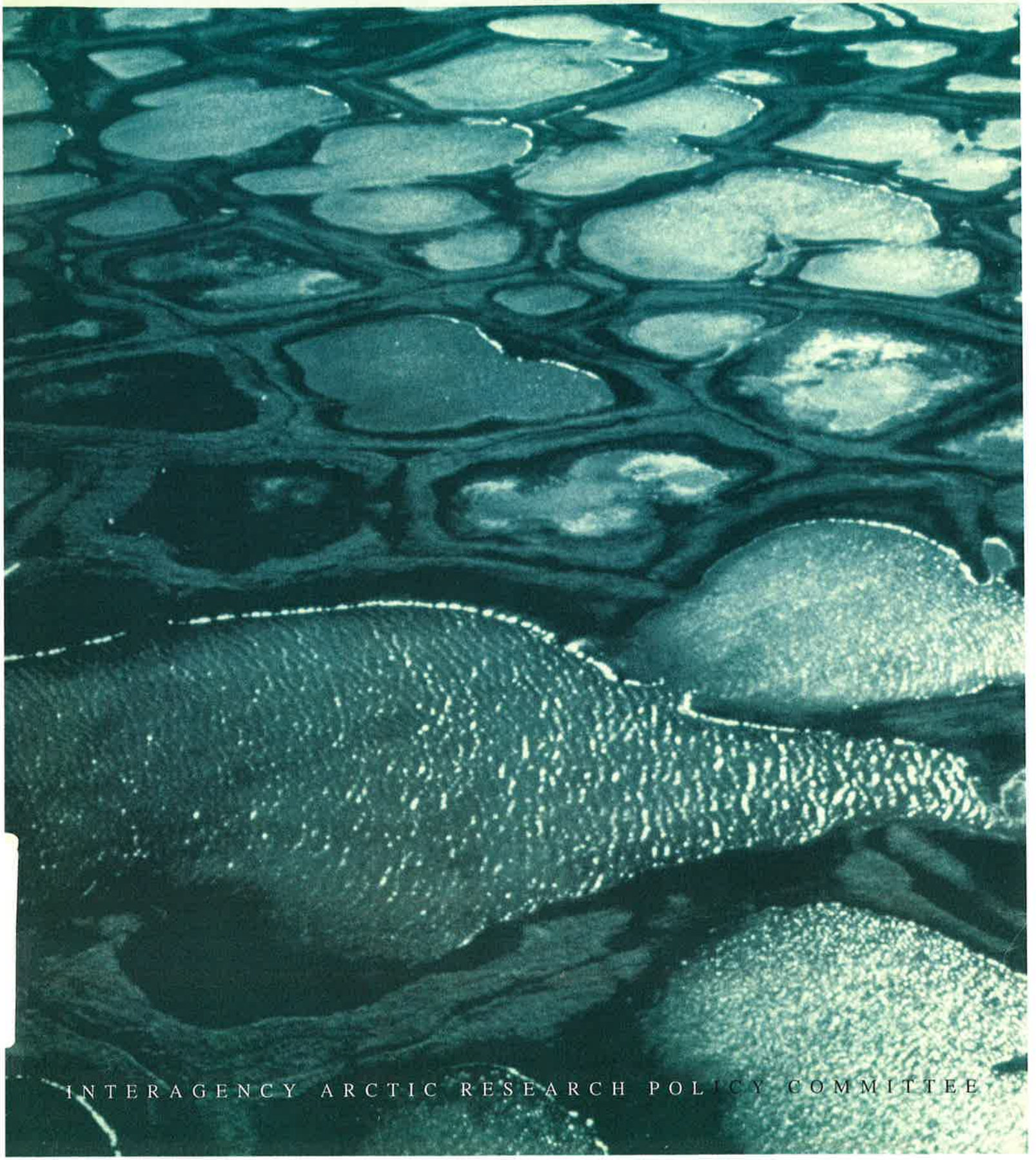
VOLUME 9 SPRING 1995

ARCTIC RESEARCH

OF THE UNITED STATES



INTERAGENCY ARCTIC RESEARCH POLICY COMMITTEE

About the Journal

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

Arctic Research contains

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

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

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

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

Address correspondence to Editor, *Arctic Research*, Arctic Research & Policy Staff, Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington VA 22230.

Cover

Patterned ground features in the National Petroleum Reserve, northern Alaska. (Photo courtesy of Dan Gullickson, BLM.)

VOLUME 9 SPRING 1995

ARCTIC RESEARCH

OF THE UNITED STATES

U.S. Arctic Research Plan
Biennial Revision: 1996–2000

United States Arctic Research Plan

Biennial Revision: 1996–2000

Executive Summary

Background

The United States has a substantial economic, strategic and environmental stake in the Arctic. As required by the Arctic Research and Policy Act of 1984 (Public Law 98-373),* a comprehensive Arctic Research Plan was prepared by the Interagency Arctic Research Policy Committee and submitted to the President, who transmitted it to Congress in 1987. Section 109(a) of the Act requires a biennial revision to the Plan. The first, second and third revisions were submitted in 1989, 1991 and 1993. This document, the fourth biennial revision to the Arctic Research Plan, updates the previous four documents and elaborates on 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 (announced by the U.S. Department of State, September 1994), research goals and objectives agreed upon by the Interagency Committee, and guidance provided by the Arctic Research Commission.

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 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 local, regional and global environmental issues; and
- Meeting post-Cold War national security and defense needs.

The Arctic Research and Policy Act requires cooperation among agencies of the U.S. Government having 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, under the chairmanship of the Director of the National Science Foundation (NSF), continues to provide the mechanism for developing and coordinating U.S. Arctic research activities.

Revision to the Plan

This fourth revision to the United States Arctic Research Plan includes two major sections. The first of these presents the Integrated Interagency Research Plans. For this biennial revision of the plan, agencies agreed that the following four programs are ready for immediate attention as multiagency focused efforts:

- Arctic Contamination Research and Assessment;
- Surface Heat Budget of the Arctic Ocean;
- Beringian Systems Program; and
- Arctic Data and Information.

The second major section is the Agency Programs, which represent the objectives of Federal agencies, focusing on the period covered by this revision (1996–2000). They are presented in six 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 and 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, submarines and ice platforms; land-based and atmospheric facilities and platforms; coordination; and data facilities.

Budgetary Considerations

Appendix C presents a summary of each agency's funding for the 1994–1996 period. The total interagency Arctic budget estimate for FY 95 is $174.9 million; for FY 96 it is $169.6 million.

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

1. Introduction

Public Law 98-373, 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.

The United States has a substantial economic, strategic, and environmental stake in the Arctic. The Arctic is defined by ARPA to include "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, Chukchi Seas; and the Aleutian chain." Non-U.S. Arctic marginal seas are the Barents, East Siberian, Greenland, Norwegian, Kara, White and Laptev Seas and Baffin Bay. The marginal seas, including the Bering and Chukchi, contain abundant marine organisms (including some of the richest commercial fisheries in the world) and support sensitive food chains and ecosystems.

Our recognition of the value of the Arctic has matured dramatically in recent years. We now appreciate more fully its economic and strategic significance to our nation. More than 50% of the U.S. continental shelf and coastline lies within Alaska, with much of it in the Arctic.

The Arctic shelves contain some of the richest commercial fisheries in the world, as well as large populations of birds and marine mammals. Contaminant accumulation in the food chain may have a direct impact on the global human population. For example, the U.S. pollock fishery in the Gulf of Alaska and Bering Sea is estimated to be a $2 billion industry, yet there is insufficient information about contaminants in the Bering Sea ecosystem for the long-range planning necessary to assure that this fishery and others will remain free of influence from Arctic contaminants.

Increased resource development and use of the Arctic Ocean as a transportation corridor present additional risks to the Arctic environment. A better understanding of Arctic systems, including biological, atmospheric, oceanic, ice and sediment-transport dynamics, is necessary to effectively respond to catastrophic events. Expanded safety and environmental protection measures and services must be preceded by baseline research activity and impact modeling to identify appropriate service and response levels.

As required by the Arctic Research and Policy Act of 1984 (Public Law 98-373),* a comprehensive Arctic Research Plan was prepared by the Interagency Arctic Research Policy Committee (IARPC 1987) and submitted to the President, who transmitted it to Congress in July 1987. Section 109(a) of the Act requires a biennial revision to the Plan. The first, second and third revisions were submitted in 1989, 1991 and 1993. This document, the fourth biennial revision to the Arctic Research Plan, updates the previous four documents and elaborates on requirements of Section 109(a) (see Appendix D).

The 1987 Plan presented a detailed agenda for United States Arctic research and was the result of an extensive process of planning, consultation and revision. The biennial revisions build on the published Plan. In addition to the individual agency research activities (described in Section 3), this revision presents several integrated, interagency research programs (Section 2). These cooperative efforts were initiated in the 1992-93 period and will continue into 1996 and beyond. Each represents ongoing or planned programs of more than three Federal departments and has direct relation to economic, social and international developments in the Arctic and scientific questions related to regional and global processes.

