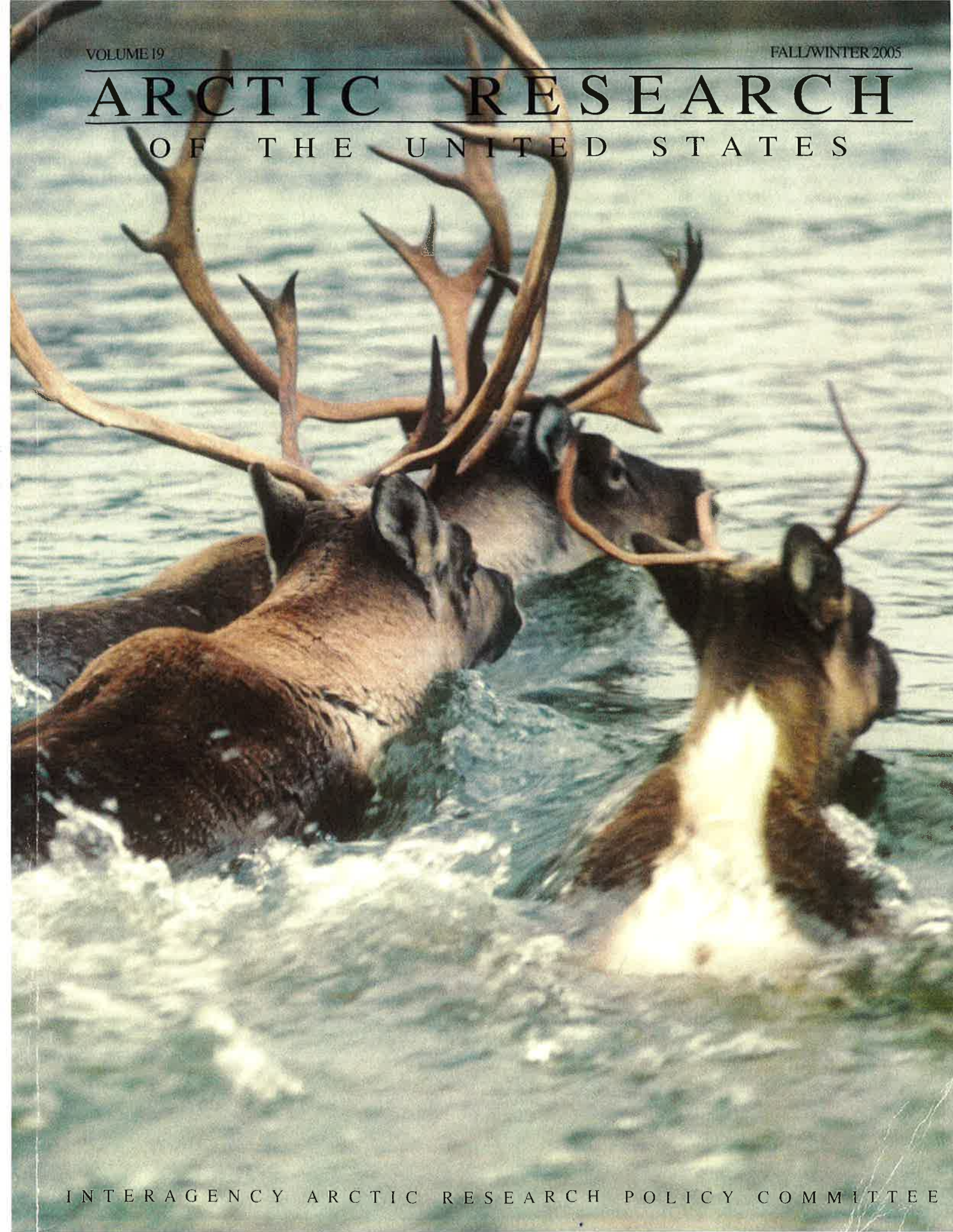


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ARCTIC RESEARCH

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). The Interagency Committee was 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 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

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ARCTIC RESEARCH

OF THE UNITED STATES

INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

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U.S. Arctic Research Plan *Biennial Revision: 2006–2010*

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United States Arctic Research Plan

Biennial Revision: 2006–2010

Introduction

The United States Arctic Research Plan was prepared by the Interagency Arctic Research Policy Committee (IARPC). The Plan is a consensus document that reflects the views of thirteen IARPC agencies. It responds to recommendations of the U.S. Arctic Research Commission and to recommendations of scientists who provided advice to the IARPC agencies.

The Plan includes six special focus multi-agency research programs agreed to by the

Federal agencies and includes multiagency cross-cutting issues such as research support and logistics, facilities, international activities, and data and information. The Plan describes high-priority research needs of the agencies. The Plan also responds to environmental and strategic objectives of U.S. Arctic policy.

The Plan is a living document. In accordance with the Arctic Research and Policy Act, it is revised every two years.

Executive Summary

Background

The United States has substantial economic, scientific, strategic, and environmental interests in the Arctic. As required by the Arctic Research and Policy Act of 1984, as amended (see Appendix E),* a comprehensive Arctic Research Plan is prepared by the Interagency Arctic Research Policy Committee. The President delegated the authority to transmit the report to Congress to the Director of the National Science Foundation on February 17, 2005. Section 109(a) of the Act requires a biennial revision to the Plan. This document updates the Plan and elaborates on the requirements of Section 109(a).

United States research in the Arctic and this biennial revision are governed by U.S. national policy on the Arctic, research goals and objectives agreed upon by the Interagency Committee, and guidance provided by the Arctic Research Commission.

Guiding Vision

It is in the national interest of the United States to support scientific and engineering research to implement its national policy objectives, including:

- Protecting the Arctic environment and conserving its living resources;
- Promoting environmentally sustainable natural resource management and economic development in the region;
- Strengthening institutions for cooperation among the eight Arctic nations;
- Involving the indigenous people of the Arctic in decisions that affect them;
- Enhancing scientific monitoring and research on local, regional, and environmental issues (including their assessment); and
- Meeting post-Cold-War national security and defense needs.

Interagency Coordination

The Arctic Research and Policy Act requires cooperation among agencies of the U.S. Government with missions and programs relevant to the Arctic. It established the Interagency Arctic Research Policy Committee to “promote Federal interagency coordination of all Arctic research activities” [Section 108(a)(9)]. The Interagency Committee, chaired by the National Science Foundation (NSF), continues to provide the mechanism

for developing and coordinating U.S. Arctic research activities.

Revision to the Plan

This revision to the United States Arctic Research Plan includes two major sections. The first presents the Special Focus Interagency Research Programs. For this biennial revision of the Plan, agencies agreed that the following six programs are ready for immediate attention as interagency focused efforts:

- The International Polar Year (IPY)
- Study of Environmental Arctic Change (SEARCH)
- Developing a Research Plan for a Sustainable Bering Sea
- Arctic Health Research
- Research on Resource Evaluation
- Research on Civil Infrastructure.

The second major section is the Agency Programs, which represent the objectives of Federal agencies, focusing on the period covered by this revision (2006–2010). They are presented in seven major categories, and where common activities exist they are presented as collective programs:

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

Since the passage of the Act, the Interagency Committee, the Arctic Research Commission, and the State of Alaska have addressed issues related to logistics support for Arctic research. This revision considers issues related to surface ships and ice platforms; land-based and atmospheric facilities and platforms; coordination; and data facilities.

Budgetary Consideration

Appendix C presents a summary of each agency’s funding for 2006–2010. The total interagency Arctic budget estimate for FY 05 is \$352 million; for FY 06 it is \$312 million. Program descriptions reflect the general direction of agency programs. The data reported here and in the tables in Section 1.2 and Appendix C were compiled from individual program submissions from participating Federal agencies. The information covers expenditures for research but may exclude administrative costs that are included in agency budget source documents.

* Amended on November 16, 1990 (Public Law 101-609); see Appendix E.

1. Introduction

1.1 National Needs, Goals, and Objectives

United States research in the Arctic and this biennial revision are governed by the U.S. Arctic Policy Statement of 1994, the Declaration on Establishment of the Arctic Council, research goals and objectives agreed upon by the Inter-agency Committee, and guidance provided by the Arctic Research Commission.

1.1.1 Guiding Vision

The national interest of the United States requires support of scientific and engineering research to implement its national policy objectives, including:

- Protecting the Arctic environment and conserving its biological resources;
- Assuring that natural resource management and economic development in the region are environmentally sustainable;
- Strengthening institutions for cooperation among the eight Arctic nations;
- Involving the Arctic's indigenous people in decisions that affect them;
- Enhancing scientific monitoring and research on, and assessment of, local, regional, and global environmental issues on Earth and in near-Earth space; and
- Meeting national security and defense needs.

U.S. Arctic research uses the northern polar region as a natural laboratory to study processes that also occur at lower latitudes. Where appropriate, this research is coordinated with the efforts of state and local governments and the private sector. The research is carried out in a manner that benefits from and contributes to international cooperation. Arctic research policy is subject to periodic review and revision. The role of the Arctic in meeting national needs and addressing key policy issues is further highlighted below.

1.1.2 Nonrenewable Resources

The U.S. imports approximately 50% of its petroleum. About 17% of our domestic oil production comes via the Trans-Alaska Pipeline System from the Prudhoe Bay region in Arctic Alaska. The Department of the Interior (USGS and MMS) estimates that at least 36% of the Nation's future

reserves (undiscovered resources) of oil and natural gas liquids lie beneath northern Alaska and adjacent offshore areas. The State of Alaska reports that northern Alaska contains known gas reserves of 30.9 trillion cubic feet (tcf), which is about 18% of the Nation's gas reserve; currently plans are being discussed for a gas pipeline to transport this resource south. Gas hydrate resources exist in Arctic Alaska. The USGS estimates that 98% of these resources occur under Federal waters in the Beaufort Sea. In addition to oil and gas, the Arctic has large coal deposits. The U.S. Arctic has been estimated to contain about half as much coal as the remainder of the United States. However, U.S. Arctic coal production is limited by the lack of infrastructure and will continue to be limited until the energy needs of Alaska grow substantially or Pacific Rim countries provide sufficient impetus for further coal development.

Minerals are also important Arctic resources. The Red Dog lead-zinc-silver mine, north of the Arctic Circle, is one of the largest zinc-producing mines in the world, producing 72% of the U.S. zinc output, according to data from the U.S. Geological Survey. The Arctic shelves also contain mineral deposits. At least one offshore tin mine has been brought into production in Russia. Dredging for sand and gravel on the Arctic Ocean shelves supports hydrocarbon development and other large coastal and offshore construction projects.

1.1.3 Renewable Resources

Arctic and Bering Sea waters support some of the most productive fisheries in the world. The Bering Sea supplies nearly 5% of the world's fishery products. An estimated 4 million metric tons of 43 commercial species are caught every year by fishing fleets from the United States, Russia, Japan, and other nations. Since the passage of the Magnuson Fishery Conservation and Management Act in 1976, American groundfish operations in Alaska have developed into an industry with an annual product value estimated at \$2.2 billion. Dutch Harbor-Unalaska, Alaska, is the leading U.S. port in the quantity of commercial fish landings. Alaska leads all states in both total volume and total value of fish landings.

1.1.4 Global Change

A greenhouse effect occurs on Earth, because its atmosphere of water vapor, carbon dioxide, and other constituents traps outgoing long-wave radiation emitted from the Earth's surface. Without the greenhouse effect, the global surface air temperature would be about 33°C lower. Anthropogenic emissions of greenhouse gases and aerosols and land use changes alter the incoming and outgoing distribution of solar energy that powers weather and climate. Climate model projections of future global distributions of surface air temperature resulting from increased greenhouse gases indicate that the Arctic region will be expected to have a larger warming compared to tropical and marine latitudes (Serreze et al. 2000). (See Section 2.1.)

1.1.5 Social and Environmental Issues

Arctic populations live in close contact with their environment and are highly dependent on marine and terrestrial ecosystems. Contaminants pose a potential threat to the health of Arctic residents who rely on subsistence foods (fish, marine mammals, moose, and caribou). Heavy metals, organochlorines, soot, and other pollutants accumulate at high latitudes because of atmospheric and oceanic circulation patterns and subsequent concentration in food chains and organic soils (Schlosser et al. 1995). The effects of environmental change, including climate changes, can have impacts on Arctic ecosystems, on the response of wildlife to ecosystem productivity, and on the human use of wildlife.

Other issues of importance to Arctic residents include changes such as those resulting from large-scale development and population influx. Many of these changes are positive, such as increased educational and employment opportunities, better medical care, and the use of modern technology. Other changes, such as social and cultural disruption, are a cause for concern. Research addressing the phenomena of rapid social change, human-environment interactions, and the viability of small subsistence-dependent communities sheds light on the complex relationships between environment, economy, culture, and society.

High latitudes are also particularly susceptible to adverse conditions in the space environment, which can disrupt satellite operations, communications, navigation, and electric power distribution grids, leading to a variety of socioeconomic losses. These space environment effects, generally referred to as "space weather," are often associ-

ated with transient phenomena on the sun that may cause geomagnetic storms on Earth.

1.1.6 U.S. Goals and Objectives for Arctic Research

Arctic research is aimed at resolving scientific, sociological, and technological problems concerning the physical and biological components of the Arctic and the interactive processes that govern the behavior of these components. The objectives include addressing the needs for increased knowledge on such issues as using the Arctic as national defense, natural hazards, global climate and weather, energy and minerals, transportation, communications, renewable resources, contaminants, environmental protection, health, adaptation, and Native cultures.

More specific long-term goals have been developed by the Interagency Committee to further guide the revision of the Plan:

- Pursue integrated, interagency, and international research and risk assessment programs for the purpose of managing Arctic risks;
- Continue to develop and maintain U.S. scientific and operational capabilities to perform research in the Arctic;
- Promote the improvement of environmental protection and mitigation technology and the enhancement of ecologically compatible resource use technology;
- Develop an understanding of the role of the Arctic in predicting global environmental changes and perform research to reveal early signals of global changes as manifested in the Arctic;
- Develop the scientific basis for responding to social changes and the health needs of Arctic people;
- Contribute to the understanding of the relationship between Arctic residents and their use of wildlife and how this relationship might be affected by global climate change and transported contaminants;
- Engage Arctic residents, scientists, and engineers in planning and conducting the research and report results to these individuals and the public;
- Continue to document and understand the role of permafrost in environmental activities;
- Advance knowledge of the Arctic geologic framework and paleoenvironments;
- Contribute to the understanding of upper atmospheric and outer space phenomena, particularly their effects on space-borne

- and ground-based technological systems;
- Develop and maintain databases and data and information networks; and
- Develop and maintain a strong technological base to support national security needs in the Arctic.

In addition to these goals and objectives for Arctic research developed by the Interagency Committee, the Arctic Research Commission has provided further guidance for U.S. Arctic research. This revision of the Plan is consistent with these Commission recommendations.

1.2 Budgetary Considerations

The Act does not provide separate additional funding for Arctic research. Agencies request and justify funds for these activities as part of the budget process. Table 1 summarizes each agency's Arctic research funding for the 2004–2006 period. The total interagency Arctic expenditure for FY 05 was \$387 million; for FY 06 it is \$355 million. Appendix C contains a detailed listing of existing Federal agency programs and budgets, divided by major subelements. The Plan contains the detailed agency budgets through FY 06. The data reported here were compiled from individual program submissions from participating Federal agencies. The information covers expenditures for research but may exclude administrative costs that are included in agency budget source documents. Program descriptions may be assumed to reflect the general direction of agency programs.

Table 1. Arctic research budgets by individual Federal agencies (in millions of dollars).

Agency	FY 04 Actual	FY 05 Estimated	FY 06 Proposed
DOD	52.3	50.4	12.9
DOI	52.7	65.4	65.3
NSF	96.2	97.3	95.8
NASA	31.6	35.5	28.7
NOAA	35.8	35.1	36.0
DOE	11.7	15.1	15.1
HHS	29.6	30.5	30.6
SI	0.5	0.9	0.9
DHS/USCG*	21.7	16.8	22.0
EPA	1.3	0.8	0.8
USDA	4.3	4.3	4.3
Total	337.8	352.0	312.3

* Figures for the proposed FY06 budget represent funding required by USCG to operate icebreakers in the Arctic for NSF, which was designated in the President's FY06 budget as the agency to which ice operations funding is transferred.

1.3 Interagency Coordination

The Arctic Research and Policy Act (Appendix E) requires cooperation among agencies of the U.S. Government with missions and programs relevant to the Arctic. It established the Interagency Arctic Research Policy Committee to "promote Federal interagency coordination of all Arctic research activities" [Section 108(a)(9)]. The Interagency Committee, chaired by the National Science Foundation (NSF), continues to provide the mechanism for guiding and coordinating U.S. Arctic research activities. The biennial revisions of the U.S. Arctic Research Plan serve as guidance for planning by individual agencies and for coordinating and implementing mutually beneficial national and international research programs.

Since the last revision of the Plan, significant progress has been made in implementing recommendations, and accomplishments continue to be identified. These include activities of the Interagency Committee and the Arctic Research Commission. Additional information can be found in the journal *Arctic Research of the United States*

(Volume 18, Spring/Summer 2004), published by NSF on behalf of the IARPC.

The Act mandates coordination of U.S. Arctic research programs. Mechanisms for appropriate levels of coordination continue to evolve. Three levels of coordination and cooperation are needed for an effective national Arctic research program:

- Individual agency, and independent investigator, research programs;
- National coordination; and
- International collaboration.

Each element requires a mechanism for internal program development, review, and implementation, and each needs to be linked to the other two. The national effort is performed through the Interagency Committee. A staff oversight group of the Interagency Committee provides coordination, assisted by working groups representing specific agency programs. These are reported in the subsequent sections.

Coordination with global change programs is an integral part of Arctic program development and implementation.

1.4 International Cooperation

The U.S. is now in its sixth year as a regular member of the Arctic Council, since concluding its two-year chairmanship of the Council on October 13, 2000, in Barrow, Alaska. Iceland chaired the Council for the 2000–2004 period and passed the gavel to Russia in 2004. The Arctic Council is an eight-nation forum established in 1996 to bring together, in a senior policy setting, the environmental conservation elements of the former Arctic Environmental Protection Strategy (AEPS) and issues of common concern related to sustainable development. In addition to the eight nations (Canada, Denmark/Greenland, Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States), many of the Arctic's indigenous communities are recognized as Permanent Participants of the Arctic Council.

The Arctic Council is entirely consistent with the objectives articulated in the U.S. Arctic Policy Statement of 1994 and offers an important vehicle for pursuing them. These policy objectives include:

- Protecting the Arctic environment and conserving its living resources;
- Promoting environmentally sustainable natural resource management and economic development in the region;
- Strengthening institutions for cooperation among the eight Arctic nations;
- Involving the indigenous people of the Arctic in decisions that affect them;
- Enhancing scientific monitoring and research on local, regional, and environmental issues; and
- Meeting national security and defense needs.

The United States has been an Arctic nation, with important interests in the region, since the purchase of Alaska in 1867. National security, economic development, human rights, and scientific research remain cornerstones of these interests. At the same time the pace of change in the region—particularly political and technological developments—continues to accelerate, creating interdependent challenges and opportunities for policy makers in Arctic regions.

U.S. Arctic policy reflects these elements of continuity and change. It emphasizes environmental protection, sustainable development, and the role of indigenous people, while recognizing U.S. national security requirements. It also is concerned with the need for scientific research—particularly in understanding the role of the Arctic in global environmental processes—and the importance of inter-

national cooperation in achieving Arctic objectives.

The Department of State's Office of Polar Affairs works in close consultation with the State of Alaska, Alaskan indigenous people, and Alaskan nongovernmental organizations (NGOs) on Arctic issues and policy making. Federal agencies continue to give careful consideration to local Alaskan needs, including the unique health, social, cultural, and environmental concerns of indigenous communities, when developing Arctic programs and policies. Alaskans will continue to be included as appropriate on U.S. delegations to Arctic-related meetings. U.S. Inuit, Aleut, Gwich'in, and Athabaskan populations are now represented as Permanent Participants on the Arctic Council, the Gwich'in and Athabaskans as a result of a ministerial decision in October 2000 in Barrow, Alaska. The Council now has six Permanent Participants, including the Aleut International Association.

The Arctic Council today includes five observer nations (Germany, France, the Netherlands, Poland, and the United Kingdom) with Arctic research and environmental interests. These nations have contributed to the environmental working groups of the Council and stated that they were interested in taking a more active role in the Council's work. In November 2004, a bank, the Nordic Environmental Finance Corporation, became an official Observer and fund manager for a newly created project funding vehicle called the Project Support Instrument.

1.4.1 Environmental Protection

During its chairmanship the U.S. expanded its international cooperation in the area of Arctic environmental protection.

The United States remains fully engaged in the Arctic Council Action Plan to Eliminate Pollution in the Arctic (ACAP), which is focused on dealing with threats identified in the Council's Arctic Monitoring and Assessment Program. The Environmental Protection Agency has provided leadership for an ACAP program to reduce emissions and safely manage and destroy persistent organic pollutants in the Russian Federation.

The National Science Foundation and NOAA provide crucial leadership for the Arctic Climate Impact Assessment (ACIA), in cooperation with the Arctic Monitoring and Assessment Program, and for the Conservation of Arctic Flora and

Fauna (CAFF) Working Group, in cooperation with the International Arctic Science Committee. The U.S. is financing all of the ACIA Secretariat, among other contributions.

U.S. engagement in prevention and remediation activities follows a decade of international cooperation to monitor and assess the levels of environmental pollution. Beginning in 1989, the eight Arctic countries first discussed the need for international cooperation to address environmental protection. In 1991, in Rovaniemi, Finland, they established the Arctic Environmental Protection Strategy (AEPS). In 1996, in Ottawa, Canada, the Arctic Council was created to address issues of sustainable development in the Arctic and to oversee and coordinate the programs previously established under AEPS. This nonbinding effort has primarily operated through four working groups to address environmental issues relevant to the circumpolar area:

- *Arctic Monitoring and Assessment Program (AMAP)*: Assesses the health and ecological risks associated with contamination from radioactive waste, heavy metals, persistent organic pollutants, and other contaminants. Recommends targeted monitoring to collect current data from areas of special concern.
- *Conservation of Arctic Flora and Fauna (CAFF)*: Studies the adequacy of habitat protection and ways to strengthen wildlife protection through an international network of protected areas and more effective conservation practices.
- *Protection of the Arctic Marine Environment (PAME)*: Creates international guidelines for offshore oil and gas development in the Arctic, organizes and promotes the drafting of a regional action plan for control of land-based sources of Arctic marine pollution, and collects information on Arctic shipping activities.
- *Emergency Prevention, Preparedness and Response (EPPR)*: Provides a forum in which participants work to better prevent, prepare for, and respond to the threat of environmental emergencies in the Arctic. Activities include risk assessment and recommendation of response measures.

1.4.2 Sustainable Development

The Arctic Council Declaration describes sustainable development as “including economic and social development, improved health conditions,

and cultural well-being.” Further, the concept of sustainability is reflected in the description of environmental protection, which refers to “the health of the Arctic ecosystems, maintenance of biodiversity in the Arctic region, and conservation and sustainable use of natural resources.”

At the Arctic Council Ministerial meeting in Reykjavik, Iceland, in November 2004, the Sustainable Development Working Group issued a report, *Capacity Building Overview of the Arctic Council*, in both Russian and English, which provides a complete overview of Arctic Council activities.

1.4.3 Scientific Research

The United States continues to plan to further international scientific research through development of an increasingly integrated national Arctic research program. During the U.S. chairmanship the United States took steps to support international cooperation in monitoring, assessment, and environmental research, as well as social science research related to sustainable development. U.S. support for the Arctic Climate Impact Assessment remains a key example of promoting international collaborative research in the environmental sciences and in social science related to sustainable development.

The Interagency Arctic Research Policy Committee, with advice from the U.S. Arctic Research Commission, coordinates Federal efforts to produce an integrated national program of research, monitoring, assessments, and priority setting that most effectively uses available resources. U.S. Arctic policy recognizes that cooperation among Arctic nations, including coordination of priorities, can make essential contributions to research in the region. To this end the Framework Document on Sustainable Development, support for the Survey of Living Conditions in the Arctic, and the AMAP assessment on the state of the Arctic environment provide important tools in influencing future research priorities.

1.4.4 Conservation

The United States works both nationally and internationally to improve efforts to conserve Arctic wildlife and protect habitat, with particular attention to polar bears, walruses, seals, caribou, migratory birds, and boreal forests.

Consistent with the Agreement on Conservation of Polar Bears, the U.S. and Russia signed an agreement in October 2000 to improve conserva-

tion of their shared population of polar bears. The Senate consented to the agreement in July 2003. Several official studies are ongoing, including a study of pollution contamination of seals around two villages in northern Alaska. The U.S. also works to better implement existing measures, such as the 1916 Migratory Bird Treaty and other conservation measures, to mitigate seabird bycatch by commercial fishing vessels.

1.4.5 Cooperation with the Russian Federation

Via the Department of State's Environmental Diplomacy Funds (EDF), the U.S. successfully concluded international projects that assess pollutants in Russia for the benefit of the entire Arctic region. The findings of these projects will have relevance not only in Russia, but in the entire Arctic region. U.S. financial and resource contributions to these projects have helped ensure a strong international presence on issues that ultimately affect our own Arctic inhabitants and ecosystems.

In addition to the broad-based cooperation within the Arctic Council, which, among other things, aids in establishing a more effective environmental regulatory infrastructure in Russia, other multilateral forums now exist to address specialized concerns. Through NATO, we engage the

Russian military on defense-related environmental issues. On a trilateral basis, with Norway, we focus on the cleanup and consolidation of waste generated from military activities through the Arctic Military Environmental Cooperation (AMEC) process. Our support of the International Atomic Energy Agency's International Arctic Seas Assessment Program also has provided a conduit for monitoring and assessing radioactive contaminants in the seas adjacent to the Russian Arctic. In 2003 the United Kingdom became the fourth official member of AMEC.

The former Soviet Union (FSU) had an extensive nuclear power program with numerous supporting waste management activities that involved ad hoc storage of low- and intermediate-level radioactive wastes by shallow land burial and in surface water impoundments, as well as storage of high-level wastes. The Mayak, Tomsk, and Krasnoyarsk sites all lie within a few kilometers of the edge of the West Siberian Plain and Basin. Past and continuing disposal of wastes at Mayak, Tomsk, and Krasnoyarsk to surface waters (for example, the Ob and Yenisey Rivers) and surface water impoundments, and by deep well injections at Tomsk and Krasnoyarsk, have the potential to contaminate the Arctic Ocean, the western Siberian oil and gas fields, and the regional water resources.

1.5 Revision to the Plan

This seventh revision to the United States Arctic Research Plan includes two major sections:

- Section 2. Special Focus Interagency Research Programs; and
- Section 3. Agency Programs.

The Agency Programs section includes discussion of representative programs of Federal agencies, focusing on the period covered by this revision (2006–2010). Examples of programs are presented in seven major categories, and where common activi-

ties exist they are presented as collective activities. Individual agency mission accomplishments were discussed in the Spring/Summer 2004 issue of *Arctic Research of the United States* and will be updated in 2006. Several overall themes transcend essentially all integrated and research mission components.

Section 4 presents current activities related to field operational support necessary for implementation of the proposed interagency programs and research mission activities.

2. *Special Focus*

Interagency Research Programs

The Interagency Committee's research policy states:

The IARPC agrees that a more comprehensive approach to funding of research and baseline programs is required to ensure a long-term, viable research and development presence in the Arctic. This presence will ensure support of the national needs, which include renewable and nonrenewable resource development, environmental protection, and partnerships with the private sector and residents of the Arctic. It will complement other national and international scientific programs, such as Global Change. To this end the IARPC agencies agree to develop an integrated interagency program sufficient for meeting national needs.

For this biennial revision of the plan, agencies agreed that the following six programs are ready for immediate attention as multiagency focused efforts:

- The International Polar Year (IPY)
- Study of Environmental Arctic Change (SEARCH)
- Developing a Research Plan for a Sustainable Bering Sea
- Arctic Health Research
- Research on Resource Evaluation
- Research on Civil Infrastructure.

These coordinated, multiagency programs are being designed to:

- Focus research activities in concert with national policy;
- Build on individual agency efforts in reconnaissance, monitoring, process studies, and modeling;
- Facilitate research and logistics coordination through regionally focused programs;

- Take maximum advantage of remote sensing and new technologies;
- Strengthen interagency data and information management;
- Draw on the strengths of the academic, industrial, and government research communities in planning and implementing programs;
- Support and enhance programs to acquire long-term measurements of key parameters and environments; and
- Enhance international research collaboration.

The U.S. has a substantial economic, strategic, and environmental stake in the Arctic. Domestic energy reserves and the growth in Bering Sea fisheries harvests are two examples of our dependence on Arctic resources. Sound management decisions for sustainable development of Arctic resources hinge on enhanced understanding of the environment, leading to better forecasts. In addition, there is a strong international commitment to collaborate.

Benefits to the Nation from Arctic research include improvements in:

- Knowledge of fishery resources and controlling dynamics;
- Models and data for assessing past climates and global change and their effects;
- International cooperation in a strategic region;
- Forecasts of weather, ice, and ocean conditions;
- Protection of the Arctic environment;
- Understanding of the causes, effects, and limits of air and water pollution; and
- Protection and understanding of cultures and cultural resources.

2.1 The International Polar Year: 2007–2008

The years 2007–2008 will mark the 50th anniversary of the International Geophysical Year (IGY) and of the third International Polar Year. This period has been designated the fourth International Polar Year (IPY) by the National Academies of Sciences (NAS), the International Council for Science (ICSU), the World Meteorological Organization (WMO), the Antarctic Treaty System and its adhering nations, the Arctic Council, and many other international organizations. The National Science Foundation (NSF) was designated by the President's Office of Science and Technology to be the lead U.S. agency in organizing IPY activities.

Preparations are underway worldwide to make the IPY a period of intense activity that promises, in the words of the NAS publication *A Vision for the International Polar Year 2007–2008*, to “further our understanding of physical and social processes in the polar regions, examine their globally connected role in the climate system, and establish research infrastructure for the future, (and) ... serve as a mechanism to attract and develop a new generation of scientists and engineers with the versatility to tackle complex global issues” (see <http://books.nap.edu/catalog/11013.html>).

The 1957–1958 IGY and IPY activities greatly increased our knowledge of the world around us and provided profound legacies that continue to benefit research and researchers today. These activities also resulted in the 1959 Antarctic Treaty, which “promotes international scientific cooperation including the exchange of research plans and personnel and requires that results of research be made freely available.” The U.S. played a leading role in shaping and implementing the 1957–1958 IGY activities and plans to do so again in 2007–2008. IPY activities planned for this period are consistent with agency missions and the NAS report of an implementation workshop (*Planning for the International Polar Year 2007–2008: Report of the Implementation Workshop*, <http://books.nap.edu/catalog/11110.html>). U.S. activities during IPY 2007–2008 will focus on research, education, and public outreach efforts and will be coordinated among the Federal agencies and international partners that support research in polar regions.

The following is a discussion of Federal agency planning for the International Polar Year.

2.1.1 National Science Foundation

International science years of the past, including IPY 1882–1883, IPY 1932–1933, and the International Geophysical Year of 1957–1958, provided bursts of internationally coordinated research that led to significant discoveries about our planet and left a long-term legacy of data and observations for future generations. In particular, the IGY of 1957–1958 brought a tremendous increase in our ability to predict weather worldwide, to measure the thickness of the Antarctic ice sheets, and to understand the dynamics of Earth's magnetosphere. However, there are still significant gaps in our understanding of the polar regions and the processes that structure polar environments. For example, the factors in the Arctic that are responsible for increasing surface air temperature and decreasing sea ice cover are poorly understood. In the Antarctic, little is known about why a portion of the West Antarctic ice sheet is rapidly melting, thinning, and retreating, thereby contributing to global sea level rise. In both polar regions, many organisms are adapted to withstand prolonged periods of darkness and extreme cold, yet we do not understand how these adaptations evolved or how these organisms may respond to increased variability in the polar environment.

The NSF views IPY 2007–2008 as offering the potential for scientific advances of global importance comparable to those achieved in the previous IPYs. NSF is poised to support the IPY in a variety of ways and will emphasize three major research areas in an Announcement of Opportunity due to be released in the late summer of 2005. These areas of emphasis are compatible with the guidelines developed by ICSU and the U.S. National Academies. They have evolved within the research community as high-priority topics derived from workshops and existing science programs. Education and outreach are also areas where NSF, with its partners in other agencies, can make a significant impact on the understanding of how polar regions influence society and the global environment. Thus, NSF has a particular interest in conducting activities in the polar regions that will leave a lasting legacy of data, observing capabilities, and educational resources for scientists and educators of the future.

Within NSF, the Office of Polar Programs (OPP)

is committed to implementing these activities with the assistance of the research and education directorates. Partnerships for IPY will occur at many levels—within NSF, through interagency collaborations, and in the international arena. The NSF directorates that have expressed interest include Biological Sciences (BIO), Computer and Information Sciences and Engineering (CISE), Education and Human Resources (EHR), Engineering (ENG), Geosciences (GEO), Mathematical and Physical Sciences (MPS), and Social, Behavioral and Economic Sciences (SBE). Federal agencies such as NOAA, NASA, NIH, USGS, DOE, EPA, and the Smithsonian Institution, as well as national science agencies of other countries, have closely related interests. Thus, maximizing the value from partnerships is a key overarching theme for NSF as we plan for IPY.

The following are areas where NSF will play a significant role in IPY.

Study of Environmental Arctic Change

SEARCH is a broad interdisciplinary, multi-scale interagency program with the core goal of achieving a predictive understanding of recent and ongoing changes in the Arctic environment. In addition to understanding how changes in the Arctic are interrelated, SEARCH will investigate the links between Arctic change and global processes and will assess the impacts that Arctic change may have throughout the Northern Hemisphere. SEARCH will evaluate the possibility that observed changes in the Arctic can be used to anticipate changes elsewhere on the globe.

For the period of the IPY (2007–2008), NSF's principal interest related to SEARCH is the implementation of an Arctic Observing Network (AON). The purpose of AON will be to understand environmental change in the Arctic system and its interplay with global oceanic and atmospheric circulation. AON will employ an Arctic-wide coverage of standard integrated measurements, long-term observations, and modeling and analysis. Development of the AON system by U.S. scientists will be closely coordinated with related efforts being planned by the EC and a number of other nations. The combined international effort will result in a substantial increase in our ability to monitor and study change in the Arctic.

Research related to the Bering Ecosystem Study (BEST) is also under consideration. The Bering Sea supports one of the most productive fisheries in the world, contributing about 40% of all finfish and shellfish landings in the U.S., yet

it is one of the least-studied areas of U.S. waters. In recent years, it has become evident that this seasonally ice-covered sea is subject to decadal changes in climate that have resulted in abrupt and unexpected changes in the ecosystem. Of particular concern is the possibility that the combined effects of climate change and fisheries removals may shift marine ecosystems into alternate stable states that may have a lower yield of species valuable to people. Identifying the mechanisms driving ecosystem change, including social and cultural factors, in the Bering Sea is a key research need.

