyukuk River. The routes have been surveyed annually since 1993, and five previous years of data contribute to understanding landbird species diversity, distribution and habitat use as well as improving landbird monitoring techniques.

The importance of riparian shrub habitats to avian species was evaluated in a tundra ecosystem. Species diversity, nest density and nest site characteristics were documented for neotropical migrant birds. The park serves as the northernmost breeding grounds for several species of neotropical migrant birds. The northernmost limits of their range may be the best areas for early detection of population changes, so careful documentation of these populations is important.

Yukon–Charley Rivers National Preserve

A military F-15 fighter jet crashed in the headwaters area of the Charley River in 1995. The aircraft's impact resulted in a fire that severely burned a localized area to mineral soil. An unknown quantity of unburned fuel contaminated the area, and although larger pieces of the aircraft were removed, the area is still littered with metal fragments. An ongoing soil, vegetation and water quality monitoring project will ensure that the site recovers to a natural, undisturbed state. The project also develops procedures and techniques necessary to address expected similar incidents as a result of substantial military aircraft operations over the preserve.

A three-year study of Dall sheep habitat will determine seasonal movement patterns of sheep within the preserve. The project will also improve the timing of sheep surveys, quantify the mingling of sheep from discontinuous areas of habitat, identify sensitive sheep use areas (such as lambing and rutting areas) and temporal use of those areas, help mitigate the impacts of increased low-level mili-

tary flight operations, and develop a long-term monitoring plan. Fifteen sheep were radio-collared in April 1997. To date, data show individual movements of up to 40 miles.

A wolf radio-tracking project was initiated in 1993. The objective is to determine the demography of wolf packs using the preserve. Identified preserve wolf packs have received protection on State lands adjacent to the western boundary of the preserve, where the State is using non-lethal predator control in an effort to enhance the recovery of the Forty Mile Caribou Herd. Seventeen wolves in eight packs are being monitored in order to continue to protect them.

Peregrine falcon populations were monitored along the upper Yukon River and on the Charley River. Nesting territory occupancy, breeding success and productivity on the Yukon River have been documented annually since 1979 and on the Charlie River since 1993. Bands and satellite radio-tags have been used to determine migration routes, wintering areas, and dispersal, movement and mortality of adults. Pesticide levels have been measured periodically. Substantial recovery of American peregrine falcons has been documented in the preserve during this project.

Caribou antler on tundra in the Wrangell–St. Elias National Park and Preserve.

Landbird species were monitored as part of a statewide Boreal Partners in Flight effort. Two off-road point count transects were initiated in 1997 and will be monitored annually henceforth. The data will contribute to understanding landbird species diversity, distribution and habitat use in the preserve and to improving landbird monitoring techniques.

Long-term monitoring of water quantity and flow rates on the Kandik, Nation and Yukon Rivers was initiated in 1992. Information for the Kandik and Nation Rivers was important because of potential development on private lands that would utilize water from the preserve. Yukon River data collection is part of a Canada–U.S. effort to collect long-term water quality information. Beginning in FY 98, spring, summer and fall data collection on the Kandik and Nation Rivers will be expanded to year-round data collection. The objective of this project is to continue the long-term monitoring plan.

Wrangell–St. Elias National Park and Preserve

In 1997 the park began a multi-faceted study to monitor the extent and effect of spruce bark beetle infestation in an 800,000-acre study area in the Copper River Basin. Study objectives were to:

- Complete a vegetation and infestation map of the study area using photointerpretation;
- Implement forest inventory plots to provide detailed descriptions of coniferous communities for a vegetation map and determine what factors are influencing the likelihood of infestation;
- Establish permanent plots to monitor the effect of bark beetle infestation on vegetation, structure and wildlife over time; and
- Conduct landscape analyses of beetle infestation and proposed management activities in relation to ownership boundaries, subsistence resources and agency management goals.

In the first year, park staff established sixty forest inventory sites, established potential long-term monitoring sites, and had aerial photography flown for ongoing photointerpretation and vegetation mapping.

The Mentasta Caribou Herd occupies the western and northern portion of the park and adjacent lands. These caribou are an important faunal component of the area and are highly valued for their intrinsic ecological, cultural and recreational roles. From a high of approximately 3100 animals in 1985, the herd began to decline, until in 1997 it was estimated to consist of only 614 individuals. The primary reason for the decline appeared to be poor calf survival and recruitment, as shown by summer and fall monitoring surveys and a preliminary study of radio-collared cow caribou. Factors such as habitat deterioration or hunting did not seem to be involved. In 1993 the park initiated a study to determine calf survival rates and causes of mortality. This research was a cooperative effort between the NPS and the USGS-BRD. Using aerial surveys and radiotelemetry, biologists determined

the proportion of pregnant cows, calf survival and causes of calf mortality. Pregnancy rates remained high (approximately 80–90%), but calf survival was low (5–25%). Predation by wolves and brown bears accounted for the majority of calf mortality.

Before the park was established, all-terrain vehicles (ATVs) were employed, and their use continues. Where the use level is high, trails have formed and impacts to the landscape, drainage and vegetation have developed. In an assessment of ATV impacts, researchers examined the relationships between ATV impacts on vegetation and soils and the amount of use, the vegetation type, the soils and permafrost. Impacts of ATVs vary significantly between both vegetation and soil types. Natural and geosynthetic materials were tested for their ability to mitigate impacts on ATV trails in mixed shrub–sedge tussock bogs underlain by permafrost. Six hardening treatments were tested on heavily and moderately impacted trails. Post-installation monitoring, which began in 1996 and will continue, shows that all treatments are able to withstand ATV traffic while allowing regrowth of vegetation.

A vascular floristic inventory of 13 million acres in the park was initiated in 1994 and completed during 1997. Site selection emphasized areas with unique lithology and geomorphology, areas with no previous botanical collections, and communities known to have sensitive and endemic taxa. Inventory results are in preparation.

The USGS and park staff conducted a geochemical investigation of mineral properties within the park and preserve. In most of the mineralized areas the extent of metal contamination and baseline geochemical signatures were unknown. The goals of the study were to quantify the modern-day effects of historic mining activity on stream sediment and surface waters at Nabesna, Bremner and Kennecott, determine a geochemical baseline at Gold Hill where small-scale placer mining is active, and develop a geochemical baseline in mineralized, unmined areas at Orange Hill and Bond Creek. Stream sediment, water and rock samples collected from these areas are being chemically analyzed for more than 50 elements, such as antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum and zinc. Parameters measured at water sample sites include pH, conductivity and flow. Differences in pH and conductivity are directly related to the different geologic settings of the areas. Carbonate rocks are common around Kennecott and Nabesna deposits, and calcite is present in bedrock and veins at Bremner and Gold Hill. Carbonates tend to counteract acid-generating reactions caused by the breakdown of sulfide minerals such as pyrite and neutralize the solutions. Most metals are not mobilized in water under these higher pH conditions. In contrast, at Orange Hill and Bond Creek there is a lack of carbonate rocks and an abundance of finely dispersed pyrite and its breakdown products. The acidic waters are able to mobilize and carry metals in solution, resulting in higher conductivities and metal contents in waters at Bond Creek and Orange Hill.

Bureau of Land Management

The Federal Land Policy and Management Act of 1976 gives the Bureau of Land Management (BLM) responsibility for managing the land and resources of the public lands of the United States, including those in Arctic Alaska. Management is based on the principles of multiple use and sustained yield, a combination of uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources. These resources include soils, recreation, range, timber, minerals, watersheds, fish and wildlife, wilderness, and natural, scientific and cultural values.

	Funding (thousands)	
	FY 96	FY 97
Natural Ecology	1,500	2,500
Minerals Research	0	115
Cultural Resources	250	200
Pipeline Monitoring	500	550
Fire Control	350	350
Mining Administration	250	320
Total	2,850	4,035

The research work is typically site specific for identified problems, as opposed to research for the sake of expanding knowledge.

The BLM's focus has been shifting from commodity development through stages of multiple-use management and resource conservation to ecosystems management. The Department of the

Interior established the U.S. Geological Survey (USGS), Biological Resources Division, which is responsible for most of the Department's biological research (including the BLM's).

Breeding Bird Surveys

Three drainage systems were surveyed for all species of breeding birds as part of a nationwide effort to determine trends in North American bird populations. Surveys were initiated in 1996 with the establishment of a Breeding Bird Survey (BBS) route on the Unalakleet River, which flows into Norton Sound. In 1997 an additional route was established on the Anvik River, and a preliminary survey done on the Bonasila River. In 1998 the Bonasila will become a permanent BBS route. The BBS program was administered initially by the U.S. Fish and Wildlife Service (USFWS) and now by the Biological Resources Division of the USGS and the Canadian Wildlife Service. The objective of these surveys and the BBS program is to collect data on bird species and numbers throughout North America, which provides a source of standardized data on populations of breeding birds.

The BBS program has existed since 1966. Currently the BBS consists of approximately 3700 active survey routes throughout the continental U.S., Canada and Alaska. Each route is randomly located and 25 miles long, with 50 stops at half-mile intervals. All birds seen or heard within a quarter mile of each stop during a three-minute point count are tallied. For each species the total number of individuals counted along a route is used as an index of relative abundance. A trend analysis statistical procedure is used to produce an estimate of population change, or trend, presented as a mean percent change per year. In Alaska many routes are set up and run along rivers because of the lack of a road network.

Thirty-four species of birds have been recorded on the Unalakleet route, 42 on the Anvik route, and 54 on the Bonasila route. The Canada goose and common redpoll were the two most abundant species on the Bonasila River, while the Wilson's warbler and bank swallow were most abundant on the Anvik, and the blackpoll warbler and northern waterthrush on the Unalakleet River. The population trends of these species in these watersheds, most of which are migrants from Central and South America, can only be determined if annual surveys are continued.

Stream Analysis and Mining

Stream data were collected in June 1997 in the George River drainage, 75 miles southwest of McGrath. The project involved gathering geomorphic information to characterize the streams and creeks of the area to prepare a stream reclamation plan. The data will be used to reclaim Julian Creek to a pre-mining functional condition that will provide for fish passage and fish rearing/feeding areas.

Cooperation in Archaeology

On April 25, 1997, BLM-Alaska Director Tom Allen signed (as the first Federal signer) the "Multi-Agency Five Year Agreement with the State of Alaska, Office of History and Archaeology Concerning Support for Alaska Project Archaeology Program." This agreement formally established a cooperative relationship among various agencies and the State of Alaska, Office of History and Archaeology, for achieving mutual heritage education goals. This includes providing classroom curriculum enrichment materials about Alaska's heritage, such as its archaeological and historic sites in the Arctic, as well as throughout other parts of the state.

BLM-Alaska, in cooperation with the national Heritage Education office in Dolores, Colorado, co-authored the following publication for use by teachers (grades 4–7) in Alaska's schools statewide: *Intrigue of the Past, Discovering Archaeology in Alaska.* BLM is facilitating the distribution of this publication and is helping with the multi-agency effort to train teachers in the use of this and other educational materials in their classrooms. These publications and other efforts are designed to foster a better public understanding of the importance of protecting archaeological and historical resources in Alaska and elsewhere for their educational and other benefits.

National Petroleum Reserve–Alaska Studies

In February 1997 the Secretary of the Interior announced the beginning of an Integrated Activity Plan (IAP)/Environmental Impact Statement (EIS) for 4.6 million acres on the northeast corner of the National Petroleum Reserve–Alaska (NPRA). An 18-month time frame was given to accomplish this task.

The NPRA sits atop Alaska and the continent. The Arctic Ocean, with the Chukchi Sea west of Point Barrow and the Beaufort Sea to the east, forms the northern boundary of the reserve. The eastern and southeastern boundary follows the western bank of the Colville River from its mouth at Harrison Bay to the confluence of the Etivluk River. Here the boundary plunges due south to the Continental Divide at the crest of the Brooks Range. The boundary follows the divide westward to a point due south of Icy Cape. A line from that point to Icy Cape makes the western boundary.

There are three predominantly Inupiat Eskimo villages in the area of particular interest: Barrow, with a population of over 4000; Atqasuk, with a little over 200; and Nuiqsut, with just over 400.

The planning area consists of primarily coastal plain—wetlands with many lakes. It is totally underlain by permafrost. The entire area is important for subsistence. The northern third is high in resource values. It is a key area for nesting and molting migratory waterfowl and is the location of a Teshekpuk caribou herd calving area. It is also potentially high in oil and gas resources.

The planning effort is being conducted with the cooperation of the Minerals Management Service (MMS), which has extensive experience developing EISs on nearby areas. Work on this EIS has occurred in an exceptionally open and cooperative environment, featuring an on-going dialogue among all interested groups and including the State of Alaska and the North Slope Borough as active partners in the document's preparation. Other Federal agencies have been actively involved in reviewing various sections of the draft document, including the USGS, the Natural Resources Conservation Service and the USFWS. Various public groups and organizations have received scoping or update briefings from BLM management in Alaska as well.

Substantial effort has been made to apply the best available science to the process:

- The interdisciplinary team who prepared the draft conducted a science symposium to capture all the latest scientific information. Nationally known specialists in Arctic science from industry, USFWS, Alaska Fish and Game, University of Alaska, Ducks Unlimited and the North Slope Borough attended and provided that information.
- A special workshop on caribou and waterfowl was held to bring specialists from Federal, state and local governments together to discuss what is known about the relationship of oil and gas development and the various species of waterfowl and caribou. The product of the workshop was a set of stipulations to be included in the various alternatives addressed in the draft document.
- The Secretary visited the NPRA this summer to obtain a personal understanding of the issues, the country and the people involved.
- A special subsistence workshop was held on the North Slope to tap the store of traditional knowledge and scientific information held by the North Slope people.
- A process for peer review was established in conjunction with the USGS (using specialists from a variety of Federal agencies) and with the State of Alaska.

The draft analyzes the impacts of five alternative management schemes and contains an analysis for impacts on subsistence as required by section 810 of the Alaska National Interest Lands Conservation Act (ANILCA). The alternatives cover management of all resource values in the area. They include opening or not opening all or parts for oil and gas leasing and options for designating the Colville River as a Wild and Scenic River (with the suitability determination yet to be made). They include various management options for use and/or protection of resource values and include the use of stipulations to reduce potential impacts.

The EIS process is still on track for a July 1998 decision. The draft EIS was made available for public comment in December 1997. The comment period ended March 12, 1998. The draft EIS did not contain a preferred alternative. This is so the decision will reflect the best public interest in view of all the information available. Current project planning calls for a final EIS to be made available by June 26, 1998, with the Record of Decision published by July 31, 1998.

The draft was made available to the public via the Internet on November 24, 1997. The use of a web page has provided an innovative approach to public access of project information. Visit the home page at http://aurora.ak.blm.gov/npra/

Mineral Land Assessments

In February 1996 the Alaska staff of the U.S. Bureau of Mines (USBM) was transferred to the BLM with a mandate to conduct mineral assessments under the auspices of ANILCA, section 1010.

Industrial Minerals

In 1995 the USDA Forest Service (USFS) and the USBM entered into a three-year interagency agreement to conduct a survey of the mineral materials located within the Chugach National Forest (CNF), Alaska. When the USBM Alaska personnel were transferred to the BLM, the interagency agreement was transferred also. The field work for the project was conducted by the BLM in 1996. The intent of the project was to determine the location, accessibility, quantity and quality of mineral material sources. Sources of materials for aggregate, shot-rock, riprap and other common varieties used in the construction industry were the main focus.

Two major areas of interest were identified during the preliminary literature search: the Kenai Peninsula study area and the Cordova study area. These areas are located along existing transportation systems and are identified with major ongoing and proposed road construction activities. Field work in 1996 was limited to the road corridor of the Seward and Glacier Districts on the Kenai Peninsula.

During 1996 the BLM conducted a 40-day field season mapping and sampling 27 material sites and gravel deposits in the Kenai Peninsula area. To identify potential new material sources, "grass roots" exploration was conducted in areas with no previous mining or gravel extraction. Work was restricted to the areas along the existing roads, highways and trail systems. A total of 67 samples were collected. Ground-penetrating radar geophysics tests were performed at 12 sites to aid in determining the depth to the water table and/or bedrock.

Two reports were prepared and delivered to the USFS in early 1997: *Mineral Materials Survey of the Seward and Glacier Ranger Districts Road Corridor, Chugach National Forest, Alaska: Volume I. Summary and Site Descriptions* and *Volume II. Application of Ground Penetrating Radar to Site Delineation and Reserve Estimation*.

Mineral Investigations of Native Land Selections

During the summer of 1997 the BLM completed field work on a one-year mineral assessment of Ahtna, Inc. selections within the Wrangell–St. Elias National Park and Preserve, Alaska. The assessment was conducted to provide Ahtna, Inc. the necessary minerals information to finalize their regional selections within the park (as requested by the National Park Service).

Through a literature search and field investigation, the BLM identified mineral occurrences located within a one-mile radius of the Ahtna, Inc. selections. Of these occurrences, 9 were historically producing mines, 25 development prospects, 21 exploration prospects and 9 raw prospects. The majority (55) were hard rock deposits and 9 were placer deposits. Mines, prospects and occurrences were sampled to aid in determining the type, amount, distribution and economic viability of mineral deposits located on Ahtna-selected lands within the park boundary. A report was completed in the second quarter of FY 98.

Tongass National Forest Mineral Assessments

Studies of the mineral development potential of mining districts in southeast Alaska are continuing at the request of the USFS. The objectives of the Chichagof–Baranof and Stikine area studies currently underway are to identify the type, amount and distribution of mineral deposits, determine ore reserves, complete economic feasibility studies, and address the economic and environmental effects of mineral development.

The Chichagof–Baranof study was initiated in 1995. Field work for the study was completed in 1997. Two reports detailing work accomplished in 1995 and 1996 have been completed and released. The draft of an economic feasibility report on two mineral deposit types in the Chichagof–Baranof area was released in the fall of 1997. The final Chichagof–Baranof report is due to be completed in the summer of 1998.

The Stikine area mineral assessment, encompassing the Wrangell and Petersburg forest areas, was initiated in 1997. A report detailing the first year's activities as well as background information on land status, geology, mining history and previous studies and a bibliography will be completed during FY 98. Current plans call for the Stikine mineral assessment to be completed in 1999. Yearly reports are anticipated along with a comprehensive final report to be completed in 2000.

Upper Koyukuk Mineral Assessment

The Upper Koyukuk mineral assessment is an examination of Federal, state and Native lands. The program is a comprehensive study of past and current mining activities as well as future mineral development potential in the Koyukuk Mining District.

The district comprises approximately 11.6 million acres drained by the upper Koyukuk River and the Kanuti River. The region contains over 320 known mineral properties, including placer and lode gold, copper, tin, tungsten and massive sulfide sites.

Collecting GPS data from the workings of the Clear Creek Mine.

The four-year program will include literature and records searches, an airborne geophysical survey, geologic field investigations, and construction of an extensive mineral database for the district. Results will be made available to the public in three open-file reports. During the 1997 field season, approximately 30 sites were visited and 264 samples collected for analysis. The sites included historic and active placer mines, an underground placer mine, and other areas of potential mineralization.

Geophysical Surveys

In 1997 an airborne geophysical survey of mineralogically prospective areas in the Wrangell and Petersburg areas was conducted. The objective of the survey was to define mineral exploration targets, refine geologic maps, enhance the BLM's current mineral assessment, and spur economic activity in the area. Funding for the study included $300,000 of carry-over funds from the BLM and $200,000 from Wrangell's share of the Southeast Alaska Economic Fund. Survey contract administration was provided by the State of Alaska, Division of Geological and Geophysical Surveys (ADGGS).

A geophysical survey of potentially mineral-bearing areas in the vicinity of Wiseman, Alaska, began in August 1997. The instruments being used include a magnetometer and an induced electromagnetic conductivity sensor operating in five frequencies. Approximately 530 square miles were covered, with lines flown at quarter-mile spacing. The project participants include the BLM and the ADGGS. The BLM has supplied funding in the amount of $220,000, and ADGGS provided contract administration and management. The results of the survey were slated to be available to the public in the spring of 1998.

Abandoned and Inactive Mine Inventory

The BLM is examining abandoned and inactive mine (AIM) sites in the Tongass National Forest (TNF) and CNF for the USFS as part of an interagency agreement initiated in 1990. Project work was started by the USBM and subsequently transferred to the BLM in February 1996. To date, 109 sites have been examined for physical and chemical hazards in the TNF and 137 sites evaluated in the CNF. Work in 1997 included returning to seven significant AIM sites in the TNF and performing an integrated site assessment to more clearly define the chemical hazards present. Inventory-level sampling was completed at three AIM sites. Inventory work was conducted at several AIM sites in the CNF during 1997 to establish consistency with the previous evaluations and facilitate a comprehensive prioritization for AIM sites in both forests (TNF and CNF together comprise USFS Region 10).

The BLM has provided individual site files for the 109 sites evaluated in the TNF. Presentation packets including a narrative summary for all sites was also provided. Oral presentations detailing results and prioritization of sites were given to Chatham, Stikine and Ketchikan district personnel in 1996 and 1997. Future work includes additional integrated site assessment and removal preliminary assessment reports at high-priority AIM sites. BLM personnel will provide additional data as requested by the USFS.

Geologic Analyses and Studies

The Energy and Minerals Team is participating in the geologic analyses of three parts of the Arctic. Recently announced oil and gas discoveries with their subsequent development plans have implications for disposition of Federal minerals.

A geologist and a geophysicist from the Energy Minerals Team are working with USGS geologists to determine the nature and extent of the economic bedrock geology beneath the Arctic National Wildlife Refuge. This includes areas defined under sections 1002 and 1008 of ANILCA. Analysis of seismic data and field geology suggests that this is a predominantly clastic stratigraphic section and is of lower Paleozoic age.

Both onshore discoveries and offshore exploration drilling on Alaska State leases affect the Arctic National Wildlife Refuge 1002 area. Geological and

seismic analyses of recent exploration activity shows that features similar to those currently garnering industry interest extend and exist beneath the 1002 area. As a result these analyses show there is potential for drainage of Federal leasable minerals when recent discoveries, such as at Sourdough well, begin producing. However, it is determined that no drainage will occur until these Alaska State leases begin producing. Currently announced industry plans do not project development on these State leases before 2001.

Other geological investigations of northeastern Alaska stratigraphy and biological marker compound geochemistry of oils show that three separate petroleum systems are present and have generated oil that has subsequently charged potential reservoirs. Prudhoe oils of the Ellesmerian System are present in the subsurface of the northwestern portion of the 1002 area. Surficial oil seeps and oil-stained sands belonging to the Hue-Sagavanirktok System are present across the 1002 area from Katakturuk Creek to Manning Point and the Niguanak area. The oil seep at Angun Point does not match any of the previous oils. Oil at Angun Point is speculated to be from a third independent petroleum system generated by Tertiary rocks offshore. This work will be included in *Short Notes on Alaskan Geology*.

The Integrated Activity Plan (IAP) for the NPRA involves the Energy and Minerals Team at several levels. Team members and MMS geologists and geophysicists defined potential plays for the reserve and determined both in-place and recoverable oil and gas reserves for its northeast portion. Geologists and geophysicists are interpreting well logs and seismic data to delineate the extent of newly defined plays to determine how they affect potential lease tract values. All tracts are being analyzed to determine geologic parameters needed as inputs to calculate minimum acceptable lease values. In addition, potential lease play definitions and descriptions are being prepared for the remaining parts of the reserve not originally included in the IAP. Both in-place and recoverable resource numbers will be determined, but tracts in the remaining part of the reserve will not be analyzed at this time.

The Energy and Minerals Team participated with geologists from the USGS and the MMS in field work in the westernmost Brooks Range. Understanding this surficial geology has application in defining plays in the Chukchi Sea lease areas and the western NPRA. In addition, the regional geological analysis ties in with understanding the nature and disposition of several potentially large base metal deposits found in the southernmost NPRA.

Geochemical analyses of oil shows found in the Chukchi Sea exploration program show that the oil does not resemble any of the currently described North Slope oils. There is an enigma, however, because the oil is most likely generated from the same source rock that generated a significant portion of the Prudhoe oil group. Chukchi Sea oil bears a strong correlation to oils found in the Sverdrup Basin of the Canadian Arctic Islands. A pre-rift re-rotation of land masses juxtaposes the Chukchi area to the Sverdrup basin during pre-Jurassic time. This geometry suggests a larger area may be prospective for oil. These data will be included in *Short Notes on Alaskan Geology*.

Geological Survey

In FY 94 the Fish and Wildlife Service and the National Park Service Arctic research programs were transferred to the National Biological Survey (later National Biological Service) (NBS), a new bureau constituted by combining the biological research functions of a number of Department of the Interior (DOI) bureaus. As a result of the FY 97 Appropriations Act, the NBS was transferred to the U.S. Geological Survey and became the Biological Resources Division (BRD).

The BRD conducts research in the Arctic to generate information that will help DOI agencies

	Funding (thousands)	
	FY 96	FY 97
Energy and Minerals	4,500	2,625
Natural Hazards	3,500	2,625
Global Change	2,500	750
Marine and Coastal Geology	1,000	188
Geomagnetism	250	250
Ice and Climate	480	188
Hydrology	130	100
Mapping	1,070	563
Marine Mammals	1,660	1,660
Migratory Birds	2,390	2,390
Fisheries Research	360	360
Cooperative Research	330	330
Terrestrial Ecology	1,130	1,130
Park Research	1,140	1,140
Total	20,440	14,299

Bull caribou in fall looking out on its winter range, northern edge of Denali National Park and Preserve, Alaska.

in Alaska meet their resource management responsibilities. These responsibilities include the conservation of migratory birds, certain marine mammals, endangered species, anadromous fishes and all biota inhabiting National Wildlife Refuges and National Parks and Preserves. Research addresses the effects of development, disturbance, hunter harvest and natural environmental cycles on fish and wildlife populations. Other research seeks to develop improved census and survey methods that will better detect trends in populations. All research has the ultimate goal of providing information that will lead to better management decisions and actions to promote conservation of living resources in the vast ecosystems of the Arctic. Fish and wildlife populations in the U.S. Arctic are extensively shared with Canada and Russia, and a portion of the research effort is directed toward treaty and other international requirements to jointly manage shared resources.

Most Arctic research of the BRD is conducted from the Alaska Biological Science Center (ABSC), Anchorage, and the Cooperative Research Unit at the University of Alaska Fairbanks. Some additional research is performed by others of the 15 national research centers or the more than 50 cooperative research units, each of which has special capabilities that may be applicable to problems in Arctic research.

Ecological research in Arctic ecosystems is difficult, given the harsh conditions, frequently inaccessible habitats and often wide-ranging movements of Arctic biota. It is also very costly. Since it has often been necessary to develop new methods of obtaining information, some of the most advanced technologies have been developed for, or first applied to, research in the Arctic. Satellite-linked biotelemetry and molecular genetics are but two of many new techniques that have been successfully applied to the problems of fish and wildlife conservation in the Arctic.

Wildlife Ecology

Research on the unmanipulated wolf/prey community of Denali National Park and Preserve (DNPP) has continued unabated since 1986. BRD scientists, in cooperation with the National Park Service (NPS), are currently studying the population dynamics and predator/prey relationships of gray wolves and caribou and are planning in FY 98 to launch new research on moose, the other major prey of wolves in DNPP. To date, the studies have provided new information on the population dynamics, predation behavior, social structure and genetic relationships of wolves; the population dynamics, reproductive performance and calf survival patterns for caribou; and the influences of weather and landscape use patterns on wolf/caribou relationships. During these studies, wolf density increased from below 4.0 wolves/1000 km^2 during 1986-87 to 7.8 wolves/1000 km^2 by 1990, with the onset of a six-year period of above-average snowfall. Caribou numbers increased from 1986 to 1989, reaching about 3200, then declined precipitously to around 2000 animals by 1993 as a result of high losses of calves to predation (primarily wolves and grizzly bears) following the severe winters and increased mortality of adults during the severe winters. Since 1993, wolf numbers have declined to about 5.5 wolves/1000 km^2 with the decline in caribou and a return to near-average snowfall, while the caribou numbers have stabilized at 2000. Although biologists only conducted moose censuses every five years during this period, it appears that moose numbers have stayed relatively stable.

Denali National Park and Preserve also supports a naturally regulated grizzly bear population that has not been subject to harvest for at least 80 years.

Grizzly bears are an important visitor attraction in DNPP, and the impact on bears from efforts to improve visitor access to the park is a primary concern. NPS managers suspect that current human access alters grizzly bear distribution within some portions of the park. Public pressure for more access into Denali along current routes is constant, and alternative access points are proposed on both the north and south sides of the park. Continued human developments adjacent to the eastern boundary of the park are fragmenting bear habitat. Sport harvest of grizzly bears east of the park has been very intensive in the past, and reduction in bear density is the objective of the current harvest program in the State of Alaska's Game Management Unit 13, southeast of the park. There is concern that intensive harvest and habitat fragmentation may eventually alter natural gene flow. Grizzly bears are specifically mentioned in the park's enabling legislation, and protection of the grizzly bear population is an important concern of park administrators. This combination of threats and responsibilities resulted in the need to:

- Understand grizzly bear population ecology and identify intrinsic and extrinsic factors that drive bear population dynamics, especially those that could be altered by human activities;
- Identify the natural variation in population parameters to assist in identifying human-caused perturbations; and
- Develop cost-effective, non-invasive methods to monitor the grizzly bear population.

Beginning in 1991, NPS and BRD biologists chemically immobilized grizzly bears from a helicopter and placed radio collars on 28 female and 30 male bears, not including dependent young. The female age distribution was bimodal, with no females between the ages of 9 and 16. Annual survival rates of independent bears were high—above 95% for both males and females. The average litter size of newborn cubs was high (2.2 cubs), and the average age of young at the time of family breakup was typical for Alaska grizzlies (3.0 years). The average annual survival rate of dependent newborn cubs and yearlings was unusually low, however, and is the subject of ongoing research. Naturally regulated grizzly bear populations may be characterized by high but variable dependent bear mortality, periodic recruitment and a dynamic female age structure, at least in sub-Arctic environments such as interior Alaska.

Berry availability and quality may be factors driving grizzly bear population dynamics on the north flank of the Alaska Range. Fall nutritional status affects both female bear fecundity and cub survival. In this area, fall nutritional status is largely dependent on berry availability. The primary berry sources in the study area are blueberry, crowberry and soapberry. The objectives of this study are to determine the distribution patterns for these plants, measure the interannual variation in berry crops, and determine the nitrogen content and relative importance of plant nitrogen fixation to bear diet. This study is part of a larger ABSC grizzly bear ecosystem research project in DNPP. Biologists are using the data to evaluate the relationship between berry availability and bear population dynamics. The primary study area covers 1750 km^2 in the western part of the park on the north flank of the Alaska Range. BRD biologists used aerial surveys of the study area, ground checks and data on bear movements and foraging from radio-collared bears to assess the distribution patterns of soapberry, blueberry and crowberry plants and to select areas for monitoring berry crops. They specifically looked at the distribution of soapberry plants in relation to moraines and outwash of known age of the Muldrow and Foraker Glaciers. They established 29 permanent transects to measure soapberry, blueberry and crowberry crops. Soapberries, blueberries and crowberries were collected near the transects and divided into a whole berry sample and a seed sample. These samples were analyzed for total nitrogen and stable nitrogen isotope ratios. The study area contains extensive stands of soapberry plants on neoglacial moraines of the major glaciers and smaller stands on glacial outwash. Blueberry and crowberry plants are abundant throughout the study area and include patches with up to 1000 m^2 of continuous blueberry cover. The soapberry crop was consistently good in 1994–1997. Berry counts on transects showed considerable variation among bushes, but individual bushes had similar crops each year. Overall observations of the blueberry and crowberry crops and counts along transects in 1994–1997 showed small productive patches within a matrix of unproductive bushes. The blueberry crop was 50% higher in 1995 than in 1994; the crop was poor in 1996, followed by a large crop in 1997. Crowberries were virtually absent throughout the study area in 1994 but had good crops in 1995–1997. Soapberries may be important to bear fall nutritional status in this area. In 1994 both soapberries and blueberries were available in the study area, but grizzly bears fed primarily on soapberries from late July until snowfall. Soap-

berries in this area offer efficient foraging and a relatively high protein content. The large soapberry stands occupy a unique place in space and time in the study area ecosystem. They occur on relatively recent glacial moraines, where they are the primary nitrogen fixers. This successional pattern differs from many other areas of Alaska, where alders or *Dryas* sp. are the primary nitrogen fixers.

BRD biologists investigated the effect of vehicle traffic on the Denali Road in DNPP on Dall sheep seasonal migration during 1995–1997. Several sections of the park road intersect sheep migration corridors between the Alaska Range and the Outer Range. Sheep leave typical escape terrain and travel up to 10 km through valley shrub habitat and conifer forest to reach these seasonal ranges. Occasionally road traffic has interrupted the sheep's attempts to cross the road. This study was conducted to determine the timing of migration; the number, sex and age class of migrating sheep; sheep and vehicle driver behavior at road crossings; and whether thwarted attempts to cross the road occur often enough to alter or jeopardize migration patterns. Aerial surveys were conducted to determine sheep abundance before, during and after spring migration. Biologists documented migration attempts through daily observation of staging areas and known migration trails and recorded detailed information on sheep–vehicle interactions at the road. To supplement direct observations, they used infrared-triggered cameras and time-lapse cameras to photograph sheep traveling on trails through migration corridors. Spring migration attempts were observed as early as 12 May 1996 and as late as 7 July 1997. Group size ranged from 1 to 62 individuals. Generally, group composition was either ewes with younger animals or rams, although occasionally adult rams traveled with ewe groups. Sheep that migrated prior to mid-June were ewe groups of 1–4 individuals or rams. Larger ewe groups with lambs initiated migration during the third week of June. Overall, spring migrations occurred at various times of the day, with sheep approaching the road between 0400 and 2000 hours. Unsuccessful migration attempts, in which sheep retreated from the road and returned to their winter range, were observed each spring. In most cases these sheep were successful in later attempts to cross the road. Observed fall migration attempts occurred between 23 August and mid-October. Group size ranged from 1 to 32 individuals. Ewe and ram groups migrated separately. Sheep approached the road at various times of the day between 0800 and 2100 hours. Although there were no thwarted attempts to cross the road during fall migration, ram groups were delayed by the road for up to 7.5 hours due to traffic.

For the 10th consecutive year the NPS, in cooperation with the BRD Forest and Rangeland Ecosystem Science Center (FRESC), Corvallis, Oregon, collected data on the reproductive characteristics of golden eagles in DNPP in 1997. Using two aerial surveys, biologists monitored 72 golden eagle nesting areas in the northeastern portion of DNPP. Territorial pairs occupied 63 nesting areas, resulting in an occupancy rate of 88%. Laying rate was 71%, with 45 territorial pairs producing eggs. Nesting success, measured as the number of laying pairs raising one fledgling, was 73%. Thirty-six successful pairs raised 57 fledglings. The overall population production, measured as the number of fledglings per territorial pair, was 0.90. This was the second highest year for golden eagle productivity in the study area in 10 years. Since 1988 the overall annual reproductive output of golden eagles in DNPP was influenced most strongly by the proportion of pairs that lay eggs. Laying rates for golden eagles in DNPP are highly correlated with numbers of snowshoe hare and willow ptarmigan observed on the study area.

In 1997 the FRESC and NPS biologists began to examine the behavior and movements of juvenile and subadult golden eagles from natal areas in DNPP. Using satellite radiotelemetry they are collecting data on eagle movements during post-fledgling periods, migration, winter and subsequent summers. In late July and early August 1997 (after nestlings were more than 60 days of age) they deployed 22 satellite radio transmitters (PTTs) on juvenile golden eagles. PTTs were deployed on 12 females and 9 males at 14 nests (14 siblings, 7 singles). PTTs were attached to juvenile eagles using a backpack harness constructed of Teflon ribbon. The entire package weighed about 102 grams (less than 3% of the total body weight of the eagles). The duty cycle for all PTTs is 8 hours on and 72 hours off; PTT life is estimated at 3 years. They are using the Service Argos Data Collection and Location System to obtain locations of the radio-tagged eagles. The ABSC is assisting with data collection.

An integrated watershed approach to long-term ecological monitoring has been under development at DNPP since 1992. The DNPP monitoring program is being developed as a prototype for other parks in the sub-Arctic. Because of minimal information on variability and interactions among sub-Arctic biota and different environment vari-

ables, a multidisciplinary sampling approach has been used. Early efforts have been concentrated in and around a single watershed—Rock Creek, a readily accessible headwater stream near park headquarters. Pilot studies have tested techniques and documented variability for methods in air quality, weather, stream water chemistry, hydrology, soils, vegetation, stream invertebrates, and bird and small-mammal populations. These individual efforts have provided significant insight into what might be effective approaches to monitoring within single watersheds.

Current research is focused on integrating watershed findings and scaling to additional watersheds. Additional approaches to monitoring key biological and environmental changes at various levels of scale from the watershed to the full six-million-acre park and beyond are also being investigated. In addition, stronger links between the long-term environmental monitoring program and tactical short-term management needs are being forged.

A coastal brown bear study in Katmai National Park and Preserve (KNPP) was recently completed after seven years of field work. The project was a cooperative effort of the Alaska Department of Fish and Game, the NPS and the BRD. Research objectives included an estimate of the bears' reproductive histories and population dynamics, their movements and distributions, and habitat relationships. Preliminary data analyses have identified significant differences in the population dynamics of this population of unhunted bears compared to nearby hunted areas, where at KNPP there are more adult males to females, adults have a higher mean age, cubs experience a lower survival rate and females are less productive (litter size). Additionally, biologists have found KNPP bear densities to be the highest ever reported (550/1000 km^2), and although home ranges for some KNPP female brown bears are the smallest ever reported (less than 10 km^2), some of KNPP's female bears traveled less than 240 km annually to and from summer ranges. KNPP brown bears exploit a wide range of food resources, including mussels, clams and a host of invertebrates exposed only at low tides. Biologists also conducted studies that focused on bear–habitat relationships. Preliminary findings support the notion that bear habitat quality is chiefly a function of nutrient resource availability and that nutrient resource maps may prove acceptable indicators of bear habitat suitability. Additional work at KNPP has focused on bear–human interactions at various backcountry locations. Findings have shown that although human activity may highly influence bears' patterns of use, bears are able to adequately access salmon resources. Work is ongoing to map vegetation communities, salmon resource availability, and other nutritional resources so that managers can better understand bear–habitat relationships.

Research conducted on the Arctic coastal plain of the Arctic National Wildlife Refuge (ANWR) in northeastern Alaska addressed the potential impacts of petroleum development on the ecology of this unique wilderness environment. Biologists designed research at the landscape level to encompass the 2.5-million-acre coastal plain of ANWR. The Porcupine Caribou Herd uses this area as its primary calving ground. Snow geese breeding on Banks Island stage in this area in the fall. Polar bears den on the area's Beaufort Sea shoreline. The area hosts a resident population of muskox. The research incorporated the relationships of these fauna to the habitat of the coastal plain. Using remote sensing, biologists developed a vegetation map of the coastal plain from Landsat thematic mapper and ground survey checks. This map, which has 16 land cover types, has been the basis for assessing habitat use and value. Additionally, remotely sensed data on vegetation growth rates from the normalized difference vegetation index (NDVI) derived from the advanced very high resolution radiometer (AVHRR) on polar-orbiting satellites provide the opportunity to assess the habitat conditions of the coastal plain for caribou and other species during the non-winter period. These data allow biologists and managers to link growing-season vegetation changes with caribou habitat selection. With the growing concern over global climate change, these landscape-level relationships could provide the basis for monitoring changes that may be occurring. Preliminary analysis of NDVI and caribou calf survival shows a marked relationship (85%) between onset and rate of spring growth and neonatal mortality. Additional analyses and continued research will be necessary to determine the causal relationship inferred and to predict the impacts of vegetation changes engendered by global warming.

Fisheries Research

Fisheries biologists from the ABSC are conducting a detailed study of the ecology and survival of chum salmon in Yukon River tributaries in Alaska. This research was initiated in 1996 in response to an information need of Federal and state land managers for a better understanding of

the factors controlling chum salmon production. Some runs in the Yukon River watershed have diminished to the point where important commercial and subsistence fisheries have been limited in recent years. The primary hypothesis being tested is that, in general, the severity of winter weather determines the number of chum salmon smolts moving downstream each spring. To evaluate the hypothesis, biologists are intensively studying sections of selected Yukon River tributary streams to assess the number of adults entering the sections, the density of healthy eggs and fry incubating within the sections, and the number of fry emigrating from the sections. Estimates of stage-to-stage survival will be made from these observations. The survival estimates can then be correlated with environmental variables (for example, temperature, snowfall, ground ice and extent of upwelling subsurface water) to examine to what extent the environment determines freshwater production of chum salmon. Research will continue through 2000 so that annual variation can be assessed. The results should improve the capabilities of Federal and state fisheries biologists in predicting run sizes, allowable harvests and optimal spawner escapements.

Migratory Birds

The black brant is a sea goose that depends on coastal habitats from high Arctic nesting sites in Canada, Alaska and Russia to primary wintering areas in the Pacific coastal states, the Baja California peninsula and mainland Mexico estuaries. Concern about the species stems from a long-term downward trend in winter populations and the degradation and loss of important staging and winter estuarine habitats from commercial and recreational development and disturbance. Other factors that may be limiting population recovery include harvest and predation at nesting colonies in Alaska.

The ABSC, in cooperation with the FWS, the Canadian Wildlife Service, Nature Reserves (Russia), the Bureau of Land Management, and the University of Alaska Fairbanks, has been working on various aspects of the life history of black brant for over a decade. More recently the Japanese Association for Wild Geese Protection (a private conservation organization), Ducks Unlimited Inc., and Ducks Unlimited (Mexico) have joined this international effort to understand the population dynamics of black brant. Several studies were recently completed, including an assessment of the demographic characteristics of molting brant on Alaska's North Slope, and seasonal and annual survival of adult brant.

Brant that lose their clutches or do not nest undertake a molt migration, usually in late June, to secluded areas in the high Arctic. They congregate in large numbers on molting areas for a month or more until new flight feathers are grown. Important molting areas have been discovered on Alaska's North Slope near Teshekpuk Lake and Wrangel Island, Russia. These areas, dominated by large freshwater lakes and ocean estuaries, provide essential habitat for tens of thousands of brant from many nesting colonies during the annual wing molt. A six-year capture–mark–recapture study of brant that molt in the Teshekpuk Lake area revealed that brant originated from ten nesting colonies in Canada and Alaska. The captured birds were 76% adults and 57% males. Ninety-one percent of known-age recaptures were less than six years old. Fewer one-year-olds and more two-year-olds were present than expected. Sixty-one percent of adult females were failed breeders. Brant that were captured in more than one year showed high site fidelity to lakes where they were originally banded, a behavior that may have evolved if survival is enhanced because of few predators, low human disturbance and abundant food and cover. These criteria are met in the Teshekpuk Lake area, where few predators of brant exist, anthropogenic disturbances are limited, extensive grass–sedge foraging sites providing nutrient-rich foods are abundant, and escape cover is extensive. The Teshekpuk Lake brant molting area is within a larger block of land in the National Petroleum Reserve–Alaska that is under consideration for petroleum leasing.

An eight-year study of seasonal and annual survival of adult brant was based on resightings of leg-banded birds at nesting colonies in western Alaska; at major spring and fall staging habitats on the Alaska Peninsula, the Strait of Georgia in British Columbia, and Humboldt Bay, California; and wintering areas in Baja California. Seasonal survival was the same for males and females. The mean monthly survival rate was lowest in late spring migration (mid-April to early June)—the period of greatest subsistence harvest on the breeding grounds in Alaska—and highest in winter (early January to early March)—the period of greatest sport harvest. The annual survival rate did not vary among years, averaging 0.840 from 1986 to 1993. Biologists concluded that subsistence harvest likely is the most important factor controlling the size of the population, and reductions in the

harvest on the Yukon–Kuskokwim Delta, Alaska, would result in an increased number of breeders and geese in the population.

Brant demographic and survival studies were made possible because more than 40,000 birds have been marked with alphanumeric-coded plastic leg bands. Incidental to these studies was the discovery of a previously unknown wintering area for Alaska birds. Colleagues working on Hokkaido and Honshu Islands in Japan observed three brant with leg bands that had been affixed to hatching-year birds from a nesting ecology study on the Yukon–Kuskokwim Delta in western Alaska. In addition, an after-hatching-year bird from the Prudhoe Bay area of Alaska was discovered among flocks on Kokkaido Island. Biologists examined weather patterns and speculate that these brant take a westward transoceanic flight route from their primary fall staging area at Izembek Lagoon, Alaska, to the islands of Japan, where they mix with wintering birds from high-Arctic Russia.

Satellite telemetry has proven to be an effective tool in tracking long-distance migrants during annual flights from nesting to wintering areas. The ABSC has pioneered the use of this technique to better understand migration timing, migration routes and corridors, staging habitat locations and migrant survival. Tundra swans nest in western Alaska (on the Alaska Peninsula, the Yukon–Kuskokwim delta and the Seward Peninsula) and across the Arctic Coastal Plain from Barrow east through the Canadian high Arctic. Even though the swans are conspicuous, biologists and managers have a poor understanding of tundra swan migration pathways. The movements of satellite-marked tundra swans were tracked during autumn and spring migration between the outer Yukon–Kuskokwim delta and wintering areas in California. Marked swans migrated eastward across the delta during early October. After crossing the Alaska Range, swans stopped briefly on the Susitna Flats of Upper Cook Inlet. They then migrated eastward into the Yukon, Canada, and from there flew southward, paralleling the Wrangell Mountains through the interior of the Yukon to a staging area in northeastern British Columbia. They gradually migrated through central Alberta and southwest Saskatchewan and across Montana to a staging area in southeastern Idaho. Swans remained in Idaho from mid-November until early December, when they migrated across Nevada to the Sacramento–San Joaquin delta of California. Spring migration routes were similar to those used in autumn.

The Colville Research Station, a collaborative effort between the FRESC and the FWS, has operated as a remote field camp on the Colville River delta in northern Alaska since 1987. Its primary mission is to provide scientific information needed in the conservation and management of Arctic-breeding birds and the ecosystems on which they depend. The Colville River delta provides some of the best habitat for breeding waterbirds (tundra swans, geese and loons), breeding shorebirds and fall-staging shorebirds in northern Alaska. FRESC biologists have completed studies on tundra swan productivity, habitat use and parental care; mating strategies of the rock ptarmigan; spectacled eider productivity and habitat use; and the use of wetlands by grazing waterfowl. Ongoing studies include developing monitoring protocols for nesting shorebirds and Lapland longspurs; comparative demography and breeding ecology of red-throated, Pacific and yellow-billed loons; and the breeding ecology, survival and dispersal of shorebirds. FRESC biologists are working with the FWS and the Conservation of Arctic Flora and Fauna (CAFF) program to initiate Alaska- and world-wide monitoring of tundra-breeding birds and the tundra ecosystem.

Marine Mammals

The FWS has trust responsibility for managing three species of marine mammals: polar bears, Pacific walruses and sea otters. Polar bears and Pacific walruses are apical carnivores in Arctic regions. The BRD has responsibility for conducting research to satisfy FWS information needs for these two species. The U.S. shares both species with Russia, and polar bears are also shared with Canada. The international nature of the populations requires the U.S. to coordinate research programs with both Russia and Canada. The focus of current research relates to international actions necessary to conserve shared populations. Both species are subject to legal harvests by Alaska Natives, and research seeks to develop methods for defining and monitoring populations to establish sustainable population goals. Resource development in the Arctic habitats and their potential impacts on populations of polar bears and Pacific walruses are also topics of research interest.