This revision to the Plan was provided for review to all the groups identified in the Act (the Arctic Research Commission, the State of Alaska, residents of the Arctic, the private sector and public interest groups), as well as the participating Federal agencies, the Polar Research Board of the U.S. National Academy of Sciences, and individual scientists and engineers.

1.1 National Needs, Goals and Objectives

United States research in the Arctic and this biennial revision are governed by U.S. national policy on the Arctic (announced by the U.S. Department of State, September 1994), research goals and objectives agreed upon by the Interagency Committee, and guidance provided by the Arctic Research Commission.

National Needs and Problems

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 biological resources;
- Assuring that natural resource management and economic development in the region are environmentally sustainable;

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

- 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 local, regional and global environmental issues; and
- Meeting post-Cold War national security and defense needs.

Where appropriate this research should be coordinated with the efforts of state and local government and the private sector. The research should be carried out in a manner that benefits from and contributes to international cooperation. Arctic research policy is subject to periodic review and revision.

U.S. Goals and Objectives in Arctic Research

Arctic research shall be aimed at resolving scientific 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 a natural laboratory, 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 programs;
- 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 in the Arctic and determine their significance;
- 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 use of wildlife and how this relationship might be affected by global climate change and transported contaminants;
- Include Arctic residents in planning and conducting the research and report results to these individuals and their communities;
- 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;
- 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.

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

Agency	*FY 94 Budget*	*FY 95 Estimate*	*FY 96 Proposed*
DOD	35,226	33,653	23,183
DOI	37,984	32,677	33,885
NSF	40,484	40,500	46,500
NASA	47,460	40,520	38,970
NOAA	10,336	10,470	10,396
DOE	2,170	1,970	1,970
DHHS	6,439	6,749	6,838
SI	705	550	675
DOT	3,456	2,664	2,164
EPA	1,200	407	250
DA	5,020	4,218	4,218
DOS	700	550	550
Total	191,180	174,928	169,599

* Capital facilities are not included in these estimates.

1.2 Budgetary Considerations

The Act does not provide separate additional funding for Arctic research. Agencies are expected to request and justify funds for these activities as part of the normal budget process. It was anticipated in the 1987 Plan (p. 17) that agencies would provide levels of funding consistent with the Plan's recommendations and existing programs. Table 1 presents a summary of each agency's funding for the 1994–1996 period. The total interagency Arctic budget estimate for FY 95 is $174.9 million; for FY 96 it is $169.6 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 96. Program descriptions may be assumed to reflect the general direction of agency programs.

1.3 Interagency Coordination

The Arctic Research and Policy Act (Appendix D) requires cooperation among agencies of the U.S. Government having 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, under the chairmanship of the Director of the National Science Foundation (NSF), continues to provide the mechanism for developing 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 in implementing recommendations has been made 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 8, Fall 1994), published by NSF on behalf of the IARPC.

The Act mandates a requirement for implementing a coordinated U.S. Arctic research program. 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 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. The Working Group on Arctic Ocean/Atmosphere has developed specific program strategies, as has the Social Science Task Force. A data and information group and a logistics and operational support group are pursuing a number of interagency activities. These are reported in the subsequent sections. The Environmental Monitoring and Assessment Working Group prepared the Arctic contamination research and assessment plan (see Section 2, p. 9).

Many interagency agreements and planning and coordinating activities already exist. Coordination with global change programs is an integral part of Arctic program development and implementation. Improved communication at all levels through existing newsletters and journals is encouraged.

1.4 International Collaboration

A new U.S. Arctic policy, announced on September 29, 1994, has helped sustain the momentum of Arctic international cooperative programs (see Appendix G). Responsive to the increasing economic, environmental and international significance of Arctic issues, U.S. policy recognizes that cooperation among Arctic nations, including coordination of priorities, can make essential contributions to research in the region.

The policy highlights six principal objectives:

- 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 local, regional and global environmental issues; and
- Meeting post-Cold War national security and defense needs.

In implementing the Arctic policy, the United States plans to:

- Expand cooperation under the Arctic Environmental Protection Strategy and international organizations to improve protection of the environment while providing for environmentally sustainable development;
- Further scientific research through development of an integrated national Arctic research program;
- Improve efforts to conserve Arctic wildlife and protect habitat, with particular attention to polar bears, walruses, seals, caribou, migratory birds and boreal forests;
- Strengthen international cooperation for preparing for and responding to environmental disasters;
- Support international cooperation in monitoring and assessment and environmental research;

- Involve the State of Alaska more directly in the Arctic policy process;
- Support participation by Alaska's indigenous people in Arctic policy deliberations affecting their environment, culture and quality of life; and
- Improve overall international cooperation, especially U.S.–Russian Arctic environmental cooperation.

Arctic Environmental Protection Strategy

Beginning in 1989, the eight Arctic countries—the United States, Canada, Denmark, Finland, Iceland, Norway, Russia and Sweden—began discussions on improving Arctic cooperation. In 1991, in Rovaniemi, Finland, they reached agreement on the Arctic Environmental Protection Strategy (AEPS). AEPS is the major international forum for international Arctic cooperation, and the U.S. has been active in all AEPS working groups and will be a key player in the 1996 Ministerial meeting when the groups present findings and recommendations. The Strategy comprises principles, objectives and an action plan, with the following implementing working groups:

- *Arctic Monitoring and Assessment Program (AMAP)*: AMAP is assessing the health and ecological risks associated with contamination from radioactive waste, heavy metals, persistent organics and other contaminants, some of which originate many miles away from the Arctic region.
- *Conservation of Arctic Flora and Fauna (CAFF)*: CAFF is studying the adequacy of habitat protection and considering ways to strengthen wildlife protection, possibly through an international network of protected areas, more effective laws and conservation practices.
- *Emergency Prevention, Preparedness and Response (EPPR)*: EPPR addresses the problems of man-made disasters. The group has focused recently on risk assessments, dealing with nuclear disasters and rapid response to oil spills.
- *Protection of the Arctic Marine Environment (PAME)*: PAME is studying national and international legislation to determine how these laws can be strengthened to further protect the Arctic marine environment. PAME is examining a range of sources and contaminants, including offshore oil and gas development, ocean dumping of radioactive wastes and other matter and land-based sources of pollution.

In addition, a new task force was established at the September 1993 Ministerial meeting, in Nuuk, Greenland, to broaden the Strategy by investigating sustainable development issues.

Conservation

The United States cooperates with other Arctic nations to conserve the region's rich and unique biological resources and is engaged in a cooperative review of existing Arctic wildlife reserves, including relevant U.S. reserves in Alaska. This review includes examining with Canada whether existing reserves and reserve management policies in our two countries adequately protect the habitat of the Porcupine River caribou herd.

The United States is working with other Arctic nations to strengthen conservation of polar bears, seals and walruses. Consistent with the Agreement on the Conservation of Polar Bears, we are discussing means of improved conservation of polar bear populations whose range extends to both Russia and the United States. The United States is also exploring options to better implement measures, including the 1916 Migratory Bird Treaty, to conserve populations of migratory species of birds that breed in the Arctic.

Environmental Safeguards

The United States is working with other Arctic nations to protect the marine environment from pollution from land-based and offshore development activities and from potentially increased use of the Arctic Ocean as a shipping corridor. The U.S. is also reviewing the adequacy of current U.S. emergency response measures and will urge other Arctic nations to adopt marine environmental safeguards no less stringent than our own.

Sustainable Development and Environmental Assessment

The Nuuk Ministerial meeting produced a Declaration on Environment and Development in the Arctic and established a Task Force on Arctic Sustainable Development. The Declaration stressed the importance of the United Nations Conference on Environment and Development to the Arctic and reaffirmed the Ministers' commitment to conserve, protect and, as appropriate, restore the ecosystems of the Arctic. Federal agencies are reviewing environmental assessment procedures to assure that development planning takes into account cyclical economic impacts, social impacts on indigenous people and long-term environmental impacts. At the Senior Arctic Officials Meeting in Iqaluit in March 1995, the United States urged all other Arctic nations to adopt and implement transparent domestic procedures for environmental

assessment that assure that development planning addresses the full range of economic, social and environmental impacts from national government projects that affect the Arctic.

