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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 (IARPC) and the Arctic Research Commission (ARC). Both the Interagency Committee and the Commission were authorized under the Arctic Research and Policy Act (ARPA) 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.

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.

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Cover

The new polar icebreaker USCGC Healy, *commissioned on 21 August 2000. The* Healy *provides a new platform for Arctic research, with capabilities that substantially surpass those of older icebreakers.* *See page 123 for more information on the* Healy.

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Report from Federal Agencies for 2000–2001

This issue of *Arctic Research of the United States* presents highlights and results of major fiscal year 2000 and 2001 Arctic research programs and selected projects of the Federal agencies. For more information, you may contact the agency staff representatives listed on page 130.

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.

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 01, NSF awarded funds for 438 Arctic research projects at 146 institutions in 41 U.S. states and the District of Columbia.

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 2001*, available from the Office of Polar Programs, National Science Foundation, Arlington, VA 22230.

	Funding (thousands)	
	FY 00	FY 01
Arctic Natural Science	9,988	10,525
Arctic System Science Prog	14,351	15,600
Arctic Social Sciences Prog	1,459	1,619
Arctic Education research	225	240
Arctic Research Support	151	147
Arctic Data/Info/Coord	88	92
Arctic Research Commission	700	1,003
Arctic Logistics/Instrumentation	23,230	25,405
Other NSF Science Programs	17,295	17,596
Total	67,487	72,227

Arctic System Science

The NSF established the Arctic System Science (ARCSS) program in 1989. ARCSS research contributes to the U.S. Global Change Research Program. Administration of the program uses review expertise and financial support from the OPP, as well as contributions from other NSF Directorates and other Federal agencies as appropriate. ARCSS is coordinated and managed by the OPP. 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 as a system in a global change context. ARCSS is an interdisciplinary program that examines the interactions within and between the climatic, geologic, biologic, and socioeconomic subsystems of the Arctic. ARCSS is predicated on the knowledge that the Arctic system is sensitive to and important in global change.

ARCSS has five linked components. The current ARCSS program includes Ocean/Atmosphere/Ice Interactions (OAII); Land/Atmosphere/Ice Interactions (LAII); Paleoenvironmental Arctic Sciences (PARCS); Russian–American Initiative on Shelf–Land Environments in the Arctic (RAISE); and Human Dimensions of the Arctic System (HARC).

Science steering committees (SSCs) for each component facilitate coordination and integration and provide a focal point for communication with the scientific community. Planning by the SSCs is focused on three thematic questions: Are detected changes predictable? How do human activities interact with changes in the Arctic to affect the sustainability of ecosystems and societies? How will changes in Arctic cycles and feedbacks affect Arctic and global systems?

Recommendations for overall coordination and integration of the ARCSS components and individual projects are provided by the ARCSS committee of the Arctic Research Consortium of the U.S. The committee includes representatives

from each SSC, as well as investigators not supported by ARCSS with a disciplinary interest that enhances the scientific breadth and experience of the group.

NSF/ARCSS has been particularly successful at establishing partnerships with other Federal agencies. Considerable cost and in-kind 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

PARCS contributes 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 have been partially supported by the NSF program called Earth System History.

The PARCS program developed out of the ear lier Paleoclimates from Lakes and Estuaries (PALE) program, which had the goal of constructing paleoclimatic history from the sediments of Arctic and sub-Arctic bogs and lakes. PARCS incorporates the goals and focus of the PALE project but recognizes that important and untapped information about Arctic environmental history also resides as tree-ring records and in sediments from the marginal seas, continental shelves, slopes, and abyss of the Arctic Basin. 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, land use change, and the physical conditions and productivity of the Arctic Ocean, but additional new proxies are sought. With the emphasis on variation of climate over the last 20,000 years, the PARCS program is a part of an international program, Circumpolar Arctic Paleoclimate Experiment (CAPE), to produce a reconstruction of the circumarctic environment.

Contemporary and Process Studies

OAII and LAII are process oriented and rely more on experiment and less on description than PARCS. 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 has conducted the Surface Heat Budget of the Arctic Ocean (SHEBA) project from a ship frozen into the drifting ice pack in the Beaufort Sea. SHEBA measured the impact of clouds and albedo on sea ice for a full annual cycle. Although the experimental phase of the project is now completed, analysis and modeling efforts to better understand the impacts of solar heating on the climatologically changing ice cap are continuing. The Shelf–Basin Initiative (SBI) was begun to better understand the role of the large continental shelf seas in terms marine biological productivity and the exchange of water, nutrients, heat, and energy with the permanently ice-covered central Arctic basins.

Terrestrial studies were expanded under the new Arctic Transitions in the Land–Atmosphere System (ATLAS) project. ATLAS is examining a series of terrestrial sites across the gradient from boreal forests in central Alaska to the tundra in northern Alaska. Detailed understanding of the plant–soil ecosystem at each site may allow predictions about the likely impact of global warming on the northward migration of terrestrial ecosystems. In close association with ATLAS, the United States Tundra Experiment (USTEX) project, a part of the ITEX (International Tundra Experiment), is using the same sampling methodologies to evaluate tundra plant growth as used by all other participating countries. The use of these common methods will allow direct comparison of the regional tundra responses to climate change.

The Russian–American Initiative on Shelf–Land Environments in the Arctic (RAISE) is designed to foster closer collaboration between Russian and U.S. scientists. As most of the river flow into the Arctic Ocean is from the major Russian rivers, evaluating the impacts of climate change on the Arctic would be difficult without collaborative studies within Russia. Current projects include an investigation of the hydrologic cycle in tributaries of large Russian rivers, which would allow a better understanding and prediction of river flow and an evaluation of sediment discharge from large eastern Russian rivers.

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 and land use practices. Research at the natural sciences–human dimension interface will increase policymakers' 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 glaciology, atmospheric sciences, ocean sciences, earth sciences, contaminants, biological sciences, and environmental research.

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 glacier mass balance. The research takes place in Alaska, Greenland, the High Canadian Arctic, Svalbard, Russia, Iceland, Norway, and Sweden. In addition, some limited funding goes to support research in high-altitude and midlatitude 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, such as synthetic aperture radar (SAR) interferometry. In addition, declassified intelligence satellite photos are providing information on decadal-scale changes.

The U.S. National Ice Core Laboratory (NICL), located at the Denver Federal Center, is operated through an interagency cooperative agreement with the U.S. Geological Survey. The NSF funding is from both the Arctic and Antarctic science programs and the Paleoclimate Program.

One of the important areas of research is to better understand 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, till rheology, electrical conductivity, and turbidity of glacial meltwater. These parameters are measured in boreholes in the ice at several locations on the glaciers. Recent studies of the Greenland ice sheet have shown that the ice-covered area around the southern Greenland periphery has receded over the past decade.

Among the largest uncertainties in ice volume changes during the late Quaternary is the extent of ice sheets over Franz Josef Land, Novaya Zemlya, and the adjacent seas. Deglaciation of the Barents/Kara Sea ice sheet may have been initiated by a rapid global sea-level rise 13,000 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.

Atmospheric Sciences

Numerous investigators are studying atmospheric components of environmental change, how they are characterized, and their consequences for the Arctic. The program supports research aimed at the physical and chemical understanding of the processes responsible for, and impacts resulting from, environmental change.

One example can be found in measurements that characterize polar stratospheric cloud particles. The first of their kind, these measurements are being used to test our understanding of the formation of polar stratospheric clouds by comparing field measurements with microphysical models. Polar stratospheric clouds are critical to understanding the details of ozone depletion, particularly in the Arctic.

Tropospheric ozone plays a key role in the oxidative chemistry of the troposphere and has an important impact on the radiative balance of the atmosphere. Understanding the processes that control the origin, trends, distribution, and effects of tropospheric ozone is a high priority in atmospheric chemistry research. Research continues toward understanding the production and loss of tropospheric ozone through remote sensing,

in-situ measurements of trace gases and radicals involved in ozone photochemistry, and chemical and transport modeling studies.

Recently this has included groundbreaking research on the interactions between air and snow in the presence of light. It has been shown that pore-air levels of NO_x, HONO, and some oxidized organic compounds are greatly altered by snow photochemical processes and that OH levels are affected. This may be important both for ozone-related reactions and for processes controlling general levels of reactive radicals.

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

Ocean Sciences

Researchers found major regime shifts in the ecosystems of the Barents Sea in July 1997, when a large coccolithophore bloom (*Emiliania huxleyi*) was encountered for the first time in the region in connection with investigations of the inner front of the southeastern Bering Sea. During the ensuing fall, approximately 10% of the approximately 16 million short-tailed shearwaters died in the Bering Sea. This event, which attracted considerable attention in the scientific and popular press, is likely a result of the coccolithophore bloom. This could be because coccolithophores are much smaller than the diatoms that usually prevail in these waters, and their presence favors small copepods and microplankton over the larger krill on which the birds feed. The coccolithophore bloom appears to have resulted from atmospheric conditions and an oceanic structure that caused an unprecedented depletion of nutrients in the surface layers. The *E. huxleyi* bloom returned in subsequent years.

Farther to the north, others found that a continued decline in benthic populations in the area south of St. Lawrence Island might be indicative of global change processes influencing ecosystems in the region. Measurements indicate a decline in carbon deposition to the benthos relative to measurements from the late 1980s and early 1990s. This is hypothesized to relate to reduced hydrographic flow in the region. The species composition has shifted, and the new dominant bivalves have probably resulted in an energy loss for the populations of spectacled eiders, diving ducks, and walruses. During its winter stay in the Bering Sea, the entire world population of the spectacled eiders feeds in this polynya.

Important issues in the Arctic Ocean 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.

This area is difficult to reach and presents significant logistical challenges for researchers. In the late 1990s U.S. Navy submarines supported civilian scientists on unclassified cruises, known as Science Ice Experiments (SCICEX), under the Arctic Ocean ice cap. These cruises have ended, but there is a new agreement to continue to use submarines to conduct science experiments on a more limited basis when feasible, so there are still opportunities for some sample collection. Results from the original cruises are still being analyzed and were becoming available during 2000 and 2001.

One recent result from SCICEX was a comparison of the phylogenetic composition b-Proteobacterial ammonia-oxidizing bacteria (AOB) assemblages in plankton samples collected in the Arctic with similar ones from the Antarctic, which identified a novel 16S rDNA sequence distantly related to *Nitrosospira* in all samples that were positive for AOB. The widespread distribution of this ribotype in cold oceans suggests that it represents a dominant species of planktonic AOB. Its trans-polar distribution contrasts with that of another group of polar prokaryotes, the gas vacuolate bacteria, which display polar endemism. These differences in distribution can be related to the influence of the adaptive strategies of these two groups of organisms on their potential for trans-global dispersal.

Modeling and data analysis have revealed a partial recovery of the cold halocline layer (CHL) in the Eurasian Basin. This layer of cold water isolates the ice from warmer Atlantic water underlying it. Its diminution in the 1990s was considered likely to lead to a reduction in ice cover. Conditions in 2000 were similar to those seen in 1991 by

the icebreaker *Oden*, somewhere between the historical mean and the extreme CHL retreat seen by the mid-1990s, in keeping with the behavior of the Arctic Oscillation index. Researchers have begun to examine the circulation and heat content variability of summertime Pacific waters into the Arctic Ocean. This will assist in an examination of the so-called cool halocline of the western Arctic, where waters of up to a degree above freezing reside just below the mixed layer.

Several ocean science investigations are being conducting in the Arctic regions to better understand the ocean's role in climate change and how it is characterized. A field component (North Pacific–Bering Sea) of a major study is being undertaken to compare directly the fractionation relationship in natural alkenone-producing algae with those developed in laboratory experiments. Although laboratory and field studies suggest that isotopic analyses of alkenones show great potential as a CO_2 proxy because cell geometry may be estimated, the relationship between specific growth rate and carbon isotopic fractionation in natural samples has not been well defined. For this reason the principal investigators will develop and evaluate a novel method based on combining ^{13}C labeling and isotope-ratio-monitoring gas chromatography–mass spectrometry to determine in-situ growth rates of *Emiliania huxleyi* and *Gephyrocapsa oceanica* in the ocean. The objectives of this research are to define the range of growth conditions where the ^{13}C-alkenone-labeling technique gives reliable estimates of growth rate and to identify under what conditions bias may be anticipated. In addition, the principal investigators will evaluate the effects of nutrient and light limitation on carbon isotopic fractionation and explore how culture techniques affect ^{13}C labeling and the relationship between carbon isotopic fractionation, growth rate, and aqueous CO_2 concentrations using dilute batch versus continuous culturing experiments. Lastly, in a select suite of experiments, the rate of incorporation of ^{13}C into alkenones will be compared with other lipids for *E. huxleyi* and *G. oceanica* to provide insight into the physiological functions and biosynthetic pathways of alkenones. Results from this study will help calibrate and validate the use of carbon isotopes in alkenones as a CO_2 proxy, essential knowledge if the paleoceanographic community is to use this proxy to better understand mechanisms of climate change.

In another study, researchers will determine the in-situ rates of gross and net primary productivity in the North Pacific Ocean using measurements of the isotopic composition and saturation level of dissolved oxygen. Marine productivity affects a wide range of fundamental properties of the earth from, for example, the concentration of CO_2 and O_2 in the atmosphere to the magnitude of potential fisheries harvests. Within the near future, potential climate-change-induced alterations of ocean productivity could feed back into changes in the rate of anthropogenic CO_2 buildup in the atmosphere. Our ability to quantify rates of marine productivity is critical to our understanding of how the earth's carbon cycle has changed in the past and will change in the future.

Another project considers the mechanisms of denitrification—the chemical reduction of the dissolved nutrient NO_3^- largely to inert N_2 gas—in the polar oceans and specifically the Bering Sea. Denitrification in the ocean, the loss of nutrient nitrogen essential for biological processes, is conventionally thought to take place only in conditions of relative dissolved oxygen deficiency (less than 5–10 μM O_2). The northern polar ocean shows significant nitrate depletion relative to phosphate despite the concentration of oxygen rarely falling below 15 μM throughout much of the region. It has been known for many years that the Bering Sea in particular exhibits a sizeable nitrate deficit, but whether this arises in the water column or in the sediments, or perhaps is even advected in from low-latitude oxygen minimum zones in the Pacific, remains unclear. Isotopic measurements of nitrate will be used to assess the relative roles of sedimentary vs. water column denitrification based on observed distinct isotopic signatures accompanying these two processes. Using a recently developed isotopic analytical method, the $\delta^{18}O$ of oceanic nitrate will also be developed as a tracer to complement the interpretation of $\delta^{15}N$ differences to study these aspects of the oceanic nitrogen cycle. A further line of enquiry of the study is to consider the proposition that the modern polar Pacific Ocean operates as an analog of the glacial Southern Ocean, a key unknown in interpreting Holocene variations in atmospheric CO_2, thus broadening our understanding of geologically recent climate change.

In a modeling project, investigators are quantifying the physical mechanisms controlling the rates of biological carbon export and the uptake of anthropogenic carbon dioxide (CO_2) in the North Pacific Ocean using a basin-wide general circulation model (GCM). The model is operational and has already been used to evaluate mechanisms of

subduction and water mass formation in the North Pacific and is currently being tested using chlorofluorocarbon tracers (CFCs). The approach used is to first incorporate bomb-produced ^{14}C into the model to validate its advective and diffusive fields. By adding this carbon-based tracer the model will then have been verified with both CFCs and ^{14}C — two tracers with different boundary conditions and time histories. Next, the three-dimensional distribution of biological carbon export and remineralization rates are determined by using the observed distributions of several biological productivity tracers, specifically nitrate and phosphate (and their dissolved organic counterparts), three dissolved atmospheric gases (oxygen, argon, and nitrogen), and the $^{13}C/^{12}C$ ratio of the dissolved inorganic carbon (DIC). Investigators then simulate the anthropogenic CO_2 perturbation and utilize independent reconstructions of the anthropogenic DIC and $^{13}C/^{12}C$ changes in the North Pacific to validate model predictions. Finally, the model response to decadal variability in forcing is examined. There are several reasons to choose the North Pacific Ocean as the site for a basin-scale modeling study. There are three JGOFS time-series sites that yield observed carbon fluxes and anthropogenic CO_2 signals to compare to model predictions. The lack of deep-water formation at its poleward boundary simplifies the meridional circulation compared to the North Atlantic and southern oceans and justifies shorter model runs. Finally, the North Pacific has been the site of intensive chemical tracer measurements, specifically CFCs, ^{14}C, and $^{13}C/^{12}C$, over the last 10 years.

Earth Sciences

ANS supports research in a wide range of fields of geology, including paleoclimatology, glaciomarine sedimentology, permafrost, glacial geology/geomorphology, surficial processes, paleontology, petrology, tectonics, and solid earth geophysics. The paleoenvironmental studies focus on understanding the past Arctic environments by examining the sedimentary and paleontological record of terrestrial coastal plain, continental shelf, and deep marine sediments.

The tectonic evolution of the Arctic Ocean Basin and the Bering Sea is a major scientific problems that needs to be addressed. Tectonic activity such as subsidence, uplift, and seafloor spreading has opened the basin since the mid-Mesozoic. New geological and geophysical studies will help our understanding of the evolution of the basin, which is a crucial missing link in understanding much of Arctic history.

During August and September 2001 the new U.S. Coast Guard icebreaker *Healy* and the German research vessel *Polarstern* from the Alfred Wegner Institute in Bremerhaven made an "epic" journey to map and sample the 1800-km Gakkel Ridge in the Arctic Ocean, the world's slowest-spreading mid-ocean ridge. This was the *Healy's* maiden scientific voyage, and her performance exceeded anyone's expectations and everyone's scientific goals.

The primary objective was to sample the Gakkel Ridge using dredges and wax corers. Basalts and peridotites were recovered from approximately 225 sites along the ridge, which is about three times the number proposed. Using the hull-mounted multi-beam sonar system on both ships produced a high-resolution map of the Gakkel Ridge. These systems were not expected to work well in the ice because the ice is noisy against the hull and it interferes with the sonar. However, the sonars on the new *Healy* and *Polarstern* worked well.

The scientists found many unexpected features. The bathymetric map revealed that there were many more volcanoes than expected, and some were similar to those found on land. Seismic measurements from the *Polarstern* showed that the crust thickness varies along the ridge axis. These variations may be related to volcanic centers.

Scientists used an instrument called a miniature autonomous plume recorder (MAPR) to locate hydrothermal activity by measuring the temperature and optical properties of water columns. With the discovery of hydrothermal vents along the Gakkel Ridge, it is believed that hydrothermal activity can occur anywhere, even at extremely slowly spreading ridges. They recovered fresh sulfides, which are part of "black smoker" chimneys and the most striking manifestation of hydrothermal activity. Black smokers could potentially support previously unknown marine organisms.

Permafrost is ubiquitous in cold climates, and its occurrence and thickness increase during cold periods and decrease in warmer periods. Discontinuous permafrost is ice-rich permafrost that is thawing or degrading; its temperatures range from $-5°$ to $-2°C$. Therefore, its occurrence and distribution are particularly sensitive to climate changes. Recent studies have shown that increases in air temperatures in the Arctic have been greater than increases in temperatures in the temperate climates. Such temperature increases should have been reflected in an increase in

permafrost temperatures, but a number of other parameters such as the depth and duration of annual snow cover can also affect the permafrost. As a result, there is concern about the future of permafrost and response to warming trends.

Closely related to the concerns about permafrost thawing is the role of the tremendous volume of clathrates or frozen gas hydrates that are associated with and found below the permafrost and off the shelf areas. Gas hydrates are frozen methane and water that can hold methane at concentrations approaching that of liquefied natural gas. Methane hydrates could have a major influence in stabilizing climate during periods of major cooling; more important is the concern over the stability of these deposits during a warming trend. Large releases of methane could increase atmospheric concentrations of methane. Furthermore, they could also change the strength of seafloor sediments, which could affect seafloor stability.

Contaminants

ANS encourages basic science research on the physical, chemical, and biological processes that sequester and disperse contaminants. Quantification of these processes for a variety of contaminants, including heavy metals, radionuclides, persistent organic pollutants (such as pesticides and industrial chemicals), hydrocarbons, ozone (and its precursors), and aerosols derived from various parts of the Arctic, is fundamental to appreciating and mitigating their impact on human physical and socioeconomic systems.

Research on ultraviolet impacts found that the presence of humic materials in Arctic Norwegian coastal waters results in rapid attenuation of ultraviolet radiation compared to extinction coefficients obtained in Antarctic waters. As this will minimize the loss of integrated primary production due to ultraviolet radiation in the euphotic zone, it means that it is important to understand the seasonal aspects of humic materials in coastal waters, the timing of atmospheric ozone depletion, and the timing of the spring phytoplankton bloom, which is important for fish larvae.

In a study using natural and anthropogenic radionuclides in sea ice sediments to characterize the sources of these sediments and possible modifications as they are transported across the Arctic in the transpolar drift, researchers found that samples of sea ice sediment recovered from sea ice floes around Svalbard all had detectable ^{137}Cs activity. Measurements of plutonium isotope ratios ($^{240}Pu/^{239}Pu$) on these samples show that the source of the plutonium is fallout from the atmospheric testing of atomic weapons. There was no evidence in the sea ice sediment samples of a source of plutonium from Russian nuclear facilities in the Siberian Arctic. However, measurements of the $^{240}Pu/^{239}Pu$ isotope ratio in bottom sediments from the Fram Strait and Northeast Water Polynya show that non-fallout plutonium may have been added to these areas in the past.

Environmental Research

The purpose of NSF's ANS environmental research 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.

ANS researchers found that the needle retention of forest white spruce in the Chugach Mountains in the south of Alaska was about half of that in the White Mountains in interior Alaska and the Brooks Range in northern Alaska. The trees above the forest limit (within the treeline zone) showed premature needle loss and thus lower needle retention than forest trees. This difference in needle retention between forest and treeline is greatest in the southernmost mountain range (the Chugach Mountains) and least in the northernmost mountain range (the Brooks Range). Tree growth decreased northwards and up in elevation, and the greatest difference between elevations was in the southernmost Chugach Mountains, where climatic differences between treeline and forest sites are most extreme. These results have implications for vegetation in a warming scenario.

The Arctic Long Term Ecological Research (LTER) projects continue to provide insights into Arctic and near-Arctic habitats. Research at Toolik Lake in the northern foothills of the Brooks Range has identified a host of interrelationships between atmosphere, soil, water, and dominant biotic components. In a finding that could have important consequences for land use policies in watersheds from the Chesapeake Bay to Puget Sound, researchers have discovered that small streams contribute more to removing nutrients such as nitrogen from water than do their larger counterparts. There's a strong relationship between the

size of a stream and how rapidly that stream removes nutrients. The smaller the stream, the more quickly nitrogen can be removed and the less distance it will be transported down the stream. The findings are based on data collected initially from streams in NSF's Arctic Tundra Long-Term Ecological Research site in Alaska and subsequently from 12 sites across the country.

Biological Sciences

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

In a project combining biomedical physics knowledge and an interest in oceanography, researchers demonstrated the physics by which polymers in the dissolved organic matter pool of seawater form nanogels that can assemble spontaneously and reversibly into microgels, and they related this to the role of assembled microgels in bacterial production. Of fundamental significance to the field of oceanography by contributing an understanding of mechanisms for the study of dissolved and particulate matter in seawater, this work led to a successful biocomplexity proposal.

In another fundamental study, as part of a project on the dynamic properties of plankton in polar lakes, researchers developed a new model of kinetic theory that they believe could replace the 90-year-old Michaelis Menten and 60-year-old Monod models to become the new standard for describing and understanding nutrient flux and transport into microorganisms and other cells. The new model predicts the various cellular components relevant to transport and growth, such as permease distributions, metabolic pool concentrations, and enzyme concentrations and ratios from first principles according to kinetic theory, providing a powerful tool for designing experiments that may probe nutrient dynamics on both a system and a cellular level. Replacing a paradigm as firmly entrenched as Michaelis Menten will certainly encounter barriers, but it has proceeded so far without challenge.

In a study on population genetics, scientists produced the first genetic characterization of the major lineages of an ecologically important freshwater crustacean group (*Bosmina*). Using 16S reference sequences they developed, researchers can now determine the major group to which given populations belong. This is an important contribution to the comparative biology of Arctic freshwater organisms. They also found the first strong evidence for the origin of an Arctic polyploid animal. Newly collected nuclear phylogeography and mtDNA evidence suggest that the most successful zooplankter in glacial lakes (*Daphnia galeata mendotae*) resulted from hybridization between two species that hid out in Beringia during the last glaciation, meaning that animal species can be created by gene flow across species boundaries resulting from hybridization. The phylogeographic patterns emerging from freshwater microcrustaceans suggest a close association of eastern Canadian Arctic to European Arctic species, and a close association of western North American Arctic species with Asian Arctic species (Beringia). This challenges the argument that Greenland acts as a dispersal barrier between North American and Eurasian freshwater species in the Arctic.

Bird researchers discovered that the adrenocortical response to stress is suppressed in Arctic breeding birds. They found three possible receptor types for corticosteroids in the passerine brain, one of which appears to be different from the mammalian type. Additionally, they were able to measure mRNA for androgen receptor gene expression in a passerine brain. Moreover, field studies in Barrow revealed that snow buntings and redpolls are polyandrous (that is, each nesting females has from one to five males attending her and the nest), a condition that appears unique in Arctic passerines.

By using DNA analysis on fossil bones, researchers discovered a dramatic genetic turnover event about 20,000 years ago in brown bears and gray wolves from deposits near Fairbanks, Alaska. Prior to 20,000 years ago, North American bears and wolves show a wide diversity of distinctive DNA sequences that were later replaced by new sequences of apparently Old World origin just as the land bridge with Asia opened. These new sequences carry through to the present with minor modifications. Because they showed that pre-glacial populations of bears and wolves were genetically more diverse than post-glacial ones, these results suggest a historical rather than an anthropogenic cause of limited genetic diversity in large North American carnivores. They also showed that apparent genetic differences among brown bear populations have a very recent origin. Both results have important conservation implications. Results also indicate an extinction event

and subsequent migration from the Old World about 20,000 years ago that has not been recognized in past geologic or faunal analyses. If supported by further study on other species, this would have substantial importance for theories of faunal change in the late Pleistocene.

Transfer of Results

Scientists from the Arctic LTER brief representatives of the Alaska Department of Fish and Game (ADF&G) each year on the results of the research underway at Toolik Lake. In 2001 these meetings resulted in the ADF&G instigating a catch-and-release-only program for lake trout north of the Brooks Range after the scientists informed them of the slow growth and extreme longevity (more than 50 years) of the lake trout in this region.

In August 2000, researchers studying airborne contaminants in fish on the North Slope met in the field with delegates from the U.S. Department of the Interior, several state and Federal congressional staff members, the NSF liaison to Congress, and numerous local government officials to provide a special briefing on Arctic contaminants and their relevance to Arctic communities. Their research contributes significantly to our understanding of how environmental issues affect Inupiat people. They worked directly with village elders and other members of the community in planning experimental design and field work, thus not only benefiting from the collective wisdom of the locals, but also ensuring that the project would contribute significantly to society.

Arctic Social Sciences

The Arctic Social Sciences Program received a 25% funding increase in FY 01, bringing the total budget—including research support and logistics—to $2.3 million. The program supports research projects in sociology, political science, linguistics, traditional knowledge, anthropology, archaeology, and cross-disciplinary studies with the natural sciences. In January 2001 the Arctic Social Sciences Program sponsored a workshop to enhance the research and education linkages among the different social science disciplines, across national and cultural boundaries in the North, and among the social, natural, and physical sciences. Summaries of the workshop discussions are available on the ARCUS web site at http://www.arcus.org/ASSP_workshop/index.html. Following are highlights of Arctic social sciences projects supported by NSF.

Survey of Living Conditions in the Arctic

A new social survey of the Inuit, Saami, and Chukotkan indigenous populations will be the first systematic, comparative investigation of living conditions across the Arctic, including measures of individual, household, and community well-being. The survey is a collaborative international project involving scholars and indigenous groups from the U.S., Canada, Greenland, Norway, Sweden, Finland, and Russia. In addition to the NSF grant, the project has received support from the Nordic Council of Ministers, the Greenlandic Home Rule Government, the Commission for Scientific Research in Greenland, the Barents Secretariat, the North Atlantic Research Program, the Danish Research Council of Social Science, the Swedish Research Council of Social Science, the Social Sciences and Humanities Research Council of Canada, and Statistics Canada.

Human History in Southeast Alaska

Archaeologists working with southeast Alaska tribes have uncovered evidence that by approximately 9200 years before present, humans along the northwest coast of America were coastal navigators with an economy based on maritime subsistence and established trade networks for obsidian. This evidence strengthens the theory that humans may have first entered the Americas using watercraft along the northwest coast of North America during the late Pleistocene.

Ancient and Modern DNA

The first research project in anthropological genetics to simultaneously examine genetic variation in known ancestral and descendent populations, the Origins of Aleut Populations is a collaborative study with biological anthropologists, archaeologists, and Aleut organizations and communities. Preliminary findings indicate genetic and cultural continuity over time in the Aleutian Islands. A related study in the eastern Arctic reveals a surprising similarity of the ancient Dorset populations in eastern Canada to prehistoric Aleut populations in the western sub-Arctic. This suggests new avenues of research regarding population movement and settlement of the entire North American Arctic region.

Athabaskan Linguistics

For the first time the Athabaskan language of Tanacross has received thorough study, description, and documentation. Tanacross is unique among the Athabaskan languages with its

dynamic system of complex tones that interacts with morphology, syntax, and pragmatics. The behavior of the complex tone differs from that in Upper Tanana and Han, the only other Alaska Athabaskan languages reported to have complex tone. The documentation provides a foundation for language teaching within the Tanacross community, and community involvement with the project has increased awareness of language issues and language policy in other regions of Alaska.

Traditional Knowledge in a Changing Arctic

The Calista Elders' Council is gathering, documenting, and sharing traditional knowledge on the Yup'ik way of "being" through regional meetings, culture camps, and in-depth discussions with Yup'ik elders. Elders have been training youth in traditional Yup'ik values and rules that have guided social relations in the past, including mechanisms of social control. Documentation of these discussions has been made available to teachers, students, and community members across the Yup'ik region. The focus has been on the elders' point of view, and the project is an example of local initiative in proposing and carrying out research and education.

Circumpolar Arctic Social Science Network

Graduate students from eight Arctic countries plus Japan and six senior faculty from major circumpolar universities gathered for an intensive summer study session called "Northern Communities and Global Change: New Approaches to Community Resource Management and Use." With support from NSF, the Nordic Academy for Advanced Study, Canada's Social Science and Humanities Research Council, and others, the Ph.D. Network for Circumpolar Arctic Social Science (CASS) provides a focal point for students and faculty from diverse disciplines and academic institutions who study the Arctic. The sustained network of CASS provides an opportunity to exchange information and ideas with faculty, northern indigenous communities, and fellow students.

Education

The Teachers Experiencing the Arctic (TEA) program included 17 teachers from 13 states in FY 00 and 01. The teachers partnered with NSF-supported research teams, performed field studies with the teams, and helped to analyze the results. Each teacher involved his or her school with communications to and from the field, classroom activities, and other special projects. The infusion of research into the classroom brought greater awareness of the Arctic to non-Arctic communities and helped inspire students to contemplate science careers. More information is available on the TEA web site at http://tea.rice.edu.

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 in 2001. The seventh revision to the U.S. Arctic Research Plan included two major sections. The first of these presented the Special Focus Interagency Research Programs:

- Arctic Environmental Change;
- Bering Sea Research and Assessment; and
- Arctic Health Research.

The second major section was Agency Programs, which represents the objectives of Federal agencies, focusing on the period covered by this revision (2002–2006). 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; and
- Health.

The Interagency Plan also addressed issues related to logistics support for Arctic research and new opportunities 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 has included studies of the mechanical properties of ice, the hydraulic conductivity of frozen soils, metamorphism of dry snowpacks, and three-dimensional analyses of ice.

NSF also sponsors a program for science-based, high-technology small business firms, the Small Business Innovative Research (SBIR) program 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 TA&R program supports research associated with operational safety and pollution prevention, as well as oil spill response and cleanup capabilities, as described in *Arctic Research of the United States* (Volume 14, spring/summer 2000). The program operates through contracts with universities, private firms, and government laboratories to assess safety-related technologies and to perform necessary applied research. The TA&R program's research capabilities are enhanced by an ongoing cooperative agreement with the Offshore Technology Research Center, a joint program between the University of Texas and Texas A&M University, located in College Station, Texas. Studies are performed in cooperation with the offshore industry and with other agencies or governments.

	Funding (thousands)	
	FY 00	FY 01
Technology Assessment/Research	3,200	3,200
Environmental Studies	3,800	3,800
Total	7,000	7,000

The TAR Program has four primary objectives:

- Technical Support: TA&R provides engineering support to MMS decision makers in evaluating industry operational proposals and related technical issues and ensuring that these proposals comply with applicable regulations, rules, and operational guidelines and standards.
- Technology Assessment: Industry applications of technological innovations are investigated and assessed to ensure that governing MMS regulations, rules, and operational guidelines encompass the use of the best available and safest technologies.
- Research Catalyst: The program promotes leadership in operational safety and engineering research and oil spill research by acting as a catalyst for industry research initiatives.
- International Regulations: The program provides international cooperation for research and development initiatives to enhance the safety of offshore oil and natural gas activities and the development of appropriate regulatory program elements worldwide.

The TA&R program is focusing its research efforts in the following four areas:

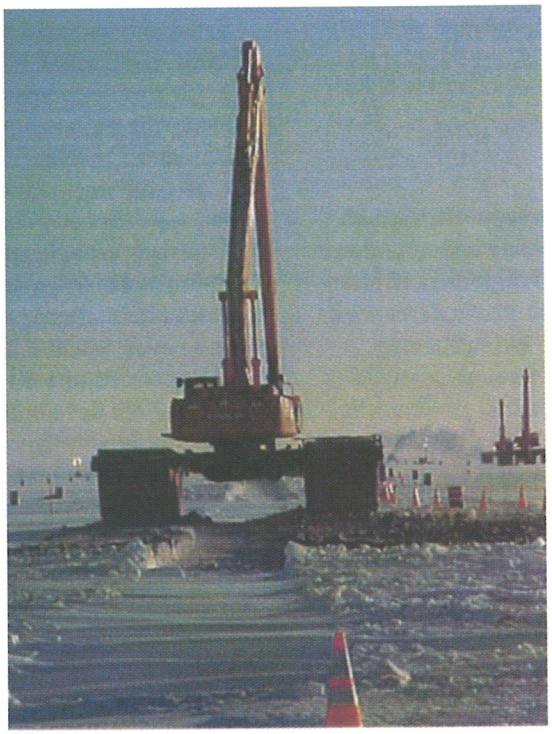
- Frontier areas of operations (both deep water and the Arctic), including safety issues as well as the integrity of structures and pipelines;
- Human and organization factors and how they can be addressed to mitigate accidents;
- The aging offshore infrastructure, including

platforms and pipelines; and
- Spill mitigation measures, including cleanup and containment technologies for an oil spill, should one occur.

Operational Safety and Engineering Research

Arctic offshore operations have been hampered more by the lack of commercially economic discoveries than by technology constraints. However, sea ice continues to be a severe environmental hazard posed by the Arctic relative to future offshore development. 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:

- A joint industry project (JIP) on "3D Finite Element Analysis of Pipe/Soil Interaction" will investigate how the soil around buried pipelines interacts with the pipe when under some type of motion or force. The results from this work will develop a better understanding of how forces due to earthquakes or ice gouging act on the pipeline and will assist in developing better design guidelines.
- To better assess the current technology for detecting leaks in a sub-sea pipeline, the MMS initiated a project called "World Wide Assessment of Industry Leak Detection Capabilities for Single and Multiphase Pipelines." The technologies selected for study will be analyzed for their effectiveness for pipelines in use in the Gulf of Mexico, Pacific, and Arctic.
- A "Strain-Based Design of Pipelines" project will develop a best-practice guide that will cover design, assessment, and testing guidelines for designers of pipelines that may experience high strains in service, as may occur in deep water and in the Arctic.
- A project titled "Real Time Reliability Assessment of Pipelines" will develop, verify, and test procedures that can be used during the in-line instrumentation of pipelines in order to characterize their reliability. This project will develop a more streamlined method for analyzing data from pipeline inspections.
- "The Performance of Offshore Pipelines" is a JIP to test and verify the accuracy of smart pigs. Several pipelines will be over-pressured to failure, and pig data and actual measurements will be compared using currently available reliability methods.
- Another project was initiated called "Reliability of Pressure Signals in Offshore Pipeline Leak Detection Systems," which will investigate the reliability of pressure safety lows used in pipeline leak prevention systems.
- A major problem with sub-sea pipelines is the uneven bottom conditions encountered when installing the systems. To address this problem a project was initiated called "Developing an Industry-Wide Best-Practice for the Assessment of Spans in Existing Submarine Pipelines."
- A JIP called "Risk-Based Optimization of Pipeline Integrity Maintenance Activities" will assess and develop risk-based models and software tools for estimating the risk levels associated with a given segment of pipe in a pipeline system.
- A JIP called "Risk Assessment and Management Based Criteria for Requalification of Marine Pipelines" will develop a requalification method for pipelines, compile a database, and develop a pipeline model including items of importance to the requalification process.
- "A Study of Paraffin Deposition in Multiphase Flowlines" is a JIP that will develop an integrated model to predict paraffin deposition in gas/oil production systems.
- The Second International Workshop on Human Factors in Offshore Operations will provide the first opportunity since 1996 to work with government and industry leaders to



Enormous backhoes with significant reach used on strengthened ice to install an offshore pipeline in the Beaufort Sea.

develop human factors tools that can be applied offshore to improve safety, quality, and reliability and reduce incidents.

- The International Workshop on Fire and Blast Considerations in the Future Design of Offshore Facilities will provide a forum for industry, regulatory agencies, and certification organizations to establish present-day technology and state-of-practice in the areas of design safety, hazard identification and management, and fire and blast loading and resistance.
- The Banff/2001 Pipeline Workshop, held in Banff, Canada, was the fifth in a series of workshops that Natural Resources Canada (NRC) has organized to address new pipeline technologies. The workshop reviewed the progress achieved from the 1999 workshop, with intensive group discussions on such topics as risk assessment and management, abandonment issues, and in-line inspections.
- MMS will sponsor an International Offshore Pipeline Workshop planned for February 2003 in New Orleans. The objective of the workshop is to bring together worldwide experience in operating and regulating offshore oil and gas activities in order to identify pipeline issues and disseminate knowledge for continued safe and pollution-free operations.
- The IUTAM Symposium: Scaling Laws in Ice Mechanics and Ice Dynamics workshop was held in Fairbanks, Alaska, on January 12–15, 2000 and was attended by over 100 scientists. The aim of the symposium was to develop a better understanding of the ice deformation process and the role of ice movements in the atmosphere–ice–ocean system.
- "A Survey of Supervisory Control and Data Acquisition (SCADA) System Technology and their Reliability in the Oil and Gas Industry" will determine the current state-of-practice for SCADA technology and assess the reliability of current SCADA technology for pipeline leak detection.
- "A Manual for Sound Coiled-Tubing Drilling Practices" is being developed that will address all facets of safe and efficient operations of this new technology.
- A related project called "Ultrasonic Nondestructive Evaluation of Spoolable Composite Tubulars" will develop a technology for extremely rapid, in-situ ultrasonic nondestructive testing of spoolable composite tubulars.
- A companion project titled "Interdisciplinary Design for Composite Coiled Tubulars" will illustrate the effect of hybrid fiber reinforcement on resistance to damage initiation and progression.

Although these 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 harsh environments. In addition to the development of numerical models, 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 because of 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.

Oil Spill Response Research

The MMS is the principal U.S. government agency sponsoring offshore oil spill response research. MMS maintains a comprehensive international Oil Spill Research (OSR) program, which originated in the late 1970s, to improve oil spill response technologies and procedures. This program has expanded the existing capabilities to respond to an open-ocean oil spill. The scope of the MMS oil spill response research program was increased in 1986 by aligning the MMS program with Environment Canada (EC) and the National Institute of Standards and Technology. The OSR program complies with Title VII of the Oil Pollution Act (OPA) of 1990 and cooperated with the Interagency Coordinating Committee for Oil Pollution Research, as called for in the OPA.

The MMS and EC have jointly produced a catalog of crude oil and oil product properties. This information is critical to responders in planning a clean-up strategy. The oil properties catalog was first compiled by EC in 1984, and MMS has jointly funded the catalog program since 1989. The current catalog contains information on over 431 types of crude oils and petroleum products, including many Outer Continental Shelf crude oils. The catalog is available from EC's website (www.etcentre.org/spills).

The MMS has been involved in a multinational effort, including Norwegian, Canadian, German, and American researchers, to develop a prototype of a skimmer system capable of effectively cleaning up oil in broken ice conditions. Mechanical oil

Test of the MORICE skimmer unit at the Ohmsett test facility.

clean-up in broken ice has been difficult and inefficient. The goal of this program, called Mechanical Oil Recovery in Ice Infested Waters (MORICE), is to improve the equipment and techniques for mechanical recovery of oil spills in ice-infested waters. MORICE, initiated in 1995, has demonstrated the potential to improve mechanical recovery in ice-covered waters during a series of small test tank experiments and field trials without oil. In January 2002 the full-scale prototype and two types of recovery units were tested and evaluated in the large outdoor test tank at the Ohmsett facility in Leonardo, NJ. The prototype was tested in simulated Arctic broken ice conditions, with various concentrations of oil.

The MMS and ExxonMobil participated in a series of experiments at the Ohmsett facility to evaluate the effectiveness of Corexit 9527 and 9500 dispersants on two crude oils: Alaska North Slope crude produced in Prudhoe Bay and Hibernia crude produced in Canadian waters off the coast of Newfoundland. These experiments took place during February and March 2002 in the large outdoor test tank at the Ohmsett facility. These tests will provide a more realistic scale to determine dispersability of these crudes under simulated Arctic cold water conditions. The results will be used to support regulatory decisions in the U.S. and Canada regarding the use of dispersants as an alternative response strategy in these areas.

Ohmsett is the National Oil Spill Response Test Facility managed by the MMS. 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 conduct full-scale oil spill response equipment tests with a variety of crude oils and refined petroleum products. Equipment tests are conducted under controlled, reproducible conditions and include the capability for variable, artificial wavemaking. Ohmsett provides a unique facility to conduct tests and develop new devices and techniques that detect, map, contain, and clean up oil spills. The primary feature of the facility is a pile-supported, concrete tank filled with 9.84 million liters of brackish water. The tank has a movable, cable-drawn towing bridge 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.

During 2001–2002 the Ohmsett facility has been upgraded to be able to simulate Arctic conditions in the test tank. The water is maintained at near-freezing temperatures through the use of a commercial chiller unit. Ice is grown in 8- to 10-in.-thick sheets at the Cold Regions Research and Engineering Laboratory in New Hampshire, cut into sections, and shipped to Ohmsett in refrigerated trucks. This new capability allows simulated Arctic ice field conditions to be maintained throughout the winter and enables testing and training to be conducted at Ohmsett during what is normally a slow period. In addition, the capability to test dispersants at a more realistic scale was added to the Ohmsett facility during 2000.

Alaska Environmental Studies Program

As the managing agency for the Department of Interior's Outer Continental Shelf offshore oil and gas leasing program in Alaska, the MMS Alaska Outer Continental Shelf (OCS) Region has conducted environmental studies since 1974 to obtain information needed to make sound leasing decisions and to monitor the human, marine, and coastal environments. In Alaska, more than $265 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 physical oceanography, endangered species, living resources, fate and effects, and socioeconomics. The information is used in MMS decision making and monitoring related to proposed and existing offshore oil and gas development in Alaska.

Regional government leaders, traditional knowledge sources, environmental groups, oil and fishing industry personnel, studies contractors, other scientists, MMS components, 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 pooling of shared knowledge results in a synthesis of information that identifies studies needed to meet the current focus on post-lease and monitoring information requirements.

Coastal Marine Institutes (CMIs) were initiated by MMS to take advantage of highly qualified, scientific expertise at local levels and to achieve cooperative research goals in key OCS regions. In 1998 the MMS renewed funding of the CMI at the University of Alaska Fairbanks (UAF) to benefit from its nationally recognized scope and depth of scientific expertise. 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, internationally renowned for its coastal and 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. In addition to 15 ongoing studies, 9 new studies are being evaluated for funding through the CMI in FY 02.

Endangered and Protected Species

The bowhead whale, an endangered marine mammal of high importance to Native cultures in the Arctic, migrates through areas that have been explored for oil and gas, including the Northstar offshore production site. Efforts to define the migration corridors of bowhead whales and their responses to offshore operations and environmental factors continue under the ongoing MMS-conducted Bowhead Whale Aerial Survey Project (BWASP) and an MMS-funded study, "Analysis of Covariance of Human Activities and Sea Ice in Relation to Fall Migrations of Bowhead Whales." BWASP results indicate that fall bowhead whale sightings tend to be farther offshore in heavy ice years across the central Alaskan Beaufort Sea (142–155°W longitudes). While factors other than sea ice may have localized effects on site-specific distributions, broad-area distributions of bowhead whales in the central Alaskan Beaufort Sea apparently are related to overall sea ice severity. The analysis of covariance study will further test hypotheses regarding the relative degree to which various human activities and sea ice may explain the variance in observed bowhead whale distributions.

Northstar, the first offshore oil development in the Alaskan Beaufort Sea.

A multi-year study, "Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information," has been unique in the extent of its coordination with area whale hunters. Residents of Kaktovik, Alaska, have assisted and continue to assist in the study design, field implementation, report review, and knowledge sharing needed to determine the importance of the eastern Alaskan Beaufort Sea area to feeding bowheads. Other study components included aerial photography, behavioral observations, isotopic analysis of baleen and muscle tissue, stomach content analysis, and energetics modeling.

Beluga whales are an important species for Native subsistence. More than 300 are harvested annually in Alaska. The movements of beluga whales are being documented using satellite telemetry under the MMS/UAF CMI study titled "Satellite Tracking of Eastern Chukchi Sea Beluga Whales in the Beaufort Sea and Arctic Ocean." During 2001 eight whales were instrumented with the help of Native subsistence hunters in Kasegaluk Lagoon near the village of Point Lay. Data from this and a previous MMS-funded study suggest that female belugas may not move as far north in the Beaufort Sea as male belugas do. Tagged females remained within about 60 km of shore and quite near the continental shelf break in the Beaufort Sea. Conversely all instrumented males traveled north of the shelf break over waters exceeding 3000 m in depth. The investigators plan to instrument additional whales near Point Lay during 2002.

Ringed seals, the most abundant seal in the world, are the primary prey of polar bears and a significant source of food for Natives living in the Arctic. The MMS funded three studies during 1999–2001 addressing the distribution, abundance,

and/or behavior of the species. An MMS/UAF CMI project, "Correction Factor for Ringed Seal Surveys in Northern Alaska," was designed to provide insights into the precision and accuracy of seal counts taken during spring aircraft surveys. Generally, when surveys are underway, seals are transitioning from resting in subnivean lairs, in which they cannot be seen from aircraft, to basking on the surface of the ice. Therefore, it is important to correct estimates derived from surveys for the proportion of seals invisible in lairs. Date-specific correction factors have been developed as a result of this study. A follow-up study titled "Timing and Reinterpretation of Ringed Seal Surveys" began in 2001. The goal of this project is to develop models of the proportion of seals visible as a function of snow conditions and to re-analyze previous aerial surveys in light of the correction factor. A third MMS-sponsored study of ringed seals, "Monitoring Key Marine Mammals, Arctic: Beaufort Ringed Seals," was funded through a cooperative agreement with the Alaska Department of Fish and Game (ADF&G). This study consisted of three annual aircraft surveys of seals near the areas of oil and gas development at Prudhoe Bay. The surveys were designed to be comparable with earlier surveys funded by MMS and conducted by the same ADF&G research team as in the 1980s. Fieldwork was completed in 1999, but analysis of the data has yet to be completed. The results of the MMS/UAF CMI studies of correction factors will have a bearing on the interpretation of the past and future aircraft surveys.

Eiders (a species of sea duck) are harvested by Alaska Natives for subsistence and are believed to be declining throughout the Arctic. A new study, funded in FY 01 through the MMS/UAF CMI and titled "Importance of the Alaska Beaufort Sea to King Eiders," was designed to provide information about how king eiders make use of the waters of the OCS or adjacent near-coastal areas. In this study, eiders will be implanted with satellite transmitters in the Prudhoe Bay area and monitored as they assemble in near-coastal waters to molt and subsequently migrate to their wintering areas.

Physical Oceanography

In the first phase of a three-year mooring program, an MMS/UAF CMI study reported the first successful winter-long measurements of currents directly under the ice in the nearshore Beaufort Sea. Three upward-looking acoustic Doppler current profilers were moored on the sea bottom within the barrier islands near the Northstar and Liberty offshore development prospects. Collected data included water and ice velocity, temperature, salinity, and water clarity (transmissivity) from August 1999 to August 2000. Once landfast ice formed and blocked the wind, current speeds dropped drastically, with less than 1% of current speeds exceeding 20 cm/s.

A second, soon-to-be-completed CMI oceanographic study examined circulation, thermohaline structure, and cross-shelf transport in the Alaskan Beaufort Sea using time-series measurements from moored instruments along the outer shelf and slope. The U.S. Navy supplemented this study with concurrent hydrographic measurements made by a nuclear-powered submarine under the ice.

Knowledge of predominant weather patterns in the Beaufort Sea enables us to better evaluate the potential effects of an oil spill and develop response strategies in case an oil spill occurs. An MMS/UAF CMI study of cyclonic and anticyclonic weather regimes that average 7–10 years in the Beaufort Sea will improve modeling of potential oil spills. Anomalous weather patterns in recent years will receive additional scrutiny to determine whether a new pattern is emerging.

The goals of the study titled "Synthesis and Collection of Meteorological Data in the Nearshore Beaufort Sea" are to collect new data from the deployment of meteorological stations and to collate historical meteorological data from the Beaufort Sea locations subject to immediate development. Three meteorological stations were installed in January 2001 on the Beaufort Sea coast and one station on the Northstar production facility. This study will provide a complete time series of wind data to MMS modelers and researchers for use in their ongoing modeling of the near-shore Beaufort Sea. These data are uploaded to a web site (www.resdat.com/mms), where they are available to the public.

Fate and Effects

An MMS/UAF CMI study recently examined and reported on the historical changes in trace metals and hydrocarbons in the inner shelf sediments of the Beaufort Sea. The study used a combination of dated sediment cores, freshly collected surface sediment, 30 years of prior analytical measurements by the investigator, and data from the prior MMS Beaufort Sea Monitoring Program. Of multiple metals, only vanadium and barium were possibly higher in more recently collected and analyzed sediments. The levels of vanadium and

Oceanographic vessel used for MMS-sponsored sediment geochemistry studies in Shelikof Strait, Alaska.

barium found were still low and well below harmful levels. The hydrocarbon analyses primarily found natural compounds indicative of decayed marine plankton and peat from onshore. No petroleum signal was found. The study concluded that the near-shore Beaufort Sea has remained a relatively clean environment as far as trace metals and hydrocarbons are concerned, despite the petroleum-related industrial activities there during the past 30 years. A follow-up CMI study is examining inshore Beaufort Sea sediments closer to Barrow and a staging site for early oil and gas exploration in the Naval Petroleum Reserve–Alaska.

A just-completed oceanographic study examined sediment quality in surface sediments and dated cores from likely contaminant depositional areas in lower Cook Inlet and Shelikof Strait. Concentrations of hydrocarbons and metals in dated sediment cores were at background levels throughout the area and demonstrated that sediment concentrations of these contaminants had not increased since the first oil and gas development in Cook Inlet. Based on multiple criteria the study concluded that the concentrations of contaminants found did not pose an ecological risk to marine organisms in the study area.

In the first of three laboratory studies, the effects of weathered North Slope crude oil, ultraviolet light, and their synergistic effects on zooplankton are being studied by an MMS/UAF CMI project. Establishment of a correlation coefficient between total lipid content and polycyclic aromatic hydrocarbon (PAH) uptake will allow estimates of the PAH load of predominant plankton on the basis of abundance data and their lipid profile. The further distribution of PAH into the ecosystem through zooplankton feces is also being evaluated. Another CMI study looks at the kinetics and mechanism of slow PAH desorption from lower Cook Inlet and Beaufort Sea sediments. This study will lead to better predictive capability for the environmental fate of PAH in Arctic sediments. A third laboratory-based MMS/UAF CMI study examines petroleum-degrading bacteria communities in Beaufort Sea sediments and will compare the current community to that existing at the onset of coastal Beaufort Sea development in the late 1970s.