Ice Sheet Stability, Dynamics, and History

The global ice sheets are dynamic features that contain unprecedented records of climate over the past several hundred thousand years. Future changes in the ice sheets of both polar regions will affect sea level, and this is one of the major uncertainties in Intergovernmental Panel on Climate Change (IPCC) climate models. In Antarctica, NSF expects to emphasize studies of the stability and history of the major ice sheets. How do they work, how fast are they changing, and what will they be like in the future decadal-to-century time frame? Inquiry into these questions involves direct studies of ice sheet dynamics but also includes work to understand processes important for interactions of ice sheets with the lithosphere, oceans, and atmosphere. The combination of space-based and surface-based studies is critical to success in this area.

A comparison of the dynamic behavior of the Antarctic and Greenland ice sheets is also a potential topic of IPY research. One component of this comparative work may include obtaining a high-temporal-resolution ice core in West Antarctica for comparison with the climate records obtained from the Greenland ice cores. There will likely be an opportunity to leverage logistics support to the ice-core camp with support for other ground-based activity in West Antarctica and to couple detailed ground- and space-based observations. The work in West Antarctica might include traverse-based studies, or other types of work that will be possible from our logistical hubs, that could be linked to related work in East Antarctica as well as a study of change in the Ross Sea region.

Because of the long lead time required for developing and implementing ice coring programs, NSF is also looking at the IPY as an avenue to create an international collaborative framework to facilitate international ice coring projects beyond

the IPY. The Center for Remote Sensing of Ice Sheets (CReSIS), a Science and Technology Center led by the University of Kansas and supported jointly by NSF and NASA, will conduct and foster multidisciplinary research that will result in technology and models necessary to achieve a better understanding of the mass balance of the polar ice sheets (e.g., Greenland and Antarctica) and their contributions to sea level rise. The focus areas for CReSIS relate closely to the goals of IPY.

NSF-supported studies of ice sheet stability, dynamics, and history will be conducted in close coordination with related work supported by NASA, the British Antarctic Survey, the Institute Polaire Emil Victor (France), and other nations.

Frontiers in Polar Biology: Life in Extreme Cold and Prolonged Darkness

Ecologically important biogeochemical processes begin before the traditional operational season in polar regions and continue beyond the end of the traditional field season. Living organisms are known to continue functioning at temperatures well below freezing and during periods of prolonged darkness. New technologies (genomics, proteomics, etc.) offer the opportunity to gain a deep understanding of how organisms have adapted to these extreme environments. The Long Term Ecological Research (LTER) sites at Toolik Field Station in Alaska, at Palmer Station on the Antarctic Peninsula, and in the McMurdo Dry Valleys, as well as research platforms operating the Arctic and Southern Oceans, offer the opportunity to bring these new technologies to bear in research on the polar regions. A recent NAS report, *Frontiers in Polar Biology in the Genomics Era* (<http://books.nap.edu/catalog/10623.html>), describes some potential research benefits of these new tools. Within NSF, there is interest in OPP and in the Biology and Geology Directorates in this area of research. OPP has examined the technical feasibility of extending Antarctic operations into the austral fall and early winter and may be able to implement such capability by 2007. Supporting winter work elsewhere in the polar regions will require evaluation of options on a case-by-case basis.

Education and Outreach

The Office of Polar Programs has maintained strong support for linking research in the polar regions with formal education and outreach to the public. NSF has fostered U.S. scientists' interests in sharing their research with broad audiences. Many polar researchers have been successful in

seeking support from education programs for more directed efforts, such as NSF's IGERT and GK-12 programs, as well as Arctic Research and Education and Geosciences Education. Strong international partnerships in educational activities have developed in association with research programs in both polar regions. In the Arctic, such partnerships include U.S. collaboration with groups from Russia, Greenland, Iceland, Canada, Denmark, Norway, Sweden, and Finland. In the Antarctic, partnerships include U.S. collaborations with many nations that participate in the Scientific Committee on Antarctic Research (SCAR).

OPP sponsored a workshop in June 2004 (www.ldeo.columbia.edu/~mkt/PolarED_Web.htm) to bring together educators, researchers, media and museum outreach experts, agency representatives, and others to discuss effective mechanisms to conduct education and outreach in support of the IPY. The workshop highlighted many of the education and outreach efforts that have already been supported by NSF, including Teachers Experiencing Antarctica and the Arctic (TEA), Teachers and Researchers Exploring and Collaborating (TREC), Antarctic Artists and Writers Program, various journalists in the field, museum exhibits, and Research Experiences for Undergraduates (REU). The NSF Education and Human Resources Directorate (EHR) has been a key partner with OPP in many of these efforts and will play a key role in developing educational programs for IPY. The NSF Office of Legislative and Public Affairs will develop an agency-wide outreach effort and will provide coordination for multiagency outreach.

EHR plans to build on the fascination of students with the remote polar regions to enhance their interest in science and engineering careers with the aid of educational materials developed in connection with IPY research. Other agencies, such as NASA and NOAA, have robust polar research and education programs interested in supporting IPY efforts. NSF is developing the foundation for international and interagency partnerships to bring together support and expertise from the community of researchers and educators. Another area where NSF can have a significant IPY impact is in research on distance education, both in terms of technology and in terms of the science of learning as it applies to different cultures. The aim of these efforts is to develop highly visible, long-lived education and outreach products for IPY research and to provide opportunities for educating the next generation of polar researchers, the public, and policy makers.

Data Management

Archival and distribution functions for data required for support of Arctic and Antarctic IPY research are distributed among all the U.S. national data centers. These data are held in global archives at the National Climatic Data Center (NCDC) (climatology and meteorology), at the National Oceanographic Data Center (oceanography), at the National Geophysical Data Center (seismology, geomagnetism, marine geology and geophysics, solar and ionospheric studies, ecosystems, topography, and paleoclimatology), and at the National Center for Atmospheric Research (upper atmosphere and ionospheric studies). For example, data sets for a vast array of cryosphere-specific variables in the Arctic (sea ice, snow cover, permafrost, etc.) are archived and distributed through the National Snow and Ice Data Center (NSIDC) and the World Data Center for Glaciology in Boulder, Colorado (<http://www.ngdc.noaa.gov/wdc/>). These also include satellite-derived measurements, in situ observations, and ancillary information from the Antarctic and the Arctic that have been supported by NASA, NOAA, and NSF. NOAA/NESDIS/NCDC in Asheville, NC, holds the global satellite data archives for polar-orbiting satellites.

For data management, a new focus on "Virtual Observatories" is being developed and promoted by the "Electronic Geophysical initiative Year" (<http://www.eGY.org>). As more researchers provide their data on individual or institutional web or FTP sites, rather than submitting to data centers, the current "push data" approach (where the data must be submitted to the National and World Data Centers System) is now becoming more difficult to implement. Therefore, the worldwide data management community is focusing on providing more effective access to globally distributed data sets via the "pull data" concept. The eGY group and the ICSU World Data Centers Panel are working toward a convergence of data centers into "data clearinghouses," while the Virtual Observatories are developing a network of interconnected data holdings and retrieving/visualizing software that constitutes the worldwide "data fabric." NSF is supporting the concept of Virtual Observatories as a means of managing relevant data for IPY.

Other Areas of IPY Research

In addition to large-scale projects such as those mentioned above, NSF plans to support IPY activities that address the ICSU and NAS guidelines in a broad spectrum of areas, particularly

research that addresses opportunities in the social sciences, systematic and biotic diversity surveys (e.g., the ongoing Census of Marine Life), implementation of observing systems, and research in the Southern Ocean on the transport and fate of nutrients and carbon.

One example of research in the social sciences is the study of endangered languages in Arctic cultures, where we have the opportunity to create a legacy of knowledge that will inform future generations of scholars while at the same time strengthening local cultures. The Documenting Endangered Languages (DEL) program is a multi-year funding partnership between NSF and the National Endowment for the Humanities (NEH) to support projects to develop and advance knowledge concerning endangered human languages. This program is made urgent by the imminent death of an estimated half of the 6,000–7,000 currently used human languages. Working with the SBE Linguistics Program, the OPP Arctic Social Sciences Program has identified DEL as a natural IPY project. The unfortunate situation of the estimated 52 Arctic indigenous languages is no exception to the international prognosis. Following the first DEL Announcement of Opportunity, over 10% of the proposals were to research Arctic languages, and the DEL Management Group anticipates that over 10% of the recommended proposals will be for research in the Arctic region. NSF and NEH have agreed to funding for DEL for three years, with an evaluation and possibility for renewal in 2008, during the IPY. The IPY provides an opportunity to bring publicity and resources to the pressing issue of endangered languages in the Arctic.

With regard to the implementation of observing systems, the National Ocean Partnership Program, through the Ocean-US office, is pursuing the establishment of an Integrated Ocean Observatory System (IOOS). The IOOS is planned to include three "Regional Associations" in Alaska, including the Chukchi Sea and North Slope, Bering Sea, and northeast Pacific. NSF is working with the National Oceanic and Atmospheric Administration and local groups to identify and support these regional associations. NSF is working with the research community in Barrow, Alaska, to develop a plan for a major observatory to be located in that community, with an emphasis on research that contributes to SEARCH and other high-priority Arctic programs. To enable the IOOS and to provide for a new generation of polar research, NSF is committed to supporting work in developing and

deploying novel instrumentation. New work is especially needed in chemical and biological sensors (for example, for studies of nutrients and plankton). In addition, a new set of platforms must be developed for making and transmitting observations from under the ice pack, including both gliders and autonomous underwater vehicles. Finally, NSF will be deploying the first shore-based polar observatory off Palmer Station in January 2006 and is confident that this experience will be invaluable in planning other polar coastal observatories.

Logistics Support

Arctic and Antarctic Research Support and Logistics are supported through logistics contracts and other agreements. These support contracts provide a flexible mechanism that is capable of supporting a wide range of potential science and educational activities. NSF also works with the U.S. Coast Guard, NOAA, the University–National Oceanographic Laboratory System (UNOLS), the Canadian Coast Guard, and others to provide shipboard facilities for marine research in both polar regions. Other support is available in the Arctic through a cooperative agreement with the Barrow Arctic Science Consortium (BASC) in Barrow, Alaska, to provide research support and logistics for researchers working on the North Slope of Alaska and a cooperative agreement with the Institute of Arctic Biology at the University of Alaska Fairbanks to support operation of the Toolik Field Station, an NSF LTER site. Cooperation with other national polar research programs offers an avenue for supporting international projects.

One aspect of logistics support that is being explored is the feasibility of supporting year-round research or extending the research season at more locations in the polar regions than are now set up to do so. (South Pole, McMurdo, Palmer, and Summit are staffed for year-round research, plus there are remote sensors operating year-round at a variety of locations.) Year-round research and research in remote areas is complicated and expensive to execute, yet it is necessary to provide adequate spatial and temporal coverage to address research questions. Evolving technology has made it possible to collect many measurements remotely through instrumentation or the use of remotely operated vehicles. There are many improvements to be made to the technology to ensure consistency of data collection under extreme conditions and make use of renewable

energy sources. Sensors could be integrated into a network that uploads data via satellites in real time. Upgrades and improvements of existing infrastructure include improvements in the information technology infrastructure at research hubs such as Barrow, Alaska; development of unmanned sensor networks in the Arctic and Antarctic; development of remote power for sensors, particularly using renewable resources; and improvements in field research facilities (e.g., laboratory space and equipment, living quarters, communications, and safety).

2.1.2 Department of Energy

DOE is planning to support the IPY in a variety of important ways through the Atmospheric Radiation Measurement Program and the Climate Change Prediction Program.

Atmospheric Radiation Measurement Program

The ARM Program will continue its year-round operation at the North Slope of Alaska (NSA) site. This site is providing data about cloud and radiative processes at high latitudes. These data are being used to refine models and parameterizations as they relate to the Arctic. The NSA site is centered at Barrow and extends to the south to the vicinity of Atkasuk and to the east to Oliktok Point. DOE will also support IPY-related proposals to conduct experiments using either the NSA site and/or the ARM Mobile Facility.

Climate Change Prediction Program

The CCPP will continue research to develop coupled climate models. The CCPP is developing ocean and sea ice models that are components of the Community Climate System Model (CCSM). In addition to coupled climate simulations, researchers apply the ocean and sea ice models to a variety of ocean and sea ice problems, including eddy-resolving ocean simulations, studies of the thermohaline circulation, and polar ice feedbacks. CCPP also supports analyses of the causes and consequences of biases in the mean climate and circulation of the Arctic.

2.1.3 National Oceanic and Atmospheric Administration

NOAA will be supporting the IPY through programs involving exploration, observations, prediction and modeling, and data, outreach, and decision support.

Ocean Exploration in Polar Regions

NOAA's Office of Ocean Exploration (OE) plans to support multiple projects in both the Arctic and Antarctic in conjunction with the IPY. OE expects to solicit specific projects for the IPY via Federal Register announcements in calendar years 2005, 2006, and 2007. Ocean Exploration, together with the Arctic Research Office of NOAA and the Russian Academy of Sciences, will facilitate an expedition to the Pacific Arctic in 2008, as part of the ongoing RUSALCA (Russian–American Long-term Census of the Arctic) program.

Causes and Impacts of Recent Changes in the Pacific Arctic

Unprecedented minima of sea ice area have occurred in the Pacific Arctic during the three most recent summers. Summer 2003 and 2004 brought record forest fires and drought to eastern Siberia and Alaska after a decade of warm spring-time temperature anomalies. In surrounding seas there has been a northward shift of ice-dependent marine animals, with pelagic species such as pollock favored over bottom-feeding flatfish. Many Pacific Arctic changes are continuing, despite the observation that climate indices such as the Arctic Oscillation were negative or neutral for six of the last nine years. The Pacific Arctic may be having a larger role in shaping the persistence of Arctic change than has previously been recognized. NOAA will work with its partners to carry out expeditions in this area to gather observations about ecosystem indicators of climate change and to set up systems to monitor these changes in the environment over space and time.

International Arctic System for Observing the Atmosphere

A system of strategically located, long-term Atmospheric Observatories will be developed around the Arctic to carry out both routine measurements made at meteorological stations and intensive measurements at the surface and through the depth of the atmosphere. Measured quantities can include solar radiation, aerosols, air chemistry, trace gases, cloud properties, water vapor, ozone, temperatures, winds, precipitation, surface albedo, and stratospheric properties. The Atmospheric Observatory partnership includes the United States, Canada, Russia, Norway, Finland, and China.

Polar Stratospheric Ozone Depletion Observations

As a part of the International Geophysical Year

in 1957, column ozone measurements were initiated at South Pole, Antarctica, using Dobson spectrometers. In 1985 the annual stratospheric ozone depletion over Antarctica—the “Antarctic Ozone Hole”—was identified. In less than five years it was proven that the ozone hole was caused by human-emitted fluorochlorocarbons (CFCs), and the ozone hole has become a globally recognized “poster child” for showing how humans can cause global-scale changes.

The Arctic stratospheric ozone changes, though lesser in magnitude than the Antarctic ozone hole, are by no means of lesser importance. Key studies will be undertaken in the Arctic to monitor these changes.

Short-term Arctic Predictability

The STAP study will explore the variability and associated predictability of weather, sea ice, ocean wave, and land surface processes in the Arctic region in the 3- to 90-day time range, with special emphasis on improving forecast guidance for high-impact events in the 3- to 14-day lead time range.

Advances in Satellite Products and Their Use in Numerical Weather Prediction

Spatially comprehensive observations of the atmosphere in the data-sparse polar regions significantly and positively impact high-latitude numerical weather predictions. In addition, errors in model forecasts for the high latitudes often propagate to the mid-latitudes, implying that improvements to high-latitude forecasts will result in better mid-latitude forecasts. These findings provide the motivation to improve our ability to measure the state of the polar regions with satellites and to expand the use of these data in numerical weather prediction systems.

Arctic Climate Modeling

The general goal of this project is to improve predictions of the Arctic environment on time scales ranging from seasonal to climate change. Thus, NOAA's research will focus on analyzing and modeling the physical processes and teleconnections between the Arctic and the rest of the globe.

Arctic System Reanalysis

A concerted effort during the IPY to construct pan-Arctic atmosphere–ocean–ice–land data sets, and to assimilate and enhance these with a high-resolution (coupled) reanalysis system optimized for the Arctic region, will provide researchers with

an unprecedented description of the Arctic environment over the past several decades. The operational analysis system (post-2008), expected to be a legacy of this activity, would provide constantly updated depictions of the Arctic environment and would foster improved short- and medium-range weather forecasts as well as seasonal climate outlooks. Improved understanding of Arctic climate processes resulting from the development of the ASR will lead to better global climate models, in turn reducing uncertainty in projected future climate states of the Arctic. The ASR will also serve as a vehicle for diagnostic evaluation of ongoing changes in the Arctic system.

NOAA's Data, Information, and Change Detection Strategy for the IPY

NOAA's fundamental data management responsibilities will be to securely archive IPY data sets and ensure that these and other relevant polar data are easily accessible for current and future users. NOAA will utilize the existing World Data Center (WDC) System and NOAA National Data Centers (NNDC) to serve as a clearinghouse and facilitator for data-management issues and will work with IPY participants to ensure that ICSU/WMO IPY Data Committee guidelines are followed. NOAA will also ensure that international standards such as the Open Archival Information System Reference Model and the ISO19115 metadata standards are met.

NOAA intends to build and maintain a pan-Arctic view of climate variability and change that will serve decision makers with information products. These range from baseline atlases against which future assessments can be carried out, to the Near Realtime Arctic Change Indicator web site, where information on the present state of Arctic ecosystems and climate is given in historical context.

Decision Support

The cornerstone of NOAA's Regional Climate Decision Support program for Alaska and the Arctic is to establish an integrated program spanning stakeholder-influenced research and development of decision support tools for the sustained delivery of customer services.

This includes establishing in Alaska a Regional Integrated Sciences and Assessment (RISA) and a Regional Climate Center (RCC) with formal liaisons to NOAA's National Weather Service and the State Climatologist Office to foster the growth of climate services.

2.1.4 Department of State and Department of Health and Human Services

Arctic Human Health Initiative

The AHHI will advance the joint research agenda of the Arctic Council, an eight-nation intergovernmental forum for sustainable development and environmental protection, in the areas of infectious disease monitoring, prevention, and response; the effects of anthropogenic pollution, UV radiation, and climate variability on human health; and telehealth innovations. Specifically, the leaders of these research programs will build on their years of circumpolar collaboration to extend the International Circumpolar Surveillance network of hospitals and public health facilities into Russia and include additional infectious diseases of concern, to continue monitoring contaminants in human blood and tissues to reveal temporal and spatial trends and to combine experiences from the rapidly expanding disciplines of biomarker research and molecular epidemiology with these monitoring programs, and to extend circumpolar cooperation on telehealth, particularly to Arctic regions in the Russian Federation. In addition, the AHHI will draw on the outstanding leadership of the Arctic Council member states' national and international research programs in the areas of human genomics, hypothermia/hibernation, and health impacts of climate change (including the spread of zoonotic and arboviral diseases in the Arctic).

The Fogarty International Center (FIC) of the National Institutes of Health (NIH), as the designated DHHS lead in the Arctic Council and the Interagency Arctic Research Policy Committee (IARPC), plans to collaborate with other NIH institutes and DHHS agencies to pursue these priorities as well as to actively explore other opportunities for trans-NIH and interagency collaboration (e.g., with NSF, NASA, etc.), such as mental health. For example, FIC is working with the National Institute of Mental Health (NIMH), the Substance Abuse and Mental Health Services Administration (SAMHSA), and others to plan a symposium focusing on suicide prevention in the Arctic as part of the next conference of the International Association of Suicide Prevention, which will take place in Durban, South Africa, in September 2005. It is expected that the outcomes of the symposium will provide input for the 13th International Congress on Circumpolar Health, to be held in

Novosibirsk, Russia, in June 2006 as a “Gateway to IPY.”

The AHHI steering group, led by the U.S. Centers for Disease Control and Prevention, will work with the International Union for Circumpolar Health (IUCH), the FIC, and other partners to develop a program of outreach and public education focused on the promotion of good health for Arctic residents and better integration of the findings of Arctic health research. The IUCH will make its triennial congress in 2006 available to facilitate IPY health activities and its congress in 2009 to underscore the health legacy of IPY.

2.1.5 U.S. Geological Survey

The U.S. Geological Survey serves the U.S. by providing reliable scientific information to:

- Describe and understand the earth;
- Minimize loss of life and property from natural disasters;
- Manage water, biological, energy, and mineral resources; and
- Enhance and protect our quality of life.

The USGS intends to participate in the IPY through extension and enhancement of programmatic activities in research, assessment, and monitoring in the polar regions that support the scientific mission of the organization and address the themes and goals of the IPY. These activities span biology, geology, hydrology, geography, and information sciences and will include five themes: status, change, global linkages, new frontiers, and unique vantage point.

Theme 1. Status

- Research and monitoring of status and distribution of fish, wildlife, and vegetation;
- Determination of species at risk;
- Permafrost evaluation, including assessment of thermal regime, organic carbon characteristics, and distribution;
- Evaluation of hydrologic inputs, including the influence of large river deltas, snow- and water-borne contaminants, and freshwater inputs; and
- Evaluation of surficial and geochemical processes in understanding the changing polar environment.

Theme 2. Change

- Integrated monitoring for assessing regional changes in carbon cycle of Arctic watersheds;
- Extension of current ground and satellite-

based monitoring of glaciers and icecaps for volumetric changes and monitoring of thermal changes in permafrost;

- Reconstruction of past climate and evaluation of current changes from sediment and ice cores;
- Monitoring and assessment of changes in rates of coastal erosion and surficial process; and
- Evaluation of changes in the status and distribution of circumpolar vegetation, fish, and wildlife (including invasive species) and freshwater discharges in the Arctic.

Theme 3. Global Linkages

- Evaluation of the nature of Arctic and boreal hydrologic interactions and the relationships between climate and plant growth, productivity, permafrost depth, and resulting effects on nutrient availability and heat source and sinks; and
- Evaluation of the potential for methane hydrate decomposition in a regime of Arctic warming.

Theme 4. New Frontiers

- Development of a micro-seismicity array in the Antarctic South Pole quiet sector for high-resolution studies of the earth's interior;
- Establishment of an absolute geomagnetic observatory at South Pole for long-term time series observations of variations in the earth's magnetic field; and
- Studies of extremophile interactions in polar geochemical and nutrient cycles.

Theme 5. Unique Vantage Point

- Establishment or extension of permanent monitoring infrastructure for permafrost, global seismicity, and geomagnetic activity;
- Assessment of energy resources in the circum-Arctic area, including oil, gas, coalbed methane, and methane hydrates; and
- Production of geospatial data to include high-resolution mapping and digital aerial photography and the structuring of all data in a geospatially referenced knowledge management system as an element of the USGS's Natural Science Network.

2.1.6 National Aeronautics and Space Administration

NASA's contributions to IPY likely will involve ongoing activities (operating satellites, continuing

ground networks, scientific research, and communication/education/outreach), some episodic activities (satellite snapshots and field campaigns), new efforts related to the development and deployment of suborbital capabilities (aircraft and unmanned aerial vehicles), and coordination of remote sensing observations with in situ measurements supported both by NASA and other agencies, primarily the National Science Foundation. New opportunities associated with the President's Vision for Space Exploration initiative are also likely, particularly related to human-robotic interactions and concepts of operations in polar regions as analogs for planetary settings. In addition, NASA plans to land the first openly competed Mars "scout" mission (PHOENIX) near the north polar ice cap of the planet Mars during the IPY as part of its ongoing campaign to understand the potential habitability of Mars as well as the polar climate on the red planet. Furthermore, NASA is also interested in the polar regions of the Moon as potential human exploration sites and will be undertaking orbital reconnaissance of these regions using a new array of remote sensing instruments as part of the 2008 Lunar Reconnaissance Orbiter (LRO) Mission in 2008–2010, during the IPY. These planetary polar activities naturally dovetail with those being planned and coordinated by other Federal agencies and offer unique opportunities for investigating the unique aspects of Earth's polar regions during the IPY in a comparative planetary framework.

Currently, NASA operates 20 satellites that collect information about the polar regions. The Ice Cloud and Land Elevation Satellite (ICESat) was specifically designed to measure changes in the elevation of Earth's great ice sheets and the ice sheet processes that are manifest in the surface topography in unprecedented detail. In addition, the mission has revealed new information about recent thickness characteristics of sea ice in the entire Arctic and Antarctic regions. Upcoming Earth orbital missions such as Cloudsat and Calipso will provide three-dimensional information on the structure of Earth's atmosphere, and, as with all near-polar-orbiting satellites, coverage will be at a maximum in the polar regions. Other polar aspects of the Earth system, such as storage and fluxes of freshwater and carbon, ocean biology, land cover and land use change, etc., are also being addressed by ongoing missions and scientific research.

NASA has demonstrated success in the past in developing comprehensive polar observations through international collaborations with the

Canadian Space Agency (CSA) to carry out the Antarctic Mapping Mission and the Arctic Snapshot of Arctic sea ice characteristics at very high spatial resolution using microwave remote sensing methods (i.e., SAR). NASA expects to continue to develop these international efforts through a coordination of activities with its colleagues at space agencies in other countries.

NASA is also implementing polar-oriented missions that reach beyond Earth, including the PHOENIX Mission that will land near Mars's North Pole in 2008, the Lunar Reconnaissance Orbiter that will map lunar polar regions for the first time starting in 2008, and the Mars Reconnaissance Orbiter (MRO) that will explore Martian polar regions in three dimensions from Mars orbit. Polar analogs in Mars exploration are vital; for instance, scientists have used Earth's polar regions to simulate aspects of Mars for over 30 years. As an example, the Dry Valleys of Antarctica are the best "Mars analog" known on Earth, in terms of basic physical processes. The ASTEP Program (astrobiology) uses polar activities in Antarctic, Axel Heiberg, Svalbard, and Siberia, and in the future potentially Iceland.

NASA efforts for the IPY are envisioned to focus on:

- Understanding of polar feedbacks in the Earth system;
- Development of a "snapshot" of the polar regions to serve as a baseline for future generations of observations, requiring coordination with international and industry partners;
- Ongoing satellite missions, including ICESat, Cloudsat/Calipso;
- New airborne surveys targeted at measuring land-ice elevation changes and thickness characteristics;
- Comprehensive observations of polar atmospheric composition, dynamics, and thermodynamics;
- Utilization of polar regions as a stepping stone to exploring planetary environments, with emphasis on Mars and the Moon;
- Understanding the poles of other planets and similarities and differences to those on Earth; and
- A sustained public engagement through a suite of communication, education, and outreach efforts to allow individuals around the globe to explore science of the poles and life on Earth.

NASA continues to study Earth as a system through the unique sampling capability afforded

by remote sensing. During the IPY and beyond, NASA will continue to develop this capability to understand polar processes, the role of the polar regions in Earth's environment, and the nature of poles on other planets in our solar system. Developing and coordinating new scientific initiatives and opportunities associated with the President's Vision for Space Exploration with other Federal agencies (NSF, USGS, and NOAA, for example) within the framework afforded by the IPY are important aspects of NASA's involvement.

2.1.7 U.S. Department of Agriculture

The U.S. Department of Agriculture plans to continue its mission-related activities in the Alaska region. The Agricultural Research Service (ARS) will continue its work towards preserving Alaskan plant diversity by preserving and archiving high-latitude plant germplasm through traditional seed collocation and modern molecular methods. The U.S. Forest Service, through the Pacific Northwest Research Station, is responsible for managing the Alaskan boreal forest and will continue its commitment in support of the Bonanza Creek LTER, which takes place at the Bonanza Creek Experimental Forest. The Natural Resources Conservation Service (NRCS) will continue to provide assistance to State, Native Alaska, and private landowners through the USDA Farm Bill. The Forest Service and NRCS will continue their joint activities in permafrost and wetland soil research. The Cooperative State Research, Education and Extension Service will continue its educational support for the University of Alaska, which is the Alaska land-grant institution. CSREES will also continue its extension activities through the Alaska extension services and experimental research stations. CSREES is currently contributing to the inter-agency Study of Environmental Arctic Change (SEARCH) by providing resources to a joint solicitation with NASA for proposals on land use and land cover change. SEARCH is one of the primary activities of NSF for the IPY, and the USDA will continue to work with the interagency working group of SEARCH to promote joint interests in Alaska.

2.1.8 Smithsonian Institution

The Smithsonian is prepared to engage in a variety of research, education, and outreach programs in support of the IPY. Some of the following

plans—all of which have been developed with interagency collaboration—are already underway; others need further discussion and are offered here as ideas for consideration.

Of all U.S. governmental agencies, the Smithsonian probably has the longest record of association with IPY activities, because of its critical role in the first U.S. IPY field expeditions of 1881–1884, in caring for its collections, and in publishing many of its proceedings. Hence SI participation in IPY 2007–2008 will include both historical and contemporary dimensions.

The SI contribution will be based on the institution's time-tested strengths: the research of its scientific personnel, the special value of its museum collections as national treasures, and its broad public outreach program, coupled with the unique position of Smithsonian museums on the National Mall and their special attraction to the general public and the nation.

On the scientific side, the SI is already playing the leading role in framing the U.S. sociocultural and Native studies programs based on staff expertise through the National Museum of Natural History's Arctic Studies Center (ASC) and the value of its ethnological collections. An ASC Arctic ethnologist is playing a key role in planning the IPY 2007–2008 social and cultural agenda as a member of both the U.S. National IPY Committee and the main ICSU–WMO Joint Committee for the International Polar Year. The ASC will continue its leading role in the social and cultural planning through its meetings, symposia, publications, exhibits, coordination activities, and other means.

Smithsonian scholars are also active in other fields of Arctic and Antarctic research, particularly in biology, paleontology, ocean, and astrophysics studies that will be included in the Smithsonian's IPY program. SI also curates the U.S. National Antarctic Meteorite collection.

The Smithsonian offered to organize and host a national IPY symposium at the beginning of the IPY 2007–2008 activities, with the participation of the leading SI scientists and representatives of other agencies and research institutions.

SI is eager to offer its Arctic and Antarctic collections (ethnological, botanical, zoological, mineral, films and archival materials, etc.) and to facilitate all types of IPY collection research as its contribution to the interagency IPY 2007–2008 program. Of particular value are the ethnological and biological collections from Barrow, Alaska, Ellesmere Island (Greeley Expedition), and Ungava Bay, Arctic Canada, from the first IPY 1881–1884

expeditions, as well as scientific instrument collections and records of the early IPY stations, as well as its the instrument collections from the IGY at the Air and Space Museum.

SI offers its space and personnel resources to serve as the key IPY interagency hub for education, outreach, and public communication during 2007–2008 (and even earlier), through its museum programs, outreach, and exhibit ventures.

The following are proposed IPY events for the National Mall:

- The first event will be the opening of the new Smithsonian exhibit, *Arctic: A Friend Acting Strangely* (October 2005), focused on the current impacts and science of Arctic environmental change. This exhibit has been produced with financial support from NOAA and NSF and will be a part of the National Museum of Natural History's "Global Links" Exhibition Program.
- SI proposes organizing a national IPY symposium at the beginning of the IPY period (2007–2008).
- As part of this symposium, SI will organize a small exhibit on the history of the early U.S. IPY efforts based on its collections, instruments, and photographic and documentary records. SI invites other agencies to join resources in exhibiting objects or graphic materials related to their own contributions to the U.S. IPY efforts.
- The major Smithsonian public contribution could be a much larger exhibit, such as *Science at the Poles: IPY 2007–2008*, to publicize its preliminary results and major accomplishments. This might take place in early or mid-2010 and, as a major public venture,

would have to be supported by substantial agency contributions.

2.1.9 Environmental Protection Agency

EPA plans to support other agencies' IPY efforts through its Environmental Monitoring and Assessment Program (EMAP) and its involvement in the Global Earth Observation System of Systems (GEOSS). For 15 years, EMAP has developed cost-effective and policy-relevant sampling approaches for freshwater and marine resources. EPA has supported monitoring of coastal resources in south-central and southeastern Alaska, as well as freshwater monitoring in central Alaska. The State of Alaska has submitted an IPY "Expression of Intent" for Arctic and Bering Sea Coastal Assessments. EPA will give non-budgetary support to this proposal. Other agencies also may wish to support this effort and perhaps support a larger potential effort of developing a circum-Arctic or even circumpolar coastal monitoring program, using EMAP approaches, to obtain baseline conditions. This larger effort could be done in the context of IPY 2007–2008.

EPA is involved in GEOSS as a data collector, integrator, and user. Also, EPA is co-chair of the GEO Secretariat's User Requirements and Outreach Subgroup. EPA is interested in how the ocean observing network is expected to be included under GEOSS and how all the other earth observations overlap with IPY. EPA looks forward to collaborating with other agencies in GEOSS activities related to the IPY.

2.2 The Study of Environmental Arctic Change

2.2.1 Introduction

The following discussion is drawn in part from the Science Plan for the Study of Environmental Arctic Change (SEARCH) program, a research program sponsored by the Interagency Arctic Research Policy Committee. The Science Plan was prepared by the former SEARCH Project Office, Polar Science Center, Applied Physics Laboratory, University of Washington, Seattle.

In addition to U.S. SEARCH efforts, the International Study of Arctic Change (ISAC)—the international umbrella for SEARCH—has led to first discussions of coordination of research on environmental change in the Arctic among many interested nations. The International Polar Year 2007–2008 (IPY) offers an opportunity to consolidate and expand existing studies and implement a network or system of measurements that is driven by the needs identified within the scientific community as well as by stakeholders and planners.

As discussed in detail in the SEARCH Science Plan, observed changes in the atmosphere, in the oceans, and on land in the Arctic are affecting virtually every part of the Arctic and now have potential impacts, both direct and indirect, on human society. These changes include a decline in sea-level atmospheric pressure [typically a 2-mb decrease in multiyear averages (Steele and Boyd 1998) over the Arctic with a peak change of 4 mb near the center of the basin (Walsh et al. 1996), or on the order of one standard deviation in AO Index]. Other observed environmental changes include:

- Reduced sea ice extent [3% per decade (Parkinson et al. 1999)] and thickness [–42% in the last 25 years (Rothrock et al. 1999)].
- Shift in the balance between Atlantic and Pacific waters and changes in salinity and temperature (e.g. Morison et al. 2000). The revealing changes in upper ocean temperatures and salinities are five times the RMS variability in the 1970s and exceed extreme values measured in the corresponding locations in the previous 50 years (EWG 1997, Steele and Boyd 1998).
- Sea level rise in the Russian Arctic. There are 2- to 20-cm increases in sea level in the Russian marginal seas over a 50-year period, with interannual variations on the same order (Pavlov 2001). Proshutinsky et al. (2001) argue that

this is driven by changes in atmospheric forcing of the barotropic circulation.

- Permafrost warming (0.5°C) and thawing in the intermittent permafrost region of Alaska (Osterkamp and Romanovsky 1999) and warming and thawing of permafrost in the Russian Arctic (Pavlov 1994) since the late 1980s.
- Decreasing permafrost temperatures in eastern Canada (Wang and Allard 1995).
- Below-average Northern Hemisphere snow cover in recent years by reductions in spring snow cover since the mid-1980s (Robinson et al. 1993, 1995).
- Decreasing mass of small Arctic glaciers (Dyurgerov and Meier 1997, Dowdeswell et al. 1997).
- Drying trend, increased forest fires (Oechel and Vourlitis 1996, Stocks 1991), and southern pest infestations in Alaska.
- Long-term increase in river runoff (Petersen et al. 2003).
- Large increase in Bering Sea jellyfish populations. According to Brodeur et al. (1999) the biomass of large jellyfish in the Bering Sea has soared in the 1990s.
- Whale migrations shifting with decreased ice extent (Tynan and DeMaster 1997, Treacy 1998).
- Increase in Barents Sea cod size with temperature increases (Bogstad and Gjosaeter 1994, Brander 1994).
- More terrestrial plant growth. According to the SEARCH Science Plan, studies point to increased plant growth (Mynemi et al. 1997), northward advances of the tree line (D'Arrigo et al. 1987, Nicholls et al. 1996), increased fire frequency (Oechel and Vourlitis 1996, Stocks 1991), and thawing and warming of permafrost (Pavlov 1994, Osterkamp and Romanovsky 1996, 1999).