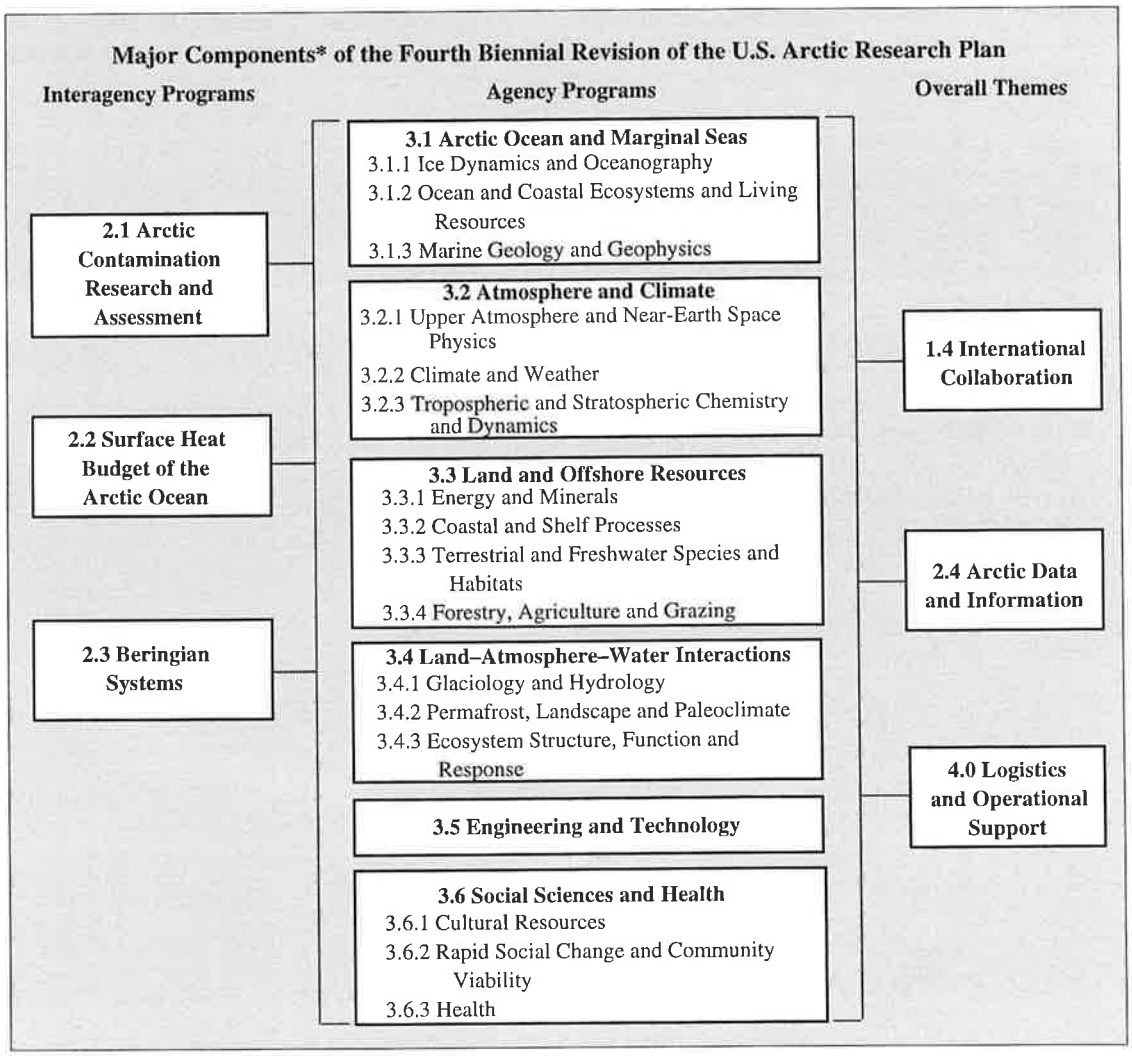
Arctic Council

Meeting the expanded need for environmental cooperation in the Arctic will require strengthened international institutions. To advance this goal, the United States announced at the Ottawa Summit of February 1995 it would join Canada in efforts to organize an Arctic Council comprising the governments of the eight Arctic nations. The United States views formation of the Arctic Council as a useful step in the creation of a formal policy forum through which Arctic nations can oversee implementation of the AEPS, as well as address issues such as sustainable development, health, communication and transportation. Formation of an Arctic Council will also be an important step toward greater involvement of the region's indigenous peoples in decisions that affect them. Representatives of indigenous groups will receive permanent participant status to ensure meaningful involvement in the proceedings of the Arctic Council.

Cooperation with Russia

The end of the Cold War has had significant influence upon U.S. Arctic policy, and the new atmosphere has created opportunities for enhanced cooperation on Arctic issues. Russia, in the throes of transition to a market-based economy, faces major challenges in dealing with problems of pollution and species conservation that have impacts on the Arctic region. Russia has substantial scientific expertise but limited economic resources. Within the limit of budgeted assistance, the United States is now considering Arctic environmental issues in formulating initiatives for assisting Russia.

In September 1994 the U.S. and Russia agreed to improve the Murmansk radioactive waste pro-



* Numbers refer to descriptions of components within the Plan.

cessing facility, and in December 1994 a bilateral agreement on Arctic contaminants was signed in Moscow. The Agreement on Cooperation in the Prevention of Pollution in the Arctic is considerably broader than the initial draft, as it includes all Arctic contaminants, rather than simply radionuclides as first suggested. Assistant EPA Administrator Nitze called the agreement a foundation for sustainable management of the Arctic's natural resources and said the agreement will help us understand the environmental problems that threaten Native people on both sides of the Bering Strait. He noted that U.S.–Norwegian and Russian cooperation on the processing and storing of low-level radioactive wastewater in Murmansk was a vital part of the new Arctic agenda. Nitze also reported that the U.S. National Park Service has offered to host a meeting in Alaska to advance the proposed Beringia Heritage International Park. Vice President Gore and Prime Minister Chernomyrdin signed the Arctic Agreement on December 16, 1994.

The Komi oil spill demonstrates that major threats to the Arctic remain. However, the Arctic also presents real opportunities for U.S. leadership.

1.5 Revision to the Plan

This fourth revision to the 1987 United States Arctic Research Plan includes two major sections:

- Section 2. Integrated Interagency Research Plans; and
- Section 3. Agency Programs.

The Agency Programs represent the objectives of Federal agencies, focusing on the period covered by this revision (1996–2000). They are presented in six major categories, and where common activities exist they are presented as collective activities. Individual agency mission accomplishments were discussed in the Fall 1994 issue of *Arctic Research of the United States* and will be updated in 1996. The complementarity of the interagency programs and the agency programs is shown in the figure on p.7. 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. Integrated Interagency Research Plans

In 1990 the Interagency Committee agreed on the following policy:

> 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, starting in 1992, an integrated interagency program sufficient for meeting national needs.

Subsequently the IARPC agencies examined Arctic research from an interagency perspective. For this biennial revision of the plan, agencies agreed that the following four programs are ready for immediate attention as multiagency focused efforts:

- Arctic Contamination Research and Assessment;
- Surface Heat Budget of the Arctic Ocean (SHEBA);
- Arctic Data and Information; and
- Bering Systems Studies.

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 explosive 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 its effects;
- International cooperation in a strategic region;
- Forecasts of weather, ice and ocean conditions;
- Protection of the Arctic environment;
- Understanding of causes, effects and limits of air and water pollution; and
- Protection and understanding of cultures and cultural resources.

The role of the Arctic in meeting national needs and addressing key policy issues is further highlighted below.

Nonrenewable Resources

The U.S. imports approximately 50% of its hydrocarbon needs. Twenty-five percent of our domestic production comes via the Trans-Alaska Pipeline System from Prudhoe Bay, Alaska. The best estimates are that at least 20% of the Nation's future reserves lie on the northern Alaskan coastal plain and adjacent continental shelf. Also, 12% of the Nation's gas reserves lie in the same region, and there are plans for a gas pipeline to transport this resource south. Gas hydrate reserves have been estimated to range from 10^{11} to 10^{14} cubic meters in Alaska and its offshore region. In addition to oil and gas, the Arctic has tremendous coal and peat resources. The U.S. Arctic has been estimated to contain about as much coal as the remainder of the U.S. However, U.S. Arctic coal production will be limited until the energy needs of Alaska grow substantially or the 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 60% of the U.S. zinc output. The Arctic shelves also contain mineral deposits. At least one offshore tin placer 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.

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 fishermen 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. In 1989, Alaska pollock, with landings of 1.1 million metric tons, was the most important U.S. fish in quantity, amounting to 28% of the U.S. commercial landings. This amount is an 88% increase over U.S. landings in 1988 and more than a five-fold increase over the 1984–1988 five-year average. Dutch Harbor–Unalaska, Alaska, was 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.

Dramatic and unexplained fluctuations have occurred in the catch of groundfish and shellfish and the stocks of marine mammals. There is considerable concern that the walleye pollock population will "crash" as others have in the past. Managing for sustainable yields requires further research.

The impact on the coastal economy of Alaska and other northwestern U.S. states is magnified by substantial capitalization in vessels, port facilities and processing plants and related income to a broad sector of the economy. A sustainable, predictable fishery stock is fundamental to the viability of this sector of the U.S. economy. Research on Arctic marine ecosystems is essential for understanding and managing their resources.