In the first of three modeling studies, Rutgers University used the Sigma-Coordinate Rutgers University Model (SCRUM), coupled to a sea ice model, to provide a 1982–1996 hindcast of ice and water circulation in the Arctic Ocean. The resulting circulation fields are being used by MMS in stochastic oil-spill-trajectory modeling for proposed offshore oil and gas lease sales in the Beaufort and Chukchi Seas. A CMI modeling study is following up with a fine-scale coupled ice–ocean model for the nearshore Beaufort Sea to improve modeling capabilities within and near the barrier islands. In a third modeling study the MMS is participating in a consortium to advance the state of the art in oil weathering models, including the addition of Alaska-specific oils and ice conditions.

In the first of three oil spill statistical analyses, MMS collated and analyzed onshore North Slope and Trans-Alaska Pipeline System oil spill statistics. These data were used in evaluating the oil spill risk for the nearshore Liberty prospect. MMS is re-evaluating the oil spill risk for the general offshore case in the Beaufort and Chukchi Seas with parallel fault-tree and statistical engineering approaches. These studies include an analysis of differences in potential spill causes in these Arctic areas versus elsewhere in the U.S. OCS, primarily the Gulf of Mexico.

Monitoring

A multi-disciplinary, site-specific Beaufort Sea monitoring study, "Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA)" was initiated in June 1999. This study examines impacts associated with the first anticipated Federal oil development on the Alaskan OCS, the Northstar and Liberty prospects near Prudhoe Bay, Alaska. Phase I of ANIMIDA recently reported the results of measurements and analyses of ambient noise, resuspension of sediments, and sediment quality. Ambient noise and vibration levels in air, ice, and water were recorded at multiple locations around the Northstar and Liberty sites during active construction of the Northstar Island.

Measurements were obtained for multiple construction activities such as sheet pile driving by vibrahammer, plowing operations, general truck movement on and near the island, island-mounted machinery, and pipeline trench backfilling operations. ANIMIDA measurements of suspended sediment levels and of trace metal and hydrocarbon contaminants in bottom sediment, suspended sediment, and benthic biota were made prior to Northstar Island construction.

Scientists sampling sediments as part of the ANIMIDA study in the near-shore Beaufort Sea.

Designed to provide long-term continuity beyond what could be expected through industry-sponsored studies alone, MMS-sponsored monitoring will continue in ANIMIDA Phase II (years 2–5) and beyond. Phase II also expands monitoring by measuring the partitioning of contaminants between dissolved and particulate water phases and by measuring trace metals, hydrocarbons, persistent organic pollutants, and biomarkers in fish; effects on kelp in the Boulder Patch (an area of Special Biological Concern); and the perceived effects on Native subsistence whaling.

The MMS Bowhead Whale Aerial Survey Project (BWASP) has provided monitoring information on each fall migration of bowhead whales across the Alaskan Beaufort Sea continental shelf since the late 1970s. Both real-time information and annual BWASP reports (fall 1987–2000) provide data used by the MMS Regional Supervisor of Field Operations and the National Marine Fisheries Service to ensure that oil industry activities do not pose a threat of serious, irreparable, or immediate harm to the species. The information also helps ensure that offshore oil and gas activities will not have an immitigable adverse effect on the availability of the bowhead whale to meet the subsistence needs of Alaska Natives. Annual data analyses determine the degree to which the axis of the migration shifts from year to year. In the fall of 2000 the migration corridor was significantly closer to the shoreline in the western portion of the Alaskan Beaufort Sea than for any previous year of monitoring. Also in 2000 a large concentration of bowhead whales was observed feeding nearshore between Dease Inlet and Smith Bay, Alaska. The project also analyzes relationships of the migration to physical environmental factors such as sea ice.

The MMS and the USGS's Biological Resources Division (BRD), through an FY 99 intra-agency agreement, recently completed the "Beaufort Sea Waterfowl and Marine Birds" study. The goal of this study was to monitor the abundance and distribution of various waterfowl and marine bird species in previously surveyed central Beaufort Sea "industrial" and "control" areas. The results of the surveys suggest a significant decline in long-tailed ducks, the most abundant species, within the survey area over the past decade or longer. There was no indication that population trends differed between "industrial" and "control" areas for any of the species surveyed. However, the distinction between those classifications has become blurred somewhat because of unexpected trends in development in the respective areas.

Another important monitoring study initiated by MMS has been the "Alaska Marine Mammal Tissue Archival Program (AMMTAP)." This project, begun in 1987 with MMS funding, is now managed by the USGS-BRD. Alaska Natives use many marine mammal species for subsistence and thus are concerned about possible contamination from OCS-related discharges. Also, chemical pollution might adversely affect disease resistance in marine mammals. Work in FY 02 will improve access of AMMTAP data through the Internet. The collection of marine mammal tissues over a period of years allows for determination of potential contaminants for comparisons with levels in specimens associated with oil spills or in the vicinity of drilling operations. Because only fresh specimens are considered suitable for the rigorous analysis protocol, the collection of marine mammal tissues depends to a large extent on subsistence hunters who participate directly in the project.

"Seabird Samples as Resources for Marine Environmental Assessment," an MMS/UAF CMI study, collects, and curates seabird tissues in cooperation with the University of Alaska Museum to provide further resources for contaminant and other scientific researchers. Loans and

tissue samples from this collection have already been made available to scientists for contaminant and oil-spill-related studies.

Socioeconomics

Since 1976 the MMS Alaska Environmental Studies Program has been unique in its emphasis on social and economic studies relating to the potential effects of offshore oil and gas development. Because of the nature of subsistence activities and dependence in the villages and coastal communities of Alaska, the study of the effects of offshore development in Alaska goes beyond conventional economic considerations.

In response to recommendations of Inupiat leaders of Alaska's North Slope, MMS initiated a study in 2001 titled "Quantitative Description of Potential Impacts of OCS Activities on Bowhead Whale Hunting and Subsistence Activities in the Beaufort Sea." The study, to be completed in 2003, will focus on the villagers' perceptions of the effects of potential oil spills on bowhead whale hunting and the cumulative effects on hunting by past, present, and future oil industry activities in the region. The study will collect information from the residents of Nuiqsut, Kaktovik, and Barrow through questionnaires and will consider both beneficial and detrimental potential effects.

An MMS/ADF&G cooperative agreement completed in August 2001, the "Sociocultural Consequences of Alaska Outer Continental Shelf Activities: Data Analysis and Integration," focused on the long-term consequences of the *Exxon Valdez* oil spill for coastal communities of south-central Alaska. It analyzed and integrated information from a six-volume series titled "An Investigation of the Sociocultural Consequences of Outer Continental Shelf" that MMS released in 1995. The 2001 study reviewed major studies of the sociocultural effects of the spill and analyzed and integrated information on adaptation, culture, and human groups (including the Alutiiq of the Pacific Gulf at historic contact; historic transformations of the Pacific Gulf, 1780–1995; the Pacific Gulf on the eve of the spill; effects, litigation, and restoration; economic and sociocultural effects; and other legacies of the spill for Pacific Gulf communities).

The level of information regarding changes in the Alaska socioeconomic environment related to OCS activities has varied over the years. A comprehensive synthesis of comparative, quantitative, and qualitative documentation of existing data will enhance the usability of this information. A project titled "Synthesis of Information on Socioeconomic Effects of Oil and Gas Activities on the Alaska OCS" continues to synthesize the results of more than 160 MMS-funded studies. The product, when completed, will be a peer-reviewed book.

GIS Databases

An MMS-funded study titled "Evaluation of Sub-Sea Physical Environmental Data for the Beaufort Sea" has integrated all Federal OCS site-specific survey shallow geological and high-resolution geophysical data and similar data sets into a GIS database in support of exploration and development projects in the Beaufort Sea, Alaska. This database will be available to the public this summer. When complete, the spatial database will be used to evaluate the seafloor and shallow subsurface for critical biological habitats, drilling and pipeline constraints, and potential archaeological sites. Access to spatial and attribute data on the location of strudel scour, ice gouge, and drain racks, in addition to data on bathymetry, faulting, near-surface stratigraphy, seismic anomalies, boulder patches, and earthquakes will be enhanced.

An ongoing MMS/UAF/University of Alaska Anchorage CMI study is in the process of completing an updated sea ice atlas for Arctic and sub-Arctic Alaska marine waters.

Information Transfer

A Beaufort Sea Information Update Meeting was convened in Barrow in March 2000. Scientists and leaders of the North Slope Borough planned this meeting in Barrow so that residents would have better access to the MMS studies. Principal investigators presented information on 14 ongoing MMS-funded studies at the two-day event. Over 100 people from Barrow and nearby communities attended. Also, MMS held its Eighth Information Transfer Meeting in Anchorage in April 2002. Principal investigators presented information on approximately 30 ongoing MMS-funded studies in the Beaufort Sea and Cook Inlet regions. A diverse audience from local communities, MMS, other Federal agencies, state and local governments, and industry attended.

The Alaska Environmental Studies Program also holds workshops on environmental research. In April 2001 a workshop titled "The Bowhead Whale Subsistence Hunt and Outer Continental Shelf Oil and Gas Activities: A Research Design Workshop" was attended by representatives of scientific and academic organizations, Federal and state agencies, industry, the North Slope Borough, and the Alaska Eskimo Whaling Commission.

Fish and Wildlife Service

The U.S. Fish and Wildlife Service conducts research in the Arctic to help meet its responsibilities for the conservation and management of migratory birds, threatened and endangered species, certain marine mammals, and anadromous fish, as well as all biota inhabiting nearly 77 million acres within 16 National Wildlife Refuges in Alaska.

Fisheries and Ecological Services

Fisheries

FWS fishery research in the Arctic continues to focus on Yukon River salmon shared by the U.S. and Canada. The FWS continues to develop enumeration techniques for quantifying salmon abundance and monitoring fishery health and to apply genetic stock identification techniques for quantifying genetic diversity and determining what portion of the U.S. harvests are of Canadian origin.

Treaty negotiations over Yukon River salmon between the U.S. and Canada, successfully concluded in 2001, reinstated both the Yukon River Panel, which provides advice to the fishery management agencies in both the U.S. and Canada, and the Joint Technical Committee, which provides scientific advice. The agreement, which will become an annex to the Pacific Salmon Treaty, awaits ratification by the U.S. Senate and the Canadian government. Another recent event that has increased the complexity of salmon management in Alaska was the resumption of Federal management of subsistence fisheries on Federal lands in October 1999. Successful management, now more than ever, requires close coordination between Federal and state agencies, especially in recent years when run strength has been poor. The FWS has identified key staff to serve as in-season managers of subsistence fisheries on Federal lands in Alaska.

The FWS continues to conduct a suite of monitoring studies to aid in-season management of Yukon River salmon. These include a mark–recapture study of fall chum salmon at Rampart, development of video technology to count fish captured at fish wheels that is intended to preclude the increased mortality of fish that results from holding and handling fish, and life history studies of several little-known whitefish species. The FWS continues to use weirs and sonar to enumerate salmon escapement on the Chandalar, Gisasa, and Andreafsky Rivers, all tributaries of the Yukon River. These monitoring studies are used to help schedule fishery openings and ensure stock conservation on National Wildlife Refuges. The FWS's Office of Subsistence Management also manages a competitive program for fishery monitoring projects. The primary purpose of these grants is to gather information that can be used in the management of fish stocks and to build experience in tribes, local governments, and individuals in conducting monitoring studies and managing fisheries.

	Funding (thousands)	
	FY 00	FY 01
Migratory Birds	3,884	3,884
Fisheries	4,068	4,068
Marine Mammals	1,768	1,768
Conserv. of Flora and Fauna (CAFF)	200	200
U.S.–Russia Environ. Agreement	150	150
Total	10,070	10,070

FWS's Conservation Genetics Lab continued the fall chum salmon project using molecular genetic methods to improve stock discrimination. The lab made additional collections of fall chum samples in a number of drainages in the U.S. and Canada. This project supports interjurisdictional efforts to rebuild fall chum salmon stocks and enhance the ability of managers to allocate the salmon run among users.

Environmental Contaminants

The FWS and its partners have actively pursued scientific studies and management solutions to complex contaminants problems in the Arctic for several decades. International research programs such as the Arctic Monitoring and Assessment Programme (AMAP) have shown that pollutants are truly a trans-Arctic, and indeed global, problem.

Anadromous and Freshwater Fish. In 2001 the FWS began collecting baseline data on contaminants in chinook and chum salmon from the Yukon and Kuskokwim Rivers; both are used for subsistence. Runs of these salmon have declined precipitously in recent years, and subsistence users are concerned about the presence of environmental contaminants in their food. The FWS is conducting analyses for heavy metals and persistent organochlorines along with analyses of histological samples and other indicators of fish health. They are cooperating with state and tribal public health agencies to generate a human health risk assessment for subsistence consumers of these salmon.

Marine Mammals. The FWS's polar bear biomonitoring program was initiated in 1995 to

determine if contaminant levels in polar bears from the two Alaskan population stocks are of concern. The initial goals of this program are to establish baseline levels of trace elements and organochlorines in tissues of adult male polar bears in Alaska, develop and maintain a contaminant database for polar bears in Alaska, and determine if there are significant differences in contaminant levels between the two Alaskan populations. Levels of polychlorinated biphenyls in adult male polar bears from Alaska are low compared to levels in polar bears in eastern Hudson Bay, Canada, and Norway. Average levels of hexachlorocyclohexane in Alaskan bears are among the highest reported in the Arctic; however, the effects this may have on polar bears are unknown. Mercury concentrations in Alaska polar bear livers are lower, and concentrations of cadmium and copper are higher, than those from western Canada. Sampling for this project will continue through FY 02. This project is part of the U.S. National Implementation Plan for AMAP, and initial results from this study are being used in the AMAP Phase II reports on persistent organic pollutants and heavy metals. Samples have also been collected for long-term storage with the Alaskan Marine Mammal Tissue Archival Project (AMMTAP) for use in future analyses of contaminant levels in the Arctic.

Walruses are benthic feeders specializing in bivalve mollusks, and contaminant loads in their tissues reflect pollutant concentrations in the sediments of the Chukchi and Bering Seas. Low levels of organochlorines and aliphatic hydrocarbons have been found in walrus blubber collected from Alaskan coastal locations. The FWS has also conducted analyses of heavy metals concentrations in walrus kidneys and livers. Results from blubber samples collected from walruses in 1991 were summarized in a 2001 journal article. The FWS intends to contribute additional walrus tissue samples to AMMTAP.

Sea otters inhabit the near-shore environment and may be vulnerable to contaminants because of their relatively high trophic status. The FWS recently analyzed liver and kidney samples from 69 sea otters obtained by Alaska Native hunters. The results indicate that concentrations of most pollutants were below or near detection levels. Results of this study were published in an FWS technical report in 2001.

Declining, Threatened, and Endangered Species. The FWS and the National Marine Fisheries Service share responsibility for administering the Endangered Species Act. The FWS has conducted studies of some declining, threatened, endangered, and recently delisted Arctic species to determine the role environmental contaminants may play in their decline and recovery.

Populations of the Arctic peregrine falcon and the American peregrine falcon in northern and interior Alaska, respectively, have been monitored by the Fish and Wildlife Service since 1978. Peregrine falcon populations declined dramatically after World War II but began increasing following restrictions on the use of DDT and other organochlorines in the U.S. and Canada in the early 1970s. Both populations have been delisted.

The FWS developed an egg monitoring program to track changes in organochlorine levels and to measure eggshell thickness. Samples were collected in 1984, 1989, 1995, and 2000. Results were summarized in an FWS technical report in 2000. In general, organochlorines and metals declined over time with the exception of mercury, which may have increased during the study period. Mercury was also found at levels known to be harmful to peregrine falcon reproduction, and the percentage of affected birds has increased over time. Because of concerns that mercury levels may be increasing, additional samples, including feathers, were collected in 2001. These results are one of the only long-term data sets on contaminants in biota from Arctic Alaska and have been featured in the AMAP Phase II reports on heavy metals and persistent organic pollutants.

Declines of spectacled and Steller's eiders, both designated as federally threatened species, have raised concerns about contaminant exposure. Several contaminant surveys of these and other eider species in Alaska and Arctic Russia have shown high levels of cadmium, copper, lead, and selenium compared to published values. Lead appears to be entering the U.S. breeding population via ingestion of lead shot. The sources of other elements have yet to be established. Studies are underway to correlate elemental residues with physiological responses in eiders.

The FWS is conducting an ongoing investigation of lead and other contaminants in Steller's eiders on their breeding grounds near Barrow. Levels of metals, organochlorine pesticides, and PCBs are also being evaluated in eider eggs. This study is continuing in FY 02.

Marine Mammals Management

The FWS in Alaska is responsible for the conservation and management of polar bears, Pacific walruses, and northern sea otters. All three species

are important subsistence resources for Alaska Natives, and the FWS is obligated to protect and maintain the availability of these species for subsistence purposes. In general, program activities address population monitoring and assessment, monitoring and recording of subsistence harvest information, cooperative activities with Alaska Natives, and the development of international agreements for populations shared with Canada and Russia. Research efforts are primarily focused on developing techniques for effective population estimation and monitoring.

Polar Bears. Negotiations were completed for the bilateral Agreement on the Conservation and Management of the Alaska–Chukotka Polar Bear Population in March 2000. The agreement was formally signed on October 16, 2000, but awaits ratification by the governments of the U.S. and Russia. In a related effort, representatives from the U.S. and Russia continue to meet to discuss the development of a Native-to-Native agreement as a companion to the bilateral Polar Bear Agreement.

The FWS, in cooperation with BP Exploration and LGL Research, conducted the second year of aerial surveys for polar bears along the coastline and barrier islands of the Beaufort Sea in 2001 in the vicinity of the Northstar Project, an offshore oil production facility. Aerial surveys were designed to determine the spatial and temporal distribution and abundance of polar bears during the open water period. Most bears were observed on barrier islands (69%), followed by the coastal mainland (4%), shore-fast ice (18%), ice floes (3%), and open water (5%). Adult females and dependent young comprised 49% of the observations. The distribution and age composition were similar between the two years of surveys.

U.S. and Russian polar bear biologists met in January 2000 to finalize a proceedings from a workshop on standardizing methods for estimating the number of polar bear dens on Wrangel and Herald Islands and coastal areas of Chukotka and Alaska. The goal is to develop a tool for monitoring the population status of polar bears.

Pacific Walruses. Since 1999 the FWS, the Eskimo Walrus Commission (EWC), and the National Park Service have sponsored a walrus harvest monitoring project in Chukotka, Russia. The project is designed to collect walrus harvest information from walrus hunting communities utilizing a network of local Native harvest monitors. Harvest monitors collected harvest data directly through observation and hunter interviews in the eight primary walrus harvest communities in Chukotka. Russian participants reported a total of 1212 walrus harvested in the year 2000.

The FWS sponsored a walrus haulout monitoring program in the Gulf of Anadyr, Chukotka, Russia to evaluate the size and composition of walrus herds at these important summer haulout sites. Russian biologists staffed terrestrial haulout sites at Rudder and Meechkin Spits from June through September 2000. As many as 20,000 animals aggregate at these remote sites, and unlike the male-dominated haulouts in Alaska, a significant proportion are females and calves.

In 2001 the FWS initiated field trials to evaluate high-resolution aerial photography for surveying walruses in sea ice. The goal is to determine if walrus groups can be detected and walruses enumerated from high altitudes. In May 2001, several walrus groups were photographed from altitudes between 2,000 and 12,000 feet above sea level. Additional field trials are planned in spring 2002.

The FWS also evaluated the potential application of commercially available satellite imagery as a survey tool. The IKONOS satellite collected imagery of Round Island, an important walrus haulout, using 1-m panchromatic and 4-m multispectral sensors. Using a classification routine based on spectral signature, the footprint of walruses was determined to the nearest square meter. Applying a density estimate generated from high-resolution aerial photographs to the subject area resulted in an abundance estimate that compared favorably with visual estimates collected by ground-based observers. Future studies will collect additional imagery over haulouts and evaluate satellite imagery for detecting and enumerating walruses on pack ice. The FWS is also evaluating the application of airborne thermal scanners as a survey tool for walruses. A test flight was flown over the Chukchi Sea pack ice and several known walrus haulouts in Bristol Bay, Alaska. The results indicate that the thermal scanner has sufficient resolution to detect and measure the aerial footprint of walrus groups on ice and land. Additional field trials over sea ice are planned in 2002.

Northern Sea Otters. The FWS and the World Wildlife Fund supported continued monitoring of sea otters in the Commander Islands in Russia as a control site for comparison with the Aleutian Islands. The sea otter population in the Commander Islands appears to be stable; however, habitat changes have been observed.

The FWS reported on a widespread decline of sea otters in the Aleutians. Counts of sea otters declined by 75% between 1965 and 2000. The rate

of population decline during the 1990s was 17.5% per year. By 2000, sea otters had declined to a uniformly low density throughout the archipelago, with a population estimate of 8,742, or approximately 10% of the potential carrying capacity.

The FWS also conducted aerial surveys on the southern Alaska Peninsula and the Kodiak archipelago in 2001 to assess the geographic extent of the population decline. The surveys indicate declines of 91–92% since 1986 for the southern Alaska Peninsula and a 56% decline since 1989 for the Kodiak archipelago. The sea otter population in Prince William Sound is now stable or growing, so it appears that the eastward extent of the sea otter population decline is located between the Kodiak archipelago and Prince William Sound.

In 2001 the FWS completed a genetics study of the population structure of sea otters in Alaska in support of completing stock assessments as required under the Marine Mammals Protection Act. Conducted in cooperation with the Alaska Sea Otter and Steller Sea Lion Commission, this study supplemented earlier population genetics work. The results are consistent with the previous study and support the identification of multiple sea otter stocks in Alaska.

Threatened and Endangered Species

The FWS participated in two noteworthy research projects on threatened and endangered species in 2000 and 2001. FWS is continuing a long-term study of the threatened Steller's eider in the vicinity of Barrow in cooperation with the North Slope Borough. The study is focused on the life history of this little-known seaduck on its breeding grounds and is trying to understand factors responsible for a high degree of variability in nesting effort and success. In both years a sample of birds was instrumented with satellite transmitters to learn more about migration and movements on the wintering grounds on the Alaska Peninsula and eastern Aleutian Islands.

The FWS was a cooperator on a two-year study with the Washington State Sea Grant Program and the National Marine Fisheries Service that evaluated the efficacy of seabird deterrent devices on longline fishing vessels in the Gulf of Alaska and Bering Sea. The goal was to refine the list of allowable devices to those that were most effective in reducing the incidental take of seabirds, especially the endangered short-tailed albatross. Results from the research indicate that streamer lines that are towed from behind fishing vessels during deployment of longline gear were 96–100% effective in reducing the incidental take of seabirds. The results were used to modify Federal fishing regulations through the North Pacific Fishery Management Council process.

Migratory Bird Management

The Migratory Bird Management Program is responsible for conducting research, monitoring, and surveys of migratory bird populations throughout Alaska. In Arctic Alaska, efforts are concentrated primarily on seaducks that use habitats in the Arctic for nesting and migration.

In 2000 the Seaduck Joint Venture was established under the North American Waterfowl Management Plan. The joint venture was established to provide a coordinated approach to research and management that addresses the widespread declines of seaduck species across North America. The focus is on gathering information on the life histories of these little-known waterfowl species and furthering our understanding of the linkages between breeding and wintering areas.

The Beaufort Sea provides an important migration corridor for over a million seaducks that nest in the Alaskan and Canadian Arctic and winter in the Bering Sea and North Pacific. FWS has markedly increased its survey efforts across the North Slope and in the Beaufort Sea. Studies are underway to determine the timing of use and the distribution of migrating king, common, and spectacled eiders and long-tailed ducks in the near-shore Beaufort Sea. FWS recently discovered important aggregations of king eiders near Harrison Bay, between the oilfield development of Prudhoe Bay and Point Barrow. Many of these king eiders nest in the central Canadian Arctic, and satellite telemetry has recently revealed an important wintering area for this species in the Gulf of Anadyr, just south of the Chukotka Peninsula in Russia.

The FWS is also conducting surveys of declining populations of scoters. Recent test surveys have indicated the need to fly breeding pair surveys a couple of weeks later than the pair surveys for other waterfowl species in interior Alaska.

National Wildlife Refuges

The National Wildlife Refuge system in Alaska encompasses 16 refuges and approximately 77 million acres. Staff on each refuge conduct a variety of research, inventorying, and monitoring studies, ranging from long-term ecological monitoring to more narrowly focused studies of specific plant,

fish, and wildlife species. Research highlights are included for several Alaskan refuges.

Arctic National Wildlife Refuge

Between 1996 and 1999, long-term ecological monitoring (LTEM) sites were established in each of the five ecological zones of the Arctic Refuge: coastal marine, coastal plain tundra, alpine, forest–tundra transition, and boreal forest. The objective is to monitor vegetation, small mammals, birds, terrestrial invertebrates, and physical parameters such as soils, permafrost, and weather on a regular basis to document long-term trends in biological and physical components. The first projects completed at the study sites included mapping of the physical setting and vegetation and establishment of permanent vegetation plots. Forest plots follow protocols developed by the U.S. Forest Service. Non-forest plots follow protocols developed for the International Tundra Experiment. Preliminary results show little difference in plant composition in the boreal forest plots between 1996 and 2001 and some differences in the tundra plots between 1996 and 2000, notably a near-doubling of the graminoid cover. This difference could be within the natural year-to-year variation for tundra in the area. Other projects at the LTEM sites include coastal erosion monitoring, site history using tree age distributions, and fire history mapping.

Kenai National Wildlife Refuge

An ongoing study on the Kenai National Wildlife Refuge is focusing on the role of spruce bark beetles, fire, and climate change in structuring ecological communities. The recession of glaciers, the rise in the treeline on mountains, the drying of kettle ponds, and declines in water levels in lakes suggest that the climate on the Kenai Peninsula is warming. A massive outbreak of spruce bark beetles has killed most of the mature stands of spruce in peninsula forests. Widespread tree death has thinned forest canopies and released growth in the surviving trees. Analysis of tree rings provides evidence of regional spruce bark beetle outbreaks in the 1810–1820s, 1870–1880s, and 1970s and subsequent forest recovery. The outbreaks of the 1970s and 1990s were strongly associated with increased susceptibility of trees to infestation as a result of drought stress from warmer air temperatures and increased evapotranspiration. A string of warm summers since 1987 has allowed the beetles to exhaust most of the available host trees. Tree ring data suggest that forests are capable of rapid natural recovery, although salvage harvest can damage or destroy surviving trees, slowing recovery. Studies of fire history indicate that fire frequency on the Kenai Peninsula increased substantially after European settlement.

Alaska Maritime National Wildlife Refuge

Norway rats have been introduced to a number of islands in the Alaska Maritime National Wildlife Refuge. They were likely introduced to Kiska in the western Aleutian Islands during World War II. Rats are widely distributed on Kiska, and the FWS has found conspicuous evidence of rat predation on crested and least auklets. Kiska is the home of one of the largest colonies of crested and least auklets in the world, with 3–6 million breeding individuals. Introduced rats are known to have caused declines or extirpated colonies of small seabird species elsewhere, but the effects of rat predation on the large auklet colony on Kiska is unknown. In 2001 the FWS and the Memorial University of Newfoundland began a three-year study of rat predation on auklets at Kiska. The study employs standard monitoring procedures for evaluating auklet productivity, a mark–resighting program to measure adult survival, and comparisons with control colonies on rat-free islands.

In 2001, least auklets on Kiska experienced very low reproductive success (13%), due mainly to chick loss; the reproductive success of rat-free auklet colonies was 55%. Chick loss was consistent with rat activity, but little direct evidence of predation was obtained. Crested auklets at Kiska experienced similar reproductive success compared to rat-free colonies.

Before any definitive conclusions can be made about the impacts of Norway rats on nesting auklets, monitoring of auklet productivity for at least two more years is required to account for intra-annual variation. Similarly, resightings of marked auklets over the next two years are necessary to reveal the impacts of rats on the annual survival of adult auklets.

Koyukuk/Nowitna National Wildlife Refuge

Recent evidence suggests that the breeding population of white-fronted geese that nest in the taiga of interior and northwest Alaska have declined by 27%. In response the FWS instituted a series of studies to investigate the life history and migration ecology of this species and try to identify factors responsible for the decline. The studies have involved breeding biology, habitat use, conventional and satellite telemetry, banding, and analysis of band returns. Analysis of band

returns indicates that the survival rate of interior white-fronted geese is significantly lower than other white-front populations and that the lower annual survival could be responsible for the population declines. Telemetry studies indicate that interior white-fronted geese migrate earlier in the fall than other mid-continental white-fronted geese and that they could be vulnerable to higher mortality rates from hunting. Migration and nesting ecology are being further investigated using satellite telemetry.

Yukon Flats National Wildlife Refuge

Research completed on the Yukon Flats in eastern interior Alaska indicates that black and brown bears are important predators of moose calves. At least 45% of moose calf kills were by black bears, yet little is known of this bear's life history in interior Alaska. Staff at the Yukon Flats National Wildlife Refuge are studying the movements, denning, and reproductive characteristics of a black bear population in the Yukon Flats. The study is occurring at 66°N latitude, which may be the northernmost study of black bears. The staff captured 29 black bears between 1995 and 1997 and obtained 900 telemetry locations from 23 of the marked bears. Mean annual home ranges for adult males and females were 15.5 and 182.5 square kilometers, respectively. The length of denning exceeded all previous reports and averaged 220 days (the range was 213–229 days). Females excavated all dens in well-drained soils in forested areas. The mean litter size for seven adult females was 2.1. The survival rates for cubs weaned to one year was low, and the mean annual survival rate for adult males was 0.86. A small sample of bears are still being followed to collect additional data on denning and reproductive ecology.

International Activities

The FWS participated in a variety of activities and projects sponsored through Area V of the U.S.– Russia Conservation Agreement and the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF) initiative during 2000–2001. The diversity of connections with our Russian colleagues is reflected in the variety of projects undertaken on behalf of migratory birds, marine mammals, and vegetation in the Arctic region.

Area V

Under the Area V Program FWS continues to support scientific exchanges with Russia to promote research and monitoring studies on polar bears, walruses, sea otters, marine birds, seaducks, and shorebirds. The FWS continues to provide small grants to Russian colleagues for a variety of research and monitoring projects that promote the conservation of species of mutual concern.

Conservation of Arctic Flora and Fauna

Representatives of Arctic countries met at the first international CAFF Flora Group Workshop in March 2001 at Uppsala, Sweden. The goal of the workshop was to establish a unified approach to conservation and sustainable use of Arctic ecosystems and resources among Arctic botanists. A proceedings from the workshop will be published as a CAFF technical report in 2002.

The vegetation map of the circumpolar Arctic is nearing completion. In addition to the primary physiognomic vegetation map, it will have a series of other ancillary and derived maps that will be on the back side of the physiognomic map sheet. Publication is expected in 2002.

National Park Service

National Park Service (NPS) units within Alaska encompass over 54 million acres, approximately 65% of the nationwide system. The largest NPS area in the U.S. is Wrangell–St. Elias National Park and Preserve in east-central Alaska. At over 13 million acres, it encompasses almost 16% of all NPS lands and, together with the adjacent Kluane Provincial Park in Canada, forms one of the largest protected areas in the world.

The central mission of the NPS in Alaska remains the same as 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 as well as future generations. As an adjunct to this central mission, the NPS is also charged with

	Funding (thousands)	
	FY 00	FY 01
Cultural Resources	1,400	1,400
Natural Ecology	2,486	2,486
Total	3,886	3,886

cooperating with partners to extend the benefits of natural and cultural resources conservation and outdoor recreation throughout the U.S. and the world. There is, however, a unique aspect to the NPS's mission in Alaska, as outlined by the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. Along with the addition of vast tracts of land to the National Park System, ANILCA continues to provide for traditional subsistence harvest of wildlife, fish, and plant resources in most of the national park units and continued consumptive use of resources in the national preserves. The commitment to perpetuate these traditional activities, increasing human activities in and around NPS lands, and numerous anthropogenic and natural stressors on resources have combined to provide a myriad of challenges to present-day NPS managers.

The vast size and ecological diversity of the Alaska NPS units also present unique management challenges. The essentially innumerable lakes, rivers, and wetlands in Alaska parks, as well as glaciers, geologic formations, wildlife, cultural sites, and a vast host of other natural and cultural resources, are of unparalleled value and significance on a global scale. The diverse habitats within Alaska's National Park System are home to a wide array of aquatic, terrestrial, and avian species and contain a rich heritage of human habitation. Although for the most part Alaska's resources are spatially removed from the effects of industrial development, urban sprawl, fragmentation, and modification, threats to their ecological integrity and quality can, and do, exist.

In the past, one of the main concerns for Alaska's natural and cultural resources has been the lack of baseline data available to describe their current quality and condition. Because many of the Alaska park and preserve units were expanded or created very recently, comprehensive inventories have, in many cases, not been possible. This lack of baseline data has been recognized on a national level and is being addressed by congressional funding designations for the NPS. This emphasis on collection of baseline data, inventory, and monitoring for natural and cultural resources should greatly expand the information base and allow the Alaska NPS to more effectively assess and manage the resources under their stewardship.

Other issues facing Alaska's parklands stem from global issues such as circumpolar pollutant transport ("Arctic haze" and deposition of airborne pollutants in Arctic areas), changes in the ozone layer, and global climate change. These issues require the NPS to take a leading role in partnering with other agencies to outline current conditions and potential "impairment" of resources resulting from these global changes. To this end, and under the guidance 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 natural and cultural research endeavors.

Other potential concerns affecting Alaska's parklands have grown and changed through the years. While some areas of concern have gradually receded, such as mineral extraction activities, others have increased in frequency or duration, such as development adjacent to NPS lands; cruise ship, watercraft, and all-terrain-vehicle use and demands; and associated increasing encroachment into remote backcountry park areas. These global and local concerns serve to remind us that our Alaska lands remain vulnerable and that the wise management of our resources depends on the knowledge and information supplied by sound inventory, research, and monitoring programs.

Research, inventory, and monitoring objectives in the NPS are driven and guided by agency major mission goals. These goals were restated by the most recent 2000–2005 National Park Service Strategic Plan. The plan complies with the Government Performance and Results Act of 1993 and directs the NPS in meeting its four main goals:

- Preserve park resources;
- Provide for public enjoyment and visitor experience;
- Strengthen and preserve natural and cultural resources and enhance recreational opportunities managed by partners; and
- Ensure organizational effectiveness.

Alaska Regional Programs

Natural Resource Challenge and Multi-Park Projects

The Natural Resource Challenge is the National Park Service's action plan for advancing management and protection of natural resources. Approved by Congress in 1999, the Natural Resource Challenge details actions in natural resource stewardship, management, and protection that the National Park Service should take to be more effective in preserving natural resources for the future. National parks fulfill an increasing

number of roles for society; not only are they treasured for their recreational opportunities, but they are also libraries, laboratories, and classrooms of tremendous importance for their extraordinary biological and physical diversity and rare vitality.

As visitation changes and increases with time, the NPS must accommodate these changes without impairment to resources. The challenge is to maintain diverse and healthy ecosystems that are unimpaired while providing recreational and educational opportunities, so that all may experience the shared heritage preserved within our national parks. The NPS believes that applying good science to resource management is the best approach to preserving this heritage. This goal is being realized by implementing a multiyear plan of action that calls for scientifically sound management of parks. This will be accomplished by increasing our understanding of the resources, increasing the involvement of the scientific community, and using education to engage the public in resource preservation.

Biological Resource Inventories. Baseline biological inventories including small mammals, vascular plants, birds, fish, and amphibians are being conducted in every Alaska national park unit. Fieldwork is ongoing, and the results will begin to become available in FY 04. The inventories have already contributed significantly to our understanding of species occurrence, in part because they were focused on remote areas and poorly understood taxonomic groups, while also directly addressing the most important gaps in our knowledge of the occurrence of vertebrates and vascular plants in Alaska's parks.

Vascular plant inventories have shown several range extensions in the Western Arctic Parklands and at least one Beringian species never before found in Alaska. A cooperative survey with the land cover mapping fieldwork in Glacier Bay National Park and Preserve documented 57 species not previously expected to occur in the park. Several previously unknown populations of rare species were located in Lake Clark National Park and Preserve during the surveys, and 20 species were added to species list. Forty occurrences of rare plant taxa were documented in Denali National Park and Preserve.

Ten specimens of the tiny shrew *Sorex yukonicus*, previously known in North America from only six locations (12 specimens), were collected during the Yukon–Charley Rivers National Preserve small-mammal inventory work. In addition, two shrew specimens of the same genus were taken from Wrangell–St. Elias National Park and Preserve. This species was not expected to occur in either park, and the records represent significant range extensions.

Marine fish inventories in Glacier Bay National Park and Preserve collected several specimens of a poorly described deep-water smelt, thus contributing to the taxonomic knowledge of this species. Lantern fish were documented at shallower daytime depths than previously known for this species, which typically migrates to the surface to feed only during the safety of darkness.

Ecological Maps. The NPS was a co-lead in the development of the Unified Ecoregions of Alaska map, a collaborative effort of state and Federal agencies and the Canadian government. The ecoregions map synthesizes the biophysical characteristics of the landscape and serves as a common basis for describing the ecosystems of Alaska. It will be invaluable in conducting further research on environmental change in northern latitudes. Ecoregion subsections are more detailed ecological maps that have been prepared for all Alaska parks and adjacent areas, more than 60 million acres. These maps and the accompanying documentation are available for use in sample design and analysis of inventory and monitoring projects, and they provide ecosystem context for research and management decisions (www.agdc.usgs.gov/data/projects/fhm).

Database Development. As the first step of the inventory program, NPS contracted with the Alaska Natural Heritage Program to compile existing information on species occurrence and to incorporate the results into the Natural Resource Species Database (NPSpecies) and the Natural Resources Bibliography Database (NPBib). NPSpecies now contains more than 17,000 records on plant and animal species occurrence in Alaska's national parks. This effort added 631 citations to NPBib, which now contains over 8,000 citations. These databases represent a repository of species and literature information that can be used by all Arctic researchers and the public and are available to all on the Internet at www.nature.nps.gov/im/apps.

Monitoring. Building from the inventory program, the NPS is developing an integrated ecosystem-monitoring program including flora, fauna, air, and water. Contingent upon future funding, monitoring will take place in all NPS units across Alaska. NPS will be providing at least one new broad-spectrum air quality monitoring station in the Western Arctic Parklands to complement one already in Denali.

Exotic Plants. The NPS is actively studying the nature and extent of exotic plant species in the national park units of Alaska. Researchers of the U.S. Geological Survey's Biological Resources Division (BRD) have completed the first field surveys of five parks: Denali National Park and Preserve, Katmai National Park and Preserve, Kenai Fjords National Park, Sitka National Historical Park, and Wrangell–St. Elias National Park and Preserve. Concurrently, Klondike Gold Rush National Historical Park conducted an in-house survey of the Chilkoot Trail area. Each of these parks has disturbed lands associated with access, mining, or development of park facilities that are susceptible to exotic species invasion. New exotics are appearing, and some are already spreading rapidly. Preliminary results from the initial study show exotic plants becoming established in all five of these parks, although they are still primarily confined to the areas that have been disturbed by human activity. In FY 02 the NPS and BRD are continuing the survey, focusing on northern park units. The NPS is cooperating with other government agencies to establish standard fieldwork and databases for a statewide exotics map.

Partnerships. NPS is working with the University of Alaska and others to develop a Cooperative Ecosystem Studies Unit (CESU) that will streamline the process for university scientists to do research in parks. GeoScientists in the Parks and Sabbatical in Parks are additional programs that connect individual scientists with research opportunities in parks.

Education Program

The Alaska region of the National Park Service has launched an education program to communicate cultural and natural research stories to the public and the research community. Alaska's natural resources and vibrant cultures are priceless assets, and national parklands are established to preserve those assets for future generations. Educational programs help assure that future generations understand and are prepared to take their turn in protecting the generous but sometimes fragile endowment left by earlier generations.

The primary thrust during this first year of the education initiative has been to create ParkWise—Your Alaska National Parks eClassroom, linking teachers and students to real data and active research in Alaska parks. The NPS developed this education web site under a cost-sharing partnership with the Anchorage School District and the School Access program of General Communications, Inc. The web site can be found at http://parkwise.schoolaccess.net. The site includes curriculum units that use a concept-based approach to learning and are specifically tied to the national education standards. Activities, maps, photos, resource links, and much more are also included. As an example, in the unit called "Fly Away!," students use math, science, and geography to follow the golden eagles of Denali National Park and Preserve. Small transmitters on the backs of the golden eagles allow wildlife biologists to track them via satellite. The students analyze the research data and plot the migration routes as they learn strategies animals use to survive in harsh climates.

The National Park Foundation and the Alaska Natural History Association are partners in fundraising for education projects. The first product of this partnership is a 20-minute video produced by the Discovery Channel, a Proud Partner of the National Park Foundation. The video provides a tour of the natural and cultural resources in Alaska parks and is intended for a broad audience, including the Discovery Channel and visitor centers in parks.

In coming years the education initiative will continue to facilitate education, using such venues as the World Wide Web, books, journals, videos, and the news media. These will provide even more opportunities for scientists, both those in the NPS and those who collaborate with the NPS, to share their natural and cultural resources research with the public and other researchers.

Learning Centers

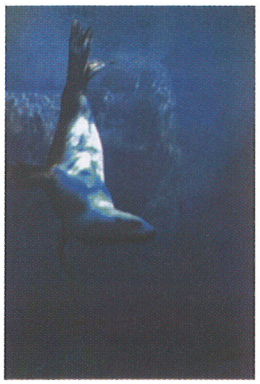
Through the Natural Resource Challenge, learning centers are being placed throughout the nation to facilitate research and enhance educational opportunities for the general public. Learning centers will be field stations for collaborative research activities, providing researchers with laboratory and office facilities. They have been designed as public–private partnerships that involve a wide range of people and organizations. In 2001 the Ocean Alaska Science and Learning Center (OASLC) was established at Kenai Fjords National Park, Seward, Alaska. Partnered with the Alaska SeaLife Center (ASLC), a $52-million marine research, rehabilitation, and education facility, also located in Seward, the OASLC is committed to understanding and maintaining the integrity of the coastal and marine ecosystems of Alaska's national parks through sponsorship of scientific research and research-based public education and outreach.

The OASLC has sponsored several projects, including developing a community-based online research library at the ASLC for researchers, teachers, visiting scientists, students, and NPS staff. Current and future research projects and programs include monitoring the endangered Steller sea lion population at the Chiswell Islands, studying the demographics of coastal black bears and black oystercatchers in Kenai Fjords National Park, establishing a harbor seal trend monitoring site in Aialik Bay, and developing the oral history and archaeology of Aialik Bay in Kenai Fjords National Park. The OASLC is also involved in education at many levels. It is a sponsor of the National Ocean Science Bowl and the Student Ocean Conference and is developing a broad range of web-based coastal and marine educational outreach programs. The OASLC has sponsored education grants for Alaska teachers to attend marine science workshops at the ASLC and has implemented monthly, research-based marine science seminars hosted at the ASLC. Although only in its infancy, the OASLC is already achieving its goals to collect coastal and marine data needed to enhance NPS resource management and to disseminate the information to the public.

The Alaska SeaLife Center, a 125,000-square-foot marine research facility, located in Seward, Alaska.

The OASLC has helped fund an international, multi-year Steller sea lion research project to address the drastic decline in Steller sea lion numbers within the western Gulf of Alaska and Aleutian Island chain. The protection of sea lions and their haulout sites is critical to the integrity of the coastal ecosystem within and adjacent to Kenai Fjords National Park. Scientists are looking at diet regimes in juvenile Steller sea lions, among other research questions. The OASLC has also assisted in funding the Chiswell Island sea lion camera project, which utilizes live cameras on the Chiswell Island rookery. More than 40 researchers have studied the footage taped from the cameras to learn more about breeding, reproduction, foraging activities, and adult/pup relationships of Steller sea lions. The cameras' live feeds are also connected to the Alaska SeaLife Center visitor floor, where tens of thousands of visitors view the sea lions in their natural surroundings. Similarly this live feed is broadcast on local TV and used as a powerful real-time education program for Seward students and residents.

View into the Steller sea lion habitat at the Alaska SeaLife Center.



Researchers are also collecting data to understand the nesting success and population status of black oystercatchers, an "apex predator" species, whose effective recovery from the massive 1989 *Exxon Valdez* oil spill remains unknown. In Kenai Fjords, oystercatcher nesting habitat is used by numerous sea kayakers, whose annual visitation totals more than 3000 backcountry user nights. OASLC's continued support for this project will help identify and mitigate potential conflicts between oystercatchers and kayakers.

The OASLC is seeking grants and other partnerships to help meet the challenge of science-based management of some our nations most significant public lands and resources. Further information on the Alaska SeaLife Center can be found at www.alaskasealife.org, and information on the OASLC can be obtained by visiting www.nps.gov/kefj/home.htm.

Archival and Research Collections

One adjunct activity that is essential to a good program of research is proper archival and collections management. Because this work is often behind the scenes, it is sometimes forgotten, but it is an integral aspect of any responsible program of research. In the NPS, museum services usually reside organizationally on the cultural resources side of the agency, but responsibility for proper cataloging and care of research collections falls equally on both the natural and cultural program sectors. Although the NPS allocates direct funding to museum services, each research project and program also includes specific plans and funds to cover curation. The job of caring for research archives and collections in perpetuity is a big one and requires the full support and attention of the researchers themselves. Though this activity is largely invisible in the individual research accounts presented here, it should be kept in mind that the task of caring for the attendant specimens and research records is a very real and important component of every NPS project.

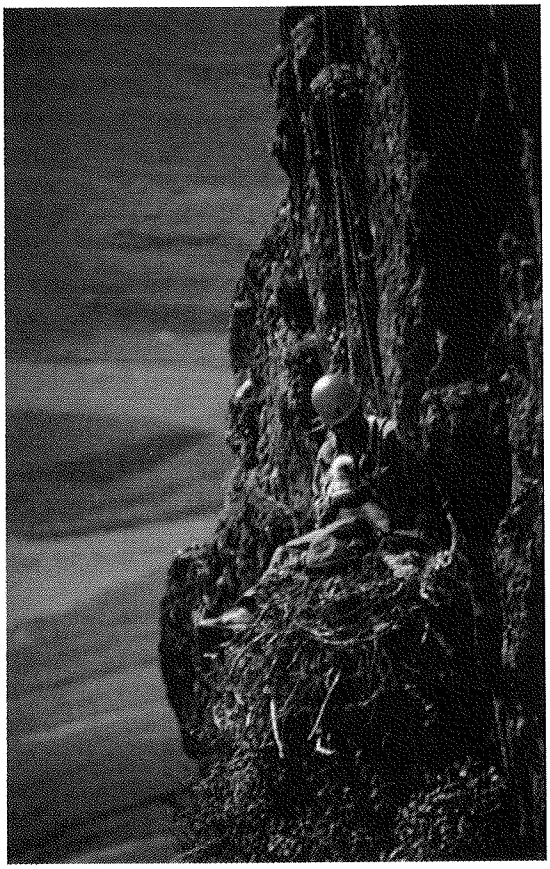
Natural Resources

Denali National Park and Preserve

Scientific research on Arctic and sub-Arctic ecosystems has been integral to the understanding, management, and protection of resources at Denali National Park and Preserve since the park's inception in the early 1900s. In 2000–2001 there

were approximately 100 scientific and scholarly projects being conducted in Denali's six million acres of taiga, tundra, glaciers, mountains, lakes, and streams. These projects were conducted by Denali staff and its cooperators (USGS/BRD and the Alaska Department of Fish and Game), as well as by investigators from other agencies and institutions. Projects included inventories of plants (including exotics), black and brown bears, microtine rodents, spiders, and insects. Long-term monitoring of physical resources checked the current status and trends of air quality, glacial movement and mass balance, water quality, snow depth, and ultraviolet radiation. Biological resource monitoring included vegetation surveys in the Rock Creek watershed; nesting success of golden eagles; and caribou, wolf, moose, and bear surveys. Research projects included studies of the potential effects of snowmobiles on wildlife and tundra/taiga soils, white spruce seed dispersal at treeline, and the levels of sound in high- and low-human-use locations in the park.

Golden Eagles. Golden eagles are common throughout western North America, but little was known about their population trends or life history at northern latitudes of North America. In 1988 the NPS started a comprehensive study of the ecology of golden eagles in Denali. The major objectives of the study were to document reproductive characteristics of the species at high latitudes, examine the response of the territorial eagle population to changes in food supplies and habitat, document their nesting chronology and nesting area habitat characteristics, and describe their food habits. Similar information on sympatric nesting species, including gyrfalcons and common ravens, is collected during golden eagle surveys. While monitoring continues, new studies in the late 1990s focus on determining factors influencing survival of juvenile eagles, describing migration routes and migratory behavior and estimating adult survival using genetic techniques.



An NPS raptor biologist gathering nesting and hatchling information from a golden eagle nest in Denali National Park and Preserve.

The Denali golden eagle study is the only long-term population study of this species in the northern latitudes of North America. The results from these studies have increased our knowledge of this species' ecology, especially at higher latitudes, where this species is migratory. NPS studies also provide one of the longer-term data sets on gyrfalcon reproduction in Alaska. On the breeding grounds the findings suggest that the territorial population of golden eagles in Denali, approximately 120–140 pairs, is stable. Laying rates, mean brood size, and overall population productivity are significantly correlated with the cyclic abundance of snowshoe hares and willow ptarmigans. The reproductive rates of eagles in Denali are similar to those recorded for this species from other high-latitude study areas in North America but are lower than for golden eagles in temperate-zone study areas in North America. Ongoing research is examining the variation in reproductive success within nesting areas, identifying factors influencing occupancy and use of nesting areas, and estimating survival of adult golden eagles. This study is partially supported by Denali's long-term ecological monitoring program and has benefited from partnerships with the USGS/BRD Forest and Rangeland Ecosystem Science Center, the USGS/BRD Snake River Field Station, the Department of Fisheries and Wildlife at Oregon State University, the University of Alaska Fairbanks, ABR Inc., and the U.S. Fish and Wildlife Service.

Another golden eagle study is documenting the survival and annual movements of juvenile and subadult golden eagles from Denali. Migratory golden eagles from Alaska spend nearly half their lives away from their breeding grounds, often in areas that are experiencing large-scale land use

Juvenile golden eagle in its nest in Denali National Park and Preserve.

changes and increases in human activities. As part of a long-term ecological study of golden eagles in Denali, the NPS is using satellite radiotelemetry to test a series of hypotheses regarding the survival and annual movements of juvenile and subadult golden eagles from Denali. The results suggest that survival of juveniles is high (about 98%) during the post-fledging dependency period. However, survival rates decrease by nearly 50% during autumn migration and winter. The sources of mortality during migration and on the wintering grounds include starvation, illegal shooting, electrocution, poisoning, poaching, and collision with vehicles. Most golden eagles from Denali depart the park in late September and migrate inland across a 200-km-wide corridor through eastern Alaska, southern Yukon, northeastern British Columbia, central and eastern Alberta, and western Saskatchewan. Wintering ranges extend from central Alberta to northern Mexico, with most birds wintering within and east of the Rocky Mountains into the western Great Plains. Few juveniles or subadults winter west of the Rocky Mountains. Juveniles and subadults return to Alaska in late May but show little tendency to use the same migration route that they used in autumn or to return to Denali during their first two years of life. Their summer range extends from the Kenai Peninsula, Alaska, to the North Slope of Alaska and the Mackenzie River Delta, Northwest Territories, Canada. Results from this study will be helpful for determining the potential effects of large-scale climate and land use change on the long-term sustainability of golden eagle populations in North America and for identifying and mitigating factors causing mortality. This project is conducted cooperatively with the USGS/BRD Forest and Rangeland Ecosystem Science Center and the Department of Fisheries and Wildlife at Oregon State University, with assistance from the USGS/BRD's Alaska Science Center. This study has benefited from partnerships with scientists from the Yukon Department of Renewable Resources, Alberta Environment, and the Canadian Wildlife Service.

Floristic Inventory. More than one-third of the 751 vascular plant species known to occur at Denali National Park and Preserve have been documented in the last four years during an intensive floristic inventory. Denali's plant ecologist is coordinating the inventory and enlisting the help of park staff, outside researchers, and park cooperators who are mapping the park's soils. During the first stage of this effort, information about the park's flora was assembled, yielding records for 489 species of vascular plants known from the park. These species had been documented during Denali's long history of plant collections, beginning with voucher specimens collected in the 1920s. In the next phase a database was created to list the characteristics (such as elevation and habitat) of "expected" species (species likely to occur in the park but not documented in the existing data sets). Locations for collecting trips were selected based on which sites might yield the most expected yet undocumented plant species. The third phase was to carry out plant inventories at the selected sites throughout the park. During these recent directed searches, voucher specimens were collected for an additional 262 species of vascular plants. Denali's checklist of flowering plants, conifers, ferns, horsetails, and other fern allies now stands at 751 species.