Because of the interplay of natural and human-caused factors, we do not know if the recent complex of changes is part of a pattern of natural variability or the beginning of a long-term shift. We also do not know what climate and ecosystem processes may be involved or what the long-term impacts may be. We do know that environmental changes in the Arctic can affect other global systems in major ways, mainly by changing the amount of solar radiation reflected from the earth's surface (snow and ice reflect energy that is absorbed by earth and open water) and by reduc-

ing the global thermohaline circulation by capping the subarctic seas with fresh water and melted sea ice flowing from the Arctic Ocean.

2.2.2 Arctic Oscillation

SEARCH scientists hypothesize, and statistical analysis and modeling studies tend to confirm, that many of the changes listed in Section 2.2.1 are related to a strengthening of the atmospheric polar vortex [e.g., SEARCH Science Plan 2001, Morison et al. 2000, Zhang et al. 1998, 2000, Maslowski et al. 2000] as characterized, for example, by the Arctic Oscillation (AO), which is a natural mode of atmospheric variation. The strengthened west-to-east motion of the atmosphere associated with an increased AO brings more warm air to the Greenland Sea, Scandinavia, and Russia.

The cause for the 1990s increase in the AO is an important research question. Some modeling studies (Fyfe et al. 1999, Shindell et al. 1999) suggest the AO is strengthened by the anthropogenic (human-caused) rise in greenhouse gases, but the recent changes are larger and earlier than these models suggest. Therefore, while anthropogenic climate change may explain part of the observed environmental changes, a significant part of the change is likely an extreme example of natural variability. This large-scale pattern of change interacts with more localized natural and anthropogenic factors to change the climate at any one location. We do not know if the recent complex of changes is part of a cyclic pattern of natural variability or the beginning of a long-term shift. We also do not know if these changes can themselves reinforce or slow environmental change.

2.2.3 Goals

SEARCH is a broad, interdisciplinary, multi-scale interagency program with a core goal of understanding the complex of recent and ongoing intertwined changes, with a view toward prediction. In addition to understanding how changes in the Arctic are interrelated, SEARCH will investigate the links between Arctic change and global processes and will assess the impacts that Arctic change may have throughout the Northern Hemisphere. SEARCH will evaluate the possibility that changes in the Arctic can anticipate changes elsewhere on the globe.

To be most effective in understanding the Arctic's many systems and their interplay, many resources and kinds of expertise must be brought

together. SEARCH is the first interagency effort to combine funding sources, disciplines and knowledge from across the United States and around the world to address an issue of this type. The effort is designed to bring researchers together to share knowledge and learn from one another. It is unique, given the complexity of the Arctic environment.

2.2.4 Critical Science Questions

The recent changes in the Arctic are complex, but a key idea of SEARCH is that many of the changes can be thought of as an interrelated complex of pan-Arctic change related to the atmospheric circulation of the whole Northern Hemisphere (SEARCH Science Plan). As discussed above, it is relatively straightforward to argue that a strengthened polar vortex can drive the observed complex of change through the effect of wind stress and the transport of heat and moisture. A critical question is to what extent the response of the Arctic can in turn affect the Northern Hemisphere atmospheric circulation through effects on albedo or the freshwater cycle and global thermohaline circulation (SEARCH Science Plan). Based on observations by the indigenous populations of the Arctic, which bear much in common with the scientific observations, it seems certain that the complex of change has ecological and social dimensions as well (SEARCH Science Plan). For example, people who depend on sea ice for transportation and subsistence gathering report firsthand the effects of decreases in ice extent. The SEARCH program will test these hypotheses in order to understand the changes seen to date, track the changes into the future, and help society to adjust to future changes. Science questions related to these hypotheses will guide the efforts of SEARCH. For example:

- Are the changes seen in recent decades in the Arctic climate system consistent with natural variability, or are such changes at least partially attributable to human activity?
- What is the interplay among atmospheric circulation, ozone loss, and UV radiation?
- Can climate changes in the Arctic be predicted or assigned a probability?
- How will hemispheric or global climate affect or be affected by changes in the Arctic (atmosphere, ocean, land surface, and hydrology)?
- How will seasonal weather patterns in the Arctic and mid-latitudes be affected by changes in the Arctic?
- What are the likely effects and consequences of environmental Arctic change on the health

- and well-being of Arctic residents?
- What are the likely effects and consequences of environmental Arctic change on ecosystems and key species of the Arctic?
- How might Arctic-driven environmental changes affect societies and U.S. national security?

2.2.5 Major Activities

The changes of the last few years come at a time when many of the large-scale observing systems of the past have declined or been eliminated. For example, the large-scale hydrographic surveys and the ice camps maintained by the Soviet Union for many years have stopped (EWG 1997). Many of the weather stations in the United States, Canada, and Russia have been eliminated. Therefore, according to the SEARCH Science Plan, a major emphasis of SEARCH is developing a long-term, large-scale program of observations, the related analysis and modeling, and activities to apply what is learned. SEARCH includes four major types of activities:

- A long-term observational program to detect and track the environmental changes;
- A modeling program to synthesize observations, test ideas about the coupling between the different environmental changes observed, and predict their future course;
- Studies to test hypotheses about critical forcing and feedback processes; and
- An application component to understand the impact of the physical changes on ecosystems and societies and to distinguish between climate-related changes and changes due to other factors such as resource utilization, pollution, economic development, and population growth.

To achieve the goals of SEARCH, the agencies supporting it will invest not only in the four areas described above, but also in "infrastructure" activities such as:

- Development of new observing technologies;
- Creation of new computer-based models;
- Management and rescue of environmental data; and
- Construction and maintenance of field facilities.

2.2.6 Observation and Modeling

There is a need for the deployment of a comprehensive and sustained Arctic environmental

observing system. This system will require remote and in situ systems focused on land, sea, air, and ice. It must provide the critical information on the physical and biotic environment needed to meet the needs of SEARCH. The observing system must be strongly coupled to modeling and data assimilation efforts to ensure that the system's data are useful and used. This comprehensive system must evolve to meet new requirements, comply with new strategies, and incorporate new technologies. Once new observing technologies have been developed and proven in the field, a pathway will be needed to make these technologies operational. This pathway must include consideration of funding requirements, data quality and continuity, and data application.

The observing system and models will provide useful information at different geographic scales from local to regional to global. The use of satellite-based remote sensing is critical for providing the large-scale overview and finer-scale information when possible. Locally intensive observations will rely more heavily on in situ observations. Whenever possible, these should be made with autonomous sensors or samplers. Continuous use of in situ data for calibration or validation of remotely sensed data is essential and will require a multiagency approach.

2.2.7 Summary of Agency Participation

Each participating agency will contribute to SEARCH in ways consistent with its mandates, strategies, and scientific capabilities. Each will undertake specific parts of SEARCH and share data, information, and understanding to achieve the overall SEARCH goals. Results from SEARCH and other programs will provide the scientific underpinning for Arctic regional and global assessments of climate variability and change and associated impacts. Table 2 describes the major types of activity that each agency expects to undertake to support SEARCH.

2.2.8 Resource Requirements for Continuing Implementation of SEARCH

The SEARCH program is planned as a long-term effort to document and understand environmental change and associated impacts. Given this long-term perspective, SEARCH can be successful even though all activities do not begin at the same

Table 2. Agency activity areas.

National Science Foundation	Environmental processes research and observation, model development, observing technology development, social sciences research, Native-led observatories
National Aeronautics and Space Administration	Space-based and airborne measurements of atmospheric and land/ocean surface processes; model-based research
Department of Commerce/National Oceanic and Atmospheric Administration	Sustained in situ ocean and atmospheric observations, data- and model-based analyses, forecast services, impact assessments
Department of Defense/Office of Naval Research, Cold Regions Research and Engineering Laboratory	Research and technology development leading to predictive capability for environmental conditions that affect defense operations
Department of Energy/Atmospheric Radiation Measurement Program—North Slope of Alaska/Adjacent Arctic Ocean ARM Climate Research Facility	Research on atmospheric processes, quantification of surface radiation budgets, environmental modeling
Department of the Interior/Bureau of Land Management, Fish and Wildlife Service, National Park Service, U.S. Geological Survey, Minerals Management Service	Use of protected and managed land areas for long-term terrestrial in situ observations; assessment of impacts of environmental change on glaciers, vegetation, fish, and wildlife; development of best management practices
Department of Agriculture/Agricultural Research Service, Natural Resource Conservation Service, Forest Service	Impacts of high-latitude environmental change on plant germplasm, agricultural pests, soil quality, and boreal forests; assessments of environmental change on agricultural potential and forest resources.
Smithsonian Institution	Research to understand current and past responses of society to environmental change, and development of interagency outreach program
Department of Homeland Security/U.S. Coast Guard	Logistics support for ocean and sea ice research and observations
All	Integrated modeling and/or assessment efforts, joint studies, collaborative publications

time. Agency planning processes are complex and require coordination. Over the next several years the participating agencies will further define their individual roles in SEARCH and seek to obtain the resources needed to implement those roles.

2.2.9 Interagency Management of the SEARCH Program

From its inception the Interagency Working Group (IWG) of the Interagency Arctic Research Policy Committee has been responsible for developing the SEARCH program within the agencies. The responsibilities of the IWG are to:

- Approve membership and “terms of reference” for the Science Steering Committee (SSC);
- Review and approve science and science implementation plans prepared by the SSC and its subsidiary bodies;
- Solicit science advice from the SSC and develop responsive programs and plans;

- Discuss and coordinate agency plans for budget requests to support activities related to SEARCH and provide appropriate inter-agency assistance;
- Review agency activities that address SEARCH hypotheses and science questions and coordinate agency activities;
- Facilitate international efforts needed to address the SEARCH science questions;
- Identify opportunities for and promote coordination of development and use of facilities needed for SEARCH;
- Identify, encourage, and support activities to integrate and synthesize the results of science supported by SEARCH funds; and
- Identify, encourage, and support outreach and education activities based on the results of activities supported by SEARCH funds.

The SEARCH SSC will continue to provide scientific planning. In particular, it will develop the scientific bases for the thematic programs to be implemented under SEARCH and will be instrumental in devising means for synthesizing and

integrating the diverse information that SEARCH will generate. The SSC will provide scientific liaison to international science groups and aid the IWG's efforts to achieve international implementation mechanisms.

To provide guidance from different perspectives and to open a channel for community and stakeholder input during this period of SEARCH evolution and implementation, the SEARCH SSC organized an implementation workshop that was held May 23–25, 2005, in Lansdowne, Virginia. Preparation for the discussions during the workshop was guided by white papers prepared by the three SEARCH panels: Observing Change, Understanding Change, and Responding to Change.

The position papers were circulated widely to provide opportunities for the community at large to express their views on the next steps of SEARCH implementation.

A report of this SEARCH Implementation Workshop has been prepared (<http://www.arcus.org/search/meetings/2005/siw/index.php>). At the time of publication of this revision to the U.S. Arctic Research Plan (July 2005), the SEARCH Implementation Workshop report is under review by the SEARCH Interagency Program Management Committee (IPMC, formerly Interagency Working Group) of the Interagency Arctic Research Policy Committee.

2.3 Developing a Research Plan for a Sustainable Bering Sea

The Bering Sea, located between the Aleutian Archipelago and Bering Strait, is a marginal sea that connects the North Pacific to the Arctic Ocean. The Bering Sea region is productive and ecologically diverse. Its multiple habitats are ideal as homes to a rich variety of biological resources.

The ecological riches of the Bering Sea have attracted and supported aboriginal cultures for millennia. Today, Bering Sea resources continue to support the economic survival, subsistence, and cultural foundation for Alaska Natives. In addition, the Bering Sea commercial fishery is a key economic force in the region. About 50% of all fisheries landings in the United States in 1998 came from the Bering Sea (see <http://www.pmel.noaa.gov/foci/overview.html>). Walleye pollock comprise much of the fish landings. Bristol Bay supports the world's largest sockeye salmon fishery, and snow crab landings represent the largest crustacean fishery in the U.S.

2.3.1 Changes in the Bering Sea

The Bering Sea is a seasonally ice-covered, subarctic sea located at the southern extreme of seasonal sea ice cover, and thus it is likely to be exceptionally sensitive to variations in climate that impact the extent and duration of sea ice. Sea ice is a forcing mechanism that influences the temperature and salinity of the water column, its hydrographic structure, and the availability of light for photosynthesis. As such, sea ice potentially affects the timing, amount, and fate of primary production, the survival of larval fish, and the spatial distribution of fish and their predators. Thus, changes in the dynamics of sea ice, if they occur, can have profound influences on the ability of a region to support diverse ecological communities and fisheries.

Recent and rapid changes in the physical and biological characteristics of the Bering Sea have raised concerns (Overland et al. 2004). Changes in the abundance of salmon, crab, and groundfish may result in significant economic impacts. Continuing declines in some populations of marine birds and pinnipeds have prompted protective measures such as fish trawling closures around critical feeding areas used by the endangered Steller's sea lion. There have been unexplained blooms of phytoplankton never before recorded

in the Bering Sea, and between 1989 and 2000 an exponential increase in the biomass of large gelatinous zooplankton occurred, which has since collapsed (Hunt et al. 2002).

There is a clear need to better understand the causal relationships between climate, primary and secondary production, and the population dynamics of upper-trophic-level organisms. Greater understanding about how these factors influence each other is vital for determining the relative roles of climate variability and fishery harvests in structuring the Bering Sea ecosystem and for understanding the region's resiliency in the face of change.

2.3.2 Arctic Research Commission Charge

The Arctic Research Commission, in its 2001 and 2003 Reports to Congress (<http://www.arctic.gov>), targeted integrated research and assessment of the Bering Sea as key research priorities. The Commission observed that concern about the Bering Sea has engendered large and intense research synthesis and planning efforts. These efforts share a commitment by scientists from diverse disciplines and organizations to come together to define the most important research needs and to share research results. Significant research efforts have produced important results. The Commission concluded:

- Greater integration of key Bering Sea research programs is required.
- Current research has not enabled managers to predict ecological responses to management decisions implemented within the Bering Sea region.
- An integrated research program and a concerted effort are required to synthesize existing and new information for an integrated assessment.

2.3.3 Enhancing Research

Continued research is critical to better elucidate the mechanisms and processes of change in the Bering Sea as well as the Arctic. To meet the needs for an integrated assessment in the Bering Sea, Federal partners will develop a strategic plan to clarify and connect scientific questions to management needs.

Since natural ecosystems, science, and man-

agement are all dynamic processes, an iterative approach will be used to ensure linkages among decisions that need to be made, new knowledge that will be obtained, and ongoing changes that will influence outcomes. The importance of this process was reflected by the Polar Research Board of the National Research Council of the National Academy of Sciences, which published a study on the Bering Sea ecosystem that included a set of recommendations emphasizing the vital link between science and management, including:

- Adopting a broad ecosystem perspective for scientific research and resource management;
- Adopting an adaptive management approach for Bering Sea resources;
- Evaluating how well management and research institutions are able to address emerging problems;
- Providing appropriate management solutions; and
- Developing research programs to help policy makers solve short- and long-term ecological problems.

Components of Strategic Integrated Research

The Bering Sea Research Strategy includes five key components, each of which influences the others in an iterative framework. They include:

- Definition of a sustainable Bering Sea: Based on dialogue among interested parties, key concerns, common interests, and desired outcomes from management actions will be determined. In this process the essential characteristics of the Bering Sea are defined. This will provide the necessary framework around which to structure integrated assessments. Interviews were conducted with Federal and state officials and commercial and environmental interests.
- Conceptual synthesis: Existing data will be integrated to identify potential relationships among forcing functions, ecosystem changes, sources of stress, and ecological end points of concern identified in the goals. The process is interactive, iterative, and interdisciplinary, and it addresses the influences of multiple natural and human stressors on ecological and human systems. The purpose is to learn more from existing data, generate multiple working hypotheses about likely causal relationships, and define essential research needs.
- Research plans: Based on the conceptual synthesis, research questions will be refined and further research designed to produce

integrated research and assessments. The expected outcome is a dynamic research plan available to Federal agencies and others that capitalizes on existing research efforts and defines new research within a structured framework for integrating research activity and interpreting results.

- Research implementation: New research will be initiated to evaluate predictive relationships among natural and human influences on key values to be sustained. The research will investigate processes, trends, and effects, as well as monitor the impacts of management decisions. New information is fed back into goal setting, synthesis, and planning for re-evaluating goals, refining conceptual models, and developing updated research plans.
- Ecological forecasting: To be useful to living-resource managers, the results of research must lead to the ability to provide forecasts of future ecological states. Research will be conducted to build coupled physical-biological models and to develop science-based products that provide value to resource managers. A long-term goal of this research is to specify an ecological forecasting system that could be used in an operational setting for resource management.

The strategy is intended to be dynamic and to involve interplay among research findings and environmental observations, desired management outcomes, goal setting, and new insights that lead to new research. Strategy development will progress concurrently with ongoing research. The outcome over the next several years is expected to include conceptual synthesis and a first-stage integrated assessment and research plan.

2.3.4 Bering Ecosystem Study

The goal of the Bering Ecosystem Study (BEST) Program is to develop a fundamental understanding of how climate change will affect the marine ecosystems of the eastern Bering Sea, the continued use of its resources, and the economic, social, and cultural sustainability of the people who depend on it.

A BEST Implementation Plan outlines the first phase of a ten-year research program focused on the marine ecosystems of the eastern Bering Sea and the people dependent on its resources. To improve understanding of the variables and processes shaping all aspects of the Bering Sea, from physical forcing (atmosphere and ocean) to food

web responses including fish, seabirds, marine mammals, and humans, fundamental research in the physical, natural, and social sciences, appropriate for funding by the National Science Foundation (NSF), will be linked to studies funded by other agencies with interests in this important region. The BEST Science Plan (www.arcus.org/Bering/science_plan.html) outlines a broad range of questions important for understanding how climate variability could influence the ecosystems of the eastern Bering Sea and their ability to sustain the goods and services required by people. Social scientists developed a parallel Science Plan, *Sustaining the Bering Sea* (www.arcus.org/Bering/hbest/index.html), which outlines a community-based research program focused on the needs of the residents of Bering Sea communities to understand how climate variability will affect their future. These two initially separate programs have now been integrated into a single program that will study the ecosystem as a whole, including the social implications of climate change and the roles of people in the system.

The BEST program will bring together physical, biological, and fisheries oceanographers; ecologists; climatologists; archeologists; and social scientists in a highly integrated and interdisciplinary program. The work will draw on regional historical data sets derived from modern oceanographic programs over the last several decades, longer-term instrumental and written records, and knowledge of ecological change recorded by the multigenerational observations of local populations. BEST will develop the next generation of conceptual and numerical models needed to link ecological and physical change and provide better strategies to anticipate and ameliorate climate-induced impacts on subsistence and commercial resource users.

The study of ecosystem changes in the eastern

Bering Sea will involve the investigation of a full suite of variables and processes that are linked ecologically but divided by the research mandates of different agencies and organizations. The BEST program must therefore be capable of integrating a variety of complementary research efforts to develop a unified understanding. Collaborations among scientists funded through NSF, NOAA, NASA, NPRB, BASIS, AOOS, USGS, and USFWS will be required to accomplish an end-to-end understanding of the eastern Bering Sea ecosystem and its users. In the face of the rapid ecosystem changes underway, this understanding is essential to sustain the rich marine resources of the eastern Bering Sea and the people and cultures dependent on their harvest.

Planning for a comprehensive study of the eastern Bering Sea began in September 2002 with a Planning Workshop in Laguna Beach, California. Workshop participants agreed unanimously that there was an urgent need to improve our understanding of the linkages between climate variability and the responses of the ecosystems of the Bering Sea, as detailed in the Workshop Report (<http://www.arcus.org/Bering>).

In March 2003, a second planning workshop was convened in Seattle, Washington, to develop a Science Plan for the Bering Ecosystem Study (BEST) Program (<http://www.arcus.org/Bering/index.html>).

In March 2004, a workshop was convened in Anchorage, Alaska, with Bering Sea residents and social scientists to outline possible goals of a social science plan for the Bering Sea. This workshop led to the development of the social science component of BEST, now integrated into this implementation plan.

In May 2005, an Implementation Workshop was held in Victoria, British Columbia.

2.4 Arctic Health Research

The Arctic Research Commission has recommended:

“...a comprehensive, interagency study of Arctic Health. NIH has agreed to be the focal point for this effort focused primarily on the environmental health questions outlined by the Arctic Monitoring and Assessment Program and on the study of incidences and trends in the major causes of morbidity and mortality in the Arctic. NIH should lead this effort with the assistance of other agencies, especially EPA and NOAA. The potential effects of anthropogenic contaminants such as persistent organic pollutants, heavy metals and radionuclides are a growing concern in the Arctic. The effects of both communicable diseases such as tuberculosis, systemic diseases such as diabetes and cancer and external causes of illness and death such as alcoholism and accident likewise have profound effects in the Arctic. The Commission eagerly awaits the organization of this multi-agency effort under the leadership of the NIH Fogarty Center” (*Report on Goals and Objectives for Arctic Research*, U.S. Arctic Research Commission, 2005).

The Arctic Research Commission also expressed interest that such a plan address health concerns from two standpoints: What are the health concerns that people of the Arctic worry about, such as pollution? What are the actual causes of morbidity and mortality in the Arctic?

2.4.1 Epidemiology and Health Surveillance

Research Goal: To understand the epidemiologic parameters of diseases important to Arctic residents, providing data that will inform and guide programs to prevent, diagnose, and treat such diseases, ranging from acute infectious illnesses to chronic conditions dependent on diet and lifestyle. The Centers for Disease Control and Prevention has been the lead in these activities.

Infectious Diseases

Centers for Disease Control and Prevention's Arctic Investigations Program. AIP, based in Anchorage, Alaska, is a division of the National Center for Infectious Diseases. Its mission is prevention and control of infectious diseases with a focus on diseases of high incidence and concern among the indigenous populations of the Arctic and subarctic and emerging and re-emerging infectious diseases. CDC's long-term plan, “Pre-

venting Emerging Infectious Diseases: A Strategy for the 21st Century,” focuses on four goals:

- Strengthening surveillance and response nationally and internationally;
- Supporting research to understand and combat infectious diseases threats;
- Enhancing public health epidemiologic and laboratory capacity in the U.S. and internationally; and
- Working with partners in public health to implement, support, and evaluate disease prevention activities.

The plan targets certain high-priority categories of emerging infectious disease problems and special groups of peoples who are at risk for antimicrobial resistance, food- and water-borne diseases, vector-borne and zoonotic diseases, diseases transmitted through blood transfusions or blood products, chronic diseases 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.

For the 2006–2010 planning period, the Arctic Investigations Program will target vaccine preventable diseases, antimicrobial resistance, chronic diseases caused by infectious agents, and bioterrorism response.

National Institute of General Medical Sciences. The NIGMS, through a partnership with the Indian Health Service, is supporting a project carried out by the Alaska Native Tribal Health Consortium. The study, funded in part by the National Institute of Allergy and Infectious Diseases, is determining the prevalence and serotype of chronic hepatitis B, which may aid in understanding modes of communication of the disease.

Occupational Injuries and Disabilities

National Institute for Occupational Safety and Health. The CDC's NIOSH, Alaska Field Station, in collaboration with the Indian Health Service, the State of Alaska, the Alaska Native Tribal Health Consortium, and the Alaska Native Health Board, will continue studies on the epidemiology, risk factors, and prevention strategies for occupational injuries in Alaskan communities. Using surveillance and analysis as information for action, injury prevention partnerships have helped contribute to a 61% decline in occupational deaths in Alaska from 1990 through 2004. The Alaska Field Station

has focused recent work through two initiatives in Arctic research:

- **Fishing industry:** The commercial fishing industry contributes high numbers of fatal and severe non-fatal injuries. NIOSH is examining vessel stability and the deck environment surrounding the deployment and retrieval systems of fishing equipment (including the use of cranes, winches, lines, nets, crab pots, and crab pot launchers) from a mechanical and safety engineering perspective.
- **Aviation safety:** Since 2000, the U.S. Congress has supported a Federal initiative to reduce aviation-related injuries and fatalities and to promote aviation safety in cooperation with the air transportation industry in Alaska, through a partnership of four Federal agencies: the Federal Aviation Administration, the National Transportation Safety Board, the National Weather Service, and NIOSH. A large survey of the air taxi industry and a study examining the roles of fatigue and inexperience in aircraft crashes have been completed, and the results have recently been published. The information from these studies is enriching discussions with the industry about how best to implement changes to prevent crashes in Alaska. This concerted effort involves collaboration between government agencies, industry, and NGOs applying research findings to develop higher voluntary standards of practice and improved training and supervision regimes. The goal is to reduce the number of aircraft accidents and injuries in Alaska by at least 50% by the end of 2009.

In addition, the Alaska Field Station will collaborate in the integrated surveillance system for disease and injury in the Arctic, linking to the International Circumpolar Surveillance system.

National Institute of General Medical Sciences. For rural, subsistence, or working class families, disabilities can have profound effects on entire families. The NIGMS, through a partnership with the Indian Health Service, is supporting a study that examines the prevalence of disabilities in Alaskan communities.

Chronic Diseases

Centers for Disease Control and Prevention's National Center for Environmental Health. The Health Studies Branch of the National Center for Environmental Health is monitoring selected persistent organic pollutants (POPs) and heavy metals

in maternal blood and urine samples and in umbilical cord blood in Alaska Natives. The POP levels in these samples will be related to pregnancy outcome (e.g., full-term live birth, miscarriage, birth defects) and to the rate of infectious diseases in the infant's first year of life. The Health Studies Branch plans to continue enrolling women and their infants indefinitely and expects to add regional hospitals and health consortia from across Alaska. A newsletter is being developed to update study participants about the study's progress.

Another study examines the relationship between environmental exposures and breast cancer. Pregnancy history, dietary history, and other relevant risk factors are being analyzed, and laboratory analyses of blood and tissue for POPs and other analytes is underway. Aggregate results will be reported to Alaska Native health consortia and study subjects.

2.4.2 Biomedical and Behavioral Research

Research Goal: To uncover new knowledge that will help prevent, detect, diagnose, and treat disease and disability, thus improving people's health and saving lives. The spectrum of research includes basic through applied and clinical research, with the ultimate goal of translating research results into interventions and communicating research findings to patients and their families, health care providers, and the general public. The National Institutes of Health has been the lead in these activities.

Infectious Diseases

National Institute of Allergy and Infectious Diseases. The NIAID promotes the development of vaccines, diagnostic tests, and drug therapies to prevent and control infectious disease.

Hepatitis: Researchers supported by NIAID are investigating the relationships between hepatitis C virus replication, evolution, and disease progression in Alaska Natives. Complete histories of the patients, including their estimated date of infection and alcohol history, are being obtained. Blood and liver specimens are being collected both retrospectively and prospectively in order to examine levels of and variation in the virus and to compare these with disease progression. This study of a well-defined Alaska Native population may lead to many key answers regarding the natural history of hepatitis C and may impact its future

treatment worldwide.

National Institute on Drug Abuse. Since 1994, the NIDA has been funding basic and applied research at the University of Alaska Anchorage on drug abuse and related conditions in the Alaska Native population. Several of these research projects have produced data on the co-morbidity of sexually transmitted diseases in Alaska Native drug users, as well as other relationships to HIV risk, alcohol use, and unemployment.

Chronic Diseases

National Institute of Environmental Health Sciences. The NIEHS supports research programs to define and understand the effects of environmental chemicals and other factors on human health. In the Arctic, one important factor is that of persistent chemicals, specifically chlorinated aromatics, being transported to cold regions and remaining there because of the "sink" effect of low temperatures.

The NIEHS continues to have a small grant program that attempts to assess health effects from these contaminants. One program seeks to define dietary risks and benefits in Alaskan villages from bio-accumulated chemicals in traditional foods. Another focuses on the mechanism of effects of PCB compounds in children and on methods to assess damage to development. Other studies look for metabolic changes that might affect toxic impacts so that preventive and treatment modalities can be developed. Toxicogenomic studies are likewise attempting to understand variability in response to such exposures.

National Heart, Lung, and Blood Institute. A study supported by NHLBI is a working partnership between the Native-owned corporation that manages the health care of the Alaska Natives of Norton Sound and investigators from the Strong Heart Study, a 14-year study of cardiovascular disease in American Indians. These Native villages are remote and isolated, and the traditional lifestyle is being eroded by mechanization and a westernized diet. There has been relatively little outside genetic influence, and the Alaska Natives, like the American Indians of the lower 48 states, are beginning to show a marked increase in the prevalence of atherosclerosis and coronary artery disease.

The aims of the initial five-year \$7.8 million study, begun in FY 2000, were to document cardiovascular disease (CVD) and associated risk factors among 1,214 Alaska Natives who are members of approximately 40 families. This family-based,

cross-sectional study will add a longitudinal component to document recognized and emerging risk factors for CVD through analyses of morbidity and mortality surveillance data. The investigators will assay contemporary samples and serum specimens, which have been stored at the CDC office in Anchorage for 10–20 years prior to this study, for specific markers of inflammation and serologic responses to infection. In addition, the project will use genome-wide scan data from families to complete a linkage study of CVD risk factors. This is the first project to identify and map genes that contribute to the risk of cardiovascular disease in this unique and understudied population.

The NHLBI and the Canadian Institutes of Health Research (CIHR) co-sponsored a Working Group meeting in July 2004 entitled "Research with Arctic Peoples: Unique Research Opportunities in Heart, Lung, Blood and Sleep Disorders" to address three objectives related to research with Arctic peoples. The meeting was international in scope, with investigators from Greenland, Iceland, and Russia, as well as Canada and the U.S. The meeting concluded with a list of ten recommendations covering research priorities, barriers and solutions to Arctic research, and international comparisons. The report of the meeting is available at <http://www.nhlbi.nih.gov/meetings/workshops/arcticpeoples.htm>.

Additional discussions have been held between NHLBI and CIHR staff regarding potential joint activities. Several collaborative research opportunities are under consideration.

National Institute of Alcohol Abuse and Alcoholism. The goal of the NIAAA is to identify the causes and consequences of abusive and chronic alcohol consumption and to develop effective treatment and prevention strategies for adverse consequences of drinking. Over the next five years, NIAAA plans to continue the following studies in the Arctic region:

- **Prevention:** This study will determine the effect of alcohol availability and other control policies on alcohol-related consequences in Arctic communities.
- **Genetics and Environment:** This study will address individual variations in behavioral responses to alcohol that are directly linked to the influence of inheritance and environment, including the role of extended periods of darkness in responsiveness, the role of adaptive mechanisms of prolonged stress, the impact of corticosteroid activation on health and survival, and differences in expression

between men and women.

- Treatment: This study will test the efficacy of pharmacological adjuncts to alcoholism treatment in Alaska Native populations.

National Institute on Drug Abuse. The NIDA is supporting a study investigating stigmas and barriers to receiving treatment for drug abuse, mental health disorders, and HIV/STDs among Alaska Natives. The project will make significant contributions to health services research in the Arctic and other frontier and rural areas, leading to a better understanding of rural health problems and their solutions. NIDA plans to include studies of a previously overlooked problem—rural runaway youth—a group at extreme risk for substance abuse, mental health disorders, and infectious diseases, as well as violence and other forms of abuse. Another NIDA research grant is developing a community trial to prevent inhalant use in Alaska.

National Institute of Diabetes and Digestive and Kidney Diseases. The Nonalcoholic Steatohepatitis Clinical Research Network (NASH CRN) is a multicenter collaborative effort of clinical centers and a data coordinating center, supported by the NIDDK, which is intended to accelerate clinical research and progress in understanding the pathogenesis of NASH, defining its natural history, and developing safe and effective means of treatment. A comprehensive database for two clinical trials (one in pediatrics and one in adults) has been started. Ancillary studies are currently under development. Research to date suggests differences in epidemiology among different racial and ethnic groups; therefore, efforts to include a diverse participant population are critical. The University of Washington is the major referral clinic for liver disease for Alaska, Washington, Montana, and Idaho. A large proportion of the patients are Asian or from the Pacific Islands, Hispanic, or Native American. The university also serves the entire Alaska Native population, making the institution uniquely positioned to enroll NASH patients of Alaska Native ancestry as well.

National Institute of General Medical Sciences. The NIGMS, through a partnership with the Indian Health Service, is supporting two projects carried out by the Alaska Native Tribal Health Consortium regarding nutrition:

- The Alaska Native diet and assessment of the nutrition of subsistence foods; and
- Maternal nutrition during pregnancy among Alaska Natives.

National Institute of Dental and Craniofacial

Research. The NIDCR, in collaboration with the NIGMS and the Indian Health Service, is focusing on children's oral health, specifically on community intervention to reduce toddler obesity and caries. American Indian youth experience the highest rates of childhood obesity and early childhood caries in the U.S. population. At the same time, obesity is a major risk factor for type 2 diabetes, which is now occurring in American Indian youth as well as adults. The greatest dietary shift over the last 20 years has been the replacement of water, milk, and juice with soft drinks and other sugared beverages, coinciding with increases in energy consumption and leading to childhood obesity and early childhood caries. Researchers working with the Northwest Tribal Health Research Center are testing whether community and family-based interventions can alter patterns of recreational drink consumption in expectant mothers and their offspring and extend the length of breastfeeding, and whether such behavioral changes can impact childhood obesity and caries. If successful, the intervention will have great significance for the many tribal communities, including those in northern regions, facing similar issues.

National Cancer Institute. The NCI is supporting several research projects related to Arctic health:

- Alaska Native Tumor Registry: The Alaska Native Tumor Registry was initiated in 1974 through a collaboration between the NCI and the CDC, using procedures developed by NCI's Surveillance, Epidemiology and End Results (SEER) Program. Subsequently, the Alaska Native Medical Center became a partner in the program through the Indian Health Service, with technical assistance provided by the University of New Mexico. Accurate information on the unique cancer patterns occurring in this population is useful for provider education and training, program planning, studies of cancer etiology, evaluation of screening programs, and the development of interventions to improve patient care and programs for cancer prevention and risk reduction. The registry is participating in several research projects, including a study examining the relationship between breast cancer and exposure to environmental organochlorines among Alaska Native women and the Nicotine Research and Tobacco Control Program.
- Network for Cancer Control Research among American Indian and Alaska Native Popula-

tions: This network of researchers, established through NCI's Surveillance Research Program in 1990, developed a National Strategic Plan for Cancer Prevention and Control Research in 1992. The NCI shares support for network meetings with the Mayo Comprehensive Cancer Center. The web address is <http://mayoresearch.mayo.edu/mayo/research/cancercenter/nativenetwork.cfm>.