Global Change

High latitudes may experience the earliest unambiguous onset of global warming if an enhanced "greenhouse effect" occurs on Earth. Global climate models suggest that the amount of warming may be significantly greater in northern high-latitude regions than in lower latitudes, but the models do not agree on the amount of warming to be expected at high latitudes.

Furthermore, there is growing evidence that the polar regions play a key role in the physical processes responsible for global climate fluctuations and in some circumstances may be a prime agent of such fluctuations. For example, North Atlantic deep water formation may be affected by a delicate balancing in the amount of fresh water that is exported from the Arctic Basin and that flows from the East Greenland Current into the region of deep vertical convection in the North Atlantic. Heat flux through the variable ice cover of the Arctic Ocean may have a profound effect on the surface heat budget and the global climate.

Arctic biological processes can also affect global processes and result in positive feedback on CO_2 increase and warming. Active ecosystems have been shown to have recently shifted from long-term CO_2 sinks to CO_2 sources to the atmosphere. Modeling scales indicate that a shift in vegetation from tundra to trees could have significant effects on regional climate.

High-latitude warming may disturb the equilibrium of Arctic ice masses and hence global sea levels. Such events are preserved in the geologic record, and polar regions are a natural repository of information about past climatic fluctuations. Arctic regions display significant ozone decreases. These are expected to increase over the next decade, as atmospheric chlorine and bromine reach high levels because of previous releases. Their causes and implications will continue to be a subject of research. Additional data may shed light on the causes and effects of both catastrophic and evolutionary global change. Arctic research provides a critical component of virtually every science element in the U.S. Global Change Research Program.

Social and Environmental Issues

Arctic culture is part of, and highly dependent on, terrestrial and marine ecosystems. Northern indigenous communities, numbering over 100 in the Alaskan Arctic with a total population of 50,000, are supported partially by hunting, trapping and fishing. Evidence shows increased exposure in these communities to contaminants from lower latitudes. Much of the population of the Arctic is dependent on the health of the region's ecosystems. Samples of fish tissue and sediments thus far do not show contamination levels as high as in seriously contaminated urban areas in the lower 48 states, but they are not as uncontaminated as might have been expected.

Recent studies have found that concentrations of carbon dioxide and methane in Arctic haze layers are elevated with respect to background levels. Concentrations of these two gases are correlated, suggesting a common anthropogenic source (fossil fuel combustion) and subsequent transport into the Arctic. Soot carbon has been traced for thousands of kilometers across the Arctic, where it remains suspended in a dry, stable atmosphere. Ozone depletion in the polar vortex has enormous health implications to the people of the entire Northern Hemisphere.

Opportunities for Arctic Research in the 1990s

Remote Sensing

High-latitude satellite coverage and related data processing will reach a new level of capability in the 1990s. Advanced Very High Resolution Radiometer (AVHRR) data from the NOAA polar-orbiting satellites are analyzed for polar sea ice mapping by the National Ice Center. Gridded microwave brightness temperatures from the Defense Meteorological Satellite Program (DMSP) satellites are being used to produce low-resolution (50 km) information on sea ice type and distribution, now available on CD-ROM through the National Snow and Ice Data Center (NSIDC). With the launch of ERS-1 (Europe) in 1991 and JERS-1 (Japan) in 1992, high-resolution (30 m) synthetic aperture radar (SAR) data have become available on a routine basis for research purposes. The radar imagery provides a greatly enhanced capability to detect leads and ridges, ice type and ice motion. In addition to SAR image data, the ERS-1 satellite also provides routine measurements of surface winds, wave spectra and surface topography.

Other satellite data that will be available in the near future include ocean color from SeaWiFS (U.S.) and ADEOS (Japan), surface topography from TOPEX/Poseidon (U.S. and France) and GEOSAT (U.S.), and low-resolution sea ice type and distribution from the Advanced Microwave Sounding Units on the NOAA-K, L and M satellites (U.S.). Operational SAR data will also be available from RADARSAT (Canada) beginning in 1995.

There has been, and will continue to be, substantial international cooperation in the polar-orbiting satellite programs of those nations with major space programs. Sharing of data from satellites of different nations makes possible systematic, regional satellite coverage of the Arctic to support major basin-wide investigations.

In-situ Sensing

Air–ice–ocean sampling is being revolutionized by emerging new technologies. Precision navigation from portable, low-power receivers will soon be possible continuously from the satellite-based Global Positioning System now being deployed. A number of options for data telemetry are evolving, including specialized communication microsatellites, an ionospheric-path HF radio frequency with digital packet switching, and a ground-plane MF radio frequency over ice. Advances in low-power microprocessors and mass storage media (optical disk, digital audio tape, video tape) have provided a new generation of programmable, high-capacity data loggers for field experiments. Innovative sensors and signal processing techniques based on acoustic and optical propagation have opened up new dimensions in probing the structure of the atmosphere, ice and ocean. New materials and high-density energy sources have spawned a new generation of remote platforms such as buoys and autonomous undersea vehicles. Instruments based on such new technology will enable radically new adaptable and interactive observational strategies for process studies, as well as provide the means for long-term, real-time monitoring of primary variables at remote sites.

Fisheries Management

Bering Sea stocks cannot be fished indiscriminately without irreversible changes in the population structure and yield. Agreements between the Presidents of the U.S. and Russia reflect the heightened consciousness regarding the rich fishery, wildlife, mineral and heritage resources of the Bering Sea region.

Representatives of the State of Alaska have called for a study of the Bering Sea aimed at understanding the fishery dynamics and devising appropriate management options. The Arctic Research Commission has concurred with these concerns and has recommended a multiagency study of the Bering Sea as an ecosystem. The existence of long-term fishery and climatic records for this region also helps in investigating fluctuations. PICES is beginning its international activities.

Cultural Exchange

The June 1990 summit meeting reached a historic agreement on the feasibility of establishing a Russia–United States International Park in the region of the Bering Strait. This proposed park would preserve the unique natural, environmental and cultural heritage of the Bering Sea region of Alaska and Siberia.

Data

Common to all programs is the need for consistent data management among the Federal agencies. An Arctic Environmental Data Directory (AEDD), now operational as part of the USGS Earth Science Data Directory (ESDD), contains over 400 descriptions of data sets and sources pertaining to the Arctic. AEDD is linked with a comparable directory in Norway (UNEP/GRID-Arendal), with coverage of Nordic areas and parts of Russia, as the first step in a plan to provide descriptions of Arctic data from all nations in the circumpolar Arctic. The next step is to add a third compatible node in Russia for data in the Russian Arctic. The

distributed international Arctic Data Directory is used over the Internet as if all information about Arctic data were located at one site.

The National Snow and Ice Data Center (NSIDC) at the University of Colorado in Boulder has a long history of archiving cryospheric data and has recently produced several CD-ROM products of satellite and large-experiment data sets. Other national archives hold a variety of data sets.

A plan to integrate Arctic data archiving into an effective and coordinated activity will be developed and implemented over several years. A major Alaska-based bibliographic project (PolarPac) has produced a CD-ROM that includes listings of Federal agencies' Arctic reports. Both the data and the bibliographic activities will be a continuing effort to support U.S. participation in an international Arctic Monitoring and Assessment Program (see Section 2.4).

U.S.–Russia Collaboration

The ending of the Cold War and the opening of relations with the former Soviet Union offer an unprecedented opportunity to develop bilateral research programs on Arctic scientific issues of common concern to the U.S. and Russia. Several bilateral agreements already exist to promote cooperative efforts in the areas of environmental protection, oceans research, basic science, fisheries management and energy technology. A steady stream of Russian scientists and science officials have visited the U.S., offering plans and proposals for collaborative work. Proposals for specific projects with Federal agencies have resulted. Many agencies have taken the initiative to develop their own contacts and programs in Russia. Revelations about environmental contamination in the Russian Arctic and efforts to "rescue" scientific data from the former Soviet Union have been the principal motivations behind much of this activity.

Environmental Monitoring and Assessment

The increasing focus on efforts to monitor and assess the condition of ecosystems and clean up environmental contamination in the Arctic is creating opportunities for scientific and technical research in support of these activities. For example, development of improved monitoring and cleanup techniques and methods of sampling and analyzing for the presence of contaminants in Arctic ecosystems is accelerating.

Oil Pollution Control

Title V of the Oil Pollution Act of 1990 established the Prince William Sound Oil Spill Recovery Institute (OSRI), with broad interagency participation led by NOAA and including the Department of Interior, Department of Defense, Department of Transportation and Environmental Protection Agency. The State of Alaska is working to coordinate with OSRI's development of an Arctic–Subarctic oil spill research plan. The plan has $5 million in research support from the State of Alaska and authority to receive up to $23 million from an account to be established in the National Pollution Fund.