Large Mammal Monitoring. The annual Denali Caribou Herd fall composition survey was conducted during September 2001. A total of 1,116 caribou were classified, with a cow:bull:calf ratio of 100:32:12. There were relatively more calves than in 2000, when the cow:calf ratio was 100:7. Based on the current survival patterns of adult cows, about 20 calves per 100 cows need to be recruited for the population to maintain itself. The herd's estimated total population size is 1,830 caribou, consistent with the continued slow decline in caribou numbers over the last 10 years. The Denali Caribou Herd numbered more than 20,000 during the 1920s and 1930s but declined to 10,000 during the 1940s through the mid-1960s. Further declines occurred during the 1970s, when numbers reached a low of approximately 1,000 animals. The herd was subject to human harvest until the mid-1970s.

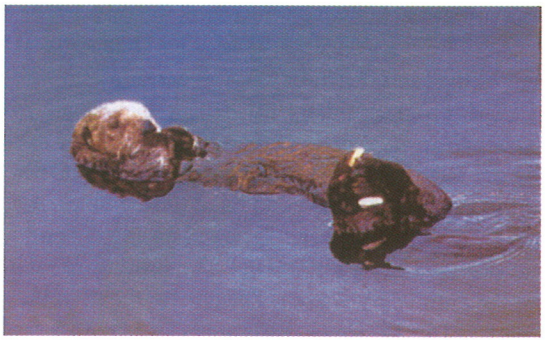
Aerial moose surveys have been conducted as part of the Long Term Ecological Monitoring (LTEM) program since 1991. Due to inadequate snow cover, no moose survey was conducted during the fall of 2001, and only a partial survey (16% of the study area) was conducted during 2000. A total of 237 moose were observed during the partial survey, and an estimated 857 moose were seen for the entire survey area. The cow:bull:calf ratio was 100:150:32. Cows, bulls, and calves represented 35%, 53%, and 12% of the estimated population, respectively. An estimated 73% of cows were without calves, 24% of cows had one calf, and 3% of cows had two calves. The overall estimated moose density was 0.21 per km^2.

Data from wolf studies have been used to determine population dynamics, as well as to

document wolf movements and factors affecting mortality. After a large-scale wolf research project (1986–1993) was completed, research and monitoring efforts by USGS/BRD have continued. Two to three radiocollared wolves are followed in each known pack inhabiting Denali north of the Alaska Range. Radiocollared wolves are located every two weeks and more often in late September and early October (to determine fall pack sizes and count pups) and in mid-March (to determine late-winter pack sizes). Telemetry locations are used to determine the area of each pack territory. Areas of each pack territory and pack counts are used to estimate wolf abundance and density. Based on preliminary fall 2001 counts, the number of pups produced was low (about 0.33 pups per mature wolf) compared to the long-term average (0.61 pups per mature wolf), and pack sizes are generally small (averaging 5.1 wolves per pack) compared to the long-term fall average (7.9 wolves per pack). The 2001 estimate is consistent with the current trends in the wolf population; over the last four years, fall pack sizes have averaged between 5.6 and 6.6 wolves per pack. The number of pups is substantially lower than in the last few years, however, and is similar to the low pup production during 1986-87, when snowfall was low.

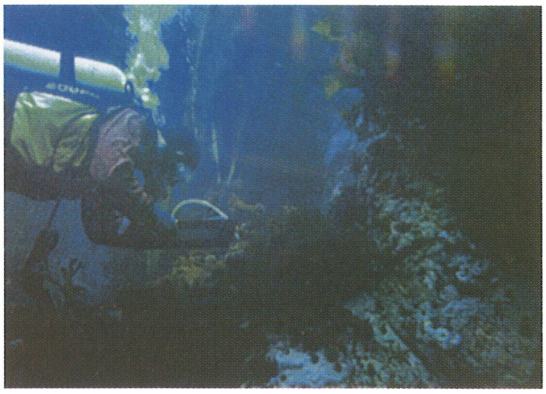
Glacier Bay National Park and Preserve

Sea otters, once nearly eliminated by fur hunters, have made a spectacular comeback throughout the North Pacific following protection in 1911 and subsequent re-introductions. Until recently, however, otters had not recolonized within Glacier Bay National Park and Preserve. Now that sea otters have reappeared at Glacier Bay, the NPS has a unique opportunity to understand more about the effect of the otters' return on the ecosystem. Since 1995, when the first five otters were observed in Glacier Bay, the population has grown to an estimated 1590 animals. Sea otters consume large quantities of clams, mussels, crabs, and other invertebrates, some of which are commercially, culturally, or ecologically important. Scientists have long known that increased predation on these species can cause long-term changes that ripple through the ecosystem.



Sea otters are making a dramatic comeback throughout the North Pacific. The otters' return is expected to have a profound effect on oceanic ecosystems.

A study of the ecology of sea otter recolonization in Glacier Bay, being conducted by NPS and USGS scientists, is divided into four parts. First, aerial surveys are flown yearly to determine the otters' population size and distribution in Glacier Bay. Knowing the number and location of the otters and the population's growth rate is key to understanding the magnitude of their likely effect on the ecosystem. Second, researchers determined the sea otter's diet by observing foraging otters through telescopes from land at various sites throughout the bay. After diving for their food, otters conveniently place the selected prey on their chests and break it apart with their paws, giving observers a chance to view the food item. In the third portion of the study, researchers estimated the densities of clams in the intertidal and subtidal zones where otters have foraged and in areas where they have not. A comparison of the size and number of clams before and after the arrival of sea otters will tell researchers the likely effect of otters on clam populations. Last, divers established multiple underwater sampling sites throughout the bay to catalogue all the species found on the seafloor. Over time this study will help determine the indirect effects of sea otter predation on other marine organisms. As otters continue to colonize the bay, it is likely that dramatic changes will occur in the composition, abundance, and size of many species in the near-shore marine ecosystem.



An NPS research scientist diving to the seafloor to catalogue species at an underwater sampling site in Glacier Bay. These sites will be resampled after sea otters have recolonized the bay to document changes in abundance and distribution.

Gates of the Arctic National Park and Preserve

Dall's Sheep. Gates of the Arctic is mandated by the Alaska National Interest Lands Conservation Act (ANILCA) to conserve natural and healthy populations of Dall's sheep while simultaneously providing the opportunity for continued

subsistence harvest. A widespread decline in populations of Dall's sheep occurred in Gates of the Arctic National Park and Preserve and throughout the Brooks Range during the late 1980s through the mid-1990s. The decline was attributed to a series of hard winters with deep snow, which made forage hard to reach and made the sheep vulnerable to predation. The results from surveys conducted in 1996 emphasized the need to develop an economical population trend survey and a way to assess sheep harvest so that the sheep population could be more closely monitored.

Sheep surveys and a sheep range use project were initiated to monitor and assess Dall's sheep population dynamics in the central Brooks Range near Anaktuvuk Pass, Alaska, in March 1998. This project was established with the following objectives: identify Dall's sheep bands and determine band sizes; determine home ranges, range fidelity, and seasonal movement patterns of the identified sheep bands; assess the local harvest of the bands; develop an economical annual trend count survey program; and continue the exchange of information regarding Dall's sheep populations in the central Brooks Range with Anaktuvuk Pass residents.

Eighteen Dall's sheep (15 females and 3 males) were captured with a net gun and radiocollared in March 1998 to the east and west of Anaktuvuk Pass. In the subsequent two years, additional Dall's sheep were captured to replace those that had died or had radiocollar failure during the previous year. The time between radiotracking flights has been dictated by scheduling and weather conditions. As a result the time between sheep relocations has varied greatly (between 6 and 69 days), making movement speeds based on sequential sheep locations or calculations of daily movement rates inconsequential. However, the maximum distances between any two relocation points for individual sheep ranged from 4 to 8 miles, with a mean of 6.0 miles. Sheep home ranges determined using minimum convex polygons ranged from 7.9 to 45.1 square miles. The mean home range size was 23.4 square miles. In some instances home range boundaries fell along obvious geographical barriers; in other instances, no obvious barrier existed. Preliminary data indicate three subpopulations within our radiocollared sample.

Aerial surveys have been conducted in July of the past four years. Survey conditions were good in 1998, extremely poor in 1999, and poor in 2000 and 2001. A total of 475 square miles were surveyed in 1998, and 386 sheep were observed. The age and sex composition during the 1998 survey was 27 lambs per 100 ewe-like sheep and 35 rams (with more than half curl) per 100 ewe-like sheep. In 1999, 422 square miles were surveyed, and 186 sheep were observed. The age and sex composition during 1999 was 34 lambs per 100 ewe-like sheep and 25 rams per 100 ewe-like sheep. In 2000, 322 square miles were surveyed, and 460 sheep were observed. The age and sex composition during 2000 was 34 lambs per 100 ewe-like sheep and 35 rams per 100 ewe-like sheep. In 2001, 307.5 square miles were surveyed, and 285 sheep were observed. The age and sex composition was 17 lambs per 100 ewe-like sheep and 30 rams per 100 ewe-like sheep.

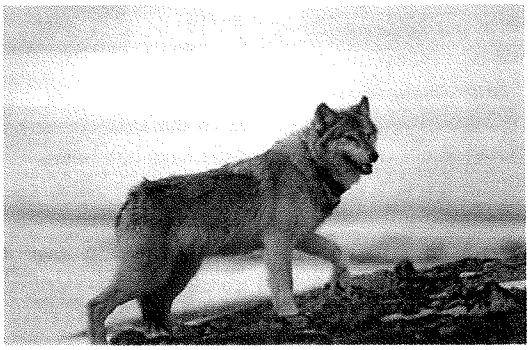
Muskoxen. Muskoxen were extirpated from northern Alaska in the middle of the 19th century. Management of muskox populations has been controversial in northern Alaska, yet the NPS lacks basic information with which to manage this species. An NPS study is documenting the current natural re-establishment of this species in Gates of the Arctic National Park and Preserve and is examining habitat use. The first reported observation of a muskox in the park was in 1989. Currently 49 observations of muskoxen have been recorded. Observations are concentrated along river drainages, primarily the Noatak River (67% of observations) and near the community of Anaktuvuk Pass, Alaska (12% of observations). Aerial surveys have been conducted to systematically locate muskoxen in 1999–2001. In 2000 three bull muskoxen were observed in three locations along the Noatak River during the winter survey. Muskoxen were observed in the park in three locations, again in the Noatak River valley, during the winter of 2001. Based on incidental observations, at least seven muskoxen have been present in Gates of the Arctic at a given time.

A geographical information system (GIS) was used to relate locations of incidental muskoxen observations to land cover and terrain characteristics. For this analysis, three habitat variables were investigated: land cover, elevation, and slope. Out of 30 land cover types in Gates of the Arctic, muskoxen locations intersected 22 types, but three of these land covers accounted for 51% of the area surrounding the observation locations. Muskoxen were most commonly found in lower elevations within the park.

Yukon–Charley Rivers National Preserve

Wolves. A recent NPS project was initiated to monitor approximately ten packs of wolves that

inhabit Yukon–Charley Rivers National Preserve. In addition to collection of baseline data on the population, this monitoring was highly desirable in light of a non-lethal wolf control program adjacent to preserve lands. This non-lethal program was implemented by the Alaska Department of Fish & Game (ADF&G) from 1997 to 2001 and was supported by a variety of Federal agencies, private organizations, and Native groups as part of the Fortymile Caribou Herd Management Plan. This wolf control effort consisted of surgical sterilization of wolf breeding pairs and relocation of remaining pack members in an attempt to lower the numbers of caribou killed by resident wolves. Forty wolves in 15 packs were sterilized, and 121 wolves were relocated. Many of these packs were immediately adjacent to the boundary of the preserve. NPS biologists monitored the wolf population via aerial radiotelemetry and the ARGOS satellite system. With the NPS and ADF&G working in a close partnership and freely sharing data and information, the NPS was able to prevent any preserve wolves from being sterilized or relocated, even when preserve wolves traveled considerable distances outside NPS boundaries. Strong partnerships were forged between the NPS, other Federal and state agencies, Native corporations, private groups, and individual citizens during this project.



A young radiocollared wolf in Yukon–Charley Rivers National Preserve.

Throughout the life of the project, an average of 20 wolves in 10 packs are radiocollared within the preserve at any given time. These wolves are located from aircraft approximately 40 times each year, documenting their home ranges, pack sizes, pup production, dispersal rates, and causes of mortality. Data collected from these packs meet two objectives: protecting the preserve wolves from sterilization or relocation, and providing crucial baseline information about the natural and healthy state of the wolf population in Yukon–Charley Rivers National Preserve. Both NPS and ADF&G plan to continue monitoring the preserve wolves, the sterilized wolf population, and the Fortymile Caribou Herd to evaluate five primary questions:

- What role did wolf control play in the growth of the Fortymile Caribou Herd?
- How much will an intact wolf population increase with an increasing caribou herd?
- How long will it take for the sterilized wolf population to recover relative to preserve wolves?
- What are the lasting impacts of sterilization to the social organization of sterilized wolves and adjacent intact packs?
- How will the increase in the preserve wolf population affect the low-density moose population?

Furbearer Populations. Biologists from the Yukon–Charley Rivers National Preserve, the Alaska Biological Science Center, the U.S. Fish and Wildlife Service, and ADF&G are working together to develop a technique to monitor furbearer and snowshoe hare populations from snow track surveys with airborne digital videography. In February 2001, flights were conducted over the preserve in complex hilly terrain to determine optimum survey altitudes and camera settings under various lighting and snow conditions. The results from this preliminary fieldwork demonstrated that videographic surveys from 900 to 300 ft above ground level were a great improvement in precision, detection of tracks, and safety over the current technique, which employs an experienced observer flying at lower altitudes. Furthermore, the new technique provides GPS locations for each track, which provides the potential for geospatial analysis and determination of habitat relationships. Statisticians associated with the interagency group have adapted the line-intersect sampling design from the ocular survey to accommodate the new technique. Computer simulations are being used to evaluate its efficiency and precision at varying population levels for different species of interest. Plans for the winter of 2002 include developing visibility correction factors from comparison of ground-based and aerial surveys and additional experimental surveys over other terrain in Yukon–Charley.

Cultural Resources

On December 21, 2000, the Director of the National Park Service endorsed the Cultural Resources Challenge, an action plan and strategy for preserving the nation's important prehistoric and historic places and collections. In many ways the Cultural Resources Challenge mirrors that of the Natural Resources Challenge in its emphasis on the collection of good, reliable resource data and sharing that knowledge through effective educational programs. As with the Natural

Resource Challenge, there is a strong emphasis on activities that reach out and invite the public to benefit from and participate in preserving the heritage of the U.S. The core elements of the Cultural Resource Challenge include Research and Knowledge; Planning; Education; Preservation, Maintenance, and Protection; and Organization and Partnerships. For the most part the inauguration of the Cultural Resource Challenge does not mark a large, new infusion of dollars into cultural resources inventory and protection but a refocus of work to the best use of the available dollars.

The Cultural Resource Challenge, with its emphasis on research, education, and partnerships, is in close step with many of the core components of the U.S. Arctic Research Plan. As the cultural resource projects summarized below and in the section on the Shared Beringian Heritage Program indicate, NPS scientific research in the cultural resources domain is diverse and broad in scope. Some of the projects touch on the health of northern people and their subsistence economies; others document the many successful and varied cultural adaptations to northern lands that have developed over the millennia; still others deal with the forging of the institutional relationships and partnerships that are so important to the fulfillment of the goals of the Arctic Research and Policy Act of 1984. With each passing year the NPS has increased its participation in an expanding network of collaborative ventures with local, regional, national, and international partners. This partnering does not veer the NPS from its mission; rather the partnerships provide the reality checks that are necessary to keep an agency from becoming insular and heading down the path to irrelevancy and bureaucratic involution. And most importantly, collaboration enables the NPS to enlist the vision and resources of others in finding better and more effective solutions to the many research and resource management problems that need to be addressed in Alaska's national park lands.

Multi-Park Projects

In 2000 the NPS published *Quest for Gold: An Overview of the National Park Service Cultural Resources Mining Inventory and Monitoring Program.* This volume by NPS archeologist Becky Saleeby reports on the results of ten years of archeological inventory conducted within nine of Alaska's national parks. In *Quest for Gold* the author looks at mining from the vantage point of an archeologist and anthropologist. The book describes and gives meaning to the patterns revealed in the distribution of sites and artifacts by comparing and contrasting the findings between each of the major mining districts. It is also the first work of its kind to give serious attention to the important role played by Alaska Natives in the early mining industry.

In May 2000 the Federal Subsistence Board approved funding for the Statewide Subsistence Fisheries Harvest Monitoring Strategy. The project was a joint undertaking of the ADF&G's Division of Subsistence and the Alaska Inter-Tribal Council; the NPS and the U.S. Fish and Wildlife Service were also major participants. In rural Alaska overall, and in most regions, fish comprise the largest component of the annual subsistence harvest. Given that subsistence harvests are granted priority over sports and commercial activities, a valid and representative reporting procedure must be in place to protect the rural subsistence community's access to this valuable resource. A variety of data collection methods are used to assess subsistence fish harvests within the state—permits, calendars, surveys, postcards, and telephone interviews. By far the most pervasive data collection method is the use of permits.

The NPS and ADF&G did an analysis and comparison of permit data with baseline surveys conducted in the same community in the same year. A baseline study is a questionnaire that contains harvest questions on all locally available species. Baseline studies are characterized by anonymity and large sample sizes and are conducted face to face. The results indicate that baseline studies enumerated more active fishing households in more than half of the comparisons with permit data. There exists the real possibility that the permit system assessment process underestimates community salmon needs by a substantial margin.

Overall the project developed a list of guiding principles:

- Collection of accurate harvest data is an essential component of any effective resource management program.
- Both baseline and time series data are needed, with the frequency of updates dependent on management and user needs.
- Partnerships strengthen harvest assessment programs.
- New programs need to build upon successful existing programs, and coordination of programs should be a primary goal.
- Programs must be developed to fit local circumstances and needs.

- Costs, including the potential for long-term funding sources, must be considered when designing and modifying programs.
- Programs need to foster communication and trust.
- Ultimately program success depends on acceptance by the participants in the fishery.
- Program results need to be available in a timely manner, understandable to the public, and readily accessible through written reports and a centralized database.
- Collection and application of contextual information, including traditional ecological knowledge, is an integral component of successful harvest assessment programs.
- Harvest assessment programs need to be subject to systematic and periodic evaluation.

The extensive final report, with detailed recommendations for a unified subsistence fisheries harvest assessment program, can be found at http://www.state.ak.us/adfg/subsist/geninfo/publctns/articles.htm.

The two-year Alagnak Wild River archeology and ethnography project is part of a multi-park project focused on documenting significant cultural resources along major river corridors in Wrangell–St. Elias, Yukon–Charley, and Gates of the Arctic National Parks and Preserves. Anthropologists interviewed elders in Igiugig and Levelock, recording over 50 Native place names in the Kukaklek Lake area at the headwaters of the Alagnak River. The archeological survey of the Alagnak and Grosvenor/Savonoski Rivers in 2001 covered 850 acres and recorded 19 previously unidentified sites, including multi-component villages with up to 60 house features. Twenty-one previously recorded sites were revisited to assess conditions and record impacts related to visitor use, erosion, and vandalism. Twenty radiocarbon dates indicate that the sites range in calibrated age from AD 80 to 1700. National Register Determinations of Eligibility were prepared for 21 sites, and the nomination of the Savonoski River Archeological District was significantly amended.

A 1200-year-old wooden plank house floor found in a village midden located on a high coastal buff in Aniakchak National Park (the trowel and the bottom of the tape mark the location of the floor). Note the orange volcanic ash lens below the plank floor and the bands of discarded food shells in the upper reaches of the midden.

Aniakchak National Monument and Preserve

A four-year (1997–2000) archeological survey project in Aniakchak covered approximately 3460 acres at the reconnaissance level. This included most of the coastal embayments of the park, as well as much of the Aniakchak, upper Meshik and Cinder River drainages. Forty archeological sites were found by the survey. Six of the prehistoric sites were village sites, with two containing over 40 house features.

Geologic research conducted as part of the survey included geomorphic and tephra (airfall volcanic ash) studies. Tephra studies show two major and numerous minor Holocene eruptions of the Aniakchak Volcano (7400 and 3400 BP). The effects of the second eruption have been well studied by USGS researchers. The second major eruption appears to have made a large section of the central Alaska Peninsula uninhabitable; the findings suggest that human occupation did not return to the central Alaska Peninsula for almost 1300 years. The earliest cultural occupation found by the survey occurred approximately 2000 radiocarbon years ago. First millennium AD occupations show a mix of Aleut and Kachemak influences, with little input from northern Bristol Bay. Later periods of occupation after 900 BP may reflect both population movements and varying ecological factors. Numerous factors may have affected the rise and fall of human populations on the Alaska Peninsula during the later Holocene. The Aniakchak area shows evidence that changes in climate, periodic volcanism, tectonism (earthquakes and tsunamis), and the movement of people from outside into the region all affected prehistoric human settlement in this region.

The NPS entered into a cooperative agreement with the University of Washington Cooperative Ecological Studies Unit (CESU) for identification and documentation of natural and cultural resources associated with traditional use of Aniakchak National Monument and Preserve by Alaska Native groups. The project will document historic and present-day uses of parkland and resources by Alaska Native groups within the boundaries of Aniakchak and uses of land and resources near or related to Aniakchak that may affect or be affected by NPS management actions. Data collection focusing on historic and contemporary lifeways of Aniakchak-area Native peoples is necessary to document the use and/or importance of specific culturally significant resources occurring within Aniakchak. An important component of the study is to identify traditional access methods and routes.

Bering Land Bridge National Preserve

To better understand subsistence uses by park neighbors, Bering Land Bridge National Preserve conducted a study of subsistence practices of two adjacent Inupiaq communities: Wales and Deering. The study examined the social organization of wild food production and distribution. Meticulous collection of household harvest survey data showed that in 1994 Wales produced an estimated average of 744 pounds of wild food per person per year, while Deering produced 672 pounds. As has been observed in other small Alaska communities, about 30% of the households accounted for 70% or more of the harvest by weight. Households' subsistence production tended to increase with the age of household heads and with household size, as predicted by the household development model. Households occupied by an active single man were productive in both communities.

In both communities, households were found to cooperate extensively in the production and distribution of subsistence foods. Cooperation among households was highly patterned, and cooperative households could be sorted into multi-household networks. Deering was found to be organized into six multi-household networks, and Wales into eight networks. Surprisingly, multi-household subsistence networks resembled traditional Inupiaq "local family" groups described by Burch for the mid-19th century.

Denali National Park and Preserve

An Ethnographic Overview and Assessment (EOA) was undertaken in FY 99 and completed in FY 01. NPS cultural resource guidelines call for EOAs to document associations between park resources and contemporary people. Usually based primarily on existing published or archival materials supplemented with ethnographic interviews with community residents, the EOA reviews existing ethnographic information and identifies data needs. An EOA can also serve as a means for implementing partnerships with traditionally associated people through collaborative research and community-member participation in writing their own histories. It also serves to inform park staff and park-associated communities of their mutual interests and responsibilities.

This EOA was completed under contract with the ADF&G Division of Subsistence. The authors reviewed existing ethnographic data for the five Athabaskan groups associated with Denali National Park. The final report profiles the early contact history of these groups. In addition, band territories, sociopolitical organization, early subsistence economies, material culture, and religion and ritual are topics that are discussed in substantial detail. The concluding chapters narrate the significant changes brought to these polities by outside forces in the early 20th century and from 1941 to the present. An exhaustive annotated bibliography is included in a 50-page appendix. Accompanying the final report are community histories written by community members. The final report concludes that, although hunting has essentially been prohibited for decades on lands within the boundaries of the original Mount McKinley National Park, subsistence remains an important feature of village life in communities surrounding the park. Moreover, open access to subsistence resources in the preserve portion of the park area continues to be of signal local importance.

Gates of the Arctic National Park and Preserve

The ongoing project of assessing the feasibility of utilizing remote sensing, map, and GIS data for archaeological investigations of remote and inaccessible areas in the park continues. This collaborative project brings the NPS in partnership with the University of Alaska Quaternary Center and the USGS Advanced Systems Center. One component of the overall project involves the assessment of classified satellite imagery in archeological applications. In 2001 the final report, *Calibration/Validation of Remote Sensing Imagery Using Archaeological Data: Part I. Assessment of Commercial Sources*, by Owen K. Mason of the

Alaska Quaternary Center, was received. The analysis of remote imagery of study locations from the USGS Advanced Systems Center continues, with additional reports pending. Another descriptive report, by NPS archeologist Gena Weinberger, *A Tool for Archeological Predictive Modeling in Gates of the Arctic National Park and Preserve* (2001), documents a GIS analysis of the environmental associations of over 1200 known sites to develop clues that would inform future predictive modeling of site occurrence and distribution in the park unit.

Staff anthropologists are conducting a three-year ethnographic study of fishing on the Kobuk River. The project is a cooperative effort involving Kobuk and Shungnak Village residents and the ADF&G Division of Subsistence. Researchers will collect in-depth information about the use of and attitudes about fish on the Kobuk River, including opinions of local residents about sport fishing practices and local knowledge of whitefish population. The study encourages community interest and involvement in collaborative fisheries management and seeks local ideas regarding the ways traditional ecological knowledge may be better incorporated into management programs.

Katmai National Park and Preserve

The NPS completed the fourth and final season of data recovery (1997–2000) at the Mink Island archeological site within the Takli Island Archeological District on the coast of Katmai National Park and Preserve. A total of 18 cubic meters were excavated at the lower midden, with 65 radiocarbon dates ranging from 7600 to 4100 years ago (calibrated). Twenty-eight cubic meters were excavated at the upper/younger midden, with 19 radiocarbon dates ranging from AD 0 to 1460 (calibrated). Information recovered will redefine the cultural history along the Katmai coast. Exquisite preservation of seven occupation floors in the lower midden will provide a snapshot of prehistoric maritime lifeways at an unprecedented level of detail. Detailed recording of the microstratigraphy and removal of sediment peels will assist in identifying human and natural taphonomic processes recorded in the site sediments. The well-preserved vertebrate and invertebrate assemblages provide a record of the paleoclimatic history of the area for much of the Holocene, including the hypsithermal and Little Ice Age. The response of nearshore marine ecosystems to paleoclimatic changes will also be interpreted. Collections are extensive and will require the next two to four years for analysis. A total of 5,000 tools were recovered with an additional 100,000 pieces of debitage, in excess of 80,000 identifiable vertebrate faunal elements, and thousands of identifiable shells. The long-term excavation, lasting up to ten weeks for four years with crews numbering up to 17, was conducted in a wilderness-designated area and adhered to minimum tool requirements.

NPS archeologists located an extensive scatter of lithic debris and stone tools on Solstice Ridge, an upland divide adjacent to the Valley of Ten Thousand Smokes. The presence of wedge-shaped microblade cores and corner-notched projectile points suggests that the scatter includes Paleo-Arctic and Northern Archaic components. The surface site was unexpected because of persistent notions that areas surrounding the Valley of Ten Thousand Smokes were mantled by a thick tephra deposit from the 1912 Novarupta eruption. NPS archeologists documented another upland lithic scatter of probable Paleo-Arctic age among former shorelines near the outlet of Hammersly Lake, the distal end of the Naknek drainage sockeye salmon run. Clusters of lithic debris including microblades, core, and tools at the Hammersly Lake site may preserve evidence of discrete occupational episodes or social groups. These sites are evidence that upland big game hunting was important to people occupying the Katmai region during the early Holocene.

The 500-year old Cutbank Site within the Brooks River National Historic Landmark, Archeological District, receives the brunt of the erosional cutting of the Brooks River. Prehistoric house

A 6000-year-old house floor from Mink Island off the coast of Katmai National Park and Preserve. Houses of this type were roughly circular and were perhaps covered with a tent-like framework of light poles and hides. The house floor, smeared with red ochre and black ash, is the level surface in the middle distance of the photograph. Small paper tags mark stratigraphic features in the rear wall of the excavation.

floors and human burials are actively eroding from the site, which is at a location frequented by Katmai visitors. Over 127 prehistoric features including at least 31 multi-roomed houses are located within 20 meters of the eroding river bank. During the summer of 2001, the current position of the eroding bank was mapped, and a large-scale map of the eroding bank was tied into previous mapping and survey monuments. A USGS/BRD hydrologist interpreted erosional processes operating on the Brooks River and advised the NPS on erosion control and monitoring measures. The Council of Katmai Descendants and the Heirs of Palakia Melgenak participated in on-site discussions concerning management actions to deal with archeological materials and human remains actively eroding from the site. A sampling plan was prepared to guide the data recovery efforts scheduled to begin in 2002. Data recovery objectives include determining the distribution of prehistoric habitations along the length of the eroding bank and the relationships between the house units, interpretation of the house structure or form, and identification of the function of single depressions and their relationship to the multi-roomed houses.

Klondike Gold Rush National Historical Park

An EOA for Klondike Gold Rush National Historical Park was funded as a NAGPRA (Native American Graves and Repatriation Act) project to identify tribes affiliated with the park and to document indigenous uses of the Chilkoot Trail and surrounding areas. The project began in FY 00. In addition to the NAGPRA goal, the project aims to add information about indigenous people who participated in the Gold Rush commemorated by the Klondike Gold Rush National Historical Park. The project also establishes research partnerships with Alaska Native tribal groups in Skagway, Haines, and Klukwan and the Canadian First Nations tribes and intends to add a Native voice to interpretation of the Gold Rush. At present there is little mention of Native people, particularly their traditional trading and subsistence uses of the Chilkoot Trail area, in the interpretive materials used in the park. The products will be an overview report that synthesizes prior ethnographic and historical literature and oral history interviews into a narrative understandable to park managers and the interested public. The overview will also include an annotated bibliography that critically evaluates significant sources of information about the culture and history of the Native people surrounding the park.

Lake Clark National Park and Preserve

A cooperative effort between the NPS, the Alaska Department of Natural Resources' Office of History and Archeology, Kijik Corporation, the Nondalton Tribal Council, and the Lake and Peninsula Borough resulted in the first archeological survey of the middle Mulchatna River in 2000. The Mulchatna River is about 160 miles long and heads at Turquoise Lake in Lake Clark; it runs through state, borough select, and Native lands. The Mulchatna River was home to several 19th century Dena'ina villages that were the ancestral homes to many of the people of present-day Nondalton. Twenty-three late-prehistoric and historic sites were located during the 12-day expedition. The Bureau of Indian Affairs ANCSA Office and the Kenai Peninsula College joined the second season of the Mulchatna Archeological Survey in 2001. This effort focused on locating late-prehistoric sites mentioned in oral historical accounts and on addressing village concerns about land management related to the preservation of these sites. Late-prehistoric Dena'ina houses were found near Marabou Landing, Russian Creek, and Dummy Creek. Several 20th century camps were located, and three sites were tested for recovery of charcoal for site dating purposes.

In partnership with the University of Oregon, the NPS initiated a three-year study, beginning in 2001, of the only known rock painting sites documented on NPS-managed land in Alaska. The Clam Cove and Tuxedni Bay pictograph sites in Lake Clark are fragile red ochre paintings of unknown prehistoric age that are subject to damage by water runoff, lichen growth, rock fracturing, and human action. The University of Manitoba has supported the study by returning the archeological collection from Clam Cove to NPS for analysis. The NPS will perform chemical analyses of the paints, attempt direct dating of the paints, perform anthropological analyses of the images, prepare a preservation plan, and develop interpretive displays for local culture centers and broader public education. The NPS contracted with Applied Photographic Research to obtain complete photographic documentation of the images, using a cross-polarized photographic technique and enhanced digital renderings for analysis. These sites are extremely important in that the images of interacting humans, animals, and spirits offer rare insight into the minds of the prehistoric inhabitants of Lake Clark that cannot be known from stone tool scatters and habitations. This project is supporting one graduate student at the University

of Oregon's Department of Anthropology. The two sites have a unique potential to contribute significantly to anthropological and archeological knowledge.

The Newhalen Tribal Council, the Newhalen School, and the NPS worked together for the third year on the Newhalen Heritage Program. The FY 00 program featured a spirit camp where high school and junior high students camped at Newhalen River Gorge Archeological Site with village elders. The elders taught the students traditional fish processing, while NPS archeologists taught the students how to map the site with state-of-the-art survey technology. Classroom demonstrations of computer-aided mapping and presentations about community preservation planning were also part of this successful program.

Noatak National Preserve

NPS archeologists, in collaboration with faculty and students from Brown University and Washington State University, continued to conduct site catchment surveys in the natural drainage units of Noatak National Preserve. Where necessary to properly characterize the sites, these surveys were accompanied by limited test excavations. Work in the Anisak River drainage revealed a wide array of sites dating from the late Pleistocene to the late prehistoric. The Anisak River is known ethnographically as a major travel corridor for people leaving the Noatak River Valley and crossing the De Long Mountains onto the North Slope. Similar inventory work in the Nimiuktuk River drainage centered on major ridgelines near Long Lake. Here, test excavations were made at two large sites dating from what appears to be the Paleo-Arctic. One site yielded numerous microblades but few diagnostics. However, nearby on the same ridge, archeologists stumbled on an isolated cache of close to 50 bifacial preforms in a highly concentrated area of only a few square meters. These large preforms represented a number of stages of manufacture and, tantalizingly, resembled similar projectile-point caches associated with Paleo-Indian sites in the lower 48. Unfortunately no datable radiocarbon samples were recovered from the cache location. The second site, on a separate ridge, produced a Kayuk-like projectile point, many large bifacial preforms, and a multitude of microblades. This rich site is thought to date somewhere in the neighborhood of 8000 years ago. The emerging archeological picture from this continued work in the upper reaches of the Noatak is one of immense complexity.

Wrangell–St. Elias National Park and Preserve

Wrangell–St. Elias National Park and Preserve launched an EOA in 1996, and most components of the study were completed by 2001. It was conducted under contract with the Copper River Native Association. The EOA used published and archival research, augmented by interviews, to describe the Alaska Native (Ahtna) communities that traditionally used the park, as well as more general information that puts each community in a regional and historic perspective. There are nine modern Ahtna villages in total, seven of which have traditional hunting territory in the Wrangell–St. Elias National Park and Preserve. The communities of Mentasta, Chistochina, and Kluti-Kaah (Copper Center) chose to provide their own written community histories through cooperative agreements with the NPS. The EOA's review of ethnographic data on the Ahtna, its component describing government-to-government relationships between the U.S. government and American Indian tribes, and its seven community histories were put together with the idea that such a compendium would be useful to NPS staff, the public, and the Ahtna people. The EOA focuses on the Ahtna's transition from the traditional to the modern era, and it outlines the influences that have affected culture change among the peoples associated with Wrangell–St. Elias National Park and Preserve.

Yukon–Charley Rivers National Preserve

NPS archaeologists conducted an in-depth investigation of a significant prehistoric site in Yukon–Charley Rivers National Preserve. The Foster–Keith Site, officially known as CHR-077, is located on a ridgeline that comprises the boundary between NPS and Doyon, Ltd. lands. The site is notable for both its density and size, consisting of over 60 discrete lithic scatter concentrations in an area approximately two miles long, as well as for the presence of Tuktu- and Campus-style blade cores. First discovered in 1986, the site has been slated for further investigation for over a decade. Previous recommendations had called for a thorough mapping effort; however, it was evident upon reaching the site that additional survey of the area was required. As a result, limited mapping was conducted by two archaeologists, while the remainder of the crew identified and recorded new features and areas. A final report and site maps will be completed by the spring of 2002.

Investigators in natural and cultural disciplines in the U.S. and Canada are collaborating to pro-

vide information for an environmental history of the upper Yukon River region. The various researchers are compiling existing knowledge in several fields, including geology, paleoecology, biology, hydrology, archaeology, history, ethnography, and indigenous knowledge. During the summer of 2001 an NPS researcher traveled the Yukon River from Dawson City, Yukon Territory, to Circle, Alaska, collecting life history stories from numerous residents in the area. The overall environmental history manuscript is scheduled for completion in 2002-03. Project partners include Parks Canada, University of Alaska Quaternary Center, Trond'ek Hwech'en First Nation, and Yukon–Charley Rivers National Preserve.

Shared Beringian Heritage Program

The Shared Beringian Heritage Program continues to foster research and community exchanges across the Bering Strait between the U.S. and Russia. The funded projects are representative of the types of activities that would be enhanced and encouraged by the eventual designation of an international park linking conservation units in Alaska and Chukotka, Russia. The program emphasizes the local and international participation that is necessary to successfully conserve the natural and cultural resources of the area and sustain the vitality of the Native people on both sides of the Bering Strait. One unique feature of the research program is that its direction is charted by a five-member Beringia Panel that draws the majority of its membership from the Native leadership of the Beringian region.

Each year participating scientists, Native leaders, resource managers, and government officials from both Russia and the U.S. meet to exchange findings and ideas at a two-day Beringia Days Conference. This event, opened to the public free of charge, is a training ground for young scientists and emerging local leaders. It provides an opportunity to meet other Beringian researchers and to organize new partnerships for future research endeavors. Representatives from many Federal, state, and non-governmental agencies from both sides of the Bering Strait are collaborating in Beringian research and activities and regularly attend the conference events. This conference gives the Beringia Panel, who are available for consultation, an opportunity to meet and talk to the researchers and gauge the progress that is being made in the various funded projects.

There is a close correspondence between the objectives of the Shared Beringian Heritage Program and the goals of the U.S. Arctic Research Plan, which was created in response to the Arctic Research and Policy Act of 1984. Some of the key goals of the Shared Beringian Heritage Program are to:

- Foster a climate of mutual understanding and cooperation between the U.S. and Russia, including the indigenous people of the central Beringian region, in environmental protection, conservation of flora and fauna, and historic preservation and interpretation;
- Provide for continued opportunities for subsistence use of resources within central Beringia and give recognition to the unique and traditional cultural activities that are characteristic of the indigenous people of the region;
- Encourage the study, interpretation, and enjoyment of historic, cultural, and archeological sites of great international significance; and
- Enhance opportunities to re-establish cultural traditions between indigenous people on both sides of the Bering Strait.

Now that a more open political climate has taken root in Chukotka, it is expected that the level of activity in the Beringia Region will increase in the next several years. More and more agencies and groups are coordinating their efforts and are helping one another achieve success in their research plans.

Since last reporting in Volume 14 of *Arctic Research of the United States*, several projects have reached their maximum three-year funding limits, and the project leads are now completing their final reports. The University of Alaska Fairbanks conducted fungi research in Kobuk Valley National Park and on the Seward Peninsula. A team of mycologists and ethnobotanists from across the U.S., Germany, Russia, and Australia studied these organisms in the Arctic. In the summer of 2001, members of the team conducted research in the Provideniya area of Chukotka, Russia.

Another successful project just completed was a survey of traditional knowledge of polar bear habitat in Chukotka. This work was carried out by the Alaska Nanuuq Commission in partnership with the U.S. Fish and Wildlife Service (USFWS) and the Association of Traditional Marine Mammal Hunters of Chukotka. Feeding, denning, and migration areas were mapped in Chukotka, using a

model of similar work performed in Alaska.

Research continues on Chukotka walrus harvest monitoring and traditional use. This work is being conducted by Kawerak, Incorporated and the Alaska Walrus Commission, with the assistance of the USFWS. An educational unit and annual workshop is included in the project to train observers in the Russian villages for walrus monitoring work and other scientific studies.

In 2000 and 2001 the NPS joined with the Chukotka Academy of Sciences and the Chukotka Native organizations to study the economic consequences of the transition to a market economy on the subsistence lifestyle and the traditional use of natural resources on the Chukotka Peninsula. With the collapse of the Soviet Union, anecdotal data suggested that Chukotkan coastal Native people had substantially increased their reliance on subsistence activities. Because increased and continuing access to many of the subsistence resources important to Chukotka Natives depends on international conventions, agreements, or treaties, it was important to arm Chukotka subsistence users with hard data that they could use to effectively make their case with the International Whaling Commission and other bodies that influence the allocation of marine resources. In the course of the research, over 400 structured interviews were conducted in three communities: Laventiya, Lorino, and Sereniki. These communities represent a mix of several attributes—dependence of wildlife resources, traditional practices and values, involvement in wage and service sectors, ethnic makeup, and impacts from the collapse of former state farms. Questions to community members cover details about household composition, participation in subsistence activities, harvest assessments, food preferences, income sources and distributions, and a host of other relevant topics of inquiry. Preliminary results indicate a major dependence on wildlife resources, high per capita harvests of marine animals, low cash incomes, and strong adherence to traditional social practices such as food sharing. These findings are consistent with the expectation that dependence on subsistence foods and products have more than doubled since the 1980s.

The NPS is funding the creation of a digital collection of the administrative library of Dr. Tom Albert, who, until his recent retirement, was the Chief Scientist and Deputy Director of the North Slope Borough's Department of Wildlife Management in Barrow, Alaska. His highly productive career spanned nearly 20 years of work in the Arctic. He was instrumental in encouraging interdisciplinary scientific research in both Alaska and Chukotka and in mentoring young scientists, both in the academic and local communities. Dr. Albert was honored in 2001 as the first recipient of the David M. Hopkins Beringia Award, presented by the NPS.

To support the geospatial information needs of funded research, GIS maps of Chukotka are being produced by the NPS GIS specialists in cooperation with Russian counterparts. Coverage includes the north coast and the eastern region of the Chukotkan peninsula. Along with the GIS data, scanned Russian topographical maps will be made available for the area covered.

A two-year study of Paleo-Indian archeology and paleoecology in the Noatak Basin of northwestern Alaska was begun in FY 01. Through intensive surface reconnaissance, mapping, and limited test excavation, the investigations aim to characterize the nature and integrity of cultural deposits and to recover a representative sample of artifacts and materials for radiocarbon dating. This work will determine the research potential of the site and in the process provide new data for scientific and popular interpretation of park resources. Paleoenvironmental and geomorphological investigations intend to provide a fine-grained regional picture of past vegetation and geological changes in the area.

Scientific education and public interpretation and reporting continue to be important elements of the Beringia Program. Dr. Richard Bland is translating and producing an English edition of the museum catalog of the Provideniya Museum. This regional Chukotkan museum contains important archeological and ethnographic collections that have been little seen outside of Russia. Also, Dr. Bland is completing English translations of additional important works written by the late N.N. Dikov, the father of archeological research in the Russian Far East. Professor Dikov's *Asia at the Juncture with America in Antiquity* (1997) and *Mysteries in the Rocks of Ancient Chukotka* (1999) were published earlier. In 2000 the Shared Beringian Heritage Program published Bland's translation of Aleksandr Lebedintsev's seminal work on the prehistoric cultures of the Sea of Okhotsk, titled *Early Maritime Cultures of Northwestern Priokhot'e.* Lebedintsev was a noted assistant to Dikov.

In 2000 Dr. James Dixon of the Institute of Arctic and Alpine Research, University of Colorado, began a three-year research and writing project

under NPS sponsorship to prepare a scholarly, yet popular, synthetic volume on the prehistory of Beringia. The primary value of the project is to make sense of the big picture of Beringian prehistory, from the Pleistocene to the late prehistoric, drawing on the results of both American and Russian scholarship on the topic. Given the hot debates about early Americans that now prevail in both the professional and popular scientific literature, a balanced synthesis could not be more timely. What is unique about this study is that it will examine the evidence from the Russian Far East as well as Alaska and take the story of cultural interaction in Beringia from the Pleistocene to the period of first European contact.

One study closely affiliated with the Shared Beringian Heritage Program, but not specifically funded by the program, is the social history of the Inupiaq Eskimo parka. Despite the parka's close cultural connection to the identity of the Inupiat of northwest Alaska, most of the prior literature on this important topic has centered on the craft or art of parka making. This two-year study demonstrated the historic and continuing function of the parka as an essential and age-old component of the Inupiaq subsistence system, where its manufacture and use is central to the maintenance of the human/animal relationship. In recent years the malleable parka in all of its many modern manifestations has become an active tool for displaying both social status and identity in the Inupiaq north. A professional report on the findings was prepared in 2001 as a Ph.D. thesis at the University of Alaska Fairbanks; it is titled *Mediated Identity and Negotiated Tradition: The Inupiaq Atigi 1850–2000.* A popular summary is in preparation and will be shared with the Inupiat people and the general public.

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 U.S., including those in Arctic Alaska. Management is based on principles of multiple use and sustained yield, a combination 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 habitat, wilderness, and natural, scientific, educational, and cultural values. Research is typically site-specific to address identified problems, as opposed to research for the sake of expanding knowledge.

	Funding (thousands)	
	FY 00	FY 01
Natural Ecology	2,900	2,900
Minerals Research	115	115
Cultural Resources	200	200
Pipeline Monitoring	550	550
Fire Control	380	380
Mining Administration	300	300
Total	4,445	4,445

Cultural and Paleontological Resources

The BLM completed assessments on 78 historic cabins in northern Alaska in 2000. Work on cabin assessments provided the BLM with the opportunity to gather information useful for other management purposes. For example, valuable information was obtained on forest conditions and fuels accumulations that could later be important to the BLM in forest management efforts, including control of natural burns and prevention of uncontrolled wildfire through prescription burning to reduce accumulated fuels. The cabin assessment work also allowed archaeologists to find and inventory remote archaeological sites without the necessity of using expensive helicopters for access.

Other work done by the BLM in 2000 and 2001 through its cultural and paleontological programs included the following:

- An off-road-vehicle inventory and experimental trail hardening in the Tangle Lakes Archaeological District continued in 2000 and 2001, covering approximately 767 acres of land, with the objective to assess the effects of off-highway vehicle use as well as to test new synthetic trail hardening materials. In 2000, 88.6 miles of trails were examined, and 49 new or previously documented archaeological

sites were recorded. In 2001, four nondesignated trails were surveyed, along with 18 unrecorded prehistoric sites and the redocumentation of 27 previously known sites.

- An emergency salvage project in the early-20th-century mining town site of Coldfoot was conducted in 2001, made necessary because of a dramatic increase in the rate of erosion by the Koyukuk River. Some recovered historic remains were subsequently sent to Texas A & M University for analysis.
- An archaeological inventory of approximately 4800 acres was completed in 2001 in the Steese National Conservation Area using GIS data to model the work.
- A cultural/paleontological/recreation survey collecting GPS coordinates on caves and rock shelter locations was conducted in 2001 in Limestone Gulch within the White Mountains National Recreation Area. Follow-up inventory work is planned there in 2002.
- Survey work in the National Petroleum Reserve–Alaska, conducted during June and July 2000, resulted in the discovery of 23 prehistoric sites along the Ipnavik River and two sites in the Pik Dunes area. Low-level helicopter reconnaissance monitoring in the Ikpikpuk River area showed no unauthorized collection of Pleistocene paleontological deposits.

Mineral Assessments

BLM's mineral assessments program consisted of two study efforts during 2000 and 2001.

Mining District Studies

The Mining District Studies program is focused on understanding past and current mining activity and assessing the potential for future mining development in Alaska. The objectives are to identify the type, grade, and size of mineral resources within a mining district and to perform mining feasibility studies using hypothetical mine models of mineral deposits having economic potential. Mineral assessments of the mining districts are being conducted systematically in response to a long-range planning document. To date, there are 15 mining districts with completed or nearly completed mineral assessments, and assessments for another 15 of the mining districts are scheduled and prioritized. Assessments of the remaining 43 mining districts have not yet been scheduled.

The final year of field work for the Koyukuk (northeastern Alaska) and Stikine (southeastern Alaska) mineral assessments was completed during 2001. Interim reports were written and published for both mineral assessments in 2001. An economic analysis was published for the Koyukuk Mining District study and started for the Stikine mineral assessment. Final reports are being completed and will be published in 2002.

Initial fieldwork was completed on the next two multi-year mineral assessment studies being undertaken by BLM in Alaska: the Aniak Mining District in southwestern Alaska and the Delta River Mining District in east-central Alaska.

Geophysical Surveys

Airborne geophysical surveys include the acquisition of total field magnetics and induced electromagnetic conductivity data to aid in geologic interpretation to further mineral exploration. BLM's work is conducted in coordination with Alaska Division of Geologic and Geophysical Surveys, which provides contract administration and management and interpretation for the data collected.

A regional airborne geophysical survey was flown in the Aniak Mining District during 2000 as part of the BLM's continuing effort to more adequately fulfill its mineral assessment responsibilities on public lands in Alaska. Areas targeted for surveys in the Aniak area hold potential for large, low-grade gold deposits associated with Cretaceous to Tertiary felsic intrusive rocks. Airborne geophysical data were purchased from private parties for parts of the Delta River Mining District, and work was completed, in collaboration with the U.S. Geological Survey (USGS), on collecting ground-based, gravity, and magnetotelluric data in the district. Work on a final report for the Stikine airborne geophysical survey was also initiated.

North Slope Research Camps

Research on the North Slope continues to increase. During the 2000 and 2001 field seasons, university, private, governmental, and other institutional researchers cooperated on studies. Research subjects ranged from climate change to snow cover and from aquatic plants to ground squirrels.

Much of the research is done within the boundaries of the three Areas of Critical Environmental Concern (ACEC). The largest of these—the 82,000-acre Toolik Lake ACEC—includes the Toolik Lake Field Station, an important logistics base for Arctic biological research and the only such

Arctic research base in the U.S. The Institute of Arctic Biology, University of Alaska Fairbanks, established the field station in 1975. It is now under a Recreation and Public Purposes Lease issued by the BLM. The field station serves scientists from about 30 universities and 20 nations. The BLM, through its membership in the Toolik Lake Steering Committee, works closely with the Institute of Arctic Biology, the National Science Foundation, and the research community to manage this ACEC.

Other Arctic research is ongoing in the Galbraith Lake ACEC, locate along the Dalton Highway, and in the 19,000-acre Iteriak ACEC, located in the northern foothills of the Brooks Range. During the 2000 and 2001 field seasons, research continued from the base camp at Ivotuk in the Iteriak ACEC.

Arctic Char in the Kigluaik Mountains

In FY 00 and 01, researchers at the University of Wisconsin, Milwaukee, and the BLM completed a cooperative project to study Arctic char on the Seward Peninsula in western Alaska. The study was initiated in 1997. Researchers used nuclear and mitochondrial DNA genetics analyses to determine the taxonomic status of isolated, relict populations of lake-resident Arctic char in the Kigluaik Mountains. The results indicate that char from some of the lakes differ significantly from other Alaska char. This work was completed and resulted in the listing of the Kigluaik char as a BLM Sensitive Species. Population estimate work will commence in 2003.

National Petroleum Reserve–Alaska

During 2000 and 2001 the BLM contributed funds to two satellite telemetry studies of Steller's and spectacled eiders, both listed as threatened under the Endangered Species Act, in the National Petroleum Reserve–Alaska (NPR-A). The study of movements of the Steller's eider was conducted primarily by the U.S. Fish and Wildlife Service and the USGS's Biological Resources Division, while the study of movements of the spectacled eider was conducted by a contractor for British Petroleum Exploration (Alaska), Inc. Both studies involved two years of telemetry data, and reports should be produced in 2002.

The BLM also continues to contribute funds to annual surveys by boat of raptors along the Colville River on the eastern edge of the NPR-A. These surveys have provided excellent long-term data, collected annually since 1978, with less frequent observations dating to 1952. The diversity and density of nesting raptors along the Colville River is matched by only a few other areas on earth. This valuable data set will aid in assessing the potential effects of future oil field development in the eastern NPR-A.

In the northeastern NPR-A, where oil and gas leases were awarded in 1999 and where another lease sale is scheduled for 2002, the BLM continues its long-term study of the impacts to vegetation of winter seismic exploration and ice road construction. This study will assess the impacts to several landcover classes at a range of disturbance levels. It will describe the recovery of the vegetation over time, in terms of duration and possible changes in species composition.

The BLM is also continuing its joint effort with the Alaska Department of Fish and Game and the North Slope Borough's Department of Wildlife Management to monitor the population dynamics, movements, and range use of the Teshekpuk Caribou Herd, which calves in the northeastern NPR-A. A report produced in 2001 analyzed ten years of satellite telemetry data for this herd.

Hydrologic Monitoring

BLM hydrologists are monitoring streamflow in Interior and Arctic Coastal Alaska in rivers important for anadromous fisheries. In 2000 and 2001, water level recorders were used to gather information on the Jim River and on Clear Creek, a tributary to the Hogataza River. Recorders have also been installed on streams that are part of the National Wild and Scenic River System, including Fortymile River and Nome Creek, a tributary to the Beaver Creek National Wild and Scenic River. Sites examining peak streamflows and channel morphology are also located in numerous drainages in the Circle, Fortymile, and Tolovana mining districts. This information is useful in designing channel and floodplain reclamation on Federal mining claims and for evaluating earlier reclamation results.

Seventeen rivers and six lakes were inventoried for water quality and quantity during a reconnaissance survey of the northeast area of NPR-A. Several were in the Colville River Special Area. Snow surveys and climate monitoring continue along the Dalton, Steese, and Taylor Highways, as well as at remote locations in the Alaskan Interior.