- Tobacco and Health Disparities Research Network: Tobacco is the leading cause of preventable illness and death in the U.S. Unfortunately, certain groups, including racial/ethnic minorities, women, youth, blue-collar and service workers, and those of low socioeconomic status, remain at high risk for tobacco use and exposure and suffer disproportionately from tobacco-related illnesses and death. To answer remaining questions about the causal mechanisms underlying disparities, NCI's Tobacco Control Research Branch is developing and implementing the Tobacco and Health Disparities Research Network. The network is a unique endeavor that aims to advance the science in understanding the etiology, prevention, and treatment of tobacco use and nicotine addiction among underserved populations in the U.S. (including Alaska Natives) and to translate that knowledge into practice and inform public policy.

National Institute of Neurological Disorders and Stroke. The NINDS anticipates funding a cooperative agreement that will support the development of a state-wide, population-based Alaska Native Stroke Registry at the Alaska Native Medical Center. It will create a model registry to conduct research on the epidemiology and management of stroke among Alaska Natives, support research strategies to reduce the burden of stroke in the population, and strengthen the research capabilities of the faculty at the Alaska Native Medical Center. The primary goals of the Alaska Native Stroke Registry are to:

- Define the natural history and clinical course of stroke among Alaska Natives, including incidence and prevalence, risk factors, clinical management, and health outcomes such as residual physical disability and mortality;
- Develop research programs to prevent stroke and improve the quality of care provided to Alaska Natives to minimize stroke sequelae; and
- Enhance opportunities for multidisciplinary

research collaborations between the Alaska Native Medical Center and institutions with established programs in stroke research.

National Institute of Child Health and Human Development. The mission of the NICHD is to ensure that every person is born healthy and wanted; that women suffer no harmful effects from reproductive processes; that all children have the chance to achieve their full potential for healthy and productive lives, free from disease or disability; and to ensure the health, productivity, independence, and well-being of all people through optimal rehabilitation.

- SIDS and Prenatal Alcohol Exposure: Since 2003, the NICHD, in partnership with the National Institute of Alcohol Abuse and Alcoholism, has funded a network of community-linked studies to investigate the role of prenatal alcohol exposure in the risk for sudden infant death syndrome (SIDS) and adverse pregnancy outcomes, such as stillbirth and fetal alcohol syndrome (FAS). The long-term goal of the network is to decrease fetal and infant mortality and improve child health in these communities. The clinical sites will be working with Northern Plains Indian communities and populations in the Western Cape of South Africa. Although these sites do not involve Alaska Native communities and populations in the Arctic, study findings may have potential relevance to these groups.
- Other relevant research priorities: Aside from SIDS, aspects and outcomes of other significant ongoing research activities of the NICHD may have relevance for Arctic health research, even if these activities currently do not target populations in the Arctic. These include the impact of environmental factors on fetal and newborn health and development; interaction between nutrition/food and environmental exposures; fetal exposure and origins of obesity and diabetes; and all matters related to nutrition and health and development. In addition, there may be opportunities to undertake vaccine-related research with indigenous populations of the Arctic region.

2.4.33 Information: Acquisition, Assembly, and Dissemination

Research Goal: To develop a responsive system for handling health information transfer in the Arctic, ranging from telemedicine systems utilized in

health care delivery, to an Internet-based health information network for researchers and the general populace, especially Native and other populations (such as the Circumpolar Health Information Center).

National Library of Medicine. In the fall of 2000, the NLM committed to developing an Arctic health web site to help organize and disseminate pertinent information regarding health issues in the Arctic, including the health effects related to the bioaccumulation of toxins in the environment. This web site, located at <http://www.arctichealth.org>, includes health information related to the indigenous populations of the U.S. Arctic, a database of information about research projects going on in Alaska, and health-related information relevant to very cold climates as well as much local Alaska information. Goals for the web site include working with indigenous peoples of the Arctic to collect and organize information on traditional medicine that may otherwise not be accessible to non-Native scientists, collecting and organizing information that may not yet be digital, and serving as a focal point for linkages with other Arctic countries for information dissemination. NLM is working with the Consortium Library and the Institute for Circumpolar Health Sciences, both at the University of Alaska Anchorage, to maintain and develop this web site.

National Institute of General Medical Sciences. The NIGMS, through a partnership with the Indian Health Service, is supporting several projects carried out by the Alaska Native Tribal Health Consortium. One applied study investigates the degree of concordance of diagnosis of effects of telemedicine versus live diagnosis. This study is significant because of the challenges of delivering health care to rural Alaska.

National Institute of Mental Health. Since 1986, the NIMH has supported the American Indian and Alaskan Mental Health Research Center. This center conducts research and promotes research training and leadership development appropriate for Native communities, disseminates research findings to communities and practitioners, and aids organizations in developing skills to conduct mental health research. The center has initiated activities in the following areas:

- **Treatment:** Working with the Cook Inlet Tribal Council, the nonprofit arm of the Cook Inlet Region Corporation, a web-based manual is being developed to address the continuum of care needed for Alaskans with alcohol, drug, and mental disorders. Care programs address

the range of needs from the homeless to women at risk of having their children taken away for abuse or neglect.

- **Health Services:** A research evaluation to examine factors associated with success in disseminating the State-of-Alaska-funded rural human services program for serious emotional problems or disturbances.

In addition, in partnership with the Indian Health Services, SAMHSA, the Canadian Institutes of Health Research, and Health Canada, NIMH is undertaking follow-on collaborative activities identified as priorities during a joint conference, held in September 2005, to address the issue of suicide prevention in indigenous populations in the U.S. and its territories and Canada.

National Cancer Institute. With support from the NCI, the Network for Cancer Control Research and the Mayo Comprehensive Cancer Center established the Native CIRCLE, a clearinghouse for research-based information and resources. Many useful, culturally sensitive materials, including school curricula, videos, pamphlets, and survey instruments, are catalogued and made available to researchers and communities for application in the areas of smoking prevention, cancer screening, and dietary change. The web address is <http://mayoresearch.mayo.edu/mayo/research/cancercenter/native.cfm>.

National Institute of Child Health and Human Development. The NICHD is working with American Indian and Alaska Native communities to identify and develop outreach programs that increase the awareness and reduce the risk of sudden infant death syndrome (SIDS) among American Indian and Alaska Native infants. The outreach programs will provide a vehicle for health care professionals and other outreach workers to interact with community leaders, including small group discussions with public health nurses, community health representatives, elders, and other caregivers of infants. Some of the issues and strategies to be discussed include:

- Developing a community-owned project;
- Incorporating the indigenous culture and traditions, such as encouraging the use of cradle boards and using talking circles;
- Involving elders in educating young parents;
- Using public health nurses, community health representatives, and home visiting programs such as Healthy Start;
- Focusing education on women's health, pre- and post-pregnancy; and
- Focusing on alcohol and smoking issues.

The NICHD plans to use information gleaned from previous meetings with community leaders and discussion groups to develop materials, coalitions, and an infrastructure that the communities can use when developing and conducting outreach programs. As a result of these interactions, representatives from the tribes and individual communities may tailor informative action plans for community-driven SIDS risk reduction strategies that meet the unique needs of their local community members.

National Institute of Diabetes and Digestive and Kidney Diseases. The NIDDK, via its National Diabetes Education Program, promotes a public awareness campaign: “*Move-IT! Reduce your Risk of Diabetes.*” This campaign is targeted to Native youth to encourage physical activity in order to reduce their risk of type 2 diabetes.

National Institute of Dental and Craniofacial Research. The NIDCR-supported Northwest/Alaska Center to Reduce Oral Health Disparity, located at the University of Washington, focuses on reducing socio-cultural barriers to improve oral health of vulnerable children in the Pacific Rim, including the northern regions of Alaska. The project seeks to better understand information regarding feeding practices and to develop culturally appropriate communications methods that will ultimately assist in the design of an appropriate web-based tool (EthnoDent) to improve the cultural competence of dentists who serve such populations as Native American and Alaska Natives.

National Center for Research Resources. To educate and inform the Alaskan public about health science research so they can make healthier lifestyle choices, NCRR, through its Science Education Partnership Awards (SEPA) program, supports the Imaginarium’s Health Outreach Caravan, which forms partnerships with the scientific, public health, educational, and cultural communities; develops mobile, hands-on, interactive, and culturally appropriate health-related programs; and develops a Health Science Teen Volunteer Corps across remote, culturally unique regions of Alaska to facilitate linkages among biomedical scientists, village elders, and local community and school programs. The program is designed to stimulate Alaskan students’ interest in science, particularly those students in remote rural areas of Alaska who are traditionally under-represented in the science professions. Ancillary activities in addition to the Teen Volunteer Corps will include teacher professional development and health fair festivals.

Fogarty International Center. The FIC is work-

ing with the National Institute of Mental Health, the Substance Abuse and Mental Health Services Administration, and others to undertake follow-on collaborative activities identified as priorities during an international symposium focusing on suicide prevention in the Arctic, held in September 2005. The discussions and recommendations are expected to provide input for the 13th International Congress on Circumpolar Health, to be held in Novosibirsk, Russia, in June 2006 as a “Gateway to IPY.”

2.4.4 Infrastructure and Capacity Building

Research Goal: To build up the capacity of Arctic institutions and organizations for competitive participation in the research enterprise (i.e., their ability to obtain research grants) through training and support of facilities or center-type grants.

National Heart, Lung, and Blood Institute. The NHLBI will continue to develop the research capacity of Alaska Native organizations and individuals through the existing Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) study and other potential funding awards currently under review. The goal will be to establish grant funding for one or more Alaska Native organizations. In addition, any grants funded in Alaska by NHLBI will be strongly encouraged to recruit and train staff from within the study population and to utilize the NIH’s minority supplement mechanisms to support training for one or more promising Native students in biomedical research.

National Cancer Institute. The NCI continues to support several training programs in the area of Arctic health:

- **Native American Student Research Program: Community-based Cancer Control:** This research and training program for American Indian and Alaska Native graduate and post-doctoral students is a collaboration between the Indian Health Service, Oregon Health Sciences University, and the tribe-operated Northwest Portland Area Indian Health Board.
- **Education for Healthcare Providers of Alaska Natives: Palliative Care:** Cancer is now the leading cause of death for Alaska Natives, surpassing trauma and infectious diseases, which were leading causes of death for many years. Given that the majority of basic primary care for Alaska Natives is provided by village-based workers and community health aides, whose training and experience is primarily in

primary and acute care, health care providers are often ill-prepared to provide palliative care to patients nearing the end of life. This program is designed to address educational needs related to system-wide implementation of a comprehensive, integrated, and culturally sensitive palliative care program for Alaska Natives. A well-trained palliative care team will become the core trainers once the program is implemented.

National Institute on Aging. The Native Elder Research Center/Resource Center for Minority Aging Research, supported by the NIA, provides an administrative structure, supported by a comprehensive array of unique programs, that directs and coordinates a culturally relevant, scientifically meritorious research career development program targeting American Indians and Alaska Natives. This project also is designed to augment already active partnerships with these communities to ensure continuous access to and involvement of elders, their families, and local systems of care in the aging research process. It is housed within the Division of American Indian and Alaska Native Programs of the Department of Psychiatry, School of Medicine, at the University of Colorado Health Sciences Center.

National Institute of Nursing Research. The NINR has expanded its activity in infrastructure and capacity building in the Arctic through its Centers Program. Specifically, in FY 2004 the University of Washington's Center for Women's Health and Gender Research formalized its collaborative relationship with the University of Alaska Anchorage's School of Nursing. The University of Alaska is now a part of the Research Development and Partnership Core at the Center.

National Institute of Neurological Disorders and Stroke. The NINDS, along with the National Institute of Mental Health 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. This program is intended to establish, expand, and enhance competitive research programs in basic neuroscience at minority institutions. It is expected also to facilitate the development of collaborative research and to stimulate the active participation of Alaska Native students. The research projects will examine themes of interest to Alaskan peoples, including circadian rhythms, hibernation mechanisms, and neural development and repair.

National Center for Research Resources. The

NCRR continues to develop Alaska's research capacity through funding from the two components of the Institutional Development Award (IDeA) program: the Centers of Biomedical Research Excellence (COBRE) award and the IDeA Networks of Biomedical Research Excellence (INBRE).

The University of Alaska's Center for Alaska Native Health Research (CANHR), funded through COBRE, has enrolled 777 participants in Yup'ik villages and will continue to enroll new participants for community-based epidemiological studies of biological and environmental variables in metabolic disorders and obesity. The center's cultural behavioral core will continue to disseminate key information to participating villages, with Yup'ik research assistants trained to give presentations using the Yup'ik language and culturally attuned symbols and concepts. In addition, the center will exploit enhanced cyberinfrastructure supported by NCRR to form networks with senior investigators outside of the state, creating a broad and strong foundation for future growth and productivity.

The INBRE award to the University of Alaska provides support to build a network that will broaden and strengthen capacity and performance in biomedical research by supporting faculty and providing research opportunities that will expose undergraduate students within the state to promote careers in biomedical research. The research efforts focus on environmental health, with an additional focus on molecular toxicology of subsistence species and on infectious agents, including zoonotic diseases. The INBRE award also supports an outreach program for smaller Alaska colleges, hospitals, and health corporations to attract students and faculty and engage them in INBRE research projects. The ultimate goal of the INBRE program is to enhance science knowledge of the Alaskan workforce and expand the undergraduate student pipeline into health careers, with particular attention to Alaska Native students.

Fogarty International Center. The FIC is soliciting grant applications for its new International Collaborative Trauma and Injury Research Training Program. This program, co-funded by seven NIH partners, the CDC's National Center for Injury Prevention and Control, the Pan American Health Organization, and the World Health Organization (WHO), aims to raise awareness of the human and economic costs caused by trauma and injury, which are leading causes of death and disability globally, particularly in the Arctic. Training will

build skills and knowledge on how to address most effectively this challenge across the range of basic to applied science, the epidemiology of risk factors, acute care and survival, rehabilitation, and long-term mental health consequences.

Substance Abuse and Mental Health Services Administration. The mission of SAMHSA is to build resilience and facilitate recovery for people with or at risk for substance abuse and mental illness. SAMHSA works in collaboration with the states, national and local community-based and faith-based organizations, and public and private sector providers. Although SAMHSA does not conduct research per se, it supports numerous activities relevant to capacity development in Alaska:

- Fetal Alcohol Spectrum Disorders Center for Excellence: This center coordinates activities to ensure that advances in both science and practice are synthesized and efficiently disseminated to the field. The center's mandates include the study of innovative clinical interventions, identification of communities with exemplary comprehensive systems of care, provision of technical assistance and training to individuals in service systems, and development of innovative techniques to prevent alcohol use by women in childbearing years.
- Circles of Care Program: This SAMHSA program provides grants for tribes and urban Indian communities to plan, design, and assess culturally specific mental health service system models for American Indian and Alaska Native children and their families.
- Child Mental Health Initiative: This cooperative agreement provides grants to states, political subdivisions, and tribes or tribal organizations to develop community-based systems of care for children (and their families) with serious emotional disturbances.
- Screening, Brief Intervention, Referral and Treatment (SBIRT): This five-year discretionary grant program is designed to assist states, territories, and tribes in expanding the continuum of care available for treatment of substance use disorders. The Cook Inlet Tribal Council, Inc., of Anchorage is one of seven SBIRT grantees.
- Co-Occurring State Incentive Grants (COSIG): Alaska has committed to improving the identification and treatment of individuals with co-occurring disorders through a diverse service delivery system of improved screening, assessment, treatment, and training. In fulfill-

ment of a state action plan for integrating mental health and substance abuse services, this effort will be accomplished through a five-year COSIG grant (awarded in 2003) to Alaska to support infrastructure development, focusing on staffing competency, credentialing, and licensure; financial planning and reimbursement; and information sharing and data collection.

- Targeted Capacity Expansion (TCE) Program: This grant program expands treatment opportunities and capacity in local communities experiencing serious, emerging drug problems and in communities that propose innovative solutions to substance abuse treatment needs not previously met. Specialized initiatives emphasize strengthened services for youth, adolescents, and minority communities, particularly in rural areas, and support services for persons in recovery (e.g., from methamphetamine and other emerging drugs), in particular those addressing the twin issues of substance abuse and HIV/AIDS. Alaskan grant recipients have included the Yukon Kuskokwim Health Corp., the Copper River Native Association, the Fairbanks Native Association, and the Cook Inlet Tribal Council.
- Access to Recovery Program (ATR): SAMHSA's signature treatment services program is a state-run voucher program for substance abuse clinical treatment and/or recovery support services. ATR is designed to expand capacity by increasing the number and types of providers, including faith-based providers; allow recovery to be pursued through many different and personal pathways; and require grantees to manage performance, based on outcomes that demonstrate patient successes. While Alaska is not a current ATR grantee, it will be eligible to apply again in FY 06 when the program is proposed for expansion to allow seven additional awards to be made.

Health Resources and Services Administration. The HRSA works to expand access to high-quality, culturally competent health care and to improve health outcomes among Alaska's minority communities through the National Health Service Corps and support of community health centers. The agency also enhances direct medical care in Alaska through the use of telehealth technology and promotion of the Health Disparities Collaborative approach to disease management through

HRSA-funded community health centers.

In addition, an HRSA grant to the Alaska Psychiatric Institute (API), Alaska's state psychiatric hospital, provides funds for API to work with the Alaska Federal Health Care Access Network to extend the clinical infrastructure of API to rural/remote areas of Alaska and integrate behavioral health services with primary care and Native health clinics through the use of telemedicine.

As part of a quality improvement effort associated with its community health centers in Alaska, the HRSA supports health disparity collaborative activities, which focus on specific topic areas.

Examples include the following centers:

- Anchorage Neighborhood Health, Anchorage: Diabetes and Depression
- Eastern Aleutian Tribes, Anchorage: Depression and Cardiovascular Health
- Edgar Nollner Health Center, Galena: Diabetes and Cardiovascular Health
- Illiuk Family and Health Services, Unalaska: Diabetes and Cardiovascular Health
- Interior Community Health Center, Talkeetna: Diabetes and Depression.

2.4.5 International Circumpolar Collaborations

Research Goal: To promote the collaborative efforts of scientists across the eight circumpolar nations to facilitate comparison of environmental monitoring results, disease rates, development of new approaches, and dissemination of best practices and care. This will lead to a more comprehensive understanding of the effects of environmental pollution, climate change, and cultural impacts on Arctic populations.

In September 2004, the National Institutes of Health (NIH) and the Canadian Institutes of Health Research (CIHR) signed a letter of intent to strengthen research cooperation on health issues of priority to American Indians, Alaska Natives, Canadian First Nations, Métis, and Inuits of the U.S. and Canada. The agreement builds on an earlier one, signed in May 2002, between the U.S. Department of Health and Human Services and Health Canada (equivalent to the Ministry of Health), which recognized common objectives of improving the health status of First Nation and Inuit peoples in Canada and American Indians and Alaska Natives in the U.S. and sharing knowledge to improve approaches to Native peoples' health issues. Together, these agreements represent significant institutional support for collaborative

projects focusing on indigenous peoples of the North through the CDC, the NIH, the Indian Health Service, and several health organizations in Canada.

National Cancer Institute. The NCI is engaged in a binational collaboration with Canada on the cancer burden in Native populations. In the U.S., cancer is the second leading cause of death for American Indians and the leading cause of death for Alaska Natives. In Canada, cancer is the third leading cause of death, following injuries/poisonings and cardiovascular disease. The First Nations and Inuit population of Canada experience health disparities similar to those of American Indians and Alaska Natives in the U.S. (i.e., a gap of 6.4 years and 4.7 years in life expectancy, respectively, compared to the general population). The purpose of the project is to assemble and analyze cancer surveillance data on the Native populations in the U.S. and Canada—culturally and genetically related but exposed to different health care and social environments—into a profile of North American cancer surveillance and cancer burden that could lead to improved understanding of risk factors and effective preventive interventions. The Alaska Native Tumor Registry described in Section 2.4.2 will play an important role in this collaborative project.

Centers for Disease Control and Prevention's Arctic Investigations Program. The Anchorage-based AIP coordinates the International Circumpolar Surveillance (ICS) system, which links existing public health laboratories and facilities in Arctic countries to address emerging infectious diseases. This initiative follows the CDC's Global Disease Strategy: "Protecting the Nation's Health in an Era of Globalization," which defines CDC's global health priorities in six areas:

- International outbreak assistance;
- A global approach to disease surveillance;
- Applied research on diseases of global importance;
- Application of proven public health tools;
- Global initiatives for disease control; and
- Public health training and capacity building.

For the 2006–2010 planning period, AIP will continue to develop public health partnerships for the international circumpolar surveillance of invasive bacterial diseases (those caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Neisseria meningitidis*, and Group A and B streptococcus) in the U.S. Arctic (Alaska), northern Canada, Greenland, Iceland, Norway, Finland, and Sweden. This network of networks provides data

for tracking the emergence of antimicrobial resistance and the impact of programs for prevention of invasive bacterial diseases. During this planning period, opportunities will be explored to initiate surveillance of tuberculosis, hepatitis B, and HIV and to extend the surveillance system to include northern regions and oblasts of the Russian Federation. In addition, ICS will expand its scope to include integrated surveillance of non-infectious diseases and injuries in the Arctic region.

National Institute of Allergy and Infectious Diseases. The NIAID has established the Population Genetic Analysis Program: Immunity to Vaccination/Infection. An Icelandic company, deCode Genetics, a component of this program, was awarded a contract to conduct research on genetic polymorphisms in candidate immune response genes, including those for transcription factors, cytokines, chemokines, and adhesion and co-stimulatory molecules, in an Icelandic population. Approximately 500–1,000 cases and an equal number of controls will be enrolled in Iceland under that country's human subject protection rules.

National Institute of Alcohol Abuse and Alcoholism. Working with local communities and in collaboration with other Federal agencies, the NIAAA is supporting a study of maternal drinking and Fetal Alcohol Spectrum Disorders (FASD), which will advance understanding of the roles of environment, culture, and general intellectual functioning in the phenotype of FASD by comparing neuropsychological tests and brain imaging studies of children in the U.S., Helsinki, and Moscow. The project also will develop a core team of expert diagnosticians at all consortium sites.

National Institute on Aging. The NIA supports research in international Arctic health through its Age, Gene/Environment Susceptibility Study (AGES), an intramural project carried out in collaboration with the Icelandic Heart Association's Reykjavik Study. The collaboration is a study of genetic susceptibility and gene/environment interaction as these contribute to traits and phenotypes common to old age. The study uses a well-

characterized, homogenous, longitudinal population sample from the Icelandic Reykjavik Study. This allows the use of mid-life data in conjunction with old-age measurements to determine phenotypes of interest for genotyping—a tremendous advantage, since diseases of old age are known to change risk factors and biomarkers. AGES focuses on traits from four biologic systems reflecting the multi-system effects of aging:

- Neurocognitive: cognition, dementia, depression, neurosensory (vision, hearing, balance);
- Cardiovascular: atherosclerosis, arterial distensibility, ventricular and valvular disease;
- Musculoskeletal: spine and hip osteoporosis, hip osteoarthritis, strength and function; and
- Metabolism and body composition: obesity, sarcopenia, and hyperglycemia/diabetes.

The AGES Study has enrolled about 5,100 subjects (including 1,000 people ages 80 or older) as of July 2005. The enrollees include persons with diverse physical and cognitive function, a large proportion of whom meet suggested criteria for frailty.

U.S. Civilian Research and Development Foundation. The NIH, together with NSF and the U.S. Department of State, will continue to support collaborative research projects, some of which are relevant to the Arctic, between U.S. scientists and their counterparts in the former Soviet Union through the U.S. Civilian Research and Development Foundation (CRDF) and its Cooperative Grants Program. During the period 2006–2010, one project in particular is relevant to Arctic health:

- “Spectrum of Mitochondrial DNA Mutations in Leber's Hereditary Optic Neuropathy in Russia/Siberia”: This project, carried out by collaborators at the Institute of Cytology and Genetics in Novosibirsk and University of California Irvine, focuses on the study of the genetics of migrating populations from northern Russia and the lower Arctic. The study will provide additional and precise information relevant to genetic epidemiology of mitochondrial disease and natural DNA variation, in an evolutionary context, in this part of the world.

2.5 Research on Resource Evaluation

In its 2003 *Report on Goals and Objectives for Arctic Research*, the Arctic Research Commission provided the following statement and recommendation:

“The Alaska National Interest Lands Conservation Act of 1980 (ANILCA §1010) directs the Secretary of the Interior to “assess the oil, gas, and other mineral potential on all public lands in the State of Alaska in order to expand the data base with respect to the mineral potential of such lands.” The Department of the Interior conducted and published several of these assessments. However, for the last several years the program has not added to the information on the resources on Alaska public lands. The environmentally sound and sustainable use of the resources on the vast area of federal lands in Alaska (about 66% of the State’s area) is essential for both the state and the nation. Resource exploitation provides the nation with needed materials and energy while providing expanded economic opportunities for the population of the State.

The Arctic Research Commission requests that the Department of the Interior resume its resource evaluation activities and cooperate with the other Federal Agencies, the State of Alaska and institutional partners to provide widely available and comprehensive coverage of all federal lands in Alaska.”

The Department of the Interior has continued to assess the energy and minerals of Alaska, and its bureaus have published numerous reports on this subject. However, with the renewed interest in information on the oil, gas, and other mineral potential on public lands in the State of Alaska, the Department of the Interior will initiate discussions with Interior bureaus and other departments to determine the feasibility of resuming publication of an annual report on these topics. IARPC expects to work with the Department of the Interior to develop this initiative in the context of funding that is made available during the period of this revision to the U.S. Arctic Research Plan (2006–2010).

2.6 Research on Civil Infrastructure

In its 2003 *Report on Goals and Objectives for Arctic Research*, the Arctic Research Commission provided the following statement and recommendations:

“Understanding climate change in the Arctic is an important goal, as the SEARCH Program has recognized. It is at least equally important, however, to begin the task of finding ways to cope with the effects of climate change, particularly on Arctic infrastructure. The effects of infrastructure problems on human life in the Arctic are particularly noted above in the section on Arctic Health. These difficulties are compounded by climate change. The destabilization of structures by changes in permafrost, changes in coastal communities caused by changing in sea level and in the frequency and strength of storm induced wave action, changes in weather patterns requiring changes in aircraft operation and many others require a strong commitment to engineering research in the Arctic. The Commission is encouraged by arrangements between the U.S. Army’s Cold Regions Research and Engineering Laboratory (CRREL) and the University of Alaska to bring the nation’s most able engineering talent to bear on these problems. CRREL is recognized around the world as an international treasure of expertise in Arctic engineering.

The Commission recommends continuing support for the U.S. Army Cold Regions Research and Engineering Laboratory and encourages their participation in infrastructure research in Alaska.

Accurate and precise geospatial (map) data are essential for many purposes including air navigation, wilderness travel, and mineral and energy exploitation. Similarly, they are fundamental requirements for the effective construction of civil infrastructure projects. The Department of the Interior through its USGS Geospatial Data Clearinghouse provides geospatial data and, in particular, digital elevation models based on a variety of measurement techniques, primarily observations from aircraft and spacecraft. Complete coverage of the 48 contiguous

states has been available for years. Full coverage of the U.S. Arctic region at high precision (1m × 1m × 1m) does not exist and is critically needed.

The Commission recommends that the Department of the Interior take steps to acquire and make available precise geospatial data for maps of the U.S. Arctic.”

The USGS has initiated the National Map Program in Alaska through the Alaska Geographic Data Committee’s (AGDC) Alaska Digital Ortho-Imagery Initiative. The AGDC comprises over 45 Federal, state, local government, university, and nongovernmental institutions, including private industry. The AGDC developed a set of technical requirements and a strategic plan with required funding and timelines that would provide high-resolution ortho-imagery and high-resolution DEMS for the entire state. Work on the AGDC initiative was formally begun in FY 02 with the acquisition of interferometric synthetic aperture radar (IFSAR) imagery (for DEM production) and high-resolution color aerial photography for the Northeast Study Area of the National Petroleum Reserve of Alaska. DOI invested approximately \$1 million in FY 02 for this pilot study through USGS contracts with private industry, supplemented with funding from the BLM.

In FY 03 the USGS and BLM expanded the coverage over NPR-A. The strategy is to focus the work on areas of the state where high-resolution data are required to support priority DOI and AGDC members’ planning and management needs. IARPC and the Department of the Interior will work to develop this program in the context of funding that is made available during the period of this revision to the U.S. Arctic Research Plan (2006–2010). IARPC also will encourage continuing support for the U.S. Army Cold Regions Research and Engineering Laboratory’s participation in infrastructure research in Alaska.

3. Agency Programs

3.1 Selected New Opportunities for Arctic Research

The following sections describe some new opportunities for Arctic research. The focus is on selected new agency programs and is not intended to be a comprehensive listing of all programs in a given research area.

3.1.1 U.S. and the Arctic Council

U.S. agencies are continuing to examine how best to contribute data to ongoing research programs being conducted through the Arctic Council's working groups and also whether there is scope for new research on issues relating to environmental contaminants, pollution, human health, and biodiversity. Given the Council's mandate with respect to sustainable development, there is also scope for renewed emphasis on research in the social sciences.

3.1.2 Remote Sensing

NASA has entered a new data-rich era of satellite observations of the Arctic, with the launch of the Earth Observing System suite of sensors. ICESat will make observations of cloud and ice surface heights, the latter being comparable with airborne laser altimeter observations of Greenland, one of the goals being to determine whether the rapid thinning of many parts of the margin of the Greenland ice sheet is continuing. The NASA satellites Terra and Aqua are providing a wide range of data types that will enrich our capability to understand Arctic processes. Two examples are AMSR, which is an advanced passive microwave sensor of high potential value for sea ice studies, and MODIS, which is a high-spectral-resolution visible and infrared imaging sensor that will enhance our ability to observe surface albedo and temperature in polar regions.

3.1.3 In Situ Sensing

NOAA has supported a temporal and spatial study of Alaskan clouds based on the use of a ground infrared imager. Measurement of clouds

is fundamentally important to studies of Arctic climate variability and change. The infrared cloud imager records calibrated images of sky radiance. This project is a first step toward studying the relationship between the Arctic Oscillation and cloudiness at various Arctic locations.

3.1.4 Fisheries Management

NOAA is also undertaking studies of the development of physical, chemical, and plankton databases for the Bering and Chukchi Seas. In addition, NOAA is carrying out an analysis of physical and ecosystem model outputs in relation to changing populations of Stellar's sea lions. NOAA also funds programs that focus on traditional ecological knowledge addressing scientific and coastal communities informational needs.

3.1.5 Cultural Exchange

Work continues on the Russia–United States International Beringian Park in the Bering Strait region. This park would preserve the unique environmental and cultural heritage of adjacent regions of Alaska and Siberia. Current plans call for continuing the highly successful past efforts on research, cultural exchanges, and publication projects.

3.1.6 U.S.–Russia Collaboration

Several bilateral agreements already exist to promote cooperative efforts in the areas of environmental protection, oceans research, basic science, fisheries management, and energy technology. An extensive amount of data has been exchanged with Russia over the last several years, which include data from north of the Arctic circle. These data are distributed among the U.S. national data centers. Many agencies have taken the initiative to develop their own contacts and programs in Russia.

In 2003, NOAA and the Russian Academy of Sciences signed a Memorandum of Understanding

on World Ocean and Polar Region Studies. This MOU resides under the Russian–U.S. Science and Technology Agreement. Because the U.S. and Russia have the opportunity to display leadership in identifying and conducting collaborative scientific activities to better explain and anticipate the types of changes that will occur in the Arctic over the coming decades, several collaborative projects have already started, and others are needed. The NEESPI project has already established the Joint Cold Land Processes and Arctic Coastal Studies based at the International Arctic Research Center, University of Alaska Fairbanks. It is anticipated that the center will provide coordination and foster further collaboration in studies over the entire Russian Arctic. NOAA has also initiated negotiations that may lead to the establishment of a sophisticated atmospheric observatory in the Russian North to complement other observatories in North America. It is anticipated that the International Polar Year will provide much needed thrust to the strengthening of Russian–U.S. scientific collaboration in the Arctic.

Under the Environmental Working Group (EWG) of the U.S.–Russian Joint Commission on Economic and Technological Cooperation, the U.S. and Russia have developed methods and procedures for using national security data for environmental problems of mutual interest. A key success of the EWG has been the creation of a series of Arctic climatology atlases using information derived from both Russian and U.S. national security data. Four CD-ROM atlases (available at <http://nsidc.org/data/ewg/index.html>) covering winter and summer oceanography, ice, and meteorology have been released with 40-year gridded time histories. The oceanographic atlases have more than doubled the Arctic oceanographic information available to the world's scientific community.

Studies of Russian, U.S., and Canadian Arctic history continue to demonstrate the ties that have linked Arctic people, cultures, and regions for the past 15,000 years.

3.1.7 Oil Pollution Control

Title V of the Oil Pollution Act of 1990 established the Prince William Sound Oil Spill Recovery Institute (OSRI), with interagency participation led by NOAA and including the Department of the Interior, the Department of Transportation, and three state agencies (Fish and Game, Environmental Conservation, and Natural Resources). During

the 1990s the State of Alaska coordinated with OSRI in developing an Arctic–subarctic oil spill research plan. OSRI's programs are funded through the approximately \$1 million in annual interest earnings it receives from a \$22.5 million fund dedicated for OSRI and maintained within the Oil Spill Liability Trust Fund. In 2002, Congress approved extension of OSRI through September 2012, with its funding to continue from the interest earnings as described above. OSRI programs are detailed at their web site (www.pws-osri.org). OSRI is located in Cordova, Alaska, and is administered through the Prince William Sound Science Center (www.pwssc.gen.ak.us), a non-profit research organization founded in 1989 to facilitate and encourage ecosystem studies in the greater Prince William Sound region.

3.1.8 Permafrost Degradation

Renewed concern for the potential damage to infrastructure and the environment due to permafrost degradation has been sparked by ongoing initiatives to provide access to the National Petroleum Reserve in Alaska (NPR–A) for non-renewable resource development, as well as increased DOD interest for potential National Missile Defense facilities in Alaska and other Arctic regions.

Roads, airfields, buildings, and pipelines founded on permafrost are at risk of damage when the ground warms or thaws. This degradation causes frozen ground to lose its strength, with consequences ranging from a reduced service life to outright structural failure. The thawing of ice-rich permafrost produces irregular settlement and slope instabilities that permanently alter the terrain and have catastrophic consequences for the infrastructure.

Permafrost degradation is not a hypothesized outcome of global warming; engineers have been dealing with the effects of permafrost degradation for some time. Factors such as microclimate, local hydrology, glacial history, geomorphology and materials, and increased snow depth can promote, and in some cases control, degradation at specific sites.

In addition to the impact to infrastructure, permafrost warming and thawing have dramatic effects on vegetation, topography, and hydrologic processes, which in turn have serious ecological and land use implications. Warming may increase the release of trapped methane. The degradation process may result in an increase in the mobility of

methane locked in existing permafrost deposits. The impact is initially localized and is highly dependent on the nature of the contaminants and the geological and hydrological conditions of the site.

The issue of permafrost degradation impacts virtually all elements of the existing infrastructure and future Arctic building programs, land use, and contaminant mobility, and it raises concerns regarding the exposure of other cold-regions nations to this threat. Although this problem has been recognized by the engineering community, knowledge of the extent of permafrost areas at risk, predictions of the rate of degradation and the resultant damage to specific structures, and a strategy for dealing with progressive damage are all lacking.