The research program on Pacific walruses is focused on the trophic ecology and use of terrestrial haulouts of Pacific walruses in Bristol Bay. The development of an international Pacific walrus database, which includes data from Russian and American scientists concerning census, harvest and habitats, is nearing completion. Drugging protocols

USGS Alaska Biological Science Center researcher weighing a polar bear cub near Prudhoe Bay, Alaska, in April. Heavy cubs are significantly more likely than lighter cubs to survive the first few months in the rigors of the Arctic environment, and heavier cubs usually are born to heavier females.

have been refined, and effective immobilization agents have been found for Pacific walruses. The use of isoflurane gas for extending the effective marking period was partially successful, but the unreliability of currently available intubation procedures for walruses limits the utility of the gas. Attachment procedures for satellite tags have been improved, and units were deployed on 30 adult male walruses in Bristol Bay during the summers of 1996 and 1997. Telemetry data indicate movements between all primary land-based haulouts in Bristol Bay, with some evidence of haulout fidelity between years. The movement data also indicate that walruses are traveling between land-based haulouts to particular regions of the southern Bering Sea, presumably for feeding purposes. Time–depth recorders were deployed on five walruses during the summer of 1997, and the units were recovered by recapturing the animals six weeks later. These units collected detailed dive profile data for the five individuals. Data analysis is underway.

BRD biologists have completed satellite telemetry studies of movement patterns of adult female polar bears, and data analyses are underway. The movements of adult females marked in the Chukchi population are extensive, and annual ranges often exceed 400,000 km^2. Maternity denning occurs primarily in Russian territory, with the majority on Wrangel and Herald Islands. Survey methodologies for aerial censuses of polar bears in western Alaska have been developed, but budget limitations and the continuing economic crisis in Russia have delayed implementation of this survey. The aerial surveys used by Russian scientists on Wrangel and Herald Islands have been revised based on a joint U.S.–Russia workshop. The revised methodologies were tested on Wrangel Island during the spring of 1998 by a U.S.–Russia team of scientists. Present movement data for polar bears are limited to adult females. A pilot study to determine if subcutaneously implanted satellite transmitters could be used to monitor the movements of adult male polar bears was initiated in the spring of 1996. Detailed movement data have been collected for seven adult males during the spring and summer months. Preliminary data analyses indicate that adult males have a tendency to be more sedentary that adult females during the same period. Technical difficulties caused the satellite transmitters to fail before animals could be recaptured the following spring, and the effort during the spring of 1998 focused on resolving this problem.

Continued analysis of movement data generated by satellite radio-collared female polar bears suggests that polar bear populations in the Beaufort and Chukchi Seas are largely discrete. Some Beaufort Sea polar bears did temporarily leave their “home areas,” however, and were most likely to do so during late winter and spring. Because polar bears breed in the spring, biologists hypothesized that bear populations of the Chukchi and Beaufort Seas, which appear from movement data to be discrete, may not be discrete genetically. New molecular genetics data support that hypothesis. Based on eight microsatellite loci in tissue extracted from approximately 300 polar bears, there appear to be no significant genetic differences between Beaufort and Chukchi Sea bears. Hence, there is a contrast between radiotelemetry data suggesting a high degree of fidelity and molecular genetics data suggesting no differences. Also, this pattern appears to contrast with that in the Canadian high Arctic, where polar bear populations living closer together than do the bears of the Beaufort and Chukchi Seas had relatively distinct genetic patterns.

BRD research has shown that the patterns of maternal denning in Alaska tend to reduce the vulnerability of denning bears to human disruptions.

Nonetheless, conflicts with denning polar bears remain a concern because bears in dens are more vulnerable to disturbance than at any other time in their life cycle and because both denning on land and the extent of human activities are increasing. Hence, ongoing research seeks to characterize denning habitats and test whether state-of-the-art thermal detection devices can allow dens to be located before human activities occur. If preferred habitats predictably can be mapped, and if denned bears can be detected with the aid of infrared scanners, biologists and managers will have a management tool that will eliminate conflicts between human activities and denned bears.

The concentration of polar bears in the central Beaufort Sea region in late summer and autumn and the larger population that exists now has the potential to increase interactions between humans and polar bears at times other than denning. For example, in 1997, 50 polar bears were trapped on the beach when the sea ice suddenly retreated north in August. The central Beaufort Sea is the home of the most productive oilfields in North America, and several stranded bears ended up hanging around oilfield facilities, where they posed a constant threat to the safety of oilfield workers. As oil exploration and development and other human activities expand to the east and west of present development centers, biologists expect conflicts between polar bears and humans to be more frequent. Similarly, 20–30 of those trapped bears spent the late summer and fall near the coastal village of Kaktovik, where they became accustomed to feeding on the scraps left by subsistence whaling activities and they learned that humans need not be feared.

To properly manage human–bear interactions, we must have better knowledge of polar bear foraging strategies and the ecological importance of near-shore habitats. In response to that need, the ABSC plans to initiate research to answer questions such as: When and why can polar bears be expected to concentrate in near-shore areas where their opportunity to conflict with humans is greatest? What limiting factors at sea may be encouraging larger numbers of bears to remain on land for longer periods than in the past? What is the importance of land-based foods such as beach-cast marine mammals and human waste relative to ringed seals, which are thought to be the main component of their diet? Answers to these and other questions will help assure that humans and polar bears can continue to coexist in Alaska's Arctic.

Cooperative Research

The Alaska Cooperative Fish and Wildlife Research Unit supports a wide variety of research in Arctic and sub-Arctic regions of Alaska, Canada and Eurasia. Aquatic studies are presently concentrated on the energetics of Dolly Varden char in Noatak National Park and Preserve (NPP); the water quality of lakes in Gates of the Arctic NPP and Katmai NPP and in Lake Becharof; and migration and habitat use of broad whitefish in the Prudhoe Bay watershed. Landscape-oriented projects are focused on environmental changes in the Kobuk Sand Dunes; the status of rare plants in the Bering Land Bridge region; habitat use and remote sensing of caribou in northern Alaska and the Yukon Territories; and vegetation response/nutrient cycling in relation to climate change in the Arctic. Studies of birds and mammals constitute the majority of Alaska Unit studies in the Arctic. These include the habitat of red-legged kittiwakes on St. George Island; the population ecology of black brant and lesser snow geese; habitat use of peregrine falcons in the upper Yukon River; sampling protocols for small mammals in Denali NPP; the biogeography of Arctic hares in northwest Alaska and eastern Russia; habitat mapping of muskoxen on the Alaskan North Slope; and the interaction of muskoxen and reindeer on the Seward Peninsula.

Additional research in Arctic regions of Alaska and Canada is being conducted by BRD scientists at Cooperative Fish and Wildlife Research Units in Minnesota, Wisconsin, New York, Missouri, Washington and Louisiana. Most of this work answers questions pertinent to the management of migratory waterfowl and wetlands habitats on breeding grounds in the Arctic, migratory flyways and wintering grounds to the south. All of these projects are tightly linked to program objectives of cooperators in several Canadian and U.S. government agencies, many state natural resource agencies, flyway councils and private organizations.

Mineral Resources Program

The regional geology and mineral resource potential of frontier areas, the geology of known mineralized terranes and the geoenvironmental behavior of mined and unmined mineral deposits and occurrences are major themes for research in Alaska as part of the Mineral Resources Program. In addition, compilation of geological, geochemical and geophysical databases into easily accessible and manipulatable digital formats is a major ongoing effort.

Tectonics and gold mineralization in south-central Alaska

Studies of the large expanse of oceanic rocks and associated plutons along the southern Alaska margin have led to the development of a new model for the generation of gold veins and have helped to resolve the tectonic history of the northern Pacific Ocean basin. Patterns of magnetic anomalies reflect the existence of three oceanic plates in the northern Pacific in early Tertiary time, separated by three spreading ridges. One of the ridges, between the Kula and Farallon plates, headed in the general direction of the North American margin, but exactly where it intersected the margin cannot be discerned from marine magnetic anomalies because all direct evidence has been subducted. The location of this triple junction is revealed, however, by a suite of Paleocene and Eocene near-trench plutons in southern Alaska. The near-trench magmatic pulse was diachronous, beginning around 63–65 Ma at Sanak Island in the west and progressing to about 50 Ma at Baranof Island to the east. Near-trench plutons are thought to have been generated as a result of subduction of the Kula–Farallon ridge below the southern Alaska margin. The triple junction evidently migrated along that margin some 2200 km in 13–15 million years. Near-trench plutonism was only one of several geologic effects of ridge subduction. In addition, the accretionary wedge was cut by numerous normal and strike–slip faults, some of which host gold–quartz veins. $^{40}Ar/^{39}Ar$ ages on sericite show that mineralization was coeval with near-trench magmatism and, by implication, due also to ridge subduction. Prior to this study, gold mineralization had been attributed only to a poorly defined metamorphic event. We can now relate mineralization to a very specific tectonic setting and use this as a new guideline for gold exploration in frontier areas around the world where ridge subduction may have occurred.

Frontier studies in the Kuskokwim mineral belt

The quality of regional geologic knowledge in Alaska lags far behind that in the conterminous U.S. Not only is the mineral resource potential of vast tracts in the state unknown, but the basic geologic data used to determine mineral potential, such as the age and thermal history of the bedrock, have not been collected. One of the most poorly understood parts of the state is the 190,000-km^2 Kuskokwim mineral belt, which stretches through southwest Alaska. The area is a frontier in two ways: the geologic framework is extremely poorly understood, and it contains a gold-bearing deposit type that is not well documented in Alaska or elsewhere. Coordinated geologic mapping, geochemical sampling and geophysical studies have refined regional geologic and metallogenic models for the belt. Regional geology is dominated by extensive sedimentary rocks intruded by late Cretaceous–early Tertiary igneous complexes. Precious-metal and related deposits are associated with the igneous complexes. Detailed mapping, analysis of structural features (faults and folds), analysis of features in sedimentary rocks, and preliminary isotopic results indicate that the igneous complexes, gold deposits and mercury deposits apparently all originated at about the same time in an intracontinental strike–slip basin system. The strike–slip basins formed over a protracted period of time behind the western Alaska Range segment of the circum-Pacific volcanic arc. Geologic studies are continuing, using this model as a guide, to identify the extent of the belt, a metallogenic model for the region, and an estimate of the region's mineral potential.

Environmental impacts of mercury and arsenic

An understanding of the geochemical behavior of arsenic and mercury surrounding developed mineral deposits and in geologic environments with naturally elevated levels of arsenic and mercury is of critical importance in predicting natural and anthropogenically induced environmental impacts and establishing scientifically sound mitigation efforts.

In the Fortymile Mining District in east-central Alaska, determining the natural levels of arsenic and other metals in the watershed versus the levels resulting from placer mining (dredge operations) is required to establish risk assessment protocols for discharge permitting by Federal and state agencies. Parts of the historic Fortymile Mining District are being evaluated by BLM for possible inclusion as part of the Nation's Wild and Scenic River System. Recreational visitor usage of Fortymile River and its tributaries has increased 40% since the mid-1970s, and there is concern about conflicting land use. Extensive areas of Fortymile River systems have been mined since 1886, and much of the area along the river system consists of currently patented mining claims. The area contains mineral deposits such as vein gold (plus silver, lead, copper, zinc and antimony), stratabound volcanogenic massive and/or disseminated sulfides, porphyry copper and others. During the preparation of a series of Environmental Impact Statements for the area (beginning in 1974), anomalously high

levels of arsenic were found in soil, sediment and surface water. It is unknown, however, how arsenic is mobilized and whether its presence poses a threat to aquatic life, wildlife or humans. The initial research effort focused on water quality in the vicinity of active mining operations. Chemical and turbidity studies were undertaken to evaluate the impact of placer mining.

The water chemistry data collected in the vicinity of mining operations give values roughly equal to or lower than the regional average concentrations of dissolved metals, based on 25 samples. Turbidity values fall within the range of turbidity values found for currently mined areas of the Fortymile River system and its tributaries. The highest turbidity value was measured in an unmined stream. The preliminary study identified no appreciable difference in turbidity values between mined and unmined areas in the river system.

Further efforts in this study area will evaluate:

- The importance of water–rock interactions as a determining factor in water quality;
- The fate and transport of the elements of interest; and
- The flux and biogeochemical cycling of arsenic between terrestrial and aquatic environments.

Studies of environmental impacts of mercury in the southwest Alaska mineral belt were designed to document, in a sub-Arctic environment, the levels and distribution of the various mercury species and to identify the geochemical processes that control the distribution, speciation and transport of mercury at selected inactive mercury mines. Identification and discrimination of natural and anthropogenically induced impacts were focused on areas where the environmental impact of mercury is a concern to regulatory, planning and land managing agencies, to the local population, and to the village and regional Native corporations. Mercury levels in stream sediments, stream water and fish were measured. Stream sediments collected near mercury mines are elevated in mercury due to erosion and local transport of cinnabar, a mercury-bearing mineral. Stream sediments in unmined areas showed no significant mercury concentrations. Stream waters collected in the vicinity of mines yielded mercury values above background levels for the region but below the present State of Alaska and EPA–CPC drinking water and in-stream standards. Fish livers and muscle tissue from freshwater fish collected downstream from mercury mines contained elevated mercury, most of which was in the toxic form, methylmercury. However, mercury contents in the edible portions of the fish were below the 1.0-ppm limit established by the Food and Drug Administration (FDA). Mercury contents in muscle tissue of salmon, the primary fish consumed by humans in the area, were well below the FDA limit. The bioavailability of mercury in vegetation and the contribution of mercury from southwest Alaska to the global mercury cycle are areas of ongoing research.

Water Resources

The USGS hydrologic activities in Alaska are divided into three broad categories:

- Collection of hydrologic data;
- Hydrologic appraisals; and
- Basic and applied research in hydrologic topics unique to cold climates.

Hydrologic Data Collection

A wide range of climate directly influences the water resources of Alaska. Precipitation ranges from less than 10 in. per year (principally snow) in Arctic Alaska to 200–300 in. per year (principally rain) in southeast Alaska. Hydrologic data are required for planning and conducting hydrologic appraisals and hydrologic research. In 1997 collecting these data constituted the major part of the Division's efforts in Alaska.

Hydrologic Appraisals

Hydrologic appraisals include studies of water resources in areas that are likely to be or that are being affected by mineral or urban development, investigations of potential hydrologic hazards, and studies of ground- and surface-water contamination on Federal lands.

Alaska has about 36% of the entire Nation's average annual streamflow; if lakes and glaciers are included, Alaska has more than 40% of the entire Nation's surface water resources. Streamflow in southern Alaska alone is comparable to the mean annual streamflow of the Mississippi River. This streamflow does not enter the ocean in the form of one large river but by way of numerous smaller rivers and streams. Alaska has 7 of the 20 largest rivers in the U.S.: the Yukon, Kuskokwim, Copper, Stikine, Susitna, Tanana and Nushagak. Alaska has so many lakes they are essentially uncounted. Nearly 100 lakes are larger than 10 square miles in size. Iliamna Lake is Alaska's largest, with a surface area of about 1000 square miles. Springs throughout the state are found as innumerable small seeps and as warm or mineral waters

that support recreational centers. On the North Slope, flows from large springs produce widespread icings in winter. In 1997 the USGS monitored about 85 surface water sites.

Snow covers most of the state for half to three-quarters of the year. Freezing and thawing of water affects virtually all of the state to some extent. Glaciers cover nearly 30,000 square miles in Alaska—about 5% of the total area of the state—but produce approximately 35% of Alaska's runoff and 10% of the Nation's runoff. If all the glacial ice melted, it would take a river the size of the Yukon about 150–200 years to drain all the water. Glaciers play a key role in water storage, timing of peak flows and sediment transport.

Ground water is an undeveloped resource in most of Alaska; in many areas, potential development of the resource far exceeds current use. Groundwater conditions are diverse: major aquifers are present in the alluvium of large river valleys (Yukon, Tanana, Kuskokwim, Susitna), in glacial outwash deposits under coastal basins (Cook Inlet) and valleys (Seward and Juneau), and in carbonate bedrock of the Brooks Range. In other areas, however, the fine-grained material of glacial and glacial-lake deposits and the low permeability of consolidated rocks offer a much less promising ground water potential. In addition, the recharge, discharge, movement and thus the availability of groundwater over much of the interior, western and northern parts of the state and on the flanks of the Alaska Range are restricted by permafrost. In 1997 the USGS monitored approximately 50 groundwater sites.

The quality of Alaskan waters is generally acceptable for most uses. However, available data do indicate naturally occurring problems, such as suspended sediment in glacier-fed streams, salt-water intrusion and undesirable concentrations of iron or arsenic in ground water at various locations. Local pollution from septic tank leakage has occurred in several locations. In 1997 the USGS collected water quality data at approximately a dozen sites.

Hydrologic Projects

Hydrologic subjects being studied include the quantity and quality of surface and ground water; hydrologic instrumentation; and glacier, snow and ice dynamics.

The Kenai River in south-central Alaska is an economically important salmon river generating as much as $78 million annually in direct benefits. Resource management agencies are concerned that increased sedimentation and loss of streamside cover associated with accelerated erosion rates caused by boat activity may threaten salmon returns to the river. Bank loss and boat activity were characterized during 1996 along 67 miles of the Kenai River, including a segment of the river several miles long where boat activity is restricted to non-motorized uses. Dates of peak boat activity coincided closely with chinook salmon returns to the Kenai River and with peaks in measured bank erosion. The boat activity period began in late May, peaked on weekend days in mid-July, and declined in early August. Several types of bank protection measures were evaluated along the Kenai River for their ability to reduce or eliminate bank erosion. These include complex engineered systems of coconut-fiber biodegradable logs attached to the bank with live willow sprouts and covered with elevated walkways, simple series of spruce trees cut down and cabled to the bank, rock riprap piled against the bank, and vertical wooden retaining walls.

In June 1997 the USGS conducted a water quality survey of the Kuskokwim River. The Kuskokwim River drains approximately 32,000 square miles, is the ninth largest river in the U.S., and is the Nation's second largest river entering the Bering Sea. The river basin is remote and largely undeveloped, although mercury mining occurred within the basin until 1971 and placer gold mining continues in the upper reaches. The central part of the river drains the Kuskokwim mineral belt, a mineralized zone enriched in the trace elements. This study focused on the water quality of the Kuskokwim River and its major tributaries with the objective of evaluating how water quality changed as the river flows downstream. To achieve this, water and bed sediment at seven sites were sampled along the Kuskokwim from McGrath to Akiak: one above the mineral belt, two within the mineral belt above the historic mercury mining, two within the mineral belt below the historic mercury mining, and two downstream from the mineralized region and below the historic mining. In addition, three tributaries—the Holitna River, Crooked Creek and Red Devil Creek—were sampled. The Holitna River is a major tributary to the Kuskokwim, Crooked Creek is a small drainage with unmined mineral potential, and Red Devil Creek drains the historic Red Devil mine site. Of the 22 aqueous trace elements analyzed, only boron, chromium, copper, manganese, zinc, aluminum, lithium, barium, iron and antimony were detected, and only barium, iron and strontium exhibited a downstream concentration change. The highest

mercury concentration was found in Red Devil Creek, but this produced no effect in the main stem of the Kuskokwim because the streamflow of the tributary is small relative to the Kuskokwim. Evidence of the mining impact on the Kuskokwim main stem was found in the bed sediment chemistry, however. Mercury and antimony concentrations in the Red Devil Creek sediments were about 1000 times higher than concentrations in the Kuskokwim River sediments. Kuskokwim River sediments collected from the left bank about 0.25 mile below the Red Devil drainage had mercury concentrations nine times greater and antimony concentrations two times greater than those of sediments collected from the right bank and those collected either upstream or downstream from the Red Devil drainage. No difference was found between sediments collected from the left and right banks at the site eight miles below the mine, and the effect of the mine appears to be localized on the left bank region near the mine.

Department of Defense

The Department of Defense continues to operate and maintain facilities in the Arctic. To support these operations, the DOD conducts a broad-based Arctic research program. The Arctic program is conducted by all three services and extends from the ocean floor to the magnetosphere.

Although overall funding for Arctic research within the Department of Defense (DoD) has decreased since the end of the Cold War, the Department still has active interest in the Arctic. Specific DoD objectives for Arctic research include (but are not limited to):

- Understanding the interaction of the Arctic environment with military systems, including human systems and environmental remediation;
- Understanding energy exchange and atmosphere–ocean interaction dynamics, and the impact of the energy exchange process on global circulation; and
- Understanding the structure and physics of the middle and upper atmosphere.

Although the DoD program is reviewed as a whole during the annual Technology Area Review and Assessment (TARA), the three military services actually conduct research to meet their specific objectives. Consequently each service's major accomplishments will be reported separately.

Air Force

The Air Force conducts research in upper atmosphere and ionospheric physics, primarily by the Air Force Research Laboratory, Space Vehicles Directorate, Battlespace Environment Division (formerly the Phillips Laboratory) and the Air Force Office of Scientific Research (AFOSR). These offices coordinate their effort to understand the effects of space weather. This research is primarily conducted in the Arctic "polar cap." The goal of the research is to understand the basic physical and chemical processes and dynamics of the polar ionosphere, with the main objectives to specify, predict and mitigate disruptions to DoD communications, navigation and surveillance systems. To actively pursue and maintain a well-rounded program, the research effort combines experimental measurements to determine specific physical processes, first-principles numerical modeling efforts, and a strong connection to ongoing theoretical research.

	Funding (thousands)	
	FY 96	FY 97
Arctic Engineering	2,369	2,892
Permafrost/Frozen Ground	1,562	565
Snow and Ice Hydrology	1,910	3,646
Oceanography	8,988	11,631
Lower Atmosphere	168	314
Upper Atmosphere	2,000	3,777
High-Freq Active Auroral Program	13,000	7,500
Medical and Human Engineering	489	720
Total	30,486	31,045

The Air Force maintains a wide range of ground-based radio, radar and optical diagnostics to perform the needed measurements. These are conducted from Nord, Qaanaq, Thule, Sondrestrom and Narssarssuaq, Greenland (in cooperation with the Danish Meteorological Institute); Ny Alesund, Longyearbyen (Spitsbergen) and Tromso, Norway (in cooperation with the University of Oslo, Norway); and Goose Bay, Labrador (Canada). The ground-based measurements are often complemented by measurements from instruments on sounding rockets and polar-orbiting satellites. From this understanding, numerical models to specify and ultimately predict the behavior of this complex region are being developed. This research and model development are needed for real-time support to DoD communications, navigation and surveillance systems.

Dayside Auroral Studies at Svalbard

Major experimental campaigns were conducted at Ny Alesund, Svalbard (Norway), in January 1997 (following initial experiments in 1993) to investigate the structure and dynamics of the dayside auroral cusp region. Because of the high lati-

tude of Svalbard (79°N), this is an ideal location to conduct sensitive optical observations of the aurora near noon. Both campaigns included optical, radio and radar measurements in cooperation with the University of Oslo. During January 1997, measurements from the NASA FAST satellite were coordinated with the ground-based optical images. These higher-resolution satellite particle and field measurements will be used to attempt to distinguish temporal and spatial variations within the cusp region.

High-Frequency Active Auroral Research Program

A complete description of the HAARP facility is available at http://w3.itd.nrl.navy.mil/haarp.html

The Air Force–Navy High-Frequency Active Auroral Research Program (HAARP) consists of a high-power, high-frequency (HF: 2.8–10 MHz) ionospheric heating facility that has been under construction since 1994 in Gakona, Alaska. Initial field experiments were conducted in 1997. A development prototype version currently operates, with plans for the facility to be completed by early in the next century. When finally completed, the facility promises to provide the world's most powerful HF transmission capabilities, combined with unparalleled frequency agility and beam-steering agility. Recent completion of the prototype made it possible to conduct preliminary investigations of HF-induced phenomena with the HAARP facility in a March 1997 campaign. Although the prototype produced relatively low power output in the 3- to 4-MHz frequency range (effective radiated power of approximately 5 MW), the full-frequency agility capability was available. In the current effort the prototype was used to investigate stimulated electromagnetic emissions and artificial periodic inhomogeneities, as well as to modulate the polar electrojet to produce extremely low frequencies, phenomena that can be excited with modest power levels.

Portion of the 48-tower developmental prototype antenna array at Gakona, Alaska.

Army

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), with offices in Hanover, New Hampshire, and Fairbanks, Alaska, is the center of engineering expertise for cold regions and winter conditions for the Corps of Engineers, the Army and DoD. CRREL is the only Federal laboratory that focuses solely on Arctic and cold regions problems and is internationally recognized as a center of excellence in Arctic research.

The U.S. Army Research Office (ARO), located in Research Triangle Park, North Carolina, has a mission to support basic research that leads to an increase in fundamental knowledge that may have short- or long-range impacts on Army capabilities. ARO is involved in Arctic research and development largely through the sponsorship of extramural basic research directed toward the topics of environmental quality and the properties and processes of snow, ice and frozen ground.

The United States Army Research Institute of Environmental Medicine (USARIEM), located in Natick, Massachusetts, conducts research to sustain and enhance the health and performance of military personnel in cold environments, including Arctic areas, through basic and applied biological and biophysical research. Researchers employ human, animal, tissue, cellular and mathematical models using multidisciplinary team approaches. A principal research goal is to define complex interactions of climatic stress (heat, cold and altitude) and the body's physiologic defense mechanisms.

The following are objectives and accomplishments for FY 96 and 97 in the program areas of Arctic Engineering, Permafrost and Frozen Ground; Snow and Ice Hydrology; Oceanography; and Medical and Human Engineering.

Arctic Engineering, Permafrost and Frozen Ground

The current CRREL program reflects recent world events. The engineering emphasis has shifted to technologies needed to support forces in underdeveloped theaters of operation, rehabilitate and more efficiently operate an aging military infrastructure, assess and clean up contamination

from past activities, and extend the capability of existing equipment to function more effectively in a broader range of operating conditions.

Together with the National Concrete Masonry Association, CRREL completed a Construction Productivity Advancement Research study to find ways to minimize thermal protection requirements for cold-weather masonry construction. Although current guidance requires mortar to be heated to 50°C, a finding of the study is that mortar need not be heated above 20°C. Additionally, the study showed that antifreeze chemicals can eliminate the need for thermal protection altogether without causing detrimental side effects to the masonry. These findings promise to take a huge bite out of the estimated $325 million annual surcharge that cold weather inflicts on masonry construction activities.

CRREL also conducted extensive research in ground-penetrating radar in FY 96 and 97. Radar maps of the total thickness of permafrost have been developed, with confirmation from the extensive drilling necessary to map the subsurface extents of contamination. Additionally, the radar is being used to detect buried metallic objects such as containers of toxic waste and ordnance.

The Army Research Office (ARO) sponsored two major efforts over the period. The first is Constitutive Behavior of Frozen Soils at Small Strains. Charles Ladd of the Massachusetts Institute of Technology is engaged in a laboratory study of frozen soil deformation at small strain rates. Triaxial compression tests are being conducted to provide axial stress–strain and volumetric strain characterization of a frozen sand as a function of relative density, confining stress, strain rate and temperature. The second ARO-sponsored effort is Solute Mobility in Frozen Porous Media, by Bernard Hallet of the University of Washington. Through a program of laboratory experiments, this effort studies the fundamental processes that govern the transport of chemical constituents in frozen porous media. The experimental data obtained will elucidate primary mechanisms and rates of solute movement in frozen porous media, as well as examine the potential for electrical field generation during freezing and the tendency for chemicals in frozen ground to concentrate at freezing fronts.

Snow and Ice Hydrology

CRREL and ARO also conduct research in mapping snow extent using remote sensors. This research supports hydrologic and climatic models in both temperate and Arctic regions. The Remote Sensing/Geographic Information Systems Center located at CRREL developed and tested an automated snow mapper for use with Landsat imagery. This algorithm rapidly finds the fraction of snow, or materials with snow-like properties, based on an idealized spectral mixture model.

CRREL conducted long over-snow traverses in the Kuparuk Basin on the North Slope of Alaska in collaboration with the University of Alaska and Colorado State University. The traverses were conducted to collect snow depth and snow property data over a wide area in order to develop and test models of snow distribution. These models can be used in the prediction of over-snow trafficability and meltwater runoff, scene prediction, and climate studies. During the traverses, more than 1000 km were covered using a small-unit support vehicle towing special research sleds built by CRREL. Over 250,000 depth measurements were taken at temperatures as low as –40°C. From these measurements, trends in snow depth have been identified. Preliminary model results predict the correct snow depths over more than 70% of the modeled area.

ARO sponsored several studies in snow and ice hydrology in 1997, including Meltwater Flow Through Snow from Plot to Basin Scale, by Mark Williams of the University of Colorado at Boulder, who is studying the spatial and temporal variation of water flow through a melting snowpack in a research project that is jointly funded with the National Science Foundation. Another project, Study of Ice Adhesion with Scanning Force Microscopy and Electromagnetic Spectroscopy, by Victor Petrenko of Dartmouth College, is undertaking a fundamental study that is aimed at acquiring an in-depth understanding of the nature of the strong and universal adhesion of ice to most solid material based on new knowledge of both the microstructure and the physical properties of the ice/solid interface. The long-term goal of this research is the purposeful development of durable, ice-phobic coatings by means of molecular engineering.

Oceanography

Understanding the interaction of solar radiation with the sea ice cover of the Arctic Ocean is critical to the heat and mass balance of the Arctic ice pack and its effect on climate. Data on the surface state were obtained from helicopter photography missions made during the height of the melt season. CRREL analyzed photomicrographs of ice thin sections using a PC-based image processing

system to determine the number of inclusions and statistics for brine pockets in young ice and first-year ice and for air bubbles in a multi-year hummock. Quantifying these inclusions is critical for both interpreting and modeling the electromagnetic properties of sea ice.

Two icebreaking ships carrying six scientists from CRREL and more than 50 other scientists representing various universities and agencies such as NASA and the Department of Energy (along with researchers from Japan, Canada and the Netherlands) established an ice station for the SHEBA (Surface Heat Budget of the Arctic) experiment. One of the icebreakers will remain frozen into the pack ice of the Arctic Ocean and drift as a floating science platform for 13 months. This experiment will provide a better understanding of the climate of the Arctic; this knowledge will improve global-scale weather and climate models.

Medical and Human Engineering

USARIEM studied the heat transfer properties of cold-stressed fingertips during cold-induced vasodilatation (CIVD). A novel manner of characterizing the CIVD effect is by ascribing a factor called heat loss efficiency. A weak linear relationship between the heat loss efficiency and the duration of CIVD was revealed. The intensity and the incidence of occurrence of heat deficits were found to be more prevalent in the first CIVD waves in both test conditions. Subsequently the heat deficit of the fingertip decreased while heat storage intensified. This technique should lead to a unique way to characterize a population susceptible to non-freezing cold injury.

USARIEM continues to study the effects of cold stress on military women's thermoregulatory responses. A study was completed comparing model and experimental results with protective clothing for cold stress impact on women. Previously USARIEM examined the magnitude of shivering thermogenesis and internal body temperature response in women exposed to cold wearing protective clothing during resting activities at various stages of the menstrual cycle. It was found that shivering thermogenesis was highly correlated with mean weighted skin temperature.

USARIEM also developed an uncomplicated approach for estimating heat loss during cold exposure. The current equation may be used to generate predictions that incorporate clothing insulation for the U.S. Army Standard Extended Cold Weather Clothing System and cold ambients down to –20°F (–28.9°C). USARIEM also initiated a study to determine the efficacy of phase-change (PC) materials incorporated into various boots used in cold regions. PC boots have a proprietary exothermic substance in a given boot that is purported to release heat upon exposure to extreme cold. Various prototype PC boots, in combination with a prototype Marine sock and current-issue sock, are being studied on USARIEM's regionally heated copper foot while exposed to a cold ramp down to –5°C (23°F). Finally, USARIEM published a study of the effect of cold water immersion at different depths on metabolic and thermal responses. Experiments were conducted in a laboratory with subjects immersed to different depths and exercising at a range of metabolic rates. The study showed that water levels above the knee at 15°C and above the hip at 25°C depressed the core temperature.

USARIEM traveled to Alaska to support an international mountaineering expedition to Mt. Sanford (altitude 16,237 ft) starting from a base camp on Sheep Glacier (altitude 6,500 ft). The expedition consisted of 12 climbers with an objective to demonstrate the practicality of physiologic monitoring in harsh climatic conditions. Five of the twelve climbers reached the summit. Overall, physiological status monitoring appeared to demonstrate outstanding potential to manage activity levels and identify sick soldiers during military operations in harsh climates.

Navy

The Office of Naval Research's High Latitude Program investigates processes (physical, biological, chemical and geological) active in all polar oceanic areas, with special emphasis given to high-latitude marginal seas. The goals of the program are to improve the Navy's understanding of air–sea–ice exchange processes, mechanisms of cross-shelf transport, and the process of deep ocean convection and to incorporate the improved dynamical understanding of these processes into new environmental models that can better support fleet activities in the next decade and beyond. These program goals are being addressed partially through participation in the joint NSF/ONR/Japan/Canada Surface Heat Budget of the Arctic (SHEBA) experiment and the ongoing ONR/NSF-sponsored Science Submarine Cruise (SCICEX) program.

All ONR Ocean, Atmosphere and Space Department-funded programs receive an annual summary report from each principal investigator. These summaries document each task's objectives, accomplishments and publications during the past year. In

Further information on ONR's High Latitude Program can be obtained from the World Wide Web site and associated links: http://www.onr.navy.mil/sci_tech/ocean/onrpgahl.htm

1998, ONR will be providing these annual summary reports as a CD-ROM with selected reports on the World Wide Web. In the future these collections will provide an easy-to-use compendium of accomplishments. In the interim a few significant highlights are summarized below.

The Navy continues to fund substantial research into the dynamics of sea ice surfaces. Sea ice provides a superb platform for studying the upper ocean without the complicating effect of surface waves. The long-term goals are to understand the turbulent transfer of momentum, heat, salt and other contaminants in naturally occurring boundary layers of the ocean and to apply this knowledge to understanding air–ice–ocean interaction in polar regions and the impact of this transfer on the large-scale coupled atmosphere–ocean dynamic system. In 1997 the Navy funded a large series of experiments to directly measure the transport of heat and salinity. The data have been used to develop relatively simple conceptual models for eddy exchange, which have been incorporated into numerical ocean circulation models with applications ranging from modeling strong heat flux in the Weddell Sea to sediment transport in the Kara Sea.

In 1997 the researchers (primarily Miles McPhee, University of Washington) directly measured such diverse elements as circulation, wind and sea velocity, and heat transport. The goal was to parameterize these complex factors into a simple form to be used in operational weather and climate models. One final result is that the parameterized mixing length should be smaller than previously thought, reducing the turbulent exchange of heat and momentum flux from air to sea in the Arctic region. This work also has direct application for modeling pollutant dispersal over the Arctic.

A second major accomplishment came during the summer 1996 and 1997 SCICEX cruises. These cruises, aboard the USS *Pogey* and *Archerfish*, respectively, had clearly defined scientific goals. The primary goal of this research was to improve the understanding of those processes in the upper Arctic Ocean that influence the heat balance and sustain the ice cover. This goal encompasses the upper halocline and includes mesoscale features including their origins, prevalence, dynamics and influence on heat transport. A secondary role of this program is to participate in assessing the potential utility of submarines as research platforms. To meet these goals the Navy sponsored research into continuously measuring the vertical distribution of horizontal currents, temperature and salinity in the upper Arctic Ocean from a submarine. These measurements were taken under the ice pack in some instances and provided a first-time characterization of the upper-ocean mesoscale (small-scale) features. Analyses of the summer 1996 SCICEX data are still in their early stages. The current data proved to be of high quality and clearly show a complex dynamic ocean structure.

National Aeronautics and Space Administration

As part of its Offfice of Earth Science, NASA supports various research programs in the Arctic that emphasize applications of airborne and space remote sensing to studies of the earth and space sciences. This issue focuses primarily on NASA's Program for Regional Arctic Climate Assessment.

NASA's Program for Regional Arctic Climate Assessment (PARCA) was formally initiated in 1995 by combining into one coordinated program various investigations associated with efforts, started in 1991, to assess whether airborne laser altimetry could be applied to measure ice sheet thickness changes. It has the primary goal of measuring and understanding the mass balance of the Greenland ice sheet, with a view to assessing its present and possible future impact on sea level. The lessons learned from this program will be applied to the more global assessment of ice sheet volume that will become possible after the 2001 launch of NASA's Geoscience Laser Altimeter System (GLAS), which has the primary goal of measuring changes in ice-sheet elevation at latitudes up to 86°N. The main components of PARCA are as follows:

- Airborne laser altimetry surveys and ice thickness measurements along precise repeat tracks across all major ice drainage basins in order to measure changes in ice surface elevation;
- Shallow ice cores at many locations to infer snow accumulation rates and their interannual variability, recent climate history and atmospheric chemistry;
- Estimates of snow accumulation rates by climate model analysis of column water vapor obtained from radiosondes and TIROS Operational Vertical Sounder (TOVS) data;
- Surface-based measurements of ice motion at 30-km intervals approximately along the 2000-m contour completely around the ice sheet in order to calculate the total ice discharge for comparison with total snow accumulation and thus to infer the mass balance of most of the ice sheet;
- Local measurements of ice thickness change in shallow drill holes;
- Investigations of individual glaciers and ice streams responsible for much of the outflow from the ice sheet;

	Funding (thousands)	
	FY 96	FY 97
Polar Ice Interactions	5,500	5,300
Ecology	6,400	2,500
Solid Earth Science	500	460
Arctic Ozone	1,000	7,500
Clouds and Radiation	1,100	1,200
Sub-Orbital Science	700	700
Iono/Thermo/Mesospheric SR&T	600	600
FAST Auroral Snapshot	5,200	4,076
Magnetospheric SR&T	1,000	1,000
Solar Terrestrial Theory	400	400
Arctic Data Systems	14,600	14,300
Research Balloon Program	0	832
Sounding Rocket Program	1,000	955
Total	38,000	39,823

- Monitoring of surface characteristics of the ice sheet using satellite radar altimetry, synthetic aperture radar (SAR), passive-microwave, AVHRR and scatterometer data;
- Investigations of surface energy balance and factors affecting snow accumulation and surface ablation; and
- Monitoring of crustal motion using permanent global positioning system (GPS) receivers and absolute gravity campaigns at coastal sites.

Field activities in 1996 and 1997 involved remeasurements along a GPS traverse to infer ice velocity across the 2000-m contour (closer to 3000 m along the eastern flank of the ice sheet), collection of several shallow (20- to 150-m-deep) cores to improve our knowledge of snow accumulation over the ice sheet, local measurements of ice thinning/thickening in shallow drill holes, and maintenance of several automatic weather stations (AWS). Also, the airborne topographic mapper (ATM) and ice-sounding radar were flown aboard the NASA P-3 to measure ice thickness along the GPS traverse and across selected outlet glaciers and to complete surface elevation and ice thickness surveys over the Jakobshavn catchment and over an area inland from the Humboldt and Petermann Glaciers.

Airborne Laser-Altimeter Monitoring of the Ice Sheet

Each year since 1991 the NASA P-3 aircraft, equipped with dual-frequency carrier phase tracking GPS receivers, a ring-laser gyro inertial navigation system, scanning and profiling laser altimeters, and (since 1993) a low-frequency radar to measure ice thickness, has flown over numerous transects of the Greenland ice sheet. In excess of 100,000 km of trackline have been mapped, covering all major drainage basins and characteristic geophysical regions in Greenland. The airplane location was measured precisely using differential GPS surveying techniques, allowing all altimetry data to be converted into measurements of ice surface elevation relative to the Earth ellipsoid. Analyses of these data indicate that ice surface elevations can be reliably measured with an accuracy of approximately 10 cm over baselines of more than seven hundred kilometers.

Mapping of the ice sheet by the ATM scanning laser onboard NASA's P-3 aircraft typically produces a set of surface elevations along a 150-m-wide swath. With an aircraft speed of 150 m/s and a laser pulse rate of 3000 per second, this results in an average of one surface elevation per 7.5 square meters, with each elevation measurement having some uncertainty due to measurement noise, aircraft pitch and roll errors, and GPS positioning uncertainty of the aircraft. To monitor elevation change the aircraft flies over the same groundtrack one or more years later, and the surface elevations are then compared.

All major drainage basins on the ice sheet were mapped with the ATM in 1993 and 1994, and the flight lines will be resurveyed in 1998 and 1999 to reveal any changes in surface elevation that have occurred during the five-year interim, providing an estimate of the change in volume of the ice sheet.

Data from the ATM have also been used to estimate surface velocity by tracking elevation features at the ice surface. During the 1997 field season, repeat flight lines were surveyed over four sections in the Jakobshavn drainage basin, with time separation between these flights ranging from two to six days. By interpolating the laser scanner data onto a 1- × 1-m grid and using cross-correlation analysis techniques, the movement of the elevation features, the most distinct of which are crevasses, were tracked. The results show that the surface velocities near the calving front are on the order of 7 km per year. This method of estimating ice velocity complements satellite-based techniques in that it offers a flexible platform for site-specific observations. When combined with the thickness data from the ice-penetrating radar, which is flown simultaneously on the P-3, these velocities can be used to estimate discharge fluxes. The method also offers an independent means of validating ice velocities derived from SAR and visible imagery.

Coherent Radar Depth Sounding of the Greenland Ice Sheet

This research involves performing airborne ice thickness measurements using a coherent radar depth sounder. The radar operates at 150 MHz and is capable of measuring polar ice sheet thickness to about 4000 m in cold ice and to lesser thicknesses in temperate glaciers. The radar uses complementary surface acoustic wave devices for pulse expansion and compression. The system operates as an unfocused SAR.

Radar data, collected over the interior ice sheet, around the margin and over outlet glaciers, were tagged with geolocation information obtained from the onboard GPS receiver. The radar data were collected in conjunction with laser altimeter measurements of ice surface elevation. A next-generation coherent radar depth sounder (NGCORDS) using microwave monolithic integrated circuits was also developed and field tested in 1997. The ice thickness along the 2000-m velocity traverse and at Summit (up to about 3200 m) was measured, and the measurements are being used in conjunction with other data to estimate Greenland's mass balance.

Ice thickness measurements were also used to assess the accuracy of high-quality digital elevation model data that were used to estimate the thickness of floating glacier sections for comparison with the CORDS measurements. An extensive data set was also obtained for the Jakobshavn outlet glacier, which is considered to have the highest iceberg production of all Greenland glaciers and is a major drainage outlet for a large portion of the western side of the ice sheet.

Accumulation Estimates from Ice Cores

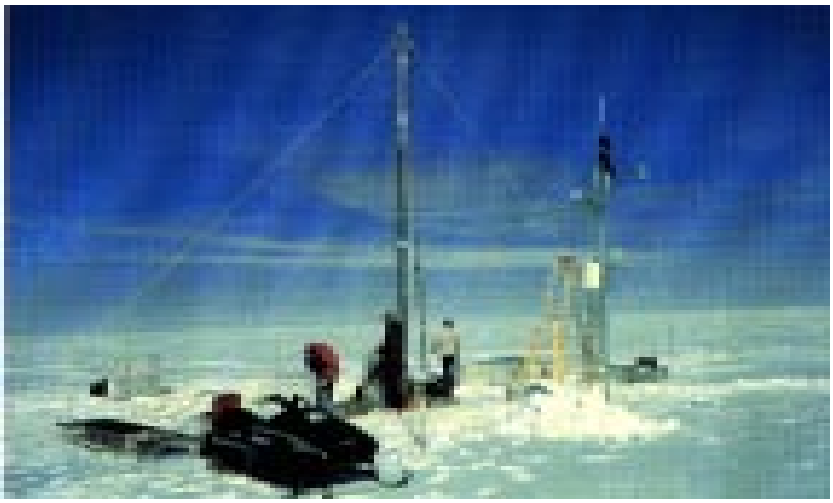
The primary objective of this work is to use multi-species chemical analyses of 20- to 150-m-deep ice cores to estimate annual accumulation at

Drilling shallow cores to establish the historical accumulation and elevation of the ice sheet over the past few hundred years.

various sites on the Greenland ice sheet. This will improve our estimates of snow accumulation over the ice sheet for comparison with ice discharge and for use in models. The core data are also analyzed for the interannual variability of snow accumulation rates, which is a major cause of short-period variability of ice sheet elevation and must be understood before we can infer long-term trends in ice sheet volume from observed surface elevation changes.

During the summer of 1995, 150-m firn and ice cores were drilled to determine annual accumulation rates at two Greenland sites, 73.84°N, 49.49°W (NASA-U) and 78.53°N, 56.83°W (Humboldt Glacier). Annual layers were identified in the cores using multiple parameters: $\delta^{18}O$ and concentrations of dust hydrogen peroxide, ammonium, calcium and nitrate. Using all parameters together to define annual layers resulted in a 350-year record for the NASA-U core with no dating uncertainty. For the lower-accumulation Humboldt core, the dating uncertainty is about 5 years over the 852-year period of record, with no uncertainty over the past 200 years. Annual accumulation over the periods of record at the two sites averaged about 0.34 and 0.14 m of water equivalent, respectively. There was no statistically significant trend in the NASA-U annual accumulation rates over the period of record. However, the Humboldt data do show an increasing trend of about $1.3 \pm 0.4\%$ per century over the period of record. A set of 20-m firn cores drilled near the main 150-m cores showed that interannual variability of accumulation exceeded spatial variability at NASA-U. The Humboldt cores showed equal spatial and interannual variability.

PICO four-inch drill setup at the NASA-U site in northwest Greenland.



In 1996, 120-m cores were collected at GITS (77.14°N, 61.04°W) and TUNU (78.10°N, 35.50°W), with several 20-m cores also collected at TUNU. In 1997, shallow firn cores were collected at eight sites around the perimeter of the Greenland ice sheet at approximately the 2500-m elevation contour. The 4-in. cores were collected by two- and sometimes three-person teams using the "sidewinder" coring device, a mechanically operated hand auger developed by the University of Nebraska. At those shallow coring sites that were co-located with automatic weather stations, more than one core was collected in order to investigate issues of short-scale spatial variability in snow accumulation. Two sites in northwest Greenland (75–76°N) had average annual accumulation values of 0.30–0.36 m of water equivalent, and two sites in west-central Greenland (71–72°N) had values of 0.40–0.42 m of water equivalent. All four sites had values that were only 70–80% of those estimated from prior work and call into question the accumulation "ridge" in western Greenland that is apparent in older data.

Accumulation Rates from Microwave Remote Sensing Data

Because of the volume scattering characteristics of microwave radiation in polar firn, data from both active and passive microwave sensors hold

information about the grain size and layering characteristics at and below the surface of the snow pack, which are related to accumulation rates. One way in which the accumulation rates in the dry snow zones are being studied is based on the polarization-dependent microwave emission characteristics at 4.5-cm wavelengths. The approach is based on the fact that the density layering in the snow is of greater impact on horizontally polarized emission than on vertically polarized emission. Thus, the differences between the two can be used to the estimate mean annual accumulation rates. Researchers have had considerable success with this approach in Antarctica, with results comparing favorably to field observations, and their effort is being extended to Greenland. The resulting maps broadly agree with previous compilations of field observations.

A second method that is applicable to the dry snow zones is based on microwave emission at a wavelength of 1.55 cm. Emissivity at this wavelength has been shown to be related to accumulation by a hyperbolic function. The relationships have been demonstrated for the dry snow zones in Greenland and Antarctica, and microwave-based accumulation maps are being developed. The relationships at this shorter wavelength, however, are somewhat complicated by snow metamorphism and the development of hoar layers near the surface.

Third, 5.6-cm backscatter data from spaceborne scatterometers show promise for estimating accumulation rates in the dry snow and percolation zones. The backscatter characteristics show a direct relationship with known accumulation patterns. The data have also been used to identify facies boundaries and detect changes in these boundaries over time. The results so far show a clear reduction in the location and extent of the dry snow zone since 1978, with the largest changes occurring in the southwestern part of the ice sheet. These changes are consistent with the decadal warming trend and increase of more than 1°C between 1979 and the present. Finally, accumulation data have also been obtained by correlating stable isotope ratio profiles (δD and δ^{18}O) from snow pits with passive microwave brightness temperature trends. These analyses yield the amount, rate and timing of density-corrected accumulation at locations around Greenland with sub-seasonal resolution.