Neotropical Migratory Bird Surveys

BLM-Alaska wildlife biologists continued to participate in the Neotropical Migratory Bird (NTMB) Conservation program during 2000 and 2001. This program is better known as "Partners In Flight." Surveys conducted provide a source of standardized data on populations of breeding birds throughout the U.S. and Canada. Breeding habitats in Alaska are largely intact and provide an opportunity to clarify the importance of breeding habitat versus migration and wintering habitats for many species of long-distance migrants. All breeding bird survey (BBS) data are reported to the Biological Resources Division (BRD) of USGS. A trend analysis statistical procedure is used to estimate the population change for every species or trend each year.

To monitor trends in North American bird populations, 10 BBS and 7 off-road breeding birds surveys (ORBBSs) were conducted annually in northern and northwestern Alaska. Survey routes were established, and initial work began in 1992 and 1993. Many species detected on these routes are identified by Boreal Partners in Flight, the working group for Canada and Alaska, as species of conservation priority. These include the olive-sided flycatcher, Hammond's flycatcher, gray-cheeked thrush, varied thrush, Townsend's warbler, blackpoll warbler, and white-winged crossbill.

BBS routes were also conducted along the Unalakleet and Anvik Rivers in western Alaska, adapting standard protocols to a river, rather than roadside, setting. Since the routes were established in 1996, 35 species have been recorded on the Unalakleet route and 42 on the Anvik survey

Three bird banding stations were established to inventory breeding landbirds in 1998, and they continued to be operated in 2000 and 2001. In June of each year, birds were banded at the Old Woman public use cabin on the Old Woman River, a tributary to the Unalakleet River that drains into Norton Sound. An ORBBS was also established in 1998 on Old Woman Mountain to provide supplemental information. Bird banding stations were also established on the upper reaches of the Anvik and Bonasila Rivers, which drain into the Yukon River near the village of Anvik. Four shorebird and 17 landbird species, with 231 individuals, were captured during 2000 and 2001. The northern waterthrush was the primary species captured, followed by Swainson's thrush, Wilson's warbler, and myrtle warbler. In 2001 the Anvik River station had returns of two northern waterthrushes banded in 1998, and eight northern waterthrushes and one Swainson's thrush banded in 2000. These recaptures provide information on breeding site fidelity and longevity.

A fall migration bird banding station was established at the BLM's Campbell Tract in Anchorage in 1997 and continued to be operated through 2000 and 2001. Migrant birds were captured with mist nets, banded, and released annually from mid-August through September. Twenty-six species were captured during the reporting time, with 413 individuals banded in 1997, 961 in 1998, 1010 in 1999, 1254 in 2000, and 1343 in 2001. The slate-colored junco was the primary species captured, followed by Wilson's warbler, orange-crowned warbler, and ruby-crowned kinglet. Returns included slate-colored junco, hermit thrush, fox sparrow, and black-capped chickadee banded since 1997.

BLM is working with USGS/BRD to determine the cause for a large number of black-capped chickadees being found with deformed bills in south-central Alaska. Chickadees banded by BLM biologists in the fall migration since 1997 with normal bills are later being recaptured with deformed, elongated bills by USGS/BRD biologists. It is anticipated that the banding data on these birds will give clues about the cause and age of onset of the bill deformations.

BLM biologists also participated in environmental outreach, presenting four or more programs in bird identification and conservation annually to students.

Fortymile Caribou Herd Recovery

Important to subsistence hunters throughout the ages, the Fortymile Caribou Herd (FCH) once occupied 220,000 square kilometers of Alaska and Yukon and, based on estimates by the biologist Olas Murie in 1935, numbered about 568,000 animals. By 1994 the FCH occupied less that a quarter of its original range and numbered 22,104. Years of research showed that wolf predation was the primary factor limiting the survival of calves and growth of the FCH. The plan included actions to increase calf survival.

In response to requests from subsistence hunters throughout Alaska and Yukon, Canada, in 1994 BLM joined state and Federal agencies and concerned citizens to begin planning for the recovery of the FCH. The FCH Management Plan (MP) was completed in 1995, and implementation began in 1996. The planning team completed its mission and was disbanded in 2000, and implementation of

the five-year plan was completed in June 2001.

The MP was carefully crafted by subsistence and sport hunters, wildlife enthusiasts, animal rights advocates, environmental advocates, ecotourism representatives, and agency representatives from Alaska and the Yukon. Implementation of the plan included reduced harvest, monitoring of land use within the FCH range, fertility control of alpha wolves, and translocation of subordinate wolves. The BLM joined with ADF&G to monitor calf survival and population growth during and after the implementation of the plan.

Today the herd is growing because of the recovery efforts and has begun expanding west and south into its former range, including the highlands of the Steese National Conservation Area and east into its former range in the Yukon. Calf/cow ratios have improved from 22 calves per 100 cows in 1994 to 38.2 calves per 100 cows in 2001, and the herd has grown by about 10% annually since implementation of the plan began (22,104 in 1994 to 40,204 in 2001). Harvest bag limits were increased in regulatory year 2001-02 and will be further increased modestly over the next few years, depending on herd growth.

Fire Effects Studies

Recent large wildfires have captured the nation's attention and caused many communities, homeowners, and agencies to seek methods to reduce wildfire risks to homes and property at the forest/urban interface. Cleared fuel breaks and prescribed burns have been employed to discourage the spread of wildfire, but sometimes less dramatic treatments are desirable for ecological, aesthetic, or engineering reasons. The BLM Alaska Fire Service (AFS) and Tanana Chiefs Conference, Inc. have initiated a three-year Fuels Treatment Demonstration project, with funding from the National Interagency Joint Fire Science Program. This study is intended to compare degrees of fuel reduction by thinning, with or without pruning, in boreal black spruce while simultaneously reducing fire risks, visual impacts, environmental effects, and cost/benefit ratios.

The BLM Northern Field Office and AFS have entered into an agreement with the Army's Cold Regions Research and Engineering Laboratory to revisit permanent transects established 25 years ago to monitor recovery from severe tundra fires in the Imuruk Basin, which is now within the Bering Land Bridge National Park. With assistance from the National Park Service, transects were relocated and resampled under the guidance of the original investigator. Vegetation and permafrost depths are being studied and compared during different stages of the recovery.

The University of Alaska is leading an effort, along with BLM, USGS, and several Federal and state partners, to develop a computer model for landscape-level analysis of fire–human interactions, vegetation change over time, and prediction of regional fire risk in Interior Alaska's boreal forest. The Interagency Joint Fire Science Program has granted funding for this project for 2002–2004 with the goal of building a prototype model that will provide land managers with thematic representations, spanning years to centuries into the future, of how forest cover and probabilities of large fire events will respond to different scenarios of fire management and climatic change. The model will utilize physical, biological, and human thematic layers and simulate ecosystem dynamics, specific to boreal forests, that influence wildlife, hydrology, and soil processes.

BLM AFS and field offices have established long-term vegetation monitoring plots at several prescribed fire or fuel treatment sites to look at vegetation changes that may impact land users and wildlife. Partners include the State of Alaska, Army Corps of Engineers (Chena Lakes Flood Control Project), and Tanacross Village Corporation. In addition, the U.S Forest Service Pacific Northwest Research Station is determining how weather and fuel dryness affect the reduction in mossy forest floor duff during fire. This question is important to many wildlife habitat improvement projects, especially those involving revegetation with desired plant species, and also for determining erosion potential and the extent of smoke pollution during future wildfires and prescribed fires.

Beaver Creek Fish Weir and Nome Creek Studies

Following the Beaver Creek National Wild River Management Plan, the BLM has continued a five-year study in 2000 and 2001 designed to inventory fish, wildlife, and habitat use within the river corridor and to monitor the effects of river management actions, population trends, and habitat use. A major emphasis of the program has been on anadromous fish in the middle and upper part of Beaver Creek. Work continued to focus on:

- Enumerating anadromous fish populations;
- Determining the timing and strength of the summer and fall salmon runs;

- Monitoring the hydrological conditions at a weir site; and
- Collecting and preserving scales and caudal fin tissue for genetic stock analyses.

Accurate salmon escapement data are important for evaluating and providing stock status information on salmon populations and harvest management strategies, particularly in mixed-stock fisheries. The weir study should provide useful information on whether recent recreational development of nearby Nome Creek is increasing harvest pressure by sport fisherman and negatively impacting the subsistence fisheries of the villages of Beaver and Steven's Village. The field work for the seven-year study to enumerate the anadromous fishes was completed in 2001.

The Nome Creek watershed, approximately 60 miles northeast of Fairbanks in the White Mountains National Recreation Areas, is the subject of additional studies by the BLM fisheries biologists. Of particular interest is Nome Creek's resident fish populations, including an Arctic grayling catch-and-release sport fishery population characterization. Life history information has been collected on the stock since the mid-1980s.

Bering Glacier Research

Ongoing research was expanded at the Bering Glacier in 2000 and 2001. The Bering Glacier is the longest (118 miles) and largest (2000 square miles) glacier on the North American continent. The glacier surges forward periodically at intervals of 20 and 30 years. There is a wealth of historical information available for the glacier, including photographs taken in 1905. The USGS has monitored the movements of the glacier since 1974 and initiated a major monitoring effort with the BLM in the late summer of 1993.

Since mid-May 1994, several major events have occurred, the meaning of which confounds glaciologists and biologists. These include a recent extraordinarily rapid surge at the terminus, unusual rapid movement far up the reaches of the glacier, separation of ice from the surrounding bedrock, the filling of Vitus Lake with terminus and calved ice, the sudden appearance of a heavy sediment load from Seal River, an unusually rapid retreat since the surge, the recent appearance of sink holes on stable forelands, and previously unrecorded ice tables forming near the east side of the glacier.

The Bering Glacier mimics the movement of Antarctic ice rivers and has thus become a world-renowned site for foreign glaciologists, and for scientists studying Antarctic glaciers, to measure and study the effects of ice movement. Nine universities have ongoing research at the site, the USGS has established permanent monitoring stations, and the State of Alaska, the BLM, and USGS are using the glacier for educational training programs for geologists and other outdoor education programs. In 1998 the Bering Glacier was nominated as a Global Fiducial Site.

Recent science-related activities focused on the glacier include:

- Presentation of a manuscript at the American Geophysical Union meetings in San Francisco in December 2001 describing the very atypical temperature and salinity structure of Vitus and Berg lakes; this study was performed by USGS, Environmental Research Institute of Michigan, and the University of Michigan;
- Receipt of a request from the Environmental Research Centre, at the University of Durham, in the United Kingdom, to study late Holocene sea level changes in support of a major effort to model worldwide sea level changes over time; and
- A National Science Foundation grant request to study the ecology of the Bering Glacier area by the University of Alaska Anchorage, the Environmental Research Institute of Michigan, the University of Iowa, the University of Edmonton (Alberta), and the University of Durham (UK), with the BLM listed as a supporting agency.

Monitoring of the glacier for changes in movement patterns, climate, and rare and sensitive species of vegetation and wildlife has become the focal point for many studies relating to global climate change. The Bering Glacier is one of the few areas in the world where changes in climate, flora, and fauna can be inventoried and studied from sea level to nearly 18,000 ft (Mt. St. Elias) in a little over 100 miles. This makes the forelands, glacier, and ice fields extremely important for studying the process of ecological succession. The University of Alaska Anchorage has entered into an agreement with the BLM to map and collect the vegetation of the region. The study, which began in 1999, has already documented several rare species of plants and at least one previously unknown species. This initial study has spurred a more intense effort in coming years. There is some speculation that many new species of flora will be documented, because, as the glacier retreats, seed is released into newly exposed soils.

More recent activities have supported the view

that the Bering Glacier is a highly significant site for biodiversity. Studies by the University of Alaska Anchorage in 2000 and 2001 have shown that fully 20% of the known plant species in Alaska are represented at the Bering Glacier. Additionally, 17 of the species represent significant range extensions from locations in either far western Alaska or the Aleutian Islands. Even more astonishing is the diversity of bryophytes (mosses, lichens, and liverworts). At least three new species previously described only in Norway were documented by the University of Iowa during the summer of 2001.

In the fall of 1998, on a site near the glacier's terminus exposed during the current retreat, a forest of standing trees, with accompanying peat layers, was discovered. While broken trees and peat are common finds at retreating glaciers, the discovery of intact, standing trees (trees in growth position) and the peat that was deposited during their lives is of great significance to several scientific disciplines. Trees like these have never before been documented. Carbon dating is currently being performed on specimens.

The variety of terrestrial wildlife is also being documented. So far, over 70 species have been documented, including a range extension of a small shrew previously thought to exist only in the Russian Far East. The Grindell Hills have a mountain goat population that is isolated by the glacier and is not hunted. Most of the areas crucial for wildlife habitat and preferred by ecotourists and backcountry recreation enthusiasts are under BLM administration.

The general region of the Copper River Delta, including the land at the terminus of the Bering Glacier, is one of the most important waterfowl staging areas in North America. Counts were made of over 800 dusky Canada geese on the forelands adjacent to the Bering Glacier and in the waters of Vitus Lake. In cooperation with the ADF&G, the U.S. Fish and Wildlife Service (FWS), and USGS, 87 dusky Canada geese from the forelands were tagged and DNA material sampled. Two other sensitive species of waterfowl, the Tule white-fronted goose and the Vancouver Canada goose, also utilize the forelands. For the Tule white-fronted goose, the forelands serve as the only staging area in Alaska, and the Vancouver Canada goose nests in the glacier's eastern areas.

Over the past 20 years, harbor seal populations have declined by some 80% in North America. The cause of the decline is not known. However, as part of a biodiversity study, the University of Alaska Anchorage, ADF&G, the BLM, and the National Oceanic and Atmospheric Administration have begun to study the harbor seals at the Bering Glacier. Ice haulouts by harbor seals are common in North America but are normally restricted to 100 or fewer individuals. At the Bering Glacier the haulout numbers are in excess of 500 individuals. The reasons for this large concentration near the Bering Glacier are not currently understood.

U.S. Geological Survey

A new chapter in the history of the U.S. Geological Survey (USGS) in Alaska began in 2001. In October the USGS Alaska Science Center (ASC) was created by combining the scientists and support staff from the four USGS divisions (Biological Resources, Geologic, National Mapping, and Water Resources) in Alaska into a single organization with four offices (Biological Science Office, Geologic Science Office, Water Resources Office, and Geographic Science Office). This is the first integrated center within USGS nationwide. More information can be found on the website at http://alaska.usgs.gov/.

	Funding (thousands)	
	FY 00	FY 01
Energy and Minerals	3,500	3,500
Natural Hazards	3,500	3,500
Global Change	1,000	1,000
Marine and Coastal Geology	250	250
Geomagnetism	250	250
Ice and Climate	250	250
Hydrology	130	130
Mapping	750	750
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	16,640	16,640

Biological Science Office

The USGS Biological Resources Division (BRD) conducts research in the Arctic to generate information that will help DOI agencies and other partners in Alaska meet their 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 National Parks and Preserves. Research is designed to address the effects of development, disturbance, hunter harvest, and natural environmental cycles on fish and wildlife populations. Other research will help 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 Fish and Wildlife 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 heavy metal tracers 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

Denali National Park has offered a unique glimpse into the dynamics of wolves and their ungulate prey through the long-term wolf–prey research program conducted there since 1986. This integrated research program grew from separate projects on wolves and caribou, and in 1998, studies of moose population dynamics were added. Wolves and their ungulate prey are monitored in Denali using standard radiotelemetry techniques to annually assess population status and trends and to determine components of each species population dynamics, including productivity, recruitment of young, and survival patterns. Since 1986, wolf and caribou populations have varied in response to changes in winter snowfall, while the moose population appears to have remained relatively stable. During 1986–1988, a period of below-average snowfalls, wolf numbers were low, averaging about 65 wolves each spring, and the population exhibited poor pup production and high dispersal of young wolves. During this period the caribou herd grew at about 7% per year, from 2500 caribou in the fall of 1986 to 3200 by the fall of 1989. With above-average winter snowfall during 1988–1994, wolf numbers more than doubled, reaching a high of 135 wolves in 1991, with high pup production and reduced dispersal. The caribou herd declined to about 2000 by 1994 as a result of poor calf recruitment and increased adult mortality. Since 1994, with a return to more average winter snowfall, the wolf population has remained relatively stable at about 90 individuals. The caribou herd has continued to experience poor recruitment and has declined to about 1700 animals. Initial results of moose research at Denali show that the moose are in superior nutritional condition throughout the park and are highly productive but that calf survival is poor, with only about 10% of the calves surviving to their first birthday.

In 2000, USGS began a study of Dall sheep demography in Noatak National Preserve, in cooperation with the National Park Service. Dall sheep populations in northwestern Alaska declined substantially following two severe winters in the early 1990s. In the Baird Mountains, within Noatak National Preserve, aerial survey counts declined by 68% from 981 sheep in 1989 to 317 sheep by 1994. As a result, subsistence and sport harvests were closed. During the ensuing debate the validity of techniques used to monitor the abundance of sheep was questioned. Further, it was recognized that understanding of Dall sheep population biology in the region, the northwestern extreme of their range, was generally lacking. In March 2000, USGS initiated a three-year study of the demography of Dall sheep in the Baird Mountains to investigate their population dynamics and to evaluate aerial survey methodologies. USGS is monitoring 35–40 radiocollared ewes annually to

assess the population's vital rates, including productivity, lamb recruitment, and adult survival. Further, using the radiomarked ewes and 8–10 radiocollared rams, they are evaluating factors that influence the effectiveness of aerial population surveys. As a result of this study, USGS expects to improve their ability to monitor sheep populations in northwestern Alaska and their understanding of factors that determine sheep population trends.

The USGS is assisting the National Park Service in understanding factors leading to the decline of a small population of caribou within Wrangell–Saint Elias National Park and Preserve, Alaska. The Mentasta Caribou Herd, a small population inhabiting the northwestern portion of Wrangell–Saint Elias, has historically been an important subsistence resource for people of the upper Copper River basin and has provided limited sport hunting opportunities. The Mentasta Herd has declined substantially over the last 15 years, from around 3200 caribou in 1987 to about 400 by 2001, leading to harvest closures. The current research effort began in 1991 to monitor population trends and investigate limiting factors of this herd. Although adult females are large-bodied and experience high calf production, the herd has been plagued with chronically high predation of young calves and has averaged fall calf recruitment of only 9.4 calves per 100 cows since 1986. Because of the low recruitment, the age structure of cows in the herd is strongly skewed to older age classes, with over a third of the cows 11 years old or older. With continued poor recruitment, the Mentasta Herd is expected to decline dramatically over the next few years as these older cows die.

In July 1999 the Alaska Department of Fish and Game (ADF&G) and the USGS Alaska Science Center began a five-year investigation of the impact of boreal forest fires on the Nelchina Caribou Herd (NCH) in south-central and interior Alaska. Wildland fire kills the late-succession fruticose lichens used as winter forage by caribou, and it may be decades before such lichens are again abundant. This collaborative research effort is evaluating relationships between fire history and lichen abundance; caribou habitat selection relative to lichen abundance; and caribou nutritional performance and survival relative to habitat selection, lichen abundance, and spatial distribution. Since the study began, USGS has captured and weighed more than 80 caribou, deployed 35–40 conventional radiocollars on four-month-old calves from the 1999 and 2000 cohorts, and maintained a sample of more than 20 GPS radiocollars on adult females. They have estimated habitat use patterns based on more than 1200 relocations of radiocollared animals by aerial radiotelemetry and more than 20,000 relocations from GPS telemetry each year. Caribou habitat selection was evaluated relative to stand age by comparing the locations caribou used to random sites. Caribou forage lichens were scarce on stands that had burned within the last 60 years for both random and used sites, indicating a lengthy recovery period for burned winter range. Caribou strongly selected older stands that had abundant forage lichens. USGS initiated a pilot study to evaluate the feasibility of using tame, hand-reared caribou to conduct on-site field trials of forage selection, foraging efficiency, and nutritional performance within stands of various ages. They plan to conduct field trials over a range of lichen availability and snow conditions to further evaluate caribou foraging efficiency, diet selection, and nutritional performance for different stand ages and lichen availabilities. USGS is collaborating with the University of Alaska to model the influence of fire frequency on the extent and quality of caribou winter range. The results will provide information directly applicable to caribou and fire management in Alaska.

The development of a long-term ecological monitoring program at Denali National Park and Preserve began in 1992. The program originally took a "watershed" approach, involving collocation of intensive study efforts for a variety of biological and physical parameters in a single watershed. The park, working closely with the USGS Alaska Science Center, is moving now to expand the spatial scale of the monitoring program to include the entire park and to develop stronger linkages with management information needs. Monitoring program development at Denali is providing excellent information about how to implement monitoring in the sub-Arctic, where the landscapes are huge and costs can be prohibitive. This information is proving useful now as the National Park Service expands its monitoring program to all parks.

In the Arctic, climate is the most influential environmental factor dictating the availability and quality of wildlife habitats and ultimately the ability of populations to survive and reproduce. Integrating population data with remotely sensed satellite imagery is an effective method to study how climate-induced habitat variations influence the migrations and recruitments of Arctic wildlife. At the Alaska Science Center, biologists are using

Advanced Very High Resolution Radiometer (AVHRR) satellite imagery to monitor the annual timing of snowmelt and vegetation growth on the calving grounds of several North American caribou herds. In collaboration with the Alaska Cooperative Fish and Wildlife Research Unit, AVHRR data were used to study a 17-year record (1985–2001) of the Alaska North Slope with respect to the annual calving distributions and recruitments of the Porcupine Caribou Herd. The AVHRR data were used to derive chronological maps of vegetation biomass (termed NDVI, or vegetation greenness). Maximum-value NDVI composites were created from satellite images collected annually for each of three specific time intervals: early June, mid-June, and early July. Dramatic temporal variability in the onset of the growing season (early June) was observed, differing by as much as three weeks between years with very late snowmelt (1986 and 2000) and years with very early snowmelt (1990 and 1998). The median NDVI on 21 June was positively correlated with annual calf survival of the Porcupine Caribou Herd. This time period corresponded to peak lactation, and the relationship with calf survival was likely the result of climate-induced annual variations in the availability and nutritional quality of forage plants. Snow cover and the rate of vegetation growth (average daily NDVI increase) were also correlated with the spatial distributions of calving caribou. The 1990s demonstrated a warming trend, with spring conditions arriving earlier through the decade. However, spring arrived relatively late in both 2000 and 2001. The apparent end to the warming trend of the 1990s suggests that broad-scale atmospheric circulation patterns may be undergoing a hypothesized cyclical regime shift, but more monitoring will be required to confirm this speculation.

Fisheries Research

Fisheries biologists from the Alaska Science Center are conducting several studies in the region dealing with a broad range of aquatic resource issues. These studies range from detailed ecological investigations to determination of the genetic population structure within species. Current research projects in the region focus on chum salmon, chinook salmon, sockeye salmon, rainbow trout, and blackfish.

Weak returns of western Alaskan salmon stocks during the 1990s have resulted in both restrictions and closures on commercial and subsistence fisheries. In response to declining populations of chum and chinook salmon in the Yukon River, USGS biologists are involved in several studies throughout the basin. These include studies of spawning and rearing habitats used by summer-run and fall-run chum salmon and chinook salmon. This research focuses on the freshwater portion of the salmon's life cycle. An important facet of this work is determining the effects of environmental conditions on the survival of chum salmon at critical life stages.

From 1997 until present, chum salmon research was conducted at one summer-run site (Chena River) and one fall-run site (Tanana River). An interagency agreement with the BLM established during 2000 has allowed an expansion of this research to an additional summer-run site within the Koyukuk River drainage. Detailed computer-based maps of the study sites and spawner distributions have been developed with surveying equipment. In addition, adult fish are enumerated at weirs, intra-gravel survival and environmental conditions are quantified, and smolt emigration is estimated using funnel traps and mark–recapture estimates of population size.

Results to date indicate that the freshwater survival of chum salmon in their northern range depends on an intra-gravel environment that allows survival during extreme winter conditions while supporting developmental rates that result in proper emergence and downstream migration timing. Two types of spawning sites are recognized, one influenced by subsurface stream flow (summer-run) and the other by upwelling ground water (fall-run). Spawning habitat selection by female chum salmon in the Chena River site results in clustered and consistent distributions. These distributions and the subsequent survival of incubating eggs and fry appear to be highly influenced by temperature and dissolved oxygen. In contrast, at the Tanana River site, dissolved oxygen and temperature were nearly constant (that is, not limiting). Infiltrating fines and reduced intra-gravel water flow may limit egg survival within the Tanana River site. This research is helping to define spawning habitat quality for interior Alaska chum salmon and could reveal mechanisms and factors controlling freshwater production, thereby assisting managers in assessing conservation and rehabilitation strategies.

During 2001, studies were initiated in the Chena River drainage to examine freshwater habitat use by juvenile chinook salmon. The overall study is designed to test a marking method, assess our ability to mark and recapture fish over the winter, determine the stability of the population within the

study site (that is, do juvenile chinook demonstrate fidelity to the site or do they freely move in and out of the site), collect genetic material to test the geographical importance of Hodgin's Slough, and develop more rigorous study designs (for example, use these results to determine the feasibility of estimating the over-wintering chinook populations in interior Alaska drainages).

There is a significant data gap concerning juvenile salmon ecology in the Yukon River Delta and during the transition to the marine environment. The transition from fresh water to the marine environment is a critical period in the life history of salmonids. USGS fishery biologists are initiating a multi-year study to examine the ecology of juvenile salmon and other fish in the Delta. These studies are designed to examine the timing of outmigration by juvenile chum salmon, identify habitats used by juvenile salmon, determine the community structure of fish in Delta habitats, and examine feeding ecology of juvenile salmonids in Delta habitats.

Recent declines in the number of sockeye salmon returning to Lake Clark has caused economic hardship in the region and raised resource concerns of regional Native Alaskan subsistence users and Federal managers (National Park Service). A lack of information regarding basic sockeye salmon ecology and dynamics exists in this area, and a prioritized list of information needs was developed with regional stakeholders. Four priority needs are to:

- Locate all spawning aggregations;
- Develop conservation recommendations;
- Develop genetic markers to identify Lake Clark fish; and
- Train local Native Alaskans in fisheries techniques.

To estimate adult sockeye salmon escapements into the Lake Clark watershed, USGS biologists established an adult sockeye salmon counting tower on the lake outlet in cooperation with University of Washington researchers. Age (scales) and size at maturity data are collected from sockeye salmon as they enter Lake Clark. Additional age and size samples are collected from post-spawning fish in beach, stream, and river habitats. This information is being used to construct life tables, which will allow future analysis of population trends (for example, increasing or decreasing trends of age classes). Comparison of age and size among populations spawning in different habitats will provide information on which types of traits may be selected for in a particular habitat type.

Prior to this study, knowledge of habitat use by sockeye salmon was generally limited to clear waters, whereas over half the Lake Clark system is highly glacial and turbid. Radiotagged salmon are followed to their final spawning destinations. Over 15 previously undocumented spawning aggregations have been verified through the radiotracking program. This information is critical to National Park Service managers in conserving and protecting spawning habitat in the face of development activities and in comparing contemporary spawning habitat use to historic habitat usage.

Genetic samples have been collected from 17 spawning sites. Samples are being analyzed as part of a collaborative research effort with the Alaska Department of Fish and Game to "fingerprint" Bristol Bay sockeye salmon populations. This research will help alleviate commercial harvest apportionment issues in the face of continued declines.

With increasing recreational angling for rainbow trout in the Alagnak River within Katmai National Park, catch-and-release regulations were imposed to protect populations from over-harvest. Since 1997, USGS biologists have been examining the potential impacts of catch-and-release angling resulting from injury to fish, physiological stress, and delayed mortality. Of 502 fish captured in two years, 23% had at least one previous hooking scar and 58% experienced at least one new hooking scar. Fish captured on barbed hooks experienced the most injuries. Stress-related hormones were significantly elevated in fish following capture. This study is ongoing and will relate immediate stress response, incidence of hooking injury, and changes in seasonal growth trajectories associated with catch-and-release fishing.

Blackfish is a unique species found only in Alaska and eastern Siberia. Blackfish are used as a subsistence food source and also provide important food source for mink and otter. Capable of breathing atmospheric air, blackfish can survive in low oxygen conditions during both summer and winter in small lakes and ponds. USGS biologists, in cooperation with the National Park Service and the U.S. Fish and Wildlife Service, are collecting samples of blackfish for genetic analyses. These analyses are examining both the population structure and presence of genes associated with survival in freezing or near-freezing conditions.

Migratory Birds

USGS-ABSC used satellite telemetry to study the migration routes and wintering areas of two

allopatric breeding populations of Pacific common eiders in Alaska: in the Yukon–Kuskokwim Delta and along the western Beaufort Sea coast. Only 5.6% of 36 females were within the wintering area of the other breeding population. Both populations wintered in the closest available ice-free habitat, perhaps to minimize migratory distance. The fact that two Beaufort Sea females wintered in areas used by Yukon–Kuskokwim Delta females creates the potential for gene flow among breeding areas, yet these two populations are largely geographically isolated throughout the annual cycle and the environmental factors influencing survival and reproduction likely differ between these groups of birds. Thus, regardless of the potential gene flow among breeding populations, ABSC researchers suggest that birds from these two breeding areas should be managed as separate populations.

The ABSC Molecular Ecology Laboratory (MEL) is staffed and equipped to conduct state-of-the-art molecular analyses for systematic and population genetics research. The MEL is capable of conducted analyses ranging from taxonomic investigations of genetic variation among different species to resolving individual-specific variation within populations of the same species. At present the MEL is conducting research on over 25 bird species, including loons, waterfowl, shorebirds, seabirds, and passerines.

In a recently completed study the MEL investigated levels of genetic variation and portioning among the seven nominal subspecies of Canada geese that breed in western North America. Large- and small-bodied forms of Canada geese were highly diverged and represent monophyletic groups. Population trees for both nuclear and mtDNA were generally concordant with varying degrees of divergence among all populations and subspecies. Genetic analyses suggest that both historical and contemporary forces have been important in shaping current spatial genetic distributions. Morphological data from breeding birds revealed patterns of differentiation similar to those obtained with genetic markers.

Detailed analyses of the genetic status of Aleutian and dusky Canada geese were also conducted as part of the overall study. The results indicated that widely separated island-nesting Aleutian Canada geese are more closely related to one another than to mainland-nesting small-bodied Canada geese. The degree of population genetic structure suggests that Aleutian Canada goose populations could be considered separate management units. Similarly a population of large-bodied Canada geese nesting on Middleton Island in the Gulf of Alaska, thought to be the result of a translocation from the Copper River Delta, was determined to be genetically distinct from geese nesting on the Copper River. These results suggest that the population on Middleton Island is not derived from translocation but rather colonized by birds inhabiting other islands within Prince William Sound.

Marine Mammals

The Department of the Interior 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 USGS has responsibility for conducting research to satisfy U.S. Fish and Wildlife Service (USFWS) 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.

Walruses. The USGS Pacific walrus research program is focused primarily on studies related to the estimation of walrus abundance, animal diving behavior and patterns of migration, and population genetics.

Walruses have a clumped distribution over a large geographic region in remote areas of the Chukchi and Bering Seas, making them difficult to count. The USGS and USFWS are investigating two methods of estimating walrus abundance: an aerial survey that would use improved animal detection and enumeration techniques and a mark–recapture survey that would utilize DNA samples to identify individual animals.

Several aerial surveys of walrus abundance have resulted in estimates with poor precision, in part because of low effective effort in detecting and enumerating walruses. In addition, the estimates have been biased because of poor accounting for the proportion of animals that are in the water during survey overflight and thus unavailable for sighting. The potential to increase survey

effort by incorporating new remote sensing technologies is being investigated by USFWS, while USGS is continuing to investigate methods for determining the haulout behavior of walruses using satellite telemetry in terrestrial and sea ice habitats to estimate the proportion of animals that are unavailable for sighting. This work is ongoing and is expected to continue for the next few years.

The feasibility a mark–recapture method for estimating walrus abundance is being investigated as an alternative to an aerial survey. Marked animals will be determined from the genetic identification of individual animals using tissue samples collected from live animals with biopsy darts and dead animals from subsistence harvests in Russia and Alaska. Genetic and statistical considerations for the method have been explored and should be explored further, starting with the collection of samples as early as the summer of 2002.

Bristol Bay, Alaska, typically receives a large number of immigrating adult male walruses during the summer, comprising a large component of the Pacific walrus population during these months. Walruses in Bristol Bay have been counted daily during the summer months at Round Island and Cape Pierce by USFWS and ADFG since the early 1980s. The USGS recently completed initial efforts at modeling these data to determine an appropriate estimator. Simulations suggest that an index derived from mean annual counts is a more sensitive index of trend than a simple parametric model-based index or the currently used index based on maximum annual counts. A more detailed analysis of abundance trends and recommendations for future monitoring designs should be completed by the end of 2002. Although these data are useful for monitoring male walrus occupation in Bristol Bay during summer, it is unknown whether observed trends in Bristol Bay reflect trends in the overall population due to unknown interannual movement patterns of male walruses between haulouts in Russia and the U.S. and unknown relationships between the status of male summering populations and the status of the overall population. It is unlikely that these patterns and relationships will be known in the near future, so current monitoring efforts should be viewed as a means of detecting interannual changes in the occupation of the main haulouts in the Bristol Bay region only.

Understanding the migration pattern and dive behavior of walruses among different areas of their range is important when considering an optimal sampling design for a population survey and when correcting aerial survey data based on animal sightability. Over the past five years, transmitters of various designs (both satellite and VHF) have been deployed on more than 50 male walruses in Bristol Bay. In addition, time-depth recorders (TDRs) were deployed and recovered from five animals in 1997. These efforts were aimed at investigating movement patterns, site fidelity, and diving behavior of walruses in the Bristol Bay area with the anticipation that telemetry studies will be extended to female walruses occupying ice habitats. During this work, animals were tracked for periods of usually several months. Transmitter failures precluded tracking for longer periods. However, beginning in 1998, two animals were tracked for over a year. TDR data have been used to estimate the proportion of time spent in the water for several male walruses. Although TDR data have provided valuable information on the dive behavior of male walruses in Bristol Bay, the ability to recover similar devices from female walruses in ice habitats, the aim of future studies, will be much more challenging.

Individual walruses must be captured by chemical immobilization so that telemetry devices can be attached to them. Past methods of walrus immobilization have been suboptimal and continues to be a significant impediment to effective research on this species. Efforts will be continued to improve these methods, but progress is slow because of a lack of understanding of marine mammal pharmacology, particularly in walruses. An international workshop on the chemical restraint of walruses was sponsored by USGS and Hubbs-SeaWorld Research Institute in February 2002 to facilitate the exchange of information on walrus capture protocols used by field and zoo personnel. Two protocols for field anesthesia were identified as having merit for future investigations, and these efforts will continue for at least another few years.

As an alternative to animal capture for deploying animal markers or transmitters, USGS has initiated a study to investigate the feasibility of using subcutaneously anchored tags that would be attached to an animal with the use of a crossbow. A prototype tagging system has been developed, and initial testing of the system on hunter-killed or beach-cast carcasses will begin in the summer of 2002. A modified system based on these tests will then be used to tag live animals in the field to estimate tag retention duration.

The USGS has initiated a population genetics study of the Pacific walrus to determine the level of genetic structuring among spatially distinct

groups that are thought to be present during certain times of the year. Some samples have already been collected from various sampling programs and institutions, as well as Alaskan and Russian subsistence hunters. Sampling efforts will continue over the next few years to obtain samples from areas for which there are no archived samples. Obtaining samples from some areas and for some times of year will be particularly challenging. In addition to DNA analysis of walrus tissues, an exploratory project has commenced, in collaboration with the Geological Survey of Canada, to analyze metal isotope concentrations in walrus teeth for identifying groups of walruses with similar isotope signatures and therefore indications of the occupation of similar geographic areas. Existing tooth samples and future tooth collections will be categorized using the same times and locations as for the collection of tissue samples for genetic analysis to contrast interpretations of animal distribution between the two approaches.

Polar Bears. In the southern Beaufort Sea, terrestrial polar bear dens occur throughout the coastal plain of northern Alaska, with their greatest frequency in northeast Alaska and northwest Yukon Territory. Much of this region is being considered for, or is undergoing, petroleum exploration and extraction. While oil exploration and construction generally occur during winter when the disruption of tundra habitats and most Arctic wildlife species is at a minimum, disturbance to polar bear maternal dens is possible and could result in reproductive failure. Knowledge of polar bear den chronology provides a defined boundary for temporal management of human activities.

Beginning in 1995 the USGS identified landforms suitable for denning and developed a map of polar bear denning habitat to aid in the spatial management of human activities. They quantified habitat components surrounding known den sites and characterized den site habitat. The final map provides the best available tool for resource managers and researchers to use in identifying polar bear maternal den habitat. This will help reduce the potential for disruptions of maternal dens by winter petroleum exploration activities.

Radiotelemetry studies of the movements of polar bears continued since the last meeting of the Marine Mammal Commission. As in all years after 1985, the majority of the radio collars deployed were platform transmitter terminals (PTTs) that communicated with satellites. Analysis of the data generated from those PTTs was a major activity during this period. A principal effort centered on describing the general movement patterns of polar bears in the Beaufort Sea region of Alaska and adjacent Canada with data from PTTs deployed between 1985 and 1995. During this period the USGS attached 152 PTTs on 104 adult female polar bears along the mainland coast of the southern Beaufort Sea and obtained 39,554 location records. Canadian researchers also attached 21 PTTs to 17 polar bears along the north and west coasts of Banks Island and the west coast of Prince Patrick Island. Those PTTs provided 6,568 location records between April 1989 and December 1995. After excluding multiple daily locations and those with inadequate precision, 12,267 location records are left from all of the Beaufort Sea. Those data formed the basis for descriptions of polar bear movements in this region.

Effective satellite telemetry systems have allowed gains in understanding of the movements of mobile animals that live in remote habitats. The polar bear may be among the greatest beneficiaries of this technology. Building PTTs into neck collars and attaching them to polar bears has provided previously unobtainable insights into polar bear movements, behaviors, and denning ecology. Neck-collar radios, however, can only be attached to adult female polar bears. Young animals cannot be fitted with collars for fear of injury that could result as they grow and the collar doesn't. Likewise, because the neck diameter of adult male polar bears exceeds that of their heads, even tight-fitting collars slide off during the normal activities of the animal. In 1996 and 1997, seven adult male polar bears were surgically implanted with subcutaneous PTT implants. Recently completed analysis of the data from these males showed that the implanted transmitter life ranged from 30 to 161 days, with a mean of 97 days. This was far shorter than the projected life span of 20–24 months. Only one implanted bear has been subsequently recaptured. Upon recapture in the spring of 2000 at age 11, he had shed his radio transmitter, and examination revealed only a small scar where the surgical implantation had been performed. Although longevity was poor, the signal strength of implanted radios was generally good prior to transmitter failure.

The seven implanted male bears provided 3,217 relocations during the months of April through September. The movements of those males were compared with 104 radio-collared females instrumented between 1985 and 1995. The short-term movement rates of male polar bears were consistently lower than those of solitary females, those

with cubs, and those with yearlings. In contrast, the mean total monthly distances moved by males, for all months, were significantly greater than the distances moved by females with cubs. The total distances moved by males did not differ significantly among months for which data are available, and there were no significant monthly interactions between month and class of bear.

In the latest effort to develop estimation procedures for Alaskan polar bears, USGS researchers described an approach to open population mark–recapture modeling to derive population estimates. They described how covariates measured, over the years, explained complex capture histories and improved estimates. A key feature of the modeling process was the construction of capture probability models to simultaneously account for conventional recapture and radiotelemetry data. They used a model selection technique that blended improved model fit with improved prediction variance. The best model suggested an increase from around 500 females early in the study to as many as 1500 at the study's end. Assuming the increase in numbers of males was comparable to that recorded for females, this could suggest a total population size of over 2500 animals—many more than previously hypothesized. Despite the significant improvements in estimates provided by the model, the USGS recommends a conservative approach to the management of polar bears in the southern Beaufort Sea.

Because the snow drifts under which polar bears den look like other drifts, winter detection is difficult. Denning bears, however, warm the chamber they occupy. If enough heat escapes through the snow above a den to increase its temperature relative to adjacent snow, infrared sensors might detect that temperature difference. To help protect polar bears and workers in areas where human activities coincide with maternal denning, researchers tested whether they could detect polar bear dens when viewed with forward-looking infrared radar (FLIR). Using FLIR mounted on the nose of a helicopter, the researchers viewed bank and bluff habitat features in which there were 12 known dens. To avoid solar warming of the landscape, they attempted to fly transects at night or during twilight of the Arctic winter. They detected 10 of the 12 known dens on at least one FLIR visit and discovered three dens not known by telemetry. Only two dens, however, were seen on all visits. We are in the process of trying to understand which variables associated with each visit to these dens allowed or prevented their detection. Although Arctic winter weather is often cold and clear, the studies were plagued by atmospheric moisture, which is known to inhibit FLIR effectiveness. Other factors reducing FLIR effectiveness included heat rising through cracks in sea or river ice, heat re-radiated from soil or snow warmed by the sun, and variations in snow surface temperatures resulting when falling or blowing snow at one temperature is deposited irregularly over older snow at a different temperature. They concluded that FLIR can be an effective tool for detecting polar bear maternal dens on the Alaskan coastal plain as long as operators are cognizant of the effects of ambient light, atmospheric moisture, and uneven snow surface temperatures in limiting its effectiveness.

In 1998–1999, BP Exploration Alaska began constructing the first artificial production island designed to transport oil through sub-seafloor pipelines, and other similar projects are under consideration. With the advent of true offshore development projects, concerns regarding the proximity of oil exploration and development to principal polar bear habitats are compounded. An oil spill in the waters and ice of the continental shelf would likely have profound effects on polar bears. A recent USGS assessment of the effects of spills calculated the probabilistic distribution of polar bears in the study area; mapped the "footprints" of a series of oil spill scenarios centered at Liberty Island; and used GIS layering to overlap the oil spill footprints with polar bear distributions to estimate the numbers of bears that would be exposed to oil in each scenario. Worst-case scenarios consisted of relatively large spills in the summer or fall. The numbers of bears affected varied greatly, depending on which direction and how far a particular spill traveled. Trajectories simulating a 5912-barrel spill in September oiled as few as 0.007 bears and as many as 25 bears. The mean number affected was 4, while the median value was 1 bear. In October the minimum and maximum numbers of bears oiled by a 5912-barrel spill were 0.05 and 60, and the mean and median were 9.5 and 2.9 bears, respectively.

Biometrics

Ongoing biometric research is developing and assessing statistical techniques for increasing the accuracy, precision, and scope of inferences and the cost-effectiveness of studies of Arctic wildlife. A maximum likelihood technique for estimating survival rates from age structure data was developed and used to estimate the survival rates of

sea otters based on carcasses recovered in Prince William Sound, Alaska. The new technique allowed detection of age-related patterns in survival rates and relaxed the previously required assumption of a stable population structure. Nonlinear regression and Bayesian techniques were used to develop models for counts of walruses at haulout sites in Bristol Bay, Alaska, and brown bears at salmon streams on Kodiak Island, Alaska. These models are being used in evaluating potential monitoring designs and developing more efficient estimators of population trends.

Geologic Resources

USGS energy research focuses on understanding specific processes and geologic settings that determine resource potential and applying that information to resource assessments. The major research effort is in the National Petroleum Reserve–Alaska (NPR-A). This multi-disciplinary investigation includes basin analysis, sequence stratigraphy, fluid-flow modeling, petroleum systems analysis, geochemistry, and structural and geophysical analysis. An oil and gas assessment of the NPR-A is scheduled for 2002, the first assessment of this area in 20 years. In addition, the oil and gas potential of basins in central Alaska (for example, the Yukon Flats) is under study, and assessments are scheduled for the end of 2002. A cooperative project with the State of Alaska is evaluating coalbed methane as a potential energy source for remote Alaskan communities.

USGS is one of five agencies involved in the national gas hydrate research program. Gas hydrate is important as a potential energy resource, a potential cause for seafloor instability, and a major source of greenhouse gases. Gas hydrate occurrence, distribution, geochemistry, and influence on sediment properties and stability are being studied via field, laboratory, and drill-hole experiments, together with theoretical analysis. The capability to identify gas hydrate by remote sensing is under development. The results will increase the amount of information that can be derived from interpretation of geophysical data that are used to identify the extent and abundance of gas hydrate worldwide. The results will also improve the ability to quantify the amount of methane present in gas hydrate.

The role of fire is being studied to better understand the fate of carbon in Alaskan landscapes. The interaction of large wildfires, discontinuous permafrost, and large carbon reserves is being measured and modeled in order to document and understand the complex response of these systems to climatic and hydrologic change. The associations between soil carbon, soil drainage, and fire severity are being determined, and input to models of fuel, nutrient, and carbon storage is being created. A regional understanding of the carbon budget is being constructed from a combination of detailed site measurements of fire, permafrost, hydrology, and carbon. New model attributes that represent the temperature, moisture, and nutrient interactions that are key to carbon exchange are being developed. These simulations are important in conducting sensitivity and uncertainty analyses on the vulnerability of structure and function of Alaskan boreal forests to projected changes in climate.

Massive sulfide deposits in Alaska, including sedimentary exhalative and volcanogenic massive sulfide deposits, are an important source of gold, silver, copper, lead, and zinc and include the world's largest zinc deposit, Red Dog, in northwestern Alaska. An examination of the relationship between these kinds of deposits in Alaska is underway to frame them into a broad genetic model, couched in terms of ore-forming processes, crustal tectonics, and fluid flow. Since these deposits can be tremendous natural generators of metal-rich acid drainage, the results obtained in the study are being used to develop geoenvironmental models. Ultimately the synthesis of geologic, mineralogic, geochemical, and isotopic data will aid in characterizing the tectonic environment in which the deposits formed, developing genetic and geoenvironmental ore deposit models, and classifying and predicting known and potential deposits.

Investigations in mineralized and nonmineralized terranes of east-central Alaska are examining processes of metal mobility and bioavailability. Sources of metals (both geologic and anthropogenic) are being evaluated by a combined examination of surface-water chemistry, bedrock and sediment mineralogy, and groundwater chemistry. Emphasis is being placed on the use of water analyses across geologic contacts as a guide to understanding water–rock interactions and the use of shallow soil water analyses as an aid to understanding element cycling and bioavailability. The results are being used to evaluate possible health effects on browsing animals (especially ptarmigan) of high cadmium in willows and to examine levels of total mercury and methylmercury in fish tissue.

Water Resources

The USGS National Stream Quality Accounting Network (NASQAN) program focuses on monitoring the quality of the Nation's largest river systems. NASQAN provides an authoritative baseline of data compiled from measurements that are repeatable and that are obtained through the use of well-documented methods. These baseline data are needed to characterize large sub-basins of these rivers, determine regional source areas of soluble substances and sediment in the water, and assess the effects of human activities on observed concentrations and amounts of soluble substances in the water.

In 2001 NASQAN began a study of the Yukon River Basin, located in interior Alaska and northwest Canada. Draining an area of about 855,000 square kilometers, the Yukon is the fourth largest basin in North America. In terms of flow, the average annual discharge of the Yukon is 5700 m^3/s, the fifth highest in North America. A fixed-station sampling network was established, consisting of five sites; three sites are on the main stem of the Yukon (one at Eagle, one near Stevens Village, and one at Pilot Station), and two sites represent different basin characteristics of the Yukon (one on the Porcupine River near Fort Yukon, a predominantly permafrost basin, and one on the Tanana River at Nenana, a glacial basin). Six to seven water-quality samples were collected at each site and analyzed for nutrients, organic carbon, major ions, trace elements, and suspended sediment. Data collection will continue at the fixed sites for five years (2001–2005). In addition, synoptic sampling trips will be made during 2002–2004 to determine water-quality conditions as they exist simultaneously over a broad area of the basin. These trips will focus on a particular reach of the river: Whitehorse to Eagle (2004), Eagle to Stevens Village (2002), and Stevens Village to Pilot Station (2003).

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 DoD has decreased since the end of the Cold War, the Department still has an active interest in the Arctic. The Arctic environment represents an important challenge for military interests, which requires enhanced understanding of specific research areas that include (but are not limited to):

- The Arctic environment and its interaction with military systems, operations, and infrastructure;
- Energy exchange and atmosphere–ocean interaction dynamics, and the impact of the energy exchange process on global circulation;
- The structure and physics of the middle and upper atmosphere; and
- Biology and biophysics for sustaining health and optimized human performance in cold environments.

While the DoD program is reviewed as a whole during the biennial 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.

	Funding (thousands)	
	FY 00	FY 01
Arctic Engineering	2,305	2,822
Permafrost/Frozen Ground	312	382
Snow & Ice Hydrology	1,377	1,586
High Latitudes Program	2,980	2,820
Lower Atmosphere	475	262
High-Freq Active Auroral Program	10,000	7,000
Medical and Human Engineering	901	850
Total	18,350	15,722

Air Force

The Air Force conducts research in upper atmospheric and ionospheric physics, primarily by the Air Force Research Laboratory's Space Vehicles Directorate, Battlespace Environment Division, and by the Air Force Office of Scientific Research (AFSOR). These offices coordinate their efforts to understand the effects of space weather. This research is primarily conducted in the Arctic "polar cap and dayside cusp regions." 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.

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, Qaanaaq, Thule, Sondrestrom, and Narssarssuaq, Greenland (in cooperation with the Danish Meterorological 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. The observational data collected and models developed are used for testing the effects of the ionosphere on DoD communications, navigation, and surveillance systems and for providing real-time support to DoD programs.

High-Latitude Scintillation Studies

The Air Force installed additional scintillation sensors in the high-latitude region in 2001 to further quantify the occurrence and impact of ionosphere scintillation. These observations span a variety of frequencies and propagation geometries and are using signals from both low-earth-orbit satellites and higher-altitude quasi-stationary satellites including the GPS (global positioning system) constellation. Observational campaigns in northern Greenland and Svalbard were conducted in coordination with incoherent scatter measurements from radars in Kangerlussuaq, Greenland, and Longyearbyen, Svalbard, to observe the formation of scintillation-producing regions near the dayside cusp of the auroral zone and their subsequent evolution and drift across the high-latitude region.

High-Frequency Active Auroral Research Program

Under the High-Frequency Active Auroral Research Program (HAARP), jointly managed by the Air Force Research Laboratory and the Office of Naval Research, the new Ionospheric Research Observatory is under construction in Gakona, Alaska. The facility includes a high-power, high-frequency (HF) transmitting system and a suite of radio and optical diagnostic instruments. The present HF transmitting system includes a phased-array antenna, consisting of 48 elements, with crossed-dipole antennas driven individually by 10-kW transmitters, resulting in a maximum radiated power of 960 kW.

Recent infrastructure additions include the development of new diagnostic instrument pads containing HF transmitting and receiving antennas, an optical telescope, and a 130-MHz radar. In a program with the University of Alaska Fairbanks, ionosphere total-electron-content (TEC) receivers were installed at five locations in Alaska to generate tomographic images of ionosphere electron density profiles.

Research has been conducted primarily via four- to five-month-long campaigns each year, with emphasis on studies relating to the generation of ELF/VLF waves in space, via modulation of auroral currents with the 960-kW HF transmitter; the production of geomagnetic-field-aligned irregularities and the subsequent effects on radio wave scattering; stimulated electromagnetic emissions (SEE); and the generation of optical emissions in space. In addition to these ground-based studies, a variety of experiments have been initiated conducted in conjunction with space platforms, including the CLUSTER, IMAGE, and WIND satellites, primarily to investigate the degree and manner in which ELF/VLF and HF radio waves propagate from the ground or ionosphere into deep space.

Army

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 Cold Regions Research and Engineering Laboratory (CRREL) is the lead Federal laboratory for Arctic and sub-Arctic expertise and is internationally recognized as a center of excellence in these areas. With offices in Hanover, New Hampshire, and Fairbanks and Anchorage, Alaska, CRREL broadens the knowledge base of cold regions through groundbreaking scientific and engineering research for the Corps of Engineers, the Army, DoD, and the Nation. The CRREL research program is designed to be responsive to the needs of the military, but a majority of the research and engineering results also benefit the civilian sector. To support this research, CRREL has a number of unique facilities that are specifically designed for the detailed scientific study of ice, snow, frozen ground, and permafrost. CRREL's research program provides critical technologies to address operational capabilities in the Arctic and other cold-regions environments.

The U.S. Army Soldier Systems Center—Natick Soldier Center (NSC)—is located in Natick, Massachusetts. NSC conducts research, development, and engineering of items and systems to support and sustain soldiers. Basic research is devoted to both product development and, in the case of human sciences, to the support of product development. The importance of human sciences has grown with the development of soldier systems and is of particular importance in light of the Army position that all new objective warrior systems be "soldier-centric." The human sciences at NSC, combined with those at other Army laboratories, academia, and industry, will ensure that the Army can develop and field soldier-centric systems. The

goal of all human sciences research at NSC is to achieve maximum product performance and maximum soldier performance, that is, soldier science is geared to getting the most out of the product in its interaction with the soldier, and the most out of the soldier in the soldier's interaction with the product.