2.1 Arctic Contamination Research and Assessment Program

Introduction

For more than a decade, there has been a growing recognition that the remote and sparsely inhabited Arctic, rather than being an undisturbed, pristine environment, is actually a concentration area for globally generated contaminants and pollutants. One of the most visible examples is Arctic haze, the seasonal build-up of atmospheric pollution. The unique seasonal stability of the Arctic air mass responsible for Arctic haze also contributes to polar ozone depletion by transporting contaminants over the polar region and into North America. Had the Chernobyl nuclear reactor accident occurred only a few weeks earlier than it did, before the seasonally stable Arctic haze air mass had dissipated, dangerous levels of radioactive contaminants would have been concentrated over Alaska and northern Canada.

Arctic contaminants include persistent organic compounds, trace and heavy metals, radionuclides and chronic hydrocarbon contaminants. Many of these contaminants are transported through the marine environment, the atmosphere and rivers. The present and potential future impacts on human health, ecosystems and economic vitality from these contaminants are not known.

To provide the basis for informed policy decisions with respect to the possible risks of and responses to this contamination, there is an immediate need for a focused research and assessment program providing an integrated, comprehensive approach to understanding the complex issue of Arctic contamination. Components must be both short and long term and must include baseline characterization activities and monitoring of contaminant dispersal. Program elements must include data and information management, data rescue and data synthesis; observation; process-oriented research; model development; impact analysis; and determination of risk.

The IARPC's Arctic Contamination Research and Assessment Program is designed to fulfill these needs. This IARPC program represents an innovative, multidisciplinary approach for the United States to begin to systematically understand the complexities of Arctic contamination.

The program has been developed in response to an IARPC *Policy Statement on Arctic Contamination* and its *Agenda for Action*, the substance of U.S. policy in the Arctic (Appendix G) and the results of the IARPC Workshop on Arctic Contamination. The key Federal agencies are the Department of Energy (DOE), the Department of Interior (DOI), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF).

Contamination and the Arctic Environment

During the past two years, a number of independent sources, including a special Russian Federation Commission, the Yablokov Commission, established by Russian Federation President Boris Yeltsin, have reported and documented a multiyear, post-World-War-II history of dumping of nuclear and toxic waste materials by the former Soviet Union (FSU) into the Arctic Ocean, its marginal seas and many of the larger river systems of the adjacent land masses.

While the Yablokov Commission's disclosures were instrumental in bringing attention to the problems of Arctic radionuclide pollution, radionuclides are just one aspect of Arctic contamination. Other pollutants, including persistent organic compounds, trace and heavy metals and hydrocarbons, may also pose serious threats to Arctic ecosystems and populations. In addition to direct discharge, contaminants are transported to the North through streams and rivers, ocean currents and atmospheric circulation. The levels of contamination and the risks posed by them are not well documented and require investigation. Anticipated increases in maritime transportation, industrial development and exploitation of natural resources, possibly compounded by changes in the global climate, could further increase the threats to the Arctic ecosystem.

The Arctic contamination issue is far more complicated than just discharge of contaminants from the FSU. Internationally, resource development, mining and petroleum production have been long-term sources introducing contaminants into the Arctic. Among the contaminants accumulating in the Arctic are persistent organic compounds from North America, Asia and Europe, coal combustion products from Europe and Asia, and other types of contaminants, such as pesticides, with a global origin. Detectable quantities of radioactivity from nuclear plants at Sellafield, United Kingdom, and Cap La Hague, France, are found entering the Barents Sea from the west. Historical and ongoing introduction of contaminants also exists within the U.S. Arctic.

In Alaska alone the Defense Environmental Restoration Program identified more than 150 sites that require some level of environmental cleanup. Six sites are currently listed on the EPA National Priorities List (NPL). Two are classified as general Superfund sites and four as Federal Facility sites. A fifth Federal Facility site has also been proposed. Of the six identified NPL sites, four have received "immediate action," three sites endanger "sensitive environments," and five sites are located near residential areas.

A 1991–1992 State of Alaska survey of 254 rural Alaskan fuel storage facilities indicated that 70% have major deficiencies. These facilities account for the bulk of the average of 300,000 gallons spilled annually in Alaska. The estimated cost of upgrading these facilities is $200 million. An assessment of the scope of the contamination is scheduled for 1994.

The Yablokov Commission Report identified that the FSU dumped (in violation of international law), or lost in the marine environment, radionuclide materials totaling more than 2,500,000 curies of radioactivity. Most of this was in the Arctic. This quantity of dumped materials represents twice as much material than has been disposed of in the Atlantic and Pacific Oceans by all other nations combined. Included in this total are large volumes of liquid radioactive waste, sealed barrels of solid radioactive waste, fueled nuclear submarines and more than one dozen intact nuclear reactors. Solid fuel wastes, totaling another 10,000,000 curies of radioactivity, are now stored in Murmansk harbor awaiting the development of depository sites.

Other reports indicate that substantially larger quantities of radioactive and toxic waste products are stored in temporary impoundments or have been dumped into lakes and rivers that are tributaries to the Arctic Ocean, including the Ob, Lena and Yenisey Rivers. One example, Lake Karachi, a small lake in the southern Urals, may have received more than 100 million curies of plutonium waste. Some of these substances may have already been introduced into the Arctic Basin or may now be migrating towards the Arctic.

Nuclear reactor accidents, such as Chernobyl in 1984, Myak in 1957 and Tomsk in 1993, as well as a multiyear history of atmospheric, surface and subsurface nuclear weapons testing, especially in

the Novaya Zemlya region, have produced radioactive atmospheric fallout over much of the Arctic. The presence of other nuclear reactors throughout the Russian Federation and eastern Europe, similar in design to those of Chernobyl, poses a continuing threat with uncertain consequences.

In March 1993 the Russian Federation also identified the existence of radioactive waste dump sites in the northwesternmost Pacific Ocean. No information exists about the impact of these wastes on the adjacent Bering Sea.

In the United States, aside from the IARPC, activities of the Arctic Research Commission (ARC) and Senate Select Committee on Intelligence have directed national attention to the Arctic contamination issue. During August 1992, both met in Alaska and publicly evaluated unclassified accounts of "significant environmental pollution dumped by the FSU onto the tundra and directly into Arctic seas and rivers that flow into the Arctic Ocean." The results of their activities and those of the IARPC are responsible for the present level of U.S. knowledge about the past dumping practices of the FSU. The ARC determined by direct discussions with the Commission on Arctic Research of the Russian Academy of Sciences that Russian scientists are interested in and able to join assessment efforts to establish the dimensions of the pollution problem and risks to Arctic nations and people.

IARPC Involvement in Arctic Contamination

The IARPC, through its *Policy Statement on Arctic Contamination*, its *Agenda for Action* and its 1993 Workshop on Arctic Contamination has taken the lead U.S. role in clarifying the Arctic contamination issue. Using presently available, limited resources, the IARPC has begun to compile existing data and analyses concerning types and distribution of contaminants, as well as field studies to determine contaminant movement and distribution.

The IARPC policy statement adopted on August 27, 1992, raised concerns about "the extent of contamination of the Arctic area and the bordering seas by radioactive material and a variety of other hazardous substances." The statement specifically mentions "many reported instances of Former Soviet Union (FSU) disposal of radioactive and other toxic wastes directly into the Arctic Ocean and into aquatic and terrestrial Arctic and sub-Arctic sites." The IARPC *Agenda for Action* to implement the policy statement endorses actions including sponsoring of "one or more workshops to evaluate and assess the compilation of existing data and analyses and to recommend future actions toward an integrated assessment of Arctic contamination." A major international workshop sponsored by the IARPC, the IARPC Workshop on Arctic Contamination, was held in Anchorage, Alaska, in May 1993.

The IARPC's 1992 and 1993 activities have set the stage for the United States to respond to the question of Arctic contamination. However, an enhanced and integrated multiagency program is required to identify the status of contaminants and the risk to Alaska, its marginal seas, human health, ecosystems and U.S. fisheries.

IARPC Workshop on Arctic Contamination

From May 2 to 7, 1993, the IARPC conducted a Workshop on Arctic Contamination. In addition to radionuclide contamination, the workshop addressed heavy and trace metal contamination, persistent organic contamination and chronic hydrocarbon contamination. The workshop's purposes were to characterize the extent of Arctic contamination by evaluating and identifying sources of existing data and information about Arctic contamination, to identify major data gaps that need to be filled to complete a thorough analysis of the Arctic contamination question, and to begin the process of determining whether specific Arctic contaminants present a risk to the environment, ecosystems or human health in Alaska, the entire Arctic or the global environment.

The goal of the IARPC, and the ultimate purpose of the workshop, was to provide U.S. Government decision makers with a factual basis for formulating U.S. policy on Arctic contamination, in other words: 1) *To acquire the information needed to understand the issue of Arctic contamination* and 2) *To use this information for formulation of U.S. policy*. These remain key objectives of the IARPC Arctic Contamination Research and Assessment Program.