3.1.9 Contaminant Behavior and Impact in Northern Polar Regions

NOAA is involved in several contaminant behavior programs that are examining the deposition flux rates and fate of atmospheric mercury at Barrow, Alaska, and tracing persistent organic and trace element pollutants in the Alaskan Arctic. The latter is the Alaskan component of a larger effort entitled "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, to contrast the occurrence of persistent organic pollutants and trace elements in this region with other Arctic airsheds, 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.

The Climate Monitoring and Diagnostics Laboratory's clean air sector at Barrow, Alaska, is also involved in monitoring gaseous elemental mercury in the Arctic environment. This is a byproduct of coal combustion, waste incineration, and certain types of manufacturing. Mercury concentrations in certain Arctic mammals are the highest in the North American Arctic (Arctic Monitoring and Assessment Program 1997). A reduction in atmospheric mercury occurs when there are sunlight, low temperatures (less than 20°C), and an underlying snowpack. The concentrations of bio-available mercury in the Barrow snowpack are 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 deposition zone for mercury air pollution.

3.2 Arctic Ocean and Marginal Seas

3.2.1 Ice Dynamics and Oceanography

Recent studies indicate that the sea ice cover is undergoing significant climate-induced changes, affecting both its extent and thickness. For instance, satellite-derived estimates of maximum ice extent suggest a net reduction between 1978 and 1996, at an average rate of -3% per decade (Parkinson et al. 1999). A recent report by Comiso (2003) indicates an even more rapid reduction in the perennial sea ice cover: -9% per decade. Data on the ice thickness, derived from submarine-based upward-looking sonar, also suggest a net thinning of the sea ice cover since 1958 (Rothrock et al. 1999, Wadhams and Davis 2000, Tucker et al. 2001). NOAA is continuing to monitor these changes to improve the fundamental understanding of the role of the sea ice cover in the global climate system and to take advantage of the sensitivity of the sea ice cover as an early indicator of the magnitude and impact of climate change.

Until satellite imagery can be used to monitor ice thickness, we must rely on measurements made from submarines, aircraft, seafloor moorings, and drifting buoys. As determined at the recent SEARCH Workshop on Large-Scale Atmospheric/Cryospheric Observations (Overland et al. 2002), this is most effectively done through a coordinated effort to establish a large-scale sea ice observing system. It is also necessary to disseminate the data collected from the various components of this system to the scientific community in a timely and consistent fashion. Once available, the data can be used to gain insight on the relationship between the characteristics of the sea ice cover and climatic forcing. Specific emphasis should be placed on efforts to work in tandem with those developing satellite-based assets designed to measure ice thickness. Data from the ice-based observing system can play a central role in assuring an optimal approach for obtaining accurate satellite-based measurements. Together, these platforms can provide an effective means of assessing the state of the sea ice cover over the entire Arctic basin.

NOAA, NSF, NASA, and DOD work cooperatively to carry out observations and modeling of the freshwater dynamics connecting the Arctic and the Atlantic. Concentrated activity occurs where the Arctic and Atlantic Oceans meet and

interact. 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.

NOAA is continuing to study the 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. Changes in the freshwater balance would influence the extent of sea ice cover; changes in the surface albedo, energy balance, temperature, and salinity of water masses; and biological processes in the Arctic. (Also see Section 2.1.)

3.2.2 Ocean and Coastal Ecosystems and Living Resources

NOAA has undertaken several programs focusing on ocean ecosystems, including analyses in the Bering Sea region to study climate variability and its impacts on ecosystems and a study of the trophic pathways on the Chukchi–Beaufort shelf. 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. Ice algae are important to microbial food webs and the dissolved and particulate carbon and nitrogen pools of the Arctic Ocean. Novel techniques to quantitatively trace carbon fixed by ice algae and water column phytoplankton through pelagic and benthic food webs using conservative fatty acid signatures are being used. 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.

NOAA's Arctic Research Office has supported projects to examine possible connections between Arctic climate and oceanic change and the declining Steller's sea lion population. The areas of interest include impacts of climate change on the Bering Sea ecosystem over the past 500 years, retrospective studies of climate impacts on Alaska Steller's sea lions, the nature of North Pacific regime shifts and their impacts on Steller's sea lions, ocean climate variability as a potential influence on Steller's sea lion populations, North Pacific climate variability and Steller's sea lion

ecology, interannual variability of biophysical linkages between the basin and shelf in the Bering Sea, and climate-related processes and killer whale abundance as factors in Steller's sea lion population trends in the Aleutian Islands. The National Marine Mammal Laboratory's Alaska Regional Office and the Protected Resources Management Division are responsible for research on the management of 22 species of marine mammals that commonly occur in Alaska, including Steller's sea lions.

NOAA's Resource Assessment and Conservation Engineering Division and Resource Ecology and Fisheries Management Division is promoting a full-scale program to provide information on the run characteristics of Yukon River chinook salmon. Over 1100 fish will be radio-tagged near the river's 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.

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 is also investigating decadal variability and climate change of the North Pacific and western Arctic, particularly in light of the declining Steller's sea lion population. (Also see Section 2.1.)

3.2.3 Marine Geology and Geophysics

The Arctic continental margin and deep ocean basin constitute one of the least understood geological regions of the world, partly because much of the offshore area is covered with sea ice. A better understanding of the tectonic history, geologic structure, sediment processes and distribution, and climatic and glacial history of the deeper basin will require extensive geophysical and geological research and the integration of

newly collected data on an international scale. In addition, the Arctic seafloor north of Alaska and on the Chukchi Plateau and Northwind Ridge remain poorly mapped. Several missions from NOAA have begun to carry out multibeam mapping operations in this ice-covered region of the U.S. Exclusive Economic Zone (EEZ) to create detailed bathymetric maps.

Objectives

- Develop and perfect new techniques for deployment of instruments in the harsh Arctic environment (for example, seismic tomography, geophysical arrays, hydraulic piston coring, and scientific deep drilling);
- Initiate Arctic marine geological and geophysical studies to provide information on past and present climate change and the history of the ice cover, support rational development of natural resources, and address fundamental questions of global geologic history and regional tectonic development;
- Define the geologic framework, deep structure, and tectonic history and development of the Bering Sea region;
- Develop the capability for systematic and comprehensive collection of geologic data in the ice-covered offshore regions using remote sensing and other technologies, such as the nuclear submarine; and
- Determine modern sediment transport by sea ice, icebergs, and other processes; characterize the seafloor sediments by coring and reflection methods; and establish a well-dated stratigraphy.

3.2.4 Underwater Research

In 2002 NOAA funded the development of an ROV, the *Global Explorer*, to investigate life under the ice, in the water column, and on the seafloor of the deep Canada Basin and the Northwind Ridge. This program, called Arctic 2002, was a collaboration between NOAA's Ocean Exploration Office and Arctic Research Office, the Canadian Department of Fisheries and Oceans, JAMSTEC, and institutes in China. The major goal of this expedition was to take censuses of marine life in the unexplored regions of the Arctic. NOAA's Office of Ocean Exploration will continue to support exploration in the Canada Basin during the summer of 2005.

3.3 Atmosphere and Climate

3.3.1 Upper-Atmosphere and Near-Earth Space Physics

The goal of this research is to study upper-atmospheric and near-Earth space phenomena unique to the Arctic regions. These include the aurora, particle precipitation, auroral convection and currents, polar mesospheric clouds, Joule heating, and geomagnetic storms and substorms. These phenomena are intimately linked to the Arctic environment and culture, particularly as Arctic inhabitants become more dependent on modern technology and the Arctic economy becomes more firmly planted in technical systems.

Many of these phenomena are driven by particles and fields originating on the sun. Particles from the sun impact Earth's magnetosphere, which is connected to the upper atmosphere and ionosphere through magnetic field lines that converge in the polar regions. A large fraction of the energy entering the magnetosphere is deposited in the polar upper atmosphere. Arctic ionospheric disturbances interrupt the performance of GPS navigation systems, surveillance systems, and high-frequency radiowave propagation.

The state of the space environment near Earth and its response to solar inputs has come to be known as space weather. The study of Arctic phenomena represents a critical element in understanding the way the space weather system works.

The Arctic region is also extremely sensitive to climate variability and change. Warming of the atmosphere at lower altitudes is occurring in conjunction with cooling of the upper atmosphere, a change that is believed to be manifested in the increasing occurrence rate of polar mesospheric clouds. These effects are being studied intensively as part of the U.S. Global Change Research Program. (See Chapter 12, p. 260 of the Strategic Plan for the U.S. Climate Change Science Program.)

Objectives

- Observe the global-scale response of the polar regions through a coordinated program involving a polar network of ground-based optical, radio, and magnetic observatories and space-based measurements;
- Develop special research tools to address key problems, including establishing a Relocatable Atmospheric Observatory and upgrading the existing incoherent scatter radars, the

array of HF radars in the Arctic, and the arrays of optical, radio, and magnetic remote sensors, and also including establishing a coordinated rocket program, promoting the use of special facilities, and making use of research aircraft;

- Maintain active theoretical programs and promote the evolution of models to describe the unique physics of the atmosphere and ionosphere in Arctic regions;
- Understand solar phenomena that affect Earth's environment;
- Understand electromagnetic waves, fields, and particles in near-Earth space; and
- Develop an understanding and the ability to make long-term predictions of radiowave propagation in and through Earth's ionosphere.

3.3.2 Climate and Weather

NOAA is currently supporting a program to study the recent changes in sea ice and snow cover and their impact on 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 (Moritz et al. 2002). Much scientific interest has focused on the Arctic Oscillation (AO). 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 is to determine the impact of the Arctic Oscillation 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.

The recently released Arctic Climate Impact Assessment (ACIA) was a four-year project of the Arctic Council and the International Arctic Science Committee that started in 2001; the overview report was released in November 2004. The larger science report is scheduled to be available in the summer of 2005. Funding for ACIA was 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. The goal of the ACIA was to examine the possible impacts of

climate change on the environment and its living resources, on human health, and on relevant economic sectors. About 180 authors were selected for the assessment from all Arctic countries. An ACIA Symposium was held in Iceland in November 2004, and briefings have been held in many countries, including to Scandinavian parliaments and the U.S. Congress. Further information on ACIA can be found on its web page at <http://www.acia.uaf.edu/>.

The Arctic Council is developing a scientific response to the ACIA that would be undertaken by its various working groups. A summary of the recommendations from the ACIA science report is being prepared for release at the same time as the science report itself. Because of the drastic changes in high latitudes foreseen by the ACIA, joint work between the Arctic countries is warranted.

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 United States (through NSF and NOAA's Arctic Research Office) being the lead country for the assessment. The goal of the ACIA is to examine the possible impacts of climate change on the environment and its living resources, on human health, and on relevant economic sectors. About 180 authors have been selected for the assessment from all Arctic countries. Further information on ACIA can be found on its web page at <http://www.acia.uaf.edu/>.

In addition, the ARM (Atmospheric Radiation Measurement) Program, DOE's principal climate change research effort, seeks 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.

ARM created a number of long-term, highly instrumented climate research sites in carefully selected locations around the world. The site locations 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 Cloud and Radiation

Testbed (CART) sites now exist, each with facilities at more than one location. In addition, an ARM Mobile Facility (AMF) is currently being developed. In spring 2003, the three ARM CART sites taken together were designated a National User Facility: the ARM Climate Research Facility (ACRF). The ARM Mobile Facility will become part of the ACRF as soon as it is deployable.

A generic, fully developed ACRF site includes facilities spread over a large area. The central facility at Barrow has the largest concentration of instrumentation at the North Slope of Alaska site. It relies heavily on upward-looking remote sensors (radars, lidars, and radiometers of several kinds) to determine the characteristics of the clouds, winds, and atmosphere as a whole above the site on a continuous basis. The inland facility at Atkasuk has a subset of the instrumentation deployed at Barrow. A temporary-use facility at Oliktok Point to the east of Barrow is available for field campaigns using instrumented tethered balloons that cannot be accommodated at Barrow because of Federal Aviation Administration constraints.

In addition to ground-based instrumentation for characterizing the atmosphere and the earth's surface, it is also necessary to make occasional instrumented aircraft flights for measuring conditions aloft and also to depend heavily on data from polar-orbiting satellites. Because of the proximity of the NSA ACRF site to the North Pole, polar orbiters view the NSA site much more frequently than sites at lower latitudes. A major field campaign called the Mixed-Phase Arctic Cloud Experiment (M-PACE), utilizing research aircraft, satellite remote sensors, and instrumentation at Barrow, Atkasuk, Oliktok Point, and Toolik Lake Field Station, was recently completed. This is one of many field campaigns that have taken place at the North Slope ACRF site.

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. The ACRF goal is to provide a high-quality legacy data set for these purposes through continuous quality improvement. ARM also periodically solicits and funds proposals utilizing ARM data to achieve ARM goals. 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; and
- Development and testing of satellite remote sensing algorithms.

It should be noted that because the NSA/AAO is an element of a National User Facility, other agencies, academic institutions, and even foreign researchers and organizations can apply to use the NSA/AAO facilities to address climate-related or other issues of their own choosing. Provided that certain criteria are met, facility use can be granted on a non-interference basis (<http://www.db.arm.gov/cgi-bin/IOP/iops.pl>). If the only need is for existing data streams, no application or approval is necessary. The data are publicly available through the ARM data archive (<http://www.arm.gov/data/>).

3.3.3 Tropospheric and Stratospheric Chemistry and Dynamics

NOAA scientists from the Aeronomy Laboratory and the Climate Monitoring and Diagnostics

Laboratory play prominent roles in the international scientific assessment of the ozone layer.

NOAA scientists from the Climate Monitoring and Diagnostics Laboratory (CMDL) conduct monitoring and research of atmospheric constituents that are capable of forcing change in the climate of the earth and atmospheric constituents that may cause depletion of the global ozone layer. The programs consist primarily of long-term measurements of solar radiation and atmospheric trace gases such as carbon dioxide, methane, carbon monoxide, halogenated compounds, nitrous oxide, surface and stratospheric ozone, and aerosols, and at sites remote from local and regional air pollution. The long-term measurements are supplemented by field campaigns using aircraft, ships, and even trains traveling the Trans-Siberian Railroad.

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 ended in 1995 in the “developed” countries, but production in economically developing countries (for example, Russia and China) will continue until 2010.

3.4 Land and Offshore Resources

3.4.1 Energy and Minerals

The geologic framework of the Arctic is very poorly understood because of the complexities of its geology, its remoteness, and its relative lack of exploration. The remote frozen environment requires long lead times for energy and mineral development. Additional information is necessary to allow the discovery, assessment, and mapping of new and dependable sources of oil, gas, coal, and strategic minerals. These resources are important for national security and independence, as well as for local use and economics.

Objectives

- Reinstate systematic mineral appraisal activities and expand programs to provide periodic assessments of the undiscovered oil and gas and strategic mineral resources in the Arctic on both broad and local scales;
- Evaluate unconventional energy resources (for example, gas hydrates);
- Identify energy and mineral resources for local use;
- Use new technologies to develop a more modern and complete geologic database, increase geologic mapping, expand modeling efforts, and design derivative maps to address broader earth-science questions; and
- Evaluate the economic, environmental, cultural, and social implications of resource extraction and transport.

3.4.2 Coastal and Shelf Processes

Specific questions about where to build causeways, man-made islands, and other structures can be answered only after basic process information is collected, interpreted, and analyzed carefully. Studies of coastal erosion and sediment transport in the Arctic are needed to understand the long-term history of the coastal area in order to intelligently manage the coastal region. The study of archeological sites can provide important information on the history of coastal platforms, erosion rates, and land-shelf interactions.

Objectives

- Map beach, littoral, and nearshore sediment and subsea permafrost and determine its associated physical and chemical properties;

- Define the processes controlling the formation and degradation of the seasonally frozen sea floor;
- Implement long-term measurements of tides, winds, waves, storm surges, nearshore currents, sediment distribution patterns, and archeological sites to understand coastal erosion and sediment transport processes; and
- Investigate the direct and indirect effects of ice on coastal erosion (the influence on waves and currents) and on sediment transport (contact with beach sediments, keel gouging, and entrainment in frazil ice).

3.4.3 Terrestrial and Freshwater Species and Habitats

The Arctic supports many species of birds, mammals, fish, and plants, which are important resources to the Nation, as well as to Alaska Natives. Some of these resources are harvested commercially or for subsistence purposes (for example, food, shelter, fuel, clothing, and tools), and others provide recreation. To assure that biological resources are protected for future generations, management agencies must have adequate data and information on the biology and ecology of these species, as well as information on environmental attributes of importance to vital biological processes (for example, feeding and breeding).

Objectives

- Determine the history, abundance, biodiversity, and distribution of fish and wildlife populations and identify their habitat requirements;
- Develop new techniques and technologies for studying and managing biological resources in the often-remote and cold-dominated Arctic environments, including recovery of ecosystems damaged by wildfires and other natural and human-induced causes; and
- Improve methods for detecting and determining the effects of human activities on the environment.

3.4.4 Forestry, Agriculture, and Grazing

Enhanced knowledge of Arctic and subarctic ecosystems, their controlling processes, and

productivity will lead to improved forest, cropland, and soil management practices for sustaining renewable resource productivity. The goals are to promote self-sufficiency and economic benefits for local inhabitants.

Objectives

- Conduct research covering northern boreal forest ecosystems and their controlling processes, focusing on forest landscape and stream ecosystem sustainability and long-term productivity in the face of episodic disturbance, global change, and atmosphere, landscape, forest, stream, and management interactions;
- Conduct soil and plant science research to enhance management practices in the face of development and low-temperature, permafrost, and wildfire impacts;
- Prepare coordinated soil resource information (maps and databases) of the Arctic circum-polar region and continue to coordinate this effort with China, Russia, Canada, Greenland, Germany, Norway, Sweden, and Finland and with the Joint Cryosol Committee of the International Permafrost Association and the International Union of Soil Science;
- Conduct animal science research focused on integrated pest management and Holarctic ruminant parasites; and
- Provide technology for enhancing the economic well-being and quality of life at high latitudes.

3.5 Land–Atmosphere–Water Interactions

3.5.1 Glaciology and Hydrology

NOAA has supported a program to study the hydrologic response of Siberian major rivers to climate change and variation (Yang et al. 2002). Arctic rivers are an important component in global ocean and climate systems, and these studies have shown changes in the 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.

The Program for Arctic Regional Climate Assessment (PARCA) is a NASA project with the goal of measuring and understanding the mass balance of the Greenland ice sheet. Primarily remotely sensed data have been used in the project, complemented by targeted in situ measurements, primarily on ice cores and at automatic weather stations (AWS).

Before PARCA in 2000, we could not determine whether the ice sheet was increasing or decreasing in volume, and mass-balance errors were equivalent to a thickness change of about ± 10 cm/yr for the entire ice sheet. Since then, analysis of repeat surveys by satellite radar altimeter (1978–1988 and 1992–1999) and by aircraft laser altimeter (1994–1999), and volume-balance estimates from comparison of total snow accumulation with total ice discharge, all show that the entire region of the ice sheet above about 2000 m in elevation has been close to in balance (within 1 cm/yr) for at least the past few decades but with smaller areas of quite rapid change that can largely be explained by temporal variability in snow accumulation rates (Davis et al. 2000). Some areas, however, appear to be undergoing thinning in excess of 1 m/yr, which may be ongoing adjustments to events since the last glacial maximum or they may indicate changes that began only recently. In particular, most surveyed outlet glaciers are thinning in their lower reaches, and a large area of ice sheet in the southeast has also thinned significantly over the past few decades, at rates that increase to more than 1 m/yr near the coast. Only part of this thinning can be explained by increased melting associated with recent warmer summers, indicating that ice discharge velocities must also have increased (Krabill

et al. 2000, Abdalati et al. 2001, Thomas et al. 2001).

Future PARCA research will address these issues, focusing on near-coastal snowfall and ablation and on the dynamics of thinning outlet glaciers. In addition to understanding coastal thinning, a major goal of future PARCA research will be the development of models that reliably hind-cast temporal variability in snowfall and surface ablation over the ice sheet, using analyses from operational weather forecasting models to provide ongoing maps of accumulation and ablation rates over both polar ice sheets. This will best be achieved by developing appropriate capabilities for Greenland, where the existing database is far richer than for Antarctica.

This work will also help prepare for the interpretation of future measurements of elevation change by the Geoscience Laser Altimeter System (GLAS) aboard NASA's ICESat, which was launched on January 12, 2003. ICESat is a three-year mission (five-year goal) to measure elevation changes on the earth's great ice sheets to an accuracy of approximately 2 cm. These data will greatly enhance our ability to ascertain where the Greenland ice sheet is growing and where it is shrinking. These data will be combined with ancillary data to investigate the mechanisms for that shrinkage.

NASA has also supported an assessment of the current state of balance of major Canadian ice caps. This makes use of survey work from the mid-1990s, from which changes in surface topography can be assessed. Initial results indicate that all of the ice caps for which analyses have been completed show some signs of thinning, primarily at the edges. The level of thinning is consistent with what has been observed in the more temperate regions of the Greenland ice sheet but don't show a strong dynamic component.

3.5.2 Permafrost, Landscape, and Paleoclimate

Additional knowledge is needed about the temperature, distribution, thickness, and depth of permafrost throughout all geomorphic provinces of the Arctic, including the continental shelf. Modern geologic processes that are responsible for the present morphology and land surface need to be better understood.

Objectives

- Undertake a comprehensive program to extract paleoclimatic records from permafrost terrains and lake sediments;
- Reconstruct the late Glacial and Holocene climate history in the Arctic via borehole monitoring and other technology;
- Improve the ability to assess and predict the degree and rate of disturbance and recovery of permafrost terrain following natural or human-induced changes;
- Improve our understanding of the effects of thawing of permafrost on the hydrology, ecosystem characteristics, and productivity of boreal forest ecosystems;
- Model the response of the hydrologic and thermal regimes of the active layer and permafrost to greenhouse-gas-induced warming in the Arctic and subarctic at different locations;
- Provide information on the moisture and thermal regime of the active layer and on degradation of permafrost due to climate warming;
- Develop results leading to the ability to predict future climate-induced changes to the Arctic landscape;
- Understand how possible climate-induced alterations to permafrost systems may influence carbon metabolism, turnover, and storage; and
- Reconstruct the late Glacial and Holocene climate history in the Arctic.

3.5.3 Ecosystem Structure, Function, and Response

Research is needed to improve our understanding of the influence of climate on land and freshwater processes and vice versa. Resource managers and decision makers need reliable envi-

ronmental impact and health risk assessments.

Topics of particular importance include heat balance relationships, landscape alteration, impacts of wildfire, identification of biological indicators of change, development of a basis for (and clarification of) current and recent contaminant levels, sources and sinks of carbon and trace gases, and long-term trends in biological diversity.

Objectives

- Distinguish ecological changes due to natural causes from changes due to human activities and evaluate management techniques for the conservation and restoration of ecosystems;
- Identify and evaluate the responses of key biological populations and ecological processes to increased CO₂ and to different climatic conditions; monitor the changes in ecotone boundaries, which might serve as integrative indicators of change; and select biological indicators for use in a monitoring program designed to detect, measure, and predict the extent of change;
- Provide opportunities for international cooperation at Long-Term Ecological Research sites and biological observatories in the Arctic;
- Identify factors contributing to reductions in regional and global biological diversity;
- Integrate process, community, ecosystem, and landscape features into a dynamic description that is realistically linked to both finer and coarser scales of resolution;
- Determine the CO₂ flux from tundra and the responses of vegetation to elevated levels of CO₂; and
- Determine the environmental factors controlling methane fluxes.

3.6 Engineering and Technology

Engineering and technology provide one of the best and possibly most direct avenues for improving and extending the infrastructure so critical to quality of life in the Arctic. In addition, enhanced engineering capabilities and advanced technologies can make crucial contributions to addressing environmental quality challenges and achieving environmentally sustainable development of natural resources. The harsh and unique environment of the Arctic makes advances in these areas particularly difficult and limits the ability to simply borrow or evolve the engineering and technology advances developed for nonpolar conditions. Only concentrated, specific efforts will produce the advanced technical capabilities the Arctic requires. Engineering and technology development programs that address the priority Arctic engineering research needs are necessary to support these efforts.

Recent concerns of infrastructure damage due to permafrost degradation have highlighted the inability of current engineering and technology design criteria to address changes in the permafrost foundation over the life cycle of these structures. These deficiencies impact the existing infrastructure in Alaska and future Arctic building programs, including roads, pipelines, buildings, airfields, and hazardous material storage tanks.

Objectives

- Develop engineering data and criteria for building, operating, and maintaining strategic and operational facilities and infrastructure in the Arctic, including the effects of permafrost degradation;
- Ensure that current engineering practices include assessment of potential impacts of warming climate on permafrost and other Arctic systems commensurate with the design life of the projects;
- Provide the capability to conduct logistics operations and research support and development in the Arctic;
- Undertake assessment of the potential impact of weather changes associated with climate warming on transportation and maintenance of lines of communications;
- Develop environmentally compatible engineering technologies for the Arctic;
- Develop enhanced understanding of cold-regions performance of new structural materials and systems;
- Provide design criteria for ship operations in ice-infested waters;
- Provide mapping and prediction of ice conditions, along with GIS-based monitoring systems, for port and harbor management;
- Provide engineering data and criteria for water resources activities and environmental impact permitting;
- Provide GIS database and mapping capability for land use, water resources, and monitoring of environmental degradation;
- Ensure that the best available, safest, and pollution-free technologies are used in the development of oil and gas in the Arctic and outer continental shelf;
- Ensure, through technology transfer and retrospective case studies, that future resource exploration and development in the Arctic take advantage of tried and proven methods, as well as incorporating innovative new technology with minimal environmental impact;
- Provide enhanced engineering criteria and techniques to use naturally occurring materials, such as snow and ice, for ice road and island construction, reducing costs and minimizing environmental impacts;
- Develop methods for mining and mine closure that are environmentally compatible in Arctic environments;
- Advance the technology for recovering fossil fuels in the Arctic, including onshore extraction and production methods;
- Develop criteria for exploiting frozen ground conditions to minimize environmental impact (tundra snow and ice roads) and enhance system performance (for example, ground-penetrating radar);
- Prevent the discharge of oil, chemicals, and other hazardous materials into the marine environment;
- Ensure quick, effective detection and cleanup of pollution discharges;
- Provide the ability to predict and map movement of pollutants in ice-infested waters;
- Develop Arctic-appropriate cleanup technologies for contaminants and remediation of sites resulting from past military and resource development;
- Evaluate enhanced marine transportation for resupply of coastal and Arctic villages;
- Develop and maintain effective surface transportation and air support facilities in the Arctic; and
- Develop mechanisms for technology transfer between government, academia, and industry.

3.7 Social Sciences

The historic, current, and future presence of human populations in the Arctic has made the social sciences a top priority and a valuable tool for Arctic research. How have various groups adapted to environmental, economic, and social change? What predictions about future adaptations can be made on the basis of the historic and prehistoric record? How can traditional knowledge enhance scientific understanding of the Arctic environment? These are just a few examples of questions that arise when considering the role of societies in Arctic research. In addition, Arctic communities have themselves become active partners in research projects responding to local needs and concerns.

In an effort to coordinate research plans among Federal agencies, an Interagency Arctic Social Sciences Task Force was established within the Interagency Arctic Research Policy Committee (IARPC). The Task Force prepared and implemented a *Statement of Principles for the Conduct of Research in the Arctic* (see Appendix F), which addresses the need for improved communication and increased collaboration between Arctic researchers and northern people. The principles have fostered greater awareness of local concerns among Arctic researchers and have helped to place a high value on the full participation of Arctic residents in research and environmental issues.

International Arctic Social Science and Health Research

International scientific organizations that have recognized the importance of Arctic social sciences include the International Arctic Social Sciences Association (IASSA), the International Arctic Science Committee (IASC), and the International Union for Circumpolar Health (IUCH). The United States has actively participated in these organizations.

The Arctic Council also admitted two new indigenous groups, the Arctic Athabaskan Council and the Gwich'in Council International, as Permanent Participants. They join the Aleut International Association, the Inuit Circumpolar Conference, the Saami Council, and the Russian Association of Indigenous Peoples of the North (RAIPON), bringing the number of Permanent Participants on the Council to six. RAIPON was elected to replace the Saami Council as chair of the Board of the Indigenous Peoples' Secretariat in November 2000.

The program of the Arctic Council's Sustain-

able Development working group depends in part on the work of social science research. Research is at the heart of the Survey of Living Conditions in the Arctic: Inuit, Saami and the Indigenous Peoples of Chukotka. The Arctic Telemedicine project, the International Circumpolar Surveillance project on infectious diseases in the Arctic, and the project on Arctic Children and Youth all depended, in part, on the contributions of social science research. The Council anticipates that additional projects underway on timberline forests, capacity building, reindeer husbandry, and ecological and cultural tourism will benefit from the contributions of social science research.

Social science research is also a significant contributor to the environmental protection agenda of the Arctic Council. Social science research, for example, is an integral component of the new Arctic Climate Impact Assessment (ACIA) and an element of the monitoring programs for toxic pollutants under AMAP's subgroup on Human Health.

Social and Health Sciences

NSF continues to provide support for peer-reviewed research projects dealing with decision, risk and management frameworks, risk and health perceptions, co-management of resources, and collaborative research with indigenous communities. Arctic social scientists work with Arctic communities in a collaborative fashion. For example, NSF's Arctic Social Sciences Program contributed to the establishment of the Alaska Native Science Commission (ANSC), an organization that provides essential linkages between researchers and local communities, facilitating communication and cooperation.

NSF plans to continue to emphasize the partnership approach in the Arctic through enhanced outreach to Arctic communities, recognizing that cooperative community relations and education form a central tenet of responsible research conduct.

Human Dimensions of Global Change

The NSF supports opportunities for research on the Human Dimensions of Global Change (HDGC). HDGC research focuses on the interactions between human and natural systems, with emphasis on the social and behavioral processes that shape and influence those interactions. NOAA's Economics and Human Dimensions program supports research investigating human responses to variations in the climate system. The

program currently focuses on the potential use and constraints to the use of climate forecast information for decision making across a range of sectors. Although NOAA's Economics and Human Dimensions program does not focus on any particular region, the role of indigenous knowledge and how it might interact with newly developed climate forecast information, as well as the ways in which Native communities adapt to their regional climate, is of interest to the program.

The Human Dimensions of the Arctic System (HARC) initiative, launched under the NSF Arctic System Science program, will focus on the dynamics of linkages between human populations and the biological and physical environment of the Arctic, at scales ranging from local to global.

Resources Management

Over 66% of the area of Alaska is managed by Federal agencies. Cultural and natural resources are protected by law, and good management can only be built on accurate baseline data. Although cultural resources, historic and prehistoric sites, artifacts, and landscapes require documentation and protection, renewable resources, especially fish and game, are also culturally defined through subsistence needs. In 1989, Alaska's subsistence laws were declared unconstitutional because they discriminated against non-rural residents. As a result, Federal land management agencies assumed responsibility for subsistence management on Federal lands. The DOI Fish and Wildlife Service (and its Office of Subsistence Management) is the lead Federal agency in this responsibility. Subsistence is defined as fulfilling both household economic needs and cultural needs, including social communication, food sharing, and maintenance of cultural knowledge and identity. Management of marine resources, such as fish and most species of marine mammals, is led by the DOC National Marine Fisheries Service.

3.7.1 Cultural Resources

The Arctic is a major repository of human experience. Archaeological remains go back some 15,000 years, providing a record of human adaptation to environmental change of unparalleled richness. The Arctic is also home to numerous indigenous cultures. Their traditional and local knowledge base can provide long-term information about northern ecosystems and wildlife, of considerable value in resource management.

The National Park Service and the Smithsonian

have been working together in Anchorage for several years on regional archeological assessments, and SI cooperation with NSF and NEH has resulted in several important exhibitions and publications. A number of agencies support research on archaeology, history, and Native culture (BIA, BLM, USFS, NPS, SI, NSF). Finds of artifacts and bones give evidence of past economies and baseline data for pollution monitoring, and historical and ethnographic descriptions tell of more recent conditions. Coastal resources (fish, seals, walrus, whales) supported the largest human populations in Alaska, and changing shorelines and maritime conditions are reflected by these sites.

Objectives

- Document and analyze the origins and transformations of Arctic cultural systems, ethnic groups, and languages;
- Study and analyze traditional knowledge systems, resource uses, and subsistence economics;
- Research paleoenvironmental changes, including ancient sea levels, in concert with cultural historical investigations; and
- Help develop explanatory models integrating cultural systems with local, regional, and global environmental changes.

Repatriation

Repatriation has also become a major priority for museums and research institutes since the passage of NAGPRA (Native American Graves Protection and Repatriation Act) in 1990. This act requires Federal agencies to document Native American human remains, associated grave goods, and items of "cultural patrimony." Agencies must report their holdings of such materials to Native American groups and consult about their repatriation. The National Park Service has a major role in NAGPRA for coordination and guidance at the national level. It can be expected that repatriation will be a major effort for at least a decade.

Repatriation at the Smithsonian has resulted in returns of most of its collections of human remains from Alaska, and consultations are beginning with regard to cultural objects. At the same time a new program, the Smithsonian Alaska Collection Project, has been initiated by the Arctic Studies Center. The project will involve consultation with various groups of Alaska Natives over cultural materials they would like to see brought to the Arctic Studies Center office in Anchorage for study, exhibition, and publication on the Internet.

3.7.2 Rapid Social Change and Community Viability

The impacts of technological and economic development on northern societies, both Native and non-Native, have been profound. While standards of living have often been improved, there have been concurrent changes in traditional cultural values. Chronic unemployment, family violence, substance abuse, and societal breakdown in general have reached epidemic proportions.

One of the recent losses contributing to community instability lies in the area of historical knowledge. While the elders remain important in transmitting knowledge, much information on the past two centuries of community history lies in museums and archives far from northern villages. With NSF assistance, the Smithsonian has been pioneering new methods of “knowledge repatria-

tion” on St. Lawrence Island, through collaborative identification, publication, and local dissemination of historical community records that have never before been available to village residents.

Objectives

- Gain insight into the short-term and long-term effects of rapid social change on Arctic cultures and societies;
- Develop culturally relevant educational programs;
- Develop practical applications of social and behavioral science to benefit Arctic residents;
- Determine linkages between social and behavioral science and health; and
- Determine ecological thresholds as they relate to economic development and community viability.

3.8 Education, Training, and Outreach

NSF and Federal agencies are committed to training young scientists and to developing educational components that link social scientists with students and other members of Arctic communities. The Smithsonian Institution conducts research and education programs in the North Pacific, Russia, Canada, and the North Atlantic region and provides museum and exhibit training in Washington, D.C., and Anchorage, Alaska. A new Arctic Studies Center publication series, *Contributions to Circumpolar Anthropology*, has been initiated and will include an English translation of a material culture atlas of Siberia, a Native history of the Bering Strait region, and archival studies of the Jesup North Pacific Expedition and works on the Yamal, Siberian archaeology, and the history of Eastern Arctic archaeology.

Programs such as NSF's Faculty Early Career Development (CAREER) program support innovative research and teaching by junior faculty members. Research Experience for Undergraduate (REU) supplements and sites provide on-site research training to college and university students.