The U.S. Army Research Institute of Environmental Medicine (USARIEM), located in Natick, Massachusetts, conducts basic and applied biological and biophysical research to elucidate novel approaches for sustaining health and optimizing performance of humans exposed to cold environments. USARIEM research findings provide the biomedical basis for Army doctrine to minimize the adverse effects of cold on individual military personnel, crews, and troop populations deployed in cold climates, including Arctic regions. USARIEM employs multidisciplinary teams of scientists using human, animal, tissue, cellular, and mathematical models to delineate pathophysiological mechanisms of cold injury, identify biomedical risk factors influencing susceptibility to cold injury, and provide physiologic data for developing and validating mathematical models predicting human cold tolerance. Additionally USARIEM formulates and validates exposure guidelines and safety limits to prevent cold injury during military training, develops strategies to safely extend cold tolerance and work capabilities in cold climates, and provides biomedical support for cold stress Health Hazard Assessment and MANPRINT (Manpower and Personnel Integration) efforts of Army materiel and clothing developers. USARIEM also writes manuals for use by soldiers deployed to cold climates. USARIEM research capabilities include state-of-the-art technology for collecting human thermoregulatory data in the laboratory and nonintrusive, ambulatory, real-time monitoring of warfighter physiological status during military operations in cold-weather conditions.

Medical and Human Engineering

USARIEM maintains an active research program in the area of human physiological responses to cold. A current emphasis concerns the extent to which the normal shivering and circulatory responses to cold exposure become fatigued. A recent USARIEM study demonstrated that multiple days of exhaustive exercise do not impair shivering but result in greater heat loss due to vasoconstrictor fatigue. USARIEM also examined the thermoregulatory effects of an 84-hour Sustained Operation (SUSOPS) where soldiers were in a state of negative energy balance (they ate 1700 calories and expended 4700 calories per day) and sleep deprivation (they slept a total of 3.6 hours over 3–5 days). This study found that SUSOPS impairs the shivering response and causes core body temperatures to fall to a greater extent following SUSOPS. USARIEM also recently developed a Cold Strain Index for use in operational settings and for evaluating physiological responses during cold exposure.

USARIEM is also active in researching how cold-induced vasodilation (CIVD), which may protect against frostbite, is modulated by various operational stressors. Recent studies demonstrated that 4% dehydration does not impair the CIVD response. Also USARIEM demonstrated that moderate altitude (approximately 6000 ft) does not impair the CIVD response. USARIEM also studies the impact of fatigue on immunological responses to cold exposure. Recent USARIEM studies demonstrated that one hour of exercise did not impair immune responses during subsequent cold exposure. However, multiple days of exhaustive exercise did impact intracellular cytokine production in immune cells during subsequent cold exposure. One finding suggested that cytotoxic T cells will not be as effective following 3–6 hours of exercise and cold exposure. USARIEM recently developed new Cold Weather Guidance for Operation Noble Eagle/Enduring Freedom. This guide is to be used by troops deploying to cold regions.

USARIEM research has also addressed issues related to tissue and heart rate changes in hypothermic animals. In one study, endothelial integrity was examined. It was found that extravasation decreased in tissues with continuous endothelium (brain and muscle) and increased in tissues with discontinuous endothelium (liver, lung, and spleen). In another animal study, ECG waveform and heart rate variability (HRV) were examined as potential autonomic signatures of hypothermia and rewarming. It was determined that T-wave amplitude and HRV may be a predictor of survival in hypothermic victims.

USARIEM research also supports the development of cold-weather predictive models. An ongoing effort is examining the effect of long-term cold exposure on expeditioners working in Antarctica for 14 months. The first phase of the study found that various cold-air models that incorporate percent body fat and core and skin temperatures are reliable predictors of the shivering response to cold air for unacclimated men and women.

The Natick Soldier Center (NSC) is embarking on research for the enhancement of cognitive readiness under simulated stressful conditions. This is a relatively new initiative at NSC in which research addresses the impact of stress on the cognitive functioning of warfighters. As fighting systems, equipment, and situations become increasingly complex, cognitive demands increase commensurately. Identifying the impact of single and multiple stressors on the ability to complete cognitive tasks and the types of cognitive deficits produced by these stressors is critical for identifying ways to optimize overall warfighter performance.

The objective of NSC's research is to develop a valid, repeatable laboratory paradigm for evaluating cognitive performance under severe stress and to apply this paradigm to test the efficacy of potential nutritional counteragents. A collaborative research group has been created that includes NSC personnel and USARIEM military nutrition and thermal researchers. A laboratory study utilizing full body immersion has been developed to simulate severe (cold) stress and to assess the potential of tyrosine—a precursor for brain catecholomines—as a means for reducing the negative impact of (cold) stress on cognitive performance. The major effort in FY 02 by NSC is to complete the laboratory study. The experimental protocol calls for approximately 25 subjects. Each will participate in two test days—one when tyrosine is administered and one when it is not. On each test day, subjects will undergo two immersions of approximately 90 minutes separated by a two-hour rewarming period. Cognitive performance (for example, delayed matching, vigilance, or addition) will be measured at prescribed time intervals.

Remediation studies and deployment at Eagle River Flats, Alaska.

Environmental Site Characterization and Remediation

The challenging conditions and problems in the Arctic present exceptional opportunities for increased understanding of the fundamental nature of phenomena such as freeze–thaw cycles, phase changes, and biological adaptations. Not only are these results critical to addressing cold regions problems, but also the insights gained are valuable in understanding processes in less extreme conditions. CRREL has demonstrated that phytoremediation can be used to treat petroleum-contaminated soils in Arctic conditions. Phytoremediation capitalizes on the interaction between natural plants and indigenous microbial communities. Secretions from the plant's root system stimulate the microbial communities to more rapidly degrade contaminants in the soil. This innovative technique has minimal equipment and energy requirements, so it is particularly well suited for locations that lack significant infrastructure.

Understanding the dispersion, persistence, fate, and environmental impacts of point or line source airborne pollutants in Arctic conditions is increasingly important. CRREL has worked with the Army Directorate of Public Works and the Alaska Department of Environmental Conservation to develop low-cost monitoring techniques for characterizing the dispersion and deposition of aerial petroleum-based fogs used for military training. Aerial plumes behave differently in winter and summer conditions, and both the prediction of the deposition area and the methods to monitor the process have environmental and homeland defense applications.

Eagle River Flats has served as the primary impact range for Fort Richardson, Alaska, for over 50 years. In the 1980s, waterfowl die-offs were recorded. In 1990, CRREL became involved in investigating the cause of the observed mortality and discovered the cause. Residual white phosphorus particles from smoke rounds fired into the flats during training were released. Because the site was a tidal wetland, the white phosphorus did not sublimate as it would in other conditions. Development of a remediation method was required to address the contaminant in situ without destroying the fragile and important wildlife habitat of the area. The method developed at Eagle River Flats has been applied to other military ranges, enhancing environmental quality.

The current effort at Eagle River Flats is centered on the six pumping systems deployed from May to September. In addition to the pump sys-

tems, remote data acquisition systems are used to monitor the remediation parameters. Four web cameras are used to send images of the flats via radio modems and the Internet to a web site, allowing investigators to monitor the conditions at the sites. Meteorological data as well as data from some of the remote sites are transmitted to the web site as well on a daily basis. Aerial photos are taken annually to determine gross changes in the physical system.

Sampling is used to determine the progress of the remediation as well as the presence of contaminated areas. Analysis of planted particles, retrieved at the end of the season, indicates the annual remediation effectiveness. The analysis is supplemented by both discrete and composite sampling of ponds under treatment. Composite sampling is used to determine if areas not under treatment are contaminated.

Arctic Engineering, Permafrost, and Frozen Ground

Environmental atlases for Alaska are nearly twenty years old and in need of updating. The need is amplified by evidence of rising temperatures and thawing permafrost. CRREL and the University of Alaska are developing an Alaska Engineering Design Information System (AEDIS). The system will be a geographical information system (GIS) -based, web-accessible application that consists of an analysis toolkit for engineers. AEDIS will include a broad array of ocean, atmosphere, and terrestrial environmental data. The toolkit will contain algorithms for determining parameters for direct application to practical engineering problems. Although a preliminary web site has been developed, it will take several years to complete this vital effort.

Snow and Ice Hydrology

A team of CRREL researchers conducted field and laboratory tests to determine the manner in which heat, mass, and chemical species are transported through snow, as well as the effect of the snow microstructure and ice layers on the transport. This research has important applications in a variety of areas, including the rate and extents of movement of chemical contamination, meltwater, and reactive gases from the atmosphere through the layers of snow into the soil. The research is also important in determining the effect of chemical reactions in the snowpack on atmospheric chemistry. Prior to this research the diffusion coefficients needed to predict the rate of diffusion of hydrocarbons through snow were unknown. CRREL researchers have conducted laboratory tests to determine the diffusion coefficients of explosives through snow and the effect of snow metamorphism on the diffusion rates. The researchers are extending those studies to include diffusion in frozen and unfrozen soil. The research team has produced the first published measurements of the permeability of ice layers in snow and the manner in which the permeability of those layers changes of over time. This process affects the flow of water, air, and chemical species through the snow.

CRREL researchers have conducted inert tracer gas studies, snow microstructure studies, and numerical modeling to investigate the rates of diffusion and advection of gaseous species through the snow and into the atmosphere. Within the last several years it has been discovered that physiochemical reactions in the near-surface snow are significant enough to influence the atmospheric chemistry of the troposphere. The researchers published the first theoretical and experimental results showing the manner in which ozone is depleted within the snowpack; this affects atmospheric ozone not only in the Arctic, but also anywhere snow lies on the ground. These findings, accomplished in joint experiments with international university researchers, are changing the paradigm of analysis within the field of atmospheric chemistry.

CRREL researchers examined the relationship between a time series of ERS-1 C-band synthetic aperture radar (SAR) backscatter measurements and spring snow cover dynamics. Measurements were compiled in a portion of the boreal forest of Saskatchewan, Canada. CRREL's one-dimensional mass and energy balance model (SNTHERM) was used to calculate surface energy exchanges and associated snow cover dynamics. The model was run for each canopy class within the study region. By altering the transfer of energy from above the canopy to the forest floor, forest canopies affect both the rate of supply of meltwater to the soil system and the remote sensing signature. Accurate monitoring and modeling of snow conditions and the forest energy state over large areas will contribute substantially to predictions of long-term changes to the boreal forest. The observed ERS SAR backscatter correlated with changes in modeled snow surface properties during freeze–thaw transitions. The CRREL researchers distributed SNTHERM results across the modeling region, providing regional-scale multi-temporal maps of snowpack properties.

The snow distribution throughout much of Alaska is heterogenous, largely because of drifting, which transports the snow. Where shrubs are present, snow can be trapped, increasing the snow depth and creating warmer conditions in the underlying soil. This benefits the shrubs by potentially enhancing growth. Researchers at CRREL have been investigating the patterns of snow distribution using end-of-winter aerial and ground-based measurements and a physically based computer model for blowing snow (SnowTran-3D). Snow–shrub interactions may have important climate feedback potential. They may also have a vital role in the transition of tundra regions to scrublands, which would have significant climatic and hydrologic ramifications. Recent results also suggest that shrubs and snow interact in an important way with respect to snow albedo. The NSF Arctic System Science program and the NASA Land Surface Hydrology Program primarily support this effort.

Oceanography

CRREL researchers participated in the icebreaking trials of the U.S. Coast Guard's newest icebreaker, the USCGS *Healy*. The trials took place in Baffin Bay during April and May 2000. The researchers designed the tests and documented the ice properties, including thickness and strength. Much of the testing program was consumed by continuous icebreaking tests. These tests were used to determine the speed of advance at various power settings through a range of level ice thicknesses. Other tests included maneuvering performance, backing and ramming through multiyear ice, and transiting pressure ridges. The 77 individual tests conducted during the trials verified that *Healy* exceeded its icebreaking design specifications. During the trials, tests were also conducted that measured hull impact loads and propulsion system performance. *Healy*'s overall performance during the ice trials demonstrated that it is one of the world's most capable nonnuclear icebreakers.

The *Marine Ice Atlas for Cook Inlet, Alaska* was published by CRREL. Sponsored by NOAA, the project combined skills from CRREL and the University of Alaska Anchorage. Maps of ice concentration and stage of development were derived from charts of ice conditions produced by the National Weather Service. The atlas also includes comprehensive information on the ice conditions, climate, and oceanography of the Cook Inlet region.

Recent evidence indicates that the sea ice cover of the Arctic Ocean has been thinning and decreasing in extent. Currently the only reliable method of assessing ice thickness over the Arctic Basin is to analyze ice draft profiles collected by transiting submarines. Under a project sponsored by the National Science Foundation, CRREL researchers have processed and obtained the release of formerly classified information on ice draft profiles from U.S. Navy submarines. Data from fifteen cruises occurring from 1986 to 1994 have been forwarded to the National Snow and Ice Data Center for public distribution. The analysis of the ice draft data revealed rapid thinning in the western Arctic that occurred in the late 1980s. The thinning has been attributed to a major shift in the wind-driven ice circulation patterns.

Researchers at CRREL are actively involved in analyzing and publishing results from the yearlong Surface Heat Budget of the Arctic Ocean (SHEBA) field program. SHEBA is a comprehensive, interdisciplinary research program with two primary goals: to determine the ice–ocean–atmosphere processes that control the ice albedo and the cloud radiation feedback mechanisms, and to improve the treatment of the Arctic in general circulation models used in studies of climate variability. The SHEBA program includes studies to enhance the understanding of the seasonal evolution of albedo, the mass of the ice, and the interplay between ice dynamic and thermodynamic processes. Findings from the field study are being incorporated into discrete element models of the ice pack and into large-scale climate models. These models illustrate that Arctic sea ice may be a sensitive indicator of climate change.

CRREL is developing a high-resolution model of the Arctic ice pack for NASA. The model ice pack is capable of producing the long, quasi-linear features seen in Radarsat Geophysical Processor System (RGPS) imagery. The ice pack is composed of discrete parcels that converge to form pressure ridges and separate to form leads. The model has been expanded to simulate the entire Arctic basin. It begins with a continuous, frozen ice pack covering the basin, and then wind drag causes the pack to move. Stress build-up in the pack causes lines of fracture to propagate through the model pack. The result is the creation of an aggregate structure that determines the paths of subsequent deformation. Simulation results are compared to NASA RGPS results using a virtual RGPS running on the model ice pack.

A study of microstructural features and brine

drainage networks in first-year sea ice is a three-year collaborative effort with researchers at CRREL and the Geophysical Institute, University of Alaska Fairbanks, funded by the National Science Foundation's Office of Polar Programs. Now in its final year, the project involves extensive fieldwork in the Alaskan Arctic gaining knowledge of the physical properties of first-year sea ice. Monitoring sites in the Chukchi Sea and Elson Lagoon provide continuous records of the ice growth and thermal regime, offering opportunities to conduct detailed studies of the microstructure and brine-related flaw structure. These studies are accomplished during several field investigations that take place each year. This project is generating a comprehensive set of images of the microstructure and brine inclusion structure. The structure is measured on scales ranging from individual inclusions to the thickness of the entire sheet. Image processing techniques are being applied to quantify the inclusions in three dimensions and to study the horizontal banding features that are frequently observed in sea ice. An analytical effort is underway to develop a relationship between the banding feature and under-ice currents.

Physical and Mechanical Properties of Ice

A laboratory study of the mechanical properties of methane hydrates is an ongoing project, now in its third year. The study investigates the mechanical properties of methane hydrates (an ice-like solid formed from methane and water) and hydrate–sediment mixtures. CRREL has developed a preparation system for hydrate specimens, and its researchers are conducting quasistatic and dynamic experiments on laboratory-prepared specimens. The program is funded by the Department of Energy and supports their long-term program in hydrate research. The overall effort focuses on developing the necessary science and technology to tap the earth's considerable methane hydrate deposits as a future source of energy. CRREL researchers have conducted experimental work by incorporating equipment and methodologies that were successfully developed and applied in various ice mechanics studies.

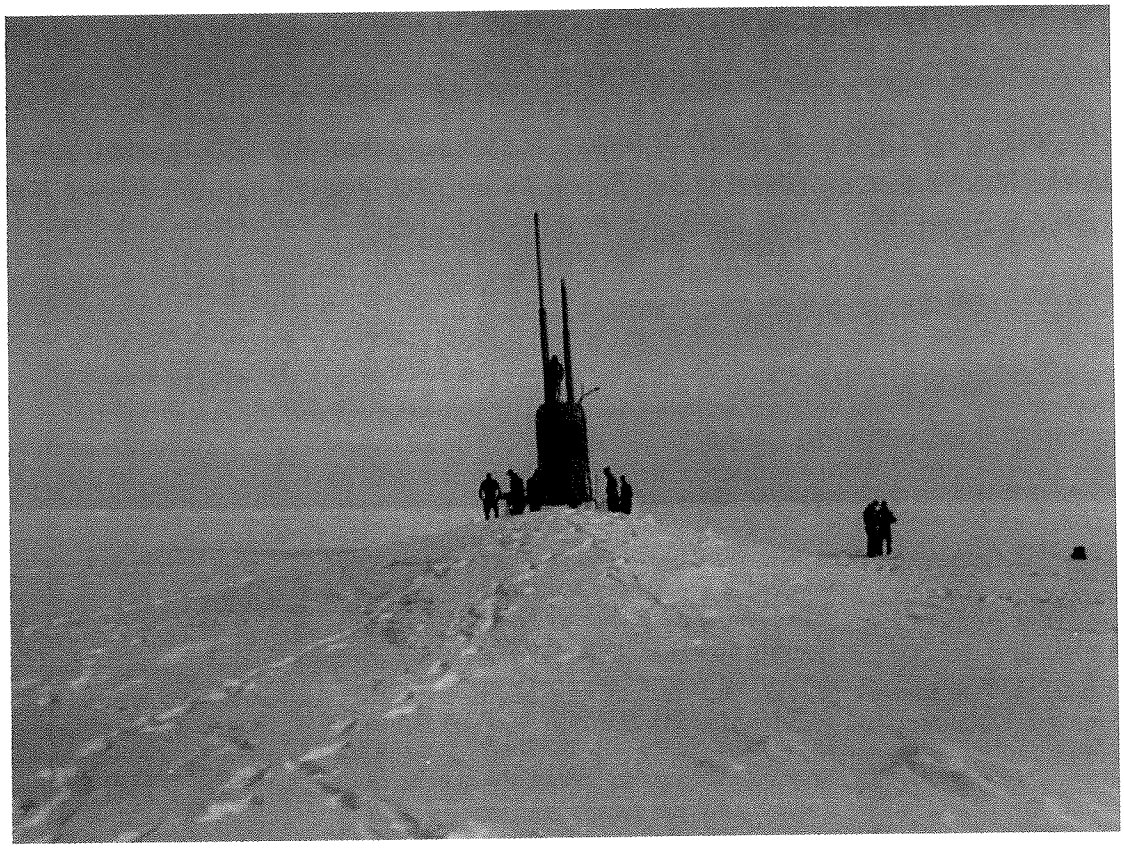
The Mechanisms of Deformation of Pure and Debris-Laden Ice is a three-year program, currently in its first year, and is a collaboration among CRREL researchers, Dartmouth College researchers, and Dartmouth College students. It is funded by the National Science Foundation's Office of Polar Programs. The aim is to understand the physical mechanisms that underlie the flow of large ice sheets. The work is motivated by the need to obtain a more in-depth understanding of the physics of glacier movement. This is particularly important because of the rapid altering thermal regimes that are anticipated under current climate change scenarios. The program involves laboratory experiments and the application of a constitutive model developed at CRREL.

CRREL researchers are using a powerful new three-dimensional river ice model to simulate the effects of ice interaction with the piers of a proposed bridge on the Buckland River in Buckland, Alaska. Recent advances in discrete element modeling allow the model to be used to simulate ice conditions in natural channels and to be combined with unsteady flow modeling. It also provides a means of simulating ice jams and ice interaction with structures that can provide estimates of ice forces and the impacts of the ice accumulation at the structure on the river flow in a reasonable time and at low cost. In this project for the Alaska Department of Transportation, CRREL investigated the ice forces and overturning moments exerted on the bridge piers by the ice and the effect of the bridge piers on the ice passage for three design alternatives.

Research at Barrow, Alaska, on Arctic coastal ice, sponsored by the National Science Foundation.

Navy

The Office of Naval Research's (ONR) High Latitude Program investigates physical, biological, chemical, and geological processes 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



USS Scranton *at the North Pole, June 2001.* Scranton *spent a portion of her Arctic mission collecting environmental data for the SCICEX program.*

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 SHEBA (Surface Heat Budget of the Arctic Ocean) experiment and the ongoing ONR- and NSF-sponsored Science Submarine Cruise (SCICEX) program.

In 2000 the U.S. Navy Submarine Force signed a Memorandum of Agreement with ONR and NSF to continue the SCICEX program. Under this second phase of the program, effort has been shifted to a new concept termed "SCICEX Accommodation." This will make use of brief periods of classified polar cruises and the considerable talents of the Navy crews to collect baseline data sets of interest to the scientific community as a whole. The types of data to be collected and the areas of collection are recommended by a committee of scientists. Upon completion of each cruise, the data are sent to the National Snow and Ice Data Center in Boulder, Colorado, for archival.

Two SCICEX Accommodation cruises have been completed. The first, conducted in the fall of 2000 by USS *L. Mendel Rivers*, collected data along a cross-basin transect used during many of the dedicated SCICEX cruises of the 1990s. Additional hydrographic data and water samples were collected along the northern shelf of the Chukchi Sea. The second Accommodation cruise was conducted by USS *Scranton* in the spring of 2001, repeating approximately half of what has become the "standard" SCICEX cross-basin transect.

National Aeronautics and Space Administration

As part of its Office of Earth Science, NASA supports various research programs in the Arctic that emphasize applications of airborne and space-based remote sensing to studies of the earth and space sciences.

Arctic Warming

Recent satellite observations have revealed a substantial widespread warming of the Arctic over the last 20 years. Estimates from a network of sparsely distributed meteorological stations located north of 60°N have indicated a warming rate of 0.06 ± 0.01°C per decade in the Arctic during the last century. When only the last 20 years of the same data set are considered, the rate increases to 0.48 ± 0.12°C per decade, suggesting a rapid increase in Arctic warming. New satellite surface temperature data from 1981 to 2000 confirm the station observations, but the pan-Arctic coverage indicates that trends are even more positive in other locations and show record-breaking warming in some regions. The trends are about 0.95 ± 0.20°C per decade over sea ice and Greenland, 0.64 ± 0.26°C per decade over Eurasia, and 1.42 ± 0.27°C per decade over North America, with the highest seasonal trends occurring in spring.

Land Ice

Greenland Ice Sheet

NASA's Program for Arctic Regional Climate Assessment (PARCA), established in 1995 with the prime objective of assessing and understanding the mass balance of the Greenland ice sheet, hit a major milestone in 2000–2001. PARCA investigators published the first comprehensive observational assessment of the mass balance of the Greenland ice sheet. Results showed that, taken as a whole, high-elevation parts of the ice sheet are in balance to within about 1 cm/yr. In contrast, most of the coastal regions of the ice sheet thinned quite rapidly during the 1990s, with net losses from the ice sheet sufficient to raise global sea level by about 0.13 mm/yr, or about 10% of the total observed rise. Although coastal summer temperatures have increased recently, particularly along the east coast, the increase cannot explain observed thinning rates of up to several meters per year. This suggests that discharge velocities must also have increased. Based on these observations, PARCA's focus has shifted to the coastal regions, with emphasis on surface ablation and its sensitivity to summer warming and possible albedo feedback and on the dynamics of those glaciers that are observed to be changing rapidly.

Additionally, melting beneath Greenland's only major ice stream in the Northeast has been discovered in the region of the ice stream onset, suggesting a likely mechanism for stream flow. The high heat flux and its situation in an area with magnetic anomalies suggest a possible volcanic source beneath the ice. Other contributions from PARCA to Greenland research include:

- The establishment of 20 automatic weather stations on the Greenland ice sheet, most providing real-time three-hourly data via satellite link;

	Funding (thousands)	
	FY 00	FY 01
Polar Ice Interactions	4,000	4,000
Ecology	2,371	619
Solid Earth Science	1,300	2,000
Arctic Ozone	12,700	6,440
Clouds and Radiation	1,500	750
Sub-orbital Science	3,300	900
Iono/Thermo/Mesospheric SR&T	1,502	1,500
Magnetospheric SR&T	400	292
Geospace Sciences	2,065	2,100
FAST Auroral Snapshot	1,500	1,500
Solar Terrestrial Theory	400	400
Arctic Data Systems	13,908	12,100
Research Balloon Program	750	750
Sounding Rocket Program	950	800
Total	46,646	34,151

- More than doubling of the number of shallow ice cores extracted and analyzed for recent climate studies; and
- Enhanced atmospheric and glaciologic modeling capabilities.

PARCA has yielded vast amounts of data that can feed and validate models and provide a baseline against which future observations can be compared. PARCA investigators have developed new technologies for airborne remote sensing and in-situ measurements. They have greatly improved our ability to model atmospheric processes that influence the ice sheet mass balance. And they have made tremendous advances in satellite remote sensing techniques relevant to glacier and ice sheet studies. Along the way they have made new discoveries about the structure and behavior of the ice sheet and its outlet glaciers. Some of these and other results were published in a special section of the *Journal of Geophysical Research—Atmospheres* in December 2001 that was dedicated to PARCA research.

Canadian Ice Caps

Airborne laser surveys of the major Canadian ice caps were conducted in 2000 to determine the extent to which they are thickening or thinning. As in Greenland, pronounced thinning was observed near the ice cap edges at the lower elevations, while little thinning or slight thickening has been detected at higher elevations in the centers of the ice caps. The observed loss of ice in much of the regions surveyed coincides with relatively warm temperatures in the late 1990s. The observations only cover the period 1995–2000, but working with Canadian glaciologists, NASA-supported investigators are relating that to the 40-year record.

Alaskan Glaciers

Differential spaceborne radar interferometry observations of the West Bagley Ice Valley, in the eastern Chugach Mountains of southcentral Alaska, were used to measure surface velocity and topography during the 1993–1995 surge of Bering Glacier. Bagley Ice Valley is the accumulation area for Bering Glacier. Bagley Ice Valley and Bering Glacier—with a total area, including tributaries, of about 5200 km^2—are the largest glacier system in continental North America. This glacier system surged in two phases from spring 1993 through summer 1995. The observations were based on data collected during the winter of 1992, prior to the surge, and during the winter of 1994, while the surge was in full progress. Algorithms were developed to derive surface-velocity vector fields and topography for this and other valley glaciers from synthetic aperture radar (SAR) images. The resulting high-resolution velocity data clearly show the West Bagley Ice Valley accelerating from its quiescent pre-surge velocity by a factor of 2.7 in response to the Bering Glacier surge. Persistence of interferometric phase coherence and the relatively moderate degree of acceleration on the western arm of Bagley Ice Valley suggest that the velocity increase may have been caused by increased longitudinal stress gradients resulting from coupling to the surging main trunk of Bering Glacier.

Sea Ice

Passive Microwave Satellite Observations

Since late 1978, satellite data have allowed monitoring of the Arctic sea ice cover on a daily or near-daily basis. These data have been used to calculate sea ice extents over the period 1979–1999 for the north polar sea ice cover as a whole and for each of nine regions within the ice cover. Over this 21-year period, the data reveal a trend in yearly average ice extents for the ice cover as a whole of $-32{,}900 \pm 6{,}100$ km^2/yr (-2.7 ± 0.5%/decade), indicating a reduction in sea ice coverage. Seasonally the reductions are greatest in summer, for which season the 1979–1999 trend in ice extents is $-41{,}600 \pm 12{,}900$ km^2/yr (-4.9 ± 1.5 %/decade).

Regionally the sea ice reductions are greatest in the Arctic Ocean, the Kara and Barents Seas (north of Scandinavia and far western Russia), and the Seas of Okhotsk and Japan (north and west of Japan). Only two of the nine regions examined show overall ice extent increases, those being the Bering Sea (between Alaska and Siberia) and the Gulf of St. Lawrence. For neither of these two regions is the increase statistically significant, whereas the 1979–1999 ice extent decreases are statistically significant at the 99% confidence level for the north polar region as a whole, the Arctic Ocean, the Seas of Okhotsk and Japan, and Hudson Bay.

Radarsat Geophysical Processor System

The Radarsat Geophysical Processor System (RGPS) is under development to produce systematic observations of fine-scale (~10 km) sea ice motion and estimates of the seasonal ice thickness distribution over the entire Arctic Ocean. This is accomplished by using the wide-swath (~460 km) imaging capability of the Radarsat SAR to provide

repeat maps of Arctic ice cover every three days. Each high-resolution (~150 m) map covers an area nearly the size of the continental U.S. At this resolution it collects almost a billion samples to cover the entire Arctic Ocean. Other spaceborne remote sensing instruments (e.g. AVHRR and SSM/I) that provide regular coverage of the Arctic Ocean have resolutions more than ten times poorer than that of the SAR. Beginning in November 1996 and continuing today, investigators at NASA's Jet Propulsion Laboratory have been acquiring three-day maps of the western Arctic Ocean within the Alaska SAR Facility (ASF) reception mask. Outside the ASF mask, the coverage is less frequent (six days) because of the additional transcription cost of data downlinked at the Tromso Satellite Station in Norway.

Sea ice motion is obtained by tracking common features in sequences of SAR maps. Drifting buoys have provided a substantial base of knowledge of large-scale ice motion during the past two decades, but there are less than ten deployed in the Arctic Ocean at any one time. The RGPS provides observations that are equivalent to deploying more than 30,000 drifters on the ice for sampling the motion and deformation fields. When the ice cover deforms, the sea ice yields along narrow fracture zones that are then filled with open water (leads) or ridged ice. Thus, dense spatial sampling is crucial for understanding small-scale processes, as the motion field is spatially discontinuous. From a surface heat and mass balance perspective, the newly opened leads are sources of new ice growth, brine rejection to the ocean, and turbulent heat transfer from the ocean to the atmosphere. Moreover, the rates of these climatologically important processes are significantly higher than at areas covered by thicker ice.

High-resolution ice motion from the RGPS, with data quality comparable to that from buoy drifts, has provided an unprecedented level of spatial and temporal detail of these deformational features. For the first time we can map on a routine basis the location, coverage, and seasonal development of these leads and ridges. The RGPS data have shown that these narrow fracture zones (up to kilometers wide) are linear features that can extend for thousands of kilometers, and these fracture patterns appear as oriented rather than random patterns from the kilometer scale to the scale of the Arctic basin. With the advent of coupled ice–ocean models with resolutions that approach the widths of leads (10 km), there is increased need for high-resolution measurements for validation and simulation. Simulation results and model performance can now be examined in detail using the small-scale RGPS observations previously unavailable.

The RGPS estimates the seasonal ice thickness distribution of sea ice using the record of openings and closings of the ice cover, air temperature, and an ice growth model. From the evolution of the seasonal ice thickness distribution, ice production can be examined.

The Arctic is undergoing measurable change this decade in several key indicators of climate warming. The four-year record from Radarsat is fortuitously timed to also potentially provide indicators of climate change through ice motion and age/thickness derivations that are used to determine the surface heat and mass balance of the Arctic Ocean. The RGPS deformation measurements provide a new level of spatial and temporal coverage and detail of the ice cover for all seasons of the year. We have, for the first time, extensive measurements of the ice motion that can be used in concert with a variety of ice models for verification studies, for driving the models as forcing fields, for data assimilation procedures, and for constructing sea ice climatologies. The value of these uses for the RGPS products will increase as the observational record becomes longer and a greater variety of seasons are recorded.

Boreal Landcover and Ecosystem Dynamics

NASA-sponsored investigators combined mapping and monitoring of boreal landcover with ecological modeling for assessing regional and continental-scale carbon flux dynamics. Using imagery from JERS SAR, they are developing a landscape segmentation map for use in an ecosystem process model. The map is coupled with landscape freeze/thaw dynamics derived using temporally dense spaceborne scatterometer data. These combined features allow determination of seasonal transitions from all regions of the landcover classification. Integration of an ecosystem model with remote-sensing-derived products allows improved quantification of carbon flux dynamics on regional and continental scales. Each element in this suite of products will be assessed using existing data sets and in-situ biophysical data collected under other activities. Integrating the suite of monitoring tools within a common framework will allow assessments of landcover change, making possible evaluation of the effects of landcover change on carbon flux dynamics and regional and local-scale ecological processes in general. Development and

validation efforts are first focused on intensive study regions in Alaska and the Boreal Ecosystem Atmosphere Study (BOREAS) region of Canada. The methods developed will be extrapolated to other American boreal regions and will be applicable to Eurasian boreal regions as well. The intent is to apply these techniques to derive contiguous products for the circumpolar and boreal regions.

Ozone Studies

Between November 1999 and April 2000, two major field experiments, the SAGE III Ozone Loss and Validation Experiment (SOLVE) and the Third European Stratospheric Experiment on Ozone (THESEO 2000), collaborated to form the largest field campaign yet mounted to study Arctic ozone loss. This international campaign involved more than 500 scientists from over 20 countries. These scientists made measurements across the high and mid-latitudes of the northern hemisphere. The main scientific aims of SOLVE–THESEO 2000 were to study the processes leading to ozone loss in the Arctic vortex and the effect on ozone amounts over northern mid-latitudes. The campaign included satellites, research balloons, six aircraft, ground stations, and scores of ozone-sondes. Campaign activities were principally conducted in three intensive measurement phases centered on early December 1999, late January 2000, and early March 2000. Observations made during the campaign showed that temperatures were below normal in the polar lower stratosphere over the course of the 1999–2000 winter. Because of these low temperatures, extensive polar stratospheric clouds (PSCs) formed across the Arctic. Large particles containing nitric acid trihydrate were observed for the first time, showing that denitrification can occur without the formation of ice particles. Heterogeneous chemical reactions on the surfaces of the PSC particles produced high levels of reactive chlorine within the polar vortex by early January. This reactive chlorine catalytically destroyed about 60% of the ozone in a layer near 20 km between late January and mid-March 2000, with good agreement being found between a number of empirical and modeling studies. The measurements made during SOLVE–THESEO 2000 have improved our understanding of key photochemical parameters and the evolution of ozone-destroying forms of chlorine.

Clouds and Radiation

The first ISCCP Regional Experiment Arctic Clouds Experiment (FIRE.ACE) was coordinated with the SHEBA project during April–July 1998. The main goals of the field experiment were to gather the data needed to examine the impact of Arctic clouds on the radiation exchanges between the surface, atmosphere, and space and to determine the role of the surface in the formation of clouds in the boundary layer. Observations are being used to improve remote sensing retrievals of geophysical parameters and to evaluate and improve climate model performance in the Arctic. The GEWEX Cloud System Study (GCSS) Working Group on Polar Clouds (see http://paos.colorado.edu/~curryja/wg5/home.html), whose management was largely funded by NASA, has initiated three major intercomparison projects during the past year, two of which are directly related to FIRE.ACE. The first is the radiative transfer model intercomparison project, where ten radiative transfer models used in climate models or satellite remote sensing are being evaluated using observations from SHEBA/FIRE.ACE. The second is the Arctic Regional Climate Model Intercomparison Project, which is evaluating nine regional models for simulations conducted for the SHEBA year. A major element of the model evaluation is preparation of high-resolution fields using satellite observations. The satellite observations are being evaluated using data from SHEBA and the ARM site at Barrow. A special section in the *Journal of Geophysical Research* on FIRE.ACE was published in July 2001, with 30 papers highlighting recent results.

Satellite Missions

Ice Cloud and Land Elevation Satellite

Development has continued on NASA's Ice, Cloud and Land Elevation Satellite (ICESat) mission, which will measure changes in elevation of the Greenland and Antarctic ice sheets as part of NASA's Earth Observing System (EOS) of satellites. Time series of elevation changes will enable determination of the present-day mass balance of the ice sheets, study of associations between observed ice changes and polar climate, and estimation of the present and future contributions of the ice sheets to global sea level rise. Other scientific objectives of ICESat include global measurements of cloud heights and the vertical structure of clouds and aerosols; precise measurements of land topography and vegetation canopy heights; and measurements of sea ice roughness, sea ice thickness, ocean surface elevations, and surface reflectivity. The Geoscience Laser Altimeter System (GLAS) on ICESat has a 1064-nm laser channel

for surface altimetry and dense cloud heights and a 532-nm lidar channel for the vertical distribution of clouds and aerosols. The accuracy of surface ranging is 10 cm, averaged over 60-m-diameter laser footprints spaced at 172 m along the track. The orbital altitude will be around 600 km at an inclination of 94° with a 183-day repeat pattern. The on-board GPS receiver will enable radial orbit determinations to better than 5 cm, and star-trackers will enable footprints to be located to 6 m horizontally. The spacecraft attitude will be controlled to point the laser beam to within 35 m of reference surface tracks at high latitudes. ICESat is designed to operate for 3–5 years and should be followed by successive missions to measure ice changes for 15 years.

Stratospheric Aerosol and Gas Experiment III

A new NASA remote-sensing satellite instrument has taken its first steps toward monitoring the health of the earth's Arctic atmosphere. The Stratospheric Aerosol and Gas Experiment III (SAGE III) was launched successfully from the Baikonur Cosmodrome in Kazahkstan on December 10, 2001, on the Russian Meteor-3M meteorological satellite. The Meteor-3M SAGE III is placed in a sun-synchronous orbit that yields solar occultation measurement opportunities between 50° and 80°N and 30° and 50°S. These measurements provide altitude concentration profiles of important climate-related trace atmospheric constituents such as ozone, aerosols, and water vapor in the earth's stratosphere and upper troposphere. The high northern latitude coverage will give insight into the processes leading to Arctic ozone depletion during late winter and early spring. These measurements of key components of the earth's atmosphere are vital for improved understanding of climate, climate change, and human-induced ozone chemistry and trends.

Gravity Recovery and Climate Experiment

GRACE was launched on March 17, 2002, from Russia's Plesetsk Cosmodrome following several years of development of this unique earth sensor. Comprising two identical satellites that change their distance apart when they pass over a gravitational anomaly, GRACE will measure changes in the earth's gravity field at 30-day increments for the next five years. The first instrument launched through NASA's Earth System Science Pathfinder Program, GRACE will detect changes in ice sheets and ocean mass by monitoring their gravity characteristics. Coupled with observed changes in ice sheet elevation in Greenland as well as Antarctica from ICESat, scientists will be able to translate volume changes into mass changes and assess the ice sheet's contribution to sea level rise.

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. Research programs focus on scientific questions that address the Arctic environment and its relation to the global environment.

Office of Oceanic and Atmospheric Research

Arctic Research Office

As preparation for the interagency Study of Environmental Arctic Change (SEARCH), in FY 01 the Arctic Research Office supported a number of projects on Arctic climate and the Arctic Oscillation, along with a few projects on transport and deposition of pollutants in the Alaskan Arctic.

Hydrologic Response of Siberian Major Rivers to Climate Change and Variation. Arctic rivers are an important component in global ocean and climate systems, and recent studies have shown remarkable changes in hydrologic regimes of the major rivers in Siberia over the past several decades. This project, at the University of Alaska Fairbanks, is a comprehensive assessment of change and variability in Siberian river systems and their connections to surface climate and atmospheric circulation.

Observation and Modeling of the Freshwater Dynamics Connecting the Arctic and Atlantic. Concentrated activity occurs where the Arctic and Atlantic Oceans meet and interact. Increasing amounts of fresh water have been pouring out of the Arctic and, in combination with intensified winds, have altered the circulation of the Atlantic. Improved observations of water masses and fluxes of water, salt, ice, and tracers between the Arctic and the Atlantic will help us understand this changing state and anticipate its future. An investigator at the University of Washington is studying observational and modeling methods relevant to the intense flows linking the Arctic and Atlantic Oceans. He is examining the feasibility of an affordable but adequate long-term measurement program in the Canadian Archipelago and Davis Strait, the Labrador Sea, and the Labrador continental shelf.

	Funding (thousands)	
	FY 00	FY 01
Atmos Trace Constituents	40	250
Fisheries Assess/Management	18,100	17,600
Marine Mammal Assessment	2,600	12,675
Ocean Assessment	15	15
Stratospheric Ozone	205	425
Data Management	468	375
Remote Sensing	465	206
Aircraft/Vessels	1,946	878
Climate and Global Change	268	42
Weather Research	40	125
West Arctic/Bering Sea Ecosystem	2,997	8,220
Barrow Observatory	790	1,200
Undersea Research	215	30
Arctic Research Initiative	1,650	1,650
Total	29,799	43,691

Variability of Thermohaline Circulation and Freshwater Storage in the Arctic Ocean. The Arctic Ocean and its marginal seas are key areas for understanding the Arctic climate system and its change through time. The present state of the Arctic Ocean and its influence on the global climate system strongly depend on the Arctic Ocean freshwater budget. Changes in the freshwater balance would influence the extent of sea ice cover; changes in surface albedo, energy balance, temperature, and salinity of water masses; and biological processes in the Arctic. Investigators in this project at the Woods Hole Oceanographic Institution are using data accumulated in U.S. and Russian research institutions, together with existing numerical ocean models, to examine the origin of the salinity anomaly in the Beaufort Gyre and to investigate its variability.

Paleoclimatic Reconstructions of the Arctic Oscillation. The Arctic Oscillation (AO) is believed to represent the surface signature of the polar vortex, and as such it may be one of the key factors impacting climate in northern latitudes. In the positive phase of the AO, pressure tends to

drop over the polar cap and to rise around 55°N, strengthening the westerlies and steering ocean storms in a more northerly direction. When high-latitude tropospheric winds are strong, there is increased warmth in northern Canada and Eurasia. Thus, the AO may be a partial cause of the enhanced extratropical winter warming trend of recent decades, perhaps in concert with greenhouse warming. Investigators at the Lamont–Doherty Earth Observatory are extending the available instrumental record for the AO by several hundreds of years into the past by using tree rings and other high-resolution records. Key hypotheses they will test include whether the recent increase in the AO in the past few decades is unusual relative to its behavior over the past several centuries.

Interactions of Laterally Advected Heat and Moisture with Arctic Cloud Properties. The circulation of the Arctic atmosphere has undergone change during recent decades. It is unclear, however, how this change is related to other variables, such as the magnitudes and pathways of horizontally advected heat and moisture into the Arctic as well as changes in cloud properties there. Newly available data sets from the NOAA/NASA Pathfinder Program offer an unprecedented opportunity to observe Arctic climate by providing measurements of atmospheric quantities spanning two decades. Investigators at Rutgers University are using these new data sets to analyze poleward transport of sensible heat and water vapor from low latitudes into and within the Arctic region and to examine how these quantities are related to cloud properties and the AO.

Arctic Archive of Model Output and Application to SEARCH. Recent environmental changes in the Arctic are well documented, and they have motivated the interagency program SEARCH, whose objective is a predictive understanding of recent, ongoing, and future Arctic environmental changes. In addition to observational and process studies, the SEARCH Science Plan includes modeling to test ideas about the coupling between the different components of Arctic change and to predict its future course. An investigator at the University of Alaska Fairbanks is developing a web-accessible archive containing the Arctic output from state-of-the-art global climate models. This archive will be made available to the Arctic Climate Impact Assessment.

Connections between Arctic–Subarctic Ocean Fluxes and the Arctic Oscillation. The goal of this project is to investigate the relationship between the AO and the variability of ocean and sea ice fluxes between the Arctic Ocean and adjacent seas. This is being done using a coupled, global atmosphere–ocean–ice general circulation model. The results of the project at the Army's Cold Regions Research and Engineering Laboratory will contribute to our understanding of how the AO influences ice and ocean variability and how sea ice export, water mass exchange, and thermohaline circulation interact on time scales longer than our present observational record.

Temporal and Spatial Variability of Alaskan Clouds Studied with a Ground-based Infrared Cloud Imager. Measurement of clouds is fundamental to studies of Arctic climate variability and change. The Arctic radiation balance is especially sensitive to clouds because of a combination of the high thermal emissivity of clouds, the small input of solar radiation during winter, the high visible reflectivity and high thermal emissivity of snow and ice, and the low water vapor content of the Arctic atmosphere. Understanding the Arctic climate system, therefore, requires a quantitative knowledge of Arctic clouds, including their spatial and temporal distributions and their thermal radiative properties. An investigator at NOAA's Environmental Technology Laboratory has deployed a newly developed Infrared Cloud Imager (ICI) in Alaska for determining spatial and temporal cloud statistics emitted in the 8–12-μm wavelength region. The ICI instrument records calibrated images of sky radiance, assigning a brightness temperature value to each pixel in an image. This project is a first step toward studying the relationship between the AO and cloudiness at various Arctic locations.

Do Recent Changes in Sea Ice and Snow Cover Impact the Arctic Oscillation? Changes are occurring in the Arctic that appear to have begun in the late 1960s and increased in the 1990s. These include tropospheric warming, reduction in ice extent, and increased variability in snow cover. Ecological impacts of these changes are already being noted. Much scientific interest has focused on the AO, which represents an Arctic-wide increase in upper atmosphere winds and a decrease in sea level pressure. A paradox is that the main shifts in the AO are seen in mid-winter, while many of the surface changes are seen in spring and summer. A second issue is whether the reductions in sea ice and snow cover in the western Arctic actually have an impact on the atmosphere. The goal of this project, at NOAA's Pacific Marine Environmental Laboratory, is to determine

the impact of the AO on low-level wind and temperature fields in spring in the Arctic and to evaluate the magnitude of feedback from sea ice and snow anomalies to the atmosphere in spring and summer.

Ocean Fronts of the Bering, Chukchi, and Beaufort Seas. The goals of this project are to describe qualitatively and quantitatively the ocean fronts of the Bering, Chukchi, and Beaufort Seas and to investigate possible links between the fronts' characteristics and the environment (bottom topography, sea ice cover, air temperature, river runoff, Bering Sea transport, and wind stress). The investigator, at the University of Rhode Island, is using both satellite and in-situ data to derive, map, and analyze ocean fronts.

Trophic Pathways on the Chukchi–Beaufort Shelf: Where do the Ice Algae Go? Microalgae grow on the undersurface of sea ice as well as within the sea ice matrix and are a well-known feature of Arctic ecosystems. They contribute a poorly known proportion of the total primary production in Arctic seas, and recent studies suggest that ice algal primary productivity has been greatly underestimated. Ice algae are important to microbial food webs and the dissolved and particulate carbon and nitrogen pools of the Arctic Ocean, and they contribute to food webs leading to numerous species of marine birds and mammals of importance in regional subsistence economies. The importance of ice algae to production budgets at higher trophic levels is uncertain, but it likely varies greatly across the Bering–Chukchi–Beaufort shelf because of physical oceanographic processes originating in the Bering Sea. Investigators at the University of Alaska Fairbanks are employing a novel technique to quantitatively trace carbon fixed by ice algae and water column phytoplankton through pelagic and benthic food webs using conservative fatty acid signatures derived originally from ice algae and phytoplankton. The results of this work will help us understand trophic dependencies and carbon budgets in Arctic food webs and predict the effects of environmental change caused by global warming and further reductions in sea ice.

Deposition Flux Rates and Fate of Atmospheric Mercury at Barrow, Alaska. The objective of this project, at NOAA's Air Resources Laboratory, is to expand the existing mercury measurement program to include direct mercury flux measurements, particulate mercury monitoring, additional mercury analysis, and atmospheric halogen chemistry. This project is further described below in the section on the Air Resources Laboratory.

Persistent Organic and Trace Element Pollutants in the Alaskan Arctic. This project, at the Pacific Northwest National Laboratory, is the Alaskan component of a larger effort titled "Study of Atmospheric Deposition in the Arctic; A Paired Study of a Site in Alaska and a Site in the Russian Far East." The scientific objectives are to gain insight into the sources, occurrence, and environmental fate of persistent organic pollutants (POPs); to contrast the occurrence of POPs and trace elements in this region with other Arctic air sheds; and to provide data in a form compatible with existing AMAP data to be used in assessing the potential risks to the environment and human inhabitants in the Arctic due to POPs.

The Arctic Research Office also supported projects to examine potential connections between Arctic climate and oceanic change and the declining Steller sea lion population. Awards were made through a competitive process administered by the Cooperative Institute for Arctic Research at the University of Alaska Fairbanks.

Impacts of Climate Change on the Bering Sea Ecosystem over the Past 500 Years. This paleooceanographic study at the University of Alaska Fairbanks on sediment cores and marine mammal bones from the southern Bering Sea is providing information on longer-term changes in Steller sea lion population levels. Results from this study are being evaluated along with other data to achieve new understanding of the natural variability of marine organisms at several levels of the food web and their relationships to climate and oceanic change.

Retrospective Studies of Climate Impacts on Alaska Steller Sea Lions. In this project at the University of Washington, a compilation of physical and biological time-series data is being evaluated to better understand the dynamics of western Steller sea lion population levels. Relationships between biological changes and physical changes are being evaluated over time, and also on a regional basis, to explain differences between eastern and western populations of Steller sea lions over the past few decades.

The Nature of North Pacific Regime Shifts and their Impacts on Steller Sea Lions. To understand the possible role of regime shifts on Steller sea lion population levels, one must first describe the regime shift. This project at the University of Washington is helping to clarify the underlying character of North Pacific regime shifts. A 100-year time series of sea level pressure is being evaluated

using different models to determine which model provides a better definition of regime shifts. Additional analyses will compare variability in North Pacific regime shift indices to trends in Steller sea lion populations and, if possible, in recruitment in the Kodiak–Aleutian region and the southeast Alaska region.

Ocean Climate Variability as a Potential Influence on Steller Sea Lion Populations. Historical oceanic and atmospheric data sets are being used in this project at Old Dominion University to investigate the question of what drives the North Pacific gyre and its variability.

North Pacific Climate Variability and Steller Sea Lion Ecology: A Retrospective and Modeling View. This project is exploring the relationship between climate variability and the ecosystems of the North Pacific Ocean and the Bering Sea. It is examining the hypothesis that bottom-up effects in these areas related to large-scale climate change have contributed significantly to the decline in the western Steller sea lion population. The importance of this factor in relation to other possible causes, such as prey reduction as a result of commercial fishing, will be assessed. The first part of the project, at NOAA's Southwest Fisheries Science Center, is compiling historical data sets and developing methods for their analysis. A second part, at the University of California–San Diego, is developing a coupled physical–biological model of the Gulf of Alaska and Bering Sea and interpreting model results. A third part, at NOAA's Climate Diagnostics Center, is providing a coupled atmosphere–ocean model, conducting model runs, and analyzing the results of those runs.

Interannual Variability of Biophysical Linkages between the Basin and Shelf in the Bering Sea. A coupled ice–ocean model developed at the Naval Post Graduate School is being used to identify interannual and interdecadal variations in the circulatory and mixing pathways by which nutrients are communicated from the deep ocean to the shelves in the Bering Sea and western Gulf of Alaska. This represents the foundation for understanding the coupling of physical processes to the food habitat that supports the higher trophic levels of fish, seabirds, and sea mammals, including the Steller sea lion. A second part of this project, at the University of Alaska Fairbanks, is emphasizing comparison of eddy field variability derived from the model and from altimeter data. Nutrient and productivity data are being collected and compiled and will be used to evaluate model results.

Climate-driven Bottom-up Processes and Killer Whale Abundance as Factors in Steller Sea Lion Population Trends in the Aleutian Islands. This project, at the University of California–Irvine and the University of Alaska Fairbanks, is a large integrated ecosystem study. It comprises measurements of primary production, zooplankton distribution and abundance, forage fish distribution, and seabird foraging as an indicator of prey concentrations, as well as killer whale distribution and abundance, in regions where Steller sea lion populations are stable and where they are declining. Collaboration with the National Marine Mammal Laboratory allows determination of diet and foraging locations of Steller sea lions and abundance estimates and identification of killer whales in the region. Measurements are being taken in conjunction with ongoing physical and nutrient measurements by NOAA's Pacific Marine Environmental Laboratory. This project is the first comprehensive investigation of the ecosystem supporting Stellar sea lions in critical habitat areas.

Decision-making under Uncertainty: Management of Commercial Fisheries and Marine Mammals. This project at the University of Alaska Fairbanks is examining the role of scientific uncertainty in the development of the Steller sea lion crisis and how resource managers might best be able to use scientific research to resolve issues. The elements of the work are examination of the structure and role of science in the decision-making system, analysis of the etiology of the Steller sea lion crisis, policy analysis of the scientific literature on the Steller sea lion decline, and analysis of decision-making under conditions of uncertainty. Special attention is being paid to how the courts have evaluated the science used by the National Marine Fisheries Service and the North Pacific Fisheries Management Council and to what extent the fishing industry leads the management council and the communities.