Two antenna horns of a radar instrument used to monitor the backscatter properties of snow and ice at the equilibrium line altitude.

Greenland Precipitation Estimated from Atmospheric Analyses

Observations of precipitation over Greenland are limited, refer to different time periods, and are of uncertain accuracy. However, the analyzed wind, geopotential height and moisture fields are available for recent years. The objective of this work is to develop a dynamic method for retrieving precipitation over Greenland from these analyzed fields twice a day. Precipitation and accumulation over Greenland from 1957 to 1995 and their seasonal interannual variations are being estimated by this approach. How the atmospheric general circulation and weather systems control precipitation and accumulation over Greenland is also being studied.

The mean precipitation for 11 years, from 1985 to 1995, shows maximum values of more than 100 cm/yr along the southeastern coast and the southwestern edge of Greenland, with a secondary band of relatively high precipitation along the western coast. A large area of very low precipitation (less than 20 cm/yr) dominates the northern interior region.

Retrieved precipitation amounts for 1985–1995 are being compared with published accumulation maps, as well as the accumulation rates from recent ice cores. Preliminary analysis shows an

average difference of 10% for these comparisons. The accumulation/precipitation data sets are compared by deriving the spatial distribution of their differences. The total annual accumulation over the entire ice sheet and its major regions is also computed from the different data sets. The annual accumulation computed by the dynamic method for the 1985–1995 period is lower than the observed data over a significant part of the ice sheet. This difference may be real, in that most of the ice core observations were acquired before this period, and a decline in precipitation amounts over Greenland for the last three decades has been inferred from a variety of atmospheric methods.

Ice Sheet Mass Balance

Ice velocity has been measured at approximately 30-km intervals, mainly along the 2000-m contour line, around the entire ice sheet. Repeated GPS data were collected at these sites, with more than 400 individual site occupations at about 180 stations. The sites were established by planting an aluminum pole vertically in the ice, with a flagged bamboo pole planted nearby to make the site easier to find for the next occupation. Spacing between sites was usually 30 km, with some areas of denser spacing on the western slope of the ice sheet and an area with 40-km spacing in the northwest. Prior to 1995 the sites were visited by snowmobile traverse, but from 1995 the work was done using a ski-equipped Twin Otter aircraft.

Ice thickness was also measured along the velocity traverse using the CORDS airborne low-frequency radar. These two sets of measurements have been used to estimate the total volume of ice discharged across the traverse, and to compare this with total snow accumulation within the ice sheet catchment area inland from the velocity traverse, to infer the mass balance, or rate of thickening/thinning of the ice sheet. Initial results indicate that, taken as a whole, this interior portion of the ice sheet is almost in balance but with localized regions thickening or thinning by 10 cm or more per year.

This analysis is complete for most of the traverse, with a major gap in the southwestern quadrant of the ice sheet, where ice thickness has yet to be successfully measured. Deep ice in this region is warmer than elsewhere, severely reducing the radar penetration. Nevertheless, planned improvements to the CORDS depth sounder should resolve this problem during the 1998 field season.

The accuracy of the estimated mass balance using this approach is primarily determined by the accuracy of the assumed snow accumulation rates. Consequently 1998 plans for PARCA include a continued program of shallow coring to further improve our estimates of snow accumulation and its temporal variability over the entire ice sheet.

Localized Ice Thickness Changes

The objective of this project is to determine local rates of ice thickness change at various sites in Greenland. The results will be used to identify regions of the ice sheet where large changes are occurring, the causes of which can be investigated in future studies. The results will also be helpful for interpreting elevation changes detected by repeat airborne and satellite altimetry.

Precise measurements of vertical velocity are compared with the accumulation rate at the same location; if the two quantities differ, the ice sheet must be either thickening (when accumulation exceeds downward velocity) or thinning (when the reverse is the case). Vertical velocity is obtained from repeated GPS surveys of markers anchored at several depths in the firn or ice. By placing the markers at depth, vertical motion due to variations in snowfall and firn compaction is avoided. In most cases, markers are placed in hot-point-drilled holes, at depths ranging from 5 to 25 m. If markers can be anchored in solid ice, then the correction for firn compaction does not need to be made. At two sites, NASA-U and Humboldt, markers were installed in ice at the base of 150-m-deep holes from which other PARCA investigators have recovered cores.

Twelve sites have been installed on the Greenland ice sheet, and as of 1997, five sites have been studied in detail. Thickness changes range from +13 cm/yr (thickening) to –54 cm/yr (thinning).

Ice Velocity and Discharge Flux from Interferometric Synthetic Aperture Radar

The objectives of this research are to measure the ice discharge of the Greenland ice sheet as close as possible to the grounding line or calving front of outlet glaciers and to compare the results with mass accumulation and surface ablation in the interior to estimate the mass balance of the ice sheet.

The approach involves using multiple-pass ERS radar interferometry data to measure the vel-

ocity, topography and grounding zones of the outlet glaciers, in combination with surface topography derived from satellite altimetry. At the grounding line, ice thickness is derived from the glacier surface elevation, assuming that the ice is in hydrostatic equilibrium. Where no grounding line is present, ice thickness must be measured by other means, such as using ice sounding radar. Mass accumulation is obtained from published data, and surface ablation is calculated using a degree-day model.

Interferometric SAR observations of the Greenland ice sheet gathered by the European Space Agency's Earth Remote Sensing (ERS-1 and 2) satellites were used to map the grounding line and ice velocity of northern Greenland glaciers. Combined with an existing digital elevation model of north Greenland, limited radar echo sounding data and prior data on mass accumulation, the interferometric results were used to measure the grounding line ice discharge of 22 glaciers and to compare these estimated fluxes with the total mass accumulation in the interior, corrected for losses by surface ablation calculated from a degree-day model. The results suggest that basal melting is a major form of mass loss to the ocean from the northern sector of the Greenland ice sheet. Basal melt rates inferred assuming steady state conditions are ten times those recorded on Antarctic ice shelves. The mass balance analysis, recently complemented with new glacier additions, continues to indicate that the northern sector of the ice sheet may be slowly thinning at present. It has also been found that the grounding line of Petermann Glacier retreated by several hundred meters between 1992 and 1996, consistent with the suggested thinning trend of north Greenland glaciers.

A similar approach, combining ERS interferometry data from 1995–1996 and ice sounding radar measurements to be collected in 1998, is being used to characterize the ice discharge of the entire coast of East Greenland.

Ice Flow in the Northeast Greenland Ice Stream

SAR interferometry controlled by GPS field surveys is providing us with a detailed picture of ice flow in the major ice stream draining much of the northeast Greenland ice sheet, which was first detected in SAR imagery. The flow patterns in the onset area are more complicated than had previously been reported, with an apparent second tributary entering from the south. Downstream, the flow changes character and seems to deviate from what would be expected from simple balance flux estimates. This may be due to problems with the data used for estimating the balance, or it may be reflecting a variability in the system related to the surging behavior of Storstrommen Glacier.

In addition to the ice flow information, newly acquired radio-echo sounding profiles and altimetry data are helping to define the character of this large feature. Multiple-azimuth photoclinometry using AVHRR data is also improving our understanding of the surface topography that is produced by the rapid ice motion. Initial results from this work show that the margins of the stream are topographic troughs and that the undulation field on the stream is strong enough to produce closed basins in several areas.

Greenland Ice Surface Elevation Changes from Satellite Radar Altimetry

Estimates of the overall mass balance and seasonal and interannual variations in the surface mass balance are obtainable from time series of ice surface elevations measured by satellite altimetry. Although satellite radar altimetry has significant limitations in coverage and accuracy over sloping surfaces, information on ice sheet surface elevation changes has been derived for central parts of the Greenland ice sheet.

One group of investigators re-examined elevation change estimates for the Greenland ice sheet by incorporating a global method for analyzing altimeter orbit error present in the ice sheet data sets. Because the predominant radial orbit error is a long-wavelength signal concentrated at the circular frequency of the orbital period, they used a global analysis of ocean altimeter data sets. For the Geosat-Exact Repeat Mission (ERM: 1987–1988) and Seasat (1978) mission, crossover data sets were created with respect to a reference (mean) ocean surface. The radial orbit error was identified by passing the sea-height crossover residuals through a stochastic filter designed to estimate the time-varying amplitudes of the sinusoidal orbit error function and the measurement system bias that may be present in inter-satellite comparisons.

The resulting orbit error corrections were applied to the Seasat and Geosat-ERM Greenland data sets, and the elevation change was analyzed

by dividing the average change in elevation by the average time interval using all crossovers. A spatial analysis reveals large geographic variations in elevation change from –15 to +18 cm/yr. After isostatic adjustment, a spatial average of 32,283 ERM × Seasat crossovers yields a growth rate of 1.7 ± 0.5 cm/yr from 1978 to 1988. This growth rate is less than 10% of that calculated in earlier analyses, primarily because of improvement in our knowledge of the satellite orbits. Given the large spatial variations in elevation change, this averaged growth rate is too small to determine whether or not the Greenland ice sheet is undergoing a long-term change due to a warmer polar climate.

Elevation changes obtained between Seasat (1978) and Geosat (1985–1989) are affected by the short three-month period of Seasat and interannual variations in the seasonal cycle, and in a separate analysis, the ice thickening rate derived from four years of Geosat data (1985 to 1989) for the area south of 72°N was found to be about 7 cm/yr. Seasonal variations in elevation, caused by variations in snowfall, firn compaction and melting, are also observed. A consistent set of improved satellite orbits and altimeter corrections have been used in this analysis. Ice thickening is observed in the southern portion of the ice sheet by about 10–20% of the mass balance. Seasonal variations in the surface elevation are also observed, ranging from a 14-cm peak-to-peak amplitude cycle with a minimum in July at elevations of 2200–3300 m to about 2 m with a minimum in late September in the upper ablation zone.

Drilling a 10-meter hole with a hand auger to insert a thermistor chain for snow and ice temperature recordings. This is done at each automatic weather station of the Greenland Climatic Network (GC-Net).

Preliminary analysis of ERS-1 radar altimetry data (1992–1996) above 76°N suggests a thinning of 11 cm/yr above 2700-m elevations on the northeast part of the ice sheet and a thickening at lower elevations with a 10-cm/yr maximum at 1200- to 1700-m elevations. On the northwest part of the ice sheet, the data suggest a thinning of 20 cm/yr above 2200 m and a thickening at lower elevations, with a 24-cm/yr maximum at 1200- to 1700-m elevations. These results from ERS-1 data are very preliminary and are not confirmed by other PARCA investigations.

The analysis of radar altimetry data to measure changes in elevation is fraught with problems. Beginning in 2001, NASA's Geoscience Laser Altimeter System (GLAS) will significantly improve the range accuracy, orbit accuracy and spatial coverage for measurements of seasonal and long-term changes of ice sheet elevations.

Greenland Network of Automatic Weather Stations

The Greenland Climate Network (GC-Net) was initiated in 1995 with the goal of monitoring climatological and glaciological parameters at various locations on the ice sheet. Stations have been added each year, so that the present network includes 14 stations and monitors 350 parameters. So far the GC-NET database contains more than 14 station-years of measurements that have been quality controlled and calibrated.

The tasks of calibration and quality control have been updated for the majority of GC-Net stations. Documentation of the data sets and the description quality control methods have been generated. Satellite-transmitted data are currently being used to extend the GC-NET record to the present. The quality control task is complicated by the fact that up to 20% of the data are not transmitted. This set of procedures was developed to optimize the data record using interpolation techniques. Once a station is revisited, continuous data can be retrieved to replace the transmitted data. Quality control procedures are applied to all AWS data sets.

An interesting cross correlation was found

between wind speed and surface temperature, with a coefficient of better than 0.5. The wind speed increase does precede the temperature increase by approximately 6–10 hours. This relation was observed mainly during winter and has important implications for microwave satellite remote sensing and for the interpretation of shallow ice cores. Because of the warmer air and the wind-pumping effect of strong wind, the snow cover temperature increases near the surface. If the temperature gradient is sufficiently large, depth hoar layers form in the middle of winter.

A mean monthly lapse rate was derived along the Jakobshavn–Summit profile of 0.6–0.7°C per 100 m for spring and summer and 0.8–1.0°C per 100 m for fall and winter. The katabatic wind along the same profile showed an increase in directional constancy towards the coast. The interannual variability of snow accumulation at various GC-Net sites, as well as the radiative and turbulent energy exchange, has been studied in detail.

Multiple snow precipitation events were identified using AWS data. Typical accumulation events are characterized by higher than normal temperatures, wind speeds increasing with the approach of a storm and then diminishing as soon as snowfall begins, an increase in downwelling long-wave radiation flux, an increase in boundary layer stability as reflected by positive Richardson numbers, an increased surface albedo, and decreasing pressure. Humidity was observed to approach saturation during snow events yet was preceded by a short dry phase just before snowfall began, indicating the invasion of a different air mass. For the Humboldt AWS, the wind direction during snow events is westerly, indicating that Baffin Bay is an important moisture source region. At TUNU-N, snow events are associated with winds from the north and east.

Estimates of Ablation Rates on the Greenland Ice Sheet from Passive Microwave Observations

The primary objective of this project is to estimate the ablation rate of the Greenland ice sheet using SMMR (scanning multichannel microwave radiometer) and SSM/I (special sensor for microwave/imaging) data. Passive microwave satellite sensors have been used to map the spatial extent and frequency of snowpack melting on the ice sheet; a continuous time series is available since October 1978. The derivation of melt frequencies from microwave data is based on the increase in microwave emissivity as liquid water is introduced into a previously dry snowpack. A simple radiative transfer model is used to estimate the SMMR and SSM/I 37-GHz, horizontal-polarization brightness temperatures associated with melting snow and ice. The modeled brightness temperatures are used as thresholds. If the observed brightness temperature exceeds the modeled brightness temperature, melt is said to have occurred that day.

Time series of brightness temperatures have been extracted from the Pathfinder SMMR data at 100-m elevation increments from 900- to 2700-m elevations near long-term climate monitoring stations at Qamanarssup sermia (64°N) and Patiksoq (70°N) in western Greenland. Microwave-derived annual melt duration (in days) was compared to the melt duration estimated from mean monthly surface temperature data for the Qamanarssup sermia and Patiksoq transects. The same time period was used to calculate average annual melt durations from the surface temperature data. Mean monthly temperatures from long-term climate monitoring stations, augmented by coastal weather stations, are used to calculate the number of days with melt. The number of days with temperatures greater than 0°C, based on an assumed normal temperature distribution, is calculated for each month and then summed to arrive at the annual melt duration. Along the Patiksoq transect there is no more than a three-day difference in annual melt duration at any elevation between the satellite and surface temperature estimates of melt duration. A snow and ice melt model is used to account for different degree-day factors for snow and ice surfaces and to account for the formation of superimposed ice. Mass balance calculations give an overall average annual accumulation of approximately 530 km^3/yr and a mean annual ablation rate of 230 km^3/yr. The ablation rate shows a large range during 1988–1996 from 100 to 500 km^3/yr, but most years experienced 200–300 km^3/yr. Approximately 13% of the ice sheet experiences net ablation, but this varies from 8% (1992) to 23% (1995).

Absolute Gravity and GPS Measurements in Greenland

Ongoing changes in the distribution and volume of ice in Greenland could cause vertical crustal motion of up to several millimeters per year or more around the edges of the ice sheet. By measuring this motion, it should be possible to learn

about those changes in ice. However, the viscoelastic response of the earth to past changes in ice loading could cause vertical motion rates that are of the same order. These viscoelastic effects must be known before crustal motion observations can be used to help constrain the mass balance of the ice caps. Theoretical arguments suggest that this can be done by combining vertical motion measurements with simultaneous observations of time variation in gravity.

Multi-year simultaneous measurements of absolute gravity and GPS crustal motion are being made at two bedrock sites at the edge of the Greenland ice sheet: Kangerlussuaq and Kulusuk. Continuous GPS measurements have been made at Kangerlussuaq since July 1995, and three two-week occupations with an absolute gavimeter have also been carried out. GPS results indicate that the crust is subsiding at a secular rate of about 6–8 mm/yr. The absolute gravity measurements are consistent with the GPS measurements. These preliminary results suggest that the ice sheet may be thickening at the rate of a few tens of centimeters per year averaged over a few hundred kilometers from Kangerlussuaq; however, a longer data span is required to support this interpretation.

Atmospheric Chemistry and Ozone

NASA supports a number of tasks related to measuring and understanding chemical and dynamic processes in the Arctic atmosphere from the upper troposphere through the stratosphere and lower mesosphere. Such studies include the measurements and subsequent data analysis using space-, aircraft-, balloon- and ground-based instruments. These activities are accomplished through NASA's Upper Atmosphere Research Program (UARP) and Atmospheric Chemistry Modeling and Analysis Program (ACMAP), as well as a number of space flight missions. A particular focus of the work supported by these programs is on the seasonal, annual and long-term changes in Arctic stratospheric ozone and the atmospheric constituents and processes that affect this change.

The 1997 Photochemistry of Ozone Loss in the Arctic Region in Summer (POLARIS) aircraft campaign primarily used the NASA ER-2 and balloon platforms based in Fairbanks, Alaska, to measure selected species within the reactive nitrogen (NO_y), halogen (Cl_y) and hydrogen (HO_x) families, aerosols and other long-lived species in the lower and middle stratosphere. The POLARIS campaign included a total of 30 ER-2 flights and three balloon flights during three deployment periods in 1997: 17 April to 15 May, 24 June to 13 July, and 3 September to 27 September. These measurements, along with computer models of the atmosphere, meteorological data and satellite data, are being used to understand the seasonal behavior of Arctic stratospheric ozone as it changes from very high concentrations in spring down to very low concentrations in autumn due to chemistry and transport at high latitudes. This behavior has been attributed to an increased role of NO_x catalytic cycles for ozone destruction during periods of prolonged solar illumination, such as occur at high latitudes during summer. Thus, the detail with which current photochemical models can describe this large natural signature in ozone serves as an indication of how well the role of increased stratospheric NO_x from anthropogenic sources, a possible consequence of future supersonic transport, can be quantified.

Measurements of the distribution of total ozone over the Arctic are measured with the Total Ozone Mapping Spectrometer (TOMS) series of instruments. Two TOMS instruments have provided data in the last two years. One, launched aboard NASA's Earth Probe (EP) satellite in July 1996, has been operated routinely since launch. Another, aboard the Japanese ADEOS satellite, operated from shortly after its launch in August 1996 until the failure of the ADEOS satellite in June 1997. Although they were launched into different orbits, which affected their spatial coverage in the tropics and midlatitudes, both satellites have provided full daily coverage of the sunlit Earth at high latitudes (poleward of approximately 50°).

The TOMS observations have proved useful in showing unusual ozone distributions over the Arctic in the winter of 1997. In particular, there was a region of large ozone depletion over the Arctic that winter, prompted largely by the presence of low temperatures throughout much of that winter and a lack of wave activity that allowed for a stable polar vortex to last well into March. At that time of spring, there is enough sunlight for photochemical ozone-depleting processes, such as those that take place over the Antarctic during September, to occur over the Arctic. The lowest ozone column amounts seen over the Arctic in the winter of 1997 were as much as 40% below comparable amounts seen early in the TOMS record (1979–1980), when the Nimbus 7 satellite provided TOMS data. The region of ozone depletion was centered over the pole for most of its existence,

which lasted until the breakdown of the polar vortex in the stratosphere. In 1997 this did not occur until April.

The lowest ozone column amount seen in the Arctic in 1997—219 Dobson Units (DU, 1 DU = 1 milli atm cm, or corresponding to 2.67×10^{16} molecules cm^{-2})—are still much above the corresponding amounts seen over the Antarctic in September/October, and the region of low ozone seen in the Arctic is appreciably smaller (roughly threefold) than that seen in the Antarctic (which has lower ozone amounts). Demonstration that this ozone depletion takes place in the lower stratosphere was provided by data from the Upper Atmosphere Research Satellite (UARS), as well as from balloon-borne ozonesondes and ground-based lidars. The lowest ozone values observed in 1996 (for which TOMS data were not available, but which were obtained using the solar backscatter ultraviolet instrument aboard NOAA's NOAA-9 operational meteorological satellite) were also appreciably lower than in prior years, but not nearly so low as in the winter of 1997 (maximum depletion some 24%, rather than 40% as in the latter year, and centered in the region northeast of Greenland rather than over the pole as in 1997). Ozone levels in the Arctic winter in 1998 were not nearly so low as in 1997 because of the very different meteorological conditions those two years.

Evidence for downward descent in the wintertime northern hemisphere polar vortex has been obtained from analysis of spaceborne data, especially that from the Atmospheric Laboratory for Applications and Science (ATLAS) and UARS. For example, analysis of data obtained during the second ATLAS flight (April 8–16, 1993) showed that in the winter of 1992-93, average descent rates ranged from 0.8 km/month at 20 km to 3.2 km/month at 40 km. These descent rates are comparable to those observed over the Antarctic during the third ATLAS mission (November 1994), but the overall descent distance in the Arctic is smaller because the vortex does not persist as long there. In the ATLAS-2 observations, a clear distinction could be seen in the distribution of long-lived tracers inside and outside the vortex in the middle and lower stratosphere.

Measurements of trace chemical species in the Arctic stratosphere are made regularly using the UARS. A particularly important set of measurements are those of the microwave limb sounder (MLS) instrument, which measures O_3 and ClO. MLS measurements have been very useful in pointing out the abundance of high levels of ClO in the Arctic. Record high ClO and low ozone values were recorded at high northern latitudes in 1997. Because of slightly higher temperatures and less persistent confinement, Arctic ozone losses have not been as severe as in the Antarctic. Interannual variability in the dynamical conditions of the Arctic vortex is in general greater than in the Antarctic, and ozone distributions in the winter and spring will therefore have much greater interannual variation than in the Antarctic. A slight cooling of the stratosphere due to increasing concentrations of radiatively active gases has the potential to exacerbate ozone depletion in the Arctic through the formation of increased amounts of polar stratospheric clouds.

Ground-based Fourier transform spectrometer (FTS) measurements at Sondre Stromfjord, Greenland, (67.02°N, 50.72°W) had been made by researchers from the National Center for Atmospheric Research from October 1994 to April 1995. A new instrument (Bomem 120-M) was installed in the summer of 1997 at Thule, Greenland, (76.53°N, 68.74°W) and has begun obtaining data. Conducted under UARP support, these measurements are a component of the international Network for Detection of Stratospheric Change (NDSC) and have yielded column abundances for HCl, HF, O_3, HNO_3 and N_2O. The results have been compared with similar observations made during the Second European Stratospheric Arctic and Mid-latitude Experiment (SESAME) and have been presented in a special issue of the *Journal of Atmospheric Chemistry*. Another recent NDSC Arctic activity was the ozone and aerosol lidar intercomparison held in Ny Ålesund, Spitsbergen, (78.92°N, 11.93°E) during the winter of 1997-98.

NASA's UARP and ACMAP continue to support measurements and multidimensional models for atmospheric chemistry and transport needed to study the global atmosphere. The mission results presented above underscore the necessity to include the full range of dynamical, radiative and chemical processes in models that are used to predict future ozone losses given prescribed scenarios for emission of CFCs, their substitutes and other chlorine- and bromine-containing compounds.

Department of Commerce

National Oceanic and Atmospheric Administration

NOAA performs research in the high-latitude regions of the planet in connection with its environmental assessment, monitoring and prediction responsibilities. Individual research programs focus on scientific questions addressing the Arctic environment and its relation to the global environment. NOAA also conducts research in support of services it performs, such as weather forecasting and fisheries management.

National Marine Fisheries Service

National Marine Mammal Laboratory

The Protected Resources Management Division and the National Marine Mammal Laboratory (NMML) of NOAA's National Marine Fisheries Service (NMFS) are responsible for the protection, management and research for 22 species of marine mammals that occur commonly in that state, including five endangered species (bowhead, fin, humpback, northern right and sperm whales), one threatened species (Steller sea lion) and one depleted species (northern fur seal). Protection involves the implementation of recovery plans for the Steller sea lion and the humpback whale, the implementation of the Northern Fur Seal Conservation Plan, the development and implementation of a conservation plan for the harbor seal, and cooperation with the International Whaling Commission regarding subsistence takes of bowhead whales. In 1994, Congress amended the Marine Mammal Protection Act (MMPA), adding several new sections, including one pertaining to cooperative agreements in Alaska. The amended MMPA notes that "the Secretary may enter into cooperative agreements with Alaska Native organizations to conserve marine mammals and provide co-management of subsistence use by Alaska Natives." The amendments specifically provide NMFS with the authority to provide grants to Alaska Native organizations to:

- Collect and analyze data on marine mammal populations;
- Monitor the harvest of marine mammals for subsistence use;
- Participate in marine mammal research; and
- Develop co-management structures with Federal and state agencies.

	Funding (thousands)	
	FY 96	FY 97
Atmospheric Trace Constituents	423	34
Fisheries Assessment/Management	7,145	5,960
Marine Mammal Assessment	2,318	2,237
Coastal Hazards	78	50
Ocean Assessment	154	150
Stratospheric Ozone	92	32
Satellites/Data Management	749	312
Remote Sensing	449	230
Aircraft/Vessels	1,606	1,457
Climate and Global Change	409	478
Arctic Ice	57	115
Weather Research	256	210
Western Arctic/Bering Sea Ecosytem	0	2,331
Barrow Observatory		211
Undersea Research		16
Arctic Research Initiative		1,000
Total	13,736	14,823

The NMFS's Alaska Regional Office (AKR) has developed a program to determine subsistence takes of Steller sea lions, harbor seals and beluga whales. Through contracts with the Alaska Department of Fish and Game and the Cook Inlet Marine Mammal Council, comprehensive data on numbers of animals taken for subsistence, or struck and lost, each year from 1992 through 1996 have been collected. These data are critical in determining whether these animals should be listed as "strategic" under the Marine Mammal Protection Act. For several years the AKR has supported and partially funded the Alaska Native Harbor Seal Commission and is working to help establish a Native commission for the management of Steller sea lions. The AKR continues to work with the Indigenous People's Commission for Marine Mammals, the Pribilof Islands Joint Management Board, the Alaska Beluga Whale Committee and several other groups to further conservation of

marine mammals taken for subsistence. The AKR has also continued the systematic collection of tissue samples from Steller sea lions, harbor seals and beluga whales in Alaska to determine whether contaminant levels in tissues intended for human consumption are at acceptable levels and also to aid in stock determination. The AKR has also been instrumental in spearheading efforts to try to overcome the negative impacts of development on the Pribilof Islands by working with the Coast Guard, EPA, U.S. Army Corp of Engineers, Alaska state agencies and the residents and governments on St. Paul and St. George Islands. Finally, the AKR has been working with Russian and American marine scientists to support additional research on local problems and on the health of the overall Bering Sea ecosystem.

Some of the changes to the MMPA in 1994 significantly affected research on marine mammals in Alaska. In addition, the general trend to downsize programs within the Federal government has eroded support for several long-term research projects. For example, NMML's bowhead research program has been terminated. One of the primary accomplishments of NMML scientists in recent years was the summary of the status of all stocks of marine mammals that occur in the waters off Alaska. This volume, titled *Alaska Marine Mammal Stock Assessments 1996,* is available at no cost and includes summaries for each species on the following topics: stock definition, population size, minimum abundance, current trends in abundance, maximum productivity, potential biological removal levels, human-caused mortality and status.

Field research at the NMML on marine mammals in waters off central and northern Alaska has concentrated on five species in recent years: Steller sea lions, harbor seals, northern fur seals, beluga whales and gray whales. In FY 97 a survey was initiated to determine the abundance and distribution of cetaceans within 200 miles of the coastline. The FY 97 survey was the first of three planned surveys and covered southeast Alaska.

The breeding range of the Steller sea lion extends from the Kuril Islands and Okhotsk Sea, eastward through the Aleutian Islands and Gulf of Alaska, and then south to central California. The number of sea lions throughout the range has declined by over 66%, from about 300,000 in the 1960s to 116,000 in 1989; the first range-wide survey in 1994 coordinated by the NMML indicated a further decline. At present the area from southeastern Alaska through Oregon is the only region where the number of animals is not declining. Counts of animals in rookeries and haulout sites within most of Alaska showed a rapid decline between the 1970s and 1989 and a continued decline (but at a slower rate) from 1989 to 1996. The causes for the decline have not been identified.

In 1990, Steller sea lions were listed under the Endangered Species Act as threatened throughout their range; no evidence existed then to separate the species by stock. Subsequently NMML and university scientists conducted joint studies that have shown genetic differences supporting a separation in the Gulf of Alaska. These genetic data, along with supporting data on the size of pups, movement patterns, fidelity to birth sites and population trends, were judged sufficient to warrant separation of the species into two management units, a western stock and an eastern stock. The population of the eastern stock has remained stable over the past 20 years, but the western stock continues to decline, culminating in its status changing to endangered in June 1997. The eastern stock remains as threatened.

Beluga whale research has taken place annually over the last five years. The primary focus of NMML-supported beluga whale surveys has been in the Cook Inlet region. Here, in cooperation with the Alaska Beluga Whale Committee, the Cook Inlet Marine Mammal Council, the Alaska Department of Fish and Game and the AKR, NMML scientists have attempted to determine the abundance of a relatively small and isolated population. Aerial surveys have indicated an abundance of whales, on the order of 1000 animals. Research has also been directed toward catching and radiotagging animals to determine movement patterns and correction factors for aerial surveys. Efforts are underway to determine if the number of animals in Cook Inlet is sufficient to support recent subsistence harvests of approximately 50 animals per year.

In the past 10 years, NOAA funding to support research on ice seals has generally not been available. At present, reliable estimates of abundance for ringed, bearded, ribbon and spotted seals are not available, although the current level of subsistence use of these animals is thought to number in the thousands annually. Therefore, the NMFS is tentatively planning to initiate surveys to determine the abundance for these species in 1998 and again in 2010. These surveys will be done in cooperation with the Alaska Department of Fish and Game, Native organizations, local residents and the AKR. In FY 97, NMML cooperated in year two of a three-year study on ringed seals. This work,

funded by the Minerals Management Service through a grant to the Alaska Department of Fish and Game, has as its objective to ascertain the extent to which ringed seal distribution is affected by industrial activities along the North Slope. A final report will be prepared after the final survey in FY 98. Annual reports are available from ADF&G on request.

The Marine Mammal Health and Stranding Response Program (MMHSRP) was established in 1992 to facilitate the collection and dissemination of data on the health of marine mammals and health trends in marine mammal populations in the wild, to correlate these trends with available data on physical, chemical and biological environmental parameters, and to coordinate effective responses to unusual marine mammal mortalities. In 1987 the Minerals Management Service provided funds to NOAA to establish and conduct the Alaska Marine Mammal Tissue Archival Project (AMMTAP) for the collection and long-term storage of tissues from Alaska marine mammals. AMMTAP continues now in conjunction with the MMHSRP with funding provided from NMFS and DOI's National Biological Service (now the Biological Resources Division of the U.S. Geological Survey). The program involves the participation and cooperation of Federal agencies, state organizations, international agencies, universities and Native American organizations. Samples continue to be collected to determine the levels of contaminants in Alaskan marine mammals, to determine the health of populations, and to examine correlations between health and contaminant levels. In addition, the data are being used by public health organizations to examine circumpolar patterns of chlorinated hydrocarbon concentrations and the potential risk to people who eat marine mammals as subsistence foods.

MMHSRP has involved the evaluation of health and contaminant issues through the analysis and banking of marine mammal tissues from subsistence hunting activities. The NMFS's Environmental Conservation Division has spearheaded the analyses of these tissues for contaminants in collaboration with the National Institute of Standards and Technology and other international research laboratories (Department of Fisheries and Oceans, Canada, and Karl-Franz University, Austria). These tissues were analyzed for a variety of projects:

- Ongoing monitoring (Steller sea lions and beluga whales);
- Specimen banking activities (beluga and bowhead whales and harbor seals); and
- Ongoing studies to determine the impact of contaminants on marine mammal health.

In FY 96 and 97, over 500 samples were acquired or analyzed for chlorinated hydrocarbons and essential and nonessential elements.

The Department of Commerce's National Institute of Standards and Technology (NIST) serves as the repository for the archived tissues and sera from Arctic animals. These samples are cryogenically frozen and stored for future analyses as needed when new methods are developed or as new questions are asked. In FY 96 and 97, samples were collected from 37 pinnipeds (8 species), 34 cetaceans (2 species), 28 polar bears and 3 sea otters. Currently the National Marine Specimen Bank contains tissues from 124 pinnipeds, 88 cetaceans, 28 polar bears and 3 sea otters. A quality assurance component spearheaded by NIST monitors the collection and analyses of these samples to ensure the consistency and accuracy of data. Two interlaboratory comparisons were performed during these budget years, and tissues were collected and analyzed for a new beluga whale liver control material.

Finally, health issues in these marine mammal populations are addressed through cooperation with the Armed Forces Institute of Pathology and the Department of Agriculture. Tissues from these animals are being analyzed for evidence of disease and will be stored for future analyses as needed. Sera from these animals have been banked for future studies of the presence of antibodies to specific diseases. In addition, specific analyses are being performed to monitor the presence of diseases of current concern.

All of the data collected are centralized into a database that can be accessed by researchers and managers. The information collected will help managers make risk assessment and impact decisions regarding marine mammal populations in the Arctic. In addition, these data will contribute to our current state of knowledge about the presence and possible effects of anthropogenic contaminants present in this fragile ecosystem.

Resource Assessment and Conservation Engineering Division

Marine Fisheries Assessment. NOAA's NMFS continued its long-standing commitment to assessment studies of U.S. living marine resources (LMRs) in the Bering Sea, Aleutian Islands and Gulf of Alaska during 1996 and 1997. This effort includes fishery-independent resource surveys, collection of data from commercial fisheries through fisheries observers, collection of recreational and

commercial harvest statistics, and basic population biology and ecological research. The scientific information generated by these activities supports Federal fishery conservation and management responsibilities in the 200-mile U.S. Exclusive Economic Zone (EEZ).

The Alaska Fisheries Science Center (AFSC) in Seattle continues to annually assess the stock condition for most species of marine finfish and shellfish having commercial, recreational or ecological significance in western U.S. Arctic waters (the Bering Sea, Aleutian Islands and Gulf of Alaska). These assessments provide measures of population abundance independent of those derived from analyses of catch and landing statistics, and they also address the status and health of the marine ecosystem as a whole. Information syntheses incorporate identification of stock units, short-term prediction of abundance trends, biological interaction of species and species groups, and general ecosystem response to environmental change. When combined with data from the commercial fleet (that is, fishing effort, location, catch composition, fish size/age, etc.) collected through the AFSC's Observer Program, AFSC stock assessments provide recommendations for managing the fisheries and conserving the supporting resource base.

LMR populations are sampled at sea aboard NOAA ships, chartered fishing vessels and cooperating foreign research vessels. Significant area-extensive survey efforts rotate every three years between the eastern Bering Sea, the Aleutian Islands and Gulf of Alaska, and the west coast of the U.S. During intervening years, standardized AFSC assessment surveys are conducted within each region. Annual estimates of stock abundance are completed for commercially important species, such as walleye pollock, Pacific cod, sablefish, yellowfin sole and king and Tanner crabs. Dedicated scientific cruises are also conducted to study biological and physical processes that affect stock assessments.

The principal survey methods include bottom trawls for demersal fish and crabs, hydroacoustic and midwater trawls for semipelagic fish, and special-purpose nets for eggs, larvae and juvenile fish and shellfish. Trawl and acoustic surveys are used to estimate biomass and define community structure; biological collections are taken to examine variability in growth, mortality and stock recruitment. In FY 96 the AFSC continued the annual bottom trawl survey effort of Bering Sea groundfish and crab and conducted the triennial bottom trawl survey of Gulf of Alaska groundfish. Winter and summer echo integration/trawl (EIT) surveys of pollock in the Bering Sea and a winter survey of pollock in Shelikof Straits in the Gulf of Alaska were also conducted. In 1997 the AFSC triennial survey effort was directed at the Bering Sea and Aleutian Islands, where bottom trawl surveys of the Bering Sea and Aleutian Islands were conducted, as well as a summer EIT survey of pollock in the Bering Sea. Winter EIT surveys of pollock in the Bering Sea and Shelikof Straits were also conducted.

Recruitment indices and processes that generate variations in abundance are studied to improve prediction through the Fisheries-Oceanography Coordinated Investigations (FOCI). FOCI is a cooperative program between the AFSC and NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle. To increase the accuracy and precision of these assessments, AFSC scientists conduct biological research to define recruitment processes, develop computer models to simulate interactions and dynamics of population change, and conduct or collaborate in extramural studies to improve sampling methods and survey designs.

Pacific Salmon. The five species of Pacific salmon in the Alaska region are one of the Nation's most valuable resources. The salmon in the vast marine areas off Alaska are managed via a complex mixture of domestic and international bodies, treaties, regulations and agreements. Research objectives are to:

- Assess interception rates of U.S. stocks in boundary fisheries associated with the Pacific Salmon Treaty;
- Assess impacts on North American stocks from large releases of Asian hatchery stocks;
- Support the Ocean Carrying Capacity Program; and
- Determine the origin of salmon incidentally caught in domestic groundfish fisheries.

Ocean Carrying Capacity. Auke Bay Laboratory's Ocean Carrying Capacity Program continues the NMFS role in the stewardship of living marine resources of the North Pacific. Early research efforts focused on measuring and assessing the effects of various high-seas fisheries such as the Japanese mothership salmon fishery and the high-seas driftnet squid fisheries. Much of the expertise, biological methodology and working relationships developed while addressing those issues is now directed towards understanding the effects of environmental and biological interactions on the productivity of the North Pacific. This

research program bridges the gap between ongoing coastal ecosystems studies in Prince William Sound and the high-seas Carrying Capacity and Climate Change study developed by the North Pacific Marine Sciences Organization (PICES) and North Pacific Anadromous Fish Commission (NPAFC) scientists from Canada, Japan, Russia and the U.S. For the past two years the research activities have included:

- Salmonid growth studies, using scale patterns as an indicator of freshwater and ocean growth patterns of salmon;
- Salmon energetics studies, linking basic physiology and behavior with habitat conditions to evaluate the effects of changes in temperature and predator/prey densities on growth, consumption and ultimately trophic interactions;
- Field and laboratory studies of oceanographic conditions, phytoplankton and zooplankton abundance and salmon abundance, distribution and stock origins; and
- Stock identification studies, which are part of an international, multi-agency program to develop comprehensive genetic, scale pattern, parasite and tag recovery databases for stock identification of North Pacific salmonids.

Survey efforts in support of these activities have ranged from inside waters of southeastern Alaska to the Aleutian Islands.

National Ocean Service

NOAA/NOS conducts environmental research and monitoring, performs information synthesis, and disseminates data and information products to support management decisions affecting coastal and marine resources and environments in the U.S. Arctic. These activities date back to 1974 as part of the Outer Continental Shelf Environmental Assessment Program (OCSEAP), which was established under an interagency agreement between NOAA and the Bureau of Land Management. The program was designed to plan, conduct and report on a suite of multi-disciplinary studies responding to the specific needs, goals and objectives of the Department of the Interior in its decisions on oil and gas leasing off the coast of Alaska. From 1974 to 1992, OCSEAP produced a mammoth record of research reports and other data products, culminating in a 74-volume series of OCSEAP final reports and a bibliography consisting of over 4000 entries. OCSEAP research and information products, such as oil spill trajectory and weathering models, seismic exposure analysis models, avian energetics models and many innovative research protocols, are largely responsible for expanding our understanding of both the physical environment and biological resources of coastal and offshore Alaska. Interpretation and synthesis of OCSEAP still continue to identify and delineate a number of environmental and resource management issues, for example, elevated levels of metals, notably cadmium, in sediment and biological tissues, particularly in reference to Pacific walruses.

Since 1984, NOAA's National Status and Trends (NS&T) program has sampled sediment and biota (mussels and demersal fish) at several sites in Alaska to determine the levels and temporal trends of contaminants, including toxic trace elements, a variety of pesticides, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs), and a number of chlorinated industrial chemicals, such as polychlorinated biphenyls. The sampling sites are located in the Gulf of Alaska, Bering Sea, Chukchi Sea and Beaufort Sea. Although sampling frequency was low, the results based on sampling efforts during 1984–1992 have recently been compiled in a report and are available electronically on the Internet (http://seaserver.nos.noaa.gov). The program is also in the process of establishing a number of permanent sampling sites in the U.S. Arctic. To that end, six sites in the coastal Beaufort Sea were sampled in September 1997 in coordination with a larger study on the distribution of petroleum hydrocarbons in the region under the sponsorship of the Department of the Interior.

More recently, since 1993 the NS&T program has been engaged in describing the spatial distribution and scales of contamination from radionuclides in surficial sediment and selected biota in the Arctic, including species that are harvested for subsistence use (anadromous fish, marine mammals, seabirds and caribou). Using statistical records of subsistence harvests in the North Slope Borough and radionuclide activity in specific tissues and whole animals, the study results demonstrated there is a very small radiation dose from typical consumption of caribou meat and a virtually negligible dose from consumption of marine foods. These results were instrumental in alleviating widespread public concerns about the quality of traditional food resources in the region following disclosure of widespread dumping of radioactive wastes in the Arctic seas by the former Soviet Union. In addition, separate reports have been prepared on the levels of radionuclides and

other contaminants in the Beaufort Sea, the Russian Far East and the eastern Bering Sea. A manuscript describing and interpreting the atomic ratio of plutonium isotopes detected in Arctic sediments is nearing completion.

NOAA, through ongoing cooperative efforts with the Environmental Protection Agency and the U.S. Air Force, is involved in preliminary contamination assessment and recommendations for remedial action at several contaminated sites at the Elmendorf Air Force Base, located near Anchorage, Alaska. Similar cooperative efforts are also envisaged during clean-up and remediation activities at other contaminated states in Alaska that are included in the National Priority List.

NOAA/NOS staff took the lead role in synthesizing and reporting on data on petroleum hydrocarbon and PAH contamination in the Arctic. A comprehensive review chapter on the subject is included in the *State of the Arctic Environment* report that will soon be published under the auspices of the international Arctic Monitoring and Assessment Program. A 188-page summary of the report was published and distributed in June 1997. The staff is also organizing a special, multidisciplinary session with international participation called "Arctic Contamination: Levels, Transport, and Human and Ecological Effects" at the Joint Meeting of the American Society of Limnology and Oceanography and the Ecological Society of America, scheduled to be held in St. Louis, Missouri, June 7–12, 1998.

Coastal Ocean Program

Bering Sea Fisheries–Oceanography Coordinated Investigations

Beginning in 1991, NOAA's Coastal Ocean Program began funding the Bering Sea Fisheries–Oceanography Coordinated Investigations (BS FOCI) to develop an understanding of stock structure and recruitment variation in Bering Sea walleye pollock. This project was supported through FY 97. Among the final products are a biophysical model and a synthesis of recruitment process studies and stock structure. A coupled multi-species biophysical model, NPZF (nutrients, phytoplankton, zooplankton, fish), was developed to investigate the production dynamics of the pelagic ecosystem on the Bering Sea, especially in relation to the early life history stages of walleye pollock. This work has led to a better understanding of how and why variable physical and biological processes regulate the dynamics of biological production in upper ocean ecosystems. Given appropriate real-time biophysical oceanographic data from moorings, ship and satellite observations, this model predicts the larval pollock growth rate. This information is vital to understanding the potential contribution of the year class to the fishery. The NPZF model, when coupled with models treating larval mortality or juvenile growth and mortality, can predict pollock recruitment strength, which will help NMFS manage the resource.

The recruitment component of BS FOCI focused on understanding the causes of the variable mortality of pollock larvae in the various habitats of the southeastern Bering Sea. The synthesis concludes that pollock spawning occurs in discrete concentrations during winter and spring in a variety of habitats, including oceanic (basin and slope) and shelf waters. The application of BS FOCI recruitment studies in fishery management is in regard to the "Donut Hole" issue. This is a region in the deep central Bering Sea that could be fished by foreign vessels. BS FOCI research shows that the food supply in this region is insufficient to sustain a local population. This means the adult fish in the region had to originate in U.S. and Russian waters and would contribute to the spawning population on the U.S. shelf. Based on BS FOCI and acoustic population estimates, fishing was curtailed in the region by an international coordination group led by NMFS.

Southeast Bering Sea Carrying Capacity

The Coastal Ocean Program initiated a regional ecosystem study in FY 96 in the Bering Sea. The objective of the Southeast Bering Sea Carrying Capacity (SEBSCC) project is to study the southeastern Bering Sea ecosystem and the role of juvenile pollock in it, including the factors that affect their survival. Researchers will develop and test annual indices of pre-recruit (age-1) abundance. In its first research cycle (FY 96–98), SEBSCC has conducted its first full year of studies that included modeling, monitoring, process and retrospective studies.

In FY 98, research will focus on contrasting the environment of the Bering Sea shelf and slope from observations made during 1996, 1997 and 1998 in order to understand the strong interannual variability in this ecosystem. SEBSCC model simulations will be used to compare circulation, its effect on pollock survival, and upper-trophic-level interactions in the southeastern Bering Sea for warm and cold years. The objective of SEBSCC is to provide a pollock recruitment index for incor-

Further information on BS FOCI can be obtained by contacting NOAA Coastal Ocean Program (NCOP), 1315 East–West Highway, Room 15140, Silver Spring, MD, 20910; 301-713-3338; http://hpcc.noaa.gov/cop/cop-home.html or NOAA Pacific Marine Environmental Laboratory, 7600 Sand Point Way N.E., Bldg. 3, Seattle, WA 98115-0070; 206-526-6798; http://www.pmel.noaa.gov/bering

poration into stock assessments in order to recommend allowable biological catch estimates.

Further information on SEBSCC may be obtained by contacting NOAA Coastal Ocean Program (NCOP), 1315 East–West Highway, Room 15140, Silver Spring, MD 20910, 301-713-3338; http://hpcc.noaa.gov/cop/cop-home.html or NOAA Pacific Marine Environmental Laboratory, 7600 Sand Point Way N.E., Bldg. 3, Seattle, WA 98115-0070; 206-526-6798; http://www.pmel.noaa.gov/bering

Coastal Change Analysis Program, Yakutat Bay Regional Study

Quantifying changes in the areal extent of wetlands and adjacent uplands is critical for linking both natural phenomena and land-based human activities to coastal ocean productivity. The NOAA Coastal Change Analysis Program (C-CAP) uses satellite imagery and aerial photography to monitor the areal extent, functional status and change in these critical habitats. C-CAP has developed a standard, nationally accepted protocol for mapping submerged aquatic vegetation, emergent coastal wetlands and adjacent uplands. Change detection projects have been conducted in over a dozen states, including Alaska.

Further information on C-CAP may be obtained by contacting NOAA Coastal Ocean Program (NCOP), 1315 East–West Highway, Room 15140, Silver Spring, MD 20910; 301-713-3338; http://hpcc.noaa.gov/cop/cop-home.html or NOAA Coastal Services Center - C-CAP Program, 2234 South Hobson Ave., Charleston, SC 29405; 803-974-6233; or NOAA National Marine Fisheries Service Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801; 907-789-6000.