The RAPS (Resource Apprenticeship Program) of the Department of the Interior has provided summer jobs for Alaska Natives through the NPS, BLM, and FWS. Other programs, such as the Cooperative Education Program and the NOAA

Sea Grant Program, also support students in Alaska. The BLM Heritage Education National Program is developing materials on archaeological and historical places in Alaska to support education of America's children and to foster a sense of stewardship of cultural heritage.

The USDA Forest Service has participated in an increasing number of programs within the region to promote Alaska Archaeology Week activities (lectures and field trips) and other opportunities for education that foster stewardship and the conservation of heritage resources. The Forest Service is continuing a comprehensive program of cultural resource presentations, subsistence awareness sessions, and site monitoring and protection.

The NSF Office of Polar Programs (OPP) has begun a new postdoctoral fellowship program supporting independent postdoctoral research at a U.S. host institution for up to three years. The program goals are to support innovative research in any area of science supported by OPP, to foster the next generation of polar scientists, and to broaden participation in polar science. In addition to support for salary, health insurance, and a modest research budget, the fellowship also supports fieldwork in the Arctic and the Antarctic through the Arctic Research Support and Logistics program and the U.S. Antarctic Program.

4. Research Support, Logistics, Facilities, Data, and Information

4.1 Research Support and Logistics

IARPC and Federal agencies will use new resources targeted for Arctic logistics to enhance the U.S. leadership role in Arctic research. The focus on logistics entails:

- Establishment, development, and maintenance of national Environmental Observatories;
- Technology and instrument development;
- Expansion of marine platforms and aircraft support capabilities;
- Integration of research, education, and Arctic community interests; and
- Further international collaboration in the support of research.

The use of the new resources will be guided by the Arctic Research Commission's report *Logistics Recommendations for an Improved U.S. Arctic Research Capability* [available from the Arctic Research Consortium of the United States (ARCUS) at <http://www.arcus.org>]. The general recommendations of the report are:

- Ensure access to the Arctic over the entire year;
- Increase the availability and use of remote/autonomous instruments;
- Protect the health and safety of people conducting research in the Arctic;
- Improve communications and collaboration between Arctic people and the research community; and
- Seek interagency, international, and bilateral logistics arrangements.

Planning will be done in partnership with Native groups and other advisory bodies and will respond to merit-reviewed proposals.

For both marine and terrestrial research the U.S. will improve basic health and safety by providing access to a pool of emergency beacons, satellite phones, and GPS receivers. There is also a need to better integrate traditional knowledge of Arctic residents with research to broaden our capability in the Arctic. The U.S. plans to increase the duration of measurements (especially during the win-

ter) by providing remotely operated instruments linked with individual researchers in their labs, with other Environmental Observatories, and with distance learning centers.

4.1.1 Oceans

The Coast Guard maintains icebreaking facilities for support to other Federal agencies pursuant to interagency agreements and to serve the Nation's interests—including security, economic, scientific, and environmental—in the polar regions. The Coast Guard has two heavy polar icebreakers—the USCGC *Polar Star* and the USCGC *Polar Sea*, which were commissioned in 1976 and 1978—and one polar icebreaking research vessel—the USCGC *Healy*, which was commissioned in 2000. During FY 04–05, the *Polar Star* and *Polar Sea* were involved with the Antarctic program or undergoing repairs, while the *Healy* was dedicated to Arctic operations. The *Healy* was away from home port in support of Arctic science for 205 days (including 12 days of science system testing) in FY 04, and 185 days (including 11 days of science system testing) were projected for FY 05.

At about the same time that the *Healy* became available, access to U.S. Navy submarines that are capable of operating in the Arctic largely ended. The submarines provided a unique capability to access the whole Arctic Ocean under the icepack year-round. While the U.S. Arctic Research Commission continues to pursue options to revive or replace this capability, NSF has begun to fund the development and testing of a long-range AUV (autonomous underwater vehicle) to begin building a capability to range throughout the Arctic Ocean, perhaps in conjunction with the *Healy* or ice camps.

North Pole Environmental Observatory

The North Pole Environmental Observatory is a Long Term Observatory in the Arctic Ocean. Oper-

ations are based out of Alert, Canada, involving an annual campaign of mooring deployments and servicing and hydrographic stations on a transect from Alert to the North Pole.

An international research team supported by the NSF established a temporary camp at the North Pole, laying the groundwork for a five-year project to take the pulse of the Arctic Ocean and learn how the world's northernmost sea helps regulate global climate. The team deployed a system of floating buoys and has anchored devices to the ocean floor to collect data on everything from the salinity of the water in the Arctic Ocean to the thickness and temperature layering of its ice cover. This is the first time such a congregation of drifting buoys has been placed at the North Pole.

4.1.2 National Ice Center

The National Ice Center (NIC) is a unique inter-agency organization with oversight from the Department of Defense (DOD), Department of Commerce (DOC), and Department of Homeland Security (DHS) and responds to both DOD and U.S. national interests as outlined in Annex II to the 1995 Navy-NOAA Umbrella Memorandum of Agreement (MOA). The Naval Ice Center (NAVICE) comprises the largest component of NIC and represents the Naval Meteorology and Oceanography Command through the Naval Oceanographic Office. The second leg of the triad, DOC, is represented under the National Oceanic and Atmospheric Administration's (NOAA) Office of Satellite Data Processing and Distribution. The U.S. Coast Guard's (USCG) Director of Operations Policy represents the third member of the triad, DHS.

NIC's mission is to provide the highest-quality operational global, regional, and tactical-scale sea ice analyses and forecasts, tailored to meet the requirements of U.S. national interests. It provides this support to U.S. armed forces, U.S. government and international agencies, academic and scientific institutions, and civil interests. Weekly global and regional-scale ice extent and coverage products are produced in support of mission planning, vessel operations, and scientific research. More frequently produced tactical-scale ice analyses and forecasts are tailored to customer-specified spatial and temporal requirements. Sea ice features of most frequent interest to operations include ice edge position, ice thickness, ice concentration, areas of compression or heavy defor-

mation, and the location and orientation of open water or thin-ice-covered leads and polynyas. All NIC ice extent and coverage products are derived from a blend of remotely sensed and in situ oceanographic and meteorological data.

NIC ice analyses are crucial to both the safety of navigation in ice-covered waters and as a U.S. contribution to international global climate and ocean observing systems. Real-time raster and digital ice products are distributed via the Internet using the NIC home page (<http://www.natice.noaa.gov>) and over military networks comprising the Defense Information Infrastructure.

The U.S. Interagency Arctic Buoy Program (USIABP), managed by NIC, collects and distributes surface meteorological and ice drift data. A historical quality-controlled archive of these data is available from the World Data Center-A or via the Internet (<http://iabp.apl.washington.edu>) from the Applied Physics Laboratory of the University of Washington.

The NIC science program, operating with fiscal support from ONR, NOAA, and NASA, is aimed at expanding the use of NIC's products within the science community and providing a route for the migration of scientific techniques (such as algorithms) into the operational environment but was recently expanded to include five post-doctoral fellows. The NIC Science Plan (available at <http://www.natice.noaa.gov>) summarizes the activities, interests, and goals of this polar science program. Current areas of in-house research include improvements to the next generation of ice forecast models, study of Antarctic hydrography, evaluation of passive and active microwave remote sensing algorithms, refinement of data assimilation techniques, and improvements to long-term sea ice forecasting techniques.

4.1.3 Land-Based Facilities

Continuing and Expanding Long-Term Observations

The response to NSF's first announcement of opportunity for Long-Term Arctic Observations indicated that there is significant need in this area. NSF is now supporting unsolicited proposals to conduct service observations to be made available to broad communities particularly to facilitate long-term observations at sites where there is already a significant history of observations. It is envisioned that this area would increase substantially under SEARCH.

Toolik Field Station

Significant improvements have been made to the laboratories, power system, communications system, and living conditions since 1999. The University of Alaska has, with NSF's encouragement and with significant input from the user community, developed a long-range development plan that has been approved by the landowner, BLM.

Barrow

Approximately 25–30 NSF projects are active each year, and greater collaboration has developed between NSF projects and other agencies. Plans for the future include building the information technology infrastructure on the recently funded T1 link and providing alternative access to the Barrow Environmental Observatory.

NOAA is supporting the construction of a new research facility in Barrow to replace the aging NARL (Naval Arctic Research Laboratory) buildings.

Barrow is also the location of the central facility of DOE's North Slope of Alaska ARM Climate Research Facility, of the NOAA Climate Monitoring and Diagnostics Laboratory Barrow Station, of the only National Weather Service upper air sounding station on the Arctic Coast of Alaska, and of the Barrow Environmental Observatory. Because of this concentration of research facilities, Barrow is likely the most highly instrumented location in the circumpolar Arctic for climate research purposes. Engineering design is also underway for a major research support facility through NOAA: the Barrow Global Climate Change Research Facility (<http://scifac.arcticscience.org>). This facility will be available for lodging, laboratory, and field support for researchers working in the vicinity of Barrow independent of the agency sponsoring the work. It is scheduled to be dedicated during the International Polar Year (2007-08).

Summit, Greenland

NSF is supporting a series of atmospheric and snow chemistry measurements at Summit, Greenland, in collaboration with NOAA. European-supported projects also continue at Summit, coordinating their activity with NSF through the station operator. However, efforts to develop a joint U.S.–European management of the station have not yet succeeded because of European administrative decisions, but progress is expected in 2004.

Circum-Arctic Environmental Observatory Network

The Circum-Arctic Environmental Observatory Network is an initiative to provide stronger collaborations among existing observatory operators so that they can leverage each other's strengths, particularly in the area of long-term observations and data standards. It is expected that U.S. observatories (Barrow, Toolik, Summit, North Pole) will learn from their international counterparts, mostly European, as they implement new capabilities.

Aircraft Support

DOC/NOAA has available hangar facilities for two H-1N helicopters at Fort Richardson, Anchorage, Alaska. These facilities have some additional space for field equipment, scientific instruments, and Arctic gear. NOAA aircraft have flown Arctic research projects while based out of Elmendorf AFB, Eielson AFB, and Thule AFB. NSF, ONR, and the New York Air National Guard have taken over the SPAWAR Arctic Logistics infrastructure at Thule.

Cold Regions Research and Engineering Laboratory

A memorandum of understanding between the National Science Foundation and the U.S. Army Corps of Engineers has been implemented that allows NSF-supported engineering and scientific researchers to use USACE laboratory facilities. Many of these state-of-the-art facilities are dedicated to cold regions research and engineering thrusts and are described below. An aggregation of unique facilities that are nationally and internationally recognized exists at the Cold Regions Research and Engineering Laboratory (CRREL). The main complex is in Hanover, New Hampshire. In addition, a permafrost research tunnel and additional coldrooms are located near Fairbanks, Alaska. Industry and academia often use CRREL's unique experimental facilities.

At the Hanover campus the main laboratory houses 24 low-temperature research laboratories capable of achieving temperatures as low as -50°F , special-purpose ice test facilities, cleanrooms, a chemical laboratory, and two specialty low-temperature materials laboratories. The Material Evaluation Facility can simulate snow and icing conditions and static and cycling temperatures ranging from -50° to 120°F and has the capability to conduct full-scale tests on automotive vehicles. The High Performance Materials Laboratory is used for strength and thermal testing of

many types of materials, including construction, road, bridge, and composite materials. Specialized testing machines, such as the Split Hopkinson Pressure Bar, enable low-temperature, high-strain materials evaluation to temperatures as low as -80°C . Other equipment includes thermal cycling chambers that allow for thermal cycling from -100° to 100°C and a specially fabricated UV-radiometry system for exposing testing materials to controlled doses of radiation.

The 73,000-square-foot Ice Engineering Facility has three special-purpose research areas: a large low-temperature towing tank, a 100-foot-long refrigerated flume for modeling rivers, and a large hydraulic model room for studying ice effects on civil works facilities, primarily locks and dams. The Ice Engineering Facility also houses a snowdrift wind tunnel.

The Frost Effects Research Facility (FERF) allows full-scale research on the impact of freeze-thaw cycles on pavements, foundations, and utility systems. This 29,000-square-foot facility contains a 182- by 75-ft soil testing area that can be maintained at temperatures below 30°F and 12 large test cells where soil can be frozen and thawed at temperatures ranging from as low as -35°F to as high as 120°F . Six to eight natural freeze-thaw cycles can be simulated in a single year. The newest addition to the CRREL's experimental capability, the Heavy Vehicle Simulator (HVS), is housed in this facility. The HVS can simulate the effect of heavy vehicles on roads and pavements.

At the Alaska campus in Fairbanks, CRREL has a research permafrost tunnel and maintains a 133-acre permafrost research site. The CRREL facilities in Alaska include two coldrooms capable of -30°F temperatures, a heavy equipment maintenance shop, a woodworking shop, a soils laboratory, a shock laboratory, and several Small Unit Support Vehicles (SUSVs) used as research vehicles.

The Technical Information Analysis Center (TIAC) serves DOD and the Nation as the most comprehensive source of cold regions information in the world. The 24,000-square-foot TIAC provides a gateway to the world's information and research resources for cold regions science and engineering. The Cold Regions Science and Technology Information Analysis Center (CRSTIAC) serves as the Nation's corporate repository for cold regions science and engineering data. This center houses the CRREL library, which contains 30,000 books, 160,000 reports, 450 journals, 450 rolls of microfilm, 250,000 pieces of microfiche, 40 CD-ROM reference titles, and topographic maps

of all 50 states. The Bibliography on Cold Regions Science and Technology, comprising 53 volumes dating from 1951, is prepared for CRREL by the Library of Congress and contains approximately 250,000 citations, including cumulative author and subject indexes.

4.1.4 Atmospheric Facilities and Platforms

Because of the strategic location of the Arctic for observing space-related phenomena, an extensive infrastructure has been established over the past four decades to observe the Arctic upper atmosphere and ionosphere. The Arctic is the site of many ground-based radio, radar magnetic, and optical observing sites. These sites and many other smaller facilities have been an important aspect of the Arctic social structure, providing economic benefits in remote regions and educational opportunities for indigenous people.

Among the major upper-atmospheric research facilities in the Arctic are the Sondrestrom Radar in Greenland, the High Frequency Active Auroral Research Program (HAARP) radar in Alaska, the Poker Flat Rocket and Research facility near Fairbanks, the Resolute Bay Observatory in Canada, the Longyearbyen Optical Station in Norway, and the SuperDARN radar network with sites spanning the Western Hemisphere Arctic. These and other smaller sites are operated in collaboration with international partners, including academic and research institutions in Canada, Denmark, Norway, and Japan.

NASA is establishing a Network for Detection of Stratospheric Change (NDSC) program at Thule and Sondrestrom, Greenland, to provide long-term data on a variety of stratospheric constituents. NASA and NSF cooperated in a program called the Program for Arctic Regional Climate Assessment (PARCA). This involved satellite and airborne surveys of different regions of the ice sheet to establish patterns of ice sheet thickening and thinning, along with ground-based surveys to establish reference data for interpreting airborne and satellite observations. Ground observations included the deployment of automatic weather stations and the analysis of shallow snow pits and deep ice cores. The results have, for the first time, shown clear regional patterns in the mass balance of the ice sheet.

NOAA is involved in shaping a network of Arctic Atmospheric Observatories. It is the objective of the NOAA program to coordinate these efforts

for the International Polar Year and beyond. At present, preliminary discussions have commenced between the U.S., Canada, Russia, Norway, Finland, and China. Existing and proposed programs include:

- Long-term trace gas, aerosol, solar radiation, ozone, cloud properties, and meteorological observations in Barrow, Alaska, carried out by NOAA's Climate Monitoring and Diagnostics Laboratory Baseline Observatory (since 1973) and DOE's Atmospheric Radiation Measurement (ARM) facilities (since 1997). The NOAA/CMDL Barrow Observatory, a manned atmospheric baseline facility located six miles northeast of Barrow, has been in continuous operation since 1973. The Barrow Observatory focuses on research relating to atmospheric constituents that are capable of forcing change in the climate of the earth through modification of the atmospheric radiative environment, as well as those that may cause depletion of the ozone layer. This facility conducts scores of continuous monitoring activities, including hosting 21 cooperative programs with universities and other government agencies. NOAA operates a three-station network of solar UV measurements with sites at Barrow, St. Paul Island, and Nome. The Barrow Observatory has expanded its research activities over its lifetime and expects to be monitoring climate change in the Arctic through the next century, as long as the requirement continues. Information on CMDL and the Barrow Observatory can be found at <http://www.cmdl.noaa.gov>.
- The Polar Environmental Atmospheric Research Laboratory (PEARL) in Eureka, Canada, with new operations to be established in 2005 and 2006, and the Alert, Canada, Global Atmosphere Watch Station (since 1986), sponsored by the Canadian Detection of Arctic Change (CANDAC) program, Meteorological Services Canada (MSC), and the NOAA Study of Environmental Arctic Change (SEARCH) program.
- Existing and possibly extended observation program (surface atmosphere, air chemistry, etc.) in Ny-Alesund, Svalbard, Norway, sponsored by the Norwegian Polar Institute (NPI), the Norwegian Meteorological Institute (met.no), and the Norwegian Institute for Air Research (NILU).
- The new Chinese Yellow River (Huanghe) Arctic Research Station, opened in 2004 on

Svalbard, Norway, by the Polar Research Institute of China.

- Potential for an upgraded meteorological station/Atmospheric Observatory in Tiksi, Russia in 2007 or 2008, sponsored by the Russian Arctic and Antarctic Research Institute, Roshydromet, NSF, and NOAA.
- The Greenland Summit Station, with additional atmospheric measurement capabilities and year-round on-site staff positions to facilitate upgrading the capabilities of this new Global Atmosphere Watch station (2004).
- The Pallas, Finland, Sodankyla Global Atmosphere Watch Station, sponsored by the Finnish Meteorological Institute (since 1994).
- The NOAA High Altitude Long Endurance (HALE) UAV program, scheduled to test operations over the Arctic Ocean in 2008–2009.

4.1.5 Central Coordination and Logistics Information Clearinghouse

Arctic Logistics Information System (ALIAS)

NSF has initiated a project to create a web site to provide scientists with key information to assist in planning and executing research programs. An electronic bulletin board, ALIAS, on the Internet (<http://www.arcus.org/ALIAS/index.html>) is designed to provide information on logistics resources throughout the Arctic.

This key development has a potentially large payoff in terms of logistical cost, researcher time, and safety, with more than 150 NSF-funded projects in the field each year. The benefit will be felt not only by the NSF research community, but also by other Federal agencies and practically all researchers in the Arctic, with the potential of commercial applications and investment.

The Department of the Interior supports an Alaska Office of Aircraft Services (OAS), which coordinates aircraft services on a reimbursable basis.

4.1.6 Safety Support to Individual Projects

Several of the key recommendations in the *Logistics Recommendations for an Improved U.S. Arctic Research Capability* [available from the Arctic Research Consortium of the United States (ARCUS) at <http://www.arcus.org>] concerned improving the safety of researchers in the Arctic, under the general recommendation that a U.S. Federal program should “protect the

health and safety of people conducting research in the Arctic." Specific recommendations were to:

- Sponsor Arctic travel skills and survival courses. NSF, through its contractors, offers three to four field training courses to 60 Arctic researchers annually.
- Supply portable satellite communications. IRIDIUM has become the standard for polar field communications. NSF has reached the goal of providing each field program that requires satellite voice communications with that capability. The next goal is to provide

data communications with reasonable bandwidth.

- Support researchers in Russia. Approximately half of the Arctic falls within Russia or its economic zone. Access to the Russian Arctic for fieldwork has always been difficult, but after the initial opening up in the early 1990s, work in Russia is now difficult again and subject to increased risk compared to western standards. NSF has taken a leadership role in examining options that might open Russia to U.S. scientists.

4.2 Arctic Data and Information

4.2.1 Arctic Data

The Alaska SAR Facility (ASF) has continued to serve the polar research community as the facility for archiving and distributing SAR data. Some of the major projects served this year include the Radarsat Geophysical Processing System project; operational support with near-real-time data (averaging less than three hours turnaround) for the National Ice Center; and the NOAA Coast Watch and Alaska Demonstration projects. In addition to these projects, ASF supports other projects, which together represent an estimated user community of 1,400 individual PIs and co-PIs.

ASF has facilitated research and applications development through involvement with the science community, participating in workshops, attending conferences, and producing and distributing new products.

ASF continues to serve as the interface with the Canadian Space Agency, ensuring that data restrictions are appropriately enforced and that data are available to the users of Radarsat-1, whose mission life has exceeded its design life by more than two years. ASF also plans to continue reception of ESA's ERS-2 SAR data and to negotiate with ESA and NASA to participate in the reception, archive, and distribution segments of their future missions (Envisat, CryoSat, ALOS).

The National Snow and Ice Data Center (NSIDC) Distributed Active Archive Center (DAAC) provides access to cryospheric data for both northern and southern hemispheres, with the present emphasis on the Arctic. NSIDC is chartered and partially funded by NOAA, through the Cooperative Institute for Research in Environmental Sciences (CIRES), to provide snow and ice data services. The center is under contract to NASA's Earth Observation System Data and Information System (EOSDIS) project as a DAAC, providing snow and ice data and information services. The DAAC processes, archives, and distributes sea ice and snow cover data from visible, infrared, and passive microwave sensors, in particular from the special sensor microwave imager (SSM/I), the moderate-resolution imaging spectrometer (MODIS), and advanced very-high-resolution radiometer (AVHRR) sensors, and related in situ data. The DAAC's passive microwave data sets include a 20-plus-year time series of sea ice extent and concentration for both polar regions. The record will

be augmented by the advanced microwave scanning radiometer (AMSR) onboard the Aqua platform, which was launched in April 2002. Altimetry and aerosol data sets from the Geoscience Laser Altimeter System (GLAS) instrument on ICESat will also be distributed by the NSIDC DAAC. ICESat was launched in January 2003.

Non-EOS satellite data include the Near Real Time Ice and Snow in EASE grid (NISE) daily product, gridded passive microwave brightness temperatures and sea ice data on CD-ROM, AVHRR polar subsets at 1.25- and 5-km grids, and other in situ data. Information on all NSIDC DAAC data sets may be found at <http://www.nsidc.org/>.

NSIDC was chartered by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) in 1982 to provide a focus for cryospheric data management activities. NSIDC operates under a cooperative agreement between NOAA and the University of Colorado's Cooperative Institute for Research in Environmental Sciences. Within NOAA, NSIDC is affiliated with the NESDIS National Geophysical Data Center. NSIDC is also the home of the World Data Center for Glaciology, Boulder. The majority of funding for NSIDC data management activities comes from NASA for operating a DAAC for cryospheric data collected by the Earth Observing System (EOS) program.

The NSIDC DAAC provides access to EOS satellite data, as well as ancillary in situ measurements, baseline data, model results, and algorithms relating to cryospheric and polar processes. NSIDC archives and distributes snow and ice products from the MODIS instrument aboard the NASA TERRA and Aqua satellites. MODIS snow cover extent, sea ice extent, and sea ice surface temperature products are available in orbital and gridded formats. These products extend the existing 30-year record of passive-microwave-derived snow and sea ice products at greatly improved spatial and spectral resolution. Other DAAC products are the Near Real Time SSM/I EASE-Grid Daily Global Ice Concentration and Snow Extent, and global brightness temperatures from the Defense Meteorological Satellite Program's special sensor microwave imager. In addition to work with data sets, NSIDC compiles the *DAAC Yearbook*, a collection of articles on applications of DAAC data, written for the general public. (The DAAC

Yearbook is available from NSIDC User Services, University of Colorado, Boulder, Colorado 80309-0449; nsidc@nsidc.org.)

As part of a larger joint NOAA/NASA program, NSIDC works closely with NOAA's NESDIS Long Term Archive team to develop a prototype long-term archive of snow and ice data, metadata, and products from EOS satellites. This effort will determine the resource requirements for a level of service to the user community that is comparable to the current level of service provided by NSIDC for EOS cryospheric data and by the National Geophysical Data Center for Defense Meteorological Satellite Program data and products.

The Arctic System Science (ARCSS) Data Coordination Center (ADCC) at NSIDC will provide ARCSS data and information to the scientific community well into the twenty-first century, consistent with mission objectives and appropriate peer reviews. The ADCC is the permanent archive and access point for data collected by investigators in the NSF's ARCSS program and serves as a catalyst for ARCSS integration through data and information management. Of note is ADCC's work to develop an automated system for climate model output data requests. ADCC averages well over 600 megabytes of data and information downloaded per month. These data sets are mostly in situ and small data groupings rather than NSIDC's more typical large, multisensor collections.

NSIDC's participation in the joint U.S.-Russian Environmental Working Group's Arctic Climatology Subgroup to produce Arctic atlases on CD-ROMs has strengthened connection to data repositories in Russia.

Investigators associated with NSIDC bring a polar scientist's perspective to data management. Work is being conducted under approximately 30 grants at any time, and topics range from studying variation in the timing and extent of snowmelt on the Greenland and Antarctic ice sheets with passive microwave data to documenting Inuit knowledge of climate change. NSIDC also seeks to synthesize and interpret research for the general public. For example, "State of the Cryosphere" web pages (<http://nsidc.org/sotc>) present aspects of snow cover, sea ice, glaciers, and sea level changes as they relate to climate change.

NSIDC served as co-chair of a World Climate Research Programme (WCRP) Task Group to develop a Climate and Cryosphere (CliC) Science and Coordination Plan. The plan, which lays a path for the coordination of the cryospheric elements of existing projects of the WCRP, was

adopted in March 2000, and a joint Arctic Climate System (ACSYS) –CliC Science Steering Group was established. The CliC project addresses interactions among all land and oceanic components of the cryosphere (snow cover, glaciers, ice sheets, permafrost and seasonally frozen ground, freshwater ice, and sea ice) and the climate system, as well as the role of the cryosphere as a climatic indicator for monitoring. Significant questions concern the contribution of glacier melt to sea level rise, the effects of changes in snow and ice cover on water resources, and the impacts of climate change on polar sea ice and on frozen ground. The text of the CliC plan is available at http://www.npolar.no/acsys/CLIC/clic_may.pdf.

4.2.2 Data Facilities

Archiving and distribution functions for data required in support of Arctic research are distributed among all the U.S. national data centers. Arctic data are held in global archives at the National Climatic Data Center (climatology and meteorology), at the National Oceanographic Data Center (oceanography), at the National Geophysical Data Center (seismology, geomagnetism, marine geology and geophysics, solar and ionospheric studies, ecosystems, topography, and paleoclimatology), and at the National Center for Atmospheric Research (upper atmosphere and ionospheric studies). Data sets for a vast array of cryosphere-specific variables in the Arctic (sea ice, snow cover, permafrost, etc.) are archived and distributed through the National Snow and Ice Data Center (NSIDC) and the World Data Center-A (WDC-A) for Glaciology in Boulder, Colorado. These include satellite-derived measurements, in situ observations, and ancillary information that have been supported by NASA, NOAA, and NSF. Global satellite data archives for polar-orbiting satellites are held by NOAA/NESDIS/National Climatic Data Center (NCDC) in Asheville, NC. Included in these archives are:

- Global infrared and visible digital imagery from the advanced very-high-resolution radiometer (AVHRR) instruments;
- Atmospheric temperature and moisture data and derived soundings from the high-resolution infrared radiation sounder (HIRS) instruments; and
- Global passive microwave data from the special sensor microwave/imager (SSM/I). Electronic access to recent AVHRR and HIRS data is available through the NESDIS Satellite

Active Archive (<http://www.saa.noaa.gov>).

Global satellite data archives for the Defense Meteorological Satellite Program (DMSP)

Operational Linescan System (OLS) data are held by the National Geophysical Data Center.

The National Oceanographic Data Center (NODC)/WDC-A is the lead agency in the United Nations Intergovernmental Oceanographic Commission (IOC) Global Oceanographic Data Archaeology and Rescue Project (GODAR). Its goal is to locate and rescue historical oceanographic data that are in jeopardy of being lost, including Arctic oceanographic data.

The Alaska SAR Facility (ASF) also operates a NASA/EOSDIS, which receives and processes polar imagery from SARs onboard Canadian (Radarsat) and European (ERS-2) satellites. The ASF also carries out a range of tasks in support of the data, including calibration and the development of data analysis tools. A major data analysis project underway at the ASF involves implementation of the Radarsat geophysical processor system (RGPS), designed to generate high-level products, including ice drift, ice deformation, and ice thickness.

NOAA's Environmental Services Data Directory (NESDD) is a vital window into the U.S. national data archives, providing a means for scientists to locate the data they require.

All data acquired at the Department of Energy's North Slope of Alaska and Adjacent Arctic Ocean ARM Climate Research Facility is available on a near-real-time basis through the ARM Archive (<http://www.ARM.gov/data/>). ARM devotes extensive efforts to quality assurance in pursuing

its goal of producing a legacy data set for climate research purposes. Not only is QA effort expended prior to data entry into the archive. In addition, if subsequent problems are discovered that are fixable (say, because of initial application of less-than-optimal calibration factors), data are reprocessed and the corrected data re-entered. If that happens, all previous requestors of the original data set are informed by email of the availability of the reprocessing data. Alerts are also included with distributed data (and subsequently) if there are any actual or suspected quality problems with the requested data sets. "Quick Look" graphs are also available through the archive to facilitate data browsing.

4.2.3 Arctic Information

Arctic and Antarctic Regions is available for use from NISC. Comprehensive polar coverage on this CD offers over 800,000 records compiled by the major polar regions research organizations in the U.S., Canada, and the U.K.

A Polar web site, a collaborative project of the Polar Libraries Colloquy and others, provides a guide to Internet resources. The address is <http://arktinen.urova.fi/polarweb/>.

NOAA has created the Arctic Theme Page (www.arctic.noaa.gov), which contains overview material on Arctic science issues aimed at the non-technical reader. Links are provided to sources of technical information, pictures, and organizations active in Arctic science.

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Appendix A: Glossary of Acronyms

ACAP	Arctic Council Action Plan to Eliminate Pollution in the Arctic	ASOF	Arctic/Sub-Arctic Ocean Fluxes
ACIA	Arctic Climate Impact Assessment	ASF	Alaska SAR Facility
ACRF	ARM Climate Research Facility	ATR	Access to Recovery Program (DHHS/SAMHSA)
ACSYS	Arctic Climate System Study	AUV	Autonomous underwater vehicles
ADCC	ARCSS Data Coordination Center	AVHRR	Advanced very-high-resolution radiometer
ADEC	Alaska Department of Environmental Conservation	AWS	Automatic weather station
AEDD	Arctic Environmental Data Directory	BASC	Barrow Arctic Science Consortium
AEO	Arctic Energy Office (DOE)	BEST	Bering Ecosystem Study
AEPS	Arctic Environmental Protection Strategy	BIA	Bureau of Indian Affairs
AFB	Air Force Base	BIO	Biological Sciences Directorate (NSF)
AFSC	Alaska Fisheries Science Center	BLM	Bureau of Land Management
AGDC	Alaska Geographic Data Committee (USGS)	BRD	Biological Resources Division (USGS)
AGES	Age, Gene/Environment Susceptibility study (DHHS/NIH/NIA)	CAFF	Conservation of Arctic Flora and Fauna
AICC	Arctic Icebreaker Coordination Committee	CANDAC	Canadian Detection of Arctic Change program
AIP	Arctic Investigations Program (DHHS/CDC)	CANHR	Center for Alaska Native Health Research, University of Alaska
ALIAS	Arctic Logistics Information System	CAREER	Faculty Early Career Development program (NSF)
AMAP	Arctic Monitoring and Assessment Program	CART	Cloud and Radiation Testbed
AMEC	Arctic Military Environmental Cooperation	CCSM	Community Climate System Model
AMF	ARM Mobile Facility	CCPP	Climate Change Prediction Program (DOE)
AMMTAP	Alaska Marine Mammal Tissue Archival Project	CDC	Centers for Disease Control and Prevention (DHHS)
AMSR	Advanced microwave scanning radiometer	CFC	Chlorofluorocarbon
ANSC	Alaska Native Science Commission	CIHR	Canadian Institutes of Health Research
AO	Arctic Oscillation	CIRES	Cooperative Institute for Research in Environmental Sciences
AON	Arctic Observing Network	CISE	Computer and Information Sciences and Engineering Directorate (NSF)
AOSB	Arctic Ocean Science Board	CLiC	Climate and Cryosphere program
API	Alaska Psychiatric Institute	CMDL	Climate Monitoring and Diagnostic Laboratory (NOAA)
ARC	Arctic Research Commission	COBRE	Centers of Biomedical Research Excellence (DHHS/NIH/NCRR)
ARCSS	Arctic System Science	COSIG	Co-occurring State Incentive Grants (DHHS/SAMHSA)
ARCUS	Arctic Research Consortium of the United States	CRDF	U.S. Civilian Research and Development Foundation
ARM	Atmospheric Radiation Measurement program (DOE)	CRISIS	Center for Remote Sensing of Ice Sheets
ARPA	Arctic Research and Policy Act		
ARS	Agricultural Research Service (USDA)		
ARS	Arctic System Reanalysis (NOAA)		
ASC	Arctic Studies Center		

CRREL	Cold Regions Research and Engineering Laboratory	GOCADAN	Genetics of Coronary Artery Disease in Alaska Natives study (DHHS/NIH/NHLBI)
CRSTIAC	Cold Regions Science and Technology Information Analysis Center	GODAR	Global Oceanographic Data Archaeology and Rescue Project
CSA	Canadian Space Agency	GPS	Global positioning system
CSREES	Cooperative State Research, Education and Extension Service (USDA)	HAARP	High Frequency Active Auroral Research Program
CVD	Cardiovascular disease	HALE	High Altitude Long Endurance UAV program (NOAA)
DAAC	Distributed Active Archive Center	HARC	Human Dimensions of the Arctic System (NSF)
DEL	Documenting Endangered Languages program	HDGC	Human Dimensions of Global Change program
DHS	Department of Homeland Security	NEH	National Endowment for the Humanities
DMSP	Defense Meteorological Satellite Program	HF	High frequency
DOC	Department of Commerce	HIRS	High-resolution infrared radiation sounder
DOD	Department of Defense	HIV	Human immunodeficiency virus
DOE	Department of Energy	HRSA	Health Resources and Services Administration (DHHS)
DOI	Department of the Interior	HVS	Heavy vehicle simulator
DOS	Department of State	IARPC	Interagency Arctic Research Policy Committee
DOT	Department of Transportation	IASC	International Arctic Science Committee
EDF	Environmental Diplomacy Funds	IASSA	International Arctic Social Sciences Association
EEZ	Exclusive Economic Zone	ICESat	Ice Cloud and Land Elevation Satellite
EHR	Education and Human Resources Directorate (NSF)	ICS	International Circumpolar Surveillance (DHHS/CDC)
EMAP	Environmental Monitoring and Assessment Program (EPA)	ICSU	International Council for Science
ENG	Engineering Directorate (NSF)	IdEA	Institutional Development Award (DHHS/NIH/NCRR)
EOS	Earth Observing System	IFSAR	Interferometric synthetic aperture radar
EOSDIS	Earth Observation System Data and Information System	IGY	International Geophysical Year
EPA	Environmental Protection Agency	IHS	Indian Health Service (DHHS)
EPPR	Emergency Prevention, Preparedness and Response	INBRE	IDeA Networks for Biomedical Research Excellence (DHHS/NIH/NCRR)
ERS	European Remote-sensing Satellite	IOC	Intergovernmental Oceanographic Commission
EWG	Environmental Working Group	IOSSA	Integrated Ocean Observatory System
FAA	Federal Aviation Administration	IPA	Intergovernmental Personnel Act
FAS	Fetal alcohol syndrome	IPCC	Intergovernmental Panel on Climate Change
FASD	Fetal alcohol spectrum disorder	IPMC	Interagency Program Management Committee
FERF	Frost Effects Research Facility	IPY	International Polar Year
FIC	Fogarty International Center (DHHS/NIH)	ISAC	International Study of Arctic Change
FOCI	Fisheries–Oceanography Cooperative Investigations		
FSU	Former Soviet Union		
FWI	Freshwater Initiative		
FWS	Fish and Wildlife Service		
FY	Fiscal year		
GCM	General circulation model		
GEO	Geosciences Directorate (NSF)		
GEOSS	Global Earth Observation System of Systems (EPA)		
GIS	Geographic information system		
GLAS	Geoscience laser altimeter system		