Aeronomy Laboratory

The stratospheric ozone layer protects the earth's ecosystems from biologically harmful solar ultraviolet (UV) radiation. Changes in 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 in several of the last ten years have led to unusually low Arctic ozone values. If current international control measures of the Montreal Protocol are followed, CFCs are expected to return to their pre-Antarctic ozone hole values by about the year 2050. The Arctic stratosphere, therefore, will remain susceptible to the influence of elevated atmospheric abundances of anthropogenic chlorine for several more years.

Scientists in two NOAA Laboratories, the Aeronomy Laboratory and the Climate Monitoring and Diagnostics Laboratory, participated in a NASA-sponsored experiment to study Arctic springtime ozone loss. The field campaigns of the SAGE III Ozone Loss and Validation Experiment (SOLVE) were conducted from November 1999 to March 2000 and included several flights of the NASA ER-2 research aircraft. Onboard were instruments that measured ozone, reactive nitrogen compounds, water vapor, and tracer species such as halocarbons and nitrous oxide. A balloon gondola carried instruments to measure vertical profiles of trace gases and meteorological parameters. Scientists from NOAA, NASA, other agencies, and academia participated in the experiment. Following are some of the significant findings from the study.

In one of the Arctic stratosphere's coldest winters on record, February and March 2000, participating scientists measured ozone losses as great as 50% at an altitude of about 60,000 feet in the ozone layer. The findings may be an indication that future cold winters in the Arctic could prolong the depletion of ozone by man-made chlorine compounds, even though chlorine is now diminishing in the atmosphere in response to international agreements.

An unusual class of large polar stratospheric cloud particles was observed for the first time, using a NOAA instrument that measures reactive nitrogen compounds in the atmosphere. The newly discovered class of particles has given scientists a better understanding of the processes that set the stage for chlorine-caused ozone depletion in the stratosphere above the Arctic and will enable scientists to make better predictions of ozone loss in the Northern Hemisphere in the future. In FY 00 NOAA field and modeling research identified that forest fires in the boreal regions of northwestern Canada have a long-range influence on air quality thousands of miles away, in the southeastern U.S. The work revealed that distant forest fires could, at times, be an important factor in the ability of municipalities to meet U.S. air quality standards.

NOAA scientists are playing prominent roles in the 2002 international scientific assessment of the ozone layer, in preparation during 2001–2002. The document, the World Meteorological Organization/United Nations Environment Programme's *Scientific Assessment of Ozone Depletion: 2002*, will be completed in December 2002. Hundreds of scientists worldwide are contributing to the planning, preparation, reviewing, and publication of this document. NOAA scientists are participating as co-chair, chapter lead authors, chapter authors, chapter contributors, reviewers, and coordinating editor. The assessment will give "state-of-scientific-understanding" information regarding the earth's ozone layer, including information concerning the Arctic polar region.

Climate Monitoring and Diagnostics Laboratory

The Climate Monitoring and Diagnostics Laboratory (CMDL) conducts monitoring and research of atmospheric constituents that are capable of forcing change in the climate of the earth through modification of the atmospheric radiative environment and atmospheric constituents that may cause depletion of the global ozone layer. This program consists primarily of long-term measurements of atmospheric trace gases such as carbon dioxide, methane, carbon monoxide, halogenated compounds, nitrous oxide, surface and stratospheric ozone, aerosols, and solar radiation at sites remote from local and regional air pollution. The long-term measurements are supplemented by field campaigns using aircraft, ships, and a train car traveling the Trans-Siberian Railroad. These data are used to develop and test predictive models and to keep scientists, policy makers, and the public abreast of the current state of the chemical and radiative balances in the Arctic atmosphere.

Barrow, Alaska, CMDL Atmospheric Baseline Monitoring Station. CMDL has operated a

staffed, atmospheric background monitoring station at Barrow, Alaska, for 28 years. In addition to the wide suite of atmospheric baseline measurements, the Barrow station supports 20 cooperative research projects, with the majority coming from Alaska. In addition, air is collected in flasks on a weekly basis in a 50-site global network that includes Arctic sites at Cold Bay and Shemya, Alaska; Ocean Station "M"; Iceland; Summit, Greenland; and Spitzbergen, Norway. Vertical profiles of a large suite of trace gases are obtained over Poker Flats, Alaska, on a biweekly basis with an aircraft flying profiles to 26,000 ft above sea level.

Boreal Forest Fires Contribute High Levels of Carbon Monoxide. Based on background carbon monoxide (CO) measurements from the CMDL flask-sampling network and the Barrow Baseline Observatory, a recent study by CMDL and NOAA's Aeronomy Laboratory scientists has shown that 63% of the variability in the CO measurements north of 30°N can be explained by boreal forest fires in northern Russia and Canada. CO concentrations were exceptionally high in the Arctic in 1998 because of fire areas in Russia five times the average over the 1991–1999 period. This study also suggested that officially reported Russian fire areas were significantly underestimated.

High Levels of Wintertime Carbon Cycle Gases Traced to Siberian Gas Fields. Each winter and spring the Arctic Basin is inundated with air pollution from Eurasia, known as "Arctic haze." In a study of the haze at the Barrow Baseline Station in the dark season, utilizing measurements of excess carbon dioxide (CO_2), methane (CH_4), and CO, backward air trajectories, meteorological analyses, and emission factors for CO_2 and CO have shown that the largest excess levels of these gases occur when the air flows from the west Siberian gas fields in winter. In these large fields, about 6000 km from Barrow, some gas flares in the gas and oil extraction processes, and the effluents from this combustion are the probable sources for the excess CO_2 and CO. The excess CH_4 is attributed to leakage in the natural gas extraction and transportation processes.

Advancing Spring Snowmelt in Northern Alaska Affecting Birds. The trend of earlier disappearance of snow in spring, observed previously for Barrow, has now been documented at six other locations in the Alaskan Arctic. Since the mid-1960s, spring melt has advanced on average 8.0 (±4.0) days. Earlier spring snowmelt is attributed to a decrease in winter snowfall and warmer, cloudier spring conditions. In turn, changes in snowfall, temperature, and cloudiness are attributed to variations, or shifts, in regional circulation patterns. The combination results in earlier melting of the snowpack in spring over the North Slope of Alaska. One consequence of an earlier melt is the increase in the net surface radiation budget. An early melt enhances the gain of radiant energy at the surface, warming the air in turn.

The changing Arctic climate has affected birds and wildlife in the Barrow area. Populations have flourished in response to the earlier arrival of spring, but they now appear to be in jeopardy because warmer conditions have also caused a retreat in sea ice that adversely affects the birds' feeding grounds. There is concern that indigenous people who depend on fishing and hunting will be adversely affected in the future.

New Optical Depth Data on Arctic Haze and Asian Dust in the Arctic. Atmospheric aerosols affect the earth's radiation budget directly through interactions with solar and terrestrial radiation and indirectly as cloud condensation and ice nuclei. This is especially true in the Arctic when airborne pollutants and soil dust from Eurasia are transported poleward. In March 2000, CMDL added continuous measurements of spectral aerosol optical depth at Barrow by addition of a sunphotometer. The data can be used to distinguish varying types of aerosols on the basis of spectral signatures that relate to particle size distributions. There is a nonlinear relationship between relative size and visible optical depth. Also, various types of aerosols tend to cluster along a best-fit curve, suggesting that a nonlinear function might characterize diverse aerosol types and thin cirrus clouds as well. Asian dust observed at Barrow is thicker optically than Arctic haze and is composed of larger particles. Under the most pristine conditions, size spectra appear highly variable but have a limited range of optical depths.

UV Radiation in the Alaskan Arctic. UV radiation instruments are operated at Barrow, Nome, and St. Paul to monitor the effects of stratospheric ozone depletion. This network was established in 1998 with temporary funding from NOAA's Arctic Research Office and will not be continued past mid-2002. Annual variability in ultraviolet (UV) levels is evident for all three sites, with maximum levels for all wavelengths occurring in May or June. Nome has the highest UV levels at 305 and 320 nm for the past three years compared with Barrow and St. Paul. Barrow is at the highest latitude of the three sites and receives much less solar radiation

over the course of a year, even though the sun is above the horizon for 24 hours a day in summer. St. Paul is usually under the influence of low-level stratus clouds that block out much incoming UV radiation. These data will be used to help establish the extent of large uncertainties in satellite-based estimates of UV irradiance in the Arctic.

Measurements of CFCs and Halons along the Trans-Siberian Railway. Global measurements show that atmospheric concentrations of chlorofluorocarbon-12 and the bromine-containing halons are continuing to increase in spite of the Montreal Protocol. Industrial production of CFC-12 in the developed countries ended in 1995, but production in economically developing countries (for example, Russia and China) will continue until 2010 according to current amendments of the Montreal Protocol. For halon-1211, CMDL global atmospheric observations show that emissions are 50% higher than expected from industrial sources. In summer 2001, CMDL scientists, with partial support from the Arctic Research Office, joined the Trans-Siberian Railway Observations into the Chemistry of the Atmosphere (TROICA-7) expedition that conducted continuous atmospheric measurements from a train car transiting from Moscow to Khabarvosk and return. The species measured every 70 seconds were nitrous oxide, sulfur hexafluoride, CFC-12, and halon-1211, and species measure every 140 seconds were CFC-11, CFC-113, chloroform, methyl chloroform, carbon tetrachloride, hydrogen, methane, and CO. Large spikes in concentrations occurred in cities.

CMDL used similar instruments at tall tower sites in Massachusetts, Wisconsin, and North Carolina, sampling air influenced by large metropolitan areas. Pollution events show strong correlation between the anthropogenic trace gases (for example, CO, CFCs, SF_6, and halons). The TROICA-7 expedition showed a somewhat different pattern. Pollution events were not always correlated with high CO over Russia in the summertime. It is suspected that the high CFC and halon emissions were coming from leaky refrigerators and fire extinguishers located in factories that have been closed because of Russia's economic difficulties. A TROICA-8 expedition is planned for the fall and winter of 2002.

CFC and Halon Measurements from the ER-2 in the Arctic Stratosphere. The CMDL Airborne Chromatograph for Atmospheric Trace Species-IV (ACATS-IV) and Lightweight Airborne Chromatograph Experiment (LACE) are gas chromatographs designed to measure CFCs, N_2O, SF_6, and other trace gases from aircraft. Measurements of these trace gases in the lower stratosphere can provide insight into the chemistry and transport at that altitude. The ACATS-IV and LACE instruments were operated on the NASA ER-2 aircraft flying into the Arctic vortex during the Stratospheric Aerosol and Gas Experiment-III (SAGE-III) Ozone Loss and Validation Experiment (SOLVE) missions operated out of Kiruna, Sweden, during January–March 2000. Record ozone losses for the Arctic stratosphere were reported for the winter of 2000. Those losses are predominantly attributed to ozone destruction driven by the most widespread presence of polar stratospheric clouds in the Arctic since the 1970s and near-peak levels of total halogen chlorine and bromine in the lower stratosphere. Measurements of chlorinated and brominated source gases in the lower stratosphere, combined with surface measurements of these gases, attest to the high availability of inorganic halogen in the older air masses of the Arctic vortex. Organic chlorine and organic bromine were more than 50% converted to inorganic chlorine and inorganic bromine in air masses with mean ages greater than 4.5 and 3.0 years, respectively, measured in the Arctic stratosphere in January–March 2000. Cumulative O_3 loss and O_3 loss rates in the Arctic vortex during SOLVE have been calculated from measurements made by instruments aboard the ER-2 aircraft and balloons. Analysis of in-situ data showed a cumulative O_3 loss of 58 ± 4% at an altitude of 19 km between February 3 and March 12, 2000. Ozone loss rates at 19 km were as high as 51 ± 3 ppb per day during late winter. Studies of the evolution of O_3:N_2O relationships showed that chemical O_3 loss between 14 and 22 km caused a 61 Dobson unit reduction of column O_3 between late November 1999 and March 5, 2000. The ozone loss and loss rates deduced in these studies are in good agreement.

Geophysical Fluid Dynamics Laboratory

Projections of 21st century climate change produced by global atmosphere–ocean general circulation models (AOGCMs) constructed and run at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey, are being used in the Arctic Climate Impact Assessment (ACIA). The aim of ACIA is to provide information to Arctic governments, organizations, and peoples on policy options associated with environmental, economic, health, and other issues impacted by climate variability and change. GFDL's contribution to the project consists of many gigabytes of

data detailing the model-simulated response of the climate system (ocean, atmosphere, sea ice, and land surface) to plausible future emissions of greenhouse gases and aerosols. While uncertainties remain regarding future emission scenarios and the climate system's response, the AOGCM results are being used with the results of other models to help guide the understanding of what may happen in the Arctic in the decades ahead. (GFDL's model output is available at http://nomads.gfdl.noaa.gov/.)

In a study published recently in the *Journal of Climate*, researchers at GFDL used the same global AOGCM to investigate the role of the Arctic Oscillation in variations of surface air temperature over the Northern Hemisphere. The model simulates the Arctic Oscillation in a highly realistic manner, so it is an excellent tool for such studies. Consistent with observational analyses, a positive phase of the model's Arctic Oscillation is associated with warmer-than-usual temperatures over southeastern North America and northern Europe, as well as cooler-than-usual temperatures over northeastern North America and southern Europe. The researchers used the model output to identify biases in the relationship between observed hemispheric mean temperature and the Arctic Oscillation, biases that result from a spatially incomplete observational network.

Work is underway to develop a new coupled global AOGCM, with significant enhancements to the simulation of the Arctic. A new sea ice model that incorporates improved representation of ice processes has been developed for the new AOGCM. Details of the sea ice model were published in the *Journal of Atmospheric and Oceanic Technology*. The ocean component of the new AOGCM will feature a modified spatial grid to reduce numerical problems previously encountered in Arctic simulations.

Air Resources Laboratory

Mercury is a toxic metal that can appear in various forms. Gaseous elemental mercury is a byproduct of coal combustion, waste incineration, and certain types of manufacturing. Its atmospheric lifetime is on the order of one year, which permits very-long-range atmospheric transport and creates well-mixed global background levels in air of roughly 1.6–2.0 ng/m^3. These background levels are thought to be increasing by approximately 1% per year. Mercury in the Alaskan coastal Arctic environment is important because mercury concentrations in certain mammals are highest in the western Arctic. Mercury accumulates in Arctic peoples as a result of consuming large quantities of meat in the subsistence hunting, fishing, and whaling diet.

Recent monitoring by ARL's Atmospheric Turbulence and Diffusion Division and Oak Ridge National Laboratory at the Climatic Monitoring and Diagnostics Laboratory's clean air sector at Barrow, Alaska, have detected episodic springtime depletion events in which local concentrations of gaseous elemental mercury drop to 10% or less of the global background level. These depletion events have been found to occur only in the springtime with sunlight, cold temperatures (below –20°C), and an underlying snowpack. Simultaneous monitoring of reactive gaseous mercury, a species nearly absent in background air, has shown strong increases during these depletion events reaching up to 1.0 ng/m^3, the highest concentrations ever measured anywhere on the globe. The production of reactive gaseous mercury is well correlated to levels of incoming solar ultraviolet radiation, and its lifetime in the air depends strongly on the amount of atmospheric turbulence present. Monthly measurements of mercury in the clean air sector snowpack have shown mercury concentrations rising from undetectable amounts in the winter to about 100 ng/L in late May, with 10% of this mercury being bioavailable, that is, in a form that passes easily into living animal and plant tissue. These concentrations of bioavailable mercury in the Barrow snowpack are also the highest ever measured anywhere in the world.

If the mercury events found at Barrow are prevalent throughout the coastal Arctic, this region would represent a significant deposition zone for mercury air pollution. If we assume a uniform springtime snowpack over the entire Arctic (33.4 million square kilometers as defined by AMAP) of 50% water equivalent and 0.5-m thickness, then the Arctic region would be an annual deposition zone of 790 metric tons of mercury pollutants, or about 10–15% of the total global air mercury pollution burden.

Pacific Marine Environmental Laboratory

NOAA's Pacific Marine Environmental Laboratory (PMEL) conducts fisheries oceanography and ecosystem studies in the Bering Sea and the western Gulf of Alaska. Fisheries–Oceanography Coordinated Investigations (FOCI) is a cooperative program among PMEL, NMFS's Alaska Fisheries Science Center, NOS's Coastal Ocean Program, and the University of Alaska. FOCI's goals

are to increase understanding of the Alaskan marine ecosystem, to document the role of walleye pollock in the ecosystem, to determine factors that affect pollock survival, and to develop and test annual indices of pre-recruit pollock abundance. FOCI scientists conduct research on the character and dynamics of the biophysical environment through field and laboratory experiments, computer simulations, and conceptual models.

In the Gulf of Alaska, FOCI predicts pollock recruitment from relationships of fish survival to baroclinicity, transport, wind mixing, and climate forcing. In the Bering Sea, a FOCI component, Southeast Bering Sea Carrying Capacity, now in its final year of research, has monitored strong interannual ecosystem variability, including two recent near-shelf-wide blooms of coccolithophores, and it demonstrated that the seasonal ice pack directly affects the shelf's primary productivity. From these and other findings, FOCI is developing a predictive ability for Bering Sea pollock.

FOCI is also investigating decadal variability and climate change of the North Pacific and western Arctic, particularly in light of the declining Steller sea lion populations. The Bering Sea is influenced by the Pacific Decadal Oscillation (PDO) from the south and the Arctic Oscillation (AO) from the north. In particular, the AO contributes to increased warming and early ice and snow melt in the spring. PMEL is participating in the Study of Environmental Arctic Change (SEARCH). PMEL, with support from NSF, is maintaining a weather station at the North Pole and is currently developing protocols for monitoring and detecting Arctic change.

Cooperative Institute for Arctic Research at the University of Alaska Fairbanks

The Arctic Climate Impact Assessment (ACIA) is a four-year project of the Arctic Council and the International Arctic Science Committee that started in 2001 and will be completed by the end of 2004. Funding for ACIA is from the eight Arctic-rim nations, with the U.S. (through NSF and NOAA's Arctic Research Office) being the lead country for the assessment. Climate change and notable increases in UV radiation have become important issues in the Arctic over the past few decades, and the goal of the ACIA is to examine their possible future impacts on the environment and its living resources, on human health, and on relevant economic sectors. Three major volumes to describe these impacts and the policies to meet them will be completed by 2004.

About 180 authors have been selected for the assessment from all Arctic countries, and chapter workshops took place in 2001. The ACIA is using the IPCC SRES B2 scenario, which is being implemented on five climate models at the Canadian Climate Center, NCAR, GFDL, Hadley Center, and the Max Planck Institute. Time slices around 2020, 2050, and 2080 are being used, which are the ones also used by the IPCC. Further information on ACIA can be found on its web page at http://www.acia.uaf.edu/.

National Undersea Research Program

NOAA's National Undersea Research Program (NURP) is responsible for establishing programs for the assessment, protection, development, and utilization of U.S. underwater resources. In meeting this responsibility, NURP has established six regional centers for support of in-situ research and technological development. The West Coast and Polar Regions (WCPR) Center at the University of Alaska Fairbanks supports undersea research along the west coast of the U.S. and in the Arctic and Antarctic regions.

Jellyfish in the Bering Sea. Recently it has been demonstrated that jellyfish biomass has undergone an increase in the southeast Bering Sea by nearly an order of magnitude. The population is centered on a region of major spawning and recruitment for pollock and other commercial species. *Chrysaora melanaster* may be able to impact recruitment success of walleye pollock on the middle shelf and thus impact the community make-up of the entire region. Understanding the role of jellyfish in the ecosystem would be critical for managers and modelers who wish to develop an understanding of ecosystem-wide dynamics. Jellyfish also seem to be extremely sensitive to climatic variations. Because of this, and because of their rapid growth rates, they may reveal the impact of interannual variations of parameters such as wind stress or temperature in a manner that is difficult to study with other species. This could be useful in understanding the impact of climate change on the pelagic community.

The object of a recent WCPR Center effort was to determine jellyfish effects on food web production and ecosystem structure in the southeastern Bering Sea. The primary goal was to quantify the ecological impact of the large medusa *Chrysaora melanaster* in the Bering Sea. A secondary goal was to describe links between patterns of weather and climate at several time scales and the response of biota, particularly *Chrysaora* and pollock, on

the eastern Bering Sea continental shelf. The techniques developed by this study can also be employed in further studies of this and other species of medusa.

During the 2000 and 2001 field seasons, zooplankton tows, CTD data, and medusa samples were collected. The medusa were analyzed in diet studies using stomach content analysis, isotope analysis, and fatty acid analysis; digestion rates; and size-to-weight information based on bell diameter, wet weight, dry weight, and carbon and nitrogen content. Analysis of those components is still underway. Climate and biological data for the eastern Bering Sea have been obtained from several government agencies and scientific publications. Early findings indicate that long-term global warming may play a role in jellyfish dynamics.

National Marine Fisheries Service

Northwest Fisheries Science Center

The Northwest Fisheries Science Center (NWFSC) held a meeting of experts on persistent organic pollutants (POPs) in December 2000 to obtain data from studies in the U.S. Arctic for inclusion in Phase II of the assessment by the Arctic Monitoring and Assessment Program (AMAP). Following that meeting, relevant laboratories provided data from analyses for POPs in Arctic species, and these data were formatted at NWFSC and transferred to the AMAP Thematic Data Centres. In addition, text describing the levels of POPs in marine species from Alaska was submitted by NWFSC to AMAP for inclusion in the second AMAP assessment. The first draft of this assessment was reviewed by the lead authors and key national experts at a "cross-fertilization" meeting in Stockholm, and revisions are being made for a 2002 publication.

Analyses of the summer distributions of cetaceans relative to the ecological and physical structure of the southeastern Bering Sea shelf were based on line-transect survey data collected during the late 1990s. Analyses include that of a remnant population of the endangered North Pacific right whale on the southeastern Bering Sea shelf. NWFSC scientists contributed input to the Science Steering Committee of NSF's Ocean–Atmosphere–Ice Interactions program. The importance of sea ice as critical habitat for polar marine mammals and birds is also being studied in collaborative efforts by NOAA scientists and other U.S. and Canadian researchers.

A paper detailing the analyses of 77 killer whale biopsy blubber samples for selected organochlorine compounds and lipid content has been published. The paper reported that concentrations of chlorinated biphenyls and DDTs were relatively high compared to other marine mammal species that occur in Alaska. Furthermore, biological factors such as age, sex, reproductive status, and birth order were found to be important influences in the accumulation of organochlorine compounds in killer whales. A manuscript describing lipid and organochlorine contaminant profiles in gray whales was also published.

National Marine Mammal Laboratory

NMFS's National Marine Mammal Laboratory (NMML), Alaska Regional Office, and Protected Resources Management Division are responsible for research on and management of 22 species of marine mammals that commonly occur in Alaska, including five endangered species (bowhead, fin, humpback, North Pacific right, and sperm whales), one species that is threatened in one portion of its range and endangered in another portion of its range (Steller sea lion), and two depleted species (Cook Inlet beluga whale and northern fur seal). Field research by the NMML staff on marine mammals off central and northern Alaska concentrated on the following species during 2000 and 2001: Steller sea lions, harbor seals, Cook Inlet beluga whales, and large cetaceans (fin, blue, humpback, and North Pacific right whales) in the Bering Sea.

Steller Sea Lions. This species is currently listed under the Endangered Species Act as threatened in the eastern portion of its range and as endangered in the western portion of its range. The number of Steller sea lions declined dramatically between the 1960s and the late 1980s, and the decline has continued in the western portion of the species' U.S. range, although at a slower rate, from 1989 to the present. In 2000, Congress significantly increased the resources available to determine the likely causes of the Steller sea lion decline. In addition to funds provided directly to NOAA and other organizations, $19 million was made available to universities and organizations for studies on Steller sea lions ($15 million was available through the Steller Sea Lion Research Initiative and $4 million through the Cooperative Institute for Arctic Research). The new and ongoing studies are expected to greatly enhance NMFS's ability to responsibly manage this population.

Alaska Harbor Seals. In recent decades Alaska harbor seals have declined dramatically in some

regions and are currently increasing in some other regions. The primary objectives of NMML's research on this species are to obtain data on the abundance of the species throughout Alaska and to collect information on haulout patterns that can be used to better interpret abundance information. Obtaining information on Alaska harbor seals is critical, as they are an important component of the Alaska Native subsistence harvest. A comanagement agreement, signed by the Alaska Native Harbor Seal Commission and NMFS, has charged the Harbor Seal Comanagement Committee to prepare an Annual Action Plan for this culturally important species.

Cook Inlet Beluga Whales. Research on the Cook Inlet beluga whale stock has been conducted annually over the last nine years. This stock was designated as depleted under the Marine Mammal Protection Act in 2000. Scientists from NMML, in cooperation with the Alaska Beluga Whale Committee, the Cook Inlet Marine Mammal Council (CIMMC), the Alaska Native Marine Mammal Native Hunters Committee, the Alaska Department of Fish and Game, and NMFS's Alaska Regional Office, have attempted to determine the abundance of this relatively small and isolated population. Analysis of sighting data from aerial surveys has indicated that the abundance of Cook Inlet beluga whales declined by nearly 50% between 1994 and 1998. Some recent effort has been directed toward catching whales and outfitting them with radio and satellite tags to determine movement patterns and correction factors for aerial surveys. NMFS has entered into an interim cooperative agreement with CIMMC to comanage the Cook Inlet beluga stock. The interim agreement allowed for the harvest of one beluga during 2000.

Abundance and Distribution of Large Cetaceans in the Southeast and Central Bering Sea. NMML researchers were able to determine the abundance and distribution of large cetaceans in the southeast and central Bering Sea because of new collaborations and new technologies. A line-transect survey conducted in 1999 and 2000 in collaboration with the Alaska Fisheries Science Center, and in association with a groundfish stock assessment survey, provided new information on cetacean abundance and distribution with respect to fish and invertebrate assemblages. This new information is being used to update marine mammal stock assessment reports. In addition, cooperative research with Scripps Institute of Oceanography and NOAA's Pacific Marine Environmental Laboratory (PMEL) has focused on using passive acoustic recorders to record calls from large whales in the Gulf of Alaska and the Bering Sea. These passive recorders are remotely documenting the seasonal occurrence of North Pacific right whales and other baleen whale species during seasons in which conducting fieldwork is impractical because of short day length or inclement weather. NMML scientists also worked cooperatively with the Woods Hole Oceanographic Institution to correlate cetacean calls received by the U.S. Navy's Sound Surveillance System with bathymetric features and remotely sensed data on ocean productivity. Information collected using passive acoustics will provide important insights into the seasonal distributions of large cetaceans and the relationships between large cetaceans and their environment.

Resource Assessment and Conservation Engineering Division and Resource Ecology and Fisheries Management Divisions

Marine Fisheries Assessment. The Alaska Fisheries Science Center (AFSC) of NMFS continued its long-standing commitment to assessment studies of U.S. living marine resources in the Bering Sea, Aleutian Islands, and Gulf of Alaska during 2000 and 2001. This effort included 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.

During 2000 and 2001, living marine resource populations in western U.S. Arctic waters were sampled at sea aboard NOAA ships, chartered fishing vessels, and cooperating foreign research vessels. Significant area-extensive survey efforts were conducted in the eastern Bering Sea, the Aleutian Islands, and the Gulf of Alaska. The principal survey methods included 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 were used to estimate biomass and define community structure, and biological collections were taken to examine variability in growth, mortality, and stock recruitment.

Recruitment indices and processes that generate variations in abundance are being studied to

improve prediction through the Fisheries–Oceanography Coordinated Investigations (FOCI) program. FOCI is a cooperative program between AFSC and NOAA's Pacific Marine Environmental Laboratory 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. Pacific salmon return to spawning grounds in the Yukon River basin and support important commercial and subsistence fisheries in both the United States and Canada. These returns have been the focus of numerous harvest allocation disputes between the two countries, and returns have declined severely in recent years. A drainage-wide radio tagging project was initiated in 2000 by the Auke Bay Laboratory's Stock Identification and Assessment Program and the Alaska Department of Fish and Game to provide information on the run characteristics of Yukon River chinook salmon. Work in 2000–2001 developed baseline information on the behavior and movement patterns of chinook salmon. A full-scale program is planned for 2002, when over 1100 fish will be radio tagged near the river mouth and tracked to upriver spawning areas in order to provide information on stock composition and timing, nation of origin, migration patterns, and locations of previously undocumented spawning areas.

National Environmental Satellite, Data, and Information Service

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. Ice analyses are distributed in JPEG format and as geographic information system (GIS)-compatible files via the NIC web page (http://www.natice.noaa.gov). Metadata that detail the data sources integrated into routine ice analysis products are available on the NIC web page. As part of the Environmental Working Group, in 2000 NIC released the *High-Resolution Arctic Sea Ice Climatology*, which contains historical data from 1972 to 1994.

During 2000–2001 the NIC Science and Applied Technology Department expanded to include new personnel in the positions of chief scientist, visiting scientist, post-doctoral fellow, support staff, and technicians. The main goals of the department include the following:

- Improve the efficiency of data processing and analysis through the development of automated data fusion techniques;
- Automate the analysis and classification of data;
- Improve the operational ice forecasting models;
- Optimize the SSM/I algorithms for operational sea ice analysis; and
- Develop new ice products by applying new techniques and by incorporating data from new sensors.

The NIC science team evaluated the existing suite of sea ice concentration algorithms for the Special Sensor Microwave Imager and modified the operational sea ice algorithm. A passive microwave algorithm was developed that uses a principal-components combination of SSM/I brightness temperatures and NIC-provided local ice conditions from visible and infrared data to improve global sea ice concentrations. In addition, an algorithm was implemented to track ice motion using 85-GHz SSM/I. SSM/I and ice model products are available in near-real-time on the NIC experimental products web page (http://www.natice.noaa.gov/science).

NIC manages the U.S. Interagency Arctic Buoy Program (USIABP), which provides an important source of surface meteorological data and ice drift information in the Arctic. Since its inception in 1991, the mission of the USIABP has been to establish and maintain a network of 40 evenly spaced meteorological buoys on the drifting Arctic ice pack. NIC achieves this goal through coordinated deployments and international cooperation by participants in the International Arctic Buoy Programme (IABP). During 2000–2001, nearly 95% of all Arctic drifting meteorological buoys reported data in real time over the Global Telecommunications System. 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 (1979–2001) database, which is archived by the Polar Science Center at the University Washington (http://iabp.apl.washington.edu) and NSIDC. These data have been found useful in the initialization 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.

National Snow and Ice Data Center

The National Snow and Ice Data Center (NSIDC), Boulder, (http://nsidc.org) was chartered by NOAA/NESDIS in 1982 to provide a focus for NOAA cryospheric data management activities. It celebrated 25 years as a World Data Center for Glaciology in 2001. NSIDC is operated under an agreement between NOAA and the University of Colorado's Cooperative Institute for Research in Environmental Sciences, and it is affiliated with the NESDIS National Geophysical Data Center. NSIDC is the home of the NSF Arctic System Sciences Data Center and Antarctic Data Coordination Center, and it is a NASA Distributed Active Archive Center for Earth System Enterprise data sets. Recently a Frozen Ground Data Center was established at NSIDC, supported by the International Arctic Research Center at the University of Alaska Fairbanks.

NSIDC products published in 2000 and 2001 included the Environmental Working Group Arctic Climatology Project series of oceanography, meteorology, and sea ice atlases on CD-ROM. These digital climatologies serve as a baseline against which climate-related changes in the Arctic are being measured. Cruise data were added to the Submarine Upward Looking Sonar Ice Draft Profile Data and Statistics data set. Sea ice in the western Arctic appears to be thinning, according to recent studies using data from this data set. Numerous NOAA–NASA Pathfinder products, including a sampler CD-ROM, were published. Pathfinder products address difficulties scientists experience working with satellite data sets, such as a variety of formats and media, inconsistent data processing methods, and problems with long-time-series data calibration. Snow and sea ice products from the Moderate Resolution Imaging Spectroradiometer on the NASA Earth Observing System Terra satellite were made publicly available for the first time. These continue the more-than-20-year time series of satellite passive microwave products from NSIDC, but with greatly improved spatial resolution. In addition, near-real-time maps of sea ice concentration and snow extent from Special Sensor Microwave Imager satellite data are now available. These and related data sets at NSIDC were designed to simplify the study of large-scale seasonal and interannual fluctuations. Web pages on the state of the cryosphere, Arctic meteorology and climatology, and Antarctic ice shelves and icebergs were developed to help educate the public about the cryosphere and climate change. NSIDC continues to collaborate with Russian colleagues to publish new Russian data sets, including historical sea ice chart and meteorological data.

In-house scientific expertise helps NSIDC improve the quality of research data sets and respond quickly to inquiries on snow and ice topics from the general public. Research highlights included NSF-funded work detailing evidence of a large-scale shift in polar climate (locations in Alaska and northern Eurasia, for example, have warmed by nearly 6.0°C in the winter months over the past 30 years) and NASA-funded work showing that warmer summers are responsible for the recent extensive disintegration of some Antarctic ice shelves. Results from a NOAA-funded project show that approximately 55–60% of the land area in the Northern Hemisphere experiences seasonal freezing and thawing, and the maximum extent of seasonal freezing has decreased by about 20% during the past few decades. On an international level, NSIDC is involved in setting directions for Climate and Cryosphere (CliC), a World Climate Research Programme core project established in March 2000 to coordinate research on the role of the cryosphere in the global climate system.

National Oceanographic Data Center

NODC has had an active data exchange program with institutions of the former Soviet Union (FSU) since 1993. Support for this work has come from NOAA's Office of Global Programs and NOAA's Environmental Science, Data, and Information Management (ESDIM) program. Exchange of data has taken place under the auspices of Global Oceanographic Data Archaeology and Rescue, a project of the Intergovernmental Oceanographic Commission. Since 1993, NODC has acquired from the FSU more than 425,000 upper ocean temperature profiles made by mechanical bathythermograph instruments and data from more than 340,000 ocean station data (bottle) casts, most of which include salinity as well as temperature.

The acquired data are for the entire world

ocean, including substantial amounts of data from the sub-Arctic seas adjacent to the FSU. All NODC data have been provided to the republics of the FSU via the World Data Center system. NODC supported the joint preparation and distribution of three oceanographic atlases with FSU institutions. Additional atlases and monographs are planned.

National Climatic Data Center

NCDC updates and maintains a 120-year-long mean monthly temperature time series zonally averaged over the Arctic. This work is done in collaboration with the Russian State Hydrological Institute. Long-term daily precipitation time series for the former Soviet Union have been rescued and homogenized. These data are available from NCDC and are being used in Arctic studies, including the Arctic Climate Impact Assessment. This work was done by NCDC in collaboration with the Russian Research Institute for Hydrometeorological Information and the Institute for Global Climate and Ecology.

National Ocean Service

The Center for Sponsored Coastal Ocean Research (CSCOR) supports research programs in the Gulf of Alaska and the Bering Sea that examine the dynamics of ecosystems supporting important commercial fisheries and mammal populations. In 2001, fieldwork began in the Global Ocean Ecosystems Dynamics (GLOBEC) Gulf of Alaska program. Monitoring cruises took place in March, April, May, June, August, October, and December, measuring hydrography, zooplankton distribution and abundance, and salmon distribution, abundance, and condition. Long-term moorings were deployed to gain a time series of temperature and salinity, and drifters were released and tracked to trace eddy movement. Process studies took place in April to examine the dynamics of early to mid-spring phytoplankton bloom and the responses of the zooplankton community and in July to examine strongly stratified conditions and zooplankton grazing on small phytoplankton cells. Salmon sampling took place in conjunction with the July cruise. Results will be used to develop coupled biological–physical models to provide greater understanding of the ecosystem supporting salmon during the oceanic phase of life. This program is part of a coordinated GLOBEC Northeast Pacific program, with a companion study in the northern California Current. More information is available at http://www.cop.noaa.gov/Fact_Sheets/GLOBECNEP.htm and at http://globec.oce.orst.edu/groups/nep/.

In the Bering Sea the Southeast Bering Sea Carrying Capacity (SEBSCC) program is supported through CSCOR. CSCOR supports academic and Federal scientists in a collaborative effort to understand the ecosystem surrounding pollock in the Bering Sea. SEBSCC research was completed in 2001. The program has developed environmental indices to predict pollock recruitment. More information is available at http://www.cop.noaa.gov/Fact_Sheets/SEBSCC.htm and http://www.pmel.noaa.gov/sebscc/index.html.

Also in 2001, CSCOR supported research into predator–prey dynamics impacting Steller sea lions. Awards were made in conjunction with the Arctic Research Office through a competitive process administered by the Cooperative Institute for Arctic Research at the University of Alaska Fairbanks. Projects are examining the development of juvenile sea lion foraging ability, the influence of killer whale predation, the interactions between sea lions and herring and pollock populations, and environmental variations affecting the ecosystems surrounding sea lion rookeries. Details on these projects are available at http://www.cop.noaa.gov/Fact_Sheets/SSL.htm.

Office of Marine and Aviation Operations

The Office of Marine and Aviation Operations (OMAO) supported Arctic research during the past two fiscal years primarily through the shipboard operations of the NOAA Ships *Miller Freeman* and *Ronald H. Brown*.

OMAO's fisheries and oceanographic research vessel *Miller Freeman* is a 215-ft, 1515-gross-ton stern trawler that operates a variety of biological and oceanographic sampling gear. The *Ronald H. Brown* is a 274-ft, 3180-gross-ton AGOR-class research vessel that has both atmospheric and oceanographic instrumentation to study global processes. The *Freeman*'s and *Brown*'s primary Arctic accomplishments have been as working platforms for the study of the Arctic's living resources in the Bering Sea.

The *Miller Freeman*, in conjunction with scientists from the Alaska Fisheries Science Center, conducted echo integration trawl surveys of walleye pollock in the southeastern Aleutian Basin near Bogoslof Island (February–March 2000) and on the eastern Bering Sea shelf (June–August

2000). The objectives of these studies were to analyze the acoustic data and determine the population distribution and abundance of spawning pollock.

The *Miller Freeman* and *Ronald H. Brown* conducted numerous oceanographic observations (e.g. CTD) and biological samplings as well as deploying and recovering weather, temperature, current meter, and biophysical surface and subsurface moorings in the southeastern Bering Sea. These cruises were in support of the Southeast Bering Sea Carrying Capacity project, which is part of the Fisheries Oceanographic Coordinated Investigations (FOCI). FOCI uses these data to better understand the effects of abiotic and biotic variability on ecosystems of the North Pacific Ocean and the Bering Sea in order to discern the physical and biological processes that determine recruitment variability of commercially valuable finfish and shellfish stocks in Alaskan waters.

Department of Agriculture

The Department of Agriculture supports and conducts research to improve the understanding, use, and management of natural 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.

Agricultural Research Service

The research activities of the Agricultural Research Service (ARS) are focused on 22 multidisciplinary and cross-cutting National Program Areas of high priority designed to develop a knowledge base to promote timely responses to technical agricultural problems of broad scope and national interest. Programs in the Arctic or adjacent northern regions are limited in scope. They are, however, providing critical information necessary to solve issues in such diverse areas as preservation of plant germplasm, effective and sound uses for fisheries byproducts, integrated pest management for grasshoppers, and biodiversity of pathogens and parasites in northern ruminants.

	Funding (thousands)	
	FY 00	FY 01
Forest Service–Global Change	700	719
Coop State Res–Environ	725	725
Coop State Res–Food/Saf	793	964
Nat Res Cons Svc–Global Change	560	560
Agricultural Research Service	2,000	2,000
Total	4,778	4,968

Plant Germplasm Research

The Arctic Plant Germplasm Preservation Program is collecting and preserving high-latitude crop variants of worldwide distribution, including legumes, small grains, and potatoes. Attention is also given to preserving germplasm that demonstrates medicinal potential and native Alaskan and Russian species of all types that demonstrate potential for erosion control. The plant germplasm management effort in Alaska is centered at the Alaska Plant Materials Center, Alaska Department of Natural Resources, Palmer.

A project to determine the etiology of barley yellow streak mosaic virus in Alaska barley production areas was established. The brown wheat mite, the sole vector for barley yellow streak mosaic virus, was discovered at Delta Junction, Fairbanks, and Palmer and reported for the first time in Alaska. Vector life-cycle studies and transmission studies were conducted to determine some of the parameters of the host–disease–vector relationships. The discovery of the vector is significant because it is the first report on this pest–disease relationship for the barley producers, specifically in Alaska.

In other research, there was the continued characterization of a new plant virus in native *Lupinus nootkatensis* plants with yearly reoccurrence of the disease found in Mat-Su State Park and Hatcher Pass. In addition, there was the detection and characterization of a plant virus in native *Delphinium glaucum* from Fairbanks, as well as the first report of the detection of a plant virus in *Streptopus amplexifolius* from Denali State Park. This information provides more information to further the basis of knowledge of plant diseases and host relationships in Arctic species.

Grasshopper Pests

The USDA-ARS Integrated Pest Management (IPM) program for grasshoppers in Alaska emphasizes the development of biological control for grasshoppers. Grasshoppers are the most important insects affecting Alaskan agriculture, with estimates of potential crop loss exceeding 50%. Recent changes in plant communities caused by the opening of new farmland in the Delta agricultural area have resulted in frequent grasshopper population explosions that threaten agriculture. Effective biologically based IPM strategies are needed to abate these losses. The Delta Junction agricultural area is a closed ecosystem. The area offers great potential for area-wide suppression of grasshoppers through treatment of a small fraction

of its acreage. The pest complex is 85% migratory grasshopper, *Melanoplus sanguinipes*, a ubiquitous and mobile species. In Alaska, adults promote reproduction by assembling to bask on even subtle south-facing exposures where access to solar irradiation is improved. The major basking areas are being mapped and if necessary modified to improve their basking potential. New basking areas will be created experimentally to learn how adults may be most efficiently attracted for control. Effective insecticide baits that use about 5% as much toxicant as sprays are registered for current use, and several insect pathogens will be tested as potential replacements.

Parasites of Wild Ruminants

Interactions of parasites with their hosts are often very sensitive to environmental changes. Across the Arctic, ruminant animals, particularly caribou, muskoxen, and wild sheep, are keystones for maintaining remote communities as sources of food and the focus of economic activity. Although we understand much about the biology of high-latitude ruminants, our knowledge of their parasite fauna is incomplete, even for fundamental issues.

The biodiversity for helminth parasites (certain types of disease-causing worms) in Arctic ruminants is poorly known, and there are major unresolved issues for identity, taxonomy, and distribution of a number of pathogenic parasites that occur in the muscles, digestive, and pulmonary systems of wild ruminants. Our abilities to understand disease processes in these animals, factors associated with parasites as potential regulators of host populations, and the biotic and abiotic parameters such as climate change that may control the geographic distribution and emergence of various helminth species are directly linked to accurate documentation of faunal diversity. In rapidly changing northern environments, such knowledge is vital because it allows us to understand a poorly documented facet of biocomplexity in the Arctic, the role of parasitism and disease in natural systems, and the potential exchange of parasites and pathogens at the interface of agricultural and wild ecosystems.

Parasites in the Arctic are the focus of ARS research programs in Canada and Alaska. The Research Group for Arctic Parasitology (RGAP) represents a consortium linking the U.S. National Parasite Collection with the University of Saskatchewan and the Northwest Territories Department of Resources Wildlife and Economic Development. RGAP focuses on the biodiversity and distribution of parasites and the potential impact of parasites and other pathogens within the context of global change. Studies conducted under this umbrella have involved investigations of parasitism in muskoxen, caribou, and Dall's sheep in the Northwest Territories and Nunavut, Canada. The focus of this integrated research is identification and definition of the parasite faunas in caribou, muskoxen, Dall's sheep, and other mammals and elucidation of the history, relationships, and biogeography of this assemblage across the Holarctic.

Since 1995 the base of information for biodiversity of parasites in Arctic ruminants has dramatically expanded. The lungworm *Umingmakstrongylus pallikuukensis* and the stomach parasite *Teladorsagia boreoarcticus* were described in muskoxen from the central Canadian Arctic. A major research program on the biology and distribution of *Umingmakstrongylus* was initiated and completed, with this serving as a potential model for understanding the biotic impacts of global climate change at high latitudes. In Dall's sheep the lungworm *Protostrongylus stilesi* was definitively identified for the first time. New host and geographic records were established for the muscleworm *Parelaphostrongylus odocoilei*, and a *Teladorsagia* may represent yet another cryptic and previously unknown species. These discoveries, emanating from a strategic biotic survey and inventory, indicate our paucity of knowledge about the distribution and host associations of pathogenic parasites across the Arctic at a critical time when changes in global climate could influence the distribution and emergence of disease associated with parasites.

Comparative biodiversity studies examine historical baselines and contemporary strategic collections for species richness, other parameters of parasitic infection, host distribution, and geographic range for parasites in Arctic ruminants that are predicted to be influenced by habitat perturbation linked to global change. Current research involves assessment of significant specimen collections from the 1970s in the Canadian Museum of Nature and the University of Alaska Museum. Development of biodiversity information systems and databases and the formulation of baselines for biodiversity are critical for understanding the biotic responses of host–parasite systems and the potential for emergence of disease under the current regime of climate warming and the profound environmental effects already observed and predicted in the Arctic.

Forest Service

The USDA Forest Service Pacific Northwest Research Station (PNW) is responsible for boreal forest research in Alaska, through the Boreal Ecology Cooperative Research Unit (BECRU). The research activity of BECRU is a commitment to Long-Term Ecological Research (LTER) conducted at the Bonanza Creek Experimental Forest (BCEF) LTER site, sponsored jointly by the National Science Foundation, the USDA Forest Service, and the University of Alaska Fairbanks. The BCEF-LTER seeks to understand the Alaskan boreal forest as an integrated regional system in which climate, disturbance regime, and ecological processes are interactive components, with the objective to document the controls over these interactions and their ecological consequences. Research focuses on four major disturbance types—fire, flooding, forest harvest, and beetle outbreaks—and is organized around three major themes:

- Forest dynamics;
- The changing boreal carbon cycle; and
- Landscape controls over changing disturbance regime.

These themes operate at different scales and have key societal relevance but require improved understanding of the basic scientific processes.

Forest dynamics research focuses on the interactions between population and community processes, disturbance regimes, and ecosystem dynamics. The study of the changing boreal carbon cycle focuses on ecosystem processes. These changes hinge on interactions with the hydrologic cycle and other element cycles. Carbon balance depends on spatial and temporal variation in climate and disturbance regime and on population and community processes associated with succession. Landscape controls over a changing disturbance regime focus on landscape and regional processes such as disturbance spread. These landscape processes are a logical consequence of changes in population, community, and ecosystem processes occurring at the stand scale.

The Forest Service Pacific Northwest Research Station and North Central Experiment Station are cooperating with the State of Alaska and an Alaskan Native corporation on two long-term examinations of alternatives to clearcutting in the boreal forest. One study, begun by Forest Service researchers in 1972, looked at the natural regeneration of white spruce after clearcutting and shelter wood harvesting. A recent re-evaluation of this study, 27 years after harvest, found that while the overstory treatment had no effect on the density or growth of any plant species studied, scarification had a highly significant effect. In 1999, scarified areas were still densely populated with spruce stems, while unscarified areas had far fewer stems. Initially spruce grew best on scarified surfaces, but by 27 years the growth of the tallest spruce saplings was significantly better on unscarified surfaces than on scarified surfaces. Growth trends associated with different soil surface treatments had thus reversed from earlier surveys, illustrating the value of long-term follow-up. In addition, this study provided the first data available on the long-term persistence of the grass *Calamagrostis canadensis* after timber harvest. By 27 years *Calamagrostis* cover had returned to pre-harvest levels.

The second study was begun in 1980 and, with funding from a U.S. Forest Service "Chief's Grant," was re-evaluated in 1999 and 2001. This project compared two levels of partial overstory retention with clearcut harvesting on a floodplain site in interior Alaska. It also included comparisons of different site preparation methods, including two intensities of broadcast burning. Though much of the recently collected data are still being analyzed, it is clear that harvesting and site preparation dramatically increased soil temperatures. For example, permafrost occurred on some parts of the study site before harvesting. Within two years of harvesting and site preparation, all permafrost had left the soil profile. In the 17 years since harvest, between 40 and 50% of the retained overstory trees died, most being blown down. The trees that survived experienced a dramatic spike in growth. Unexpectedly, trees in the overstory treatment that were most widely spaced grew less than those in the more densely spaced treatment. Use of the site by moose increased dramatically immediately after harvesting and remains greater today.

Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) cooperates and coordinates with state, village, regional, and Federal landowners; 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, private, and government lands in Alaska.

The NRCS has continued to work in cooperation with the University of Alaska Fairbanks, the University of Delaware, the University of Cincinnati, the University of Wisconsin, and Agriculture Canada to measure soil moisture and temperature along several transects in areas extending from nonpermafrost zones to areas of intermittent permafrost to areas of continuous permafrost. Additional soil moisture and temperature sites have been added to this network, particularly on Alaska's North Slope. Studies are also being conducted on the active layer in the permafrost zone.

The NRCS is also actively working with the National Science Foundation's Arctic System Science program on the North Slope and the Seward Peninsula. These are areas where greenhouse gas fluxes and changes to carbon storage and vegetation may be related to global climate change. Ground penetrating radar (GPR) studies at Barrow have looked at thaw lake dynamics and carbon sequestration. Working with the same group of universities in April 2001, NRCS provided GPR to look at the different soil layers and determine where coring needed to be done. NRCS also helped do the coring and interpret the cores.

Soil sampling activities were continued along the Haul Road from Deadhorse to Happy Valley. Four sites representative of the different types of tundra were sampled jointly by NRCS and the University of Alaska in August 2001. Another site was sampled near the Toolik LTER, and a complete climate station was installed. A series of sensors were installed to help better understand the freeze–thaw processes. The NRCS laboratory will completely characterize the pedons sampled.

Soil climate monitoring stations were installed at Nenana and at two locations along the Kuskokwim River in the summer of 2001. The sites are all within active soil survey projects and will provide needed baseline data for the projects. The Nenana site is located on a private farm. Another site is on the Kuskokwim Native Association farm at Aniak. The third is located on Kuskokwim Native Corporation land near the village of Napiamute. Each of these sites will serve as a benchmark location for studying typical soils, soil characteristics, and associated climate. The sites will collect data on soil moisture and temperature as well as air temperature, precipitation, and windspeed. There are virtually no data of this sort currently available for the Kuskokwim River area. The information will enhance both the soil survey effort and local knowledge.

The data collected at all of the soil climate monitoring sites in Alaska are also being incorporated into USDA's overall national study on global climate change. Several of the sites will be connected to a USDA telemetry network so that the analyzed data will be readily available to the public via the World Wide Web.

Approximately 1.3 million acres of land in Alaska are currently being soil surveyed each year. The projects are in both permafrost and nonpermafrost areas. Current projects include private and Alaska Native lands in the Yukon–Kuskokwim river basins, the western Kenai Peninsula, the municipality of Anchorage, Bering Sea islands, and the Fairbanks–North Star Borough. Public lands are currently being surveyed at Denali National Park and the Fort Greely Army installation. The soil surveys will represent the only comprehensive baseline resource data in some of these areas. Requests for surveys are increasing and are driven by resource development, as well as health and safety issues, especially on Alaska Native lands and in villages. Issues related to climate change, including the impacts of forest pest infestations, warming permafrost, and coastal storms are also driving the increased requests for survey data. Soil temperature and moisture studies, as well as vegetation surveys, are being conducted as part of the soil surveys. Survey products are being released to the public as GIS datasets and through the World Wide Web.

Department of Energy

The Department of Energy has responsibility for providing for the long-term energy security of the United States. DOE's Arctic and sub-Arctic activities support the DOE mission through studies of energy production, atmospheric modeling, and radioactivity.

The Arctic and sub-Arctic activities of the Department of Energy (DOE) include support for projects in three diverse areas:

- Energy production and power generation;
- Atmospheric modeling related to climate change; and
- Measurement, modeling, and mitigation of radioactivity.

Assessment of the recoverability and production of methane hydrates and related free-gas accumulations is an important part of these activities. DOE researchers also collaborate with other Federal and state agencies in the development of energy sources that provide affordable and reliable electric power for rural Alaskan villages

There are a number of compelling scientific reasons to study climatic change at high latitudes. Through its Atmospheric Radiation Measurements (ARM) Program, DOE investigates cloud and radiative processes at the North Slope of Alaska/Adjacent Arctic Ocean site (NSA/AAO), near Barrow. The resulting data are used to refine atmospheric circulation and other models critical to the understanding of potential climate change.

The DOE continues to have an interest in understanding radiological issues in the Arctic and Alaska. Examples include projects that measure and model the transport of anthropogenic and natural radionuclides in the atmosphere, soil, and aquatic systems.