An analysis of change in coastal land cover during the period between 1986 and 1993 was initiated in the Yakutat Bay region of southeast Alaska. The analysis quantifies land cover changes resulting from natural phenomena (such as coastal erosion, flooding, and advance and retreat of Hubbard Glacier) and anthropogenic activities (such as logging and coastal development). Researchers from the National Marine Fisheries Service (NMFS) Auke Bay Laboratory, NMFS Beaufort Laboratory, and Oak Ridge National Laboratory used Landsat thematic mapper imagery and the C-CAP protocol to classify land cover and detect change in the coastal habitat of Russell Fiord and Hubbard Glacier. This change detection analysis has been used by the Sealaska Timber Corporation for guiding their logging strategies and identifying salmon habitat, the U.S. Forest Service for augmenting their wetlands survey and the City of Yakutat for guiding their stream restoration project. Map products and the analytical comparison of imagery are available on a CD-ROM titled "C-CAP—Changes in Land Cover in the Yakutat Bay, Alaska Region: 1986–1993." This product can be ordered from the NOAA Coastal Services Center.

Coastal Remote Sensing Science, Alaska Coastal Monitoring

The NOAA Coastal Ocean Program (COP), in cooperation with the National Environmental Satellite, Data, and Information Service (NESDIS), is investing in research to advance the applications of remote sensing technologies as tools for monitoring phenomena in coastal waters and adjacent land. In FY 96, COP initiated a three-year program to investigate the applications of current and future satellite data streams in the analysis of mesoscale oceanic process in Alaskan coastal waters and the Bering Sea. This research is focused on advancing the methodologies to use synthetic aperture radar (SAR), the advanced very high resolution radiometer (AVHRR), and high-resolution ocean color satellite imagery to detect and monitor oceanic features such as fronts, eddies, internal waves, sea ice, oil spills and surface slicks.

Further information Alaska coastal monitoring may be obtained by contacting NOAA Coastal Ocean Program (NCOP), 1315 East–West Highway, Room 15140, Silver Spring, MD 20910; 301-713-3338; http://hpcc.noaa.gov/cop/cop-home. html or NOAA NESDIS Office of Satellite Data Processing and Distribution, Federal Building 4, Room 0122, 4401 Suitland Road, Suitland, MD 20233; 301-457-5120.

Techniques and applications demonstrated by this research will become available as data and information products through the NOAA CoastWatch network of regional nodes. The Alaska CoastWatch Regional Node is located at the National Weather Service's Alaska Region Office in Anchorage.

NOAA CoastWatch

COP's support for this program ended in FY 94; this program is now part of the National Environmental Satellite, Data, and Information Service (NESDIS) operations. CoastWatch continues to be a collaborative effort with participation by NESDIS, the National Marine Fisheries Service (NMFS), Oceanic and Atmospheric Research (OAR), the National Weather Service (NWS) and the National Ocean Service (NOS). COP continues its participation by supporting research to enhance the utility of CoastWatch data products and advance the applications of remote sensing technology to coastal monitoring, prediction and management.

Coastal managers, decision makers and researchers require accurate and immediate information concerning environmental processes and events that could affect the health and stability of coastal resources. The NOAA CoastWatch program supports those information needs by providing rapid dissemination of satellite and other in-situ data and information for the entire coastal U.S. through a network of regional nodes. Eight regional nodes have been established and distribute near-real-time satellite imagery and other environmental information products to over 200 users. The Alaskan coastal region is served by the Alaska CoastWatch Node located at the National Weather Service's Alaska Region Office in Anchorage.

Office of Oceanic and Atmospheric Research

Aeronomy Laboratory

The stratospheric ozone layer protects the Earth's ecosystems from biologically harmful

solar ultraviolet (UV) radiation. Changes in the nature of the ozone layer could alter the UV radiation reaching complex ecological environments such as those of the Arctic.

The abundance of stratospheric ozone is set by a balance of photochemical production and loss processes and transport of air within the stratosphere. The photochemical processes involve naturally occurring chemicals in the stratosphere, such as nitrogen species, and chemicals released at the Earth's surface by human activities, such as chlorofluorocarbons (CFCs). In recent years, anthropogenic emissions of CFCs have caused depletion of the total column of ozone in several regions of the globe. For example, the springtime abundance of polar stratospheric ozone in Antarctica has been perturbed because of the influence of anthropogenically released chlorine in the special conditions of the Antarctic polar climate. Although the springtime Arctic ozone column has not reached the same low values that have been observed in the Antarctic spring "ozone hole," extremely cold northern winters could lead to greater Arctic ozone losses. Some evidence of this was observed in the extremely cold Arctic winter of 1995-96. If current international control measures of the United Nations Montreal Protocol are followed, CFCs are expected to reach their peak in the stratosphere in about the year 2000. Therefore, the Arctic stratosphere will remain susceptible to the influence of elevated atmospheric abundances of anthropogenic chlorine for several more years.

Scientists in NOAA's Aeronomy Laboratory (AL) and Climate Monitoring and Diagnostics Laboratory (CMDL) in Boulder, Colorado, participated in an international experiment to study the seasonal loss of ozone that occurs during spring, summer and fall in the Arctic. The field campaigns of the Photochemistry of Ozone Loss in the Arctic Region in Summer (POLARIS) experiment were successfully concluded in September 1997 with the last of 33 flights of the NASA ER-2 high-altitude research aircraft. POLARIS is a multi-agency/university effort that consisted of three deployments to Fairbanks, Alaska, in April/May, June/July and September 1997. The primary scientific objective of the experiment was to understand the natural seasonal change of stratospheric ozone in the Arctic, where ozone peaks in spring and decreases to a minimum value in late summer or early fall.

The POLARIS deployments gave researchers three detailed snapshots of the seasonal behavior of ozone photochemistry and transport. Aeronomy Laboratory researchers measured ozone, reactive nitrogen compounds and long-lived trace gases (the latter in collaboration with CMDL) with instruments that are specially designed for the ER-2 aircraft platform. Other POLARIS researchers made chemical and meteorological measurements from the ground and ballooons. The comprehensive suite of POLARIS measurements, comprising measurements of key reactive chemical species, long-lived tracer species and meteorological variables, will be combined with satellite observations and computer modeling to make a quantitative evaluation of the ozone changes due to chemistry and transport and to discern the anthropogenic influences on the natural seasonal ozone decline.

Insights from the measurements and modeling of POLARIS will greatly increase the ability to explain observed and future changes of ozone abundances in the Arctic. In particular, POLARIS will enhance the scientific understanding of the effects of aviation on that region and will serve as key input to a special state-of-understanding assessment by the Intergovernmental Panel on Climate Change (IPCC) and the Montreal Protocol on the ozone layer.

In another research effort, AL scientists completed in FY 96 the final phase of a two-year series of ground-based measurements in the Arctic. Total-column measurements of ozone, nitrogen dioxide, chlorine dioxide and bromine monoxide were made at Kangerlussauq, Greenland (67°N, 51°W) and were aimed at increasing our understanding of the seasonal, diurnal and long-term behavior of stratospheric ozone. A sustained period of low temperatures that occurred over Kangerlussuaq during the Arctic winter of 1995-96 is providing researchers with a valuable opportunity to investigate how chlorine-mediated ozone destruction is accelerated by the presence of polar stratospheric clouds and/or atmospheric aerosols.

Climate Monitoring and Diagnostics Laboratory

Atmospheric Trace Constituents. NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL), located in Boulder, Colorado, has operated a background atmospheric monitoring observatory at Barrow, Alaska, since 1972. The observatory is part of a larger four-observatory network with other stations at Mauna Loa, Hawaii; American Samoa; and the South Pole. Continuous and discrete measurements of atmospheric trace constituents are taken to study their impact on global climate. Moreover, these measurements provide a long-term documentation of specific

quantities representing the background state and composition of the atmosphere. The Barrow station is a vital component of the network representing Arctic background conditions.

The program mission at Barrow, as at the other three NOAA/CMDL observatories, focuses on research related to those atmospheric constituents capable of forcing change in the Earth's climate through modification of the atmospheric radiative environment and those that may cause depletion of the global ozone layer. The mission is accomplished primarily through long-term measurements of trace atmospheric species such as carbon dioxide, carbon monoxide, methane, nitrous oxide, surface and stratospheric ozone, halogenated compounds including CFC replacements, aerosols, and solar and infrared radiation at baseline observatories and other sites spanning the globe. These measurements document global changes in the key atmospheric species, which are all affected by mankind, and identify causes of interannual variability. The resulting data are used to assess climate forcing and ozone depletion, to develop and test predictive models, and to keep scientists, policy makers and the public abreast of the current state of our chemical and radiative atmosphere.

A primary objective of CMDL is to determine regional-scale sources and sinks of several primary trace species. Toward this objective a global network of flask sampling is undertaken at more than 40 sites. The Arctic sites of this network are at Alert and Mould Bay, Canada; Cold Bay and Shemya, Alaska; Ocean Station "M"; Iceland; and Spitsbergen. Once per week, ambient air is collected in a pair of flasks for analysis of carbon dioxide and nitrous oxide. The resulting data from this array of measurements are analyzed, in conjunction with two- and three-dimensional transport–diffusion model results, for insight into the global and regional carbon cycle. For example, a distinct slowdown of the global carbon dioxide growth rate during 1992-93 has been shown to be linked to an abnormally strong terrestrial biospheric sink in the temperate latitudes of the Northern Hemisphere.

Upgraded Aerosol Monitoring System at Barrow, Alaska. Monitoring of atmospheric aerosols at NOAA's baseline station at Barrow, Alaska, began in 1974 and provides data useful for detecting changes in the sources of aerosols to the Arctic and for quantifying the radiative forcing of climate by aerosols. With financial support from the Department of Energy (DOE) Atmospheric Radiation Measurements (ARM) program, the CMDL aerosol monitoring system was upgraded in September/October 1997. The new system provides measurements of additional aerosol properties with improved calibrations under tightly controlled sampling conditions. The upgrade also includes an integrated filter sampling system, which is being used as part of the NOAA Arctic Research Initiative to characterize the chemical composition of Arctic aerosols (a joint project with NOAA/PMEL and the University of Alaska Fairbanks). These enhancements provide much-needed data on the chemical and radiative properties of atmospheric aerosols required by global climate models. The enhanced aerosol monitoring system is functionally identical to the systems that CMDL is operating at regional sites at Bondville, Illinois; Lamont, Oklahoma (DOE/ARM-sponsored); and Sable Island, Nova Scotia.

Measurement of the UV Radiation Environment in the Arctic. Although considerable progress has been made in predicting UV exposure for mid-latitudes, there are great limitations in predicting or modeling ground-level UV in polar regions because of uncertainty in surface albedo due to changing snow and ice conditions and persistent but changing cloud cover and because radiative transfer models have more uncertainty at low solar elevations. The use of ground-based UV measurements is, therefore, crucial for developing reliable algorithms for determining surface UV exposure in the Arctic from satellite data. In FY 97, in collaboration with the University of Alaska Fairbanks (UAF), CMDL used their observatory in Barrow, Alaska, as a platform for establishing accurate, reliable, portable yet inexpensive means of measuring UV irradiance reaching the Earth's surface in the Arctic. Two instruments, one for broad-band UV work (a Yankee UVB-1) and the other for narrow-band UV study (a Biospherical Instrument global field-of-view GUV-511), were mounted on the roof of the Barrow observatory in September 1997. Continuous 1- to 3-minute-resolution data from 1-Hz sampling is received, which will allow for good definition of variable cloud and aerosol influences, as well as diurnal, seasonal and annual variations. The UAF will analyze the data to determine column ozone amount, UV doses and reconstruction of spectra.

Air Resources Laboratory

During the summer of 1996 the Atmospheric Turbulence and Diffusion Division (ATDD) of NOAA's Air Resources Laboratory (ARL) conducted measurement flights over the Kuparuk basin of the Alaskan North Slope. The aircraft

system was equipped to determine trace gas and energy fluxes and meteorological parameters and to gather video, spectral indices and air samples. In addition to the airborne measurements, a site under the aircraft transects was instrumented to determine soil energy flux and temperatures for aircraft calibration and extrapolation to the remainder of the aircraft transects.

Thirteen evacuated flasks were filled during the field study. These included flask samples representing source and sink periods at San Diego State University tower sites. Additional samples were taken within the oil field emissions plumes and exterior to the boundary layer (within the free atmosphere). All flasks arrived intact at NOAA CMDL in Boulder, Colorado, where they were chemically and isotopically analyzed. Analyses of the flask contents showed source/sink isotopic signatures and enhanced pollutants within the oil field plumes.

Aircraft operations in 1996 consisted of 15 daytime and 12 nighttime transect flights over the standard north–south transect, 12 daytime flights over the east–west transect and 17 daytime flights over the new validation north–south transect. These flights were distributed roughly evenly over the study period.

Two NOAA ATDD deep soil temperature probes were placed in the coastal plain at the crossing point of the north–south and east–west aircraft transects. These probes measured temperature at logarithmically located depths in the soil. A battery-powered datalogger recorded the data. From the probe, aircraft and wetness data were used to estimate soil temperature, soil heat flux, permafrost melting rate, soil thermal conductivity, heat capacity and apparent thermal diffusivity. As with the fluxes the aircraft transect measurements can be used to determine the spatial variability of soil energy dynamics within the North Slope coastal plain.

Starting in October 1996 the ATDD designed and assisted San Diego State University with the set-up and operations of two year-round eddy-correlation flux towers for continuous measurement of trace gas and energy fluxes in the Alaskan Arctic. Design solutions focused on instrument heating, insulation and ice-resistant coatings. The towers have operated continuously since November 1996, and the data have shown that the Arctic tundra can be a significant source of carbon dioxide to the atmosphere during the early winter, when there exists a thawed soil layer under an insulating snow cover.

During the summer of 1997 the ATDD outfitted and shipped a trace gas and energy flux measurement aircraft with remote sensing instrumentation to the Surface Heat Budget of the Arctic (SHEBA) study site within the Arctic ice pack. The aircraft was operated by the ATDD over the pack ice during mid-1998.

Environmental Technology Laboratory

Using knowledge and experience learned during the 1992 Arctic Leads Experiment (LEADEX), NOAA's Environmental Technology Laboratory (ETL) has prepared for and is currently participating in the Surface Heat Budget of the Arctic (SHEBA) field program. This interdisciplinary field program, primarily sponsored by the Arctic System Science (ARCSS) program of NSF and the Office of Naval Research (ONR) High Latitude Program, is a 13-month deployment of instrumentation to a site in the Beaufort Sea from October 1997 to October 1998. Many agencies are participating, with additional field support provided by the Canadian Coast Guard, Department of Fisheries and Oceans. NOAA is also providing support for the NOAA/ETL participation.

The overall purpose of the SHEBA program is to collect the data necessary to document, understand and predict the physical processes that determine the surface energy budget and sea ice mass balance in the Arctic. This will require addressing the interaction between the surface energy balance, the atmospheric radiation and the clouds. The field program is needed because there are large discrepancies among global circulation model (GCM) predictions of present and future climate in the Arctic and because there is uncertainty concerning the role of the Arctic in climate change. The Meteorological Applications and Assessment Division of NOAA/ETL, with support from the National Center for Atmospheric Research Atmospheric Technology Division (NCAR/ATD), is measuring the energy balance at the ice–atmosphere interface and the energy transports within the atmospheric boundary layer so that these point measurements can be scaled up to be representative of GCM grid scales.

The Beaufort Sea ice camp centers on a Canadian Coast Guard icebreaker, the *Des Groseilliers*, which is being frozen into the Arctic pack ice and will drift with the ice during the year. NOAA/ETL has established one main measurement site close to the ship and four remote sites within 5 km of the ship. These remote sites are located on different ice or surface types, so the energy balance at

each site will likely be different. At the main measurement site, measurements include broadband short- and long-wave radiation; profiles of sensible heat, moisture and momentum fluxes; detailed wind, temperature and humidity profiles; and surface precipitation. At the remote sites, one-level measurements of the same quantities are being made, with the exception of precipitation.

The fluxes are being provided through several methods, including direct measurements using sonic anemometers, profile measurements using highly accurate temperature and relative humidity sensors, bulk methods and a spatially averaging scintillometer. A Doppler sodar is providing boundary layer wind and turbulence data. SHEBA collaborators will provide temperature profiles within the ice at each of these sites, providing measurements of the subsurface heat flux. The measurements at the five sites will be combined to provide values useful for direct comparisons to satellite measurements and GCM model grid values. This will be a unique data set documenting the air–ice energy balance throughout an entire cycle of seasons at an array of surface stations. It should provide the necessary description of the physical processes comprising the energy balance throughout the Arctic seasonal cycle and the understanding of the various feedback mechanisms associated with these energy balances.

ETL is also operating a new millimeter-wavelength cloud radar as part of SHEBA. It has been joined on the ship by a new Doppler lidar with dual-polarization capability for distinguishing water droplets from ice crystals. These remote sensors, developed and tested in Boulder during 1997, will probe Arctic clouds, which have a major influence on climate because of their strong control on the transfer of radiative energy through the atmosphere. Clouds are the least understood but most significant atmospheric constituent in processes governing radiative transfer. In spite of their great importance to climate change, Arctic clouds are largely unmeasured because of the harsh Arctic environment.

Over the past several years, ETL has developed new techniques that combine measurements from multiple sensors, both active and passive, for making quantitative measurements of radiatively important cloud properties such as cloud particle sizes, shapes, concentrations, ice water path/content, liquid water path/content, number of cloud layers and their heights and thicknesses. Such data will prove invaluable in validating the retrieval of similar products from polar-orbiting satellites, and work is underway to collaborate with NASA along these lines. These advanced remote sensing techniques will be applied to the year-long SHEBA measurements to establish a baseline data set for Arctic clouds. Data from these remote sensors will soon be generally accessible over the Internet just one day after they are collected in the Arctic.

National Environmental Satellite, Data, and Information Service

Satellite and Data Management

NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) in Suitland, Maryland, manages the U.S. civil operational Earth-observing satellite systems. NESDIS also has the basic responsibility for collecting, archiving, processing and disseminating environmental data; developing analytical and descriptive products to meet user needs; and providing specialized data analyses and interpretations. As part of this overall responsibility, NESDIS maintains a variety of Arctic environmental data sets. The data holdings of the National Geophysical Data Center (NGDC) in Boulder, Colorado, which includes the World Data Center-A for Glaciology (Snow and Ice), are of relevance to Arctic studies. Information on those activities are provided under the National Snow and Ice Data Center (NSIDC) below.

Instruments carried on NOAA's polar-orbiting environmental satellites are a valuable source of Arctic environmental data. These include:

- The TIROS operational vertical sounder (TOVS), which provides vertical temperature and moisture atmospheric soundings for Arctic weather analyses;
- The solar backscatter ultraviolet spectral radiometer, which produces total ozone measurements and ozone profiles;
- The space environment monitor, which determines the energy deposited by solar particles in the upper atmosphere and provides a solar warning system;
- The ARGOS data collection system, which collects environmental information from in-situ platforms such as the Arctic ice buoys; and
- The advanced very high resolution radiometer (AVHRR), which is used by the National Ice Center (NIC) for generating ice analyses and forecasts by interactive analysis of digital infrared and visible imagery.

These satellite data sets, available since 1979, are archived by the NESDIS National Climatic Data

Center (NCDC) in Asheville, North Carolina, and copies can be obtained on magnetic tapes. AVHRR and TOVS data from January 1996 to the present are available on-line via the NESDIS Satellite Active Archive (SAA). Historical data are expected to be added to the system in 1998, as system storage capacity is increased.

NESDIS, in partnership with the U.S. Navy, operates a near-real-time processing, communications and access system for synthetic aperture radar (SAR) data from the Canadian Radarsat satellite. SAR data are high-resolution (10–100 m) active microwave backscatter measurements that can be used for monitoring and studying the ocean environment and for other applications of interest to U.S government agencies. Since February 1997 the National Ice Center (NIC) has routinely used Radarsat data to determine ice edge location, ice concentration, stage of development, and frequency and orientation of leads and polynyas in the Great Lakes and frozen seas of the polar regions. Arctic data are acquired, processed and delivered electronically in near real time (less than 6 hours) to the NIC from satellite readout stations located in Tromso, Norway; Gatineau, Canada; and West Freugh, Scotland; and from the Alaska SAR Facility (ASF) located at the University of Alaska Fairbanks. All U.S government organizations and/or agencies sponsored by NOAA that have signed an affiliated user agreement may submit operational SAR data requests through NESDIS. NESDIS handles the communications for ASF SAR data, while Canadian SAR data are delivered to the NIC from the Canadian Ice Service (CIS) via a dedicated communications link known as the North American Ice Link (NAIL). NESDIS provides on-line electronic access to the SAR data for U.S. government agencies via the Satellite Active Archive (SAA).

Instruments on the Defense Meteorological Satellite Program (DMSP) satellites are also an important source of Arctic environmental data for NESDIS and the NIC. Passive microwave data from the special sensor microwave/imager (SSM/I) are received on a near-real-time basis from the U.S. Navy's Fleet Numerical Meteorological and Oceanographic Center (FNMOC) under the aegis of the Shared Processing Program (SPP). The SPP encourages the sharing of data between all of the operational environmental data processing centers of the U.S. government. SSM/I brightness temperatures, or sensor data records (SDRs), are converted by the Ocean Modeling Branch of the National Center for Environmental Prediction (NCEP) into ice concentration maps using the NASA Team ice algorithm. These maps provide the NIC with a global all-weather data source that is integrated with other data to produce weekly composite Arctic and Antarctic ice analyses. The World Data Center-A for Glaciology is responsible for archiving and distributing historical gridded SSM/I brightness temperatures and ice concentration products for the polar regions. Fine-resolution (0.5 km) visible/infrared data from the DMSP Operational Linescan System (OLS) are also used in the ice analysis process at the NIC. These data have been delivered to NESDIS from ground stations via a domestic communications satellite (DOMSAT). The delivery of these data was changed to an asynchronous transfer mode communications link from the Air Force Global Weather Center located at Offut Air Force Base, Nebraska, at the end of 1997. This transition will significantly increase the volume of OLS fine data available for ice analysis at the NIC.

NESDIS also participates in the Search and Rescue Satellite Aided Tracking (SARSAT) system, an international program using emergency position location instruments on polar-orbiting spacecraft to detect distress signals from emergency locator transmitters on aircraft and emergency position—indicating radio beacons on boats and ships. A new experimental personal locator beacon that can be carried by individuals is being tested in Alaska and has already been responsible for helping to save over 100 lives. Emergency signals received from older analog beacons and transmitters by the SARSAT satellite component are relayed to local user terminals (LUTs) in participating countries. Search and rescue coverage of part of the Arctic is provided by LUTs in Norway, Canada, the United Kingdom, Russia and Alaska. Emergency signals from newer digital beacons and transmitters received by the satellites anywhere in the Arctic are processed by the U.S. Mission Control Center at the NESDIS facility in Suitland, Maryland, and communicated immediately to rescue units.

NESDIS is participating in a number of programs of solar wind observations for geomagnetic storm warnings of interest in auroral studies and for protection of communications and electrical systems. In a joint program with the U.S. Air Force (USAF), a solar X-ray imager (SXI) will be flown on the GOES-M satellite in the year 2000. NOAA recently awarded a contract for at least two more SXIs to fly on the GOES N-Q series. The Advanced Composition Explorer (ACE), a NASA research mission, was launched in August 1997 and is in

transit to the L1 point. NOAA will receive a subset of ACE data for real-time solar wind monitoring (providing an hour's warning of solar events) under a cooperative program with NASA and the USAF. Operational use of the data is expected to begin in January 1998. NOAA, the Jet Propulsion Laboratory (JPL) and the USAF have developed a mission concept for a successor mission called Geostorm. This satellite would use a solar sail to maintain an orbit closer to the sun than ACE and thus provide more than an hour's warning time. The mission concept is a candidate for the Deep Space Five mission of the New Millennium program and if selected would fly in 2003.

Since FY 94, NESDIS has managed the NOAA CoastWatch program. This cooperative NOAA program has participation from NESDIS, the National Marine Fisheries Service, the National Weather Service, the National Ocean Service, and Oceanic and Atmospheric Research. The goal of CoastWatch is to provide coastal managers, decision-makers and researchers with timely satellite imagery and other NOAA environmental data and information for the entire coastal U.S. through a network of regional nodes. The Arctic regions of Alaska are served by the Alaska CoastWatch Node located at the National Weather Service's Alaska Region Office in Anchorage. Alaska CoastWatch users have access to near-real-time AVHRR, DMSP, GOES and Radarsat data.

National Ice Center

The National Ice Center (NIC) is a cooperative, interagency organization responsible for providing Arctic, Antarctic and Great Lakes ice information to U.S. and allied armed forces, U.S. government agencies and various segments of private industry. Manpower and fiscal resources for the NIC are provided by the U.S. Navy, NOAA NESDIS and the U.S. Coast Guard. Real-time global, regional and tactical-scale ice guidance products are generated in support of mission planning, safety of navigation and climate research. Routine products include satellite-derived sea ice analyses of current ice conditions and forecasts depicting future changes to the sea ice pack. All ice products are available in analog (paper) format via a dial-up autopolling facsimile system. Beginning in 1997 the NIC began producing routine Arctic ice products in a digital format. Analyses are distributed in graphics interface format (gif) and as geographic information system (GIS) compatible files via the NIC World Wide Web page (http://www.natice.noaa.gov). Tailored support messages are also sent electronically via autodin to DoD users. Sea ice features of most frequent interest to operational and research interests include ice edge position, ice thickness, ice concentration, areas of compression or heavy deformation, and the location and orientation of open water or thin-ice-covered leads and polynyas. Metadata, which detail the data sources integrated into routine ice analysis products, are available on the NIC web page. Historical (1972–1996) data of weekly ice analyses and multi-year climatologies of ice extent and coverage are also available from the NIC.

Approximately 95% of all data used in producing ice analyses at the NIC are derived from satellites. The largest sources of these remotely sensed data are visible and infrared imagery from the TIROS very high resolution radiometer (AVHRR) and the DMSP operational linescan system (OLS) instruments. These data are of sufficient resolution (1.0 and 0.6 km, respectively) to produce regional-scale maps of ice conditions and produce rough ship track route recommendations. Unfortunately these data suffer from the limitation that cloud cover imposes on ice detection. DMSP SSM/I passive microwave data provide an all-weather detection capability but of relatively coarse resolution (25 km) for all applications except for global-scale ice mapping. Over the past two years the NIC integrated SAR data in ScanSAR wide mode (100-m resolution; 500-km swath width) into select operational ice analysis products. SAR imagery is the only high-resolution remotely sensed data source that is capable of penetrating the perpetual cloud cover and restricted illumination conditions characteristic of the polar regions.

NIC has found SAR data to be extremely useful in classifying ice types (first-year vs. multiyear ice) and in detecting new ice and ice surface deformation. Ongoing SAR research to aid NIC operations includes the development of an automated knowledge-based ice classification system, a multiyear ice detection algorithm, an automated ice/no ice detection algorithm and an ice motion tracking system. The NIC established a chief scientist research position mid-year in 1997 to facilitate the transition of polar research to operations. Priorities of the new science program focus on several key topics, including:

- Improved efficiency of data processing and analysis through data fusion techniques;
- Automated analysis and classification of SAR data;
- Improvements in operational ice forecasting models;

- SSM/I ice product improvement through algorithm optimization; and
- Development of new ice guidance products through the use of new techniques and data from future operational sensors.

Drifting buoys are also an important source of surface meteorological data and ice drift information in the Arctic. Since its inception in 1991 the mission of the U.S. Interagency Arctic Buoy Program (USIABP) has been to establish and maintain a network of 40 evenly spaced meteorological buoys on the drifting Arctic ice pack. As manager of the USIABP, the NIC achieves this goal through coordinated deployments and international cooperation by participants in the International Arctic Buoy Program (IABP). During 1996-97, nearly 95% of all Arctic drifting meteorological buoys reported data in real time over the Global Telecommunications System (GTS). Real-time buoy data are used to initialize operational weather and ice forecast models. All buoy data are quality controlled within six months of receipt and then assembled into a historical (1979–1996) database, which is archived by the Polar Science Center of the University Washington (http://iabp.apl.washington. edu) and the NSIDC. These data have been found useful in the intialization of global circulation models and in climate change research. Buoy data are also used to generate a three-hour spatially and temporally interpolated data set of surface pressure and temperature. A recent accomplishment of the USIABP was the completion of buoy performance field tests conducted at the NOAA Climate Monitoring and Diagnostics Laboratory in Barrow, Alaska. The objective of this test was to conduct a dynamic long-term evaluation of the ability of unattended buoys to accurately measure ambient temperature and pressure to satisfy operational and research requirements. Of specific interest was the ability to accurately measure surface (2 m) air temperature. A USIABP-designed buoy with an external thermistor performed favorably when compared to the weather station standards and dramatically better than the five buoy designs used by other IABP participants. The results (specifically, levels of long-term error) are being used to generate improved Arctic surface temperature fields.

National Snow and Ice Data Center

The National Snow and Ice Data Center (NSIDC) was established by NOAA in 1982. It is operated under the auspices of NGDC through a cooperative agreement between NOAA and the University of Colorado. NSIDC is funded by NASA to operate a Distributed Active Archive Center (DAAC) and receives funding for research and data management activities from NOAA, NSF and other agencies.

The Former Soviet Union Hydrological Snow Surveys are a new snow data set available on-line from NSIDC. The data set is based on observations made at 1345 sites throughout the former Soviet Union. These observations include snow depths and snow water equivalent from 1966 through the end of 1990. The source of the data is the Institute of Geography, Russian Academy of Sciences, Moscow. The station coverage and the inclusion of snow water equivalent makes this an important data set for corroborating satellite passive microwave snow algorithms.

During 1950 to 1991 the U.S.S.R. maintained two, and sometimes three, drifting ice stations in the Arctic Ocean. In addition to supporting scientific studies, these manned ice camps operated as synoptic meteorological stations reporting position, surface weather, atmospheric soundings, solar radiation and snow conditions. NSIDC, in collaboration with the University of Washington's Polar Science Center (PSC) and the Arctic and Antarctic Research Institute (AARI), St. Petersburg, Russia, released a CD-ROM containing these observations. Rescue and organization of the data took place at AARI and PSC; ESDIM funding contributed to CD-ROM development at NSIDC.

The mass balance of the world's glaciers is an important topic to the global change research community. The Eurasian Glacier Inventory contains information for over 35,000 glaciers within the former Soviet Union and the People's Republic of China. Inventory parameters, accessible through a web page interface, include geographic location, area, length, orientation, elevation and classification of morphological type and moraines. These data are the digital version of thousands of handwritten records from the Institute of Geography, Moscow, and the World Data Center-D for Glaciology in Lanzhou, China. In FY 96 and 97, NSIDC acquired digital inventories for New Zealand, the Alps and Norway. NSIDC is working with the World Glacier Monitoring Service (WGMS) in Zurich to release these data simultaneously at NSIDC and WGMS.

Sea ice parameters for the period 1953 through 1990 from the AARI are now available electronically in gridded form. The AARI data set provides hitherto inaccessible information on ice conditionss and their spatio-temporal variations in the Eurasian Arctic. In addition to its use for basic research

NSIDC's data products, documentation and publications can be viewed or requested through NSIDC's User Services pages on the World Wide Web (WWW) using URL http://www-nsidc.colorado.edu or by calling 303-492-6199.

on trends in ice extent and concentration, the combined AARI data set is useful for comparing with estimates of ice concentration from satellite passive microwave data. The data were provided to NSIDC as part of the World Meteorological Organization's Global Digital Sea Ice Data Bank (GDSIDB), a project that supports the interests of the World Climate Research Program. Other nations that have agreed to contribute data to the GDSIDB are Canada, Denmark, Japan, Germany, Finland and Sweden. Japanese data were received by NSIDC under the program in FY 97 and are being re-gridded to an easy-to-use format.

NSIDC's project to develop cryospheric indices for NOAA's Global Climate Perspectives System recognizes the need for data sets that enhance skill in detecting climate change and applying climate models. The focus for this project is snow cover and sea ice extent, because of the importance to modelers of the positive temperature–albedo feedback mechanism regulated by these variables. Regionally complete data sets are needed to provide essential snow and ice boundary conditions and ultimately to understand how model output compares with observed changes in climate. Two cryospheric products have been produced from data acquired for the project. The first, Historical Soviet Daily Snow Depth—1874 to 1984, contains data from 280 stations as well as monthly climatologies. The original data were provided to NSIDC by NCDC via a NOAA bilateral agreement with the U.S.S.R. The second product, Northern Hemisphere Weekly Snow Cover and Sea Ice Extent—1978 to 1995, provides input for climate model boundary condition and validation studies. This product was created by mapping weekly NOAA snow charts from visible band imagery and NSIDC ice extent estimates from passive microwave data to the same grid. Quality-checking includes direct comparison with surface station data. The data set was released on CD-ROM in 1996.

NSIDC/WDC-A is implementing a Global Geocryological Database that assembles priority permafrost and frozen ground data sets. Under the U.S.–Russia Bilateral Agreement, Working Group VIII, ground temperature data have been transferred from Russian archives to the WDC-A at NSIDC. NOAA ESDIM support is contributing to the development of a Cryosols–Active layer–Permafrost System (CAPS) CD-ROM containing rescued permafrost data and bibliographic information. The CD-ROM was released at the 7th International Conference on Permafrost, in Yellowknife, N.W.T., June, 1998.

Additional data sets archived or updated through NOAA ESDIM support are Arctic and Southern Oceans sea ice, Great Lakes ice charts, Great Lakes cooperative ice observers ice gage reports, International Ice Patrol iceberg reports, U.S. Coast Guard Great Lakes surface ice reports, the International Arctic Buoy Program archive, sea ice melt pond characteristics, Canadian snow depth, Estonia snow cover 1892–1990, Chinese snow depths from 1979 to 1990, and South Cascade Glacier mass balance data. In addition over 100 canisters of film data of aerial observations of sea ice from the U.S. Navy Birdseye program for 1970 through 1986 were acquired from the U.S. Army Cold Regions Research and Engineering Laboratory in Hanover, N.H.

University of Alaska Cooperative Institute for Arctic Research

The Cooperative Institute for Arctic Research (CIFAR), a NOAA–University of Alaska Fairbanks cooperative arrangement, continued to pursue its objectives of facilitating and managing joint research projects between NOAA and universities and promoting research among organizations and programs active in the western Arctic.

NOAA Arctic Research Initiative

The NOAA Arctic Research Initiative (ARI) started in FY 97 with the overall goal to address the following national Arctic policy objectives:

- Protecting the Arctic environment and conserving its biological resources;
- Assuring that natural resource management and economic development are environmentally sustainable;
- Strengthening institutions for international cooperation; and
- Involving the region's indigenous people in decisions that affect them.

The scope of the ARI program is broad, focusing on two major scientific areas and five major subtopics:

1. Natural variability of the Bering Sea/western Arctic ecosystem
   - The Bering Sea green belt: process and ecosystem production;
   - Atmosphere–ice processes that influence ecosystem variability;
   - Atmospheric, cloud and boundary layer processes;
2. Anthropogenic influences on the Bering Sea/western Arctic ecosystem

- Arctic haze, ozone and UV flux;
- Contaminant sources, fate and effects on the ecosystem.

The number of proposals received (and funded) in FY 97 were as follows:

- Green belt biology: 15 (6)
- Air–ice–ocean interactions: 12 (2)
- Atmospheric, cloud and boundary layer processes: 4 (1)
- Arctic haze, ozone and UV-B: 10 (4)
- Contaminant sources, fate and effects: 15 (2).

The FY 98 program is similar in objective and scope; an Announcement of Opportunity was released in October 1997. Research in FY 98, where possible, also embraces research needs identified in the science planning by the Arctic Monitoring and Assessment Program (AMAP) and the International Arctic Research Center (IARC) that fall within the NOAA mission. This includes monitoring, data collection, exchange of data on the impacts and assessment of contaminants and their pathways; increased UV-B radiation due to stratospheric ozone depletion; and climate change effects on Arctic ecosystems.

Joint Bering Sea Cruise

A major accomplishment of the ARI was a joint cruise in the Bering Sea in partnership between NOAA and the University of Alaska Fairbanks to investigate the basis for the rich productivity of the eastern Bering Sea. An underlying cause for the enormous populations of higher trophic level species is thought to be the Green Belt lying along the outer edge of the continental shelf and over the slope, where enhanced and prolonged production apparently occurs. Until recently, however, a mapping of water properties, currents, nutrients and primary production had never been undertaken. Even the nature of the current over the slope, known as the Bering Slope Current, has not been well described or understood. Yet, it is this feature that is the source of nutrients for primary production and may seed the outer shelf with pollock larvae and other plankton.

From March 28 to April 13, 1997, the NOAA ship *Miller Freeman* conducted a research cruise along the Bering Sea shelf break crossing the Green Belt on seven oceanographic transects from the U.S.–Russia Convention Line in the north to the Aleutian Islands in the south. The 215-ft research ship provided a safe platform for the combined physical and biological oceanographic work in a notoriously inhospitable ocean at exposed locations over 400 nautical miles from the nearest ice-free refuge in the Pribilof Islands.

Water density observations analyzed aboard ship gave the scientists a preliminary indication of the Bering Slope Current's location and strength. It flows just seaward of the shelf break transporting 4–7 million cubic meters per second northwestward. Modern acoustic Doppler current profiler (ADCP) and global positioning system (GPS) measurements will be used to reference water-density-based geostrophic currents and provide much more accurate data on currents in this region than has been possible in the past. Chlorophyll measurements revealed heightened photosynthetic activity seaward of the shelf break. These await further analysis in conjunction with nutrient and primary productivity observations in order to map the location of the Green Belt and its relationship to the Bering Slope Current.

Other Arctic Research Projects

Other research projects conducted under the auspices of CIFAR and funded by NOAA included five projects in fisheries oceanography, several of them on salmon; two projects on hydrographic studies and sea ice dynamics; two projects on atmospheric research dealing with atmospheric forcing and mesoscale modeling; four projects on environmental assessment, monitoring and numerical modeling, including assessments for AMAP; and several modeling projects using the Arctic Regional Supercomputer facilities at the University of Alaska Fairbanks.

Office of NOAA Corp Operations

The Office of NOAA Corps Operations (ONCO) supported Arctic research during the past two fiscal years primarily through the operations of the NOAA ship *Miller Freeman* and secondarily through continuing aircraft operational and research projects.

ONCO's fisheries and oceanographic research vessel *Miller Freeman* is a 215-ft, 1920-ton stern trawler that operates a variety of biological and oceanographic sampling gear. The *Freeman*'s primary Arctic accomplishments have been as a working platform for the study of the Arctic Ocean's living resources.

ONCO's ships and aircraft are run by a combination of NOAA commissioned officers and wage licensed civilians. On ships the wage marine personnel include licensed engineers and other members of the engine, stewards and deck departments. Aviation personnel are licensed as engineers and technicians by the Federal Aviation Administration. Administrative duties and navigation of the ships

and aircraft are performed by the commissioned officers. The aircraft and ship's complements provide mission support and assistance to embarked scientists from various NOAA laboratories as well as the research academic community.

The *Freeman* conducted hydroacoustic surveys in the Arctic during the past two years, especially the Bering Sea. Hydroacoustics are used by NOAA's National Marine Fisheries Service for fisheries management. The principal objective in hydroacoustics is to collect target strength data used in scaling echo integration data, thereby estimating the absolute abundance of a particular target fish species. Winter–spring assessment operations were completed during the past two years, with a specific focus on the eastern shelf and Blogoslof areas of the Bering Sea.

A special cooperative Bering Sea survey ranging from the U.S. Bering Sea to the Russian coast was completed with the assistance of Russia and Japan. The project consisted of intership calibration of the acoustic systems aboard the *Freeman* and the Japanese research vessel *Kyowa Maru* and completion of Bering Sea hydroacoustic transit lines. Scientists from Russia, China, Poland and South Korea participated in various capacities aboard both vessels.

NOAA's aircraft have completed several routine ongoing Arctic projects during the past two years. The WP3D research aircraft completed aerosol and pollutant studies for NOAA's Environmental Research Laboratories. NOAA's charting and survey aircraft have completed endangered species assessment surveys over and near the Arctic coast of Alaska and collected survey and mapping data for the revision of nautical and aeronautical charts of Alaska's Arctic.

Office of Global Programs

NOAA's Climate and Global Change Program maintains a small program in the Arctic, driven primarily by scientific questions regarding the Arctic's role in global climate change. Coupled ocean–atmosphere models in the U.S. and Europe have suggested that the planet's response to increased greenhouse forcing will fundamentally involve changes in the thermohaline circulation of the ocean, popularly described as the "conveyor belt." In the modern ocean, dense water is formed in very limited areas of the global ocean, with the Greenland/Norwegian and Labrador Seas being the predominant Northern Hemisphere regions of deep water formation. As northward-flowing surface water in the Atlantic cools, it releases heat (thus warming northern Europe) and sinks to form a deep water mass identifiable throughout the global ocean. The rate of this thermohaline circulation varies dramatically in models with different scenarios of greenhouse gas forcing. These model runs are given some credence by observations from the paleoclimate record, which indicate strong thermohaline variability as recent as 10,000 years ago. The strongest control on the thermohaline circulation is the amount of fresh water coming into the North Atlantic from the Arctic Ocean.

The Arctic interests of the Climate and Global Change Program have thus been driven by the desire to observe and model these hypothesized Arctic–Atlantic interactions. An array of instruments to measure the flux of fresh water from the Arctic, including sea ice, has been deployed in Fram Strait since 1991, in cooperation with European investigators. Downstream in the Greenland Sea, annual measurements of salinity and transient tracers have provided a time series of deep water formation in this region, demonstrating the response of deep convection to changes in freshwater input. Several atmosphere–ocean–ice modeling efforts on varying scales are being used to examine the mechanisms at work in the long-term variability of this component of the climate system.

Department of Agriculture

The Department of Agriculture supports and conducts research to improve understanding, use and management of renewable resources at high latitudes. Research is directed toward solving problems in agriculture, forestry and the environment and improving technology for enhancing the economic well-being and quality of life for Alaskans.

Forest Service

The northern boreal forest of Alaska—the taiga—lies in the zone of discontinuous permafrost. The more than 100 million acres of Alaska's northern boreal forest is a heterogeneous mix of warm, productive sites supporting white spruce, paper birch, aspen and balsam poplar stands, intermingled with permafrost-underlain black spruce stands and shrub, riparian and wetland vegetation. About one-third of Alaska's taiga lies within the Arctic as defined by the Arctic Research and Policy Act; some two-thirds occupies sites that, by virtue of elevation, slope and aspect, have climatic conditions equivalent to those of the Arctic.

The USDA Forest Service Pacific Northwest Research Station (PNW) has been responsible for boreal forest research in Alaska. This research has been directed toward improving the understanding, use and management of Alaska's natural resources, especially the northern boreal forest. PNW scientists have been stationed at the Institute of Northern Forestry in Fairbanks and the Forestry Sciences Laboratory in Anchorage. However, budget cuts in 1996 forced the closure of the lab at Fairbanks, terminating all research save the commitment the Forest Service is maintaining toward the Long-Term Ecological Research (LTER) work conducted at the Bonanza Creek LTER site [sponsored jointly by the National Science Foundation (NSF), the USDA Forest Service and the University of Alaska Fairbanks (UAF)]. This is being accomplished through the Institute of Northern Forestry Cooperative Research Unit at UAF. Work in entomology has been sharply curtailed but continues to be sponsored by State and Private Forestry out of Anchorage, while work in silviculture, genetics, harvesting and sustainable development has been discontinued.

	Funding (thousands)	
	FY 96	FY 97
Forest Service - Environment	700	700
Cooperative State Res - Environment	725	725
Cooperative State Res - Food/Safety	793	793
Natural Resources Conservation Svc S - Global Change	560	560
Total	2,778	2,778

The PNW Long-Term Ecological Research program has been directed toward improving understanding of biological, physical and ecological processes and components of terrestrial ecosystems. PNW Ecosystems Processes scientists stationed at the Institute of Northern Forestry were actively involved in research into forest succession on highly productive forest lands (flood plains and warm slopes) and on cooler, less-productive permafrost terrain. The present level of effort is chiefly aimed at safeguarding the LTER work, which has been ongoing for over three decades.

Ecosystems Processes scientists will continue to play an important role in the LTER program. This work is centered on the 5000-ha Bonanza Creek Experimental Forest (BCEF) near Fairbanks. BCEF-LTER is led by co-principal investigators from the Institute of Northern Forestry (INF) Cooperative Research Unit and the University of Alaska Fairbanks. The primary areas of research in BCEF-LTER include:

- Patterns and controls of primary production;
- Spatial and temporal distribution of populations;
- Patterns and controls of organic matter accumulation;
- Inorganic contributions and transport of nutrients through soils, groundwater and surface waters; and
- Patterns and frequency of disturbance in Alaskan ecosystems.

Current LTER research in BCEF addresses vegetation succession in floodplain and uplands, herbivory, and resource availability to specific vegetation communities in relation to climate, nutrient availability and biogeochemical processes, but the research program is undergoing a thorough re-examination of long-term goals to provide for the development of new paradigms of boreal forest successional dynamics. This will be done by establishing a PNW research cooperative unit at the University of Alaska Fairbanks, permitting the participation of 1.5 PNW scientists, and attempting to integrate the terrestrial research described above with the aquatic work described below.

PNW Aquatic/Land Interactions research at the Institute of Northern Forestry has been terminated. The research has addressed landscape-scale processes affecting watershed stability, streamflow patterns, stream quality, and stream productivity and ecological relationships in Alaska's boreal forests. However, research centered on the 10,400-ha Caribou–Poker Creeks Research Watershed (CPCRW) near Fairbanks will be integrated into the LTER program shared between the University of Alaska Fairbanks and the new INF research cooperative unit. The composite BCEF/CPCRW LTER site encompasses more than 150 km^2 and includes environmental settings varying from highly productive floodplain forests and permafrost-free coniferous and hardwood forest stands on south-facing slopes, to low-productivity permafrost-underlain coniferous woodland on north-facing slopes and in poorly drained cold valley settings. Research includes determining the effects of permafrost on catchment hydrologic regime, and analysis of hydrologic behavior of periglacial land forms. Included are studies of the ecological relationships of headwater streams, and the linkage between landscape (catchment slopes), riparian zone and stream channel. Hydrogeochemical monitoring of headwater streams in CPCRW provides the foundation for process research, which has already documented the influences of permafrost on streamflow patterns, on steam biota and on sub-Arctic hydrologic phenomena including aufeis and pingos. This work, if supported by the PNW research cooperative unit and the National Science Foundation, will furnish a basis for assessing terrestrial/aquatic (watershed) ecosystem change in response to changing climate or environmental contamination. It is anticipated that the nationwide National Atmospheric Deposition Program (NADP) in Caribou–Poker Creeks Research Watershed will continue. Water quality of first- and second-order streams in CPCRW has been monitored for more than a decade and will continue to be monitored. The broad objectives of continuing research at CPCRW are to develop an understanding of hydrologic, climatologic and environmental relationships in taiga ecosystems, to support catchment-scale experimentation on the effects of resource management practices on these relationships, and to support multi-disciplinary long-term environmental monitoring of the stream/landscape biological and physical system.

Many general circulation models of climate change indicate that regions north of 60° latitude may be subjected to major warming in coming decades, producing increased permafrost thaw, altered vegetation distribution, altered biological productivity, altered wildfire regime, and perhaps the release of large quantities of stored organic carbon into the global carbon cycle. Soils in the taiga are rich in organic carbon, much of which is stored in permafrost. In the event that central Alaska were to experience 4–8°C of warming over the next century, much of the permafrost (currently at –0.5 to –2°C) would thaw, potentially releasing large amounts of carbon to the atmosphere and hydrosphere. It is unclear what continued research in this important arena will be permitted under the present support. It might have been possible to construct a model of the effect of discontinuous permafrost on organic carbon dynamics in streams. An ongoing experiment is testing the effects of elevated atmospheric CO_2 concentration and +4°C soil temperatures on the carbon and nitrogen balance of a model white spruce and soil ecosystem.