The workshop indicated that a dearth of credible scientific information exists upon which to make conclusions and policy. Significant workshop results include findings that:

- Persistent organic compounds appear to be transported over long distances by air, water, ice and organisms. These compounds are distributed throughout the Arctic, where many of them are biomagnified as they move through the food chain. Generally these compounds exhibit very slow degradation.
- Excluding massive oil spills, such as that from the *Exxon Valdez*, little information exists on the effects of chronic hydrocarbon contamination on Arctic food chains.
- High trace metals accumulations, some of

which may be naturally occurring, are found at many sites in the non-U.S. Arctic. No information is available on high levels of trace metal contamination in Alaskan samples.

- The distribution of the different contaminants and the magnitude of the damage and risk resulting from the introduction of radionuclides, persistent organics, heavy and trace metals, chronic hydrocarbon contaminants and pesticides to aquatic ecosystems, terrestrial ecosystems and human inhabitants of the Arctic and beyond is only minimally known.
- Forensic and other studies of marine species indicated considerable variability in actual body burdens of contaminants such as DDT for individual animals. Secondary life-cycle and intergenerational effects on species at the individual and population level of such contaminant burdens are not yet understood. Little systematic information exists about Kara Sea radionuclide dump sites or the integrity of dumped materials. Although many have existed for more than 25 years, virtually none of the critical contaminant dump sites have been investigated.
- With respect to other contaminants, little is known about their distribution, accumulation rates and patterns, or impacts on Alaska, the Arctic or the global environment.

Linkages

International

The IARPC Arctic Contamination Research and Assessment Program is primarily focused on contaminant risk to U.S. lands, waters and people. The results of the U.S. program would be shared with the Arctic Environmental Protection Strategy (AEPS) members. AEPS is a ministerial-level, legally nonbinding, international declaration established by the eight Arctic nations (Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the U.S.) to protect the Arctic. The results will be coordinated with the AEPS' Arctic Monitoring and Assessment Program (AMAP), a cooperative program established in 1991 by the eight Arctic nations to assist in monitoring and assessing the Arctic environment. The primary objective of AMAP is to measure levels of anthropogenic pollutants and to assess the effects of pollutants on the Arctic environment.

The Russian Federation is a major scientific entity in the Arctic Basin. Traditionally it has resisted research cooperation because of security and territorial interests. In the past three years this position has dramatically changed, and Russia is now cooperating openly in many respects and is providing scientific information about Arctic contamination and logistics support for studying the Arctic. In 1992 the Commission on Arctic Research of the Russian Academy of Sciences indicated that Russian scientists are interested and able to engage in joint assessment efforts to establish the factual dimensions of the pollution problem and risks to Arctic nations and people. Since then there has been much open sharing and discussion between U.S. and Russian scientists on many aspects of the Arctic contamination issue.

In September 1993 and again in December 1993, representatives from the Arctic countries met to develop mechanisms for identifying existing data about the Arctic environment. Co-sponsored by IARPC's Arctic Environmental Data Directory Working Group (AEDDWG) and the United Nations Environmental Program (UNEP) Global Resources Information Database (GRID), these meetings served to establish an interconnected distributive database system that provides on-line access to information about many of the database holdings of the Arctic nations.

Linkages also will be (or already are being) forged with the International Atomic Energy Agency (IAEA), the International Arctic Science Committee (IASC), the International Institute for Applied Systems Analysis (IIASA) and the Organization for Economic Coordination and Development's (OECD) Nuclear Energy Agency (NEA).

National

All of the United States' Arctic land is located within Alaska. The risk from contaminants to Alaskan lands, waters and people is a vital concern to the State of Alaska. The State has many ongoing relevant programs within its Department of Environmental Conservation, Department of Natural Resources, and Department of Health and Social Services. The IARPC Arctic Contamination Research and Assessment Program will coordinate with the State of Alaska government and its programs to maximize utilization of available resources and to share research results.

The indigenous people of Alaska have a lifestyle heavily augmented by subsistence activities. As such, they have a great knowledge of the Arctic. They also have the highest risk of potential impact from Arctic contamination. The participation of Alaskan Natives in contaminant research is a goal of the IARPC. Organizations such as the Native regional corporations, the Inuit Circumpolar Conference, the Alaska Federation of Natives and governmental and nongovernmental entities within the North Slope Borough (i.e., the North Slope Borough Fish and Game Management Committee) will serve as forums for Native involve-

ment in the IARPC Arctic Contamination Research and Assessment Program.

Additionally the IARPC Arctic Contamination Research and Assessment Program will coordinate its plans and activities with ongoing Federal activities, such as NOAA's National Status and Trends Program, the Fish and Wildlife Service's BerPac Expeditions, the Office of Naval Research's Arctic Nuclear Waste Program, the new National Biological Survey, and the Department of Energy's "EML-Global Networks" for measuring radioactivity in surface air and deposition.

Elements of the IARPC Arctic Contamination Research and Assessment Program

The overall goal of the IARPC program is to assess the sources, transport and fate of contaminants introduced directly to the Arctic (as well as contaminants accumulating in the Arctic from non-Arctic sources) and the effects and risks of those contaminants on human health and ecosystems in Alaska, the remainder of the Arctic and the Earth as a whole.

The research conducted, information collected and understanding achieved will provide a sound scientific basis for developing national and international policy for responding to the effects and potential impacts to ecosystems and human health.

The Arctic Contamination Research and Assessment Program recognizes the need to achieve an integrated multidisciplinary approach to understanding Arctic contamination and its impact on ecosystems and human health. This approach involves development of an integrated, comprehensive assessment, including:

- Data and information management, data rescue and synthesis;
- Observation;
- Process-oriented research;
- Model development; and
- Impact analysis and determination of risk.

Comprehensive assessments of the Arctic contamination issue are fraught with unknowns and hindered by minimal information. For example, prior to the summer of 1993, not one of the Russian Federation radionuclide ocean dump sites had been examined since inception, in some cases more than 25 years ago. For the IARPC to begin to understand the potential impacts and consequences from contaminants released or accumulating in the Arctic, two types of information are going to be needed. The first is credible information about the type, chemistry, quantity, distribution and packaging of each type of contaminant released in or accumulating in the Arctic. The second is process information about each contaminant; specifically, how it accumulates, how it is transported, how it enters the food chain (its biological uptake) and what its effects are on human and ecosystem health.

Environmental contaminants do not respect boundaries, be they physical (air, snow, ocean, biota) or political (national). As a consequence the fate and effects of contaminants in the Arctic must be assessed over wide spatial and temporal scales. Such assessments can be done with observational and monitoring data. However, the cost to assess all media at all scales would be prohibitive. To compensate for this dilemma, environmental programs strive to understand the sources, transport processes, fates and effects of contaminants and to develop models that allow for an understanding of the present situation in question, as well as for the extrapolation of this information to other scenarios.

Information Management, Data Rescue and Data Synthesis

There is a need to identify and manage data and information that has application to the assessment of Arctic contamination, specifically data and information related to the health and ecosystems that Alaskan residents and indigenous peoples depend on for recreation, subsistence and commerce. This information needs to be transferred to an appropriate archive media, such as CD-ROM; it also needs to undergo quality analysis, using any of a number of programs. There is also a need for common data formats for this information, and a need to perform the necessary data conversions and connections. Associated with each data set should be its "metadata," that is, information about the data, such as instrument characteristics, processing information, peculiarities in collecting or processing the data, known problems that have been solved, and comments from scientists who have used the data. Metadata is of great value in assessing data for future work and in using it properly. To the extent possible, metadata will have to be collected with all data rescue efforts and then properly associated with the data and assessed.

The Arctic Contamination Research and Assessment Program calls for information exchange and cooperation. Communication of results and needs among U.S. researchers, decision makers, the general public and Arctic inhabitants, as well as between the U.S. and the international community will be pursued.

Data rescue is urgently needed to prevent the permanent loss of certain data that are essential for assessing the human health and ecosystem risks posed by contaminants in the Arctic. In Russia, as well as throughout the entire Arctic scientific community, much of the data and information is

unknown to the scientific community, exist in formats or files that are not easily accessed, or is being lost to the scientific community. Part of the problem is the lack of coordination in the collection, storage, quality assurance, archiving, communication and retrieval of pertinent information.

The end of the Cold War also presents an opportunity to access United States' Arctic data sets that have been classified. The cognizant agencies are currently reviewing these data sets for applicability and possible release.

Once existing data sets are rescued and assembled, an information synthesis is required that assesses the available data with respect to quality control and quality assurance criteria, analyzes the information for implications, and identifies any data gaps for planning subsequent data collection efforts.

Observation

Observation is necessary to:

- Document temporal and spatial patterns of contaminants;
- Document indicators (including markers) of their presence;
- Identify processes that transport and transform them; and
- Produce information on the likely and potential effects of these contaminants.

This information is essential for estimating the current toxic risks to ecosystems and to people and for evaluating models that may predict future risks.