	Funding (thousands)	
	FY 00	FY 01
Nat Inst Global Env Change	186	186
Atmospheric Radiation/Planning	3,200	3,200
Alaska Fossil Fuels	3,000	9,700
Wind Activities in Alaska	1,100	1,600
JCCEM/Arctic Transport Studies	600	570
Neighborhood Environmental Watch	50	50
Total	8,136	15,306

Alaska Fossil Fuels

The Arctic Energy Technology Development Laboratory at the University of Alaska Fairbanks (UAF) was first advanced and funded by the Alaska Congressional delegation in FY 01 to conduct Arctic energy research, as well as to begin outreach to the state energy industry. Funding thus far has included $1 million in FY 01 and $3 million for FY 02. The laboratory is working closely with the power generation, coal, oil, and natural gas industries to jointly design and fund research projects for improved development of energy resources and power generation in Alaska. Current work includes:

- A website for compiling and distributing information regarding remote power generation systems in Alaska. This website will provide information about products that are known to work (and those that don't) so that communities can benefit from the experiences of others.
- An enhanced oil recovery program aimed at producing heavier crude oils from Alaska's North Slope. Heavier crude oils are more difficult, and hence less economic, to recover.
- Evaluation of fuel cell and reformer technologies for remote applications. As a result of continuing efforts in this area, UAF is gaining a national reputation for its fuel cell testing expertise.
- Evaluation of the mechanical properties of solid oxide ceramic membrane materials that will contribute to major cost reductions in manufacturing fuel cells.

The point of contact for the North Slope of Alaska Methane Hydrate Resource Assessment is Edith Allison, U.S. Department of Energy, Exploration Program Manager, Office of Natural Gas and Petroleum Technology, Washington, DC 20585; 202-586-1023.

Field studies have been conducted for several years on the Lisburne Group of northern Alaska by the University of Alaska Fairbanks with DOE support. The research objective is to characterize the development of hydrocarbon traps in folds and thrust-faulted folds in these carbonate rocks and to assess how folding and faulting influence the characteristics and behavior of the reservoirs. Hydrocarbon production from the Lisburne Group is from naturally occurring fractures, so a clearer understanding of these fractures could aid in future recovery from this difficult-to-produce reservoir. In addition to its applicability to the North Slope, the results of this project will apply generally to folded carbonate reservoirs, which are major producers and exploration targets worldwide. Results of last year's studies of asymmetrical folds in the Lisburne Group will be published in the American Association of Petroleum Geologists Memoir entitled *Thrust Tectonics and Petroleum Systems*, edited by K.R. McClay.

The DOE's Office of Natural Gas and Petroleum Technology continues to be involved in several projects related to the occurrence of methane hydrate deposits in the North Slope of Alaska.

The U.S. Geological Survey and the DOE National Energy Technology Laboratory (NETL) are integrating well log data with samples and gas analyses for a Phillips Petroleum Tarn field well on the Alaska North Slope in order to quantify the volume of methane contained in the gas hydrates. In addition, the researchers plan to correlate recently acquired well logs of a BP well at Milne Point on the Alaska North Slope with previously collected samples and gas analyses. These data may also be integrated with recently acquired 3-D seismic data provided by BP. The integrated data will provide quantitative estimates of the volume of methane contained in the hydrate deposits.

In September 2001 the DOE initiated two competitively selected industry projects to characterize Arctic hydrate deposits and assess the feasibility of methane production. The two- to four-year research and demonstration projects are expected to cost $28.6 million, of which DOE will pay $17.3 million. BP Exploration Inc. will work with the University of Alaska Fairbanks, the University of Arizona in Tucson, and the U.S. Geological Survey. The primary objective of this project is to characterize, quantify, and determine the commercial potential of in-place and recoverable gas hydrate and associated free-gas resources in the Prudhoe Bay Unit, the Kuparuk River Unit, and the Milne Point Unit areas on Alaska's North Slope. Maurer Technology Inc., working with Anadarko Petroleum Corporation and Noble Engineering and Development LTD, will evaluate and test existing best technologies to drill, complete, and produce methane from hydrates in the Prudhoe Bay/Kuparuk River area of northern Alaska.

Wind Activities in Alaska Program

The State of Alaska faces many unique challenges in helping to ensure that its citizens have access to affordable and reliable electric power. These challenges are particularly evident in rural areas of the state, where electricity is primarily produced by diesel power plants that are small, expensive, and difficult to operate and maintain. At present the cost of electricity for rural customers is eased somewhat by the availability of Power Cost Equalization (PCE), an electric rate subsidy program administered by the Division of Energy within the Alaska Industrial Development and Export Authority (Alaska-IDEA). In 2000, additional funds for the PCE were secured by the Governor and the Alaska State Legislature, and the program, which had been facing exhaustion of funding in 2001, is expected to continue for at least the next half decade. However, funds for the PCE are derived from declining revenues from the sale of oil from Prudhoe Bay, and if PCE funds are ultimately exhausted, electricity rates in rural areas are expected to rise substantially. Faced with the potential for greatly increased electricity costs, various Alaskan entities are exploring ways in which renewable sources of energy can aid in the production of electric power. To better understand the role that renewable energy can play, the DOE Wind Energy Program is engaged in collaborative efforts with Alaskan organizations at the state and local levels to explore ways in which wind can make a greater contribution in the production of electric power.

Under the DOE Sustainable Technology Energy Partnerships (STEP) Wind program, the DOE Wind Program provided funding to Alaska-IDEA to support the design and installation of a 396-kW wind energy project with the Kotzebue Electric Association (KEA) in Kotzebue, Alaska. The first phase of that project, the installation of three Atlantic Orient Corporation (AOC) 66-kW wind turbines purchased by KEA and Alaska-IDEA, took place in the summer of 1997. Those turbines, which continue to operate well, were augmented by three STEP-purchased turbines installed in April 1999. The purpose of the project, which is cost-shared

between DOE and Alaska-IDEA, is to determine the feasibility of a wind system to augment an existing diesel power plant in a remote Alaskan community.

Under a DOE grant with KEA, funding has been provided to design, purchase, and install a 2.0- to 4.0-MW wind farm to supplement electricity produced by an existing 11.3-MW diesel power plant and the 396-kW wind energy system installed by KEA, Alaska-IDEA, and the DOE-STEP program. In May 1999, four additional AOC wind turbines were installed under the Windfarm project, joining the six 66-kW wind turbines described above. In May 2002, a 100-kW wind turbine, manufactured by Northern Power Systems of Waitsfield, Vermont, was installed. Later in 2002, two additional 66-kW turbines will also be installed, bringing the total installed capacity of the wind farm to 892 kW. When the full 2.0- to 4.0-MW wind farm is completed, possibly in 2005, it will have the capability of meeting a substantial portion of Kotzebue's electric power requirements, which are characterized by a daytime peak load of 3.6 MW and a nighttime base load of approximately 2.0 MW. The National Renewable Energy Laboratory (NREL) is providing technical support to KEA to aid it in project implementation.

A project administered by the Alaska-IDEA is currently determining if a high-penetration wind system—one capable of replacing most, if not all, diesel generation capacity for substantial periods—can allow a small rural village to significantly reduce its dependence on diesel fuel for producing electricity. The project in the Village of Wales involved the installation of a 132-kW wind energy system, which augments a small existing diesel power plant. The two 66-kW turbines that comprise the Wales system went on line in 2001. A successful Wales project can serve as a model to meet the needs of perhaps 50–100 remote villages in Alaska that have significant wind resources.

The DOE Wind Program, through DOE's State Energy Program, has made funding available to the Alaska-IDEA to support wind resource assessment (WRA) in remote Alaskan communities. The WRA work represents an important initial step to determine if sufficient wind resources exist to support economically feasible wind installations in such communities. Alaska-IDEA selected five villages—Mekoryuk, Point Hope, Selawik, St. Michael, and Unalakleet—as the sites for the first resource assessment work to be completed under this project. In 1999 a training session was held in Kotzebue for representatives from the five villages who installed and maintain the WRA monitoring equipment and transmit the data to Alaska-IDEA for analysis. The WRA work in the five villages will complement similar work underway in Kotzebue, Wales, Yukutat, and Deering.

The DOE Wind Program funded an effort to characterize the potential size of the wind–diesel hybrid market in Alaska. The study data were delivered to Alaska-IDEA in 1998 and are being used to help Alaska-IDEA, the University of Alaska Anchorage, the Alaska Village Electric Cooperative, and others determine the most appropriate locations for additional wind–diesel village power systems. Approximately 90 villages were analyzed to provide information for project siting, which will accelerate the pace of wind energy use in the state.

From 1998 through 2002, the DOE Wind Program, in collaboration with the private sector, the National Aeronautics and Space Administration, and the National Science Foundation, has provided support to develop a new 100-kW wind turbine specifically designed for use in cold climates. This unit, which is now being field tested, has been developed in large measure to meet the need of Alaskan villages for additional U.S.-manufactured wind turbine options. One 100-kW cold-weather turbine is scheduled for installation at the Kotzebue Windfarm in May 2002.

In 1998 the Kotzebue Electric Association (KEA) was selected to participate in the joint DOE–Electric Power Research Institute (EPRI) Turbine Verification Program (TVP). The TVP is designed to help utilities gain experience in operating new wind turbine technologies. As a TVP-participating utility, KEA received system control and data acquisition equipment, as well as technical support from NREL and EPRI. Under the TVP, KEA has exchanged performance and operating and maintenance data with other electric utilities that participate in the program.

DOE and Alaska-IDEA continue to plan for the design and installation of a 100-kW wind energy system in rural Alaska to augment a community's existing diesel electric generation system. It is also anticipated that in the future the electricity generated by the wind and diesel systems may be augmented by electricity produced by a reversible fuel cell system. The hydrogen needed for the fuel cell's operation would be produced by diesel fuel that would be converted to hydrogen. The fuel cell system would provide electricity to the community during periods when winds are not sufficient to produce power from the wind system.

The points of contact for the Department of Energy Wind Activities in Alaska are Thomas J. Hall, Office of Geothermal and Wind Technologies (EE-12), Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, DC 20585; 202-586-8302; and Thomas Sacco, Office of Energy Efficiency and Renewable Energy (EE-14), U.S. Department of Energy, Washington, DC 20585; 202-586-0759.

When completed, the combined wind–diesel–fuel cell concept will be evaluated to determine whether there is an economic benefit in the application of this combination of technologies in rural Alaska and, if so, what factors produce the highest benefits. A DOE Cooperative Agreement to implement the Wind/Fuel Cell Project was awarded to Alaska-IDEA, and work continues to examine a potential project site near Nome.

The DOE National Renewable Energy Laboratory's National Wind Technology Center (NWTC), using funding provided by the DOE Wind Program, is conducting an analysis to fully document the configuration, performance, operational, and economic characteristics of a wind–diesel hybrid system that was installed on St. Paul Island in the Bering Sea in late 1998. That system was installed by the Tanadgusix (TDX) Corporation, an organization established in 1973 under the Alaska Native Land Claims Settlement Act. TDX is pursuing business development ventures and has established eight subsidiary corporations to accomplish this. One of these is TDX Power Inc., the owner and operator of the wind–diesel hybrid system, which consists of one Danish-manufactured Vestas 225-kW wind turbine, augmented by two 150-kW high-speed (1800 rpm) diesel generator sets. This hybrid power system produces not only electricity, but also waste heat, both of which currently meet the needs of a warehouse facility and an airport on the island. The TDX Power, Inc. hybrid system, which competes with the local electric utility, is expensive but unique and well-designed. The NWTC analysis is intended to yield data that may help in the design of wind–diesel hybrid systems in other remote Alaskan communities.

In FY 02 funding was made available to DOE to support feasibility studies to examine the expansion of the existing 225-kW wind project on St. Paul Island. Funding was also provided to determine how a wind system might be able to augment the 7.5-MW diesel electric power plant operated by the Unalaska Electric Utility, the local utility that serves Unalaska and Dutch Harbor.

Atmospheric Radiation Measurements Program

The 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 a number of 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 locations for Cloud and Radiation Testbed (CART) sites are planned. The first site, in the southern Great Plains of the U.S. north of Oklahoma City, began operations during 1992. The Tropical Western Pacific (TWP) locale is the second site to be implemented. TWP began phased operations in 1996 and is planned to be fully operational by 2002. The third CART site, the North Slope of Alaska and Adjacent Arctic Ocean (NSA/AAO), was dedicated in July 1997. Routine data acquisition at the NSA/AAO site began in October 1996 as part of the Surface Heat Budget of the Arctic Ocean (SHEBA) experiment primarily sponsored by the National Science Foundation and the Office of Naval Research (ONR). Routine data acquisition began at the ARM facility in the vicinity of Barrow, Alaska, in April 1998. A second station is located at Atqasuk.

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, some 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 they 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 average 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

For more information, visit the NSA web page at http://www.arm.gov/docs/sites/nsa/nsaao.html. The general point of contact for the ARM program is Dr. Wanda R. Ferrell, Manager, Atmospheric Radiation Measurement Program, Environmental Sciences Division, ER-74, U.S. Department of Energy, Washington, DC 20585; 301-903-0043. For the North Slope of Alaska/Adjacent Arctic Ocean CART site, the points of contacts are Dr. 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 Dr. Knut Stamnes, North Slope of Alaska/Adjacent Arctic Ocean CART Onsite Scientist, Stevens Institute of Technology, Department of Physics and Engineering Physics, Castle Point on Hudson, Hoboken, NJ 07030; 201-216-8194.

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 parameters, not the full range of parameters needed for the process studies necessary to improve the GCMs. The ARM program fills the critical gap between field campaigns and monitoring. For the NSA/AAO CART site the central facility is adjacent to NOAA's high-latitude climate monitoring facility near Barrow so as to take advantage of NOAA instrumentation already in place and avoid unnecessary duplication.

A generic, fully developed CART site includes facilities spread over a large area. On the North Slope, an area of roughly 200 km^2 is being considered. 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 continuous 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.

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 the aircraft and satellite components is underway through FIRE [First ISCCP (International Satellite Cloud Climatology Program) Regional Experiment] and other programs.

The NSA/AAO site provides data about cloud and radiative processes at high latitudes and, by extension, about cold and dry regions of the atmosphere in general. These data will be used to refine models and parameterizations for high-latitude regions and for the upper atmosphere. More specifically the issues of principal interest as they apply to cold regions are as follows:

- Atmospheric radiative transfer;
- Ice and mixed-phase cloud formation, evolution, and dissipation;
- Behavior of surface radiative characteristics;
- Direct and indirect aerosol radiative effects;
- Development and testing of satellite remote sensing algorithms.

Joint Coordinating Committee for Environmental Management Contaminant-Transport Studies

The former Soviet Union (FSU) has an extensive nuclear power program with numerous supporting waste management activities that currently involve storage of high-level wastes and ad hoc storage of low- and intermediate-level wastes by shallow land burial and in surface water impoundments. The Mayak, Tomsk, and Krasnoyarsk sites all lie within a few kilometers of the edge of the West Siberian Plain and Basin, the largest basin and region of low relief on earth. Precipitation and potential evapotranspiration vary substantially from south to north within the basin, and permafrost is an important characteristic of the landscape north of about 61°N. Hydrogeologically the region is believed to be a single groundwater basin with pervasive artesian character. The surface water hydrology of the region consists of an extensive system of rivers, lakes, and swamps that generally act as sinks for runoff or any overland contaminant flow, and the great rivers of the basin (Ob and Yenisey) are generally believed to be the ultimate sinks for any groundwater contamination sources. These rivers probably provide the main pathway to the Arctic Ocean to the north, although there has been some speculation that deep circulating supra-regional ground waters provide another potential pathway for contamination to reach the Arctic Ocean. Thus, past and continuing disposal of wastes at Mayak, Tomsk, and Krasnoyarsk to surface waters, to surface water impoundments, and by deep well injections at Tomsk and Krasnoyarsk have the potential for contaminating the Arctic Ocean, the western Siberian oil and gas fields, and the regional water resources.

DOE is sponsoring subsurface contaminant transport studies near the Mayak and Tomsk sites in Russia under the auspices of the Joint Coordinating Committee for Environmental Restoration and Waste Management (JCCEM) between the Office of Environmental Management (DOE-EM) and the Ministry of Atomic Energy (MINATOM)

The point of contact for the Joint Coordinating Committee for Environmental Management Contaminant-Transport Studies Project is Dr. Adam Hutter, Environmental Sciences Division, Environmental Measurements Laboratory (EML), U.S. Department of Energy, 201 Varick Street, NY, NY 10014; 212-620-3576.

for the Russian Federation. The purpose of the work is to understand the "field-scale experiments" of radionuclide-contaminated groundwater migration from a former surface repository at Lake Karachay towards the Mishelyak River and from deep-well injection sites of liquid radioactive wastes at the Tomsk (Siberian Chemical Combine) site. Field investigations at the Mayak site consist of hydrogeological, geochemical, geophysical, and radiometric measurements to characterize and model the subsurface migration of the groundwater plume. The results of this program will also support Hanford, Washington, vadose zone issues, including model verification and validation using the 30-year contaminant migration database developed by the Russian collaborators.

Using site characterization data and conceptual models developed jointly with their Russian counterparts, DOE modelers and their Russian counterparts have calibrated a Mayak three-dimensional groundwater model and will complete in FY 02 the development of a contaminant-migration model of the plume from Lake Karachai. A three-dimensional hydrogeological model of the Tomsk site is being developed, with a contaminant migration model of an injection site to follow. American researchers in the program are from the Pacific Northwest National Laboratory, Savannah River Laboratory, and Environmental Measurements Laboratory. Russian scientists are from Hydrospetzgeologiya, the Mayak Production Association, the Siberian Chemical Combine, the Institute of Industrial Technologies, and the Institute of Physics and Power Engineering. Funding for the program comes from the Characterization, Monitoring and Sensor Technology Crosscutting Program (CMST-CP) in the DOE Office of Environmental Management.

For the Global Measurements of Radionuclides in the Atmosphere and Deposition projects, the points of contact are Matthew Monetti and Fabien Raccah, U.S. Department of Energy, Environmental Measurements Laboratory (EML), Environmental Sciences Division, 201 Varick Street, NY, NY 10014; 212-620-3525 and 212-620-3379.

Neighborhood Environmental Watch Network: NEWNET

NEWNET is a network of environmental monitoring stations and data storage and data processing systems, with public access to the data through the Internet. This allows interested members of the public to have constant access to the stations so they can observe the results at any time. A station manager from each community is trained in station maintenance and has access to researchers and support organizations that can provide technical assistance if needed. Station managers serve as liaisons to their communities and can help citizens understand measurements.

The point of contact for the NEWNET Program is Mike McNaughton, M.S. J978, Los Alamos National Laboratory, Los Alamos, NM 87545; 505-667-6130.

NEWNET was started in 1993 with stations in Nevada, California, Utah, and New Mexico. It is based on concepts developed by DOE for the Community Monitoring Program at the Nevada Test Site Nuclear Testing Facility. These concepts date back to the Three Mile Island Nuclear Power Reactor accident in the late 1970s. Five stations are located in Alaska: in Barrow, Fairbanks, Kotzebue, Nome, and Seward.

Stations can vary in configuration. Most NEWNET stations have sensors for monitoring wind speed and direction, ambient air temperature, barometric pressure, relative humidity, and ionizing gamma radiation. Some stations have tipping bucket rain gauges, and others have additional radiation sensors. Other types of sensors are being investigated for air quality measurements.

The Alaska stations are being set up in collaboration with the Alaska Department of Environmental Conservation (ADEC) and the University of Alaska Fairbanks. The project is funded by DOE. This effort will strengthen collaborations between Los Alamos National Laboratory (LANL), ADEC, and DOE in studying the environment in Alaska. It will promote an understanding of radiological issues in Alaska and provide continuous monitoring of radiation levels. More information on NEWNET, including readings from NEWNET stations, can be found on the web at http:/newnet.lanl.gov/.

Global Measurements of Radionuclides in the Atmosphere and Deposition

The objectives of this program are to characterize, quantify, and model the environmental pathways of natural and anthropogenic radionuclides deposited on the earth's surface and to evaluate their environmental and human health impacts on regional and global scales. 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 continues to be poised to react instantly to any new introduction of atmospheric radioactivity.

Amchitka Island, Alaska, Project

Amchitka is located about 1340 miles southwest of Anchorage, near the western end of the Aleutian Islands. The U.S. Atomic Energy Com-

The point of contact for the Amchitka Island, Alaska, Project is Monica Sanchez, U.S. Department of Energy, Environmental Restoration Division, Nevada Operations Office, Las Vegas, NV; 702-295-0160.

mission, the predecessor to DOE, conducted nuclear tests on the island in the late 1960s and early 1970s. The testing was part of a program to differentiate between an earthquake and a nuclear detonation in another country.

In 2001 the DOE's National Nuclear Security Administration (NNSA) Nevada Operations Office remediated surface contamination on the island remaining from historic underground nuclear testing activities. Work on the island included the capping of mud pits that were constructed in the 1960s to contain large quantities of drilling fluid used in conjunction with the nuclear testing activities. Twelve areas were capped to isolate contaminated drilling mud from the environment. To cap the pits, over five million gallons of standing water that had accumulated from rainfall and snowmelt had to be pumped off. Approximately 1,786,000 gallons of water were treated to meet State of Alaska discharge standards prior to being released into nearby bodies of water. After the water was removed, workers brought in more than 125,000 cubic yards of native soils, which were combined with the drilling mud to create a stable surface. A geomembrane liner was placed on each pit to isolate the mud from the surrounding environment. To complete the work, additional soil was placed on top of the liner and graded to assure that any water would run off the capped surface. Each site was then revegetated. Over 8 acres of liner material were used in the capping process. In addition to this work, workers closed 16 shallow groundwater-monitoring wells.

Two underground storage tanks, which were used in producing asphalt for runway and roadway repair during historic island activities, were closed in place. The tanks were first drained of water and liquid fuel oil and then filled with native soil. Approximately 12,000 gallons of fuel oil and sludge from the tanks were removed and recycled at a site off the island. In addition, nearly 16,000 gallons of water from the tanks were treated before being released to the surface of the island. Soil samples were taken from under the tank, tested for contaminants, and found to be below regulatory cleanup levels.

Department of Health and Human Services

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

National Institutes of Health

The National Institutes of Health is an agency of the Department of Health and Human Services. Comprising 27 Institutes and Centers, the NIH is headquartered in Bethesda, Maryland, and has satellite facilities elsewhere in Maryland and in North Carolina, Montana, and Arizona. 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 and clinics.

	Funding (thousands)	
	FY 00	FY 01
National Institutes of Health	9,844	13,700
Cent for Disease Control/Prevent	3,990	4,500
Total	13,834	18,200

National Institute on Aging

The National Institute on Aging (NIA) funded a major new initiative in FY 01. The NIA and the Icelandic Heart Association are collaborating on the Age, Gene/Environment Susceptibility (AGES) Study: The Reykjavik Healthy Aging Study for the New Millennium, which examines genetic susceptibility and gene–environment interaction as these contribute to phenotypes common in old age. The study has four major focus areas:

- Neurocognitive conditions (cognition, dementia, depression, vision, and hearing);
- Cardiovascular health (atherosclerosis, arterial distensibility, and ventricular and valvular disease);
- Musculoskeletal conditions (spine and hip osteoporosis, hip osteoarthritis, strength, and function); and
- Body composition and metabolic disease (obesity, sarcopenia, and hyperglycemia/diabetes).

A detailed clinic-based examination of 9500 surviving members of the Reykjavik Study will define phenotypes for candidate gene studies. These phenotypes will also be used as end-points of the cardiovascular risk factors collected between 1968 and 1996 in the Reykjavik Study. This will enhance an understanding of factors contributing to disease in old age, apart from genetic factors. Lastly, these phenotypes can be examined in relation to selected outcomes, such as cause-specific mortality, coronary heart disease, fractures, and cancers. The study will begin examinations in the spring of 2002.

The NIA continues to fund the Native Elder Research Center, located within the Division of American Indian and Alaska Native Programs of the Department of Psychiatry, School of Medicine, University of Colorado Health Sciences Center in Denver. The Center coordinates a culturally relevant, scientifically meritorious research career development program targeted at American Indian (AI) and Alaska Native (AN) investigators, focusing on aging, health, and culture. The Center augments ongoing partnerships with AI/AN communities to ensure access to and involvement of elders, their families, and local systems of care in aging research. The aim is to increase the pool of talented investigators committed to research that holds promise for reducing the differentials in health status and access to health care that now plague 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 research on the causes, consequences, treatment, and prevention of alcohol-related problems affecting the Nation's health.

A new NIAAA treatment study will test the efficacy of pharmacological adjuncts in augmenting existing alcoholism treatments for Native Alaskans. The opioid antagonist naltrexone and the selective serotonin reuptake inhibitor sertraline will be evaluated alone and in combination in a double-blind, placebo-controlled study of 198 alcohol-dependent individuals of Alaskan heritage to determine whether these two medications can reduce the risk of alcohol relapse when used in conjunction with alcohol counseling. Eight sites in rural Alaskan communities have been brought into the study.

A recently funded three-year study, the People Awakening Project (PAP), is a two-phase collaborative study between Alaskan Natives and university researchers designed to obtain an indigenous understanding of the sobriety process. In gaining understanding of the sobriety process among Native Alaskans, the investigators hope to develop culturally and linguistically appropriate psychometric instruments for future prevention research with Native Alaskans.

National Institute of Allergy and Infectious Disease

The National Institute of Allergy and Infectious Disease (NIAID) conducts and supports scientific research on infectious and immunologic diseases. The Institute's basic and applied research promotes the development of vaccines, diagnostic tests, and drug therapies to prevent and control these diseases.

NIAID, in collaboration with the CDC and the Indian Health Service, is conducting a three-year pilot intervention trial for Haemophilus influenzae type b (Hib) disease in three Alaska Native villages known to have high numbers of asymptomatic carriers of Hib. Prior to the implementation of routine vaccination of children against Hib, roughly 16,000–25,000 children in the U.S. showed signs of Hib bacterial infection. Of the children who contracted Hib, approximately 60% developed meningitis, which has a mortality rate of 10%. The universal vaccination of children with the Hib conjugate vaccine has resulted in roughly a 95% reduction of Hib infection nationwide, but the rates of both asymptomatic Hib infection (Hib carriage) and Hib disease in Alaska Natives remain significantly higher than in the non-Native Alaskan U.S. population. To determine why this is the case and what treatment most effectively eliminates the Hib reservoir from a village, the conjugate vaccine with and without rifampin will be compared with treatment with rifampin alone (the standard treatment).

NIAID-supported researchers at the University of Washington are investigating hepatitis C in Alaska Natives. Hepatitis C is an emerging infectious disease in which approximately 80% of infected individuals develop chronic hepatitis and all are at higher risk for cirrhosis and a type of liver cancer, hepatocellular carcinoma. Complete histories of the patients, including their estimated date of infection and alcohol history, are being tracked. Blood and liver specimens over time are being collected and stored, critical for determining levels of HCV virus and disease progression. This well-defined Alaska Native population may lead to many key answers to the natural history and future treatment of hepatitis C worldwide.

In FY 00, NIAID joined several NIH institutes and centers and the Juvenile Diabetes Research Foundation International in supporting the International Histocompatibility Working Group (IHWG), a network of more than 200 laboratories in over 70 countries that collect and share data on genes of the human leukocyte antigen (HLA) complex. Researchers are analyzing HLA genes in Alaskan Yup'ik Eskimos to determine the different types of histocompatibility genes and their frequency in that population.

NIAID is supporting a demonstration and education outreach program at the University of Washington aimed at increasing organ donation and transplantation among Alaska Natives. Culturally sensitive educational materials and community health education programs describe transplant options, including living and cadaveric organ donation. A key is to train Alaska Natives so they can introduce to their own communities the information necessary for informed decision-making.

NIAID is supporting a project at the University of Washington to assist primary care physicians in the delivery of improved ambulatory care for American Indian and Alaska Native children with asthma. The project implements a pediatric asthma quality improvement intervention among eight Northwest Portland Area Indian Health Board regional practices (Yakama Nation, Puyallup, Coeur d'Alene, Shoshone-Bannock, Warm Springs, Muckleshoot, Umatilla and Makah) and the Yukon–Kuskokwim Delta region of Alaska.

National Cancer Institute

The mission and goal of the National Cancer Institute (NCI) is to stimulate and support scientific discovery and its application to achieve a future when all cancers are uncommon and easily treated. As leader of the National Cancer Program, NCI provides the public with scientifically sound cancer information using all forms of communication to help move research findings into clinical practice, chart and improve the quality of cancer prevention and care, and reduce disparities in the burden of cancer. NCI's Arctic-specific activities include surveillance research, cancer registries, cancer education, research training, and support for participation in clinical trials.

The Alaska Native Tumor Registry (ANTR) was initiated in 1974 in collaboration with NCI and the Centers for Disease Control and Prevention. The procedures and policies followed were those of the NCI Surveillance, Epidemiology and End Results (SEER) Program, and the registry has been annexed to the SEER Program. ANTR has just completed the first analysis and report: *The Alaska Native Cancer Survival Report.* Discussions are underway with the Army Corps of Engineers and the Air Force to study contaminants and cancer patterns at military sites.

Colorectal cancer incidence among Alaska Natives has been the highest among all racial and ethnic groups in the U.S. To complicate the matter, one of the recommended screening practices, fecal occult blood testing, has an unusually high rate of false positives in Alaska Natives because of the high rates of infection with Helicobacter pylori. Investigators at the Southcentral Foundation in Anchorage have abstracted the medical records of Alaska Natives from an urban site (Anchorage) and Yup'ik Eskimos from a rural site in the Yukon–Kuskokwim Delta region. Among the findings was that, of the 102 cases diagnosed in both groups from 1994 through 1998, only one case had been screened either by flexible sigmoidoscopy or colonoscopy prior to diagnosis.

The objectives of the study were to document the screening recommendations of health care providers; to identify the screening procedures performed; to compare rural and urban screening practices; and to compare screening practices of patients at greater risk because of a history of polyps. Finally, recommendations were made relative to the future implementation of statewide colorectal cancer screening programs. These recommendations included improving risk communication for both urban and rural groups, increasing the number of providers with training in flexible sigmoidoscopy, and targeting family members of colorectal cancer patients for increased screening. The project was performed in collaboration with the Alaska Native Medical Center and the Yukon–Kuskowim Health Corporation and approved by the Alaska Area Indian Health Service Institutional Review Board.

NCI also supports research in the Arctic via the Community Clinical Oncology Program (CCOP), which links community cancer specialists, primary care physicians, and other health care professionals to the Cooperative Groups and Cancer Centers to conduct NCI-approved cancer treatment and cancer prevention and control clinical trials. Since its inception in 1983, the research has broadened to include chemoprevention, symptom management, continuing care, and quality of life.

The Virginia Mason CCOP in Seattle, Washington, has affiliate centers in both Anchorage and Fairbanks, Alaska, through which residents in those towns can enter NCI-sponsored clinical trials. CCOP physicians are more than just the doctors in charge of a person's cancer therapy but serve as the all-around "cancer" doctors for the community and have facilitated the large-scale cancer prevention trials such as the Breast Cancer Prevention Trial, the Study of Tamoxifen and Raloxifene, the Prostate Cancer Prevention Trial, and the Selenium and Vitamin E Cancer Prevention Trial. CCOPs also support numerous smaller clinical trials for the prevention of colorectal cancer, lung cancer, and head and neck cancer.

The Native Cancer Information Resource Center and Learning Exchange (CIRCLE) has been a national clearinghouse for cancer education materials specific to American Indian and Alaska Native communities for lay and professional use since 1998. The center has become the educational arm for the American Indian/Alaska Native Leadership Initiative on Cancer, funded as a cooperative agreement. It has the most up-to-date bibliography in the nation on cancer affecting American Indians and Alaska Natives.

NCI supports pre- and post-doctoral research projects among American Indian and Alaska Native populations under experienced mentors in the NCI-supported Network for Cancer Control Research. American Indians, Alaska Natives, Hawaii Natives, and Samoans have received training in cancer research methods and design since 1995.

Dramatic changes in the health care delivery system, sovereignty and enacted self-governance

legislation among Native American tribes, and significant cultural aspects have impacted differentially on cancer care among Native populations. Information has been gathered on possible barriers to early diagnosis for Native Americans, including type of insurance coverage, distance to a medical center, and treatment compliance or refusal.

The University of North Carolina–Chapel Hill is conducting research to determine the role of the Epstein-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 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. Additional NPC samples will be obtained from Chinese, Caucasian, Black, and possibly Inuit Americans.

National Institute on Drug Abuse

The National Institute on Drug Abuse (NIDA) supports over 85% of the world's research on the 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. NIDA has funded several recent extramural initiatives at the University of Alaska Anchorage (UAA).

One project is studying the ecologies of risk in subgroups of women and their risk behaviors and potential for diseases relative to the use of drugs and condoms. The research study used individual level predictors, contextual variables related to sexual decision-making, psychosocial constructs, and selected demographic variables to develop subtypes of women and to better understand their pattern of drug-using and sexual behaviors (particularly among Alaska Native women) that put them at risk for sexually transmitted and other blood-borne diseases.

A five-year project at UAA and the University of New Mexico is the first systematic study ever to deal with ethically important aspects of rural and frontier health care for stigmatizing illness, such as substance abuse, AIDS, and sexually transmitted diseases. Stigma is a particularly important barrier to obtaining health and social services in rural and frontier settings. The NIDA-supported extramural research benefited from UAA's Telemedicine Project, which helps bridge the great geographic expanse of Alaska in a series of "research at a distance" projects. These projects use desktop videoteleconferencing 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.

Future NIDA Arctic research plans include expanding the research portfolio on substance abuse and health and social consequences, including infectious diseases, violence, and crime, and developing prevention and treatment strategies.

National Institute of Environmental Health Sciences

The National Institute of Environmental Health Sciences (NIEHS) funded a project on St. Lawrence Island to be carried out by Alaska Community Action on Toxics and the State University of New York at Oswego. The goals of this project are to:

- Determine whether the traditional food sources for Alaska Native residents of St. Lawrence Island are contaminated;
- Assess sources of contaminants and pathways of exposure to residents of St. Lawrence Island and the broader Norton Sound community; and
- Develop reliable information for the island's residents that will assist them in minimizing exposure to contaminants and addressing environmental justice and health issues.

Another study, being carried out by the University of Alaska Anchorage, focuses on geographic modeling of traffic and asthma rates. The purpose of the study is to evaluate the relative weight of individual risk factors and the weight of environmental proximity to traffic as a risk factor associated with the incidence of asthma in children. The study is based on kindergarten and first grade children (more than 1600 students) in twelve neighborhood schools. The schools represent contiguous neighborhoods with residents of varied socioeconomic status. The catchment area of the schools will be mapped, and traffic parameters on the roadways within the neighborhoods will be measured. Surveys will indicate the length of time the child spends in this neighborhood on a daily

basis as well as the number of years that the child has lived at this address. Each address will be mapped and the traffic parameters calculated within a buffer zone of each child's home. The primary definition of asthma will be based on weighted survey responses including a medical diagnosis of asthma, the use of asthma medication, or the presence of asthma symptoms without symptoms of upper respiratory infection. Multi-level regression analysis will increase the power of the study to examine the relationship between proximity to traffic and the incidence of asthma in young children.

A project by the Aleutian–Pribilof Island Association is studying dietary risks and benefits in Alaskan villages. It addresses the risks associated with environmental contaminants bio-accumulating in traditional foods and how they compare with the health, social, economic, and cultural consequences that could result from a shift to alternative, market-based diets. The project's aims are:

- To develop, utilize, and evaluate a model that requires greater community responsibility, involvement, guidance, and participation with researchers and government agencies;
- To document the diets of two Alaskan villages, including types, quantities, and methods of food preparation, for the purpose of guiding contaminant research;
- To collect preliminary data on nutritional value, as well as levels of persistent organics, radionuclides, and heavy metals, in subsistence foods;
- To provide a balanced assessment of both the risks associated with environmental contaminants and the nutritional, cultural, and physical benefits of a traditional Native diet; and
- To evaluate a model for combining a variety of village-specific data streams, including diet, epidemiological effects, and contaminant levels in animal tissue, human blood, and traditional foods for the purpose of providing a risk/benefit analysis.

Each phase will be coordinated from the Aleutian–Pribilof Islands Association by the principal investigator and supplemented by the support and assistance of local village coordinators, village advisory groups, and a technical team of experts.

As part of the Arctic Monitoring and Assessment Programme (AMAP), in May 2000 the NIEHS co-sponsored a successful International Conference on Arctic Development, Pollution and Biomarkers of Human Health, which demonstrated the Institute's commitment to the Arctic region. The participants attending this conference were a diverse group of stakeholders with interests in the health of the Arctic environment. The voices, opinions, and concerns of Alaska Natives were heard during one of the early conference sessions and throughout the conference. These individuals made a strong statement about the traditional way of life and traditional knowledge. Not only is the physical existence of the Alaska Natives threatened by pollution and contamination, but so too is their spiritual existence. This concern was voiced by every Alaskan, Native or non-Native, who spoke. Increased awareness of these issues was an important outcome of the conference. More information about the conference is available at http://www.niehs.nih.gov/external/arctic/.

The mandate for AMAP includes a specific charge to collect and exchange data on impacts on the Arctic environment, so that the data can be used to protect the health of the Arctic environment and its inhabitants.

National Institute of Mental Health

The National Institute of Mental Health (NIMH) supports mental health services research as it relates to Arctic, ethnic, minority, and other rural populations. Many of the Arctic mental health research activities are part of the general American Indian and Alaska Native programs, including:

- Continued support of an American Indian and Alaska Mental Health Research Center; and
- Program announcements on research on mental disorders in rural populations and American Indian, Alaska Native, and Native Hawaiian mental health research.

The NIMH, along with the National Institute of Neurological Disorders and Stroke and the National Center for Research Resources, is collaborating in the joint sponsorship of the Alaskan Basic Neuroscience Program at the University of Alaska Fairbanks (UAF), part of the Specialized Neuroscience Research Program (SNRP) at Minority Institutions initiative. The purpose of the SNRP initiative is to establish and enhance competitive research programs in basic neuroscience at minority institutions. The five-year SNRP award will support a new program at UAF to develop a research program in neuroscience, to foster collaborations with other neuroscientists at outside research institutions, to establish a graduate training program, and to upgrade existing space into a state-of-the-art research facility. The overarching theme is neural adaptive mechanisms to stress. The research

projects will study circadian rhythms, hibernation mechanisms, and neural development and repair. Present NIMH involvement includes programmatic input and non-voting membership on the Internal Advisory Committee. Future NIMH involvement will include input into the hiring of new senior faculty as well as the establishment of a graduate training program.

The NIMH has also supported a related grant to study circadian rhythms at the University of Alaska Fairbanks. The suprachiasmatic nuclei (SCN) are the major "biological clocks" in mammals and control most circadian rhythms expressed by the animal. Studies are examining the degree to which neurochemical changes in the SCN of selectively bred mice are related to observed changes in circadian-controlled behavior. This proposal addresses the role of key regulatory mechanisms within the SCN influencing physiological and behavioral traits and how the circadian clock in mammals adapts an individual to the earth's day–night cycle. A Disability Supplement was also awarded to a UAF undergraduate.

The National Center for American Indian and Alaska Native Mental Health Research at the University of Colorado Health Sciences Center is pursuing the assessment, epidemiology, care, and prevention of serious psychological dysfunction and major mental illness among American Indians and Alaska Natives.

The University of Chicago has a grant titled "Child Welfare, Legal Practice and Alaska Native Identity." This research examines the impact of legislation and related regulations on child protective services in the Native villages of interior Alaska. This project will develop an ethnographic study of how tribes handle child welfare cases, ensuring appropriate delivery of social services to meet the emotional and physical needs of Native children, both on the village level and through intervention in state courts. This research will draw on relevant social scientific theoretical and comparative perspectives to explore how the "best interests" of Native children are worked out in negotiations between state courts and Athabascan tribal courts, evaluating the efficacy of a social service delivery system split between two courts.

National Institute of Neurological Disorders and Stroke

The National Institute of Neurological Disorders and Stroke (NINDS) funds several projects related to the Arctic.

One project is studying Viliuisk encephalomyelitis (VE), a relentlessly progressive fatal neurodegenerative disease that is endemic in the Sakha Republic of eastern Siberia. The prevalence of this disease is close to 2% in some areas. There are strong indications that VE is a communicable infectious disease with a pattern of dissemination characteristic of leprosy and other latent and chronic infections, but the causative agent has not been identified. Over 200 cases of the disease were diagnosed within the last several years. VE has been endemic for decades in the remote Viliui valley, but it is quite new in the southern densely populated Lena–Aldan region, where a growing number of VE cases are being recorded. With the opening of the Russian borders and increasing travel, there is a threat that this fatal disease may penetrate into highly populated, rapidly developing regions of the world, such as the Russian Far East, China, Korea, Japan, and Alaska. Contributing to the seriousness of the problem are the high prevalence and mortality of VE, the trend toward further geographical spread, the occurrence of the disease among young people with resultant early incapacitation, and the absence of any means of prevention or specific therapy.

NINDS, in collaboration with the National Center on Minority Health and Health Disparities (NCMHD), the National Center for Research Resources (NCRR), and the National Institute of Mental Health (NIMH), supports an innovative funding mechanism called Specialized Center Cooperative Agreement (U54) Programs. The purpose of these programs is to augment and strengthen the neuroscience research capabilities of faculty, students, and fellows at predominantly minority institutions. The Alaskan Basic Neuroscience Program (ABNP) at the University of Alaska Fairbanks (UAF) was funded in FY 00 to stimulate neuroscience research related to the dramatically increasing health problems of the Alaska Native population and to facilitate collaborative research with neuroscientists at other institutions. The research focus at the ABNP is on neuroprotective adaptations in response to stress that address questions focusing on neuroprotective mechanisms during hibernation, neuronal regeneration, circadian rhythms, and thermoregulation. Since the inception of this program, significant strides have been made in promoting neuroscience research at the UAF as part of the University of Alaska's Academic Development Plan, expansion of the research capabilities of UAF, and advances in neuroscience research related to cir-

cadian rhythms, hibernation, and thermoregulation. A statewide conference in July 2001 brought researchers at the UAF and the University of Alaska Anchorage together with the broader scientific community, leading to a substantial increase in the involvement of Alaska Natives in scientific research and involvement of Alaska Natives as members of the External Advisory Committee.

Fogarty International Center

The mission of the Fogarty International Center (FIC), the international arm of the NIH, is to promote and support scientific research and training internationally, through a number of mechanisms and programs, to reduce disparities in global health.

Through support provided by the Fogarty International Research Collaboration Award (FIRCA), researchers at Vanderbilt University and at the Institute of Chemistry of the Estonian Academy of Sciences in Tallinn are collaborating to characterize a novel prostaglandin enzyme in Arctic coral and to compare its properties with that of the mammalian enzymes (cyclooxygenases), which are the targets of aspirin and other non-steroidal anti-inflammatory drugs. The investigators expect to clone the full-length cDNAs and express these enzymes in prokaryotes as well as in eukaryotes.

Another FIRCA, awarded in 2001 to investigators at Stanford University and the Vavilov Institute of General Genetics of the Russian Academy of Sciences, supports the study of diversity in human DNA sequences in order to characterize demography of ancient human populations, including approximately 50 previously collected samples from six Siberian peoples (Buryats, Tuvinians, Yakuts, Evenks, Chukchis, and Eskimos). This is particularly significant in elucidating the genetic ancestry and demographic histories of Native American groups, particularly the migration of populations to the New World from northeast Asia. Statistical and dynamic models will help explain the rate and distribution of genetic mutation, genetic divergence, and eventually, demographic changes. The project will further strengthen the productive scientific cooperation between the collaborating U.S. and Russian geneticists.

In addition, NIH has supported collaborative biomedical research projects between U.S. scientists and their counterparts from the former Soviet Union through the U.S. Civilian Research and Development Foundation (CRDF), some of which are relevant to Arctic research. During the period 2000–2001, one CRDF project in the area of environmental health unites researchers at Texas A&M University and the Institute of Biochemistry and Physiology of Microorganisms, Russian Academy of Sciences. The project's aim is to establish the most effective approaches to make in-situ bioremediation of soil contaminated by recalcitrant black oil more efficient, predictable, and suitable for cleaning up environments in cold climates. The potential for indigenous bacteria to degrade black oil constituents at low temperature will be evaluated, and factors controlling biodegradation rates will be estimated. In addition, a set of methods will be developed to be used in order to achieve microbiological cleaning of contaminated soil.

Centers for Disease Control and Prevention

Arctic research programs of the Centers for Disease Control and Prevention (CDC) are conducted by three of its components: the National Center for Infectious Diseases, the National Center for Environmental Health, and the National Institute for 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, the Alaska Native Tribal Health Consortium, the Indian Health Service (IHS), the Alaska Area Native Health Service (AANHS), 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 three U.S. field stations operated by the National Center for Infectious Diseases of the CDC. 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 on 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 communities; local regional and

Native health organizations; universities; other divisions, programs, and centers within CDC; the National Institutes of Health; the Indian Health Service; and the State of Alaska.

Emerging Infectious Diseases

Infectious diseases are a continuing menace to all peoples of the globe, regardless of age, gender, lifestyle, ethnic background, or socioeconomic status. They cause suffering and death, curb sustainable economic development, and impose an enormous financial burden on all societies. Arctic populations have long endured the debilitating effects of both endemic and epidemic infectious diseases, the effects of which have impacted both social and economic development in circumpolar regions of the globe.

International Circumpolar Surveillance Initiative

The International Circumpolar Surveillance (ICS) project was established in 1999 to create an infectious disease surveillance network of hospital and public health laboratories and authorities throughout the Arctic states: the U.S. (Alaska), northern Canada, Greenland, Iceland, Norway, Finland, Sweden, and northern regions and oblasts of the Russian Federation. ICS will allow for the collection, comparison, and sharing of uniform laboratory and epidemiological data on infectious diseases of concern and will assist in formulating prevention and control strategies.

In 1999–2000, isolates of *Streptococcus pneumoniae* recovered from patients with invasive disease (pneumonia, meningitis, or bacteremia) were collected and forwarded to one of three reference laboratories in Alaska, Canada, or Denmark for characterization and testing for antimicrobial resistance. Identified cases were also reported to local public health personnel, who review and provide clinical, demographic, and immunization history. Case and culture information was forwarded to the ICS coordinator at the AIP for analysis, report generation, and dissemination.

In 2000, surveillance of diseases caused by *Haemophilus influenza*, *Neissera meningitidis*, and Groups A and B *Streptococcus* was undertaken by ICS in the U.S. Arctic and northern Canada. In addition, data on invasive pneumococcal disease in 2000 will be provided by public health laboratories in Iceland, Norway, and Finland. ICS will allow for the collection of standardized data on infectious diseases and the direct comparisons of disease rates, pathogen characteristics, and intervention effectiveness among participating countries.

The prevention and control of certain high-priority emerging infectious disease issues have been targeted by CDC, including:

- Antimicrobial resistance;
- Food and waterborne diseases;
- Vector-borne and zoonotic diseases;
- Diseases transmitted through blood transfusions or blood products;
- Chronic disease caused by infectious agents;
- Vaccine development and use;
- People with impaired host defenses;
- Diseases of pregnant women and newborns; and
- Diseases of travelers, immigrants, and refugees.

Antimicrobial Resistance

In recent years, antimicrobial resistance has emerged in a number of pathogens causing disease among residents of the U.S. Arctic, thus limiting treatment options for those seeking medical care. Problem pathogens include *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Helicobacter pylori*, and *Staphylococcus aureus*.

Methicillin-resistant *Staphylococcus aureus* (MRSA) infections have been a common problem in hospitals in the U.S. for more than two decades. More recently this has become a problem infection in persons without known associations to hospital settings. Outbreaks of boils associated with *Staphylococcus aureus* continue to occur in Native villages, and anecdotal reports suggest that episodic clusters also occur in urban areas. An investigation in 1996 of an outbreak in one rural village showed that the risk of developing infection was more common in those who used a home sauna. During the summer of 2000 a marked increase in boils associated with MRSA infection as reported from one regional hospital in Alaska. An investigation conducted between May and July revealed that 85% of skin infections were due to MRSA and that 75% were community acquired (that is, not acquired during a hospital stay). A case control study in one village found that persons with MRSA infections had used more antibiotics in the year before the outbreak than persons who did not have MRSA infection and that while the use of home saunas was common among both cases and controls, MRSA was more frequently recovered from saunas used by case patients. The public health response to this outbreak included a revision of treatment guidelines to include the use

of less antibiotics, a community education campaign regarding judicious use of antibiotics, and the development of guidelines for proper cleaning of home saunas.

High rates of *Helicobacter pylori* infection have been documented in Alaska Natives. *Helicobacter pylori* causes stomach ulcers and gastritis in about 10% of persons infected and has been associated with iron deficiency anemia and the development of gastric cancer. Among children 0–4 years of age, 32% have antibodies to *Helicobacter pylori*. By 20 years of age, 86% are seropositive. A study of the impact of this infection on the health of this population confirmed that rates of active infection measured using the C13 Urea Breath test ranged from 60 to 98%. Treatment commonly includes a 14-day course of a combination of two or more antibiotics. An early study found that after two years following successful treatment, 55% of patients were reinfected. A further study showed that 26% of *Helicobacter pylori* isolates cultured from gastric biopsies from Alaska Native patients seeking medical care were resistant to clarthomycin and 76% were resistant to metronidazole, two antibiotics commonly used to treat *Helicobacter pylori* infection. Ongoing studies on *Helicobacter pylori* infection in Alaska Natives include an evaluation of the rate and risk factors for reinfection with *Helicobacter pylori* following the successful treatment of infection and an evaluation of laboratory methods used to diagnose *Helicobacter pylori* infection.

Foodborne and Waterborne Diseases

Alaska has the highest rates of food-borne botulism in the U.S., and the rate has more than tripled from 1950 to 1997. The majority of these cases have been associated with consumption of fermented foods prepared from fish or marine mammals. Improved recognition of mild cases has probably contributed to part of the observed increase in cases. Experiments performed in 1999 showed that *Clostridium botulinum* toxin production was greatest when fish head fermentations were carried out in sealed plastic buckets, compared to traditional methods such as placing fish heads into a grass-lined hole in the ground. A high index of suspicion by health care providers in Alaska, early diagnosis, and rapid antitoxin treatment has markedly reduced the fatality rate of food-borne botulism from 31% during 1950–1959 to no deaths since 1994. In 1998 a collaborative effort between the Bristol Bay Area Health Corporation and the CDC's Arctic Investigations Program designed a community-based botulism prevention strategy that included the production of an educational video titled *A Helping Hand: Keeping Your Family Safe from Botulism.*

Chronic Diseases Caused by Infectious Agents

Hypochromic microcytic anemia has long been found to be common among Alaska Natives despite a diet rich in bioavailable iron. In the 1990s it was found that fecal blood loss may be a major contributing factor to iron deficiency anemia in Alaska Natives and that hemorrhagic gastritis was associated with *Helicobacter pylori* infection. A large population-based serosurvey has shown that the seroprevalence of *Helicobacter pylori* in Alaska Natives is 75%. The rate increased with age. By 14 years of age 78% of children were found to have evidence of infection. Iron deficiency was found in 20% of males and 36% of females. A significant association between iron deficiency and seropositivity for *Helicobacter pylori* was found in those persons less that 20 years of age. Iron deficiency anemia remains common among Alaska Native preschool children. In one village surveyed in 1999, of 123 children between 1 and 5 years of age, 38% were iron deficient and 17% were anemic. Serologic evidence of *Helicobacter pylori* infection was found in 41% of these children, and there was a strong statistical association between *Helicobacter pylori* seropositivity and both anemia and iron deficiency. Ongoing studies include an evaluation of the role of *Helicobacter pylori* infection in the development of iron deficiency anemia in Alaska Native children and adults.

Vaccine Use and Development

Rates of invasive pneumococcal infection (bacteremia and meningitis caused by *Streptococcus pneumoniae*) for Alaska Natives are the highest in the U.S. and are approximately five times higher than non-Natives living in Alaska. Disease is most common in the very young and the elderly (73 cases/100,00 Natives greater than 55 years old). Case fatality from pneumococcal infection is highest (greater than 15%) in the elderly. Once fully susceptible to antibiotics, *Streptococcus pneumoniae* has acquired resistance to commonly used antibiotics. In Alaska 13% of isolates recovered from patients with invasive disease in 2000 were found to be fully resistant to penicillin. A 23-valent pneumococcal polysaccharide vaccine has been licensed for use in adults in the U.S. since 1983. The overall effectiveness against invasive

pneumococcal disease among immuno-competent persons greater than 65 years of age is 75%; however, efficacy may decrease with increasing age. A new 7-valent pneumococcal conjugate vaccine was licensed in 2000 for the prevention of pneumococcal disease in infants and young children. The AIP has maintained a statewide surveillance system for invasive pneumococcal disease since 1986 and will use this system to monitor the effects of the 23-valent pneumococcal vaccine in Alaska Native adults and the 7-valent pneumococcal conjugate vaccine in infants and children in Alaska.