Wildfire is a major determinant of boreal forest pattern and productivity in central Alaska. Research at INF is continuing into fire ecology and fire effects on ecosystem processes, forest succession in relation to wildfire, and forest productivity including the stability and productivity of forest streams affected by fire. Pre-burn and post-burn research has continued in the Yukon Flats National Wildlife Refuge, on the 1988 Selawik fire in northwest Alaska, and on the 1950 and 1985 Porcupine River fires, providing pioneering information on the long-term consequences of wildfire in Alaska's boreal forest. Detailed study of wildfire history (Project Frostfire) has been initiated at BCEF and CPCRW in support of the expanding LTER program and has been funded by the Department of Energy. Prescribed burning of an experimental site will be initiated in 1998, and research is expected to peak in that year and the following two.

An Ecosystem Processes scientist at the Forestry

Sciences Laboratory, Anchorage, has terminated research on the population dynamics of moose in the Copper River Delta—a non-Arctic biome—due to funding constraints but is continuing research on moose population and behavioral ecology in Denali National Park. This work will be expanded and redirected to encompass the feedback relationship between ungulate herbivory and successional responses of the tundra floral associations in Alaska's interior. At the Copper River Delta, research had concentrated on defining the basic seasonal movement patterns and seasonal use patterns in relation to habitat, determining seasonal foraging habits, defining sexual activity and reproduction, and determining winter habitat and possibilities for habitat enhancement. While the field work has been brought to a close, publication of the analytical results is continuing for the near term.

PNW Environmental Health and Protection Research has been terminated under the anticipated funding for FY 97 and beyond.

PNW Inventory and Economics Research scientists at the Forestry Sciences Laboratory, Anchorage, are responsible for the inventory and analysis of the boreal forests of Alaska. A state-wide cooperative soils and vegetation inventory was initiated in 1981 and is continuing. Satellite imagery and aerial photography are used in classifying land cover types; analysis addresses timber, understory vegetation, biomass, soils and wildlife habitat. The project has completed inventorying nearly two thirds of the state and has produced numerous resource bulletins describing the resources. Additional scientific papers covering wildlife, biomass, forest products and inventory techniques have also been published.

Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) cooperates and coordinates with state, village, regional and Federal land owners; NRCS field office personnel in Alaska; and other agencies in Alaska to provide technical resource planning and application assistance to these landowners, users and planners. Coordinated resource management plans, allotment management plans or interim plans are developed. Soil maps are made of Native lands along with other private and government lands in Alaska.

The NRCS has continued to work in conjunction with UAF and Agriculture Canada to measure soil moisture and temperature along several transects in areas extending from non-permafrost zones to areas of intermittent permafrost to areas of continuous permafrost. Studies are also being conducted on the active layer in the permafrost zone. The information gathered from these transects and similar ones in Canada and Russia has allowed a group to develop a new soil order in soil taxonomy: Gelisols. This proposal has been finalized and is ready for inclusion in the next additions of the *Keys to Soil Taxonomy*. Its implementation will greatly help in mapping and interpreting soils in Alaska and other parts of the world where there is permafrost. This will allow the transfer of technology from region to region. In the last couple of years more soil moisture and temperature sites have been added along the Haul Road at Happy Valley, Toolik Lake and Coldfoot. Also, sites were added near Fairbanks, at Barrow and at Atquasuk. New dataloggers have been added to record soil moisture and temperature data, and new sensors that work over a wider range of conditions and hold up under extreme temperatures have been tested and put on line at these sites.

The NRCS is also actively working with the National Science Foundation's (NSF) Arctic System Science (ARCSS) program on the North Slope of Alaska, where greenhouse gas fluxes and changes to carbon sequestration may be subject to potential changes from global climate change. This work has added more sensors for soil moisture and temperature south of Deadhorse along the Haul Road and also at Barrow. Sites were sampled in 1995, 1996 and 1997 at various locations related to NSF projects and other projects of UAF. These sites were sampled in conjunction with scientists from UAF. Complete characterization is being run on these samples in the laboratory in Lincoln, Nebraska. The information gathered from this sampling and others will help develop a much larger soil database for Alaska. Earlier work showed up to 30% or more carbon storage in the sensitive permafrost area than was previously thought. The data from these and other samplings will be used in many soil process models being developed. These areas in the Arctic may be either sources or sinks of carbon if there is global warming. Estimates of the amounts and possible changes cannot be made by modelers, however, until the baseline information is gathered. NRCS soil scientists and a group of university scientists will be using ground-penetrating radar to see if it can help determine the amount of carbon in the permafrost.

NRCS is also working with a new NSF proposal to look at soil and vegetation changes from Barrow to the Seward Peninsula. Planning work is under-

way, and field work will start in the summer of 1998.

The NRCS, with the University of Alaska and in cooperation with the Forest Service and Park Service, has established some new sites to study soil processes in wetlands. The same parameters that have been monitored at the sites established several years ago will be measured (soil temperature, moisture, redox properties, depth of the water table etc.). Wetlands are a major component of soils in Alaska, and this work will help NRCS and others better understand, identify and manage these critical areas. Selected sites were sampled in the summer of 1996 to look at the effects of biological activities. This is part of a broad NRCS project to look at wetland sites from the warm south (Texas) to cold northern areas (Alaska).

A joint cooperative activity has been established between cryopedologists from the NRCS, the University of Alaska, Agriculture Canada and the International Permafrost Association, as well as many other scientists from the U.S. and Europe. A draft circumpolar map has been produced showing soils in Canada, Alaska and far-eastern Russia within the limits of northern discontinuous permafrost. The map is in a GIS environment at a scale of 1:10,000,000. The map units contain the classifications of the U.S., Russia and Canada. There will be a supporting database that contains the polygon identification, percentage of each component in the polygon, parent material, drainage, local surface form, soil classification, texture, vegetation and soil code. Other items could include carbon and nitrogen contents and particle size distribution. A variety of maps can be made from this information to help understand and manage areas containing continuous permafrost. The draft map has been presented at meetings in the U.S. and Russia, and modifications are being made and more information added based on comments received. There has been widespread interest in the map from many sources. It is also being expanded to include the soils area of Greenland and parts of northern China.

A joint soil carbon map of North America was produced by scientists in the U.S., Canada and Mexico. This map has shown where there are data problems in Alaska, as the Alaskan part shows much lower carbon values than found in adjoining areas of Canada. The map shows the large amount of carbon at the high latitudes that is at risk of mineralization if there is global warming.

NRCS soil scientists started soil survey work in the summer of 1997 on Fort Wainwright under contract to the Defense Department; preliminary maps are being made and data collected. Also, with the National Park Service, extensive work was done in Denali National Park.

Copies of the Proceedings of the International Meeting on Permafrost Affected Soils *published in 1995 are still available and may be obtained by writing to John M. Kimble, NSSC-NRCS-USDA, Federal Building, Room 152, MS 33, 100 Centennial Mall North, Lincoln, NE 68508-3866 (email jkimble@gw.nssc.nrcs.usda.gov). This publication contains the papers that were presented at the meeting in 1993.*

Cooperative State Research, Education, and Extension Service

The Cooperative State Research, Education, and Extension Service (CSREES) funds research projects at the University of Alaska's Agriculture and Forestry Experiment Station (AFES). AFES research projects are aimed at solving problems related to agriculture, forestry and the environment. The AFES research objectives are to provide new information for managing renewable resources at high latitudes and to improve technology for enhancing economic well-being and quality of life at high latitudes. AFES is part of the School of Agriculture and Land Resources Management at the University of Alaska Fairbanks. This association provides direct linkage between research and teaching in forestry, agriculture and natural resources. Scientists who conduct research at the experiment station also teach, sharing their expertise with both undergraduate and graduate students.

In identifying local Alaskan research needs, experiment station scientists regularly meet with land managers, foresters and farmers from throughout the state to discuss specific needs and problems. AFES researchers also work directly with producers through farm forums, agricultural field days, greenhouse workshops, vegetable conferences, reindeer herder workshops and forestry workshops. Because of these contacts, most AFES research projects in the plant and animal sciences and resources management program were developed in cooperation with industry and state and Federal agencies. Research results are frequently reported in *Agroborealis*, a journal of AFES.

In one recent project Jay McKendrick has been studying long-term tundra revegetation and continuing changes in plant communities on gravel pads in the Prudhoe Bay vicinity. The application of 7–8 cm (3 inches) of topsoil provided the best results, with significant increases in both vascular plant cover and moss cover on abandoned exploration pads. Revegetation experiments that began in 1972 have provided valuable information for long-term management decisions. Conclusions and recommendations drawn from the first 10 years of study have now been reversed as more information has become available. More value and bet-

ter management decisions should provide a better understanding of the natural potential that tundra has for accelerating the rehabilitation process. More detailed results can be found in the spring 1997 issue of *Agroborealis*.

C.L. Ping has been studying the characteristics of permafrost soils along a north–south transect in the Kuparuk River Basin of Arctic Alaska. He studied the morphological, chemical and physical properties of the cryogenic soils and estimated the carbon storage in soils of different ecosystems. Permafrost soils are significant in that they account for almost 30% of the total terrestrial carbon and could act as a large positive feedback to global warming. Initial results from studies by Ping and G.J. Michaelson indicate that previous estimates of carbon storage in the Arctic tundra were underestimated by a factor of two. The carbon content in their samples ranged from 24 to 52%, which is lower than the 58% reported for soils in the temperate region.

Such long-term studies are the result of a viable partnership between the Land-Grant system and the Federal government. Formula funding from USDA's CSREES allows high-priority state needs to be met.

Department of Energy

The Department of Energy has responsibility for providing for the long-term energy security of the United States. To carry out this responsibility, DOE's Arctic activities support the DOE mission by expanding our understanding for predicting the consequences of continued dependence on fossil fuels, including the potential effects on global and regional greenhouse warming.

DOE's Arctic research studies include investigating the role of Arctic ecosystems in the global flux of carbon, measuring greenhouse gases, developing a research site on the North Slope of Alaska for studying the influence of clouds on radiation transport, and measuring radionuclides in the Arctic atmosphere and deposition as a tool for quantifying long-term migration pathways of energy-related contaminants. DOE researchers also collaborate with other Federal agencies such as NOAA, EPA and NASA in investigations of the sources and levels of energy-related contaminants in the Arctic environment.

	Funding (thousands)	
	FY 96	FY 97
Environmental Measurements	40	40
Nat Inst Global Env Change	186	186
Carbon Balance/Tundra Ecosystem	132	132
Atmos Radiation/Planning	3,812	3,400
Total	4,170	3,758

Atmospheric Radiation Measurements Program

The Atmospheric Radiation Measurements (ARM) program is part of DOE's effort to resolve scientific uncertainties about global climate change with a specific focus on improving the performance of general circulation models (GCMs) used for climate research and prediction. The ARM program focuses on one critical feature of the GCMs: the transport of solar and thermal radiation (sunlight and radiant heat) through the Earth's atmosphere to and from the Earth's surface. Within this area the greatest uncertainties are associated with clouds: their formation, quantitative description, behavior and optical characteristics as influenced by atmospheric and underlying surface conditions.

The ARM approach is to create long-term, highly instrumented climate research sites in carefully selected locations around the world. The site locations proposed and under development were selected primarily on the basis of what needs to be learned about clouds and radiation to improve the models, but secondarily on the basis of cost and logistics. Three research installations known as Cloud and Radiation Testbeds, or CART sites, were selected for ARM. The site locations and current status are as follows:

- The Southern Great Plains site in Oklahoma has been operating since 1992.
- The Tropical Western Pacific site, covering an area from near Indonesia to near Christmas Island, began phased operations in 1996 and is planned to be fully operational by 2001.
- The North Slope of Alaska adjacent to the Arctic Ocean (NSA/AAO) site became operational in December 1997.

The CART sites have a planned life of ten years. The rationale for their long duration is that virtually all process-focused meteorological and climatological efforts to date have been based on short-term field efforts (a few weeks to a few months). During these brief periods, particular meteorological phenomena of interest occur at most a few times. This restricts these efforts to one or two case studies, which, while they produce important qualitative understanding, are limited by the statistics of small numbers in the accuracy and precision with which the relevant phenomena can be quantitatively described. With all of its potential economic and other societal impacts, global climate change is nevertheless the result of small radiative effects—a difference of a few watts per square meter in the energy balance out of an aver-

age energy flow of several hundred. To improve our ability to predict climate change, the physical effects that must be measured and accurately modeled are small. Doing this requires the statistics of large numbers—many cases, not just a few.

On the other hand, climate monitoring efforts have been ongoing for decades. However, these efforts focus on measuring a few important climate-related variables, not the full range needed for the process studies necessary to improve the GCMs. The ARM program fills the critical gap between field campaigns and monitoring.

For more information about NSA/AAO, visit the web at http://www.arm.gov/docs/sites/nsa/nsaaao.html

On July 1, 1997, the NSA/AAO CART site was formally dedicated in a ceremony symbolizing our partnership with the local community in developing the ARM facilities. Martha Krebs, Director of the DOE Office of Energy Research; Ben Nageak, Mayor of the North Slope Borough; and Max Ahgeak, President of UIC (Ukpeagvik Inupiat Corporation, ARM's engineering, construction and support contractor) jointly cut the ribbons releasing a weather balloon. Barrow Technical Services (a subsidiary of the UIC) has been contracted to provide continuing liaison with the North Slope community. The NSA/AAO site began operation in December 1997 as a phased deployment in conjunction with SHEBA (Surface HEat Budget of the Arctic Ocean), a multi-agency program led by the National Science Foundation (NSF) and the Office of Naval Research (ONR).

The general point of contact for the ARM program is Wanda R. Ferrell, Manager, Atmospheric Radiation Measurement Program, Environmental Sciences Division, ER-74, U.S. Department of Energy, Washington, DC 20585; 301-903-0043.

The NSA/AAO site is in close proximity to the National Oceanic Atmospheric Administration's (NOAA) high-latitude climate monitoring facility near Barrow. This placement allows ARM to take advantage of NOAA instrumentation already in place and avoid unnecessary duplication. NSA/AAO currently includes a 130-ft meteorological tower, a 40-ft-long instrument shelter and three instrumentation decks, all on pilings (because of the permafrost). In addition, laboratory and office space are also located in the former Naval Arctic Research Laboratory (NARL) complex a mile from the NOAA Barrow site. The site data system is also located at NARL.

A generic fully developed CART site includes facilities spread over a large area; an area of roughly 200 km^2 is being considered for NSA/AAO. The central facility will have the largest concentration of instrumentation, which will rely heavily on upward-looking remote sensors to determine the characteristics of the clouds, winds and atmosphere as a whole above the site on a continual basis. Around the central facility, two to four auxiliary stations are planned at a distance of one to a few kilometers for characterizing the cloud field over the central facility. The larger area surrounding the central facility and the auxiliary stations (the extended CART site) will eventually be instrumented with a sparse network of automated surface weather stations similar to those used at many small airports but augmented with radiometric instrumentation and systems for measuring surface fluxes of water vapor and sensible heat. On the boundaries of the extended CART site, small versions of the central facility are needed. For about 12 months, the ice island in the Arctic Ocean perennial ice pack, instrumented as part of the SHEBA project, will be one of the NSA/AAO boundary facilities.

For the North Slope of Alaska/Adjacent Arctic Ocean CART site, the points of contact are Bernard Zak, North Slope of Alaska/Adjacent Arctic Ocean CART Site Program Manager, Sandia National Laboratories, PO Box 5800, Albuquerque, NM 87185-0755; 505-845-8631, and Knut Stamnes, North Slope of Alaska/Adjacent Arctic Ocean CART Onsite Scientist, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800; 907-474-7368.

In addition to ground-based instrumentation for characterizing the atmosphere and the Earth's surface, it will also be necessary to make occasional instrumented aircraft flights to measure conditions aloft, primarily over the central facility, and to depend heavily on data from polar-orbiting satellites. Coordination with NASA, NOAA and other agencies regarding both the aircraft and satellite components is underway through FIRE (First ISCCP [International Satellite Cloud Climatology Program] Regional Experiment) and other programs.

Responses to Carbon Dioxide and Concomitant Climate Change

High-latitude ecosystems (Arctic, boreal forest and northern bogs) contain vast stores of carbon—about 500 Gt, mostly in the soil active layer and upper permafrost. This is equivalent to about two-thirds of the carbon now in the atmosphere. Arctic ecosystems alone contain about 180 Gt of soil carbon, or 12% of the global soil carbon pool, even though they make up only 6% of the total land area.

DOE-sponsored research on ecosystem responses to carbon dioxide and concomitant climate change is designed to determine the combined effects on ecosystem function of elevated levels of atmospheric carbon dioxide and likely changes in other environmental variables. The effort includes documentation of the current net ecosystem carbon dioxide flux, compared with values from the historic and recent geologic past (Holocene), and development of an experimental base for predicting future fluxes.

Over the past two annual cycles (both summer and winter fluxes), daytime carbon gain in undisturbed ecosystems in the Siberian forest tundra zone (forest tundra, bog, wetland and shrub tun-

The point of contact for the Carbon Dioxide Program is Roger Dahlman, Environmental Sciences Division, ER-74, U.S. Department of Energy, Washington, DC 20585; 301-903-4951.

dra) was balanced by a similar seasonal pattern of nighttime CO_2 efflux. Consequently the average net daily flux was relatively small throughout the year. Disturbed sites differed from undisturbed sites during summer in having greater daytime CO_2 influx (2.1–2.5 fold), greater nighttime CO_2 efflux (1.8–2.6 fold), greater average daily CO_2 influx (1.6–3.0 fold), and a six-week shorter season of positive daytime carbon gain; winter respiration was also 4.3 times greater in disturbed than in undisturbed sites. Thus, the seasonal amplitude of CO_2 exchange (integrated summer uptake minus integrated winter efflux) was 2.3–3.3 times greater in disturbed than in undisturbed sites. Regional extrapolation of these results shows that the greater seasonal amplitude of CO_2 exchange due to increased disturbance at high latitudes accounts for most of the recent increase in amplitude of atmospheric CO_2 observed at high-latitude monitoring stations. This provides an alternative to Keeling's 1996 hypothesis that this increased amplitude reflects increased production in response to high-latitude warming.

Organic Contaminants in the Alaskan Arctic and Siberia

The point of contact for information on Organic Contaminants in the Alaskan Arctic is Matthew Monetti, Environmental Sciences Division, U.S. Department of Energy, Environmental Measurements Laboratory, 201 Varick Street, NY, NY 10014; 212-620-3625.

The DOE's Environmental Measurements Laboratory has been investigating the presence and chronological record of atmospherically deposited, combustion-produced, potentially toxic and/or carcinogenic organic contaminants such as polychlorinated dibenzo-p dioxins and dibenzofurans (PCDD/F), polycyclic aromatic hydrocarbons (PAH) and coplanar polychlorinated biphenyls (c-PCB) in Alaska. This effort came about through two collaborations with the EPA. The first was participation in the EPA's Arctic Contaminants Research Project (ACRP). The main emphasis of the ACRP was evaluating the depositional history on the North Slope of Alaska, an area over 200,000 km^2 bounded by the Brooks Range to the south and the Arctic Ocean to the north. Most of the region is wilderness tundra with several small villages scattered throughout. The only potentially significant source of these contaminants within this region is the oil-processing activities at Prudhoe Bay, Alaska. Prudhoe processing is unlikely to have an impact on the entire North Slope region.

The more recent collaboration was on a study of the chronology of atmospheric deposition of polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and coplanar polychlorinated biphenyls into lake sediments in the U.S. under the EPA Dioxin Exposure Initiative. In this study, samples obtained in the ACRP were used to investigate deposition in Arctic Alaska.

The approach used for reconstructing the historical deposition of contaminants was the collection and analysis of sectioned lake sediment cores. Material deposited directly into a lake or washed in from the drainage basin becomes incorporated into the sediment. Refractory materials are preserved at greater depths in the sediment as more sediment continues to accumulate over time. Lake sediments were collected from ten lakes in Alaska during the ACRP. Sediment cores were dated by standard radiometric techniques, and the samples were analyzed for target contaminants, thereby developing a chronological record of contaminant deposition. Because of the slow sedimentation rate in the lakes studied, the temporal resolution is coarse compared to other lakes studied by this method.

Sediment cores from two lakes have been analyzed for PAH—Wonder Lake in Denali National Park and Lake Schrader in the Arctic National Wildlife Refuge. Two classes of PAH were found: parental PAH produced from combustion, and biogenic PAH derived from natural precursors. The composition of parental PAH resembles those observed in other environmental samples but the levels were two to four orders of magnitude lower than those found in sediments from other lakes in the contiguous U.S. The concentrations of biogenic PAH were one to three orders of magnitude higher in concentration than those of combustion-produced PAH. The data do not reveal any substantial increase in PAH contamination to the Alaskan Arctic as has been observed in other regions of the U.S.

PCDD/F and c-PCB were also analyzed on two sediment cores. One core was from Wonder Lake and the other from Chandler Lake in the Gates of the Arctic National Park and Preserve. Deposition of PCDD/F and c-PCB is several orders of magnitude lower than values measured in other regions of the U.S. Even so, it appears that the deposition of these contaminants has more than doubled in the past 40 years. Detectable concentrations of PCDD/F were measured in preindustrial sections of these Alaskan cores. It is possible that some synthesis is occurring, resulting in the formation of PCDD/F from chemically unrelated natural precursors together with a chlorine donor.

For the Global Measurements of Radionuclides in the Atmosphere and Deposition projects, the points of contact are John Kada and Matthew Monetti, Environmental Sciences Division, U.S. Department of Energy, Environmental Measurements Laboratory, 201 Varick Street, NY, NY 10014; 212-620-3524 and 212-620-3625.

Global Measurements of Radionuclides in the Atmosphere and Deposition

The objective of this program is to characterize, quantify and model the environmental pathways, and to evaluate the environmental and human health impacts on regional and global scales, of natural and anthropogenic radionuclides deposited on the Earth's surface. A component of this program is the operation of a high-quality global radioactivity sampling network by DOE's Environmental Measurements Laboratory, which includes stations in the Arctic and sub-Arctic (Alaska, Canada, Greenland, Iceland and Norway). Through the global network, DOE is poised to react instantly to any new introduction of atmospheric radioactivity.

Arctic Waste Assessment Program

For the DOE Collaboration in ONR's Arctic Waste Assessment Program, the point of contact is Thomas Beasley, U.S. Department of Energy, Environmental Measurements Laboratory, 201 Varick Street, NY, NY 10014; 212-620-3636.

This Office of Naval Research (ONR) program, which terminated in 1996, included research on the occurrence of selected radionuclides in water, sediment and biota collected from the Arctic Ocean Basin. These investigations were part of a larger U.S. effort to determine if radioactive waste management practices of the former Soviet Union have compromised fisheries resources in the Arctic Ocean or have, in any way, led to radioactivity levels of concern in this ecosystem. The program was under the direction and sponsorship of ONR. Collaborating with DOE's Environmental Measurements Laboratory in this research was a consortium of several DOE laboratories (Oak Ridge National Laboratory, Argonne National Labora-ory and Pacific Northwest Laboratories) and the IsoTrace Laboratory of the University of Toronto.

The results of measurements made by the consortium in 1994 and 1995 have led to the following conclusions:

- ^{129}I concentrations in the western Arctic Ocean are generally 5–10 times lower than concentrations seen in the Barents and Kara Seas. Sellafield-derived ^{129}I has been advected into the Laptev Sea, and there is increasing evidence of its transport to the Beaufort Sea at depths between 200 and 400 m.
- There is evidence from sediment analyses that ^{237}Np, in excess of that expected from global fallout, has entered the Arctic Ocean. It is likely that the mechanism for import was via the Ob and Yenisei Rivers. Preliminary measurements of ^{237}Np in a small suite of seawater samples collected from the Beaufort Sea show easily measurable concentrations of this radionuclide at levels that exceed those expected from global fallout input.
- Sediments raised from the Canadian Basin show the presence of fuel reprocessing Pu whose release date to the environment approximates 1957, the date of the large chemical explosion at the Mayak Complex, which released high-level radioactive waste over more than 20,000 km^2.

Department of Health and Human Services

The Department of Health and Human Services supports and conducts Arctic health research through the Centers for Disease Control and Prevention and the National Institutes of Health.

Centers for Disease Control and Prevention

	Funding (thousands)	
	FY 96	FY 97
National Institutes of Health	3,576	7,620
Centers for Disease Control/Prevent.	2,851	3,080
Total	6,427	10,700

Arctic research programs of the Centers for Disease Control and Prevention (CDC) are conducted by the National Center for Infectious Diseases (NCID), the National Center for Environmental Health, the National Center for Injury Control and Prevention, and the National Institute of Occupational Safety and Health. These programs represent an excellent example of interagency cooperation and collaboration with the State of Alaska Division of Public Health, the Alaska Native Medical Center (ANMC), the Alaska Area Native Health Service (AANHS) of the Indian Health Service (IHS), local and regional Native health corporations, universities and other state and local agencies and organizations.

National Center for Infectious Diseases

The Arctic Investigations Program (AIP) located in Anchorage, Alaska, is one of the field stations operated by the National Center for Infectious Diseases (NCID). The mission of AIP is the prevention of infectious diseases among residents of the Arctic and sub-Arctic, with a focus on diseases of high incidence and concern among the indigenous populations of these regions and more recently emerging and re-emerging diseases. Research on the prevention and control of infectious diseases in these remote and widely scattered populations with limited resources is accomplished through the development of partnerships with local communities; local regional and Native health organizations; universities; other divisions, programs and centers within CDC; the National Institutes of Health; the Alaska Area Native Health Service; the Alaska Native Medical Center (ANMC); and the State of Alaska. To further increase the participation of American Indian and Alaska Native community members in infectious disease prevention research, priority setting and training opportunities, the first emerging infectious diseases cooperative agreement program was initiated in Alaska in 1997.

The prevention and control of infectious disease uses a strategy that includes the application of traditional and innovative epidemiologic and laboratory methods to determine the etiology of disease, the establishment of surveillance systems to determine diseases rates in the affected population, the identification of risk factors for disease acquisition and transmission, the evaluation of established or new intervention methods, and the implementation, promotion and long-term monitoring of successful prevention and control programs. This approach has been successfully used by AIP for the prevention and control of hepatitis B and Haemophilus influenzae type b in the Alaska Native population. This strategy serves as a model for the prevention and control of other diseases of high incidence in Alaska. As one of CID's three field stations in the U.S., AIP is uniquely positioned to facilitate or augment the development of emerging infections prevention programs, not only in Alaska but also within Arctic populations residing in other circumpolar countries. Priority diseases currently targeted for prevention by AIP in the Arctic include those caused by hepatitis A, B and C, Haemophilus influenzae type b, Streptococcus pneumoniae, respiratory syncytial virus and Helicobacter pylori.

Hepatitis A

Hepatitis A virus (HAV) infection is a major disease problem for Alaska Natives. The disease typically follows a pattern of cyclic recurrences every 10–12 years. The latest statewide epidemic began in late 1986 and peaked in 1988-89. By the end of 1990 the epidemic included over 1100 documented cases of disease in Alaska Natives. However, during 1992 the incidence of disease was again increasing in several areas throughout the state, and the disease peaked again in 1993, with a steady decline since then. The recurrence of village outbreaks depends on the presence of a young susceptible population.

The focus of AIP's HAV Arctic research program has been to understand and describe the population of Alaska Natives susceptible to HAV infection and to test candidate HAV vaccines in the population. Testing of banked serum samples from previous statewide serosurveys for antibody to HAV has enabled assessment of susceptibility to HAV infection. In conjunction with the ANMC and private industry, a study demonstrated the usefulness of one dose of vaccine without concurrent immune globulin in an outbreak setting. In addition, a safety and immunogenicity study of a candidate hepatitis A vaccine was conducted among Alaska Native preschoolers and adults and non-Native adults, and the vaccine is currently undergoing trials in Alaska Native infants. This study has allowed comparisons of various vaccination schedules in children, examination of potential age trends in response to vaccine in Alaska Native adults, and comparisons of Native adults with non-Native adults. A six-year follow-up of this group will enable assessment of antibody persistence.

Hepatitis B

Infection with the hepatitis B virus (HBV) is a serious health problem in many parts of the world. In the Alaska Native population the prevalence of hepatitis B has been very high. In 1982 a collaborative AIP, ANMC and State of Alaska Division of Public Health statewide program was instituted to immunize all susceptible Alaska Natives. Between 1982 and 1987 over 52,000 Alaska Natives were screened for hepatitis B markers, and over 43,000 susceptibles were identified and vaccinated. In the one region of Alaska where surveillance was established prior to the hepatitis B control program and where 90% of susceptibles were vaccinated, the incidence of acute symptomatic hepatitis B cases decreased from 215 cases per 100,000 population to 6 per 100,000 within five years and subsequently has fallen to less than 1% in 1996-97. This demonstrated that community-based mass immunization can effectively reduce acute symptomatic hepatitis B virus infection in at least 90% of susceptible persons in a hyperendemic population.

The hepatitis B control program in Alaska became the first successful program to halt the spread of hepatitis B in a large geographic area. Since it has greatly decreased the number of acute cases of hepatitis B, it is likely that the long-term sequelae such as vasculitis and hepatocellular carcinoma will also decline in this population over time. The strategy used in this program has been integrated into control programs in other countries. The alpha fetoprotein screening program for hepatitis B carriers is a model for hepatocellular carcinoma control in other parts of the world, and the information gathered on the long-term efficacy of the hepatitis B vaccine is being used to develop policies for revaccination schedules. A recent study in conjunction with other divisions of NCID and an Alaska Native corporation determined the prevalence of hepatitis B in six villages in southwest Alaska where routine hepatitis B vaccination was implemented ten years previously. The prevalence of hepatitis B carriage was zero in children 2 to 10 years of age compared to 15% of age-matched controls tested in 1983. This demonstrates that similar results could be accomplished in other endemic areas using childhood vaccination programs. Current research is focusing on long-term follow-up of infants and adults immunized with hepatitis B vaccine and responses to booster immunizations, which will allow recommendations to be developed regarding revaccination schedules.

Hepatitis C

Hepatitis C virus (HCV) is an important cause of morbidity and mortality in the U.S. and many other parts of the world. The prevalence of hepatitis C in the general U.S. population is between 1 and 2%. HCV has also been associated with hepatocellular carcinoma (HCC). Anti-HCV was found in 65, 75 and 86% of patients with HCC, respectively, from Italy, Spain and Japan, areas with a moderate prevalence of HCV in the general population. More importantly, HCC has been associated with end-stage cirrhosis. In the U.S., HCV-associated cirrhosis is the number one reason for liver transplant (OLT). In Alaska Natives, HCV-associated cirrhosis is also the prime reason for referral for OLT. The Alaska Native Medical Center (ANMC) laboratory has identified over 500 persons who are positive for anti-HCV.

In collaboration with the ANMC and the University of Washington Molecular Biology Laboratory, AIP is studying the natural history of HCV in Alaska Natives. The risk factors associated with acquiring HCV and the factors associated with the progression of liver disease are being identified. These factors relate to both the host and the infecting microorganism. The investigation of the HCV virus includes such properties as the viral genotype and the level of virus in the blood. To enable this investigation a retrospective serum bank search is being performed for consenting patients. The earliest and most recent sera that are positive for anti-HCV are sent for testing for HCV-RNA and genotype. In addition, a prospective analysis of patients with HCV will be performed to determine the rate of development of complications such as cirrhosis and hepatocellular carcinoma. In another study, persons with HCV who might benefit by currently licensed anti-viral therapy are being identified. Currently 300 persons are enrolled.

Helicobacter pylori

Helicobacter pylori, one of the most common infections of humans, causes chronic active gastritis and primary duodenal and gastric ulcers. In the general U.S. population the seroprevalence of IgG antibodies to H. pylori is 30–40%, with the rate of seroconversion estimated at 0.5% per year. What appears to be the increasing frequency of seropositivity in older adults in developed countries is mostly due to the cohort effect, with the prevalence of antibody in adults actually reflecting acquisition of disease earlier in life. In developing countries and in lower socioeconomic classes, there is a higher prevalence of infection; seroprevalences often approach 100%, with most persons in these circumstances becoming infected before 10 years of age. Increased transmission of infection occurs in these disadvantaged socioeconomic groups because of crowding or poor hygiene. Although the actual route of transmission is unknown, oral–oral or fecal–oral transmission is suspected. The contamination of drinking water may play a role. Man is the only known reservoir.

Attention focused on H. pylori in Alaska Natives when it was discovered that anemia due to fecal blood loss appeared to be associated with H. pylori. High rates of iron deficiency anemia had been observed among Alaska Natives dating back to the 1950s, despite adequate intake of nutrients offering optimum iron nutrition. Therefore, gastrointestinal blood loss was examined as a cause of anemia, leading to the discovery that 99% of those with increased fecal blood loss had chronic active gastritis due to H. pylori. To determine the prevalence of H. pylori in Alaska Natives, over 2000 serum samples collected in the 1980s in Alaska Native communities were assessed for H. pylori IgG antibodies. Overall, 75% were positive for H. pylori, with rates increasing from 32% among 0- to 4-year-olds up to 86% in those 20 years or older. There was a marked regional variation, which was most pronounced among the youngest children (0–4 years), where rates ranged from 5% in south-central (Anchorage vicinity) to 65% in interior Alaska. Ferritin determinations on the same samples supported an association between H. pylori infection and iron deficiency, especially in those under 20 years of age.

The high rates of anemia, gastritis and gastric cancer in Alaska Natives are likely related to the high rates of infection with H. pylori. The overall impact in terms of the potential health and economic costs resulting from chronic H. pylori infection in this population is still unknown, but it could be substantial. Current research is focused on establishing laboratory-based surveillance systems that allow evaluation of diagnostics, monitoring antimicrobial resistance, determining rates of re-infection following treatment, and determining the extent and clinical impact of this infection on the residents of Alaska.

Streptococcus pneumoniae

Alaska Natives have experienced unprecedented rates of invasive disease due to Streptococcus pneumoniae that are among the highest reported in the world. In southwest Alaska, for example, the annual incidence of invasive pneumococcal disease from 1980 through 1986 was 108 per 100,000 persons per year, and in those over 59 years the age-specific rate was 145 per 100,000. The highest rate was in children under the age of 2 years: 1195 per 100,000. This attack rate in the children under 2 years is twice as high as in Alaska Native children the same age living elsewhere and 20 times the rate for Alaska non-Natives. The incidence and mortality rates of invasive pneumococcal disease among all age groups of Alaska Natives are five times higher than among Alaska non-Natives.

Pneumococcal serotypes associated with invasive disease are also reflected in the organisms carried by healthy individuals. This held true in a 1992 survey of nasopharyngeal carriage isolates from healthy children that were representative of the invasive strains in the region. In addition, the proportion of invasive organisms that were resis-

tant to at least one drug did not differ from the nasopharyngeal isolates from asymptomatic children. Twenty-nine percent of pneumococcal isolates from the nasopharynx of asymptomatic children 5 years old were intermediate or resistant to penicillin. The capsular serotype 6B organism was the etiology of 22% of the invasive disease in infants under 24 months of age from 1982 to 1991, a substantial proportion (77%) of which had intermediate levels of penicillin resistance compared to an expected 4.7% in the U.S. population. Also, all of the multiple-drug-resistant organisms were type 6B.

The case-fatality rate for Alaska Natives with invasive pneumococcal disease is relatively low (8%), the same as the Alaska non-Native rate, and compares favorably with rates of 5–33% elsewhere in the U.S. This is noteworthy considering that the proportion of pneumococcal cases with pneumonia and meningitis is high in Alaska Natives and that this is a remote, isolated population living in a harsh environment with difficult travel.

The reason for the unprecedented rates of pneumococcal disease in the Alaska Native population is not entirely clear, but there appear to be several contributory factors, such as crowded living conditions, poor ventilation and exposure to smoke, which are common conditions in rural Alaska. The emerging type 6B pneumococcus, which exhibits multiple resistance to commonly used antibiotics, coupled with increased use of antibiotics, confers extra risk to the pneumococcal infection problem.

There are potential opportunities for controlling pneumococcal disease in this population by vaccination and by limiting the prescription of antibiotics to those of proven effectiveness. The groups at high risk for invasive pneumococcal disease are at both ends of the age spectrum. Alaska Natives over the age of 55 years are now routinely offered a 23-valent pneumococcal polysaccharide vaccine. However, effective pneumococcal vaccines are not licensed for the high-risk group under 2 years of age. Research is in progress on promising new conjugate pneumococcal vaccines in the Alaska Native population. Research is also underway in educating providers and consumers in the appropriate use of antibiotics to see if this can impact carriage rates of resistant pneumococcal strains.

Haemophilus influenzae

In the 1960s and 1970s Alaska Native children had the highest endemic rates of meningitis in the U.S. Haemophilus influenzae type b (Hib) was the leading cause of the meningitis and of the other invasive infections in these children. The AIP began conducting statewide surveillance for Hib disease in 1980, when the rate of Hib meningitis and all invasive Hib disease in Alaska Native children under 5 years of age was 264 per 100,000 and 601 per 100,000, respectively, and the rate of invasive disease in those under 1 year was 1,700 per 100,000. Subsequent AIP studies have characterized the epidemiology of Hib disease in Alaska. Although the Native population represented only 16% of the population, they experience 51% of all invasive Hib disease in Alaska. The rate of invasive Hib disease in Alaska Native infants in southwestern Alaska was ten times that of non-Natives in Alaska and in the rest of the U.S. Early and intense exposure to Hib increased the risk of Hib disease in the Alaska Native population, and breastfeeding offered protection. The disease was more likely to occur in younger infants, with 25% of all Hib disease and 35% of meningitis occurring before six months of age, compared to 15% and 17%, respectively, in Alaska non-Natives. Alaska Native children also suffered greater neurological morbidity as a result of Hib meningitis than non-Native children.

Believing that active immunization of infants was the most promising way of preventing disease, AIP conducted immunogenicity trials of various Hib vaccines among Alaska Natives beginning in the 1970s, which yielded valuable information on the response to vaccines in this high-risk population. In 1991, universal active Hib vaccination of infants was begun with a Hib conjugate vaccine (PRP-OMP) that AIP had shown to be superior to other Hib conjugate vaccines. It was the only vaccine that induced a response after the first dose, and it also remained the most immunogenic after two doses. Since the age distribution of Hib infections was much younger in Alaska Natives than in the U.S. population, the AIP-generated immunogenicity information was especially important in helping the AANHS and the state choose an appropriate vaccine for routine use. The incidence of invasive Hib disease in Alaska Native children under 5 years, which had reached 75 per year in the 1980s, began to decline dramatically, and by the mid-1990s, incidence had decreased to two to three annually.

In January 1996 the statewide vaccine program replaced the PRP-OMP vaccine, which had been used for five years, with a new combination vaccine of a Hib conjugate component (HbOC) with DTP. Because of the dramatic drop in Hib disease, it was postulated that the decrease was partially attributable to a decrease in nasopharyngeal Hib

carriage, and Alaska could safely switch to a different Hib conjugate vaccine. Studies in the U.S. and Finland showed a dramatic decrease in Hib carriage from a prevaccine rate of 3–5% to 0% in Finland and 0.3% in Georgia. In the prevaccine era in Alaska, Hib colonization was as high as 7% in one region and fell to 2% in 1992 in the same region. From 1992 to 1996 there were one to three invasive Hib infections per year in Alaska Native children under 5 years of age. However, between May and June of 1996 there were five cases of invasive Hib disease in Alaska Native children. In response to the increase in invasive Hib disease, AANHS, in consultation with CDC's Division of Bacterial and Mycotic Diseases, recommended that the IHS offer the PRP-OMP Hib conjugate vaccine as an initial dose for Alaska Native infants in high-risk regions, a practice that was also recommended to the American Academy of Pediatrics (AAP) Committee on Native American Child Health. Between January 1, 1996, and September 1997, there were 16 cases of Hib disease in Alaska Native infants. A carriage study was performed in six villages of southwestern Alaska. Among children under 5 years the carriage rate of Hib was 9.5%, indicating that in this highly immunized population, conjugate vaccines had not reduced oropharyngeal carriage of Hib. This study has implications for Hib disease prevention in other countries with high rates of invasive disease caused by Hib.

Respiratory syncytial virus

Respiratory syncytial virus (RSV) is the most important cause of acute lower respiratory infections in infants in the U.S. It occurs in annual outbreaks that usually peak in February and is responsible for one-fourth to one-third of all pediatric hospitalizations for pneumonia and one-half of the hospitalizations for bronchiolitis. Native American children suffer from greater morbidity and mortality from acute respiratory infections in general than other children in the U.S. The mortality from pneumonia for all Native American infants is twice that of infants in the general U.S. population.

Hospitalization rates for RSV disease for Alaska Native children from 1986 through 1992 were ten times higher than for other U.S. populations. An intense review of hospital records for Alaska Native infants from Anchorage and southwestern Alaska helped characterize the epidemiology of the Alaska Native RSV disease. The hospitalized Anchorage infants appeared more similar to those in the general U.S. population than did the infants from the southwest region. For Anchorage infants the peak age of hospitalization was 4.5 months, similar to the U.S. peak age of 2–5 months, but the peak for the southwestern region infants was 2 months. Sixteen percent of the hospitalized children from the southwest were less than 1 month of age, compared to less than 5% for Anchorage Alaska Native and U.S. infants. The more severe disease also occurred in younger infants. Despite the similarities of Anchorage Native infants to the U.S. population, the hospitalization rate for these infants was 33 per 1000, among the highest reported in the world. The rate was even higher in southwestern Alaska, with one in ten infants requiring hospitalization for RSV.

There are known risk factors for serious RSV disease. Young age, prematurity, cardiac disease, chronic pulmonary disease or immunodeficiency increase the risk of complications. Since the disease itself provides limited protective immunity, repeated infections can also occur. Certain environmental conditions also place young infants at increased risk. Environmental smoke has been well documented as a risk factor. The presence of a wood-burning stove increases the risk of Navajo children to lower respiratory illnesses. Passive smoke is also an important risk factor for Alaska Native infants, since 50% of Alaska Native men and women smoke, which usually occurs indoors and especially during the winter months. Another risk factor is crowded households.

A prospective case-control study among Alaska Native infants in southwestern Alaska, carried out by AIP, AANHS, an Alaska Native health corporation, and Johns Hopkins University, has confirmed the increased severity of RSV disease associated with young age and pre-existing medical conditions. The study also demonstrated that the hospitalization for any viral respiratory illness is a risk factor for hospitalization with RSV within the same year. The study also demonstrated that some protection against RSV is afforded by breastfeeding. Assessment of antibody levels suggest a trend that maternal antibody may provide some protection to the younger infant.

National Institute of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH) found that for the ten-year period between 1980 and 1989, Alaska experienced 34.8 worker deaths for every 100,000 workers employed in the state, a rate approximately five times the national rate of 7.0 per

100,000. After identifying Alaska as the highest-risk state in the U.S. for job-related traumatic fatalities, NIOSH responded by establishing a research field station, as part of its Division of Safety Research, in Anchorage in 1991.

The major research questions addressed by the project are:

- How many severe occupational injuries occur in Alaska?
- In which Alaskan industries and occupations do severe occupational injuries occur?
- What risk factors are identifiable for these events?
- Which of these risk factors can be eliminated or mitigated?
- How can this most effectively be accomplished?

The objectives of the program are:

- To characterize and reduce occupational risks in workplaces and industries by using epidemiologic surveillance and analytic methods and engineering hazard and task analysis techniques;
- To establish and refine statewide occupational injury and fatality reporting systems;
- To conduct prevention-oriented research addressing high-risk operations and populations (for example, commercial fishing, air transport and logging);
- To use the on-site location as a "living laboratory" for conducting state-of-the-art injury surveillance, intervention trials and demonstration projects; and
- To promote worker injury prevention technology transfer to and from Alaska.

The NIOSH Alaska Field Station designed and implemented a comprehensive surveillance system for fatal and non-fatal occupational injuries, the Alaska Occupational Injury Surveillance System (AOISS). AOISS obtains risk factor information and permits quantitative epidemiologic analyses to be used for sound public health and prevention planning. The AOISS database contains over 500 fatality records, as well as over 2400 non-fatal injury records from the Alaska Trauma Registry (which is partially supported by Alaska Field Station funds).

The Alaska Field Station has established strong relationships with many other Federal, state, municipal and non-governmental agencies that are engaged in detecting, investigating and/or preventing occupational injuries and fatalities. Included in this group are the jurisdictional agencies overseeing the highest-risk industries in Alaska. These relationships, formalized within the Alaska Interagency Working Group for the Prevention of Occupational Injuries, have fostered injury surveillance, a broader understanding of occupational injuries in the state, and an opportunity to effectively influence the immediate response to emerging occupational injury problems (such as helicopter logging fatalities, drowning from man-overboard events, and occupational homicides) in the state. In addition to surveillance and investigation activities, in-depth studies have been focusing on identifying and reducing risks associated with commercial fishing, logging and air transport in Alaska.

Between 1990 and 1996, 508 Alaskan workers died, an average of one every five days, from job-related injuries, including 160 commercial fishermen, 82 pilots, 44 military personnel, 23 fish processors and 21 loggers. The leading causes of these deaths were drowning (175), aircraft crashes (162), being crushed (44), falls (22), motor vehicle crashes (22) and homicide (21). Many of the deaths were among young people, resulting in over 14,500 worker-years of potential life lost before age 65. The dollar cost to society in lost future productivity (wages) due to these 508 premature, work-related deaths is estimated to be $536,320,000.

Progress

The combined efforts of many agencies and individuals have resulted in the following: Alaska experienced a 30% decline in work-related deaths in 1996 compared to 1991; commercial fishing deaths in 1996 were down 33% from 1991; in 1996, 89% of commercial fishermen survived vessel sinkings/capsizing, whereas in 1991 only 73% survived. NIOSH published *Commercial Fishing Fatalities in Alaska: Risk Factors and Prevention Strategies* in September 1997 to foster further progress in this area.

For the 18-month period of January 1, 1992, to June 30, 1993, helicopter logging pilots had the highest-risk occupation in Alaska. In July 1993 NIOSH facilitated an interagency intervention that resulted in a marked decrease in helicopter-logging-related fatalities.

As a result of epidemiologic and process analysis of severe injury events, the Alaska Field Station has proposed a number of technological innovations (such as log truck stake extensions and fishing vessel retrofit sponsons) and procedural innovations (such as redundant or fail-safe communications in logging transport operations and encouraging the wearing of personal flotation devices during com-

mercial fishing operations) to improve worker safety in Alaskan industries.

The surveillance technology developed by the NIOSH Fatality Assessment and Control Evaluation (FACE) program has been transferred to the Alaska Department of Health and Social Services (ADHSS), Division of Public Health, Section of Epidemiology, Occupational Injury Prevention Program via the state-based FACE program, with technical assistance and collaboration by the Alaska Field Station.

Alaska Trauma Registry

The following data are for the industry in which hospitalized injuries occurred, as recorded in the Alaska Trauma Registry. In January 1997 the occupation field in the registry was reworked to NIOSH specifications, which will permit future classifications of injuries by occupation as well.

Industry	*Injuries 1991–1995*	*Injury rate per 100,000*
Logging	215	2,500
Water transportation	118	1,300
Wood product manufacturing	30	940
Construction	365	630
Mining	30	540
Fishing	390	460
Land transportation	84	370
Seafood processing	136	260
Oil and gas	99	210
Air transportation	69	190
Military	202	180

Special Populations: Alaska Natives

Alaska Natives have a drowning rate that is more than 17 times the national average. The NIOSH Alaska Field Station has worked in conjunction with the Alaska Area Native Health Service (AANHS) of the Indian Health Service (IHS) to set up a surveillance system for drowning in Alaska. As part of this effort, Alaska death certificates are reviewed annually to abstract demographic information. Follow-up reports are requested from the state troopers, police departments and medical examiner offices to collect risk factor information such as personal flotation device usage and alcohol involvement. The data from this system are used by the AANHS to evaluate their "floatcoat" programs in the different service units. Alaska Natives have a high drowning rate (particularly young adult males) because the rivers are used as highways in bush Alaska. Dozens of Alaska Natives drown each year, mostly from boating incidents and from breaking through the ice while traveling via snowmobiles. A paper pertaining to drowning in Alaska for 1988–1992 was published in the November/December 1996 issue of *Public Health Reports*.