IUCH	International Union for Circumpolar Health	NIDA	National Institute on Drug Abuse (DHHS/NIH)
IWG	Interagency Working Group	NIDCR	National Institute of Dental and Craniofacial Diseases (DHHS/NIH)
JAMSTEC	Japan Marine Science and Technology Center	NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases (DHHS/NIH)
LTER	Long-Term Ecological Research	NIEHS	National Institute of Environmental Health Sciences (DHHS/NIH)
MMS	Minerals Management Service	NIGEC	National Institute for Global Environmental Change (DOE)
MOA	Memorandum of agreement	NIGMS	National Institute of General Medical Sciences (DHHS/NIH)
MODIS	Moderate resolution imaging spectroradiometer	NIH	National Institutes of Health (DHHS)
M-PACE	Mixed-Phase Arctic Cloud Experiment	NILU	Norwegian Institute for Air Research
MPS	Mathematical and Physical Sciences Directorate (NSF)	NIMH	National Institute of Mental Health (DHHS/NIH)
MSC	Meteorological Services Canada	NINDS	National Institute of Neurological Disorders and Stroke (DHHS/NIH)
NAGPRA	Native American Graves Protection Act	NINR	National Institute of Nursing Research (DHHS/NIH)
NAS	National Academies of Science	NIOSH	National Institute for Occupational Safety and Health (DHHS/CDC)
NASA	National Aeronautics and Space Administration	NISE	Near Real Time Ice and Snow in EASE grid
NASHCRN	Nonalcoholic Steatohepatitis Clinical Research Network (DHHS/NIH/NIDDK)	NIST	National Institute of Standards and Technology
NATO	North Atlantic Treaty Organization	NLM	National Library of Medicine (DHHS/NIH)
NAVICE	Naval Ice Center	NMFS	National Marine Fisheries Service
NCCOS	National Centers for Coastal Ocean Science	NNDC	NOAA National Data Centers
NCDC	National Climate Data Center	NNSA	National Nuclear Security Administration (DOE)
NCI	National Cancer Institute (DHHS/NIH)	NOAA	National Oceanic and Atmospheric Administration
NCRR	National Center for Research Resources (DHHS/NIH)	NODC	National Oceanographic Data Center
NDSC	Network for Detection of Stratospheric Change	NOS	National Ocean Service (NOAA)
NESDD	NOAA's Environmental Services Data Directory	NPI	Norwegian Polar Institute
NESDIS	National Environmental Satellite Data and Information Service	NPR-A	National Petroleum Reserve-Alaska
NEWNET	Neighborhood Environmental Watch Network	NPS	National Park Service
NGDC	National Geophysical Data Center	NRCS	Natural Resources Conservation Service (USDA)
NGO	Non-governmental organization	NSA	North Slope of Alaska
NHLBI	National Heart, Lung and Blood Institute (DHHS/NIH)	NSA/AAO	North Slope of Alaska/Adjacent Arctic Ocean
NIA	National Institute on Aging (DHHS/NIH)	NSF	National Science Foundation
NIAAA	National Institute on Alcohol Abuse and Alcoholism (DHHS/NIH)	NSIDC	National Snow and Ice Data Center
NIAID	National Institute of Allergy and Infectious Diseases (DHHS/NIH)	OAS	Office of Aircraft Services
NIC	National Ice Center	OE	Office of Ocean Exploration (NOAA)
NICHD	National Institute of Child Health and Human Development (DHHS/NIH)	OLS	Operational linescan system
		OMAO	Office of Marine and Aviation Operations (NOAA)

OMB	Office of Management and Budget	SEER	Surveillance, Epidemiology, and End Results program (DHHS/NIH/NCI)
ONR	Office of Naval Research		
OPP	Office of Polar Programs (NSF)		
OSRI	Oil Spill Recovery Institute	SEPA	Science Education Partnership Awards (DHHS/NIH/NCRR)
PAME	Protection of the Arctic Marine Environment	SI	Smithsonian Institution
PARCA	Program for Arctic Regional Climate Assessment	SIDS	Sudden infant death syndrome
PCB	Polychlorinated biphenyls	SSM/I	Special sensor microwave imager
PEARL	Polar Environmental Atmospheric Research Laboratory	SPAWAR	Space and Naval Warfare Systems Command
PMEL	Pacific Marine Environmental Laboratory (NOAA)	SSC	Science steering committee
POP	Persistent organic pollutant	SSM/I	Special sensor microwave/imager
PRB	Polar Research Board	STAP	Short-Term Arctic Predictability study (NOAA)
RAIPON	Russian Indigenous Peoples of the North	SUSV	Small unit support vehicle
RAPS	Resource Apprenticeship Program (DOI)	TCE	Targeted Capacity Expansion program (DHHS/SAMHSA)
RCC	Regional Climate Center (NOAA)	TEA	Teachers Experiencing Antarctica and the Arctic program (NSF)
REU	Research Experience for Undergraduates program	TIAC	Technical Information Analysis Center
RGPS	Radarsat Geophysical Processor System	TREC	Teachers and Researchers Exploring and Collaborating program (NSF)
RISA	Regional Integrated Sciences and Assessment (NOAA)	UNOLS	University–National Oceanographic Laboratory System
ROV	Remotely operated vehicle	USACE	United States Army Corps of Engineers
RUSALCA	Russian–American Long-term Census of the Arctic	USCG	United States Coast Guard
SAMHSA	Substance Abuse and Mental Health Services Administration (DHHS)	USDA	United States Department of Agriculture
SAR	Synthetic aperture radar	USFS	United States Forest Service
SBE	Social, Behavioral and Economic Sciences Directorate (NSF)	USGS	United States Geological Survey
SBIRT	Screening, Brief Intervention, Referral and Treatment program (DHHS/SAMHSA)	USIABP	United States Interagency Arctic Buoy Program
SCAR	Scientific Committee on Antarctic Research	UV	Ultraviolet
SEARCH	Study of Environmental Arctic Change	WCRP	World Climate Research Program
		WDC	World Data Center
		WHO	World Health Organization
		WMO	World Meteorological Organization

Appendix B: Tenth Biennial Report of the Interagency Arctic Research Policy Committee to the Congress

February 1, 2002, to January 31, 2004

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 2002.

Activities and Accomplishments

During the period covered by this report, the IARPC has:

- Prepared the 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 00 and 01 and included summaries of IARPC meetings and activities. The Fall/Winter 2003 issue contains the full text of the 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 (App.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 \$295 million in Federal support for FY 02 and \$299 million in FY 03.
- 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.
- Continued work to coordinate 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.
- Began consideration of research programs on Resource Evaluation in Alaska and on Civil Infrastructure.
- Convened formal meetings of the Committee and its working groups, staff committees, and task forces to accomplish the above.

*Prepared by the National
Science Foundation for
the Interagency Arctic
Research Policy
Committee.*

Appendix C: Arctic Research Budgets of Federal Agencies

Dept/Bureau	Program name	Budget (dollars in thousands)		
		FY 04 actual	FY 05 estimated	FY 06 proposed
DOD	Arctic Engineering	1,150	1,138	800
DOD	Permafrost/Frozen Ground	400	200	353
DOD	Snow and Ice Hydrology	1,900	844	752
DOD	High Latitudes Program	2,959	1,200	250
DOD	Lower Atmosphere	100	0	0
DOD	High-Freq Active Auroral Program	45,100	46,500	10,000
DOD	Medical and Human Engineering	700	512	699
	DOD TOTAL	52,309	50,394	12,854
DOI/MMS	Technology Assessment/Research	434	320	500
DOI/MMS	Environmental Studies	5,251	5,016	5,547
DOI/USGS	Energy and Minerals	2,000	4,300	4,300
DOI/USGS	Natural Hazards	7,500	9,500	9,500
DOI/USGS	Global Change	1,000	1,400	1,400
DOI/USGS	Marine and Coastal Geology	250	250	250
DOI/USGS	Geomagnetism	250	250	250
DOI/USGS	Ice and Climate	250	200	200
DOI/USGS	Hydrology	1,370	1,250	1,250
DOI/USGS	Mapping	1,540	1,400	1,400
DOI/USGS/BRD	Marine Mammals	1,660	1,800	1,800
DOI/USGS/BRD	Migratory Birds	2,350	2,300	2,300
DOI/USGS/BRD	Fisheries Research	360	980	980
DOI/USGS/BRD	Cooperative Research	330	330	330
DOI/USGS/BRD	Terrestrial Ecology	1,110	1,020	1,020
DOI/USGS/BRD	Park Research	1,070	1,000	1,000
DOI/BLM	Natural Ecology	1,035	1,135	1,184
DOI/BLM	Minerals Research (Non-O & G)	2,030	3,868	3,000
DOI/BLM	Minerals Research (O & G, NPR-A)	1,393	2,400	2,400
DOI/BLM	Cultural Resources	179	128	104
DOI/BLM	Pipeline Monitoring	0	0	0
DOI/BLM	Fire Control	339	317	317
DOI/BLM	Mining Administration	0	0	0

The data reported here were compiled from individual program submissions from participating Federal agencies. The information covers expenditures for research but may exclude administrative costs that are included in agency budget source documents.

For many agencies, regional allocations specific to Alaska and the Arctic in this table may be subject to further revision during FY 05.

Coast Guard Arctic research cost data are based on overall mission costs attributed to polar icebreaking assets dedicated to Arctic research deployments. The total cost of the polar icebreaking mission is documented in the Coast Guard's Mission Cost Model and includes all direct, indirect, and overhead costs associated with the Coast Guard's polar icebreaking mission.

The National Science Foundation supports research in the Arctic via the Arctic Research Program of the Office of Polar Programs. It also supports meritorious research proposals that may be submitted to other programs in the Foundation. The dollar amount expended in other programs for FY 05 will not be known until the end of FY 05.

<i>Dept/Bureau</i>	<i>Program name</i>	<i>Budget (dollars in thousands)</i>		
		<i>FY 04 actual</i>	<i>FY 05 estimated</i>	<i>FY 06 proposed</i>
DOI/NPS	Cultural Resources	1,351	1,477	1,477
DOI/NPS	Natural Ecology	1,950	2,150	2,150
DOI/NPS	Inventory and Monitoring	5,000	6,168	6,168
DOI/BIA	Cultural Resources	600	600	600
DOI/BIA	Subsistence Studies	1,250	1,250	1,250
DOI/FWS	Migratory Birds	3,800	5,417	5,417
DOI/FWS	Fisheries	4,300	6,546	6,546
DOI/FWS	Marine Mammals	2,231	2,162	2,162
DOI/FWS	Conservation of Flora and Fauna (CAFF)	200	138	138
DOI/FWS	U.S.-Russia Environmental Agreement	350	350	350
	DOI TOTAL	52,733	65,422	65,290
NSF/OPP	Arctic Natural Science	12,258	13,700	13,600
NSF/OPP	Arctic System Science Program	20,251	19,600	19,500
NSF/OPP	Arctic Social Sciences Program	2,455	3,005	2,400
NSF/OPP	Arctic Education Research	250	350	350
NSF/OPP	Arctic Research Support	848	840	875
NSF/OPP	Arctic Data/Info/Coordination	191	180	180
NSF/OPP	Arctic Research Commission	1,556	1,190	1,190
NSF/OPP	Cyber Infrastructure and Sensors	1,240	815	815
NSF/OPP	Arctic Logistics/Instrumentation	37,390	37,400	36,650
NSF/OPP	Sub-total OPP	76,439	77,080	75,560
NSF	Other NSF Science Programs	19,808	20,200	20,200
	NSF TOTAL	96,247	97,280	95,760
NASA	Cryospheric Sciences	5,000	5,000	5,000
NASA	Terrestrial Ecology	700	1,200	920
NASA	Solid Earth Science	2,000	2,000	2,000
NASA	Physical Oceanography	500	500	500
NASA	Biological Oceanography	180	250	320
NASA	Arctic Ozone	6,500	6,500	4,000
NASA	Atmospheric Chemistry	1,500	2,000	2,000
NASA	Clouds and Radiation	1,200	1,200	1,200
NASA	Sub-orbital Science	2,000	2,000	2,000
NASA	Arctic Data Systems	12,000	12,000	8,000
NASA	Interdisciplinary Polar Feedbacks	0	2,000	2,000
NASA	Interdisciplinary Sea Level	0	800	800
	NASA TOTAL	31,580	35,450	28,740
DOC/NOAA	Arctic Research Program	0	0	3,017
DOC/NOAA	Cloud Radiation	10	10	425
DOC/NOAA	Atmos Trace Constituents	400	425	17,500
DOC/NOAA	Fisheries Assessment/Management	17,000	17,500	7,325
DOC/NOAA	Marine Mammal Assessment	6,675	7,325	185
DOC/NOAA	Ocean Assessment	10	50	200
DOC/NOAA	Stratospheric Ozone	250	250	343
DOC/NOAA	Data Management	331	340	300
DOC/NOAA	Remote Sensing	345	435	1,100

Dept/Bureau	Program name	Budget (dollars in thousands)		
		FY 04 actual	FY 05 estimated	FY 06 proposed
DOC/NOAA	Aircraft/Vessels	950	1,100	23
DOC/NOAA	Weather Research	25	50	2,100
DOC/NOAA	Western Arctic/Bering Sea Ecosystem	2,100	2,100	450
DOC/NOAA	Barrow Observatory	600	600	2,300
DOC/NOAA	Ocean Exploration	355	1,250	200
DOC/NOAA	Tsunami Warning/Environ. Observations	250	250	0
DOC/NOAA	Arctic Research Initiative	1,650	1,060	340
DOC/NOAA	Ocean Observations/Arctic Fluxes	360	360	0
DOC/NOAA	Arctic Climate Research (SEARCH)	2,000	1,960	0
DOC/NOAA	CIFAR	0	0	198
DOC/NOAA	Undersea Research	2,530	0	0
	NOAA TOTAL	35,841	35,065	36,006
DOE/EM	Amchitka Island Studies	1,370	525	525
DOE/FE	Arctic Energy Office	5,500	7,000	7,000
DOE/FE	Arctic Methane Hydrates	1,080	2,500	2,500
DOE/SC	Atmos Radiation Measurement	3,200	3,200	3,200
DOE/EE	Geothermal Activities in Alaska	260	185	185
DOE/SC	Nat. Inst. Global Environmental Change	225	125	125
DOE/EE	Wind Activities in Alaska	0	1,500	1,500
DOE/EM	Neighborhood Environmental Watch	40	40	40
	DOE TOTAL	11,675	15,075	15,075
DHHS	National Institutes of Health	25,000	26,000	26,000
DHHS	Centers for Disease Control/Prevent.	4,600	4,500	4,600
	DHHS TOTAL	29,600	30,500	30,600
SMITHSONIAN	Anthropology	400	750	750
SMITHSONIAN	Arctic Biology	50	100	100
	SMITHSONIAN TOTAL	450	850	850
DHS/USCG*	Arctic Science/Logistics Support	21,691	16,800	22,000
DHS/USCG	Extramural Science Support	30	38	45
	DHS TOTAL	21,721	16,838	22,045
EPA	Research and Development	237	0	0
EPA	Regional Activities	1,010	500	500
EPA	International Activities	100	285	285
	EPA TOTAL	1,347	785	785
USDA/FS	Forest Service-Global Change	653	653	653
USDA/NRCS	Natural Resources Cons Svc-Soil Survey	260	260	260
USDA/CSREES	Formula Funds	1,389	1,389	1,389
USDA/ARS	Agricultural Res Service-Global Change	2,000	2,000	2,000
	USDA TOTAL	4,302	4,302	4,302
	GRAND TOTALS	337,805	351,961	312,307

* Figures for the proposed FY06 budget represent funding required by USCG to operate icebreakers in the Arctic for NSF, which was designated in the President's FY06 budget as the agency to which ice operations funding is transferred.

Appendix D: Federal Arctic Research Program Descriptions

Department of Defense

- Arctic Engineering: The study and development of technologies for construction and maintenance of facilities and equipment in Arctic environments.
- Permafrost/Frozen Ground: The study of the formation, structure, characteristics, and dynamics of permafrost and frozen ground.
- Snow and Ice Hydrology: The study of the snowpack and river, lake, and sea ice, their formation, structure, and dynamics.
- Oceanography: The study of Arctic Ocean features and processes including sea ice dynamics.
- Lower Atmosphere: The study of Arctic weather with an emphasis on heat budget.
- Upper Atmosphere: The study of physical processes in the thermosphere, ionosphere, and magnetosphere. Studies also include applied research to investigate, predict, and assess the impacts from the thermosphere, ionosphere, and magnetosphere to communication, navigation, surveillance, and satellite systems.
- High-Frequency Active Auroral Research Program (HAARP): The use of radiowave energy to study basic physical response and composition of the ionosphere and upper atmosphere.
- Medical and Human Engineering: The study of human response to cold climates and methods to mitigate those effects.

Department of the Interior

Minerals Management Service

- Technology Assessment and Research Program: Research to support Minerals Management Service offshore operations. Studies address operational needs for permitting of drilling and production operations, safety and pollution inspections, enforcement action, accident investigations, and well control training requirements.
- Environmental Studies Program: Research to provide information needed for prediction, assessment, and management of impacts from

offshore natural gas and oil and mineral development activities on human, marine, and coastal environments of Alaska.

U.S. Geological Survey

- Energy and Minerals: Research to assess the distribution, quantity, and quality of energy and mineral resources with an increasing emphasis on characterizing the environmental impact of resource occurrence and use. This information assists the Nation in managing its land, formulating environmental policies, and ensuring stable and safe supplies of resources.
- Natural Hazards: Research to forecast and delineate hazards from earthquakes, volcanoes, landslides, and related phenomena. Losses from future natural hazard events can be significantly reduced through studies of past and potential events applied to disaster mitigation and response planning.
- Global Change: Research to investigate the impact that potential global change, such as global warming, would have on our planet. This is part of the U.S. Global Change research program, which provides the scientific basis for developing policy relating to natural and human-induced changes in the global earth system.
- Marine and Coastal: Research to address issues of national, regional, and local concern that involve marine and coastal geology. These issues involve natural hazards, natural resources, and environmental quality and restoration; they span the full continuum from coastal wetlands and seashores to the deep ocean.
- Geomagnetism: Research to measure, map, and model the earth's magnetic field within various time scales and to publish and disseminate this information for use in navigation and orientation by Federal, state, local, and international groups. Eleven magnetic observatories are operated, and repeat magnetic field surveys are performed to determine how and how fast the earth's magnetic field is changing.
- Ice and Climate: Research to understand the

causes, characteristics, and effects of changes in glacier conditions over annual to decadal time scales, as well as of changes in snow conditions in mountainous areas over monthly to seasonal time scales.

- Hydrology: Research to monitor and assess the sensitivity of surface water and wetland hydrology to variations and changes in climate.
- Mapping: Program to develop geologic and environmental maps of Arctic Alaska.

U.S. Geological Survey—Biological Resources Division

- Marine Mammals: Research on marine mammals to provide information needed for USGS to fulfill its stewardship responsibilities under the Marine Mammal Protection Act.
- Migratory Birds: Research on migratory birds to provide basic biological information needed for responsible implementation of the Migratory Bird Treaty Act.
- Fisheries: Research related to land management responsibilities on National Wildlife Refuges and National Parks or focusing on treaty issues involving the U.S. and Canada.
- Cooperative Research: Research addressing issues relating to short-term or site-specific resource management issues.
- Terrestrial Ecology: Research related to land management, emphasizing potential effects of resource development on National Wildlife Refuges.
- Park Research: Research related to land management, emphasizing issues specific to National Parks.

Bureau of Land Management

- Natural Ecology: Inventorying and monitoring the quantity and status of waters, soils, vegetation, fish and wildlife populations, and habitats in Arctic Alaska. This is a major effort to support lands and resources management in this unique area.
- Cultural Resources: Studies of man's prehistoric activities in the Arctic. Recent findings in northern Alaska have helped in understanding man's migration into North America.
- Pipeline Monitoring: Program to ascertain that permittees are in compliance with the agreement and grant right-of-way for the Trans-Alaska Pipeline in Arctic Alaska. There is constant monitoring of pipeline integrity and the status of the natural resources in and adjacent to the right-of-way.

- Fire Control: Studies of fuels, ignition, burning, fire spreading, and methods of control of wildfires in the Arctic. A network of remote automatic weather stations has been established. The primary purpose of this network is to help understand the influence of weather on wildfires.
- Mining Administration: Monitoring of placer mining on public lands in Arctic Alaska. The goal is to assure compliance with the approved plan of operations and minimize the impact of mining on the riparian wetland resource.

National Park Service

- Cultural Resources: Research and investigation of cultural resources as they pertain to historic places in National Parks. The Shared Beringian Heritage Program promotes international cooperation in multidisciplinary studies of Beringia.
- Natural Ecology: Research to monitor and understand natural resources in National Parks.

Bureau of Indian Affairs

- Cultural: Research and investigation of learned and shared behaviors as they pertain to historic places and cemetery sites applied for under the provisions of the Alaska Native Claims Settlement Act (P.L. 92-203).
- Subsistence: Research on the customary and traditional uses of fish, game, and plant resources.

National Science Foundation

- Arctic Natural Sciences: Research in atmospheric, space, ocean, biological, earth sciences, and glaciology that is primarily investigator-initiated; this is basic research that is concerned with processes and phenomena in the entire Arctic region, including Alaska, Canada, Greenland, Svalbard, Russia, the Arctic Ocean and adjacent seas, and the upper atmosphere and near space.
- Arctic System Science (ARCSS): An interdisciplinary program that examines the interactions within and between the climatic, geologic, biologic, and socioeconomic subsystems of the Arctic. ARCSS is a regional component within the U.S. Global Change Research Program.
- Arctic Social Science: A multidisciplinary and interdisciplinary program focused on issues

- of human–environment interactions, rapid social change, and community viability.
- **Arctic Science Support:** Support for Intergovernmental Personnel Act (IPA) personnel assigned to the Arctic Sciences Section of the Office of Polar Programs (OPP), and scientific meeting, panel, and publication support.
- **Arctic Data and Information, and Advisory and Coordination:** Support for a program of Arctic data and information research and advisory services, including support for the Interagency Arctic Research Policy Committee, and conferences, workshops, and studies to further develop and implement Arctic research planning and policy.
- **Arctic Research Commission:** Support for the Commission staff and members. Funding for the Arctic Research Commission is included in the NSF budget for administrative convenience.
- **Other Sciences:** Research supported in divisions and programs outside the OPP in atmospheric, ocean, biological, earth sciences, and glaciology that is primarily investigator-initiated basic research.
- **Engineering:** Engineering research that is related to the Arctic.
- **Education:** Education research that is related to the Arctic.

National Aeronautics and Space Administration

- **Cryosphere:** This program is focused on the Arctic ice cover and its interactions with the oceans and atmosphere. The long-range goals are to significantly improve our ability to represent high-latitude processes in models of global climate and climate change and to understand the current and likely impact of changes in ice mass on sea level.
- **Ecology:** This program is focused on the function of high-latitude terrestrial ecosystems and their interactions with the atmosphere and hydrosphere, with particular emphasis on carbon cycling and land–atmosphere interactions.
- **Solid Earth and Natural Hazards Science:** This program is focused on improving our understanding of the earth’s gravity field, oscillations in the length of day and tilting of the axis of rotation, geodesy to determine the rate of past-glacial rebound of the lithosphere for ice mass and structural studies, the earth’s magnetic field to determine crustal structure, and topography and topographic change of the Arctic and Antarctic regions. The program also contributes to other polar studies by providing a frame of reference with which to monitor changes such as the volume of the ice sheets.
- **Arctic Ozone Studies:** This program is supporting a number of tasks related to chemical and dynamical processes in the Arctic stratosphere, with the aim of measuring and understanding changes in Arctic stratospheric ozone in an atmosphere with increasing abundances of greenhouse gases.
- **Arctic Data Systems:** NASA provides support for two Distributed Active Archive Systems (DAACs) for high-latitude data: one at the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado, and one at the Alaska SAR Facility (ASF) in Fairbanks, Alaska. The ASF is responsible for acquiring, processing, archiving, and distributing synthetic aperture radar (SAR) data from several non-U.S. spacecraft, and the NSIDC handles most other satellite data over the high latitudes. In addition, NASA supports the development of several high-latitude “Pathfinder” data sets, comprising higher-level information derived from various satellite data.
- **Clouds and Radiation:** NASA supports comprehensive studies of the impact of Arctic clouds and aerosols on the Arctic radiation balance and its impact on the global radiative balance. Studies supported include modeling and analysis of satellite cloud and aerosol data obtained over the polar regions. In addition, NASA supports missions to the Arctic (e.g. FIRE-ACE) that include ground, ship, and airborne sensors coordinated with satellite observations to study the processes that contribute to the evolution of cloud and aerosol distributions.
- **Geospace Physics:** NASA provides support for a vigorous program of experimental and theoretical studies of geospace phenomena originating in or affecting Arctic regions, including the mesosphere, thermosphere, ionosphere, and magnetosphere. It includes these programs listed in the NASA budget table: Sun-Earth Connection Theory Program, Fast Auroral SnapshoT Explorer spacecraft, Geospace Low Cost Access to Space (sub-orbital) program, and the Geospace Sciences Supporting Research and Technology program.

Department of Commerce

National Oceanic and

Atmospheric Administration

- **Atmospheric Trace Constituents:** Continuous and discrete measurements of atmospheric trace constituents (for example, greenhouse gases) that are important to understanding global change.
- **Marine Fisheries Assessment:** Assessment by the National Marine Fisheries Service (NMFS) of U.S. living marine resources in Arctic waters.
- **Marine Fisheries Research:** NOAA's Pacific Marine Environmental Laboratory (PMEL) and Alaska Fisheries Science Center (AFSC) conduct the Fisheries Oceanography Coordinated Investigations (FOCI) program in the Bering Sea and North Pacific. FOCI is concerned with understanding and predicting the impacts of interannual variability and decade-scale climate change on commercially valuable fish species.
- **Marine Mammal Assessment:** Long-term research by NMFS's National Marine Mammal Laboratory on the population biology and ecology of Arctic marine mammals. NMFS also participates in the Marine Mammal Health and Stranding Response Program, which oversees the Arctic Marine Mammal Tissue Archival Program (AMMTAP) in collaboration with the Department of the Interior (FWS, BRD, and MMS) and the National Institute of Standards and Technology (NIST). The AMMTAP collects, analyzes, and archives tissues for contaminants and health indices to provide a database on contaminants and health in marine mammal populations in the Arctic.
- **Coastal Hazards:** Activities directed towards developing a better understanding of the effects of tsunami propagation and run-up.
- **Ocean Assessment:** A wide range of programs and activities directed toward NOAA's environmental stewardship responsibilities, including environmental monitoring and assessment, technology transfer, and education and outreach. Ocean assessment includes the National Status and Trends Program, the Coastal Ocean Program, and other pertinent activities of the recently formed National Centers for Coastal Ocean Science (NCCOS), National Ocean Service.
- **Stratospheric Ozone:** A program that is developing an understanding of the dynamics and chemistry of Arctic ozone depletion, as part of activities directed to understanding the global depletion of stratospheric ozone.
- **Satellites/Data Management:** Research addressing NOAA's responsibilities for collecting, archiving, processing, and disseminating environmental data and providing specialized data analyses and interpretations.
- **Remote Sensing:** A substantial program (jointly with NASA, NSF, and DOE) for developing, testing, and using ground-based remote sensors for Arctic meteorological research. The emphasis is on prototypes for future operational systems that can operate in the Arctic with minimal attention. The scientific issues include boundary layer turbulence and structure, cloud macro- and micro-physical properties, and cloud-radiative coupling relevant to Arctic climate.
- **Aircraft/Vessels:** Platform support from the Office of Marine and Aviation Operations (OMAO) to conduct the research and observations associated with NOAA's Arctic research program.
- **Climate and Global Change:** Studies that are assessing Arctic processes as forcing functions of climate and global change and as "barometers" of global change. NOAA's Arctic Research Office chairs the Interagency Working Group on the Study of Environmental Arctic Change (SEARCH).
- **Arctic Ice:** The National Ice Center, jointly operated by NOAA, the U.S. Navy, and the U.S. Coast Guard, provides analyses and forecasts of ice conditions in all seas of the polar regions, the Great Lakes, and Chesapeake Bay. The National Snow and Ice Data Center (NSIDC), affiliated with NOAA's National Geophysical Data Center (NGDC), archives many new and rescued ice data sets.
- **Arctic Weather:** Research primarily addresses four concerns: 1) Forecasting snow in mountainous terrain for real-time use and for climate-related information; 2) Remote sensing for detecting clouds and for developing cloud phase techniques; 3) Improving the numerical modeling of weather over both the short and long term in complex terrain such as Alaska; and 4) Locating and understanding the dynamics of the Arctic Front.
- **Boreal Forest Fires and the Arctic:** Modeling, research, and observations to understand the influence of Northern Hemisphere boreal forest fires on atmospheric chemistry in the Arc-

tic, especially focusing on the production of surface-level ozone and other pollutants and the atmospheric and climate effects of the input of soot.

- **Arctic Research Initiative:** The Arctic Research Office was formed in FY 00 to administer the Arctic Research Initiative and to build a NOAA program focused on Arctic science issues of national importance. For this purpose, the “Arctic” is defined loosely as the northern hemisphere land area underlain by permanent or discontinuous permafrost, and ocean areas subject to permanent or annual sea ice cover. Consideration of watersheds and airsheds that flow to the Arctic can extend the geographic boundaries significantly, as can consideration of impacts of Arctic processes on hemispheric weather and climate. In FY 03, newly appropriated funds are available to initiate a NOAA contribution to the interagency Study of Environmental Arctic Change (SEARCH). Under the overall guidance of the NOAA Strategic Plan, the ARO has formulated more specific goals that relate to its specific mission. These goals are:
 - Characterize poorly known high-latitude marine habitats, and understand and model factors controlling the populations of key marine species in the Arctic and sub-arctic;
 - Understand ecosystem impacts of critical contaminants and human uses in the Arctic; and
 - Understand causes and impacts of atmospheric, oceanic, and climate variability and change in the Arctic.

Several projects are planned over the next few years to address these goals and contribute to the SEARCH Science Plan. These projects are: a) Retrospective Analysis of Ocean Climate and Populations of Key Living Marine Resources; b) A collaborative, international program of Arctic exploration; c) Bering Sea Ecosystem Study; d) Atmospheric and Cryospheric Change in the Arctic; e) Arctic/Sub-arctic Ocean Fluxes; f) Arctic System Reanalysis; g) Arctic Climate Impact Assessment; h) Environmental Sources, Fate, and Impact of Mercury and Persistent Organic Pollutants in the Arctic; i) Assessment of Environmental and Economic Impacts of Oil and Gas in the Arctic; j) Development of an updated AMAP Strategic Plan.

Department of Energy

- **Amchitka Island Studies:** Amchitka Island is located near the western end of the Aleutian Islands. The U.S. Atomic Energy Commission, the predecessor to DOE, conducted three underground nuclear tests on the island in the late 1960s and early 1970s. In 2002 the DOE’s National Nuclear Security Administration (NNSA) Nevada Site Office prepared and submitted a Closure Report to the Alaska Department of Environmental Conservation for the surface remediation work completed in 2001. Future work planned for Amchitka includes finalizing the risk assessment and the draft closure report for the subsurface in FY05. After closure, sampling and monitoring will continue every five years.
- **Arctic Energy Office:** The AEO supports research that is appropriate for regions “where permafrost is present or located nearby.” Specifically, the office sponsors research in two broad categories: Fossil Energy and Remote Power Production. Funding permitting, the AEO plans to continue work in these areas. Two examples of the 15 projects currently supported are:
 - **Tundra Travel Model for the North Slope of Alaska:** This project investigates the potential for a new standard for tundra travel that will allow resource exploration for an increased period most winters.
 - **Rural Alaska Natural Gas from Coal:** For the first time in Alaska, a light-weight drill rig has been used to drill through the permafrost, gravels, and coal seams to test the feasibility of producing natural gas from coal deposits in remote areas. The eventual goal is to facilitate replacement of diesel fuel for generating electricity in Alaskan villages that have gas-producing coal resources nearby.
- **Arctic Methane Hydrates:** DOE is involved in several projects aimed at evaluating the methane hydrate resource on the North Slope of Alaska and in the Canadian Arctic. The primary objective is to characterize, quantify, and determine the resource potential of the gas hydrate and associated free gas in the region. The USGS estimates that roughly 45 Tcf of methane is stored in the form of hydrate beneath the North Slope permafrost.
- **Atmospheric Radiation Measurement (ARM) Program:** DOE will continue operation of an

ARM Climate Research Facility (ACRF) on the North Slope of Alaska with instrumentation at Barrow and Atkasuk to improve mathematical simulations of cloud and radiative transfer processes in general circulation models (GCMs); continue to make existing ACRF data streams publicly available through the ARM archive (<http://www.arm.gov/data/>); and make the NSA ACRF facilities more broadly available to researchers through the proposal process (<http://www.db.arm.gov/cgi-bin/IOP/iops.pl>). Operation of the North Slope of Alaska ACRF facility and support for related modeling and other Arctic research efforts using NSA/ACRF data streams are DOE's main contribution to SEARCH (Study of Environmental Arctic Change), an interagency effort.

- **Geothermal Activities in Alaska:** DOE cost-shares geothermal resource exploration with the Chena Hot Springs Resort in Alaska. The exploration consists of performing geophysical surveys, creating geologic and surface temperature maps, drilling shallow temperature gradient holes, and conducting geochemical analyses of thermal water. After the field work is completed, a conceptual geological model of the Chena Hot Springs system will be created and a drill site will be selected. The Geothermal Technologies Program has also initiated a GeoPowering the West program in Alaska. An Alaskan Geothermal Working Group has been established. DOE funded the Alaska Division of Energy to support this effort and sponsored a mission for 15 Alaskans to travel to Nevada to tour producing geothermal sites and to talk to developers, regulators, and others about geothermal development. In the future the Geothermal Technologies Program plans to follow up on the opportunities discovered through this initiative.
- **National Institute for Global Environmental Change:** Through NIGEC, university scientists can apply for research support to study ecological effects of climatic change in Alaska (and other states). In FY04, two university projects were funded in Alaska. One, conducted by Columbia University and completed in FY04, examined the response of Alaskan and Pacific Northwest forests to recent multiple environmental changes, including climatic changes. The question addressed whether environmental changes, which have been relatively large and rapid in subarctic regions,

are having a discernable effect on the growth and health of forest trees. The second, conducted by the University of Oregon and the University of Alaska and to be completed in FY05, is examining potential effects of warming on plant parasites in the understory of boreal forests. Any changes in plant parasites caused by global warming could have effects, negative as well as positive, on basic plant growth and the goods and services supplied to humans by Alaskan forests.