Haemophilus influenzae type b was the most common cause of bacterial meningitis in preschool children prior to the development and widespread use of protein conjugate vaccines. Routine immunization of all Alaska Native infants with a *Haemophilus influenzae* type b conjugate vaccine began in 1991 and reduced the incidence of invasive *Haemophilus influenzae* type b infection more than tenfold. The effectiveness of these vaccines is largely due to the induction of circulating antibody and the interruption of oropharyngeal carriage leading to the protection of susceptible children through herd immunity. Despite the success of *Haemophilus influenzae* type b conjugate vaccines in preventing disease in the rest of the country, cases continue to occur among fully and partially vaccinated Alaska Native children at a rate of 15 cases/100,000 (1996–1997), ten times the rates found in children in other parts of the U.S. In February 2000 a community-wide investigation of *Haemophilus influenzae* type b carriage in three villages in western Alaska found an overall oropharyngeal carriage in 1.8% of persons, providing a reservoir of infection for unvaccinated or incompletely vaccinated children. A pilot intervention assessing the feasibility of using *Haemophilus influenzae* type b conjugate vaccine and chemoprophylaxis to eliminate orophyarngeal carriage has been initiated in six villages in western Alaska.

National Center for Environmental Health

Exposure to Environmental Persistent Organic Pollutants

The National Center for Environmental Health's Division of Environmental Hazards and Health Effects will continue studies on human exposure to environmental persistent organic pollutants in the Arctic. Maternal and umbilical cord blood samples from Alaska Natives are being evaluated for nonpersistent pesticides and trace metals. This study is underway in Barrow and Bethel and in communities in the Aleutian and Pribilof Islands. A study of environmental contaminants as cofactors in breast cancer in Alaska Natives is nearing completion. Two hundred study subjects were enrolled, and analysis of their biologic samples will begin this summer. A unique aspect of this study is the analysis of serum collected from the subject women and stored in the CDC/AIP serum bank. By analyzing stored serum collected many years ago, researchers will be able to model exposure to organochlorines over time. A protocol for assessing arsenic exposure and associated health effects in rural Alaska communities is in development. The study will evaluate current and long-term human exposure to inorganic arsenic among Alaskans by measuring arsenite and arsenate in urine and in hair or toenails. The health conditions of study participants will also be assessed. This study will be conducted in collaboration with ANHB and the State of Alaska's Division of Public Health.

National Institute for Occupational Safety and Health

Injury Prevention

The Alaska Field Station (AFS) of the National Institute for Occupational Safety and Health (NIOSH) 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 activities. The AOISS database contains more than 600 fatality records and 3000 non-fatal injury records from the Alaska Trauma Registry (ATR).

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 preventing occupational injuries and fatalities. 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, commercial fishing

fatalities, air transportation fatalities, and construction injuries.

Surveillance information on non-fatal, work-related injuries comes from various data sources. Trauma registries are a unique source of injury data, including information on demographics, geography, disability, medical cost, payment sources, cause of injury, discharge diagnosis, and injury severity. The ATR has proven to be a useful information source for monitoring non-fatal work-related injuries in Alaska. All 23 hospitals in Alaska report to the ATR, making it a population-based data source from which injury rates can be calculated. Analysis of the trend data and identification of hazardous processes have led to injury prevention strategies specifically targeted to high-risk areas.

The objectives of this work include using information from the ATR to:

- Reduce the morbidity resulting from work-related injuries in Alaska by providing data for developing appropriate prevention strategies;
- Facilitate state, Federal, and international work-related injury comparisons that permit trend analysis;
- Improve awareness of non-fatal work-related injury as a significant health problem;
- Assist in evaluating work-related injury-prevention strategies; and
- Facilitate research for the prevention of non-fatal work-related injuries.

The combined intervention efforts of many agencies and individuals have resulted in the following beneficial effects:

- Alaska experienced a 39% decline in work-related deaths in 2000 (50) compared to 1990 (82), or a 45% decline in the average number of annual fatalities, from 82.7 for 1990–1992 to 45 in 1998–2000;
- Commercial fishing deaths in 2000 decreased 73% from 1990; and
- The fatality rate decreased from 155 per 100,000 workers in 1990 to 51 per 100,000 workers in 2000.

Aviation Initiative

Aviation crashes are now the leading cause of occupational fatalities in Alaska. Between 1990 and 1999, aviation crashes in Alaska caused 106 work-related pilot deaths, equivalent to 420 per 100,000 pilots per year, approximately a hundred times the mortality rate for all U.S. workers and nearly five times the rate for all U.S. pilots (88 per 100,000). Congress supported a Federal initiative to reduce aviation-related injuries and fatalities—the Alaska Aviation Safety Initiative—a three-year commitment (FY 00–02) led by NIOSH with three other Federal agencies: the Federal Aviation Administration (FAA), the National Transportation Safety Board (NTSB), and the National Weather Service (NWS).

The purposes of the joint initiative are to reduce the number of aircraft crashes and deaths, to promote aviation safety within the air transportation industry in Alaska through epidemiologic risk analysis of aircraft crashes, and to evaluate aviation safety interventions. The initiative's methods and objectives are to:

- Gather and analyze injury and fatality data to identify risk factors;
- Bring together aviation industry working groups to characterize the problems;
- Develop aviation safety information for pilots, companies, and the flying public;
- Evaluate the effectiveness of and changes in flight safety practices; and
- Evaluate progress and suggest additional improvements.

The overall goal of the three-year joint initiative is to reduce aircraft crashes and injuries in Alaska by at least 50% by the end of 2009.

Commercial Fishing

The commercial fishing industry is a major contributor to the high numbers of fatal and severe non-fatal injuries in Alaska. While most (61%) of the 233 Alaskan commercial fishing fatalities from 1991 to 1999 were attributed to the loss of the vessel due to capsizing or sinking (vessel-related), a substantial proportion of these deaths (39%) were attributed to an injury occurring on deck (machinery-related), usually involving machinery or fishing equipment or falling overboard. Of the 285 severe non-fatal injuries in the commercial fishing industry from 1991 to 1998, 49% were machinery-related. Interventions to date (including the Commercial Fishing Industry Vessel Safety Act) appear to have been successful in reducing fatalities due to vessel-related events but have not had a significant impact on machinery-related events. Several critical areas have been identified for remediation: machine guarding, machinery placement, and engineering controls. The interaction among the vessel, its equipment and machinery, and the worker must also be addressed in prevention efforts.

AFS has contracted with an engineering firm to

examine interactions that have led to many of the fatal and nonfatal injuries in the fishing industry. NIOSH now is focusing on crab vessels that operate in the Bering Sea. Several interventions have been identified to modify the equipment and environment to improve deck safety. Engineering assessments of the decks of crab boats will be conducted, and educational handouts promoting potentially useful modifications will be disseminated throughout the industry. NIOSH also will begin evaluating the purse seining fleet in southeast and Kodiak Alaska, including visits and interviews with fishermen at these locations.

International and Circumpolar Collaboration, Conferences, and Workshops

Through its Alaska Field Station, NIOSH has continued its international research in partnership with commercial fishing research scientists and injury prevention program workers; the Circumpolar Health networks; and the World Health Organization's International Safe Communities. AFS co-sponsored the International Fishing Safety and Health Workshop at Woods Hole, Massachusetts, in October 2000. The conference was attended by 125 participants. More than a dozen countries were represented at this conference, including Sweden, Norway, Israel, Canada, Iceland, and Argentina. The proceedings volume will be available in the summer of 2002.

The AFS also hosted meetings for the American Society for Circumpolar Health and the Institute for Circumpolar Health Studies, including an annual meeting and public presentations on recent research findings, both held in May 2000. The annual meeting was attended by representatives from several countries, including Canada, Finland, Greenland, Norway, and Sweden. These series of events have led to the development of new joint research projects.

The NIOSH Alaska Field Station was a sponsor of the Tenth International Conference on Safe Communities in May 2000. The conference featured scientific presentations from more than six dozen speakers and included six sessions on occupational safety and health. There were 175 attendees at this event, including residents of 21 countries. Several AFS staff are now involved in joint research projects with other International Safe Communities scientists on occupational safety and health issues, including evaluation strategies for community-based work safety programming. The proceedings volume for this event was published in May 2000.

In addition, AFS staff have provided technical assistance to colleagues at Karolinska Institutet, Stockholm, Sweden; The Alberta Injury Prevention Centre, Alberta, Canada; and Harstad Safe Communities, Harstad, Norway, in the past year. AFS also briefed officials from the World Health Organization's Secretariat office in Sweden on the AFS mission and ongoing research projects.

Health Resources and Service Administration

Telehealth is defined as the use of telecommunications and information technologies for providing clinical care, health-related professional and patient education services, public health, and administrative services at a distance. The Health Resources and Services Administration (HRSA) has established an Office for the Advancement of Telehealth (OAT) to promote the use of telehealth technologies for addressing the needs of underserved populations. In 2001 the office administered two telehealth grants in Alaska with the primary purpose of delivering clinical care services to remote areas of the state.

The Alaska Federal Health Care Access Network (AFHCAN) is a 37-member organization with representation from Federal agencies, tribal health organizations, rural health care facilities, public health care organizations, tertiary health care centers, and the State of Alaska. The initial focus of the project is on improving access to health care services for Federal beneficiaries, but the project plans to expand services to all residents of its service area. In FY 01 the network included 235 sites, serving a population of 200,000, or 30% of the population of the state. Clinical consultations began in FY 01. A comparison study is being undertaken by the project to compare clinical consultations at a distance with in-person care for post-surgical ear tube replacements. Findings from this evaluation should be available by 2003.

The East Aleutian Tribes Telemedicine Program serves six remote villages of the Aleutians East Borough, which encompasses 6985 square miles of land, with a population of 2500 spread over 8029 square miles of the Bering Sea and the Pacific Ocean. The clinical network, funded in late FY 00, began to provide clinical services in March 2002. Clinical services will initially focus on seven areas: dermatology; ear, nose, and throat; selected emergency medical services; mental health; radiology; nutritional consultations; and obstetrics and

gynecology. In addition to clinical services the network has the ability to support two-way videoconferencing for quality assurance, staff supervision, preceptorship of health professions students and health aides, continuing medical education, and administrative meetings. The project also provides access to Internet library sites. The activities under this project are closely coordinated with those of the AFHCAN telemedicine project.

The Arctic Council Sustainable Development Working Group (SDWG), in its 1998 declaration, included telemedicine among the array of activities that could help improve the health of Arctic residents. Phase I of the telemedicine initiative included completion of the Arctic Telemedicine Report, which summarized telemedicine activities in the Arctic region. Based on the report's recommendations, Phase II was initiated to develop broader communication channels among the Arctic nations for sharing lessons learned from Arctic telemedicine projects and facilitating collaboration among them. The SDWG, through the State Department, requested assistance from HRSA's telehealth office in establishing collaborative partnerships to implement Phase II. Dr. Dena Puskin, Director of OAT, serves as the lead representative for telemedicine to the SDWG. An international steering committee formed to help direct this initiative includes the State Department, the University of Alaska, the State of Alaska, and the Alaska Federal Health Care Network. During May and June 2001 the goals and objectives for Phase II, together with a preliminary strategic plan, were formally drafted and shared with the steering committee.

Smithsonian Institution

The Smithsonian's Arctic Studies Center conducts research on northern environments, peoples, and cultures throughout the circumpolar region, maintains collections, publishes scientific materials, and sponsors a variety of educational programs.

The Smithsonian has been engaged in Arctic research for more than 150 years. Throughout this period Smithsonian scientists have collected natural history and anthropological materials from Labrador and Greenland to Alaska and have conducted field studies throughout most of the circumpolar world. During the 19th century the Institution's research focused primarily on pioneering explorations and collecting programs in Alaska and the western Arctic and sub-Arctic. In the 20th century, research turned toward archaeology and physical anthropology and the problems of the peopling of the Americas and the origins and spread of Eskimo peoples.

With the creation of the Arctic Studies Center (ASC) in 1988, the Smithsonian expanded its Arctic programs in Canada and Alaska and opened new research programs in Russia. From its inception the ASC has embraced a cooperative anthropological paradigm that integrates northern community interests and concerns with the Smithsonian's long-standing commitments to cultural heritage resources and research.

Today the ASC is the only anthropological research center with capabilities for conducting international research throughout the circumpolar region. The expansion of its research mission has occurred concurrently with the development of educational programs, which include exhibitions, internships, fellowships, museum training programs, and cooperative research projects in Labrador, Quebec, Alaska, and Russia. In recent years many northern Native peoples have been able to visit the Smithsonian to view and sometimes borrow collections from their home regions. Access by Alaskans to Smithsonian collections, archives, and staff have been greatly enhanced by the establishment of a regional office in cooperation with the Anchorage Museum of History and Museum of Natural History and the National Museum of the American Indian, which jointly run research and educational programs out of the Alaska office.

	Funding (thousands)	
	FY 00	FY 01
Anthropology	400	400
Arctic Biology	50	50
Total	450	450

Research

During the current reporting period, ASC anthropologists and research associates have conducted archaeological, ethnographic, and historical research in Arctic and sub-Arctic regions of Quebec, Labrador, Alaska, Russia, and Mongolia. William Fitzhugh's work along Quebec's Lower North Shore extended previous Smithsonian archaeological research on the Labrador coast westwards into the Gulf of St. Lawrence, searching for the western limits of early Maritime Archaic Indian, Paleoeskimo, and early historic Inuit culture and their interactions with resident Indian cultures during the past six thousand years. Fieldwork in 2001 resulted in the discovery of Maritime Archaic sites containing large longhouses not previously known south of Labrador, as well as late-16th-century Basque whaling sites that will provide information about early European industrial activities in the New World and relations with resident Native American groups. Farther north, along the Labrador coast, Stephen Loring conducted community archaeology projects with the Labrador Innu and Inuit that revealed the presence of 6000-year-old Archaic Indian groups on the northern interior of Labrador and early adaptations of 17th- to 19th-century Inuit to the European presence on the central Labrador coast.

Stephen Loring's publication of a new edition of Lucien Turner's 1894 *Ethnology of the Ungava District* makes this classic Smithsonian Bureau of American Ethnology study available to the public and scholars in an updated and definitive form. Loring's work with the northern Quebec Makivik Corporation and the Avataq Cultural Institute has led to new research on Inuit–caribou adaptations and the impacts of climate change on this relationship.

Research in Alaska has been concentrated in two regions: St. Lawrence Island and southern Alaska. For the past several years Igor Krupnik has been engaged in oral history and "knowledge repatriation" projects with members of the Native communities in Savoonga and Gambell, whose Yup'ik populations are closely related to Native groups in adjacent regions of Chukotka, Siberia. In addition to ongoing research with Native observers on the impacts of climate and environmental change on local subsistence resources, Krupnik, Willis Walunga, and others have compiled archival documents and photographs related to the history of St. Lawrence Island and its peoples and have made this information available to local communities in a volume titled *Our Words Put to Paper.* This pioneering community-based effort at compiling local history has been so successful that several hundred copies of this volume have been requested by local schools and residents. During this period Krupnik also published a volume of oral traditions of the Siberian Yup'ik people.

A similar community approach involving oral history and archaeology of the outer coast of Kenai Fiord in southern Alaska has provided Aron Crowell and his Alutiiq collaborators with exciting opportunities for developing a research program that will elucidate information from local elders about climate and subsistence resource changes during the recent past. With the aid of this information, a team of archaeologists and paleoecologists has begun to develop models that will be tested with prehistoric archaeological and paleoenvironmental data in order to reconstruct patterns of human–environmental relations over long periods of time.

Farther west, in the Siberian High Arctic 350 miles north of the Lena Delta, Smithsonian researchers teamed up in 2000 with Russian archaeologist Vladimir Pitulko and Russian paleontologists and geographers to excavate a 8000-year-old Mesolithic site on Zhokhov Island. Pitulko had previously tested the Zhokhov site, but new excavations were needed to clarify its unusual economy composed of equal parts reindeer and polar bear but with very little evidence of sea mammals or "Eskimo-like" technology. The new excavations proved even more mysterious because they failed to reveal the presence of dwellings, despite masses of driftwood and

Excavations at Zhokhov Island, 2000.

midden accumulation present in the site's large, deep frozen deposits. Despite discovering remains of grass baskets, engraved ivory objects, wood sled-runners, and a Mesolthic stone technology similar to that of the East Siberian Sumnagin culture, continued research at Zhokov in 2001 failed to produce clear evidence of dwellings, geography, and occupation seasonality. If this site was at the Arctic coast, as seems likely given the presence of polar bear, driftwood, and reindeer, the Arctic shoreline has retreated 350 miles to the south in the 8000 years since Zhokhov was occupied at the end of the peak warm period of the Siberian "hypsithermal."

Smithsonian research also expanded for the first time into the southern reaches of Siberia, in areas that would not normally be considered Arctic or even sub-Arctic. Mongolia, however, qualifies as "Arctic" because of its extremely cold winters and the presence of reindeer, permafrost, and thermokarst features resembling pingos. Exploratory research conducted here by William Fitzhugh with paleoecologist Steven Young of the Center for Northern Studies of Wolcott, Vermont,

Mongolian Dukha family and their reindeer.

produced numerous surprises that have stimulated plans for new research in ethnology, archaeology, and paleoenvironments. Work among the Dukha (known as Tsaatan in Mongolia) living in northern Mongolia near the Russian border revealed a striking case of cultural survival by a people who number only a few hundred and who are currently the southern-most reindeer herders in the world. Studies of Dukha herding practices, ethnobotany, and history are needed because these people have recently become politically isolated from their Tuva-speaking relatives in Russia, and their reindeer are threatened with genetic deterioration and loss of pasture resources resulting from climatic warming and violent livestock-killing winter storms ("zud") in recent years. Equally interesting are the surprising similarities between the modern vegetation of the northern Mongolian steppe and alpine zones with the ancient plant assemblages of Beringia; questions about prehistoric relations between Bronze and Iron Age Mongolia with the Russian Arctic and North Pacific region; and the possibility that Mongolia's elaborately carved Bronze Age "deer-stone" monuments may be related to the origins of the Scythian animal-style art and animal-based art of Siberia and the North Pacific. Research on these and other topics is currently being planned as part of a multidisciplinary effort with Mongolian scientists.

Vikings: The North Atlantic Saga

April 2000 brought the culmination of a major Smithsonian research and education effort carried out by the National Museum of Natural History and its Arctic Studies Center: the opening of *Vikings: The North Atlantic Saga* in Washington, DC. Planned with the Nordic Council of Ministers, with support from Volvo of America Corporation and museums and institutions in Scandinavia, Finland, Scotland, Great Britain, Iceland, and Canada, this project brought together information on the little-known expansion of Vikings from northern Europe across the North Atlantic in the 8th and 9th centuries, settling the northern British Isles, Iceland, Greenland, and eventually North America in the year A.D. 1000.

The research and exhibition program featured new archaeological, historical, and paleoecological information revealing the massive influence of both climate and human agency on the Viking expansion out of their Scandinavian homelands and the impacts that this expansion had on Europe, North Atlantic lands, and North America. The culmination of this process of exploration, migration, and adaptation occurred with the A.D. 1000 Vinland voyages of Bjarney Herjolfsson, Leif Eriksson, and Thorfinn Farlsefni and his wife Gudrid, who, if the Icelandic sagas are correct, bore the first European to be born in the New World.

The exhibition, its catalog, and the publicity that accompanied the exhibition's national tour is bringing the West Viking story and Leif Eriksson's discoveries to a broad North American audience and is producing widespread recognition that the Norse discovered and settled North America, albeit briefly, 500 years before Columbus.

Logo for the Looking Both Ways *exhibition, from a painting on a wooden box from Kodiak Island.*

Looking Both Ways: Heritage and Identity of Alutiiq People

In June 2001 the ASC opened another exhibition—this time at the opposite end of North America—in Kodiak, Alaska. Produced by Aron Crowell and a team of Alutiiq community scholars and academic specialists, *Looking Both Ways: Heritage and Identity of Alutiiq People* presents the history, art, and material culture of the Alutiiq peoples of southern Alaska in a strikingly beautiful exhibition accompanied by a scholarly book and educational materials. The exhibition is based on the collections of Smithsonian naturalist William J. Fisher, who made collections and conducted research for the Smithsonian in Kodiak and nearby regions of southern Alaska in the late 1880s. The Fisher collection had never been previously described or published, but it included remarkable materials that proved to be of great interest to today's Alutiiq people, who took on a major role in research and preparations for the exhibition. The show opened to great acclaim at the Kodiak Museum and is scheduled to be seen in several museums in Alaska and at the Smithsonian in Washington during the next two years.

In addition to this exhibition, the Alaska Regional office has been coordinating several research and educational programs for the benefit of Alaska Native peoples and residents. In addition to its oral history and archaeology projects, the office is conducting training programs in museum studies and offers internships and research opportunities. Through its recently instituted Alaska Collections Project, conducted with assistance from the Rasmuson Foundation, Phillips Petroleum, and the National Museum of the American Indian, groups of Alaskan village elders and cultural experts are being invited to Washington to study collections from their home regions. In addition to providing new documentation and cultural background, oral history, and general observations about these materials, they are selecting objects that will be loaned for exhibit and study at the ASC facilities at the Anchorage Museum of History and Art. This project is having a positive effect on traditional cultural heritage through the reconnection of people with a part of their heritage that has in many cases disappeared from their lives during the past century. The Alaska Collections Project is building bridges between young and old in the communities and is establishing personal relationships and confidence between communities and the Smithsonian. Concurrently the Institution has been returning objects, materials, and human remains from its collections to villages and communities throughout Alaska in accordance with the Native American Grave Protection and Restoration Act.

Environmental Protection Agency

The U.S. Environmental Protection Agency's Arctic research program is designed to protect the health of Arctic residents and safeguard the Arctic environment.

EPA research in the Arctic is focused on the source, transport, fate, and effects of contaminants in the environment; the risk and benefits of subsistence foods; global climate change and UV-B radiation; and the combined effects of multiple stressors in the Bering Sea. An emerging EPA Arctic focus will help the agency target resources more effectively. The EPA Arctic Program is founded on research and development, regional implementation, and international activities. Within this framework, EPA research has three primary objectives:

- Improving basic knowledge about Arctic stressors and effects;
- Understanding and reducing the risk to Arctic residents and the Arctic environment; and
- Implementing innovative technologies to solve environmental problems.

These primary objectives are being addressed through a variety of research and management efforts. The following discussion provides a brief summary of EPA-sponsored research projects, each highlighted under a particular objective. This has been done while recognizing that an individual project may address more than one objective.

	Funding (thousands)	
	FY 00	FY 01
Research and Development	163	160
Regional	210	190
International	90	160
Total	463	510

Arctic Stressors and Effects

EPA has increased the understanding of, and awareness among, regional, national, and international partners concerning the risks associated with contaminants in the U.S. Arctic. Activities include leading international efforts to assess heavy metals in the Arctic, investigating mercury deposition, and partnering on enhancing education about Arctic contaminants.

Arctic Monitoring and Assessment Programme Phase II Assessment: Heavy Metals

The Arctic Monitoring and Assessment Programme (AMAP) is one of five working groups operating under the direction of the Arctic Council, a high-level, eight-nation forum implementing the Arctic Environmental Protection Strategy. The AMAP mission is to assess environmental contamination in the Arctic. The first AMAP assessment was published in 1998. An important and comprehensive document, the assessment highlighted potential risks to the Arctic from contaminants. However, U.S. data were missing from the first assessment. At the beginning of AMAP Phase II in 1998, the U.S. was requested to serve as lead country. In March 1999 the EPA Office of Research and Development (ORD) agreed to fulfill this role.

Initial efforts defined the scope and features of the heavy metals assessment, completed at the international workshop called Heavy Metals in the Arctic held in Anchorage, Alaska, during September 1999. In 2000, EPA funded scientists to identify and assemble research results from 1996 to the present, as well as earlier work not represented in the AMAP Phase I assessment. Particular efforts were directed toward identifying U.S. research on heavy metals in the Arctic.

To facilitate the retrieval, organization, and dissemination of U.S. heavy metals research, as well as support a U.S.-based Arctic data center, EPA provided a grant to the University of Alaska Fairbanks for database development. Funds were used to support expansion of the SynCon Data Base to create a U.S database on heavy metals and support the establishment of the international AMAP Thematic Data Center for freshwater and terrestrial Arctic environments.

In June 2001, EPA sponsored another interna-

tional workshop, titled Trends and Effects of Heavy Metals in the Arctic, held in McLean, Virginia. Scientists from eight nations reported on their latest research and provided short papers for inclusion in the assessment. At the workshop, key experts began drafting the assessment.

The first draft of the heavy metals assessment was delivered for review at the AMAP Assessment Steering Group meeting held in Stockholm, Sweden, in August 2001. In response to identified needs and a shortened timeline, EPA established a five-member U.S. science team including four scientists and a scientific secretary. The team worked with international scientists to produce follow-up drafts. The final draft was reviewed in June 2002, and the final assessment was submitted to the AMAP Secretariat for publication in July 2002.

The AMAP Phase II heavy metals assessment is scheduled to be reviewed and approved by the Arctic Council Ministers at a meeting in Finland in October 2002. EPA provided additional funding to support publication of the assessment reports.

Mercury and Arctic Sunrise

One of the key findings in the AMAP Phase II heavy metals report is the transformation of mercury in the Arctic at polar sunrise. EPA has been instrumental in investigating the nature and geographical extent of the phenomenon termed the Arctic sunrise, where atmospheric elemental gaseous mercury levels have been shown to drop drastically when sunlight returns to the region during the Arctic spring. The majority of atmospheric mercury is present in elemental form, but reactive gaseous mercury has much higher wet and dry deposition rates. Thus, speciation of mercury is of particular interest in the Arctic because of the sunrise phenomenon and the greater local impact of reactive forms.

Over the past two years, EPA has sponsored speciated mercury measurements at the National Oceanic and Atmospheric Administration (NOAA) observatory in Barrow, Alaska, in partnership with NOAA and the Department of Energy's Oak Ridge National Laboratory. The site is operated by the Observatory Operations Group of NOAA's Climate Monitoring and Diagnostics Laboratory, where NOAA has operated a continuous total gaseous mercury analyzer since January 1999. With this instrument the Arctic sunrise phenomenon, first observed at station Alert in Canada, was confirmed at Barrow. It is now believed that during transformation, elemental gas-phase mercury (Hg^0) is converted to reactive gaseous mercury (Hg^{2+}) by photochemically produced halide radicals and deposited to the snowpack via dry deposition processes. Measurements of Hg^{2+} and Hg^0 during Arctic sunrise will help elucidate the transformation processes leading to the Hg^0 depletion. State-of-the-art technology is being used to take speciated measurements. Atmospheric trace metals will also be analyzed.

Research continues at NOAA's monitoring site in the U.S. Arctic at Barrow. Since a portion of the mercury accumulating in snow during the period of enhanced deposition may be incorporated into and affect the biological food chain, the research emphasis is now shifting toward measuring mercury levels in snow during Arctic spring. The EPA snow sampling project for mercury and major ion analyses involves high school students in Barrow, Alaska, and Chukotka Peninsula, Russia. Students will periodically collect snow samples, which will be shipped to the University of Michigan for analysis of mercury and major ions. Students and teachers will participate in data interpretation and learn about the entire scientific program through involvement with scientists at EPA, the University of Michigan, and the Barrow Arctic Science Consortium. In Barrow, speciated ambient mercury concentrations measured at the NOAA CMDL laboratory will be compared to mercury accumulation in the snowpack. In Chukotka, mercury concentrations in snow will be used to investigate how widespread this phenomenon may be and estimate the range of ambient concentrations that result.

Transpacific Transport of Contaminants

In July 2000, EPA partnered in convening the First International Conference on Transpacific Transport of Contaminants through Nautilus of America, Inc. Over 100 scientists from the U.S., Canada, and Pacific Rim nations including Japan and China gathered in Seattle to discuss issues surrounding long-range transport of contaminants. The final report included recommendations for research to better understand the implications of long-range transport and highlighted a key finding that all nations are "downwind" from others, even those increasingly recognized as major contributors to the global pool of contaminants.

Contaminants in Alaska: Is America's Arctic at Risk?

EPA, in partnership with the State of Alaska, Department of the Interior, and other governmental, nongovernmental, and tribal entities, published the document *Contaminants in Alaska: Is*

America's Arctic at Risk? Presented by Alaska's Lieutenant Governor at the Arctic Council meetings in Barrow in October 2000, it triggered state interest in research and international action to prevent contamination of fish and wildlife of Alaska, with particular emphasis on subsistence foods used by Native residents. As a result, new research initiatives were launched, and the state initiated a Wild and Traditional Foods program to address Arctic contaminants.

UV Monitoring

EPA, in collaboration with the National Park Service, maintains a network of ground-based UV monitoring instruments at 14 national parks and 7 urban locations in the U.S. One of these PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) sites is in Denali National Park, Alaska. While below the Arctic Circle, the site offers useful data for northern regions in comparison with other areas.

U.S. Federal agencies continue to operate a network of ground-based UV monitoring instruments in response to a U.S. Global Climate Research Program plan published in 1995. Participating agencies are EPA, USDA, NOAA, NSF, the Smithsonian Institution, NASA, and DOE.

The USGCRP FY 00 document *Our Changing Planet* recognizes the need to understand changes in UV fluxes and how these changes affect human health and the productivity of ecosystems. Through PRIMENet, data from Denali National Park and other UV monitoring sites provide a basis for primary research and assessments of the consequences of climate change.

Understanding and Reducing Risk

EPA and others have broadened the risk assessment approach to effectively bring together scientific research and management strategies to enhance risk reduction. In the Arctic this specifically targets reducing risk to humans potentially exposed to contaminants in traditional foods, as well as addressing the profound changes occurring in the Arctic and Bering Sea region from the combined effects of many stressors. EPA is focusing resources and time in the Arctic to integrate ecosystem-level risk assessment with human health and cultural risk.

Benefits and Risks of a Traditional Diet

EPA ORD is working in partnership with Native, academic, state, and other Federal agencies on evaluating both the benefits and risks of contaminants that may be found in wild caught food. Through a grant to the Aleutian/Pribilof Islands Association (APIA) from the National Institute of Environmental Health Sciences (NIEHS), scientists are working with two Native communities, St. Paul and Atka, to identify preferred food consumption, proportion of wild and store-bought foods consumed, and levels of contaminants in foods, as well as the values and benefits of collecting and consuming traditional foods. EPA was instrumental in assembling the research team and facilitating the research design during 2000 and 2001 and is playing a lead role in developing assessment goals and problem formulation for conceptual model development. During 2002–2004 EPA will work with the assessment team on data evaluation and assessment of the benefits relative to the potential risk of consuming traditional foods.

Heavy Metals and Persistent Organic Pollutants in Traditional Foods

Increasing concern by Native people in Alaska about the levels of pollutants in traditional foods led EPA (Region 10, ORD) to provide funding to the Sea Otter and Sea Lion Commission, a Native-based scientific organization, to assess the levels of heavy metals and persistent organic pollutants in seagull eggs used for subsistence. The Commission used funding to train local people to collect and transport eggs and prepare specimens and to support lab analysis. Collections were completed during 2000 and 2001. Results from the work are pending. EPA also provided funding to support ongoing work through the Native American Fish and Wildlife Society to enhance the scientific training of Native people for contaminants work.

Bering Sea Integrated Assessment

EPA has initiated efforts to address the combined effects of climate change, contaminants, fishing pressure and habitat alteration, and other stressors on the ecological, economic, cultural, and health aspects of Alaska communities. Founded on community-based environmental protection initiatives, EPA Region 10 and the ORD National Center for Environmental Assessment established the Bering Sea Regional Geographic Initiative, which has provided funds to assist tribes and other organizations in developing goal statements describing the elements of a sustainable Bering Sea. This effort also defines the EPA focus under SEARCH, the Study of Environmental Arctic

Change. The Bering Sea assessment is anticipated to serve as a focal case study under SEARCH that broadens the focus from climate change and the Arctic Oscillation to encompass human and ecological dimensions of change. This work also directly supports a new IARPC effort to conduct an integrated assessment for the Bering Sea.

Bering Sea Interagency Working Group

In March 2001 the Interagency Arctic Research Policy Committee passed a resolution to form an Interagency Working Group (IWG) on the Bering Sea, chaired by EPA, in response to a key recommendation by the Arctic Research Commission for more integrated research in the region. To begin the process the IWG met three times by conference call over the course of several months and then held a retreat in October 2001 to identify key components for an assessment plan. Discussions centered on a definition of sustainability for the Bering Sea, the scope of the assessment, and the partners required for success. The IWG concluded that a larger dialogue with the scientific community would be necessary to define the scope. It is anticipated that a scientific symposium will be convened in 2003 to obtain input from the scientific community. In addition, further dialogue with communities was identified as a key objective to better define goals. Follow-up from the Alaska Forum on the Environment results will aid in this effort. Finally, commitment by multiple Federal agencies will be needed for successful implementation. To engage interest, a combined research and assessment strategy may be developed.

Alaska Forum on the Environment

In February 2002, EPA sponsored four Bering Sea sessions at the Alaska Forum on the Environment. The first session focused on commercial fishing regulations and status to provide information to communities and tribes. The session was designed to respond to a specific request by tribes made during a tribal consultation on the Bering Sea. The second featured speakers from a cross section of interested parties in the Bering Sea region. They addressed key issues of concern, from diverse perspectives, about changes being observed. This session offered alternative perspectives to trigger discussion in the remaining two sessions, designed to provide an open forum for participants to express their concerns, to offer their views on the nature of sustainability in the Bering Sea region, and to suggest future action. A number of specific recommendations emerged from the sessions, including baseline goals for an integrated assessment for a sustainable Bering Sea. A summary of results is expected to be published by December 2002.

Bering Sea Global International Waters Assessment

In September 2002, EPA and the United Nations Environmental Program, Global International Waters Assessment (GIWA), jointly convened an international scientific meeting, bringing together scientists from the U.S. and Russia to conduct a scoping assessment for the Bering Sea, including the marine and freshwater systems of the watershed. The assessment was designed to establish an understanding of the status of different ecological and human components of the system using a scaling process that will allow the assessment to be compared to other oceans around the globe. The draft assessment was delivered to GIWA in November 2002. It is anticipated that the second stage of the assessment will be completed in 2003.

Implementing Technologies

Introducing and implementing innovative technologies and management opportunities has been a cornerstone within EPA. In the Arctic, EPA's current focus is on reducing contaminants reaching the Arctic through long-range transport and building capacity within the U.S. Arctic to reduce potential environmental impacts.

Reducing PCBs in Russia

The Russian Federation continues to depend on PCBs and PCB-containing equipment. Russia has not accepted the Protocol on Persistent Organic Pollutants (POPs) of the Convention on Long-Range Transboundary Air Pollution (LRTAP) because it is currently unable to phase out PCB use. To assist Russia in phasing out PCB use, EPA proposed a multilateral technology transfer and demonstration project under the auspices of the Arctic Council Action Plan (ACAP). The objective of this multilateral cooperative pilot program is to protect the Arctic ecosystems and indigenous U.S. populations by assisting the Russian Federation to:

- Develop an inventory, or source term for PCBs in the Russian Federation;
- Cease the use of PCBs;
- Develop and construct or retrofit facilities for producing and using PCB alternatives;
- Provide safe disposal and destruction of

PCBs and PCB-contaminated equipment and material; and
- Remediate PCB sites that have the greatest potential to impact the Arctic.

The project is being implemented in three phases. Phase I, implemented during 1997–1999, centered on organizing the effort and developing an inventory of PCBs in Russia. The first Russian national inventory is now complete. Phase II involves conducting feasibility studies to identify effective collection, storage, destruction, and remediation techniques, as well as identify alternative dielectric fluids and technologies to convert and retrofit facilities to produce and use PCB alternatives. Initiated in 2000, Phase II is expected to be complete in 2002. A pilot project to implement the use of alternative dielectric fluids and destroy up to 1000 tonnes of PCBs in Russia is planned during Phase III, which begins in mid-2002.

General Assistance Program Grants

EPA through Region 10 is investing heavily in building capacity within Alaskan villages to manage community-based environmental protection programs and to implement sustainable technologies amenable to rural Arctic that can achieve local environmental goals. From this, EPA anticipates seeing emerging management strategies and technologies that will reduce local environmental pollution and improve quality of life. This investment, while not represented in the research budget, represents an annual investment of over $12 million.

Arctic Program

The ORD National Center for Environmental Assessment established an Arctic Program Office in Anchorage, co-located with the Region 10 Alaska Operations Office. This continues to be a central clearinghouse within and outside the agency for information and activities relevant to the Arctic. Arctic Program staff are working with EPA Region 10 staff and other program offices to develop an integrated EPA Arctic Strategy to address the unique concerns of Arctic communities and ecosystems.

Department of Transportation

DOT supports Arctic research through the U.S. Coast Guard, which operates polar icebreakers as national polar research assets for Arctic oceanographic expeditions of both government and nongovernment researchers.

U.S. Coast Guard

Icebreakers

The Coast Guard supports Arctic research through its operation of three polar icebreakers, USCGC *Polar Sea* and USCGC *Polar Star*, which serve as high-latitude research platforms in both the Arctic and Antarctic, and the new polar icebreaker USCGC *Healy*, which started Arctic science cruises in 2001. Support of Arctic research by the U.S. Coast Guard dates back to the 1880s, when voyages on revenue cutters were made by scientists, including the renowned naturalist John Muir on the Revenue Cutter *Corwin* in 1881 and others on the Revenue Cutter *Bear* commanded by Captain Michael Healy in the 1880s and 1890s. 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. The Coast Guard icebreakers *Northwind, Burton Island,* and *Glacier* supported these cruises. In the 1980s these vessels were decommissioned 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 projects and larger science teams placed added requirements on these ships. This led to a major upgrade of their capabilities in 1987 through the Polar Science Upgrade Project, a five-year program to enhance the scientific support capabilities of these vessels. 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 significantly improved the research capabilities of the Polar-class vessels.

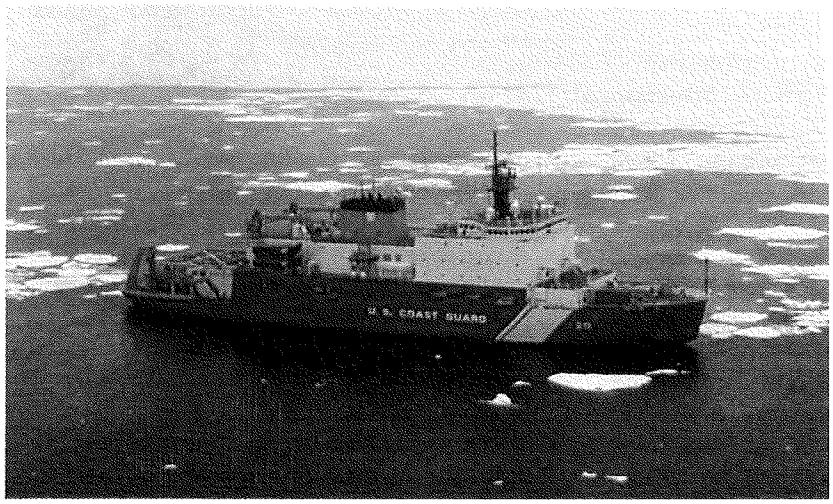
	Funding (thousands)	
	FY 00	FY 01
Test and Evaluation	3,750	500
Arctic Science Support	2,530	10,330
Extramural Science Support	30	30
Total	6,310	10,860

USCGC Healy

To meet the expanding needs of the future, the Coast Guard commissioned a new research platform designed primarily for Arctic science though capable of work in the Antarctic as well. The new vessel, USCGC *Healy*, was built by Avondale Industries in New Orleans, Louisiana. The *Healy* is 420 ft long, has a beam of 82 ft, and displaces 16,000 long tons. The maximum speed is 17 knots, with a range of 16,000 nautical miles at 12.5 knots. The *Healy*'s primary mission is to function as a world-class high-latitude research platform. The *Healy* is able to conduct scientific operations during all seasons in the Arctic, including wintering over for planned missions.

The scientific support capabilities of the *Healy* substantially surpass those provided by the Polar-class icebreakers. The ship is able to accommodate 35 scientists on a routine basis and provide surge accommodations for up to 50. Over 5000 square feet of science lab and support space is provided, including a main science lab, a wet science lab, a biological and chemical analysis lab, an electronics lab, a meteorology lab, and a photography lab. In addition the *Healy* has five hydraulically

operated cranes, two oceanographic winches, and a double-drum core/trawl winch. It also provides over 4,000 square feet of open deck space and 20,000 cubic feet of scientific storage space in three cargo holds. Installed bathymetric and oceanographic instrumentation includes a bottom profiling system, a Seabeam bottom mapping sonar system, an XBT data acquisition unit, and an acoustic Doppler current profiler. Lab spaces are 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. In addition there is a dedicated Inmarsat-B with high-speed data transmission and e-mail capabilities for scientists.



USCGC Healy *enters the ice for the first time, April 2000.*

After delivery on 9 November 1999 by Litton-Avondale Industries, *Healy* underwent a period of fitting-out availability and propulsion system repairs. The ship departed New Orleans on 26 January 2000 to conduct machinery, hull, and science suite testing. Initial warm-water trials were completed in March. Ice trials were conducted from April to June in Baffin Bay in the eastern Arctic. *Healy* performed well, with icebreaking performance exceeding design requirements of 3.0 knots through 4.5 ft of ice. The maximum thickness of unbroken level ice encountered was 5.5 ft, which *Healy* transited at a continuous speed of 2.6 knots. Ice ridges of 45 ft were broken through in three rams. *Healy* transited the Northwest Passage in July and arrived at Seattle on 9 August. The ship was commissioned on 21 August 2000.

Arctic Research Cruises

The Coast Guard's major Arctic research efforts supported during the past two years were the Arctic West Summer Cruises aboard *Polar Star* and *Polar Sea* and the Arctic East Cruises aboard *Healy.*

After returning from Operation Deep Freeze 2000 in April 2000 and following an in-port period for repairs, *Polar Star* conducted a Western Arctic Cruise from 27 July to 21 September 2000. *Polar Star* conducted the St. Lawrence Island Polynya Project (SLIPP01) during March–April 2001 and departed Seattle for Operation Deep Freeze on 1 November 2001.

The Western Arctic Cruise 2000 was conducted in three phases. First-phase projects included the Marine Atmospheric Emitted Radiance Interferometer (M-AERI) project; a study of the source of ice-rafted detritus in sea ice; the collection of bio-optical data; the use of organic markers to trace carbon cycles; a polar bear population study; isotopic radium measurements to trace shelf-basin water; and studies of the geology and geophysics of the Northwind Ridge and Hanna Canyon. The second phase was a study of radionuclide tracers in the Canada Basin. The third phase involved testing a remotely operated vehicle and bottom dredging near Barrow, Alaska. The following organizations were supported during the cruise: University of Miami, Old Dominion University, University of Maryland, U.S. Fish and Wildlife Service, U.S. Geological Survey, NOAA, Wayne State University, and FIT Zurich, Switzerland.

En route to SLIPP01, *Polar Star* deployed NOPP vertical profiling drifters for Lawrence Berkeley Laboratory and then embarked 18 scientists for a two-week study of biological, physical, and chemical processes in the polynya, an area of open water within the ice-covered sea south of St. Lawrence Island. In the polynya, which forms every winter, are found walrus, bowhead whales, bearded seals, and several species of ducks, including the spectacled eider, a threatened species. The polynya is also important to two Native communities on St. Lawrence Island that rely on this oceanographic feature for subsistence hunting and fishing.

The following organizations were supported during the SLIPP01 cruise: University of Tennessee, University of Wyoming, University of Charleston, NOAA's National Marine Mammal Lab, Alaska Department of Fish and Game, the Institute of Chemical Physics, Russia, and the Zoological Institute, Russia. In addition, a teacher from Farragut Elementary School, Knoxville, Tennessee, was aboard the ship as part of NSF's Teachers Experiencing the Arctic/Antarctic (TEA)

program. The purpose of the research was to understand seasonal changes in the benthic community and carbon cycling and how this affected the population of the spectacled eider. A series of measurements were made at 35 stations involving light meter casts, CTD/water collecting casts for salinity and primary productivity measurements, vertical tows for zooplankton, van Veen grabs, and HAPS benthic corer deployments. Measurements at 34 of these stations were done at locations that have been periodically occupied for benthic sampling since 1988. Measurements were also made southwest of the island in a zone where spectacled eiders were observed during the cruise. In addition, seabird observations and collections were made from helicopters. Seabird and marine mammal observations were also made from the ship during transits between stations.

The *Polar Sea* supported Operation Deep Freeze 2001 from 4 November 2000 to 30 April 2001 and then conducted the Arctic West Summer 2001 from 23 July to 19 August 2001. During this period operations focused on the recovery and deployment of NOAA hydrophone moorings and the deployment of drifters near the Yukon River Delta. Scheduled work with the U.S. Fish and Wildlife Service was cancelled when the ship developed a rudder problem and returned to Seattle.

Healy departed Seattle on 12 June 2001 to conduct two successful science operations in the eastern Arctic: the Arctic Mid-Ocean Ridge Expedition (AMORE) (31 July–2 October) and the Atlantic Layer Tracking Experiment (ALTEX) (7 October–6 November).

During the AMORE cruise, *Healy*, working in tandem with the German icebreaker R/V *Polarstern*, completed dredging, rock coring, water sampling, and SeaBeam bottom mapping along the Gakkel Ridge and reached the geographic North Pole. The following institutions were supported during the cruise: University of Tulsa, Columbia University, Woods Hole Oceanographic Institution, Oregon State University, University of Hawaii, Monterey Bay Aquarium Research Institute, University of Bergen, Texas A&M University, and the TEA program.

During the ALTEX cruise the *Healy* conducted tests of an autonomous underwater vehicle in first-year and multiyear ice fields and conducted hydrographic sampling. *Healy* also made radar measurements of various types of sea ice to obtain ground-truth information to permit calibration of satellite radars. The following institutions were supported during this leg of the cruise: National Ice Center, Naval Research Laboratory, University of Denmark, NASA Jet Propulsion Laboratory, National Oceanic and Atmospheric Administration, PMEL, the Monterey Bay Aquarium Research Institute, and SSI Inc.

International Ice Patrol

The Coast Guard International Ice Patrol (IIP), located in Groton, Connecticut, participated in two iceberg-detection research programs, one using airborne radar and the other satellite-based radar. 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.

The first of the IIP's research efforts was an evaluation of the iceberg-detection capability of IIP's newly installed MSS-5000 airborne surveillance system. The MSS-5000, which is integrated with the AN/APS-135 side-looking airborne radar, is IIP's primary iceberg-detection system. The results of the IIP's testing of the MSS-5000 system were presented at the International Ice Charting Working Group (IICWG) Science Workshop in Tromsø, Norway, on 13 November 2001 and will be available on the IICWG web site (http://nsidc.org/noaa/iicwg/index.html).

The second program was a joint U.S.–Canadian effort to evaluate and refine the capability to detect and track icebergs using satellite-based radar. During 2001, IIP concluded a three-year research program with the Canadian Ice Service (CIS), Environment Canada to evaluate the effectiveness of Radarsat for operational iceberg detection and classification. Radarsat is an earth-observing satellite with synthetic aperture radar developed and operated by Canada to monitor environmental change and natural resources. This project is now entering the operational test and evaluation stage. During this project, CIS and IIP compared Radarsat data with data acquired during IIP reconnaissance flights to determine its effectiveness in locating and tracking icebergs.

Department of State

The Department of State continues to be involved in multilateral and bilateral activities related to environmental protection and scientific research in the Arctic.

In the international arena, U.S. policy in the Arctic focuses on environmental protection and sustainable development. In 1991 the U.S., along with Canada, Denmark, Finland, Iceland, Norway, the Russian Federation, and Sweden, became signatories to the Arctic Environmental Protection Strategy (AEPS), a high-level forum designed to identify priorities for regional cooperation with regard to environmental protection in the Arctic. Organizations representing Arctic indigenous communities were admitted as Permanent Participants to the AEPS.

In 1996 the eight Arctic countries signed a declaration establishing the Arctic Council and expanding the mandate of the AEPS to deal with issues of sustainable development. The Council now comprises four environmental working groups:

- Arctic Monitoring and Assessment Program (AMAP);
- Conservation of Arctic Flora and Fauna (CAFF);
- Emergency Prevention, Preparedness, and Response (EPPR); and
- Protection of the Arctic Marine Environment (PAME).

A fifth subsidiary body, the Sustainable Development Working Group (SDWG), was established at the Arctic Council's Ministerial meeting in Iqaluit, Canada, in 1998. There are now six indigenous Permanent Participant members of the Council, including four whose membership comprises Native communities in Alaska. The Permanent Participants sit at the Arctic Council table as equal members and are a source of traditional knowledge for many Council studies.

The U.S. served as the second chair of the Arctic Council in 1998–2000. The Department of State's Office of Oceans Affairs, which represents the U.S. on the Council, housed the Council's secretariat during the U.S. chairmanship. During this time period the Department of State improved the flow of communication among Council members and supported important Council initiatives on environmental protection and sustainable development. The Department of State continues to pursue these goals and remains a leader on the Council after passing the gavel to Finland for 2000–2002. Iceland will assume the chair for the 2002–2004 period.

The Department of State has been a strong supporter of many recent Council initiatives, such as the Arctic Council Action Plan to Eliminate Pollution in the Arctic (ACAP). This program, approved at the 2000 Ministerial meeting in Barrow, Alaska, outlines actions to address some of the pollution threats in the Arctic identified during the first AMAP assessments, such as PCBs, pesticides, and mercury. The Department of State contributed $100,000 from its Environmental Diplomacy Funds (EDF) to EPA's involvement in the Evaluation of Dioxins and Furans in the Russian Federation. A Department of State EDF grant of $420,000 was transferred to NOAA for use on the Arctic Council project on Persistent Toxic Substances, Food Security, and Indigenous Peoples of the Russian North. The Department of State is also assisting in the production of AMAP's updated assessments with $28,000 and has aided participation by Alaskans in the activities of the Arctic Council with $80,000 in funding for travel.

Another initiative strongly backed by the U.S. is the Arctic Climate Impact Assessment (ACIA). With NOAA and NSF leading the way, this comprehensive effort, which has the support of all Council members, will evaluate and synthesize knowledge on climate change, climate variability, and increased ultraviolet radiation and their consequences on the Arctic environment. The final reports are expected in 2004.

In the area of sustainable development, the U.S. focuses on human health in the Arctic. The Department of State, along with the State of Alaska, is coordinating Council members' activities in the area of telemedicine. The Department of State supports the project led by the Centers for Disease Control on emerging infectious diseases in the Arctic, as well as a cord blood study to identify and monitor the level of contaminants to which indigenous people in northern Alaska are subjected. Department of State funding is also provided for health initiatives and ecotourism projects of the Arctic Council. Budgeting for these sustainable development projects over the last two fiscal years totals $100,000.

As coordinator of U.S. policy towards the Arctic Council, the Department of State welcomes input from individuals and agencies interested in participating in the work of the Council or contributing to the knowledge base that underlies the Council's working groups. Interested parties are encouraged to visit the Arctic Council website (www.arctic-council.org). The website lists current and future activities of the Council, as well as the names and addresses of individuals and secretariats related to specific aspects of the Council's work.

Ninth Biennial Report of the Interagency Arctic Research Policy Committee to the Congress

February 1, 2000, to January 31, 2002

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 January 2000.

Activities and Accomplishments

During the period February 1, 2000, to January 31, 2002, the IARPC has:

- Prepared and published the sixth biennial revision to the United States Arctic Research Plan, as required by Section 108(a)(4) of the Act.
- 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 98 and 99 and included summaries of IARPC meetings and activities. The Fall/Winter 2001 issue contained the full text of the sixth 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 $241.9 million in Federal support for FY 2000 and $240.4 million in FY 2001.
- Arranged for public participation in development of the sixth biennial revision to the U.S. Arctic Research Plan as required in Section 108(a)(10).
- Supported continued U.S. participation in the non-governmental International Arctic Science Committee, via the National Research Council.
- Participated in the continuing National Security Council/U.S. Department of State implementation of U.S. policy for 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 the Arctic Council. The Council incorporates a set of principles and objectives for the protection of the Arctic environment and for promoting sustainable development. IARPC supports the contributions being made to projects under the Council's Arctic Monitoring and Assessment Program by a number of Federal agencies.
- Approved coordinated Federal agency research initiatives on 1) the Study of Arctic Environmental Change (SEARCH), 2) Bering Sea Integrated Assessment, and 3) Arctic Health. These initiatives are designed to augment individual agency mission-related programs and expertise and to promote the

resolution of key unanswered questions in Arctic research and environmental protection. The initiatives are intended to help guide internal agency research planning and priority setting. It is expected that funding for the initiatives will be included in agency budget submissions as the objectives and potential value are of high relevance to the mission and responsibilities of IARPC agencies.

- Convened formal meetings of the Committee and its working groups, staff committees, and task forces to accomplish the above.

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Arctic Research Commission

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