The NIOSH Alaska Field Station, in conjunction with the AANHS, has developed a surveillance definition for subsistence activities, including hunting, fishing and trapping. This case definition is being used by the Alaska Field Station, working with the AANHS, to gather subsistence-related injury and fatality information for Alaska Natives. This surveillance for severe subsistence-related injuries and their risk factors in Alaska is forming the basis for future prevention strategies for these events. During 1991–1995, there were 82 subsistence-related injuries requiring hospitalization of Alaska Natives occurring in the following settings: 47 during subsistence hunting, 28 during subsistence fishing, 4 during subsistence whaling, and 3 during subsistence gathering activities. The causes of these injuries included the use of tools and implements such as knives (24), guns (18) and snowmobiles (7), as well as exposure to cold (5). These data have been recently shared with the Alaska Native Epidemiology Center and will be used by AANHS injury practitioners in community-based injury prevention activities.

International and Circumpolar Collaboration

NIOSH Alaska continues its active international collaboration in circumpolar health research through direct interagency relationships and via the Injury Prevention and Occupational Safety and Health Working Groups of the International Union for Circumpolar Health. This collaboration led to a special session on cold injury and hypothermia at the Tenth International Congress on Circumpolar Health in Anchorage in May 1996. From May through August 1996, Juhani Hassi, Director, Oulu Regional Institute, Finnish Institute for Occupational Health (FIOH), was a visiting scientist in the Alaska Field Station. He continued his own research on cold-related injury during his stay. Also, the FIOH began a collaborative effort with the Alaska Field Station to provide technical assistance in occupational injury and hazard surveillance and prevention to the Barents Sea region of northwestern Russia and northern Norway, Sweden and Finland. This led to George Conway, Chief of the NIOSH Alaska Field Station, being detailed to the FIOH for August 1997 to provide technical assistance in injury surveillance and prevention activities and to collaborate in the development of a Barents surveillance agenda and

comparative mortality projects. Dr. Conway also provided training in surveillance and epidemiologic techniques to a group of Finnish, Russian and Norwegian scientists in Haukipudas, Finland, in late August 1997. NIOSH has also participated as a co-sponsor in planning for the International Symposium on Problems with Cold Work, held in Stockholm in November 1997.

Conferences and Workshops

The NIOSH Alaska Field Station sponsored helicopter logging safety workshops in 1995, 1996 and 1997 in response to an epidemic of helicopter-logging-related deaths. The workshop proceedings were published and disseminated widely.

The NIOSH Alaska Field Station conducted the Second Fishing Industry Safety and Health (FISH II) Workshop in Seattle, Washington, on November 21–22, 1997. The two-day workshop consisted of presentations from scientists, researchers, regulators, educators, health care providers and commercial fishermen, and from working groups tasked with identifying root causes of specific injuries (fatal and non-fatal) and corresponding countermeasures. The FISH II Workshop presentations and working group recommendations will be published and disseminated through a proceedings volume.

National Center for Environmental Health

Fetal Alcohol Syndrome

Between 1991 and 1995 the National Center for Environmental Health (NCEH), the AANHS and the ADHSS entered into formal agreements to establish the Alaska Fetal Alcohol Syndrome Prevention Project. The project's purpose was to develop a surveillance methodology for fetal alcohol syndrome (FAS) that could be used by other states and countries to provide the epidemiologic data for developing and implementing prevention efforts.

The project, staffed by NCEH personnel, worked closely with ADHSS epidemiologists to link multiple data sources and evaluate the usefulness of each for purposes of FAS surveillance. In all, 16 data sources were used, including data from the Alaska Native Medical Center and from two Alaska Native regional health corporations. Other sources included state programs for children with special needs and state data sets such as Medicaid and vital statistics. The project was also provided access to the hospital discharge data from the state's two largest private hospitals and to the files of two pediatricians in private practice who are considered referral physicians for FAS.

Of the 630 potential cases identified, 568 had medical charts available for review, of which 248 had a chart notation of "FAS," which included "possible FAS," "probable FAS" and "suspect FAS." NCEH and ADHSS epidemiologists used a five-criteria surveillance case definition to ascertain cases. The findings indicate a high prevalence among Alaska Natives; the observed rate is 3.0 per 1000 live births for five-criteria cases and 5.2 per 1000 live births for FAS-noted cases for Alaska Native children born between 1977 and 1992. The 1977–1992 rates for the state's non-Native population were 0.2 per 1000 live births for five-criteria cases and 0.3 per 1000 live births for FAS-noted cases. Project epidemiologists found substantial under-reporting of FAS in each of the 16 data sources examined, indicating that multiple data sources and active screening programs are needed to enhance case ascertainment.

Project staff obtained birth certificate data for 102 cases, which showed that 63% of FAS mothers were not married at the time of delivery, 41% had not completed high school, and 69% had either no prenatal care (33%) or began prenatal care after the first trimester (36%). These mothers are older women, many of whom had previous children. Medical charts and birth certificates documented an average maternal age of 29±5. In addition, project staff documented that 14 of the mothers gave birth to more than one FAS case, averaging 2.3 FAS children each.

The results of the project's activities have been widely disseminated in Alaska and were presented at the Xth Congress of the International Union for Circumpolar Health in Anchorage in 1996. An FAS Working Group was formed through the International Union after the IXth Congress in 1993. The Working Group received a grant from NCEH to offer a workshop on diagnosing FAS at the Xth Congress to improve case ascertainment among circumpolar nations. In addition, the project's results have been accepted for publication in the *Journal of the American Public Health Association*.

The state's DHSS commissioner has established a statewide coordinator for the prevention of FAS. The associated risk factors for FAS as documented by the project will be used in developing prevention strategies.

In 1997, NCEH awarded DHSS a five-year

cooperative agreement (one of five awarded nationwide) for conducting enhanced surveillance for FAS. In developing the request for proposals for the FAS surveillance cooperative agreements, NCEH addressed the constraints to surveillance documented by the Alaska project. All recipients are required to link multiple data sources and to use the same surveillance case definition. NCEH has also awarded ADHSS a three-year cooperative agreement to develop an Alaska Birth Defects Registry. Enabling legislation has been passed to require reporting specified birth defects, among them FAS, to public health officials. NCEH is providing both financial and direct assistance under the cooperative agreement.

Endocrine Disrupters

The NCEH epidemiologists collaborated with the Indian Health Service, the National Cancer Institute and the Alaska Area Native Medical Center to study the health effects among Alaska Native women exposed to environmental chemicals such as organochlorines, which may act as endocrine disrupters. Some of these chemicals have the potential to mimic female hormones and thus have been theorized to increase women's risks for breast cancer. This was an ideal population for such a study because endocrine disrupters tend to concentrate in colder climates, and many of the women in the study consumed a subsistence diet rich in fish, which contain high levels of several endocrine-disrupting chemicals. For the study, serum samples were analyzed that had been previously collected and stored in the Arctic Investigations Serum Bank. The results of this study will soon be published in the scientific literature.

National Institutes of Health

The National Institutes of Health (NIH) is one of eight health agencies of the Public Health Service, which is part of the Department of Health and Human Services. Comprising 24 institutes, centers and divisions, NIH is headquartered in Bethesda, Maryland, and has satellite facilities in North Carolina, Montana and New Mexico. The NIH's mission is to uncover new knowledge that will lead to better health for everyone. NIH supports research on Arctic-related health issues through grants and contracts to non-Federal scientists and through the projects carried out by scientists in NIH laboratories.

National Institute on Aging

In FY 97 the National Institute on Aging (NIA) initiated funding of a five-year center core grant to establish and maintain the Native Elder Research Center (NERC). The center will be located within the Division of American Indian and Alaska Native Programs of the Department of Psychiatry, School of Medicine, at the University of Colorado Health Sciences Center in Denver. It will serve to incorporate American Indian (AI) and Alaska Native (AN) members and culturally relevant priorities into local systems of health care and aging research processes. The center will also recruit and equip AI/AN investigators for successful research careers at the interface of aging, health and culture. The expected outcome is improved health status and access to care for this special population.

National Institute on Alcohol Abuse and Alcoholism

The National Institute on Alcohol Abuse and Alcoholism (NIAAA) is the lead Federal agency responsible for supporting and conducting biomedical and behavioral research on the causes, consequences, treatment and prevention of alcohol-related problems affecting the Nation's health. The NIAAA continues to support research projects in Alaska. In 1994 a five-year grant was awarded to the University of Connecticut Health Center to conduct a collaborative study with the University of Alaska Anchorage to examine the genetic, biological and behavioral characteristics of Native Alaskans receiving treatment for alcoholism. The project has begun its fourth year and has met several objectives. Research assistants who are Alaska Natives have been trained in procedures using standardized methods to obtain clinical assessment and laboratory data. To date, 330 subjects (168 women and 162 men) have been recruited into the study. Preliminary analyses of data collected to date indicate that subjects are typically affected with a very severe form of alcohol dependence. The age of onset of DSM-III-R (alcohol dependence) ranges from 12 to 49 years of age. However, most males have an onset around 18, while the onset age for females is about 20 years of age.

The clinical assessment battery used in this study is identical to that used in the Collaborative Study on Genetics of Alcoholism (COGA), which will contain a sample of approximately 10,000 subjects collected at six sites in the continental

U.S. The COGA sample represents a range of alcohol problems and contains a sufficient number of Hispanic and African–American subjects for comparison across different ethnic groups. Comparisons with the sample of Native Alaskans can help to determine if there are specific differences in the development of alcohol problems among these groups.

A second project was supported by a grant awarded to the Prevention Research Center in 1997 to determine whether alcohol availability control can change alcohol-related outpatient visits at the area hospital in an isolated geographic community. Findings from this project, Impact of Banning Alcohol on Outpatient Visits in Barrow, Alaska, were recently published in the *Journal of the American Medical Association*. During a 33-month period, possession and importation of alcohol were legal, banned, legal again and banned again. Based on review and analyses of outpatient records, there was a substantial decrease in alcohol-related visits during the ban periods. When the ban was lifted, alcohol-related visits showed a substantial increase. In a geographically isolated community, control of alcohol availability may be an effective public health intervention in reducing problems associated with alcohol abuse.

National Institute of Arthritis and Musculoskeletal and Skin Diseases

From 1989 to 1996 the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) supported research on spondyloarthropathies (SpA) in circumpolar populations, through an interagency agreement with the Indian Health Service (IHS) in Anchorage, Alaska. The SpA include Reiter's syndrome, ankylosing spondylitis, reactive arthritis, arthritis associated with inflammatory bowel disease, psoriatic spondylitis, idiopathic seronegative enthesopathy and arthropathy syndrome in children, and undifferentiated SpA. The etiology and pathogenesis of the SpA are poorly understood, although it is clear that both genetic and environmental factors are involved. All spondyloarthropathic diseases appear to be associated to some degree with Class I histocompatibility antigen HLA-B27; some are clearly triggered by infection.

Collaborative studies were conducted with Russian investigators from the Institute of Rheumatology of the Russian Academy of Medical Sciences in Moscow. Over a period of five years, U.S. investigators from the NIAMS and the IHS collected cross-sectional data from Inupiat and Yupik Eskimos in four Alaskan regions, and Russian investigators collected data from four settlements of Siberian Eskimos and Chukchi Indians on the Chukotka Peninsula. Both groups of investigators used the same data collection methods and disease criteria.

The objectives of this project were:

- To determine the prevalence of SpA disorders in circumpolar populations, which are known to have a high frequency of HLA-B27;
- To describe the spectrum of SpA disease, including clinical manifestations, natural history, sequelae and severity; and
- To lay the groundwork for investigating the role of specific genetic and environmental factors in the pathogenesis and expression of the disease.

The prevalence and spectrum of SpA were found to be similar in the U.S. and Russian study populations, and no predisposition to a particular form of spondyloarthropathy was observed. Among adults who were positive for the presence of HLA-B27, the prevalence of all types of SpA was estimated to be 4.5% for all the populations combined, and the prevalence of ankylosing spondylitis was estimated to be 1.6%. In these circumpolar populations the risk of developing ankylosing spondylitis for persons with HLA-B27 appears to be much lower than the rates that have been observed in other Indian populations in different geographic regions. No difference in disease frequency was found between men and women, although women tend to have slightly milder diseases. More research is needed in other defined populations to determine the difference in prevalence for the entire spectrum of spondyloarthropathic diseases.

National Cancer Institute

The National Cancer Institute coordinates the National Cancer Program, which conducts and supports research, training, health information dissemination and other programs with respect to the cause, diagnosis, prevention and treatment of cancer, rehabilitation from cancer and the continuing care of cancer patients and the families of cancer patients. Through a variety of programs, NCI:

- Supports and coordinates research projects conducted by universities, hospitals, research foundations and businesses throughout this

country and abroad through research grants and cooperative agreements;
- Supports education and training in fundamental sciences and clinical disciplines relating to cancer through career awards, training grants and fellowships;
- Supports research projects in cancer control;
- Supports a national network of cancer centers;
- Collaborates with voluntary organizations and other national and foreign institutions engaged in cancer research and training activities;
- Encourages and coordinates cancer research by industrial concerns where such concerns evidence a particular capability for programmatic research; and
- Collects and disseminates information on cancer.

Surveillance, Epidemiology and End Results Program

The Surveillance, Epidemiology and End Results (SEER) program is an important component for epidemiologic and surveillance research at the NCI and across the U.S. The SEER program collects and publishes cancer incidence and survival data from ten population-based cancer registries. The geographic areas comprising the SEER program's database represent approximately 14% of the U.S. population. Currently 25% of the American Hispanic population, 41% of the Asian/Pacific Islanders population (43% of all Chinese Americans and 60% of all Japanese Americans), 27% of American Indian and Alaska Native populations, and 12% of the African American population reside in SEER areas.

Over the past several years NCI has funded two interagency agreements with the Indian Health Service, one for the support of the Alaska Native Tumor Registry for the surveillance of the cancer burden among Alaska Natives and an earlier, more complex project to describe not only cancer incidence and mortality in Alaska Natives and American Indians but also the patterns of care, risk factors and cultural entities that form barriers to early detection and treatment. SEER investigators have provided technical assistance to the registry.

The SEER program has recently completed a monograph entitled *Racial/Ethnic Patterns of Cancer in the United States 1988–1992*, which provides a concise description of the occurrence of the major cancers among most racial/ethnic groups in the U.S. Age-adjusted incidence rates are shown graphically by age group and sex for Alaska Native, American Indian (New Mexico), Black, Chinese, Filipino, Hawaiian, Hispanic, Japanese, Korean, Vietnamese, White (total), White Hispanic, and White non-Hispanic populations. Age-adjusted mortality rates are also shown for these groups, with the exception of Koreans and Vietnamese, for whom national data are not yet available. The SEER program uses mortality data from the National Center for Health Statistics (NCHS) to compare with SEER incidence data.

EBV Expression in Nasopharyngeal Carcinoma

The University of North Carolina Chapel Hill is conducting research to determine the role of the Epstien–Barr virus (EBV) in the etiology of nasopharyngeal carcinoma (NPC), an epithelial malignancy that develops with high incidence in southern China, in northern Africa and among Eskimos. The viral genes that are expressed in NPC include the latent membrane proteins LMP1 and 2 and a new family of mRNAs, transcribed through the BamHI A fragment. Glutathionein transferase fusion proteins will be synthesized to produce monospecific antisera to identify the proteins in transfected cell lines and in NPC tumor tissues. The proteins will be tested for interactions with cellular proteins and for transactivation of the LMP1 promoter. To investigate the high incidence in specific populations and to explore a possible genetic contribution to NPC, additional NPC samples will be obtained from Chinese, Caucasian, Black and possibly Inuit Americans.

Community Clinical Oncology Program

The Virginia Mason Research Center (VMRC) Community Clinical Oncology Program (CCOP) has a component in Anchorage, Alaska. This component allows Alaskans with cancer to have access to the NCI Clinical Trial Network. The VRMC CCOP brings the advantages of state-of-the-art cancer treatment and cancer control trials to patients in metropolitan Seattle and in smaller communities in western Washington and Alaska by strengthening and expanding both the core institution participation in the activities of the CCOP and their relationship with the component institutions, Valley Medical Center (Renton, WA), Evergreen Medical Center (Kirkland, WA), Olympic Memorial Hospital (Pt. Angeles, WA) and Providence and Humana Hospitals (Anchorage, AK), and the physicians who practice in these hospitals.

Data-Based Cancer Intervention Research

The State of Alaska Department of Health and Social Services has entered into a cooperative

agreement with NCI to develop a project that will serve as a model of data use in planning and evaluating statewide cancer prevention and control interventions. The specific goals of this project are to:

- Reduce Alaska's age-adjusted cancer mortality rate by 50% by the year 2000;
- Develop and institutionalize a comprehensive cancer prevention and control program in the Alaska Division of Public Health; and
- Assure a mechanism to implement state-of-the-art techniques to translate research findings into public and private practice and to assure that services are available to prevent and control cancer.

Extending over a seven-year period, the project will be accomplished in four phases: data appraisal, planning, implementation of model interventions and evaluation. Priority areas for the initial phase of this project are cessation and prevention of tobacco use, cervical cancer detection and breast cancer detection.

Cancer Risk Assessment

NCI is supporting research at the Mayo Foundation examining the origins of colon cancer among Alaskans. Alaskans have the highest incidence and the highest mortality of colon cancer of any racial/ethnic group in the U.S., and colorectal cancer is one of the leading causes of cancer mortality in the U.S. today. Although the underlying etiology is still not fully understood, it is increasingly apparent that genetic susceptibility plays a prominent role in a subset of these patients. Hereditary non-polyposis colon cancer (HNPCC) may account for the majority of the inherited forms of colon cancer, and it is estimated that as many as 1 out of every 200 individuals in the general population may be a carrier. This frequency makes HNPCC one of the most common inherited genetic disorders in humans. Until recently a strong family history of cancer was the only measure available to the clinician to decide which patients were at great risk. However, two types of molecular genetic markers have recently been identified that may enhance the ability to define colon cancer risk for families and individuals. These include the demonstration of tumor microsatellite instability ("mutator phenotype"), which is indicative of defective DNA mismatch repair, and the direct analysis of the genetic susceptibility loci responsible for this particular phenotype. One of the goals of this research is to determine the frequency of tumor microsatellite instability in an Alaska Native population.

Exposure to Organochlorines in Alaskan Native Females

Recent studies have reported associations between breast cancer and elevated levels of organochlorines (such as DDT and PCBs) in adipose tissue and serum. Alaska Natives may be at increased risk of exposure because their diets are disproportionately high in protein and fat from marine sources established as having high concentrations of organochlorines. Alaskan Natives are covered by a cancer registry and are further defined by the existence of a banked serum repository of samples collected since 1967 in conjunction with a variety of health investigations. NCI, in collaboration with the Centers for Disease Control and Prevention, the Alaska Area Native Health Service and the Indian Health Service, has initiated a pilot study to assess the Alaska Native population, the variability of organochlorine levels in the serum, and the extent and quality of data in the Indian Health Service medical records on known breast cancer risk factors. Components of the pilot study include analyses of previously collected serum samples and a medical records review for 60 breast cancer cases and 60 controls; new collections of serum, urine and adipose tissues from Alaska Native women undergoing breast biopsy/surgery at the Alaska Native Medical Center; and a quality assessment/quality control evaluation beneficial to the Alaska Area Native Health Service. Sera that participating women may have stored in the Indian Health Service/CDC Serum Bank will be acquired and used. These data will be analyzed to determine if the amount of organochlorine chemicals in a woman's serum and adipose tissue is associated with biopsy outcome. Data collected in this pilot project will guide decisions regarding a proposed future full-scale investigation of breast cancer among Alaskan Natives.

National Institute of Child Health and Human Development

The National Institute of Child Health and Human Development (NICHD) continues to support research at the Institute of Arctic Biology, University of Alaska, on the role of the endocrine system in hibernating mammals and on mechanisms by which Arctic ground squirrels spontaneously adopt subzero body temperatures without freezing. Investigations have explored the role of the reproductive endocrine system in influencing the seasonal timing of hibernation, the neural sub-

strates of this system in influencing the seasonal timing of hibernation, and the neural substrates of this system and the role of the circadian clock in controlling the weekly and daily timing of hibernation. The most recent work focused on how decreased brain temperatures in ground squirrels and black bears influence the kinetics of sleep regulation. These studies are the first ever done that make continuous physiological and neurological measurements on bears during hibernation.

National Institute of Diabetes and Digestive and Kidney Diseases

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) supports two research grants addressing the health of residents in the Arctic. One is being conducted by the University of Alaska Anchorage. This collaborative research project, entitled Diabetes Prevention in Yupik Eskimos, is designed to determine to what extent intervention can decrease the prevalence of diabetes, hyperinsulinemia and cardiovascular risk factors among Yupik Eskimos living on St. Lawrence Island and the west coast of Alaska. The project would also investigate dietary patterns, physical activity levels and anthropometric data and attempt to correlate these with the occurrence of diabetes, cardiovascular risk factors, diabetes complications and insulin levels. As part of the ongoing Alaska–Siberia Medical Research Program, identical baseline data are being gathered in the population of Yupik Eskimos across the Bering Straits on the Chukotka Peninsula in Siberia.

The age-adjusted prevalence of non-insulin-dependent diabetes mellitus (NIDDM) among Alaska's Eskimos, Indians and Aleuts overall increased 11%, from 15.7 to 17.4 per 1000 over the two-year period from 1985 to 1987. Rates in 1987 varied from 6.7 to 40.8 per 1000 in various Indian Health Service units in Alaska. These estimates are based only on clinically recognized cases. Comparing preliminary rates to Chukotka Natives 15 years and older, the St. Lawrence Island rate is 9.7 per 1000, while the Chukotka rate is 1 per 1000. Since Siberian Yupik Eskimos of Chukotka and Alaska are genetically closely related, one hypothesis is that dietary and lifestyle differences account for the difference in diabetes prevalence. This represents a unique opportunity for research since these populations were essentially one until 1948, when contact ceased due to political reasons, and lifestyles diverged as a result.

A second grant is to the University of Alaska Fairbanks, titled Sympathetically Mediated Gene Activation in Brown Fat. Several factors contribute to the onset of obesity, including molecular imbalances in energy metabolism. Mammals in their native environments are protected from obesity and the cold by adaptive thermogenic survival mechanisms. The objective of this research is to further delineate the relationship between thermogenesis, energy imbalance and obesity by elucidating the control mechanisms underlying the activation of thermogenesis in brown adipose tissue. The major effector of thermogenesis is the brown-adipose-tissue-specific mitochondrial uncoupling protein. The working hypothesis is that several DNA-binding proteins control the onset of thermogenesis following cold exposure by regulating the rate of mitochondrial uncoupling protein gene transcription in brown adipose tissue. By elucidating the signaling mechanisms controlling thermogenesis and energy expenditure, this research will result in a better understanding of defective energy expenditure, energy imbalance and obesity.

National Institute on Drug Abuse

NIDA supports over 85% of the world's research on behavioral, psychological, biological, medical and sociological aspects of drug abuse and addiction, including the correlates and consequences of drug abuse, such as HIV and other infectious diseases, violence and crime.

From 1991 to 1997, NIDA funded a cooperative agreement with the University of Alaska Anchorage (UAA) as part of its AIDS community-based outreach/intervention research program. The objectives of this research project were to monitor the HIV status of injecting drug users and crack cocaine users in Alaska and to evaluate the effectiveness of an innovative, culturally sensitive program in reducing AIDS risk behaviors among drug users relative to the NIDA standard intervention (which consists of four components: street-based outreach, HIV risk reduction education and counseling, HIV antibody testing, and post-test or booster counseling and education). This project extended beyond HIV and studied other medical conditions such as hepatitis and Streptococcus pneumoniae (S. pneumoniae).

Drug users are at high risk for HIV, as well as S. pneumoniae, which can cause pneumonia and meningitis. Drug users participating in the study were encouraged to take the S. pneumoniae vac-

cine, which can greatly reduce their chances for developing an opportunistic infection if they contract AIDS. The vaccine can also prevent S. pneumoniae in non-HIV-positive drug users.

Important findings from the UAA cooperative agreement project include:

- Female drug users (including Alaska Natives, Whites and Blacks) are at especially high risk of HIV infections, as indicated both by high levels of certain diseases, such as hepatitis B (HBV), and also by various high-risk sexual behaviors.
- With female study participants, for every increase of five sex partners, a woman was 1.4 times as likely to report having had HBV.
- Women with a history of trading sex for money or for drugs were also more likely to report a history of HBV.
- Among women, Alaska Natives were more likely than either Black or White women to report having had gonorrhea or chlamydia.
- Alaska Native women report significantly less use of condoms than any other sex/race group.
- The unique combination of Alaska Native women with White men (a frequent sexual pair in Anchorage) is associated with less condom use.

This latter finding is of particular interest given that the White men (independent of any other sex/ethnic group) being studied are more likely to be injecting drug users (IDUs) and that Alaska Native women have the highest percentage of sex partners who are IDUs.

More recently NIDA funded several new research initiatives at the UAA. These include:

- A study to develop interventions for reducing HBV, HCV and HIV. This is both an efficacy study and a feasibility study design of a two-group randomized clinical trial in which IDUs are assigned to a syringe exchange condition or a pharmacy sales condition. Data to be monitored include the results of urine testing for amphetamines, cocaine metabolites and morphine, as well as serological testing. It is estimated that approximately 80–85% of current injectors are positive for hepatitis C (HCV). Estimates are not yet available regarding the HBV status of current injectors.
- A new fellowship grant that deals with the relationship of HCV and depression among drug users will help to provide a foundation on which effective HCV treatment, intervention and prevention policies can be developed.
- A First Independent Research Support and Transition grant has been awarded to UAA to study the ecologies of risk in order to develop a model to predict and identify subgroups of women and their risk behaviors relative to the use of drugs and condoms.

The NIDA-supported research at UAA has also benefited from UAA's Telemedicine Project, which helps to bridge the great geographic expanse of Alaska in a series of "research at a distance" projects. These projects use desktop video teleconferencing technology to investigate the transformation of epidemiological and health-related research from a model based on physical proximity to one that can be shared over great distances. In collaboration with the NIDA-supported research, the Telemedicine Project is continuing to explore the uses of narrow-band telecommunications and information technology to improve the delivery of health care to all citizens of Alaska.

In other Arctic-related research matters, NIDA staff, in conjunction with National Institute of Allergy and Infectious Diseases staff and Russian counterparts, organized the first U.S.–Russian meeting on Emerging and Reemerging Infectious Diseases (EREIDS). The meeting was held in St. Petersburg, Russia, in December 1996 with the express purpose of developing joint EREIDS research teams comprising scientists from the U.S. and the former Soviet Union (FSU). Support for the meeting was provided by the U.S. (the Fogarty International Center and the NIH Office of AIDS Research), the Civilian Research and Development Foundation for the FSU, and the Russian Ministry of Science. The meeting and collaborative process that came out of it were recognized as an important part of the Vice President Gore/Premier Chernomyrdin accords for greater cooperation between the U.S. and the FSU. The St. Petersburg meeting was also recognized as helping to implement the Presidential Decision Directive on EREIDS, which was released in June 1996 by Vice President Gore and which emphasized greater focus on EREIDS, including focus in an international context. FSU participants at the St. Petersburg meeting included researchers from Siberia and the Russian Far East. Discussions included, but were not limited to, Arctic EREIDS research and future U.S. and FSU collaborations.

Future NIDA Arctic research plans include expanding the substance abuse and health and social consequences research portfolio, including infectious diseases, violence and crime.

National Institute of Environmental Health Sciences

The National Institute of Environmental Health Sciences (NIEHS) supports studies relating to the mechanisms, diagnosis, treatment and prevention of diseases and disorders caused by environmental chemicals and other factors. NIEHS has instituted a number of activities that address the potential human health consequences of environmental contamination for the Alaska Native population. Projects directly related to health include a survey program to identify prenatal exposure to environmental pollutants, a study of the health consequences of methyl mercury exposure, and an environmental justice grant program to establish an environmental awareness program for Alaskan Natives living in the Yukon Flats. In addition, beginning in FY 97, NIEHS has been planning a conference, under the auspices of the Arctic Monitoring and Assessment Program, on environmental biomarkers that will address new methodology for detecting the effects of environmental pollutants in the Arctic and approaches for integrating such measurement into public health programs.

Prenatal Exposure to Environmental Pollutants

The NIEHS is supporting a survey of umbilical cord blood for environmental pollutants among Alaska Natives. Environmental pollutants of major concern among Native people of Alaska are persistent organic pollutants (POPs) and toxic metals, particularly prenatal exposure to methyl mercury. Exposure to the pollutants is from the consumption of traditional foods, particularly marine mammals. The pollutants are persistent in body fats and cross the placenta, resulting in fetal exposure, and they may impair neurological development. The blood samples are collected by the Alaska Department of Health, and analyses are done through an interagency agreement between the NIEHS and the CDC with funding from the NIEHS National Toxicology Program. Analyses of 50 umbilical cord blood samples from a fish-eating population in southeast Alaska to date show increased levels of DDE, a degradative product of the pesticide DDT, in 100% of the samples and increased levels of hexachlorobenzene in 60% of the samples. Other POPs were below the limits of detection. Analyses of these samples is still in progress. Additional umbilical cord blood samples will be obtained in FY 98. Analyses will include POPs, chlorinated hydrocarbons and toxic metals, particularly methyl mercury and lead, both of which are developmental neurotoxicants. Cadmium is also a concern because it accumulates in the kidneys and may produce nephrotoxicity later in life.

The objective of the studies is to determine if prenatal exposure to these toxins is at levels that may impair development. Related NIEHS-supported research projects are focused on determining minimal toxic levels of these pollutants, data that will be applied in evaluating the health risks to Alaska Native children.

Support for Scientists in Alaska

NIEHS has provided the University of Washington Environmental Health Sciences Center with supplemental funding to enable scientists in Alaska to perform mercury analyses of biological samples. This project will equip laboratories with state-of-the-art instrumentation in Fairbanks, train Alaskan investigators in its use and design a population-based study to evaluate hair mercury levels in a subgroup of Alaska Natives. Native peoples of Alaska are at risk from methyl mercury because of their consumption of marine mammals and fish and because of mercury contamination of streams and river sediments as a consequence of gold mining.

Environmental Justice Grant to the University of Alaska

A grant has been awarded to the Council of Athabascan Tribal Governments as part of the NIEHS Environmental Justice Program to establish an environmental awareness program in the Yukon Flats. This area contains 1500 rural residents in scattered, isolated villages distributed over 55,000 square miles. This population is composed of Alaska Natives (Eskimo, Aleut and Indian) who rely on traditional hunting, fishing and trapping for survival. Environmental concerns include radioactive and hazardous wastes at military and mining sites, landfills, and oil spill contamination. This project is surveying communities to form an inventory of environmental health concerns and preparing a community profile for each village. The program provides continuing training for local regional health care providers and environmental health planning and training workshops in the communities' schools. It is also planned to establish a geographic information system for the region to compile existing data on environmental health hazards and develop a capacity to monitor potential hazardous environmental conditions locally. The overall aims are to form partnerships among community members, village-based health providers and environmental health researchers and to

empower the villages to conduct assessments and develop and implement prevention strategies.

Conference on Biomarkers

NIEHS, in association with the Arctic Monitoring and Assessment Program (AMAP-2), has proposed an international conference on the role of biomarkers in identifying susceptibility to the health effects of environmental pollutants, especially among Alaska Native populations. The conference will integrate environmental medicine and epidemiology with newer technologies in molecular biology as an approach to identifying the various environmental, cultural and genetic factors that determine the health status of inhabitants of the Arctic.

Arctic populations provide an opportunity to apply new molecular technologies to identify health factors not presently recognized. As Arctic lifestyles undergo change, it is important to identify and pursue research opportunities inherent in this population. There are unique factors in the Arctic climate that enhance exposure and susceptibility to pollutants. While many of the pollutants in the Arctic are common in other climates, the role of subsistence diets is important as a route of exposure, particularly toxic metals and persistent organic pollutants. Nutritional deficiencies may alter susceptibility to health effects. The conference will introduce molecular biomarkers that may be used in epidemiological studies for early detection of health effects and identify genetic polymorphism that has enabled these populations to adapt to the extreme climate and traditional diets. Application of the evolving molecular tools may provide insight as to whether past adaptive changes will influence risk to future lifestyle changes.

National Heart, Lung, and Blood Institute

The National Heart, Lung, and Blood Institute (NHLBI) conducts research on matters relating to the cause, prevention, diagnosis and treatment of heart, blood vessel, lung and blood diseases; the use of blood and blood products and the management of blood resources; and sleep disorders. NHLBI has made an Academic Career Award to the University of Washington Pacific Medical Center to develop and improve the clinical, educational and research activities relating to pulmonary vascular disease in Alaska and the Pacific Northwest. A comprehensive clinical program for the care of patients with primary and secondary pulmonary hypertension will be based in a focused clinic at the University of Washington Medical Center, with multispecialty care facilitated by a nurse coordinator.

University and community physicians are developing local clinical practice guidelines for the evaluation and care of patients with primary pulmonary hypertension and pulmonary hypertension secondary to airflow obstruction and for the prevention, evaluation and treatment of pulmonary thromboembolism. At the School of Medicine, new curriculum elements are proposed, including a problem-based learning exercise in pulmonary hypertension for second-year students and a clinical decision making analysis of prevention of pulmonary thromboembolism in hospitalized patients for third-year students. Opportunities to pursue a project in pulmonary vascular science are also being provided for students involved in the school's Medical Student Research Training Program.

Educational programs are also directed toward housestaff and fellowship trainees at the affiliated hospitals and community physicians throughout the Washington–Alaska–Montana–Idaho region. A regional newsletter is distributed emphasizing progress in pulmonary vascular science and current patient management issues. Communication is increased among individuals conducting clinical and basic research relating to pulmonary vascular disease from several disciplines and affiliated institutions. Pulmonary vascular research is also highlighted annually at a new regional meeting, The John Butler Symposium in Pulmonary Vascular Science, honoring the memory of the founding Pulmonary Division head at the University of Washington and an international figure in the study of the pulmonary circulation.

National Institute of Mental Health

NIMH supports a variety of research projects that have an impact on Arctic populations. The Institute's goals and objectives include support of mental health services research as it relates to Arctic, ethnic, minority and other rural populations. Many of the Arctic mental health research activities supported by NIMH are part of general American Indian and Alaska Native programs. They include:

- Continued support of an American Indian and Alaskan Mental Health Research Center;
- Support of a five-year, large-scale assessment

of the prevalence rates for major mental disorders among Native Americans, their mental health service utilization patterns, the impact on psychiatric morbidity of selected risk factors, and the cross-cultural generalization of the results;

- The D/ART (Depression/Awareness, Recognition and Treatment) program; and
- Program announcements on Research on Mental Disorders in Rural Populations and American Indian, Alaska Natives and Native Hawaiian Mental Health Research.

The D/ART program, a public and professional education campaign sponsored by NIMH in collaboration with private organizations and citizens, is based on over 40 years of research on the diagnosis and treatment of depressive disorders. Its goals include the alleviation of symptoms through early intervention and effective treatment for individuals who suffer from depressive disorders. Through a variety of information sessions, health fairs, screenings, referrals and consultation, the program directly reaches approximately 4000 Alaskans each year. Media activities reached an estimated 109,000,000 people. Activities during 1997 included lectures to faculty, Alaska Community Mental Health Services Association, leaders of Anchorage's human service agencies, a grandparents club, church groups, and staff of a senior home health care program. A statewide video teleconference sponsored by the Alaska Mental Health Board featured D/ART and its success in establishing local community support groups. An innovative "talking circle" video conference on women's issues, which involved 181 schools across Alaska, was hosted through the University of Alaska Anchorage. Depression information and screening were part of the conference program.

D/ART staff participated in health fairs at a major business firm and the Mat-Su Community Mental Health Center and sponsors ongoing weekly support groups for people with depression. Depression screening programs and workshops, important elements in D/ART's Alaska-based activities, are offered on National Depression Screening Day and throughout the year, with special efforts planned in the deep winter months following the holiday season. For additional rural outreach, people from rural Alaska received depression information by mail and were referred to local mental health centers for screening. Education materials were shared with village health aides and village priests as well as primary care physicians. Also, a media blitz expanded depression education efforts through television and radio public service announcements, live interview, print articles and print ads that reached over 110,000,000 people.

National Library of Medicine

The mission of the National Library of Medicine (NLM) is to aid in the advancement of medicine and to improve public health through effective dissemination of the results of research. As part of this broad mission, during FY 96 and 97, NLM continued to index and catalog the published reports of health-related Arctic research. In 1996, NLM published a *Current Bibliographies in Medicine on American Indian and Alaska Native Health*, with over 2000 citations, including many relevant to Arctic health. NLM continued to enhance access by Arctic health researchers and practitioners to the relevant health literature via on-line database services. In June 1997, NLM initiated free access to Medline via NLM's web site, with the intent of improving availability of such information, especially in rural and remote areas such as the Arctic. NLM continued its support of the National Network of Libraries of Medicine, which includes the Pacific Northwest Regional Medical Library at the University of Washington in Seattle and the Alaska Health Sciences Information Service at the University of Alaska Anchorage. Both have a mandate to serve health professionals in Arctic areas.

During FY 96 and 97, NLM supported the University of Washington's Alaska outreach subcontract with the University of Alaska. This project includes ongoing efforts to train Alaskan health professionals in rural and remote areas, including the Arctic, on accessing and using health and medical information resources from a variety of sources. The emphasis is on the use of Internet-based access from remote villages and some regional medical centers and includes site visits as well as telephone and on-line consultation. The villages selected for outreach include Arctic and sub-Arctic sites such as Talkeetna, Healy, Galena, Bethel, Nome and Barrow. Also, the University of Alaska outreach staff participated in the Tenth International Conference on Circumpolar Health and the Sixteenth International Polar Libraries Colloquy, both held in Anchorage.

NLM has initiated two additional projects, through the University of Washington, that will also benefit Arctic Alaska. These include a project that is intended to develop and test a resource book for

planning and conducting outreach to health information professionals and users, and a tribal connections project that will analyze and upgrade Internet connectivity in selected American Indian reservations and Alaska Native villages. These projects will help improve the information access training and the Internet connections available to rural health professionals in remote and Arctic Alaska. These will in turn enable health practitioners and researchers in remote areas to communicate more effectively with colleagues throughout the region, the country and the world. Finally, NLM is supporting telemedicine projects at the University of Washington and the University of Alaska. These projects will develop, test and evaluate the use of telecommunications and computers for delivery of medical care and consultations at remote locations, including rural Alaska.

Indian Health Service

The mission of the Alaska Area Native Health Service (AANHS) of the Indian Health Service is to raise the health status of Alaska Natives to the highest possible level. The AANHS is primarily a health care organization. As such, research is clinically oriented, designed to investigate identified problems, and almost always undertaken with other governmental agency and tribal collaborators. Additional activities just getting underway include:

- A pilot study of 50 umbilical cord blood specimens from Alaska Native infants in western Alaska to assess the level of exposure to persistent organic pollutants (POPs) via subsistence food contamination;
- A long-term monitoring program to examine maternal and umbilical cord blood in a yearly sample of Alaska Native residents on the Arctic and Bering Sea coasts to follow trends in POPs and heavy metals and to examine the data for association with child health outcomes; and
- A joint proposal from AANHS, ANEC, the Arctic Slope Native Association and the Institute for Circumpolar Health Studies of the University of Alaska to operate a Children's Environmental Health Center to investigate the health effects of environmental pollutant exposure including prenatal exposure on Alaska Native infants born to residents of the Arctic coast.

Smithsonian Institution

The Smithsonian Institution's mission in Alaska is primarily carried out through the Arctic Studies Center, which opened an office in Alaska in 1993 and which has produced a wide range of programs serving both the northern research community and Native interests.

The Arctic Studies Center (ASC) was created by the Smithsonian's National Museum of Natural History (NMNH) in 1988 to promote the study of Arctic peoples, cultures and environments. Building on 150 years of Smithsonian Arctic exploration and science, its mission lies in cultural, biological and environmental studies in the Arctic and sub-Arctic, particularly in Alaska but also throughout the circumpolar North. This year, the occasion of the Center's tenth anniversary and the fifth year since the establishment of ASC Regional Office in Anchorage, affords an opportunity to review the history and status of the Center's programs.

The Arctic Studies Center is the only significant Federal program devoted to Arctic cultural research and education. In keeping with the Smithsonian's commitment for "the increase and diffusion of knowledge," the Center conducts field research and museum studies; produces exhibition and outreach programs for Smithsonian visitors, regional audiences and national media; and maintains a variety of educational programs. Training museum professionals and conducting outreach to enhance the legacies of northern peoples are central to its mission. It is the sole U.S. agency with a stable institutional setting for cultural studies in the Arctic, and unlike most Federal agencies, because it is a trust instrumentality, it is chartered to work internationally. The ASC has developed a close collaboration with a number of northern Native communities and organizations through joint exhibition and research initiatives.

Guiding Principles

Building on 150 years of Smithsonian enterprise, three program components—research, collections development and public programs—are essential to the signature "Smithsonian" blend of scholarship and public education. Additional guidance is provided by the following overarching themes:

	Funding (thousands)	
	FY 96	FY 97
Anthropology	450	450
Arctic Biology	50	50
Total	500	500

- Interdisciplinary approach. More than other inhabited regions, the North still remains a natural ecological system made up of elements that cannot be studied in isolation. ASC programs use cross-disciplinary approaches that integrate social, biological and natural science data.
- Circumpolar scope. Unique features of the holarctic region, such as the lack of significant geographic barriers, make the circumpolar world ideal for long-term studies of human–environment interactions on a truly global scale, historically and in the modern day.
- International character. Because a circumpolar perspective requires international collaboration, the ASC maintains close relationships with scholars and local peoples throughout the Arctic and participates in international organizations and agencies.
- Community focus/local access. Research and public programs are planned with local participation and community access in mind. Training, resource access and multi-level reporting provide access for a wide range of interest groups and education levels.
- Preservation of cultural legacies. An overarching guide is the enhancement and preservation of cultural legacies of northern peoples.

Research Programs

Research, including its conduct, analysis and reporting, is central to the ASC program and has

been a Smithsonian guiding principle since its foundation in 1846. ASC research includes field-, laboratory- and museum-based projects that explore significant problems and topics of the Arctic and sub-Arctic world. Both individual and team-based work is conducted, often in an international setting.

The Center staff emphasizes anthropological archeology, ethnology, ethnohistory and related aspects of biology, geography, geology and ecology. Research problems of interest to ASC staff and research associates fall into a variety of culture change and transformation studies that focus on northern human–environment interactions from the Pleistocene to modern times. The ASC also investigates modern processes of culture contact and transformation from the perspectives of history, contemporary issues, demography, geography and ecology. Over the past 20 years Smithsonian Arctic and sub-Arctic studies have concentrated on research in three circumpolar regions:

- Native cultural history, environmental relations and Inuit–European transformations in the eastern Canadian Arctic;
- Trans-Beringian contacts and evolutionary systems in the greater North Pacific region; and
- Culture history and cultural transformations in the context of modernization and industrial development in the Yamal region of western Siberia (Russia).

Staff

The Center operates with a staff of anthropologists split between the National Museum of Natural History in Washington, D.C., and the Anchorage Museum of History and Art in Alaska. Although the staff is small, research associate appointments add geographic and thematic depth and bring the Center into contact with other scholarly constituencies. Current research associates include Anne Fienup-Riordan (Anchorage), Ernest S. Burch, Jr., of Harrisburg, Douglas Siegel-Causey of the University of Nebraska, and Norman Hallendy of Carp, Ontario. Fellows, volunteers and interns are invaluable sources of assistance and receive research and training opportunities during their tenure at the Smithsonian. The staff maintains wide-ranging contacts with researchers in Alaska, Canada, Greenland, Scandinavia, Russia and Japan.

Each year the ASC hosts several visiting foreign scholars under its Visitor's Research Program, while the Community Scholars Program brings northern Native artisans and community scholars to work with Smithsonian collections in Washington, D.C. Special projects and grants bring more northern Natives to Washington and Anchorage for a variety of reasons, including collection study, training and consultation. Collaboration with U.S. and Alaska state government research and education programs provide further channels for affiliation.

Collections

Having pursued northern studies since the 1850s, the Smithsonian possesses one of the world's finest anthropological collections from Arctic regions. The most important early collections are ethnological materials acquired by Smithsonian naturalists between 1858 and 1890 from the Mackenzie District, Ungava, Baffin Island, Coppermine, Alaska and Siberia. In the early 1900s, with northern cultures being transformed by Western contact, Smithsonian researchers turned to archeology to explore the history of Arctic peoples and cultures. Inspired by the quest of finding the origins of Eskimo culture and the first traces of pioneering peoples out of Asia, Smithsonian archeologists obtained large collections from Kodiak, the Aleutian Islands and the Bering Strait. Between 1927 and 1965 the Smithsonian's Henry Collins excavated sites in Alaska and Canada, rising to become the heralded "dean of Arctic archeology." Recent work in Labrador, Baffin, the Aleutian Islands, the Gulf of Alaska and Siberia have expanded ASC activities throughout the circumpolar region. Unlike many museum collections, the Smithsonian's are comprehensive, systematic and remarkably well documented. Archival holdings, including field notes, photography, unpublished reports and other information gathered by the researchers who made these early collections, add substantially to the value of the Institution's northern collections. Today these records are valuable not only for scientific reasons but because they provide information on the context of early fieldwork—Native assistants, information about local conditions, participation of private companies and the military, and governmental relations.

In addition to its ethnological and archeological collections, NMNH natural science departments also hold large collections of northern fauna, flora, minerals and paleontological remains. These collections document North American Arctic and sub-Arctic regions before the industrial age and are important resources for studies of global change, pollution baselines, food-chain pathways and paleo-environments.

Relationships, Policy and Partnerships

The ASC nurtures relationships with other museums, institutes and private and public organizations. While the basic ASC mandate lies in cultural studies, Center programs range across the natural sciences, humanities and arts and use resources of other Smithsonian offices and departments. Outside the Institution it maintains relationships with the National Science Foundation, National Park Service, State Department, NOAA and other Federal and Alaska state agencies. Most ASC programs are conducted as cooperative ventures with U.S. and/or foreign partners, university groups and Native communities.

The ASC represents the Smithsonian at various Federal agencies and on research boards such as the Interagency Arctic Research Policy Committee, the Arctic Research Commission and the Arctic Research Consortium of the United States. It helped lobby to create the Arctic Social Science Program in the Division of Polar Programs at the National Science Foundation in 1990. The Center has a prominent role in policy issues and takes seriously its advisorship to government and international bodies. The National Museum of the American Indian, which recently became part of the Smithsonian, works together with the Center in northern research and education.

Recent Programs

As the principal venue for the Smithsonian's Arctic enterprise, the ASC uses its resources for the benefit of the Nation and the world at large. In recent years it has expanded its earlier focus on North America into international research, collection sharing, exhibition and public education. These programs have brought Smithsonian programs to many foreign nations and local northern communities for the first time.

Crossroads of Continents

This first international joint venture with the Soviet Union/Russia led to *Crossroads of Continents: Cultures of Alaska and Siberia*, a ground-breaking exhibition that toured North America in 1988–1991. The project produced three international symposia, and its catalog and educational publications included *Crossroads of Continents* (1988) and *Cultures of the North Pacific Rim* (1994).