- **Neighborhood Environmental Watch: NEWNET** is a network of environmental monitoring stations and data storage and data processing systems, with public access to the data through the Internet. Five stations are located in Alaska: Barrow, Fairbanks, Kotzebue, Nome, and Seward. Stations 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. Sensors are being investigated for air quality measurements. The Alaska stations are being operated in collaboration with the Alaska Department of Environmental Conservation (ADEC) and the University of Alaska Fairbanks (<http://newnet.lanl.gov/>).
- **Wind Activities in the Arctic:** To better understand the role that wind energy can play, the Wind Energy program continues to be 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. Efforts are particularly focused on smaller rural communities, where the cost of diesel-generated electricity is very high. In the past, DOE has supported work at Kotzebue, Wales, Nome, Nightmute, Nunapitchuk, Selawik, and Unalakleet. DOE-sponsored wind-related work will continue in Alaska at least through FY05.

Department of Health and Human Services

National Institutes of Health

- Basic and applied research that relates primarily in the areas of cancer, drug and alcohol abuse, cardiovascular disease, and mental health that affect Arctic residents.

Centers for Disease Control and Prevention

- A research program designed to evaluate infectious disease prevention and control strategies in the Arctic and subarctic, with a special focus on diseases of high incidence and concern among the indigenous peoples of the circumpolar region.
- An occupational injury research program focusing on the Nation's geographic area with the highest risk of occupational-related injury.
- Research on human exposure to environmental persistent organic pollutants in the Arctic.

Health Resources and Services Administration

- HRSA provides national leadership, program resources, and services needed to improve access to culturally competent, quality health care in order to improve health outcomes among Alaska's minority communities through the National Health Service Corps, telehealth technology, and community health centers.

Substance Abuse and Mental Health Services Administration

- The mission of SAMHSA is to build resilience and facilitate recovery for people with or at risk for substance abuse and mental illness. SAMHSA works in collaboration with the states, national and local community-based and faith-based organizations, and public and private sector providers.

Smithsonian Institution

- Anthropology: Research and interpretation of Arctic cultures and natural history; training of Arctic residents and Natives in museum studies, collections care, conservation, and cultural heritage programs; studies of the origin and history of northern cultures and their interactions with their environment and with European cultures are central features of this research.
- Arctic Biology: Basic research on biological and evolutionary studies in botany, zoology, and other natural history fields. Interactions of Arctic flora and fauna with human cultures are emphasized.

Department of Homeland Security

U.S. Coast Guard

- Arctic Science/Logistics Support: The costs of providing and maintaining polar icebreakers for use in the Arctic.

- Extramural Science Support: Funding provided to other agencies for Arctic science studies, research, or vessel availability studies.

Environmental Protection Agency

- Research and Development: Intramural and extramural basic and applied research founded on the risk assessment and risk management paradigm. EPA research interests in the Arctic include water quality, watershed cumulative effects, air quality, land use, bioremediation and the combined impact of contaminants, climate change, and resource use on freshwater and marine ecosystems. Research efforts address issues of long-range transport and transformation of contaminants to the Arctic and the status and trends of contaminants such as persistent organic pollutants and heavy metals within the Arctic environment.
- Regional Activities: Activities of EPA's Region 10 (Pacific Northwest and Alaska office) are conducted in partnership with tribes, the state, and local communities to resolve key issues in rural sanitation, clean drinking water, clean-up of formerly used defense sites, regulation of local industry, and other issues key to protecting human health and the unique Arctic and subarctic environments.

Department of Agriculture

Forest Service

- Research directed toward improving the understanding, use, and management of Alaska's natural resources, especially the northern boreal forest. Research centers on the dynamics of mixed stands and the cumulative effects of management activities on hydrology, soils, vegetation, wildlife, carbon reserves, insects, and fire in boreal ecosystems.
- Important portions of the boreal ecosystems research are conducted at the Bonanza Creek Long-Term Ecological Research Site near Fairbanks, Alaska.

Natural Resources Conservation Service

- Research in support of the National Cooperative Soil Survey program addressing permafrost, soil cryogenic processes, soil reduction and oxidation properties, temperature, water status and gas flux in wetlands, reindeer and

caribou grazing needs, and vegetation trends.

- Establishment of a network of climatic stations in both the Arctic and Antarctic as well in other areas with soils affected by permafrost, allowing for studies of changes in the active layer and providing data for many other users. They are linked to sites established by NSF-funded projects, all of the sites have complete soil characterization data, and all of the data collected are provided to NSIDC.
- Research on vegetation, landform, carbon sequestration, and other greenhouse gas relationships in support of the Global Change Research Program.
- Research in support of the snow survey program. Snowfall measurement techniques are being studied to support the snow survey, which continues to be used to predict snowmelt, water availability, river breakup timing, and wildlife movements.
- Research conducted jointly with scientists from Russia and other countries to look at active layer dynamics and soil genesis, classification, and formation.
- Establishment of climatic stations, with both below- and above-ground sensors, in much of Alaska, with comparable sites in the permafrost regions of China as well as in Antarctica.

Agricultural Research Service

- Research on plant sciences emphasizing germplasm preservation to protect native and Russian plant species with emphasis on medicinal value and utility for erosion control.
- Research in animal sciences to investigate Alaska fisheries byproduct use (especially for feed stocks), integrated pest management for grasshopper control in Alaska's central basin, and the biosystematics of Holarctic ruminant parasites to assess pathogen distribution in food resources of northern communities.

Department of State

- Coordination of U.S. involvement in the Arctic Council and its working groups, including the Arctic Monitoring and Assessment Program; Conservation of Arctic Flora and Fauna, which the U.S. vice-chairs; Emergency Prevention, Preparedness, and Response; Protection of the Arctic Marine Environment, which the U.S. chairs; Sustainable Development; and the Arctic Council Action Plan to Eliminate Pollution of the Arctic.
- Chairmanship of regular meetings of the interagency Arctic Policy Group and overall responsibility for the coordination and formulation of U.S. policy in the Arctic.

Appendix E: Arctic Research and Policy Act, As Amended

PUBLIC LAW 98-373 - July 31, 1984; amended as
PUBLIC LAW 101-609 - November 16, 1990

An Act

To provide for a comprehensive national policy dealing with national research needs and objectives in the Arctic, for a National Critical Materials Council, for development of a continuing and comprehensive national materials policy, for programs necessary to carry out that policy, including Federal programs of advanced materials research and technology, and for innovation in basic materials industries, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled:

TITLE 1-ARCTIC RESEARCH AND POLICY

SHORT TITLE

SEC. 101. This title may be cited as the "Arctic Research and Policy Act of 1984, as amended".

FINDINGS AND PURPOSES

SEC. 102.(a) The Congress finds and declares that—

- (1) the Arctic, onshore and offshore, contains vital energy resources that can reduce the Nation's dependence on foreign oil and improve the national balance of payments;
- (2) as the Nation's only common border with the Soviet Union, the Arctic is critical to national defense;
- (3) the renewable resources of the Arctic, specifically fish and other seafood, represent one of the Nation's greatest commercial assets;
- (4) Arctic conditions directly affect global weather patterns and must be understood in order to promote better agricultural management throughout the United States;
- (5) industrial pollution not originating in the Arctic region collects in the polar air mass, has the potential to disrupt global weather patterns, and must be controlled through international cooperation and consultation;
- (6) the Arctic is a natural laboratory for research into human health and adaptation, physical and psychological, to climates of extreme cold and isolation and may provide information crucial for future defense needs;
- (7) atmospheric conditions peculiar to the Arctic make the Arctic a unique testing ground for research into high latitude communications, which is likely to be crucial for future defense needs;
- (8) Arctic marine technology is critical to cost-effective recovery, and transportation of energy resources and to the national defense;

(9) the United States has important security, economic, and environmental interests in developing and maintaining a fleet of icebreaking vessels capable of operating effectively in the heavy ice regions of the Arctic;

(10) most Arctic-rim countries, particularly the Soviet Union, possess Arctic technologies far more advanced than those currently available in the United States;

(11) Federal Arctic research is fragmented and uncoordinated at the present time, leading to the neglect of certain areas of research and to unnecessary duplication of effort in other areas of research;

(12) improved logistical coordination and support for Arctic research and better dissemination of research data and information is necessary to increase the efficiency and utility of national Arctic research efforts;

(13) a comprehensive national policy and program plan to organize and fund currently neglected scientific research with respect to the Arctic is necessary to fulfill national objectives in Arctic research;

(14) the Federal Government, in cooperation with State and local governments, should focus its efforts on the collection and characterization of basic data related to biological, materials, geophysical, social, and behavioral phenomena in the Arctic;

(15) research into the long-range health, environmental, and social effects of development in the Arctic is necessary to mitigate the adverse consequences of that development to the land and its residents;

(16) Arctic research expands knowledge of the Arctic, which can enhance the lives of Arctic residents, increase opportunities for international cooperation among Arctic-rim countries, and facilitate the formulation of national policy for the Arctic; and

(17) the Alaskan Arctic provides an essential habitat for marine mammals, migratory waterfowl, and other forms of wildlife which are important to the Nation and which are essential to Arctic residents.

(b) The purposes of this title are—

(1) to establish national policy, priorities, and goals and to provide a Federal program plan for basic and applied scientific research with respect to the Arctic, including natural resources and materials, physical, biological and health sciences, and social and behavioral sciences;

(2) to establish an Arctic Research Commission to promote Arctic research and to recommend Arctic research policy,

(3) to designate the National Science Foundation as the lead agency responsible for implementing Arctic research policy, and

(4) to establish an Interagency Arctic Research Policy Committee to develop a national Arctic research policy and a five year plan to implement that policy.

ARCTIC RESEARCH COMMISSION

SEC. 103. (a) The President shall establish an Arctic Research Commission (hereinafter referred to as the "Commission").

(b)(1) The Commission shall be composed of seven members appointed by the President, with the Director of the National Science Foundation serving as a nonvoting, ex officio member. The members appointed by the President shall include—

(A) four members appointed from among individuals from academic or other research institutions with expertise in areas of research relating to the Arctic, including the physical, biological, health, environmental, social and behavioral sciences;

(B) one member appointed from among indigenous residents of the Arctic who are representative of the needs and interests of Arctic residents and who live in areas directly affected by Arctic resource development; and

(C) two members appointed from among individuals familiar with the Arctic and representative of the needs and interests of private industry undertaking resource development in the Arctic.

(2) The President shall designate one of the appointed members of the Commission to be chairperson of the Commission.

(c)(1) Except as provided in paragraph (2) of this subsection, the term of office of each member of the Commission appointed under subsection (b)(1) shall be four years.

(2) Of the members of the Commission originally appointed under subsection (b)(1)—

(A) one shall be appointed for a term of two years;

(B) two shall be appointed for a term of three years; and

(C) two shall be appointed for a term of four years.

(3) Any vacancy occurring in the membership of the Commission shall be filled, after notice of the vacancy is published in the Federal Register, in the manner provided by the preceding provisions of this section, for the remainder of the unexpired term.

(4) A member may serve after the expiration of the member's term of office until the President appoints a successor.

(5) A member may serve consecutive terms beyond the member's original appointment.

(d)(1) Members of the Commission may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code. A member of the Commission not presently employed for compensation shall be compensated at a rate equal to the daily equivalent of the rate for GS-18 of the General Schedule under section 5332 of title 5, United States Code, for each day the member is engaged in the actual performance of his duties as a member of the Commission, not to exceed 90 days of service each year. Except for the purposes of chapter 81 of title 5 (relating to compensation for work injuries) and chapter 171 of title 28 (relating to tort claims), a member of the Commission shall not be considered an employee of the United States for any purpose.

(2) The Commission shall meet at the call of its Chairman or a majority of its members.

(3) Each Federal agency referred to in section 107(b) may designate a representative to participate as an observer with the Commission. These representatives shall report to and advise the Commission on the activities relating to Arctic research of their agencies.

(4) The Commission shall conduct at least one public meeting in the State of Alaska annually.

DUTIES OF THE COMMISSION

SEC. 104. (a) The Commission shall—

(1) develop and recommend an integrated national Arctic research policy;

(2) in cooperation with the Interagency Arctic Research Policy Committee established under section 107, assist in establishing a national Arctic research program plan to implement the Arctic research policy;

(3) facilitate cooperation between the Federal Government and State and local governments with respect to Arctic research;

(4) review Federal research programs in the Arctic and recommend improvements in coordination among programs;

(5) recommend methods to improve logistical planning and support for Arctic research as may be appropriate and in accordance with the findings and purposes of this title;

(6) recommend methods for improving efficient sharing and dissemination of data and information on the Arctic among interested public and private institutions;

(7) offer other recommendations and advice to the Interagency Committee established under section 107 as it may find appropriate;

(8) cooperate with the Governor of the State of Alaska and with agencies and organizations of that State which the Governor may designate with respect to the formulation of Arctic research policy;

(9) recommend to the Interagency Committee the means for developing international scientific cooperation in the Arctic; and

(10) not later than January 31, 1991, and every 2 years thereafter, publish a statement of goals and objectives with respect to Arctic research to guide the Interagency Committee established under section 107 in the performance of its duties.

(b) Not later than January 31 of each year, the Commission shall submit to the President and to the Congress a report describing the activities and accomplishments of the Commission during the immediately preceding fiscal year.

COOPERATION WITH THE COMMISSION

SEC. 105. (a)(1) The Commission may acquire from the head of any Federal agency unclassified data, reports, and other nonproprietary information with respect to Arctic research in the possession of the agency which the Commission considers useful in the discharge of its duties.

(2) Each agency shall cooperate with the Commission and furnish all data, reports, and other information requested by the Commission to the extent permitted by law; except that no agency need furnish any information which it is permitted to withhold under section 522 of title 5, United States Code.

(b) With the consent of the appropriate agency head, the Commission may utilize the facilities and services of any Federal agency to the extent that the facilities and services are needed for the establishment and development of an Arctic research policy, upon reimbursement to be agreed upon by the Commission and the agency head and taking every feasible step to avoid duplication of effort.

(c) All Federal agencies shall consult with the Commission before undertaking major Federal actions relating to Arctic research.

ADMINISTRATION OF THE COMMISSION

SEC. 106. The Commission may—

(1) in accordance with the civil service laws and subchapter III of chapter 53 of title 5, United States Code, appoint and fix the compensation of an Executive Director and necessary additional staff personnel, but not to exceed a total of seven compensated personnel;

(2) procure temporary and intermittent services as authorized by section 3109 of title 5, United States Code;

(3) enter into contracts and procure supplies, services and personal property;

(4) enter into agreements with the General Services Administration for the procurement of necessary financial and administrative services, for which payment shall be made by reimbursement from funds of the Commission in amounts to be agreed upon by the Commission and the Administrator of the General Services Administration; and

(5) appoint, and accept without compensation the services of, scientists and engineering specialists to be advisors to the Commission. Each advisor may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code. Except for the purposes of chapter 81 of title 5 (relating to compensation for work injuries) and chapter 171 of title 28 (relating to tort claims) of the United States Code, an advisor appointed under this paragraph shall not be considered an employee of the United States for any purpose.

LEAD AGENCY AND INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

SEC. 107. (a) The National Science Foundation is designated as the lead agency responsible for implementing Arctic research policy, and the Director of the National Science Foundation shall insure that the requirements of section 108 are fulfilled.

(b)(1) The President shall establish an Interagency Arctic Research Policy Committee (hereinafter referred to as the "Interagency Committee").

(2) The Interagency Committee shall be composed of representatives of the following Federal agencies or offices:

(A) the National Science Foundation;

(B) the Department of Commerce;

(C) the Department of Defense;

(D) the Department of Energy;

(E) the Department of the Interior;

(F) the Department of State;

(G) the Department of Transportation;

(H) the Department of Health and Human Services;

(I) the National Aeronautics and Space Administration;

(J) the Environmental Protection Agency; and

(K) any other agency or office deemed appropriate.

(3) The representative of the National Science Foundation shall serve as the Chairperson of the Interagency Committee.

DUTIES OF THE INTERAGENCY COMMITTEE

SEC. 108. (a) The Interagency Committee shall—

(1) survey Arctic research conducted by Federal, State, and local agencies, universities, and other public and private institutions to help determine priorities for future Arctic research, including natural resources and materials, physical and biological sciences, and social and behavioral sciences;

(2) work with the Commission to develop and establish an integrated national Arctic research policy that will guide Federal agencies in developing and implementing their research programs in the Arctic;

(3) consult with the Commission on—

(A) the development of the national Arctic research policy and the 5-year plan implementing the policy;

(B) Arctic research programs of Federal agencies;

(C) recommendations of the Commission on future Arctic research; and

(D) guidelines for Federal agencies for awarding and administering Arctic research grants;

(4) develop a 5-year plan to implement the national policy, as provided in section 109;

(5) provide the necessary coordination, data, and assistance for the preparation of a single integrated, coherent, and multiagency budget request for Arctic research as provided for in section 110;

(6) facilitate cooperation between the Federal Government and State and local governments in Arctic research, and recommend the undertaking of neglected areas of research in accordance with the findings and purposes of this title;

(7) coordinate and promote cooperative Arctic scientific research programs with other nations, subject to the foreign policy guidance of the Secretary of State;

(8) cooperate with the Governor of the State of Alaska in fulfilling its responsibilities under this title;

(9) promote Federal interagency coordination of all Arctic research activities, including-

- (A) logistical planning and coordination; and
- (B) the sharing of data and information associated with Arctic research, subject to section 552 of title 5, United States Code; and

(10) provide public notice of its meetings and an opportunity for the public to participate in the development and implementation of national Arctic research policy.

(b) Not later than January 31, 1986, and biennially thereafter, the Interagency Committee shall submit to the Congress through the President, a brief, concise report containing-

- (1) a statement of the activities and accomplishments of the Interagency Committee since its last report; and
- (2) a statement detailing with particularity the recommendations of the Commission with respect to Federal interagency activities in Arctic research and the disposition and responses to those recommendations.

5-YEAR ARCTIC RESEARCH PLAN

SEC. 109. (a) The Interagency Committee, in consultation with the Commission, the Governor of the State of Alaska, the residents of the Arctic, the private sector, and public interest groups, shall prepare a comprehensive 5-year program plan (hereinafter referred to as the "Plan") for the overall Federal effort in Arctic research. The Plan shall be prepared and submitted to the President for transmittal to the Congress within one year after the enactment of this Act and shall be revised biennially thereafter.

(b) The Plan shall contain but need not be limited to the following elements:

- (1) an assessment of national needs and problems regarding the Arctic and the research necessary to address those needs or problems;
- (2) a statement of the goals and objectives of the Interagency Committee for national Arctic research;
- (3) a detailed listing of all existing Federal programs relating to Arctic research, including the existing goals, funding levels for each of the 5 following fiscal years, and the funds currently being expended to conduct the programs;
- (4) recommendations for necessary program changes and other proposals to meet the requirements of the policy and goals as set forth by the Commission and in the Plan as currently in effect; and
- (5) a description of the actions taken by the Interagency Committee to coordinate the budget review process in order to ensure interagency coordination and cooperation in (A) carrying out Federal Arctic research programs, and (B) eliminating unnecessary duplication of effort among these programs.

COORDINATION AND REVIEW OF BUDGET REQUESTS

SEC. 110. (a) The Office of Science and Technology Policy shall—

(1) review all agency and department budget requests related to the Arctic transmitted pursuant to section 108(a)(5), in accordance with the national Arctic research policy and the 5-year program under section 108(a)(2) and section 109, respectively; and

(2) consult closely with the Interagency Committee and the Commission to guide the Office of Technology Policy's efforts.

(b)(1) The Office of Management and Budget shall consider all Federal agency requests for research related to the Arctic as one integrated, coherent, and multiagency request, which shall be reviewed by the Office of Management and Budget prior to submission of the President's annual budget request for its adherence to the Plan. The Commission shall, after submission of the President's annual budget request, review the request and report to Congress on adherence to the Plan.

(2) The Office of Management and Budget shall seek to facilitate planning for the design, procurement, maintenance, deployment and operations of icebreakers needed to provide a platform for Arctic research by allocating all funds necessary to support icebreaking operations, except for recurring incremental costs associated with specific projects, to the Coast Guard.

AUTHORIZATION OF APPROPRIATIONS; NEW SPENDING AUTHORITY

SEC. 111. (a) There are authorized to be appropriated such sums as may be necessary for carrying out this title.

(b) Any new spending authority (within the meaning of section 401 of the Congressional Budget Act of 1974) which is provided under this title shall be effective for any fiscal year only to such extent or in such amounts as may be provided in appropriation Acts.

DEFINITION

SEC. 112. As used in this title, the term "Arctic" means 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.

Appendix F: Principles for the Conduct of Research in the Arctic

Introduction

All researchers working in the North have an ethical responsibility toward the people of the North, their cultures, and the environment. The following principles have been formulated to provide guidance for researchers in the physical, biological, behavioral, health, economic, political, and social sciences and in the humanities. These principles are to be observed when carrying out or sponsoring research in Arctic and northern regions or when applying the results of this research.

This statement addresses the need to promote mutual respect and communication between scientists and northern residents. Cooperation is needed at all stages of research planning and implementation in projects that directly affect northern people. Cooperation will contribute to a better understanding of the potential benefits of Arctic research for northern residents and will contribute to the development of northern science through traditional knowledge and experience.

These "Principles for the Conduct of Research in the Arctic" were prepared by the Interagency Social Science Task Force in response to a recommendation by the Polar Research Board of the National Academy of Sciences and at the direction of the Interagency Arctic Research Policy Committee. This statement is not intended to replace other existing Federal, State, or professional guidelines, but rather to emphasize their relevance for the whole scientific community. Examples of similar guidelines used by professional organizations and agencies in the United States and in other countries are listed in the publications.

Implementation

All scientific investigations in the Arctic should be assessed in terms of potential human impact and interest. Social science research, particularly studies of human subjects, requires special consideration, as do studies of resources of economic, cultural, and social value to Native people. In all instances, it is the responsibility of the principal investigator on each project to implement the following recommendations:

1. The researcher should inform appropriate

community authorities of planned research on lands, waters, or territories used or occupied by them. Research directly involving northern people or communities should not proceed without their clear and informed consent. When informing the community and/or obtaining informed consent, the researcher should identify—

- a. all sponsors and sources of financial support;
 - b. the person in charge and all investigators involved in the research, as well as any anticipated need for consultants, guides, or interpreters;
 - c. the purposes, goals, and time frame of the research;
 - d. data-gathering techniques (tape and video recordings, photographs, physiological measurements, and so on) and the uses to which they will be put; and
 - e. foreseeable positive and negative implications and impacts of the research.
2. The duty of researchers to inform communities continues after approval has been obtained. Ongoing projects should be explained in terms understandable to the local community.
 3. Researchers should consult with and, where applicable, include northern communities in project planning and implementation. Reasonable opportunities should be provided for the communities to express their interests and to participate in the research.
 4. Research results should be explained in nontechnical terms and, where feasible, should be communicated by means of study materials that can be used by local teachers or displays that can be shown in local community centers or museums.
 5. Copies of research reports, data descriptions, and other relevant materials should be provided to the local community. Special efforts must be made to communicate results that are responsive to local concerns.
 6. Subject to the requirements for anonymity, publications should always refer to the informed consent of participants and give credit to those contributing to the research project.

7. The researcher must respect local cultural traditions, languages, and values. The researcher should, where practicable, incorporate the following elements in the research design:
 - a. Use of local and traditional knowledge and experience.
 - b. Use of the languages of the local people.
 - c. Translation of research results, particularly those of local concern, into the languages of the people affected by the research.
8. When possible, research projects should anticipate and provide meaningful experience and training for young people.
9. In cases where individuals or groups provide information of a confidential nature, their anonymity must be guaranteed in both the original use of data and in its deposition for future use.
10. Research on humans should only be undertaken in a manner that respects their privacy and dignity:
 - a. Research subjects must remain anonymous unless they have agreed to be identified. If anonymity cannot be guaranteed, the subjects must be informed of the possible consequences of becoming involved in the research.
 - b. In cases where individuals or groups provide information of a confidential or personal nature, this confidentiality must be guaranteed in both the original use of data and in its deposition for future use.
 - c. The rights of children must be respected. All research involving children must be fully justified in terms of goals and objectives and never undertaken without the consent of the children and their parents or legal guardians.
 - d. Participation of subjects, including the use of photography in research, should always be based on informed consent.
 - e. The use and disposition of human tissue samples should always be based on the informed consent of the subjects or next of kin.
11. The researcher is accountable for all project decisions that affect the community, including decisions made by subordinates.
12. All relevant Federal, State, and local regulations and policies pertaining to cultural, environmental, and health protection must be strictly observed.

13. Sacred sites, cultural materials, and cultural property cannot be disturbed or removed without community and/or individual consent and in accordance with Federal and State laws and regulations.

In implementing these principles, researchers may find additional guidance in the publications listed below. In addition, a number of Alaska Native and municipal organizations can be contacted for general information, obtaining informed consent, and matters relating to research proposals and coordination with Native and local interests. A separate list is available from NSF's Office of Polar Programs.

Publications

- Arctic Social Science: An Agenda for Action.* National Academy of Sciences, Washington, D.C., 1989.
- Draft Principles for an Arctic Policy.* Inuit Circumpolar Conference, Kotzebue, 1986.
- Ethics.* Social Sciences and Humanities Research Council of Canada, Ottawa, 1977.
- Nordic Statement of Principles and Priorities in Arctic Research.* Center for Arctic Cultural Research, Umea, Sweden, 1989.
- Policy on Research Ethics.* Alaska Department of Fish and Game, Juneau, 1984.
- Principles of Professional Responsibility.* Council of the American Anthropological Association, Washington, D.C., 1971, rev. 1989.
- The Ethical Principles for the Conduct of Research in the North.* The Canadian Universities for Northern Studies, Ottawa, 1982.
- The National Arctic Health Science Policy.* American Public Health Association, Washington, D.C., 1984.
- Protocol for Centers for Disease Control/Indian Health Service Serum Bank.* Prepared by Arctic Investigations Program (CDC) and Alaska Area Native Health Service, 1990. (Available through Alaska Area Native Health Service, 255 Gambell Street, Anchorage, AK 99501.)
- Indian Health Manual.* Indian Health Service, U.S. Public Health Service, Rockville, Maryland, 1987.
- Human Experimentation.* Code of Ethics of the World Medical Association (Declaration of Helsinki). Published in *British Medical Journal*, 2:177, 1964.
- Protection of Human Subjects.* Code of Federal Regulations 45 CFR 46, 1974, rev. 1983.

Appendix G: Acknowledgments

The following acknowledges the principal individuals responsible for this revision of the U.S. Arctic Research Plan.

The principal Federal agency contributors to this revision of the U.S. Arctic Research Plan were Charles E. Myers, Head, Interagency Arctic Staff, Office of Polar Programs, National Science Foundation; Sarah Brandel and Ann Gordon, Department of State; John Stubstad and David Cate, Department of Defense; Luis Tupas, U.S. Department of Agriculture; Igor Krupnik, Smithsonian Institution; James Devine, U.S. Geological Survey; John Calder and Kathy Crane, National Oceanic and Atmospheric Administration; Regina Farr, U.S.

Department of Transportation; Wanda Ferrell and Sylvia Edgerton, Department of Energy; Waleed Abdalati, National Aeronautics and Space Administration; Douglas Steele, Environmental Protection Agency; Jon Berkson and CDR Thomas Wojahn, U.S. Coast Guard; Philip S. Chen, Jr., and Natalie Tomitch, National Institutes of Health; and John Haugh, Bureau of Land Management, Department of the Interior.

Section 2.3 was prepared in part by George L. Hunt, Jr., University of California, Irvine, and is based in part on the reports of the workshops identified in Section 2.3 on Bering Sea research.

Report of Meeting

Interagency Arctic Research Policy Committee

March 1, 2005

Committee Members and Agency Representatives Present: Arden L. Bement, Jr. (Chair), Karl Erb, Charles E. Myers, Thomas Pyle, Scott Borg, and Neil Swanberg, National Science Foundation; George Newton, Jr. (ARC Chair) and Garrett Brass, Arctic Research Commission; John Stubstad, Department of Defense; Sylvia Edgerton and Jerry Elwood, Department of Energy; Natalie Tomitch and Peter Hartsock, Department of Health and Human Services; James Tate and Patrick Leahy, Department of the Interior; Ann Gordon, Department of State; John Berkson, Captain Dennis Holland, and Rear Admiral James Underwood, Department of Homeland Security, U.S. Coast Guard; Jeff Morris and Greg Susanke, Environmental Protection Agency; Waleed Abdalti and Mary Cleave, National Aeronautics and Space Administration; John Calder, Kathleen Crane, and James Mahoney, National Oceanic and Atmospheric Administration; David Trinkle, Office of Management and Budget; Kathy Olsen, Office of Science Technology Policy; David Evans and Igor Krupnik, Smithsonian Institution; Daniel Kugler and Luis Tupas, Depart-

Dr. Arden Bement, Jr., IARPC Chair and Director of the National Science Foundation, convened the meeting at the National Science Foundation in Arlington, Virginia.

National and International Framework for the International Polar Year (IPY)

Dr. Bement introduced Dr. Robin Bell, Columbia University, and Chair of the Polar Research Board, to provide an update on the national and international framework for IPY planning. Dr. Bell reported that the International Council for Science (ICSU) and the World Meteorological Organization (WMO) now officially jointly sponsor International Polar Year activities. U.S. members of an international Joint Committee are Dr. Bell and Dr. Igor Krupnik, Smithsonian Institution.

Dr. Bell discussed the agenda for the next IPY Joint Committee meeting, which includes extensive review of planning activities, review of the IPY Expression of Intent submissions, and development of full proposals.

Dr. Bell reported that 866 Expressions of Intent for IPY activities had been received. The highest percentage (21%) was from the U.S., and 34 other nations are participating. Geographically, the breakdown includes 159 activities proposed for the Antarctic, 483 for the Arctic, 136 bi-polar activities, and 88 non-specific but polar. Dr. Bell also reported on the initial responses by discipline. The Joint Committee is now working to group the Expressions of Intent into programs. A Consultative Forum will provide an opportunity to discuss the next steps and coordination between groups. Updates from the national committees and a discussion of logistics, data, education, and linking activities will be addressed. Full proposals will be requested by June 2005.

The U.S. National Committee is chaired by Dr. Mary Albert. It is a subcommittee of the PRB. It is

serving as a data and information clearinghouse and a coordination point.

The challenge Dr. Bell posed to the IARPC is to help leverage a leading U.S. role in forming the IPY programs, to aid in developing creative partnerships nationally and internationally, and to identify opportunities.

The IARPC members discussed the organization of the projects. The role of the Secretariat was also noted. The Secretariat will select a director for the IPY office, establish IPY web sites, develop the IPY logo, and perform WMO "project office" activities. In the future, the primary role of this office may be to coordinate and facilitate meetings.

Report on Study of Environmental Arctic Change (SEARCH) and International Study of Arctic Change (ISAC) – An Arctic IPY Activity

Dr. Bement introduced the Study of Environmental Arctic Change (SEARCH) interagency program, an Arctic IPY activity, and welcomed Dr. Peter Schlosser, Columbia University, Chair of the Science Steering Committee for SEARCH.

Dr. Schlosser described the SEARCH program as a system-scale, cross-disciplinary, long-term Arctic research program. The Arctic has been characterized in recent decades by a complex of interrelated, pan-Arctic changes occurring across terrestrial, oceanic, atmospheric, and human systems. Observed physical changes have large impacts on Arctic ecosystems and society. SEARCH is interested in the human dimension of change and issues related to local infrastructure, transportation, subsistence activities, coastal erosion, storm patterns, shipping routes, and fisheries.

The overall objective of SEARCH is to understand the nature, extent, and future development of the complex system-scale change presently seen in the Arctic. To meet the main objective, this requires:

- Determining if such changes have happened before;

ment of Agriculture;
Regina Farr and Richard
Voelker, Department of
Transportation.

Guests:

William Colglazier,
National Academy of
Sciences; Peter Schlosser,
Columbia University;
Robin Bell and Chris
Elfring, Polar
Research Board.

- Understanding the evolution of the changes;
- Understanding the forcing mechanisms and feedbacks that control the changes; and
- Understanding the interaction between changes.

The overall SEARCH Strategy, which includes the science plan and implementation strategy, is at <http://psc.apl.washington.edu/search/index.html> and at <http://www.arcus.org/search/meetings/2005/siw/index.php>.

The SEARCH organization includes a Science Steering Committee and an Interagency Program Management Committee. Established components of SEARCH include:

- Arctic/Subarctic Ocean Fluxes (ASOF)
- Bering Ecosystem Study (BEST)
- Freshwater Initiative (FWI).

Dr. Schlosser gave an update on the implementation status for the SEARCH program. The implementation strategy has been published and initial dedicated funding is in place from several U.S. agencies including NSF, NOAA, and NASA. About 43 SEARCH core projects have been funded (20 NSF, 12 NOAA, and 11 NASA). Panels and working groups will meet in May 2005 to write an implementation plan.

Dr. Schlosser briefly reviewed the history of the International Study of Arctic Change (ISAC) program. The ISAC was formed to support the large interest in SEARCH in the international community and to help carry out the SEARCH scope, which is significantly larger than the capability of any one nation to do alone. The Arctic Ocean Science Board (AOSB) and the International Arctic Science Committee (IASC) jointly sponsor ISAC. SEARCH will become a national program under the umbrella of ISAC.

Dr. Schlosser said that IPY would benefit from existing and planned SEARCH and ISAC activities in the fields of Arctic environmental change and

system-scale Arctic observing systems. SEARCH/ISAC can contribute significantly to IPY themes, and IPY could provide platforms for implementation of integrated studies on the international level.

In summary, Dr. Schlosser said the SEARCH science is firmly established, implementation is accelerating, and ISAC planning is well underway. SEARCH and ISAC will provide the structure for long-term science programs that will deliver the knowledge base required for impact assessments.

Potential Agency IPY Activities

Dr. Arden Bement requested the representatives at the IARPC meeting to provide a brief summary of their agency's planning activities. (The complete report of agency IPY planning activities is at Section 2.1, page 11 of this journal).

Comments from the Arctic Research Commission

George Newton, Jr., Arctic Research Commission (ARC) Chair, summarized the Commission's new initiatives. Most recently the ARC has focused on developing more support for SEARCH and for resource assessments in the Department of the Interior.

Mr. Newton noted that the Commission approved four resolutions at their January 2005 meeting:

- The U.S. should have an Arctic ambassador to represent the government at international meetings.
- U.S. Arctic policy should be updated.
- The Commission supports a review of U.S. icebreakers, not just from a research perspective, but as icebreakers also impact issues of homeland security, drug interdiction, and search and rescue.
- The Commission supports enhancing the role of SEARCH in the President's Climate Change Program.

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The following individuals are the principal staff representatives for the Interagency Arctic Research Policy Committee. Additional staff support is provided by the Federal agencies for specific activities through working groups, as necessary.

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