Although the United States has long conducted sampling in and around Alaska, most of this sampling has not been done on a systematic, statistically valid or representative basis. Thus, we know little about the status and trends of contaminants on a regionally representative basis. Internationally there is a fundamental lack of contaminant sampling in and around Russia, which has been a major source of contamination in the Arctic. Although many nations are conducting a broad range of activities, there is no real comparison program that allows information to be meaningfully developed on a circum-Arctic basis. While AMAP provides a mechanism to perform this function, no nation or organization is leading this effort, and as a result there is no activity in this area. Finally, the long-term commitment of resources for monitoring radioactive waste dump sites in the Arctic is not clear. An additional source of observation is contained in the traditional knowledge ("indigenous science") of northern Native peoples, whose subsistence activities are based on an in-depth awareness of their local environmental and ecological parameters.

Process-Oriented Research

Process-oriented research is an essential precursor to the development of useful models and to accurate predictions of risks and impacts. This research must include experiments that test hypotheses dealing with:

- Time-varying source functions for Arctic contaminants;
- Transport of contaminants by ice, water and air;
- Natural sources of contamination;
- Transport of contaminants by biota;
- Bioaccumulation of contaminants; and
- Accumulation of contaminants in water, soil and sediment.

Without such studies it will not be possible to determine those key processes that must be included in models and risk assessments and to predict how these terms will change with time. Examples of such studies include experiments that determine bioaccumulation factors for contaminants by Arctic organisms, determine unique Arctic contaminant transport mechanisms for contaminants such as those associated with ice formation and transport, and determine how Arctic processes can transform contaminants into forms that differ significantly from their initial state.

Model Development

With the rapid increase in the power and technology of supercomputing and the attendent advances in numerical physics research, there is a new opportunity to do high-resolution, complex computer simulations of coupled dynamic processes in the ocean–atmosphere system. These computer models can be use in four ways:

- They can be compared with natural systems to evaluate their accuracy.
- They can be used to assist (and may be the only way to succeed) in interpreting and integrating the large data sets that will be collected.
- Their results can be used as valuable input for planning observational programs.
- As a result of their success in the first three modes, we may have enough confidence to use them for prediction.

Thus, computer modeling is seen as an integral part of the entire effort, from planning to analysis.

Predicting the effect of human activities on the Arctic environment, such as Arctic haze and marine pollution, cannot be accomplished without understanding the natural systems. While scientific understanding is increasing, there remains much to be done if truly integrated models of the Arctic are to be developed for assessing potential scenarios.

Predicted scenarios are then used to provide decision and policy makers with an estimate of what could or might happen under certain conditions. The paradigms can also be used to play the "what if" game, where certain variables or parameters are held constant and the implications of certain situations are extrapolated to examine other scenarios, for example, under possible climate change conditions, catastrophic transportation events or nuclear accidents.

Higher-order paradigms take on increasing complexity, from the relatively unsophisticated (although very useful for some purposes) box model to the very complex numerical models. Given the unknowns, however, researchers have to be particularly careful that they pick the right paradigm for the purpose. Furthermore, they must communicate that purpose, the result and its associated confidence to the eventual users of the information. Obviously the choice of the appropriate paradigm or model is critical to this process.

Impact and Risk Analysis and Determination and Management of Risks

The most serious limitations arise from our lack of understanding of physical, chemical, biological and geologic processes and their natural variability and interactions with Arctic contaminants. A clear understanding of the Arctic contaminant issue and its interrelationship with the global environment will require sophisticated and sustained interdisciplinary studies.

Assessing impacts and risk to humankind and the environment from contaminants involves linking the exposure to or dosage from a particular substance with an expected response. Health, ecological and economic impacts should be considered individually, realizing that a particular contaminant may produce high health risks, for example, but low ecological impact or vice versa. When calculating impacts to humans, from the standpoint of environmental equity, the distribution of risk is an important factor for impacts to Native Arctic peoples. Rural Native communities with low population densities may not appear to have a high population risk, but unique factors related to foods and lifestyle may expose these groups to unknown risks. Therefore, an understanding of food chain interactions and contaminant concentration factors is important for calculating the risk to biota and to humans. The time dimension is also important, since environmental threats may have a long latency period.

Assessing exposures, doses and impacts involves a thorough understanding of transport processes, including physical, chemical, geochemical and biological factors, and actual environmental levels of contaminants of concern. These factors are all integrated through the modeling process by which exposure and dose estimates can be made. Given uncertainties for source terms and release rates, various scenarios balancing conservatism and realism will be needed to predict risk. Research and modeling should proceed in an iterative manner, utilizing as much site-specific data as possible. The models will predict contaminant distributions in time and space, which will then be coupled to information on concentration factors and also acute and chronic biological effects data.

Assessments of exposure and impacts may proceed from a rough calculation utilizing maximizing assumptions and very little site-specific characterization to a very data-intensive program, as the situation warrants. Model sensitivity analyses can indicate future research needs.

2.2 Surface Heat Budget of the Arctic Ocean (SHEBA)

Background

Climate may be the most pervasive and influential factor that defines the Arctic. There is scarcely any aspect of the Arctic system, including the human and natural components, that is unaffected by climate. Both historical records and paleoclimatic proxy indicators depict the Arctic as a highly variable and sensitive region in the global climate system. Climate feedback processes involving the snow cover, sea ice and ocean circulation appear to exert strong influences on hemispheric and global scales that are disproportionate to the small area of the Arctic.

For example, Arctic cryospheric and hydrological processes play vital roles in determining the planetary albedo of the earth–atmosphere system and the global-scale thermohaline circulation of the ocean.The first of these roles may be seen in the results of model projections of the equilibrium response of global climate, excluding the deep ocean circulation, to enhanced concentrations of greenhouse gases in the atmosphere. The projections of different modeling groups all depict a poleward amplification of surface temperature change that is most pronounced in the Arctic during autumn and winter. Transient model simulations that include a fully interactive deep ocean show that the large-scale thermohaline "conveyor belt" circulation driven by convection in the high-latitude North Atlantic Ocean could weaken or even shut down in response to a gradual increase of atmospheric greenhouse gas sustained over 100–200 years. A critical factor in this projected scenario is the enhanced outflow of low-salinity

water from the Arctic Ocean, resulting from the increased atmospheric transport of water vapor into the Arctic drainage.

The consequences of these climatic changes would be enormous, both within and outside the Arctic. Therefore, in looking to the future environment, it is of the utmost importance to understand both the potential climatic implications of policies and practices that may affect climate, and the reliability of the projections of future climate scenarios. The largest disagreements among the model projections of surface temperature change are concentrated in the Arctic. In other words, the enhanced climate sensitivity of the Arctic goes hand in hand with enhanced uncertainty associated with Arctic climate projections.

Because of the importance of Arctic climate and the large uncertainties in projections of its future, a major focus of research planning of the Ocean–Atmosphere–Ice Interactions (OAII) component of the NSF Arctic System Science (ARCSS) program has been to identify the Arctic processes and interactions that govern this high climatic sensitivity and to develop projects to document, understand and predict how they work. A coordinated, interagency project called Surface Heat Budget of the Arctic Ocean (SHEBA) has developed from this planning process during 1990–1995, and it is to be implemented during 1995–2000.

Objectives

SHEBA is a five-year project with three parts: a field component, a modeling component and a remote sensing component. The two primary goals of SHEBA are:

- To develop, test and implement models of Arctic air–sea–ice processes that demonstrably improve global climate model simulations of the present-day Arctic climate, including its variability; and
- To improve the interpretation of satellite remote sensing data in the Arctic so that satellites can assist effectively in the interpretation of the Arctic climate system, and provide reliable data for model input, model validation and climate monitoring.

For modeling purposes the average conditions over the oceanic portion of the north polar cap can be thought of as a column containing ocean, ice and atmosphere. The energy balance of the system within the column is driven by two external forcing functions: the solar radiation at the top of the atmosphere and the horizontal advection of sensible and latent heat by the atmosphere. The primary energy sink for the system is the outgoing long-wave radiation at the top of the atmosphere.

The sources and sinks of energy depend on the state of the system inside the column. For example, the fraction of sunlight reflected back to space varies with the cloud cover and with the surface albedo. The surface albedo depends in turn on the state of the ice cover, such as the area covered by open water, melt ponds, and ice and snow of different thicknesses and physical properties. This surface state is related in a complicated way to surface temperature variations over the annual ice cycle of accretion and ablation. The outgoing long-wave radiation depends on the surface temperature, as well as the vertical distribution and temperature of clouds and greenhouse gases in the Arctic atmosphere. The vertical transport of heat near the surface is affected significantly in winter by turbulent fluxes through open leads and by suspended ice crystal precipitation, which is not recorded in routine observations of "cloud" but nevertheless affects the absorption and emission of outgoing long-wave radiation.