Crossroads Alaska/Siberia

The large Crossroads exhibition stimulated a smaller traveling exhibit to present North Pacific collections to local audiences in Alaska and the Russian Far East. NMNH, the National Museum of the American Indian, the University of Alaska Museum, and Russian Far East museums contributed objects for this exhibition, which was funded by NSF, the Smithsonian, the National Park Service, USIA and others. The exhibit toured 12 sites in Alaska in 1993–1996 and in 1987 was the first exhibition ever to travel in the Russian Far East. Color catalogues, educational materials and media programs were produced, and 5000 Russian language volumes were delivered free to Siberian museums, Native associations, village schools and local communities.

Jesup II

Conceived and launched in 1992 as an off-shoot of the Crossroads exhibition, Jesup II is a joint effort of U.S., Russian, Canadian, Japanese and European scientists to explore the legacy of the Jesup North Pacific Expedition (1897–1902) and the current status of Native cultures of the greater North Pacific region. In the past six years Jesup II has produced four international conferences (1992, 1993, 1994, 1997) and two volumes by an international research team.

Museum Partnerships in Alaska

In 1993 the ASC established a regional office in Alaska in partnership with the Anchorage Museum of History and Art. Anticipating trends later recognized by the Smithsonian's Commission on the Future (1996) and its derivative Affiliations Program, the NMNH–Anchorage agreement provides research, education and training to Anchorage and rural Alaskan communities. In 1996 the Smithsonian's National Museum of the American Indian joined the Arctic Center's Anchorage effort by contributing to its public outreach activities. The first five-year affiliation agreement expires in December 1998 and is currently under renegotiation.

Community Archeology and Museum Training

Since 1978 the ASC has worked to provide access to Smithsonian collections, archival data and staff expertise to northern institutions and residents. Research programs and museum studies fellowships and internships create opportunities for northern residents and community scholars to work with museum collections and archives. In Anchor-

age, yearly museum training workshops have been held to train community scholars and Native museum professionals. Together with a traveling mini-exhibit series, these programs have helped stimulate local museums and culture center development in Alaska, Canada and Russia.

Archeology of the Frobisher Voyages

Archeological exploration of Martin Frobisher's "gold mines" of 1576–1578 provided insight into early European voyages and contacts with Native Inuit in the eastern Canadian Arctic. Sparked by study of an early Smithsonian archeological collection (C.F. Hall, 1862), fieldwork in 1990–1993 brought together an international team to study the first post-Norse European settlement and mining venture in the American Arctic. In addition to *Archeology of the Frobisher Voyages* (1993), the project stimulated a Canadian–American and British program that has produced several scholarly volumes, five PhD/MA theses and many international symposia, popular articles and documentary films.

National Park Surveys

During 1993–1996, ASC was funded by the National Park Service to conduct archeological surveys and paleoenvironmental research in Katmai, Kenai Fjords, Glacier Bay, Wrangell–St. Elias and Lake Clark National Parks, situated along the geologically dynamic coastline of the Gulf of Alaska. The data advanced knowledge of human adaptations and paleodemography across a broad region, while identifying impacts of glacial advances and changing sea levels on preservation of the archeological record. The results will assist the NPS in management and research planning efforts. NPS contributed salary, fieldwork, analysis and publication support, which has been vital in maintaining the ASC Anchorage office.

Western Aleutian Archeology and Paleoecology

Since 1992 the ASC has participated in the Western Aleutian Human Paleoecology and Biodiversity Project, an interagency (with U.S. Fish and Wildlife Service), international (U.S., France, Russia) and interdisciplinary research initiative set in the Near Islands, the westernmost of the Aleutian Chain. Building on the earlier Smithsonian scholarship and collections made by William Dall, Lucien Turner, Leonard Stejneger and Ales Hrdlicka, the research initiative is centered on unraveling the long-term settlement chronology, the dynamics of human and avian biogeography, and the nature of the evolution of chiefly societies in such a remote archipelago.

Historical Archeology of Russian Contact

The Center continued research and publication on the interaction of Russian fur traders and indigenous populations of southern Alaska. Earlier research on the Russian Three Saints Harbor colony on Kodiak Island was published in 1997 as *Archaeology and Capitalist World System: A Study from Russian America* (Aron Crowell, Plenum Press, 1997). Data from new contact period sites discovered in NPS surveys are providing information on material culture change and village abandonment that fill major gaps in historical knowledge about the effect of Russian contact.

Living Yamal

This project on the Yamal Peninsula of western Siberia grew from the need to evaluate western Siberian cultural resources in the face of industrial development. Three archeological surveys (1994–1997), a photograph exhibition, several video films and public and scholarly materials were produced by a Smithsonian–Russian team. The project introduced Smithsonian field and museum approaches across the Russian Arctic and pioneered museum-arbitrated roles between industry and Native culture. Another outcome will be publication of the monumental *Historical–Ethnographic Atlas of Siberia* (800 pages, 1200 illustrations) by SI Press.

Outreach, Media and Exhibits

Over the past ten years the ASC has developed a media and image profile that communicates its mission to national and international audiences. The ASC *Newsletter* has become an important vehicle for disseminating information to a large and growing clientele yearly. Numerous news releases and radio, TV and print stories document Center activities nationally and internationally. Video documentaries including *Secrets of the Lost Red Paint People*, *Viking America*, *Northern Clans/Northern Traces* and *In Caribou Country* have been produced and are broadcast repeatedly in North America and Europe. The Center also maintains a prize-winning homepage and multimedia communications system. In addition to its large traveling and mini-exhibit series, other special exhibits produced include *Canadian Inuit Sculpture*, shown in the Canadian Embassy Gallery, and *Oil From Alaska*, which opened at the Smithsonian's National Museum of American History in the fall of 1997.

Arktis/Antarktis Exhibition

In 1996-97 the Center was invited to collabo-

rate with the Kunst- und Ausstellungshalle (KAH) gallery in Bonn, Germany, to contribute anthropological perspectives to an exhibition on polar regions. Two exhibit segments, one on circumpolar archeology and another on the Nenets reindeer herders of western Siberia studied in the Living Yamal project, were prepared, accompanied by a documentary film, *Northern Clans/Northern Traces,* produced in collaboration with Spofford Films and Cybergrafix Corporation. The exhibit was displayed in Bonn through April 1998.

Arctic Studies Website

The success of ASC video programs and the prize-winning ASC website, http:/www.nmnh.si.edu/arctic/, produced with Spofford Films and Cybergrafix, shows the potential for new media in bringing ASC research and public programs to both mass and selective audiences. In cooperation with the Office of Polar Programs of the National Science Foundation, ASC prepared and mounted a series of web pages devoted to selected NSF-sponsored social science research projects. The Center will continue developing this delivery method with the aim to bring its research and educational programs to wider research and public audiences, especially to northern communities in Alaska.

Alaska Regional Office

The Alaska Regional Office of the Arctic Studies Center was established in 1994 through agreements between the National Museum of Natural History, the Anchorage Museum of History and Art (AMHA) and the Municipality of Anchorage. The five-year agreement called for cooperation in establishing a Smithsonian presence in Alaska to provide Alaskans with access to Smithsonian cultural resources. At the same time an Alaska office would enhance the Institution's research capabilities through direct contacts with Native Alaska and its cultural resources.

The Anchorage agreement called for NMNH to establish a curatorial position at the Anchorage Museum to staff the office and assist AMHA Native cultural programs. Second, NMNH agreed to work toward bringing Smithsonian anthropological collections to Alaska for use in local exhibitions, training and research. Third, NMNH agreed to work with AMHA and other Alaskan agencies to develop a series of workshops and other training programs for Alaskan residents in museums studies, research and exhibition techniques. On its side, AMHA and the Municipality agreed to provide free facilities and core services to support the office. The agreement is subject to renewal after five years and will expire in late 1998.

For the past four years the Anchorage Office has been directed by Aron Crowell, an archeologist with extensive experience in museum programs and scholarly research. Affiliation with the Anchorage office of the National Park Service has allowed the ASC to pursue archeological surveys in National Parks in addition to conducting outreach and public programs. In 1997 a grant from the Smithsonian's National Museum of the American Indian allowed the Center to add an education outreach coordinator to the Anchorage office staff.

For its first four years the Center occupied an office in the Anchorage Museum, with additional space for research and collection storage. In 1997 the Center moved into new offices in a building adjacent to the museum that had been turned over to the museum by the city and was renovated and equipped for Center use by Elmer Rasmuson, who was then a board member of the NMNH and has been a long-time friend and benefactor of the Anchorage Museum. These offices provide excellent facilities for the near future. Long-range plans announced in 1996 call for expansion of the AMHA complex within the next 5–10 years and will bring the ASC back into the museum proper. This will enable the Center to fully integrate research, collection and training activities with Anchorage museum programs.

Since its inauguration in 1994 the Anchorage Office has fulfilled its developmental stage plan, conducting a wide variety of research and educational ventures. Aron Crowell's research has been devoted to archeological fieldwork for his Gulf of Alaska program with the NPS and the analysis and reporting of this work. Archeological illustrator Mark Matson has assisted the effort in the Anchorage office under NPS funding. In addition to an important contract period study, several papers have appeared on Kodiak prehistory and geo-archeological studies conducted in Gulf of Alaska National Parks.

Major research has also gone into preparating the exhibition *Looking Both Ways: Heritage and Identity of the Alutiiq People,* including collection studies at NMNH, extensive work with archival photography and oral history sources (contract research by Dee Hunt), and in-depth discussions with Alutiiq elders about exhibition themes and the meaning and significance of material culture items and historic images (Crowell and Maria Williams).

In addition to research activities the Anchorage Office has conducted a series of outreach programs

that have been enthusiastically received and reviewed. Theses include tribal museum and museum education seminars at the Alaska Federation of Natives meeting in October 1994, at the Museums Alaska meeting in September 1996 and at the Western Museums Association meeting in September 1998.

Preserving our Heritage: A Seminar on Community Research and Cultural Documentation was held in Anchorage in October 1995. ASC provided assistance to the Alaska Native Human Resource Development Program, University of Alaska, in conducting this seminar, attended by 40 students from throughout Alaska.

A workshop called Preservation of Cultural Objects was held at the Anchorage Museum of History and Art in May 1996. This five-day intensive training program was attended by 25 participants from 16 Alaska museums and was taught by Smithsonian ethnographic conservators Carolyn Rose and Greta Hansen.

The Anchorage Office held an Elders Planning Conference for the Exhibition *Looking Both Ways: Heritage and Identity of the Alutiiq People* at the Alutiiq Museum in Kodiak in September 1997. It was attended by 45 elders and Alutiiq cultural leaders from villages throughout southern Alaska, as well as a large public audience. It involved planning of exhibit themes through discussion of the William J. Fisher collection, historical photographs and archeological materials.

Another workshop, called Alaska Native Museums and Culture Centers: Planning and Management, was held at the Anchorage Museum of History and Art in February 1998.

Since 1994 the Anchorage Office, in cooperation with the University of Alaska Fairbanks and Ilisagvik College (Barrow), has sponored six undergraduate courses leading to a museums studies minor, as part of the Museum Studies Distance Delivery Classes. Students have participated remotely by audio-conference from 25 communities over the past four years. Classes visited the NMNH in March 1996 to study the Alaska collections. The program also involves student internships and projects at ASC and the Anchorage Museum. Another undergraduate course, called Museum Studies in Anthropology, was taught through the University of Alaska Anchorage during the spring semester of 1997.

In the Tatitlek CD-ROM Project, village students worked with research materials provided by ASC and technical training from the Chugach School District to create an interactive catalog of objects in the William J. Fisher collections.

Networks and Relationships

In addition to its current relationships with the University of Alaska in Anchorage and Fairbanks, the ASC has developed partnerships with the growing ranks of small regional museums and culture centers throughout Alaska, and its mini-exhibit tours have connected them with similar institutions in Canada and Russia. They are regular participants in the Alaska Anthropological Association and Museums Alaska associations and meetings. They have entered into formal agreements with the new Inupiat Cultural Center in Barrow and the Alutiiq Museum in Kodiak, and they expect more of these relationships to develop in the future. The Center's relationship with the University of Alaska Fairbanks Department of Alaska Native and Rural Development in Anchorage, directed by Gordon Pullar, has been of great assistance in mounting a variety of workshops and educational programs.

Conclusion

The primary ASC objective for its second decade is to maintain a multifaceted research and public programs agenda. The latter can be best achieved via expanded partnership, new exhibit projects and publication. They expect to continue working with Russian, Canadian, European and Japanese researchers, as well as circumpolar Native peoples. Their most challenging role is to fulfill the outreach and collection-sharing mandate proclaimed in the Smithsonian's 150th anniversary report, *E Pluribus Unum: This Divine Paradox, the 1995 Report of the Commission on the Future of the Smithsonian Institution*, without compromising scholarly quality or collection integrity.

During its first decade the ASC succeeded in building internationally acclaimed exhibits, research programs, training and publication projects. Thanks to these efforts, Smithsonian collections and expertise have been brought out of "the Nation's attic" into the North and have been introduced to a new constituency of scholars and northern peoples around the globe. With an international research program already well defined and a new foothold in Alaska secured, the Smithsonian has turned a corner and is ready for the challenges of the new millennium.

Environmental Protection Agency

The Environmental Protection Agency's Arctic research focuses on ecosystem protection, primarily in the areas of contamination, global climate change, risk assessment and environmental technology.

The Environmental Protection Agency's (EPA) Arctic research is designed to protect the region's environment and to minimize environmentally related human health impacts. The EPA is pursuing specific research foci such as environmental transport, fate and effects of contaminants; land use, habitat and climate change; risk assessment for more defensible, credible and cost-effective risk management; and the development of environmental technology.

The EPA's Arctic research activities in FY 96 and 97 had the following broad goals:

- To estimate the extent of Arctic ecosystem contamination brought about by multimedia transport and ecosystem stress arising from human activity, and to investigate in a more comprehensive manner the effects of a variety of contaminants in Arctic ecological systems and in Arctic human and wildlife food webs;
- To provide risk-based assessment technology and other information for use by Arctic stakeholders such as Native Alaskan organizations, state environmental programs, and industries developing Arctic ecological resources; and
- To complete work on estimating the condition of two northwestern Alaska estuaries using the scientific methods developed by the multiagency Environmental Monitoring and Assessment Program.

These goals have been pursued across three dimensions of primary activity: research and development, regional activities and international activities.

Intramural and extramural research, both basic and applied, is developed according to the results of priority-setting screenings conducted under the risk assessment/risk management paradigm. Investigator-initiated research proposals submitted cover a wide range of disciplines and research interests (and are reviewed, and in some cases funded, in cooperation with other Federal partners). Some areas applicable to potentially supportable Arctic research have included exposure to endocrine disruptors (and such other environmental stressors as hazardous or toxic chemical substances, land use or land cover change, and habitat loss), ambient air quality, environmental engineering (and technology for sustainable development), bioremediation, and social sciences research. Also, partial support has been provided for Arctic issue-specific workshops and research planning meetings.

	Funding (thousands)	
	FY 96	FY 97
Research and Development	517	300
Regional Activities	237	80
International Activities	0	100
Total	754	480

Regional activities are undertaken through close cooperative planning and implementation with the states and local communities, and have addressed such issues as waste and chemicals management and education; contaminant studies at specific locales; and environmental technology demonstrations.

International activities, undertaken among the circumpolar nations, are designed to provide forums for dialogue, as well as the conduct of bilateral and multinational projects, concerning human health protection, environmental stewardship and security in the Arctic.

Health and Ecological Stressors

Increasingly there is recognition that human activities are significant influences on the ecological systems of the Arctic regions and the health of people living there. The Arctic has been shown to be a concentration area for locally and globally generated contaminants and pollutants, and such industries as agriculture, fisheries, forestry and mining may compound important health and environmental impacts.

The Agency's Environmental Monitoring and Assessment Program (EMAP), along with the National Park Service, is investigating the phenomena of Arctic haze and trophic nutrient cascade at Denali National Park. While not Arctic, Denali experiences real and perceived problems regarding deposition of atmospheric contaminants, and its nitrogen-poor and nitrogen-limited aquatic ecosystems raise questions about the impacts on wildlife such as caribou, moose, wolves and bears of trophic cascade from excess nitrogen deposition. Also, EPA interest extends to the biological ramifications of ultraviolet-B (UV-B) exposure at Denali's high latitude and altitudes, and the development and validation of an index capable of reflecting the condition (that is, ecosystem health) of freshwater benthic communities at Denali. An air quality station was operational in FY 96 and 97, and a UV-B monitoring site was established in September 1997. A final report on the development of the freshwater benthic index is expected in late FY 98. Also, in investigating contaminant inputs to the Arctic, the Great Lakes National Program Office of the Agency's Region V Office maintains the Integrated Atmospheric Deposition Network. The network monitors, among a variety of pollutants, air toxics that may accumulate in the Arctic, and it indicates possible U.S. sources of these contaminants.

The Office of Research and Development's National Health and Environmental Effects Research Laboratory (NHEERL) provided support in FY 96 to the Arctic Monitoring and Assessment Program's (AMAP) efforts to draft chapters on heavy metals and the characteristics of ecosystems and human populations relevant to pollution issues for AMAP's *State of the Arctic Environment* report, which contains the findings of six years of evaluation of the status of and trends and changes in the condition of Arctic ecosystems. Also, researchers at the University of Washington have received limited support from the NHEERL's Western Ecology Division to establish a database and to continue to analyze data from that laboratory's prior Arctic Contaminants Research Program. These data arise from analyses of heavy metals and trace elements in Arctic lichens, mosses and soils. A draft database was submitted to the Division in February 1997, and a subset of these data was deposited with the AMAP.

The Source Apportionment and Characterization Branch (Atmospheric Processes Research Division) of the EPA's National Exposure Research Laboratory (NERL) has conducted mobile source studies in Alaska. The work, done in cooperation with the State of Alaska, Environment Canada, the Coordinating Research Council, General Motors and the cites of Fairbanks and Anchorage, was undertaken to determine the effects on ambient levels of carbon monoxide (CO) from the use of oxygenates in gasoline (oxyfuel) in Anchorage and Fairbanks; both have exceeded the CO ambient air standard. In the winter of 1992-93, an oxyfuel program was introduced to the two cities. A number of health-related complaints were received by the State, prompting a study in Fairbanks by the Centers for Disease Control and Prevention (CDC). The study was inconclusive but provided information that led the Governor of Alaska to suspend the use of oxyfuel with the oxygenate MTBE. The question of the effects of oxyfuels on CO reduction, vehicle performance and human exposure under Arctic and sub-Arctic conditions was raised. In FY 95 the Congress funded investigation of the impact of oxyfuels in Arctic and sub-Arctic winter conditions, and the EPA and the State of Alaska began running a low-temperature study on vehicle emissions in Fairbanks and at NERL in North Carolina. The EPA's portable dynamometer was shipped to Fairbanks, and several vehicles were tested in low temperatures. To check on the Fairbanks results, three of the vehicles and the Fairbanks test gasolines were shipped to North Carolina and run in EPA's low-temperature dynamometer. Papers describing the effects of MTBE and ethanol on vehicle emissions at low temperatures have been published and the data presented at several scientific meetings; the publication on the MTBE work is a joint effort with Environment Canada.

The Exposure Methods and Monitoring Branch (Air Measurements Research Division) of the EPA's NERL, in cooperation with the U.S. Air Force (USAF), has investigated exposure to jet fuels in the Arctic. JP-8 jet fuel has become the standard military fuel for all types of vehicles including aircraft. Because of its low vapor pressure emissions during cold weather, aircraft starts are higher in aerosols and vapors, and fueling crews in colder climates have reported strong jet fuel odors and "drenching" by exhaust when working behind aircraft. The USAF and EPA are developing and using novel sampling and analytical methods to characterize JP-8 human exposure in cold climates that include new techniques for exhaled breath measurement and microenvironmental air sample collection. Work at Eielson Air Force Base in Fairbanks, Alaska, has shown ubiquitous human expo-

Measuring JP-8 aerosols and vapors in KC-135 exhaust at Eielsen AFB, Fairbanks, Alaska, March 1997.

sure to JP-8 using EPA's breath measurement methodology and battery-operated air sampling instrumentation. Research publications and presentations are in preparation. To date, measurements at 0°, –10° and –20°F do not support the severity of exposure described anecdotally.

EPA Region 10's Office of Environmental Assessment, along with the U.S. Fish and Wildlife Service and the U.S. Geological Survey, provided support for a study of snow contamination at two estuaries near Barrow, Alaska. The work, conducted at the Kasegaluk and Elson Lagoons at the Dease Inlet of Admiralty Bay, is part of EPA's Regional EMAP and involves ultratrace analyses on snow samples expected to reflect atmospheric input to the lagoons. Snow from five lagoon sites was sampled in April 1996 and analyzed using ultraclean methods. Several heavy metals had elevated levels in the snow. Particularly high concentrations of mercury were found in Kasegaluk Lagoon, and chlorpyrifos, endosulfans, chlordanes and dacthal were also detected. A report on the results of metals analyses was completed in December 1996, and a report on pesticide analyses was completed in September 1997. An article, to be submitted to a peer-reviewed journal, is in preparation.

In FY 96, EPA Region 10's Office of Waste and Chemical Management supported a grant to the University of Alaska Anchorage for a study called Alaska Native Use of Local Food Resources: Harvests, Contaminants, Concerns and Cultural Importance. The work focuses on developing an easily accessible database concerning the contamination of subsistence resources in Alaska. The dynamic database will be available to 226 Alaska tribes and other interested parties. The project is compiling information on:

- The contribution of different local food resources to the diets of Alaska Natives;
- Measured levels of contaminants in these local food resources and what is known or not known about the health effects of ingesting these foods;
- The cultural importance of local resource foods that are most likely to contain contaminants at levels posing a threat to human health;
- Alaska Native concerns about contaminants and Alaska Native ideas on how these concerns can be handled most effectively through informed risk management; and
- Research needed to better understand contamination to Alaska Native subsistence harvests.

The University has submitted a continuation proposal to Region 10 that has been evaluated by some IARPC agencies. It is hoped that these agencies will join with EPA in continued support of the work.

In coordination with the IARPC initiative on Assessment of Risks to Environments and People in the Arctic, EPA's National Center for Environmental Assessment is now planning and scoping work for an Integrated Response Assessment for the Pribilof Islands and Bering Sea. Of necessity, the work is multidisciplinary and is being designed and will be conducted with the cooperation of the Agency's Region 10, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the City of St. Paul, the Tanadgusix Corporation, the Aleutian–Pribilof Island Association, the St. Paul Tribal Government, the Aleut Corporation and Los Alamos National Laboratory. Considerable networking is ongoing to foster cooperation among relevant international, Federal, state and local organizations including environmental and commercial interests. The work recognizes that the Arctic Bering Sea region is a valuable natural marine resource of tremendous ecological and cultural importance and economic potential. The Pribilof Islands represent terrestrial jewels within the region. Both ecological systems are highly sensitive to ever-increasing anthropogenic challenges, including environmental contamination, global climate change and fisheries exploitation. Significant effort has been directed toward research prioritization in the region by national and international organizations. The project recognizes that while research efforts to promote better scientific understanding of Bering Sea resources are of tremendous value, scientific understanding alone is not enough to manage these resources wisely. The work is designed to explore the inter-

dependencies of ecological and human systems and to generate the kind of research questions and management options that promote long-term protection of all values in the Arctic Bering Sea region.

The concept of integrated response assessment involves a process designed to transform scientific data into meaningful information about the potential for change and about the possible risks of human activities on ecological, human health, economic and sociocultural values of importance in the region. The work differs from other current research prioritization efforts because of its primary focus on establishing management goals; integrating ecological, economic, cultural and human health issues; and applying the rigor of ecosystem-level risk assessment to allow integration of results for more practicable management. Principal accomplishments this fiscal year include obtaining commitments to participate in the process by local Aleut communities in the Pribilof Islands and Federal agencies with jurisdiction on the Pribilofs, and networking with the state and academic communities. A grant has been awarded to the St. Paul Tribal Government to survey the community for development of management goals. Two intramural interdisciplinary work proposals are in preparation to support aspects of the work.

Other Projects

EPA's National Center for Environmental Assessment and its National Exposure Research Laboratory, in cooperation with the Agency's Office of International Activities, continue to support a project called Environmental Risk Assessment for Arctic and Subarctic Energy Development. This Arctic oil and gas risk assessment project is being conducted under the Gore–Chernomyrdin Commission's (GCC) Environmental Working Group, the mission of which is to apply intelligence technologies to civilian-sector environmental problems. Information derived from intelligence satellites and other classified sources, both in Russia and in the U.S., have been combined with civilian data and used to create "derived products" (that is, unclassified, publishable maps). Geographic information system maps of an area in Siberia have been prepared and merged, and these products are being used in the design and conduct of oil and gas energy development models and risk assessments. The models and assessments are intended to allow specific Arctic energy projects to be realized and undertaken far more effectively than would otherwise be the case. Energy activities in the Arctic are extremely difficult, are prone to accident, and have a history of extensive environmental damage that has affected Russian rivers, their tributaries and the Arctic Ocean. The activity will allow development to be far more environmentally sensitive than it is currently by providing tools that preclude or minimize such damage. A White Paper was prepared for presentation at a September 1997 GCC meeting in Moscow, and a field visit is scheduled for December 1997 to meet with local Siberian representatives.

Another annually convened GCC activity (that is, its Environment Committee) facilitated by the EPA provides a forum for ongoing U.S.–Russian dialogue and policy consultations on environmental stewardship and security in the Arctic. Work under the Committee led to the 1994 U.S.–Russia Arctic Pollution Prevention Agreement. This agreement promoted garnering financial and policy support for expanding a low-level liquid radioactive waste treatment facility in Murmansk. Also, a trinational project among the U.S., Norway and Russia (that is, Arctic Military Environmental Cooperation) is focused on the development and manufacture of a prototype transportable interim storage container for damaged and undamaged spent naval nuclear fuel.

In FY 96 the EPA Region 10's Office of Waste and Chemicals Management (OWCM) funded production of a documentary called "Koyukon World View and Arctic Contamination Issues." With a grant to the Louden Village Council Tribe of Galena, Alaska, the film depicts a model, community-wide strategy for solving chemical and waste management problems. The model strategy is intended to:

- Identify chemical and waste management problems and potential risks in the Galena community;
- Develop a collaborative method for solving these problems among agencies or governments with differing cultural perspectives and environmental priorities;
- Identify specific actions or solutions to more effectively manage contaminant issues; and
- Transfer lessons learned via the documentary to other Alaska Native communities.

Also, OWCM has awarded the Alaska Native Health Board (ANHB) funds to help demonstrate solutions to Arctic waste problems and to enhance waste management capacity among Alaska Native villages. In addition, the ANHB will host two Alaska Tribal Conferences on Environmental Management to disseminate information on environmental

issues in Alaska. Finally, in FY 96, OWCM supported the development of a contaminated-site brochure describing agency programs and key contacts and distributed it to Alaskan tribes. The same effort provided logistic support to the Bristol Bay Native Association to host a contaminated-sites workshop, the goals of which were to:

- Foster information exchange and coordination among the Federal agencies (the National Oceanic and Atmospheric Administration, the Department of Defense, the EPA, the Alaska State Department of Environmental Conservation, and the Federal Aviation Administration) responsible for the clean-up of contaminated sites; and
- Provide communities affected by contaminated sites with clear, incisive information.

EPA Region V's Office of Strategic Environmental Analysis, under its National Environmental Policy Act Tribal Program (and in cooperation with the Bureau of Indian Affairs and the U.S. Forest Service), provided training for Native Americans in Fort Yukon, Alaska, on the National Environmental Policy Act (NEPA). Course work was conducted by representatives of the EPA, the Bureau of Indian Affairs and the Forest Service. The course provided an overview of the act and agency regulations, and students conducted field surveys and developed case environmental assessments for relevant Arctic projects that would require NEPA compliance. The course offered over 40 Native Americans, representing six villages, a strong understanding of the purpose of NEPA and when it applies. This understanding is enabling them to be better informed and to engage appropriately in the NEPA process.

The Agency's Office of Radiation and Indoor Air initiated in FY 97 a cooperative agreement with the University of Alaska Fairbanks and the Alaska Department of Environmental Conservation focused on developing a case study for the establishment of ECOMAP to assist with monitoring activities at Amchitka, Alaska. Now in its initial stage of activity, the work is expected to increase the level of awareness in the Alaska Native community regarding the nature of risk from radiological contamination on Amchitka Island.

Under the Agency's Environmental Technology Initiative (and in cooperation with the Department of Energy, the Alaska Division of Energy, and Kotzebue Electric), Region X and the Office of Research and Development are supporting a project for replacing diesel fuel with wind energy in rural Alaskan villages. This project focuses on determining the effectiveness of using community heating loads as a dump load for a high-penetration wind/diesel system. It may demonstrate the capability to minimize the human health and ecological risks associated with the use of diesel fuels. The system is scheduled for construction in 1997.

Department of Transportation

DOT supports Arctic research through the U.S. Coast Guard and the Federal Highway Administration. The U.S. Coast Guard operates polar icebreakers as national polar research assets for Arctic oceanographic expeditions of both government and nongovernment researchers. The Federal Highway Administration is studying a variety of highway problems in the Arctic.

U.S. Coast Guard

	Funding (thousands)	
	FY 96	FY 97
Arctic Sci/Logistics Support	12,400	12,500
Test and Evaluation	3,450	3,400
Extramural Science Support	10	30
Total	15,860	15,930

The Coast Guard's primary support to Arctic research is the operation of two polar icebreakers, the *Polar Sea* and the *Polar Star*, which serve as high-latitude research platforms in both the western Arctic and the Antarctic. Support of Arctic research dates back to the 1880s, when the renowned naturalist John Muir made a number of voyages on the Revenue Cutter *Bear* with Captain Michael Healy. Arctic research aboard Coast Guard icebreakers intensified in the late 1960s and early 1970s when the prospect of increased oil and gas exploration in the Alaskan Arctic required ecological baseline surveys in the Chukchi and Beaufort Seas. These cruises were supported by the icebreakers CGC *Northwind*, *Burton Island* and *Glacier*. In the early 1980s these vessels were phased out as the Polar-class icebreakers joined the fleet.

The two Polar-class icebreakers were designed to carry out a range of missions in the Arctic, including escorting non-icebreaking vessels through the ice, resupplying military and research bases, and supporting scientific operations. In recent years the role of the Polar-class vessels in research has expanded as more complex research projects and larger science teams have placed added requirements on the current icebreakers. This led to a major upgrade of their capabilities in 1987 through the Polar Science Upgrade Program, a five-year, $14 million program to enhance the scientific support capabilities of these vessels. Scientific laboratories and living areas were expanded to allow up to 32 scientists and technicians to embark on scientific cruises. Upgraded oceanographic winches, new cargo and science gear handling systems, expanded lab spaces, new oceanographic instrumentation, and new communications and satellite data acquisition systems improved the research capabilities of the Polar-class vessels.

The science upgrades of the Polar-class vessels suffice in meeting current requirements for research support in the Arctic. However, to meet the expanding needs of the future, the Coast Guard, in collaboration with the National Science Foundation, is moving toward the commissioning and operation of a new research platform dedicated to Arctic science. This new vessel, the USCGC *Healy*, is under construction and will be completed in early 1999. The *Healy* is 420 feet long, has a beam of 82 feet, and displaces 16,000 long tons when fully loaded. The maximum speed will be 17 knots, with a range of 16,000 nautical miles at 12.5 knots. *Healy*'s primary mission will be to function as a world-class high-latitude

Artist's conception of the USCGC Healy.

research platform. The *Healy* will be able to conduct scientific operations during all seasons in the Arctic, with the ship's systems designed to function during extended winter operations, including intentional wintering over.

Scientific support capabilities of the *Healy* will greatly surpass those currently provided by the Polar-class icebreakers. The ship will be able to accommodate 35 scientists on a routine basis and provide surge accommodations for up to 50. There will be over 3000 square feet of dedicated laboratory space, including a main science lab, a wet science lab, a biochemistry analysis lab, an electronics lab, a meteorology lab, and a photography lab. In addition the *Healy* will have five hydraulically operated cranes, two oceanographic winches, and a double drum core/trawl winch. It will also provide over 4000 square feet of open deck space and 20,000 cubic feet of scientific storage space in three cargo holds. Installed bathymetric and oceanographic instrumentation will include an echo sound processor and depth digitizer, a Seabeam bottom mapping sonar system, an XBT acquisition unit, and an acoustic Doppler current profiler. Lab spaces will be equipped with a Science Data Network providing 120 dual fiber-optic connected Ethernet ports throughout the science spaces for real-time data transfer between data processors, workstations and printers.

The Coast Guard's major Arctic research effort supported during the past two years was the Arctic West Summer Cruise aboard the CGC *Polar Sea* between May 20 and July 20, 1996. The original requirement for *Polar Sea*'s 1996 deployment centered on a two-month-long set of ice trials to test the newly installed machinery control and monitoring system and to provide crew training.
A science cruise of opportunity was planned in conjunction with this deployment, starting with an informal solicitation from Coast Guard headquarters to members of the science community with previous experience aboard Polar-class icebreakers. Based on an enthusiastic initial response and additional discussions, a small, diverse scientific party was assembled that would use all of *Polar Sea*'s science support capabilities.

Logistics and operations planning for the cruise began early in the winter of 1996, coordinated through the ship's Marine Sciences Officer and the Coast Guard Science Liaison Officer located in Alameda, California, whose primary responsibility is planning, coordinating and implementing polar science projects. Between February and April, interested principal investigators contacted or visited the ship to check its capabilities and discuss their individual projects. The final science party consisted of 12 scientists and technicians and a high school teacher sponsored through the National Science Foundation Teacher Program. Terry Tucker of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) assumed the duties of Chief Scientist. The following organizations were supported during the cruise:

- Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire;
- Army Corps of Engineers, Fairbanks, Alaska;
- Oak Ridge National Laboratory, Oak Ridge, Tennessee;
- University of Washington;
- University of Georgia;
- East Carolina University; and
- Institute for Marine Science at the Christian-Albrecht University in Kiel.

Fourteen scientific investigations were conducted dealing with the following scientific topics:

- Characteristics and functions of marine microbes in the Arctic (including microbes in the water column, sea ice and sediments);
- Air–sea carbon cycling in the western Arctic;
- Tritium and helium in the western Arctic;
- Plankton dynamics in Arctic marine carbon and nitrogen cycles;
- Distribution of dissolved organic matter in the Chukchi Sea;
- Impacts of increased temperature on benthic biota in the Arctic;
- Circulation in the Chukchi Sea;
- Northern sea route and Arctic Alaska navigation study; and
- Sediment transport by sea ice and associated physical and chemical processes.

Underway scientific operations during the cruise began with the arrival of the CGC *Polar Sea* at Nome, Alaska, on May 30 and the embarkation of the scientific party. Between May 31 and June 24, 13 major science stations were conducted in the Chukchi Sea and Arctic Ocean. Oceanographic stations included water sampling, ice coring, and bottom sediment sampling. Science dives were conducted to collect sediment and biota samples. Helicopter flights were conducted for ice reconnaissance and to gather ice characteristics data through observation and aerial photography to support the CRREL research. An ice tracking buoy was also placed on a multi-year ice floe for the National Ice Center.

In concluding the cruise, on June 24 , *Polar Sea*'s commanding officer and executive officer

International Ice Patrol C-130 used to locate and monitor icebergs.

invited all members of the science party to a "customer focus group" meeting to discuss accomplishments, problems encountered, and lessons learned during the cruise. The scientific party expressed general satisfaction with the results of the endeavor as a skillfully planned and executed scientific cruise of opportunity. On 25 June the *Polar Sea* returned to Nome and disembarked the entire scientific party.

In addition to the 1996 Arctic West Summer Cruise, the Coast Guard International Ice Patrol (IIP) located in Groton, Connecticut, participated in two joint U.S./Canadian research efforts to evaluate and refine the capability to detect and track icebergs using remote sensing. Although this research occurred south of the Arctic Circle, it has direct relevance to high-latitude navigation and is an integral part of the Coast Guard's Marine Science Program.

During 1995 and 1996 the International Ice Patrol participated in Berg Search 95, a joint experiment with several Canadian government agencies, universities and private industry researchers to evaluate the effectiveness of aircraft and satellite remote sensing systems and to prototype ground-wave over-the-horizon surface radars in detecting ships and icebergs. The satellite system evaluated was the ERS-1 iceberg and ship detection technology. Airborne sensors included forward-looking and side-looking radars. Remotely sensed data were compared with surface-truth data from on-scene vessels and aircraft to determine the effectiveness of remote sensing techniques for locating and tracking icebergs. A final report was published in April 1996.

A second joint U.S./Canadian project involved the evaluation of Radarsat for operational iceberg detection and classification. The project is part of the Application Development and Research Opportunity (ADRO) program sponsored by the Canadian Space Agency, NASA and Radarsat International. This research, undertaken by IIP and the Canadian Department of Fisheries and Oceans in 1996, compares Radarsat data with data acquired during IIP reconnaissance flights to determine effectiveness in locating and tracking icebergs. This project will be completed in 1998.

Federal Highway Administration

The goals and objectives of the Federal Highway Administration (FHWA) in the Arctic are to develop and maintain safe and cost-effective surface transportation facilities, primarily for highways and highway vehicles, just as anywhere else in the U.S. In the Arctic, however, there is a need to assure that highways are compatible with severe constraints imposed by weather conditions, the impacts of severe climate, and the fragile ecology of the area, as well as other normal environmental compatibility concerns.

	Funding (thousands)	
	FY 96	FY 97
Stream Crossings/Hydrological	783	100
Pavement Problems	898	3,100
Soils/Subbases (Permafrost)	428	260
Weather Monitoring/Storm Forcasting	100	500
Air/Water Quality Impacts	1,000	1,810
Snow Control/Pavement Treatment	229	1,584
Total	3,438	7,354

The FHWA has been monitoring and conducting research in the Arctic for many years, in addition to the numerous investigations conducted elsewhere in the U.S. that are often relevant to highway problems in the Arctic. These projects have been conducted primarily in collaboration with the various state highway agencies, espe-

cially Alaska and the states with more severe winter conditions. Together with the state highway agencies, the FHWA sponsors, collaborates with and monitors work done under the auspices of the National Academies of Science and Engineering through the Transportation Research Board, National Cooperative Highway Research Program (NCHRP). Some of this work includes funding for and collaboration with other agencies such as the U.S. Geological Survey (USGS) and the Corps of Engineers (CRREL), as well as university and private consultant contractors.

Stream Crossing Hydraulic Problems

Arctic streams typically have highly variable discharges and flood levels and are plagued by erratic floating and blocking ice. Measurements are complicated by permafrost and water flows under and above the ice layers. To deal with these conditions the USGS has been contracted for many years to measure the varying water discharge rates and the flood stages of numerous representative streams. The results of these measurements and estimates have been used in structural and hydraulic designs of bridges and culverts and in estimates of floods and risk analyses related to stream flows.

Alaska has a program to study stream channel stability and scour at bridges. Scour problems vary greatly and depend on bed loads and the highly variable runoffs and sources of sediment loads within their watersheds. Both aggrading and degrading streams may occur at bridge sites. Many riverbeds have highly erodible silts.

There have been studies that have led to revised design requirements for fish passage through highway culverts and for the use of culverts in lieu of bridges. In the Arctic regions of Alaska the requirements of different fish species have to be considered. The blockage of culverts by ice and the reduction of culvert capacity by heavy silt deposits are additional factors to be considered. Various culvert modifications have been used to enhance fish passage. Efforts have been made to increase the versatility of the FISHPASS program so that more fish species are taken into account. Currently a special effort is being made for juvenile salmon.

Soils and Pavement Subbases

An experimental project has been planned for a site near Fairbanks, Alaska, to evaluate the performance of a highly porous air convection embankment (ACE) fill that prevents thaw-degradation of underlying permafrost soils by natural convection of cold air during the winter. Treated and controlled sections, each 200 ft long, are being monitored for temperature changes, entombed shoulder failures, severe longitudinal cracking, roadway surface conditions and thaw pits. Minor efforts are being made on the possible subbase uses of geotechnical fabrics.

Pavement Studies

The Pavement Performance Division from the Office of Engineering Research and Development is pursuing major efforts to evaluate the long-term performance of pavements that are subjected to Arctic conditions. An initial thrust in these large efforts occurred under the Strategic Highway Research Program (SHRP).

Adequate lengths of Portland cement and asphalt concrete test sections have been placed for observation. Various mix designs, thicknesses and base conditions are being used at 51 sites. These sites are located in extremely cold climatic zones of the U.S. or at Canadian sites established under collaborative cooperative agreements. Observations of the behavior of the surface conditions, distresses and integrity of the pavement sections will continue for a prolonged period of time. This includes observations of deflections, rideability and surface defects such as spalling. Heat transfer and surface-to-depth temperature changes are also being measured and evaluated since they reveal seasonal changes of temperature and heat content according to time and deep-ground and local ambient air temperatures.

Factors to be considered include temporal pavement responses (diurnal, seasonal and annual) due to the separate and combined effects of moisture and temperature variations. The models of pavement behaviors and responses that are being developed and validated with the data obtained on the limited number of sections studied in the seasonal monitoring program are expected to be applicable to other similar test sections of the SHRP.

The Alaska Department of Transportation, in collaboration with the FHWA, has been involved in studies directed toward Arctic conditions. Efforts are currently directed toward the use of modified asphalt concrete where binders are selected to enhance mechanical performances over wide temperature ranges. These asphalts have been found to have the best behavior in places where permafrost problems have been controlled.

Weather Monitoring and Storm Forecasting

Investigations have started primarily in the SHRP study to provide improved weather guidance for highway maintenance and traffic operations. The objective of these investigations is to respond to problems related to ice, snowstorms, avalanches, wind, dust and fog in a strategic and timely manner. The resulting strategies are being field tested in several states.

The Roadway Weather Information System (RWIS) is a common term for the timely communication of a combination of road, pavement and ground conditions, including temperature changes, potential for heat transfer and near- and intermediate-term weather forecasts for highway operations, traffic controls and road maintenance. Systems like this, together with more exact and timely local weather forecasts, are being rapidly deployed in most pertinent states and are considered to be elements of intelligent vehicle systems (IVS).

These investigations are designed to improve weather information for the more strategic, economic, timely and properly sized efforts of highway responses to snow and ice storms, avalanches, wind, dust and fog. Expected cost savings come from smaller responses or more timely responses to storm threats. Weather monitoring and storm forecasting systems are also being used to help in deciding whether or not to close travel on highway sections due to storm conditions.

Snow Control and Pavement Treatments for Snow and Ice

Short test sections on snow fences and snow plow designs developed during the SHRP study are being evaluated and field tested in several states.

Implementation of anti-icing technology has been completed in 27 states participating in a new anti-icing study that involves the use of prewetted salt applications and liquid snow and ice control chemicals. The objectives of this anti-icing study were to allow states to gain hands-on experience in using efficient and effective procedures for snow removal and ice control. Anti-icing strategies, including various material types and improved material spreader equipment, have been expanded to consider the use of RWIS, weather forecasting and friction measurements. Field testing and evaluations were performed during the winters of 1993-94 and 1994-95 to determine the effectiveness of these strategies over a range of traffic, environmental and climatological conditions.

Investigations are being performed to develop methods for manufacturing calcium magnesium acetate (CMA) at lower production costs. These studies have been considering the laboratory conversion of waste materials, such as sewage sludge and cheese whey, that permeate to CMA using high-yield anaerobic bacteria. Other issues being considered are the determinations of the yields and purities of these waste materials, based on their processes; possible costs incurred by their commercialization; and the market strategy and industry's interest in commercialing these processes. Under Phase I of this study, CMA materials based on acetic acid are being produced at lower production costs under two contracts. The results indicate that projected costs can be competitive with those of other snow and ice control chemicals. One of the advantages that CMA offers is that it does not cause the corrosion and environmental impacts typically associated with the more common snow and ice control chemicals. Phase II pilot plans for alternate production of CMA are now underway.

Heating systems involving various heat sources and heat distribution systems have been installed on a selection of highway bridges to minimize icing deck problems. Evaluations of the performances, costs and practicality of these installations are underway in Oregon, Texas, California, Nebraska, West Virginia and Virginia. Problems related to the reduction of icing in pavements and bridge decks are being evaluated in states such as Alaska and Ohio.

Several topics are being studied as part of projects that are using ice mechanics theory and advanced analytical techniques:

- Processes by which ice can damage highway materials such as Portland cement concrete, asphalt concrete and base materials;
- Correct use of ice and packed snow scraping loads and the correct pressure for plow blades mounted under vehicles;
- Road friction;
- Robot vehicles for safe snow removal and follower vehicle for winter maintenance;
- Automatic bridge deicer systems;
- Winter maintenance vehicles; and
- Automatic vehicle display locators.

Ecological and Water Quality Impacts of Highways and Highway Operations

The FHWA, in collaboration with the U.S. Fish and Wildlife Service, is investigating the habitats of grizzly bears in order to reduce the impacts of highways and highway traffic on their environment. Grizzly bears are common in the southern portion of the Arctic in Alaska. Findings from this study should be directly applicable to their habitat areas in the mountains north of Fairbanks from the Pacific Ocean to Canada.

The water quality impacts of winter maintenance materials, primarily salts, to surface water and ground water are being investigated. Massachusetts, Ohio and Indiana are particularly concerned with the impacts of salt and other contaminants to ground water. Other U.S. highway investigations are directed toward the attenuation or removal of water contaminants that may originate from highway runoff or construction and repair materials used in highway maintenance activities. Among them is a wide range of waste materials, some of which could contaminate surface or groundwater.

Alaska is conducting an investigation to obtain and evaluate representative samples of runoff and leftover debris from snow storage operations from streets and highways in different regions of the state. These samples will be analyzed for their chemical composition and possible water contamination in relation to assumptions established by regulatory agencies.

Department of State

During FY 96 and 97 the Department of State continued its involvement in multilateral and bilateral activities related to environmental protection and scientific research in the Arctic. The most significant of these were participation in the Arctic Environmental Protection Strategy and its successor organization, the Arctic Council, and support for the U.S. Man and the Biosphere Program.

Arctic Environmental Protection Strategy/Arctic Council

The Arctic Environmental Protection Strategy (AEPS) was established in 1991 to serve as a consultative body to its eight Arctic member countries with regard to regional action on environmental issues of common concern. In July 1996, at an AEPS Ministerial Meeting in Alta, Norway, the Ministers signed a declaration establishing the Arctic Council—the successor organization to the AEPS which, in addition to its core mandate of addressing regional environmental issues, was to examine the issue of sustainable development in the Arctic. The Arctic Council's four working groups remain the same as those under the AEPS:

- Arctic Monitoring and Assessment Program (AMAP);
- Protection of the Arctic Marine Environment (PAME);
- Conservation of Arctic Flora and Fauna (CAFF); and
- Emergency Prevention, Preparedness and Response (EPPR).

Because funds were not available to provide direct assistance to AEPS and the Arctic Council during FY 96 and 97, the Department of State's support was limited to sending representatives to meetings of the working groups, to Senior Arctic Officials meetings, and to the Ministerial Meeting in Alta. The Department supported Arctic research by ensuring that agencies and individuals with Arctic policy and research interests were invited to participate as delegates to meetings of the Council and its subgroups, by participating in regularly scheduled meetings of the Interagency Arctic Research Policy Committee, and by holding monthly meetings of the Arctic Policy Group, which allowed Federal agencies with Arctic policy interests to participate in the policy formulation process.

The recent decision of the Department of State to chair the Arctic Council from September 1998 through September 2000 will necessarily increase the Department's supporting role for Arctic research and policy formation activities in FY 98, 99 and 00.

Man and the Biosphere Program

The Department of State's Bureau of Oceans and International Environmental and Scientific Affairs supports the Secretariat for the U.S. Man and the Biosphere Program (U.S. MAB), an office funded by 13 Federal agencies. The primary source of funds spent by the U.S. MAB on Arctic projects comes through the Department's International Organizations Bureau. U.S. MAB contributed funds to Arctic research in 1996-97 through its High Latitude Ecosystems Directorate (HLD) and the Northern Sciences Network (NSN).

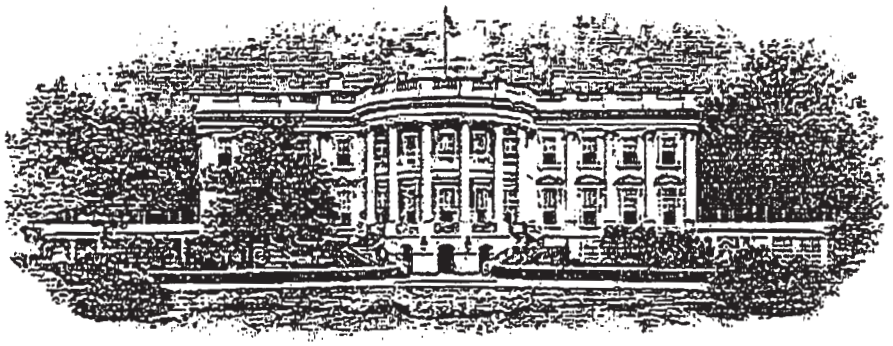
The HLD has a continuing core research project, which changed focus in 1996. The original sociological study, based primarily on surveys, analyzed community and traditional user participation in managing the Porcupine caribou herd on both sides of the Alaska/Canada border. Beginning in 1996, Phase II of the study, "Ecological Role of Hunting in Herd Dynamics and Its Implications for Co-management of Caribou," emphasizes the biological aspects and implementation of a monitoring system for users within their own villages. U.S. MAB funding for its HLD project was $50,000 per year in FY 96 and 97.

U.S. MAB continued its support of the NSN through contributions to the NSN Secretariat located at the Danish Polar Center in Copenhagen. The funds are used to support meetings and workshops held by NSN as well as to support research sites throughout the Arctic in the International Tundra Experiment (ITEX). NSN is an effort of the MAB countries with Arctic interests. U.S. MAB funding for the NSN was $6000 in FY 96 and $7000 in FY 97.

Seventh Biennial Report of the Interagency Arctic Research Policy Committee to the Congress

February 1, 1996, to January 31, 1998

THE WHITE HOUSE
WASHINGTON



THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release March 3, 1998

TO THE CONGRESS OF THE UNITED STATES:

As required by section 108(b) of Public Law 98-373 (15 U.S.C 4107(b)), I transmit herewith the Seventh Biennial Report of the Interagency Arctic Research Policy Committee (February 1, 1996 to January 31, 1998).

WILLIAM J. CLINTON

THE WHITE HOUSE,
March 3, 1998.

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

OFFICE OF THE
DIRECTOR

January 16, 1998

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

I am pleased to transmit through you to the Congress the enclosed report required under Public Law 98-373, as amended by Public Law 101-609, the Arctic Research and Policy Act.

The report is submitted on behalf of the Interagency Arctic Research Policy Committee for which the National Science Foundation serves as chair agency. The report lists activities and accomplishments of the Interagency Committee, which was authorized by the Act and established by Executive Order 12501. As required by Public Law 101-609, it also lists agency responses to recommendations of the Arctic Research Commission.

It is a distinct honor for the member agencies to serve on the Interagency Committee and for the National Science Foundation to chair it.

Sincerely,

Neal Lane

Neal Lane
Director

Enclosure

Seventh Biennial Report of the Interagency Arctic Research Policy Committee to the Congress

February 1, 1996, to January 31, 1998

Prepared by the National Science Foundation for the Interagency Arctic Research Policy Committee

Background

Section 108(b) of Public Law 98-373, as amended by Public Law 101-609, the Arctic Research and Policy Act, directs the Interagency Arctic Research Policy Committee (IARPC) to submit to Congress, through the President, a biennial report containing a statement of the activities and accomplishments of the IARPC. The IARPC was authorized by the Act and was established by Executive Order 12501, dated January 28, 1985.

Section 108(b)(2) of Public Law 98-373, as amended by Public Law 101-609, directs the IARPC to submit to Congress, through the President, as part of its biennial report, a statement "detailing with particularity the recommendations of the Arctic Research Commission with respect to Federal interagency activities in Arctic research and the disposition and responses to those recommendations." In response to this requirement, the IARPC has examined all recommendations of the Arctic Research Commission since February 1996. The required statement appears in Appendix A.

Activities and Accomplishments

During the period February 1, 1996, to January 31, 1998, the IARPC has:

- Prepared and published the fifth biennial revision to the United States Arctic Research Plan, as required by Section 108(a)(4) of the Act. The President transmitted the Plan to Congress on July 29, 1997.
- Published and distributed four issues of the journal *Arctic Research of the United States*. These issues reviewed all Federal agency Arctic research accomplishments for FY 94 and 95 and included summaries of the IARPC and Arctic Research Commission meetings and activities. The Fall/Winter 1997 issue contained the full text of the fifth biennial revision of the U.S. Arctic Research Plan.
- Consulted with the Arctic Research Commission on policy and program matters described in Section 108(a)(3), was represented at meetings of the Commission, and responded to Commission reports and recommendations (Appendix A).
- Continued the processes of interagency cooperation required under Section 108(a)(6), (7), (8) and (9).
- Provided input to an integrated budget analysis for Arctic research, which estimated $183 million in Federal support for FY 96 and $172 million in FY 97.
- Arranged for public participation in development of the fifth biennial revision to the U.S. Arctic Research Plan as required in Section 108(a)(10).
- Continued to maintain the Arctic Environmental Data Directory (AEDD), which now contains information on over 400 Arctic data sets. AEDD is available from Alaska as a resource on the World Wide Web on the Internet.
- Continued the activities of an Interagency Social Sciences Task Force. Of special concern is research on the health of indigenous peoples and research on the Arctic as a unique environment for studying human environmental adaptation and sociocultural change.
- Continued to support an Alaska regional office of the Smithsonian's Arctic Studies Center in cooperation with the Anchorage Historical Museum to facilitate education and cultural access programs for Alaska residents. The Smithsonian's Arctic Studies Center circulated its "Crossroads Alaska/Siberia" exhibition to cities in the Russian Far East from December 1996 to November 1997.
- Supported continued U.S. participation in the non-governmental International Arctic Science Committee, and the Committee's International Conference on Arctic Research Planning.
- Participated in the continuing National Security Council/U.S. Department of State review of U.S. policy in the Arctic. U.S. policy for

the Arctic now includes an expanded focus on science and environmental protection and on the valued input of Arctic residents in research and environmental management issues.

- Participated in policy formulation for development of the Arctic Council. This Council incorporates a set of principles and objectives for the protection of the Arctic environment and for promoting sustainable development. IARPC's Arctic Monitoring Working Group serves as a U.S. focal point for the Council's Arctic Monitoring and Assessment Program (AMAP).
- Focused attention within the U.S. Government on the disposal of nuclear waste and other toxic waste materials by the former Soviet Union
  on land and into the Arctic Ocean, seas and rivers; provided assistance to the Department of Defense's Arctic Nuclear Waste Assessment Program (ANWAP); and increased attention on such other Arctic environmental and human health stressors as land use and land cover change, and losses of habitat and biodiversity.
- Approved a coordinated Federal agency research initiative on Assessment of Risks to Environments and People in the Arctic. The initiative is designed to augment individual agency mission-related programs and expertise and to promote the resolution of key unanswered questions about Arctic environmental protection. The initiative is intended to help guide internal agency research planning and priority setting. The goal of the initiative is to disclose specific management questions and goals that should drive assessments and to gather credible information about the sources, transport, fate, effects and cumulative risks of Arctic contaminants and other human health and environmental stressors. This initiative proposes development of an integrated, comprehensive assessment including: 1) data rescue and synthesis; 2) observations; 3) process-oriented research; 4) model development;
  5) impacts analysis and estimation of risk; and 6) information management. It is expected that funding for the initiative will be included in agency budget submissions, as its objectives and potential value are of high relevance to the mission and responsibilities of each IARPC agency.
- Convened two formal meetings of the Committee, in November 1996, to receive public comments on the U.S. Arctic Research Plan, and June 1997, to approve the U.S. Arctic Research Plan; and held twenty-six meetings of IARPC staff committees, working groups and task forces to accomplish the above.

Appendix A: Interagency Arctic Research Policy Committee Responses to Recommendations of the Arctic Research Commission

Section 108(b)(2) of Public Law 98-373, as amended by Public Law 101-609, directs the IARPC to submit to Congress, through the President, as part of its biennial report, a statement "dealing with particularity the recommendations of the Arctic Research Commission with respect to Federal interagency activities in Arctic research and the disposition and responses to those recommendations." In response to this requirement, the IARPC has examined all recommendations of the Arctic Research Commission since January 1996. The previous IARPC report, submitted in January 1996, responded to Commission recommendations through 1995. Many of these recommendations deal with priorities in basic and applied Arctic research that ongoing agency programs continue to address.

The following recommendations are from the Arctic Research Commission report "Goals and Priorities to Guide United States Arctic Research" (1997). Commission statements and recommendations are highlighted in boldface.

Recommendations for Agencies

This is a new feature of the Commission's report. At the request of the IARPC agencies we are including specific recommendations for these agencies and interagency groups in order to make clear to them our view of the opportunities.

Interagency Arctic Research Policy Committee

The Commission recommends that the NSF, in its role as lead agency for Arctic research, call together the IARPC to agree on a plan of research to support U.S. participation in the Arctic Council and demonstrate the national commitment to carry on the goals of the U.S. Arctic Policy expressed by the President. Since the appropriation of new money to meet these commitments is unlikely, it is imperative that the IARPC agencies come to the table with the intention to redirect resources to carry out this task.

The IARPC fully agrees with the recommendation to develop a plan of research to support U.S. participation in the Arctic Council. One of the four principal thrusts of the 1998–2002 Biennial Revision of the U.S. Arctic Research Plan is an initiative titled "Assessment of Risks to Environments and People in the Arctic." This initiative includes research to support U.S. participation in the Arctic Council. IARPC member agencies approved development of an implementation plan for this initiative at their meeting in June 1997. A risk assessment working group composed of HHS/NIH, EPA, NSF and the State Department is developing implementation activities. IARPC agencies will redirect resources for this initiative where possible and when consistent with agency priorities.

On another front, the United States agencies need to update their plan for a comprehensive study of the Arctic Ocean. While current experiments are important and of high quality, there is no current plan for the study of the Arctic Ocean which provides context for these studies. The IARPC agencies with responsibilities for research in the Arctic Ocean include NSF, Navy, NOAA, USGS, USCG, EPA, NASA and parts of several others. IARPC should organize an interagency meeting of the principal agencies responsible for Arctic Ocean research. The Commission has recommended such a plan in the past and feels even more strongly that an organized effort is needed given the increasing evidence for rapid and substantial change in the Arctic Ocean. The Commission recommends that IARPC update the 1990 IARPC report "Arctic Oceans Research: Strategy for an FY 1991 U.S. Program."

IARPC fully agrees with this recommendation and will update its report "Arctic Oceans Research: Strategy for a U.S. Program" during the next planning cycle.

National Science Foundation

The National Science Foundation Arctic Science Section in the Office of Polar Programs has made great strides in recent years in their interest in and efforts on behalf of research in the Arctic. We are pleased with several developments in the last two years including the partnership with the Commission in support of the

ARCUS Logistics Study, the participation of the Section's staff on the Commission's field trip to Greenland and the foundation's support for the swath bathymetric mapping system to be deployed in 1998 as part of the SCICEX Program. Nevertheless, there still remains a substantial disparity between support for research in the Antarctic and in the Arctic. A new era is about to dawn in Arctic Research because of the arrival in 1998 of the new Coast Guard icebreaker *Healy*. *Healy* has the potential to become the most important ship for Arctic Research ever launched. On the other hand, it may languish at the dock making only occasional forays into the Arctic. The National Science Foundation has committed to *Healy* by ending its support for the ARV design activity conducted by the University National Oceanographic Laboratory System. *Healy* will be the only U.S. resource for surface studies of the Arctic Ocean. Having committed philosophically to *Healy* it is essential that NSF find the resources to operate *Healy* as a research vessel with a minimum operating schedule of approximately 200 days per year. Without sufficient operating support, the NSF commitment to *Healy* will be a hollow one. The Commission recommends that NSF support the full time operation of *Healy* as the nation's Arctic Research icebreaker.

NSF appreciates the Commission's comments on the great strides in recent years by the Arctic Science Section, Office of Polar Programs, on behalf of research in the Arctic. NSF's commitment to supporting Arctic research in all areas remains strong, but NSF is not the sole Federal sponsor for Arctic studies. As the Commission is aware, both NSF and the Office of Polar Programs must continually find the appropriate balance of support for a wide variety of disciplines and activities. In the specific case of supporting research that requires the use of the *Healy*, NSF's FY 98 budget request included funding for initial testing for scientific applications of the *Healy*. In FY 99 the Foundation also hopes to support limited research on the *Healy* during the science system testing cruises. Long-term planning (FY 2000 and beyond) includes continued support for research on the *Healy*, although it is unclear whether the amount required to fully fund 200 operating days, including science costs, would be available for this purpose from NSF. NSF will work with other user agencies to develop mechanisms for science support for the *Healy*.

Navy

The level of Navy interest in the Arctic continues to wane. The fact that the Arctic Ocean is no longer considered an area of strategic threat is due to the decrease in tensions with Russia. The result has been a precipitous decline in funding for Arctic studies at the Office of Naval Research. The Commission believes that the decrease in operations is a reason for maintaining research levels in the Arctic in order to maintain the national capability in the region. Research is generally much less expensive than operations, and the knowledge base created and maintained by research in the region may be of vital national interest in the future. Reduced military activities in the region do not justify reduced research efforts and may be an excellent justification for maintaining and even increasing research.

With this in mind, the Commission commends the efforts of the Navy in carrying out the SCICEX cruises. These expeditions into the Arctic Ocean aboard operational fast attack submarines show an extraordinary interest in the support of science by the Navy. The question of the continuation of these cruises after 1999 and the retirement of the last of the Sturgeon Class submarines is of great concern to the Commission, and the Commission recommends that the Navy explore with the scientific community the means to continue this invaluable access to the Arctic Ocean.

The SCICEX Program will begin in 1998 to collect swath bathymetric data in the Arctic for the first time from a submarine. These data will be of great value for students of the region from many disciplines. The data recoverable in 1998 and 1999 will cover only a moderate fraction of the region. The means to continue gathering swath bathymetry should be developed for the future, preferably using Navy nuclear submarines. This recent development in submarine capability is a reinforcing reason to continue the SCICEX Program. A corollary issue is the declassification of archived bathymetry data collected on previous operations. These data are a valuable resource for the research community. A program should be established to bring these data out from the classified realm respecting the security concerns which may surround the collection of these data. The construction of the new U.S.–Russian Arctic Ocean Atlas CD shows that these difficulties may be overcome.

The Department of Defense, and the Navy, invest in priorities consistent with resources. The fact that operations in the Arctic have decreased does not support maintaining Arctic research budgets at the same level as in 1990. We do not agree with the conclusion that "reduced military activities in the region do not justify reduced research efforts and may be an excellent justification for maintaining and even increasing research." Simply, Department science and technology budgets reflect priorities for DOD's national security mission, consistent with the resources available. We concur with the statement supporting the value of SCICEX experiments and will continue the existing program as budgeted, subject to priorities for DOD's national security mission.

National Oceanic and Atmospheric Administration

NOAA has been the leading U.S. agency for AMAP. In this role, NOAA has supplied both staff efforts and funding to the AMAP. These efforts have been largely conducted on a goodwill basis without organized programs or a satisfactory funding base. NOAA deserves great credit for these efforts and the Commission commends and supports their efforts. NOAA has conducted an Arctic Initiative beginning in 1996 at a funding level of approximately one million dollars. The Commission supports this initiative and recommends that it continue in the coming fiscal year and eventually becomes an ongoing part of the NOAA program.

NOAA appreciates the recognition by the Commission with regard to providing the U.S. lead role for the Arctic Monitoring and Assessment Program (AMAP). It is NOAA's intent to continue its participation in AMAP, and to provide support to assist in coordinating U.S. AMAP activities.

NOAA also appreciates the support by the Commission and Congress for the establishment of the NOAA Arctic Research Initiative in FY 96, which is managed for NOAA by the Cooperative Institute for Arctic Research (CIFAR) at the University of Alaska Fairbanks. NOAA intends to continue this program in FY 98, and conducted a workshop in October 1997 to more clearly define the objectives and scope of the program. An Announcement of Opportunity (AO) has been released calling for proposals, which will again be awarded funding on a competitive peer-review basis.

The National Undersea Research Program (NURP) has had a long and perilous history. Only occasionally has it appeared in the President's budget. The Commission believes that NOAA-NURP can be a valuable asset to the research community. In particular, the Commission takes note of the report of the "Blue Ribbon Panel" which spelled out a new paradigm for NURP. The Commission's interests in NURP's activities in the Arctic include the use of unmanned and autonomous underwater vehicles in the Arctic as well as the employment of the Navy's nuclear submarine assets under the SCICEX Program noted above. The Commission believes that the time has come for an organic act for NURP which will establish it as an ongoing activity with a structure based largely on the recommendations of the "Blue Ribbon Panel." As part of their mission NURP should undertake to fulfill the commitment made in the SCICEX MOA to support infrastructure costs of the SCICEX Program.

There have been several attempts to obtain an organic act for the National Undersea Research Program, but these have been unsuccessful. For many years, NOAA and the Department of Commerce did not include NURP in the NOAA budget. Following a reinvention of the program, based in part on a Blue Ribbon Panel report, NURP has been included in the President's budget. The role of NURP will be evaluated in the context of other NOAA priorities.

NOAA operates a suite of National Data Centers including the National Snow and Ice Data Center, the National Oceanographic Data Center, the National Geophysical Data Center and the National Climate Data Center. These data centers are charged with the responsibility for data rescue in the Former Soviet Union. The Commission recommends that the national data centers communicate the nature of their data rescue activities to the Commission and expand them as necessary to collect data vital to our understanding of the Arctic, especially the dispersal of contaminants in the region.

NOAA has prepared a report to the Commission describing the data rescue activities of the NOAA National Data Centers.

Environmental Protection Agency

The Environmental Protection Agency has abandoned the Arctic. Although the EPA was closely engaged in the Arctic and a principal support for the activities of the Arctic Environmental Protection Strategy up until 1994, sub-

sequent involvement has been minimal. This has left the United States committed to programs under the AEPS, particularly in AMAP, for which the appropriate agency refrained from providing support. The Commission considers this to have been a short-sighted and ill-informed decision and recommends strongly that the EPA make a substantial effort in the study of contaminants in the Arctic. The U.S. has been judged an under-achiever by the international community involved in the AEPS and the current discussion on the future of AMAP under the Arctic Council has become very difficult given that there are no plans for the EPA to carry out the responsibilities so clearly theirs.

The EPA has begun to show new interest in the Arctic. The Commission notes the workshop held in Fairbanks in the summer of 1996 which had the effect for EPA of reinventing the AMAP priorities which have been known to the other IARPC agencies for years. The Commission also notes that the intent to establish an Arctic baseline study station at McKinley National Park fails to understand that the Park is not in the Arctic, that experimental opportunities in a National Park are extremely limited and that there are a number of much superior sites in Alaska, notably Toolik Lake and the Barrow Environmental Observatory, which would provide a superior site where EPA could take advantage of ongoing studies by many scientists. Many in the research community have taken the selection of the McKinley site as clear evidence of EPA's failure to communicate with its IARPC partners.

The Commission recommends that the EPA commence an Arctic Contaminants Monitoring and Assessment program during Fiscal Year 1997. This program must be closely coordinated with the activities of the other IARPC agencies and the AEPS/Arctic Council planning for AMAP II.

The U.S. Environmental Protection Agency (EPA) believes that both recommendations may be addressed in a single response. The Commission's first recommendation implies that there is a single "...appropriate agency..." for the support of the Arctic Environmental Protection Strategy, which, in fact, involves a national commitment. We believe that support of the Arctic Environmental Protection Strategy is an effort for all of the environmental and human health protection and environmental management agencies represented on the Interagency Arctic Research Policy Committee. Both recommendations do not take into account the EPA's continued support of Arctic contaminants research (in particular, the EPA work to implement the Interagency Research Policy Committee's initiative on "Assessment of Risks to Environments and People in the Arctic"). That initiative recognizes that contaminants are not the sole environmental and human health threats in the Arctic. EPA's strategy is to consider potential harm from such contaminants as heavy metals, radionuclides, and persistent organic pollutants in an integrated manner that includes such potential environmental and human health stressors as land use and land cover change, losses of habitat and biodiversity, and subsistence and lifestyle circumstances. This approach to assessing risk, rather than stressor presence solely, is made clear in the IARPC initiative. Significantly the initiative focuses also on the rescue of Arctic data for risk assessment and risk management purposes.

For example, EPA's Western Ecology Division (National Health and Environmental Effects Research Laboratory) is supporting work to establish a database and to continue to process data from that Laboratory's prior Arctic Contaminants Research Program. These data arise from analyses of heavy metals and trace elements in Arctic lichens, mosses and soils. A subset of these data was deposited with the multi-national Arctic Monitoring and Assessment Program. Finally, as part of its Science To Achieve Results (STAR) program of grants to independent investigators (irrespective of the locus of the investigation), EPA continues to provide support to proposals that are highly rated in terms of merit and relevance and for which adequate funds are available. The Agency encourages Arctic researchers of all disciplines to submit proposals to the STAR program.

Department of State

The Department of State is responsible for the negotiation and operation of our international agreements in the Arctic. The Department seeks input from the IARPC agencies and others through the Arctic Policy Working Group which meets monthly with the Polar Affairs Section at State. Over the years a disconnect has occurred between the Department and the officials in other agencies making the vital decisions affecting our participation and performance in international programs. This stems principally from the lack of coordination between what the agencies will actually do and the rhetoric which is occasionally expressed in

these programs. The classic case was the complete failure of the United States to participate in the AMAP health study of contaminants in umbilical cord blood. While endorsing this program and its goals on the one hand, nobody actually took any samples. The result is that the United States has been viewed with a certain amount of scorn in AMAP meetings. The cure for this is certainly not simple. The most important step, however, is that the Department of State must, in the future, meet with Agency policy officials to review their recommendations, spell out the equivalent commitments to action by agencies and modify their positions accordingly. These meetings must be carefully prepared so that the issues to be discussed are clearly spelled out and that the nature of the commitment required from the agencies is understood well beforehand so that the agencies can come to the table prepared to make commitments.

The Department of State is responsible for the negotiation of international agreements and for coordinating the implementation of the U.S. government's obligations under these agreements. With regard to the formulation and implementation of U.S. Arctic Policy, the Department chairs monthly meetings of the Arctic Policy Group (APG) and also attends on a regular basis meetings of the Interagency Arctic Research Policy Commission (IARPC). The APG oversees Federal Arctic policy and is constituted of representatives of Federal agencies with policy interests in the Arctic. With regard to international Arctic cooperation, the Department strives to ensure that domestic Federal agencies comply with their obligations for activi-ties in the Arctic region. The creation of the Arctic Council has led to increased responsibilities and international obligations, which are overseen by
the Department. Among other tasks, the Department strives to ensure that all appropriate agencies are represented in appropriate meetings of the Arctic Council and its four subsidiary groups. The Arctic Council comprises representatives of the eight countries that have territory in the Arctic (Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden, and the United States) and is the follow-on organization to the Arctic Environmental Protection Strategy (AEPS).

At a recent meeting of senior-level representatives from APG member agencies, the Department began a review of the implementation of U.S. Arctic Policy, including future commitments to circumpolar cooperation, and obligations under the AEPS and the Arctic Council. The meeting also considered the possibility of support for U.S. chairmanship of the Council beginning in September 1998. The Department of State seeks to ensure the Council remains an effective forum for circumpolar cooperation, while addressing our national goals and local (Alaskan) interests.

The senior review also identified the need for clearly articulated U.S. goals for the Arctic Council and a commitment of resources by individual agencies, both in programs and policy, before the United States decides whether to pursue Chairmanship of the Council. Based on this meeting, the Department has drafted papers examining these issues and the goals for the Arctic Council. These will be discussed at a senior policy level in the near term to ensure we have a course plotted for our involvement in the Council and to determine if there is a clear commitment, at the Federal level, to proceed and to finalize a decision on U.S. chairmanship.

U.S. Coast Guard

The U.S. Coast Guard is the principal provider of ship time on icebreakers for U.S. scientists not collaborating with other nations. In the past, this system has produced friction and disagreement as well as some important successes. With the advent of *Healy*, the new Coast Guard icebreaker, a new system must emerge. The dialog between the scientific community which will be using *Healy* and Coast Guard designers and ship builders has been substantially improved. The formation of the Arctic Icebreaker Coordinating Committee (AICC) has been successful and is leading to improvements in *Healy*. In the future the need for liaison and coordination will change from the construction team to operations. The Coast Guard should consult closely with the AICC remembering that the U.S. academic community has, in fact, a substantial level of experience in oceanographic operations generally and in Arctic studies in particular.

The AICC and the closer cooperation which it is inducing will not help to produce the potential for a new era of U.S. Arctic Research unless a commitment to operating funds for *Healy* is forthcoming. The Commission has recommended to the National Science Foundation that it provide funds for full utilization of *Healy* at approximately 200 operating days per year. The Coast Guard should support NSF in its efforts to provide these funds.

Finally, the Commission recommends that *Healy* consider making her home port in Alaska. The savings in transit time and costs even to the eastern Arctic from home porting in Alaska will be considerable and justify the decision. Excellent port facilities in Seward, Kodiak, Dutch Harbor and elsewhere are more than satisfactory for *Healy*.

The Coast Guard concurs that the AICC has proven to be a highly beneficial and effective forum for planning and maximizing the scientific suite capabilities on CGC *Healy* and is enthusiastically committed to its continued support. This Committee has great potential to be expanded to serve in an advisory capacity for science space improvements on the two Polar-class icebreakers as well.

The Coast Guard is concerned that the additional funding required to fully utilize CGC *Healy* starting in the year 2000 has yet to be addressed and strongly concurs with the ARC recommendation of support for the *Healy*.

The Coast Guard has conducted detailed analyses on the home porting question. While there are some advantages to the Alaska locations, high infrastructure improvement costs and the lack of sufficiently large ship repair facilities make these sites less desirable. The Coast Guard position is that the proximity to Arctic waters that Alaska offers does not outweigh the higher support costs that would be incurred.

The Interagency Task Force on Oil Spills

There is a substantial dearth of knowledge about oil spills in Arctic conditions. The Commission has long recommended a substantial research program on the behavior of oil in ice covered oceans. In addition, the Commission in collaboration with the Alaska Clean Seas Association has recommended test burns in the Arctic Ocean to study the variety of questions associated with this highly effective method of disposing of oil on the sea. The Commission recommends that the Interagency Task Force commence such a program soon, before the question is made imperative by accidents in the Arctic.

The Coast Guard supports the ARC in its recommendation to commence a research program on the behavior of oil in ice-covered waters, although no funds are currently available to sup-port such a program. The Coast Guard continues to endorse the preparedness and response efforts of the Emergency Preparedness Prevention and Response Working Group of the Arctic Council, as well as individual national research, such as the Canadian effort to develop a technical manual on oil response under ice and snow conditions

Department of Defense

A number of activities fall under the Department of Defense. Chief among these is the SCICEX Program of the Department of the Navy. The 109th Airlift Wing of the New York Air National Guard provides LC-130 support for both Arctic and Antarctic research operations. In addition, DOD is conducting a program entitled Arctic Military Environmental Cooperation jointly with the Norwegian and Russian ministries of defense. The Commission encourages the Department of Defense to continue to provide support for Arctic Research and environmental studies and to communicate with the Commission on any new programs.

The Department concurs with the Commission's recommendations and will provide information on new programs as they develop.

National Aeronautics and Space Administration

The Commission has recently received a briefing on the programs undertaken by NASA in the Arctic or having a substantial component in the Arctic. These programs are clearly of a high caliber. The Commission notes, however, that these programs are very poorly publicized outside of the community of NASA Principal Investigators. The Commission recommends that NASA carry out a program of outreach to the Arctic Research Community to publicize these programs and to encourage a broader participation. NASA is always at risk for the engineering side of their programs to overwhelm scientific uses and needs. The Commission believes that by broadening the participation of the research community in their programs, NASA can benefit from the resulting community support.

NASA Research Announcements (NRAs) are widely publicized, with a total mailing list of more than 40,000, including universities and non-profit organizations. Announcement of each NRA is sent to the subset of the list that has indicated interest in receiving NRAs in the subject area. It is for the individuals on the list to indicate their areas of interest, and there are forms in each NRA for them to do so. All NRAs are issued on the World Wide Web and are announced in the *Commerce Business Daily.*

U.S. Army Cold Regions Research and Engineering Laboratory

The Army Cold Regions Research and Engineering Laboratory (CRREL) in Hanover is a national treasure. In the current climate of budget stringency the pressure on Army labs is growing. The Commission wishes to be on record in support of the national treasure that exists at CRREL. Serious reductions at CRREL would be short term helpful but a detriment to the national welfare over the long term. The Commission encourages continued support for CRREL.

The research program at CRREL is reviewed annually under the Defense Technology Area Review and Assessment (TARA) process run by the Director, Defense Research and Engineering. The 1996 TARA rated CRREL as a national treasure, as did the 1997 TARA. The Department of the Army will propose funding for it consistent with its contribution to its defense mission.

National Institutes of Health

Under the Arctic Environmental Protection Strategy, the United States has become involved in programs concerning the health of Arctic residents, particularly the indigenous people of the region. In particular, the AMAP health study has been focused on environmental effects on health in the region. It is clear that the responsibility for the national effort in this regard falls to the National Institutes of Health, particularly the National Institute for Environmental Health Sciences. The Commission recommends that NIH immediately organize an Arctic Environmental Health Study focused primarily on the measurement of contaminants in umbilical cord blood. This study will require a sampling program including sample protocols and the collection of medical history data from the mothers, an analysis program including the analysis of priority contaminants and a statistical study of the data, a laboratory program to develop new and more effective bio-indicators of environmental insult, and a program to synthesize these results and return to the Arctic community in understandable language the results and their implications for life in the Arctic.

With respect to Phase 2 of the Arctic Monitoring and Assessment Program (AMAP-2), being subsumed under the Arctic Council, which has encompassed the programs of the former Arctic Environmental Protection Strategy (AEPS), the National Institutes of Health is planning to increase its involvement in health in several areas, one of which will be the monitoring study recommended by the Arctic Research Commission.

A core activity of AMAP-1 was the monitoring of umbilical cord blood for contaminant pollutants, which the United States was not able to actively initiate during that time frame. However, the monitoring program, which is to continue during AMAP-2, has received the necessary local approvals in Alaska and will be pursued by scientists in Alaska with the technical assistance of the National Institute of Environmental Health Sciences (NIEHS), NIH and the Centers for Disease Control and Prevention (CDC), and the expected additional financial assistance from the Environmental Protection Agency (EPA), Office of International Programs.

Department of the Interior

The U.S. Geological Survey has led the effort by IARPC agencies in the assembly of a data structure for Arctic Research. Unfortunately, there has never been a satisfactory funding base for this program. In the past, many IARPC agencies have contributed to this effort but these contributions have faded. Only NSF continues to provide support. The Commission recommends that the USGS and the Department of the Interior accept that this program belongs to them and should be fully supported.

The Department of the Interior (DOI) fully supports the Arctic Environmental Data Directory (AEDD). The USGS provides the continuing leadership and support for the management of the catalog of Arctic research data and information in AEDD. This support is marked by innovation and change in response to the needs of Arctic researchers.

For example, the USGS has recently moved operational support and management of the Arctic Environmental Data Directory to the USGS EROS Data Center to enhance its links with active research in the national and international science community. The USGS has migrated to the most modern technologies of the World Wide Web in its implementation of the AEDD, which now employs direct links to every known Arctic data source in U.S. Federal agencies and their international partner organizations.

The USGS actively participates in the Federal Geographic Data Committee's standards programs and has adapted AEDD to be in full compliance with the national standards for metadata. By doing so, the contents of AEDD have been enlarged tenfold to include documentation and pointers to several thousand FGDC-compliant Arctic data hold-

ings in Alaska. The DOI is committed to continuing support for AEDD on behalf of the IARPC agencies.

The USGS (Arctic Environmental Data Directory project) should have the full support of the other IARPC agencies.

The USGS seeks funding support from IARPC agencies annually. From 1991-1993, funding support was provided by agencies whose metadata were incorporated: Commerce/NOAA, DOD, DOE, DOI, DOT/USCG, EPA, HHS/IHS, NSF, Smithsonian and State. Since 1993, NSF has funded AEDD annually. HHS/IHS funded the inclusion of Alaska socioeconomic and health data, and DOC/NOAA has funded part of the establishment of a AEDD-compatible node for housing Russian Arctic environmental data.

Although much of the physical environmental data have been documented, large gaps persist in the identification and documentation of several categories of Arctic scientific data and information. Specifically, Arctic contamination data, socioeconomic, medical, health and demographic data, and the continuing release and documentation of formerly classified data all require extensive effort to properly prioritize, document and make available to the research community. The USGS will need financial support and commitment from the agencies in which these data reside to make these data and information available.

It is particularly important that an effort be staged to save important earth science data from the former Soviet Union. Much useful data is collected in old paper records which are even more vulnerable now that fuel has become scarce in many places. The Commission has recommended that the NOAA National Data Centers undertake a data rescue project coordinated with the USGS.

The USGS has actively pursued partners to help identify and document the Arctic data and information holdings of the former Soviet Union. Based on the AEDD the USGS has helped establish a growing network of international partners to this end. In 1994 the United Nations Environment Program established the Nordic node of the Arctic Data Directory (ADD) in Arendal, Norway. Together, the USGS and UNEP began the process of documenting Arctic data from the Russian northwest. In 1996 the USGS and UNEP helped the Russian Federation establish a comparable node in Moscow operated by the Russian Ministry of Environment Protection and Natural Resources. Together, ADD now documents nearly 100 major Russian Arctic data sets. ADD complies with international standards for metadata and is completely compatible with Global Climate Change data directories in the U.S. and internationally. The USGS has opened discussions with the Japan Foreign Ministry to sponsor a fourth ADD node that would house information on the Russian Far East with a focus on contamination data and information. Finally, the USGS has worked actively and persistently with the NOAA National Snow and Ice Data Center since 1987 to take advantage of their resources in documenting Arctic data and information sources, including those in the FSU. The USGS has a close and symbiotic relationship with the NOAA data centers and concurs with ARC about their importance in gathering Arctic data and information from the FSU.

Further and reliable financial support from IARPC agencies is crucial to building this data and information resource to properly document the extensive Russian data holdings and to capture the contents of the most important Russian data sources for future research. The USGS will continue to work closely with the NOAA Snow and Ice Data Center and the partners in ADD to identify and document the highest priority FSU data sets.

More than 10 years ago NASA initiated the efforts that have developed into the two NASA Data Centers at the National Snow and Ice Data Center (NSIDC) and at the Alaska SAR Facility (ASF). NASA alone supports these centers at a cost of more than $15 million per year. NASA will continue to support NSIDC and ASF and, in so doing, will continue to lead IARPC and global attempts to provide Arctic data to the research community.

Department of Energy

The energy needs of Arctic villages in Alaska are extreme. Poor transportation to remote villages, small communities unable to take advantage of the economies of scale usually associated with municipal energy systems, a mixed economy with only modest cash flow and the lack of a sophisticated technical infrastructure all make the provision of adequate energy resources in the Arctic difficult. While the Commission has no specific programs to recommend, it asks that the Department of Energy report to the Commission on its current rural energy programs in Alaska.

The Commission fully supports the activities in the Arctic under the Atmospheric Radiation Measurement (ARM) Program. The ARM Program is an important research effort and is also

an outstanding example of close cooperation between researchers and Native communities and stands an example for other research programs.

The Department of Energy's current rural activities in the Arctic pertain primarily to education. DOE will report to the Commission on any new rural energy programs in Alaska.

The Department thanks the Commission for supporting the Atmospheric Radiation Measurement (ARM) Program's activities in the Arctic. In particular, DOE thanks ARC for stating that the "ARM Program is an outstanding example of close cooperation between researchers and Native communities and stands as an example for other research programs."

Report of Meeting

Interagency Arctic Research Policy Committee

Committee Members and Agency Representatives Present: Neal Lane (Chair), Charles Myers and Tom Pyle, National Science Foundation; George Newton, Jr., and Garret Brass, Arctic Research Commission; Robert Houtman, Department of Defense; Ari Patrinos and Merrill Heit, Department of Energy; Peter Hartsock, Department of Health and Human Services; Bonnie McGregor and John Haugh, Department of the Interior; Robert Senseney and Tucker Scully, Department of State; Richard Rooth, Department of Transportation; Joseph Alexander and Sidney Draggan, Environmental Protection Agency; Prasad Gogineni, National Aeronautics and Space Administration; Alan Thomas and Renee Tatusko, National Oceanic and Atmospheric Administration; Igor Krupnik and Robert Hoffman, Smithsonian Institution; Barbara Weber and Richard Cline, U.S. Department of Agriculture; and Douglas Posson, U.S. Geological Survey.

14th Meeting: June 3, 1997

Dr. Neal Lane, Director of the National Science Foundation and Chair of IARPC, convened the meeting at the National Science Foundation, Arlington, Virginia. Dr. Lane reviewed recent accomplishments of the IARPC, including completion of the U.S. Arctic Research Plan biennial revision. He noted the improved climate of interagency cooperation that has resulted in a number of coordinated multiagency initiatives. He stated that the task before the IARPC would be to develop a strategy to implement these initiatives in a time of decreasing or flat budgets.

Review of U.S. Arctic Policy

Dr. Lane called on Tucker Scully, Department of State, to provide an overview of U.S. Arctic policy. Following a recent review, U.S. Arctic policy was updated to include a focus on environmental protection and sustainable development of the Arctic region. One of the other elements of the Arctic policy is to strengthen cooperation among the eight Arctic states. A result has been the establishment of the Arctic Council, a high-level forum of those eight governments. The Arctic Council will formally meet in 1998. Mr. Scully noted there is a growing expectation that the U.S. will succeed to the Chair of the Arctic Council. A wide variety of preparatory activities are associated with such a meeting, and a significant interagency effort would be needed.

IARPC Program Initiatives

Reports on four interagency program initiatives were presented.

Assessment of Risks to Environments and People in the Arctic. Alan Thomas, NOAA, reported on the IARPC initiative on Assessment of Risks to Environments and People in the Arctic and on efforts to coordinate U.S. participation in AMAP, the Arctic Monitoring and Assessment Program. Joseph Alexander, EPA, stated that there are two important factors to consider: 1) there are no additional funds but a need to coordinate efforts, and 2) there is a need to look at the environment from a risk assessment perspective. Each agency would focus on its own area of expertise, and the resulting scientific information will enable IARPC to inform decision makers on how to manage environmental risk. Dr. Alexander presented a summary of a proposed new implementation initiative.

Beringian Systems. Igor Krupnik, Smithsonian Institution, provided background on the Beringian Systems initiative, a joint program with the Smithsonian, National Park Service, NOAA and other agencies. A complete description of the program is found in the fourth biennial revision of the U.S. Arctic Research Plan. The Beringian Systems initiative focuses on the region surrounding the Bering Strait, including the Chukchi and Bering Seas and adjacent portions of the North Pacific, Siberia and Alaska. Several Federal agencies support the initiative in various ways from research to logistics. The current plan has a growing base of support in government and the international science community. This new initiative is seeking ten-year funding and implementation. Garrett Brass, ARC, asked to what extent these agency roles were commitments compared to hopes or expectations. Dr. Krupnik responded that without new resources some of the planned projects would not happen.

Arctic Data and Information Systems. Dr. Lane noted that the IARPC created an Arctic Environmental Data Working Group charged with several tasks, among these being to establish a modern system to distribute Arctic data sets and information and to coordinate with the international community. Most of the agencies provided financial support for this activity. This is an excellent example of interagency cooperation. Douglas Posson, U.S. Geological Survey, has been managing this activity and presented progress and plans of the working group. In an effort to make AEDD international and circumpolar, the ADD has established partnerships with Antarctic and Nordic groups. Partnerships with Russia and Japan are in progress. The AEDD serves as a gateway to environmental databases and to other Arctic data sets. This "Arctic Gateway" is intended to support the newly formed Arctic Council and access international data sets on-line.

Infrastructure and Research Support. Tom Pyle, NSF, presented an update on infrastructure,

logistics, facilities and research support in the Arctic. A 1997 report on Logistics for Arctic Research, from the Arctic Research Consortium of the U.S. (ARCUS), also stated that "...The Arctic [must] be viewed in its global context which, in turn, necessitates a significant expansion of logistical capabilities in the service of the U.S. Arctic Research Program."

In response to this need the NSF/OPP Arctic Sciences Section has proposed an Arctic Research Facilities Coordination Program to lead a response to the recommendations of the ARCUS Logistics Working Group and Arctic Research Commission. Other functions would include:

- Maintain an IARPC logistics web page;
- Coordinate Arctic airlift support with the Air National Guard;
- Coordinate with the U.S. Navy on the annual use of nuclear submarines and work with other agencies to announce opportunities and instrument upgrades for particular cruises;
- Supervise a joint NASA/NSF logistics support contract with the Polar Ice Coring Office (PICO);
- Coordinate science support requirements and long-term planning for Toolik Lake;
- Coordinate science support requirements and long-term planning for the Barrow Environmental Observatory with the Barrow Arctic Science Consortium, DOE and NOAA;
- Coordinate science program access to Thule Air Base with Air Force Space Command, Air National Guard, ONR and Danish/Greenlandic authorities;
- Coordinate all other science projects in Greenland with the Danish Polar Center, Commission for Scientific Research in Greenland, Greenland Home Rule, State Department, PICO and NASA;
- Coordinate interagency support agreement and upgrades to buoy technology with National Ice Center's International Arctic Drifting Buoy Program;
- Coordinate Arctic science requirements for special intelligence satellite data;
- Coordinate requirements for research support/logistics in Russia in conjunction with joint programs;
- Negotiate an agreement with Canada on logistics to be developed under an Arctic Research Commission initiative; coordinate future bilateral meetings; and coordinate U.S. logistics requirements;
- Complete an MOU with the Coast Guard and coordinate agency ship time requirements for the research icebreaker USCGC *Healy*, including an annual review of costs and performance;
- Coordinate logistics requirements of NSF OPP and Arctic Affiliates; and
- Develop working relations with logistics mangers of other Arctic countries.

Approval of the U.S. Arctic Research Plan

Dr. Lane noted that the IARPC staff has been working since last fall on the fourth biennial revision to the U.S. Arctic Research Plan. The draft has been circulated through agencies and all agencies have now cleared the plan. A final copy will be sent to the White House for clearance and transmittal by July 31. Dr. Lane requested concurrence for transmittal of the Plan. There were no objections. (The President approved the Plan and sent it to Congress on July 29, 1997.)

Implementation of Program Initiatives

Dr. Lane next discussed how the Interagency Committee might move beyond the mode of research planning to the next step: implementation. Dr. Lane recognized that in a time of flat or decreasing budgets in most agencies, it is extremely difficult to obtain money for new initiatives. Sidney Draggan, EPA, noted that the EPA proposal would serve as a coordinating framework for continuing cooperation under IARPC. It is an added framework to an already existing mandate to cooperate. Joseph Alexander, EPA, added that coordination works well when parties have a vested interest. He proposed that these discussions of the initiative be done in the context of risk assessment/risk management.

Dr. Lane stated that in his experience, interagency agreements sometimes work and sometimes don't. Coordination is more likely when there is funding. It is also likely to happen if the agencies involved have something to gain. George Newton, ARC, added that not only is commitment needed, but the IARPC needs to clearly designate who will ensure that things are implemented. He asked: would EPA be ready to be the executor of the agreement? Joseph Alexander responded that EPA would.

Dr. Lane asked the IARPC members for their advice on interacting with OMB and OSTP on behalf of the Arctic budget. OMB has a responsibility to look at the Arctic Research Plan and the proposed budgets of the agencies. Dr. Lane suggested a letter could be sent to the science advisor and OMB to suggest how the Arctic initiatives would benefit from additional attention. Dr. Lane asked if IARPC members would support this expression on

behalf of the Committee. After discussion, the Committee concurred that he should write these letters on behalf of the Committee to OMB and OSTP.

Comments from the Arctic Research Commission

George Newton, Arctic Research Commission (ARC) Chair, addressed the Committee on behalf of the ARC. Mr. Newton described the activities of the Arctic Research Commission:

International Arctic Research Center. Mr. Newton stated that the International Arctic Research Center (IARC) is one of the strongest international research alliances ever formed in the Arctic. It is a joint effort between the University of Alaska and Japan. The government of Japan has approved a new initiative in Global Climate Change Prediction to be carried out jointly with the United States through the IARC. A committee of Japanese and U.S. government agency representatives, known as the Japan–U.S. Implementation Committee (JUIC) has been formed.

Bathymetry. The ARC has recently pursued the release of Arctic Ocean bathymetric data collected by U.S. Navy submarines. Tracks of classified submarine research cruises from 1957 to 1982 were specifically identified. The Navy information will be declassified and made available. Data are from 26 deployments and cover over 125,000 track miles. The ARC has also found funds to start the physical process of declassification. The release of this information will be the largest single input of Arctic Ocean bathymetry to the science community in history.

U.S.–Canada Logistics Cooperation. In December 1996 George Newton and Garrett Brass met with the Canadian House of Commons Committee on Foreign Relations and International Trade to discuss common interests in Arctic research. As a result of the visit, an initiative emerged during the Canadian–U.S. Summit meeting in March 1997 for the coordination and sharing of logistics needs and opportunities.

SCICEX/SCAMP. The SCICEX program for the use of U.S. Navy nuclear submarines as platforms for unclassified research in the Arctic has been an outstanding success. The latest development in the SCICEX program is the addition of a system known as the Sea Floor Characterization and Measurement Pod (SCAMP). This system will include an interferometric bathymetric mapping system capable of producing contour maps of bottom topography in a swath approximately 2.5 times the depth of water under the submarine. These data will be part of the SCICEX data set |and will be unclassified and released to the public. This will greatly develop our understanding of the character of the Arctic Ocean, its formation, its evolution, and sites of importance for future resource exploration.

Arctic Icebreaker Coordinating Committee. The NSF Ocean Sciences Division and the Office of Polar Programs have formed the Arctic Icebreaker Coordinating Committee (AICC). The ARC was an active promoter of the Committee and serves as one of the agency observers. The AICC, composed of Arctic oceanographers, is coordinated by the University National Oceanographic Laboratory Systems (UNOLS). The Committee has met several times, including a visit to the Avondale Shipyard in New Orleans, where the new Coast Guard Research Icebreaker *Healy* is under construction. Discussions have gone well between these community scientists and the Coast Guard, and several significant physical changes have been accommodated in the ship as a result of interactions between the AICC and the USGS.

Arctic 2000. The Commission is currently exploring the convening of a major workshop to consider the future of Arctic research in the next century.

Arctic Logistics. The ARC sponsored a study by the Arctic Research Consortium of the United States (ARCUS) on the specific needs for Arctic logistics support. The report is available on the Internet. The study drew widely from the academic research community. The results are prioritized and cover all fields of Arctic research.

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The International Arctic Science Committee has established a service to the Arctic research community: an Arctic meetings listing available via the Internet. Called SAM (Survey of Arctic Meetings), it contains information on international Arctic meetings, as well as major national meetings with international participation. The World Wide Web address for SAM is http://www.npolar.no/iasc/sam.htm.

Back Cover

Identifying lichens near Kurupa Lake in Gates of the Arctic National Park and Preserve. Note the mosquitos on the man's coat.