A simplified view relating the overall energy balance of the column to the Arctic climate sensitivity is that changes in the mean annual cycle of surface temperature evolve as part of the coupled response of the entire column to changes in external forcing. In the context of global change, such forcing may include changes in the composition of the atmosphere in the column (for example, the concentration of greenhouse gases and the concentration and vertical distribution of aerosols), changes in lower latitudes that affect the horizontal advection of sensible and latent heat, and changes in solar radiation.

SHEBA aims to address several questions concerning the state of the system in the column:

- Given the observations of the solar radiation at the top of the atmosphere and the horizontal advection of sensible and latent heat by the atmosphere, how accurately can we reproduce the presently observed state of the column, as it varies over the annual cycle, using physical formulations for the processes that represent the present state of the art?
- How sensitive is the state of the column to variations in the physical formulations that produce variations among different climate simulations?
- How much of the uncertainty in the climate sensitivity of the column is due solely to the formulation of processes within the column, as opposed to changes in external forcing from the horizontal advection of sensible and latent heat by the atmosphere, which may also react to variations in the state of the column during a climate change?

The surface energy balance at the atmosphere–

ice and atmosphere–ocean interfaces is the key to coupling between the surface state (for example, temperature, albedo, open water area and ice thickness) and the atmospheric processes that determine the overall energy balance of the ocean–atmosphere–ice column. Moreover, it is here at the atmosphere–ice–ocean interface that we find both the widest variations in treatment of physical processes by different climate models and the most powerful ice–albedo feedback that amplifies climate sensitivity.

The surface interface within the ocean–atmosphere–ice column, on a scale relevant to climate modeling, is highly heterogeneous. The most important small-scale heterogeneities are tied to surface temperature in winter and to albedo in spring and summer. The operation of climate feedback mechanisms depends on how the surface energy balance is translated into changes in the heterogeneous surface state. Particularly important for SHEBA is the distribution of absorbed shortwave radiation among ice of various thicknesses, melt ponds and leads, and the effect of this distribution on the time evolution of surface albedo. The response of a heterogeneous system to the surface radiative and turbulent fluxes that force it has never been documented comprehensively and accurately over a full annual cycle and over a region containing variable ice types, snow cover, melt ponds and leads. A major objective of the SHEBA field program is to provide this comprehensive documentation.

Cloud–radiation feedback is also characterized by the interplay between energy balance and mass balance. Over the Arctic Ocean, diabatic, and especially radiative, cooling appear to play a more important role in cloud formation and maintenance than at lower latitudes. The water balance is coupled to the energy balance through the large change in atmospheric emissivity that accompanies cloud formation, the cloud tops serving as sites of relatively large cooling rates. Because of the short lifetime of individual cloud elements, and the time scales of physical processes governing cloud–radiation interactions, in-situ observations relevant to cloud–radiation feedback will be acquired on a short-term campaign basis, in coordination with the NASA FIRE-III program. A major objective of the SHEBA/FIRE field programs is to document the key physical, chemical and radiative properties related to cloud–radiation feedback, with the aid of intensive campaigns with research aircraft.

The centerpiece of the SHEBA field program will be a drifting camp on the sea ice of the Arctic Ocean, at which the surface energy and mass balance processes will be documented over a 17-month period. The surface observations will be combined with aircraft campaigns, analysis of satellite observations and regional-scale modeling. The observational program will emphasize the interactions of the surface radiation balance, mass changes of the sea ice, the storage and retrieval of energy and salt in the mixed layer of the ocean, the formation and radiative properties of clouds and their interplay with the radiation balance, and the relationships between the air–sea–ice system and the signals received by satellite-borne remote sensors. Special emphasis will be placed on the use of modern surface-based technology. Dedicated aircraft will conduct regular surveys of the surface conditions and take a variety of measurements in the cloudy atmospheric boundary layer. Observations at the ice camp will be augmented by a number of strategically placed automatic data buoys.

Implementation

Scientific planning for SHEBA is conducted by the SHEBA Science Working Group (SWG). The overall responsibility of this group is to see that SHEBA develops as a balanced program that continues to address the fundamental goals and objectives identified during the development of the SHEBA concept and articulated in the ARCSS-OAII and SHEBA planning documents. The SWG is presently developing a SHEBA Science and Implementation Plan, which will be distributed widely in time for use in preparing proposals for field work.

The selection of principal investigators and science projects to participate in SHEBA occurs through a competitive process involving the review and evaluation of research proposals submitted in response to a sequence of Announcements of Opportunity published by the U.S. National Science Foundation, the U.S. Office of Naval Research and other Federal agencies. The project is coordinated by the SHEBA Project Office at the Polar Science Center, University of Washington, as part of the ARCSS-OAII Science Management Office. It is anticipated that, as a large, interagency project, SHEBA will establish a separate project office when research projects begin.

Phase I of SHEBA is concerned primarily with modeling studies, analysis of existing data, technology development and detailed planning to refine the concept for the drifting research camp. In addition to the preparatory research projects, Phase I will include development of a logistics plan for the field experiment, and further development of a data management plan in cooperation with the ARCSS data management activities at the National Snow and Ice Data Center (NSIDC).

Phase I research results and planning activities will provide input to the development of the Phase II program announcement, to be published in late 1995. Phase II is intended to cover the measurement program at the research camp, analysis and interpretation of the data, and integration through modeling studies. Early in Phase II SHEBA will produce the operations plan for the field experiment.

The SHEBA field experiment will begin in late March 1997 and continue until August 1998. The timing and duration of the experiment are dictated by the science priorities: it is essential to follow the evolution of the ice cover, and its relation to the surface energy balance, over at least one full annual cycle. SHEBA has been designed to sample the spring–summer transitional season and the summer melt season twice, including once at the very beginning of the field program, because the ocean–atmosphere–ice interactive processes occurring at this time of year are the most influential and the least understood in the present generation of climate models.

The measurements will be staged from and distributed around a research camp on the surface of a multiyear ice floe in the Beaufort Sea. Long experience with scientific camps on the pack ice addressing other science issues (ice dynamics, internal waves, oceanography of leads in winter, ice mechanics) shows that such a platform optimizes the science support within the constraints of safety and cost. The camp will be deployed and maintained by aircraft, utilizing refrozen leads for runways. Research and logistics flights to the camp will be staged from airports in Alaska and Canada. Flights by short-range aircraft can be staged from locations near the coast, such as Barrow, Prudhoe Bay, Barter Island and Tuktoyaktuk. Because the SHEBA field experiment is scheduled to end in late summer, the optimal platform for evacuating the camp may be an icebreaker, which should have relatively easy access, particularly if the camp drifts southward and westward.

Interagency and International Coordination

To maximize the efficiency and scientific payoff from SHEBA, the SWG has actively pursued appropriate interagency cooperation between ARCSS and other programs. During 1993 the SHEBA SWG formally requested that IARPC form an Interagency Group to look after the implementation and support of SHEBA in the context of the multiagency Federal environment and the U.S. Arctic Research Plan.

The interagency cooperation for SHEBA has been productive on a number of fronts. NSF-ARCSS and the Office of Naval Research (ONR) have jointly issued the SHEBA Phase I program announcement and conducted a joint panel review of the Phase I proposals. It is anticipated that NSF-ONR will continue to cooperate in a similar manner during Phase II.

Partly as a result of the development of SHEBA, NASA has identified studies of Arctic stratus clouds as a priority for Phase III of the First International Satellite Cloud Climatology Program (ISCCP) Regional Experiment (FIRE-III). The FIRE-III program announcement published in the summer of 1994 solicited proposals to participate in a research aircraft campaign over the Arctic pack ice during the spring of 1997. Through coordination between the SHEBA SWG and the FIRE science team, plans call for this campaign to take place over the SHEBA drifting research camp and to take advantage of the surface-based measurements to be acquired there.

The Department of Energy (DOE) has established its Atmospheric Radiation Measurement (ARM) program as a major contribution to U.S. Global Change research. This program is focused on improving the understanding of radiative transfer, including the effects of clouds, as a contribution to narrowing the uncertainty in climate projections. ARM observations are to be conducted over a period of about ten years, at specially instrumented Cloud and Radiation Testbed (CART) sites. One of three CART sites now identified by ARM is the North Slope of Alaska (NSA) site to be established near Barrow. Through cooperative planning involving the SHEBA SWG and the ARM NSA advisory panel, ARM has extended the NSA CART concept to include participation in SHEBA, with the extended title ARM NSA/AAO (Adjacent Arctic Ocean). Plans call for ARM to provide state-of-the-art instrumentation for measuring radiation and cloud properties at the SHEBA camp. SHEBA will provide logistic support and personnel to assist with the operation of the instrumentation. SHEBA will benefit from the acquisition of a data set in the moving pack ice, which will provide valuable context for the longer-term, land-based measurements at Barrow. SHEBA will benefit from access to the high-quality ARM measurements.

The SHEBA SWG has also established links with the NASA EOS Program, through the POLES project. POLES objectives include the use of satellite remote sensing data to estimate fields of surface fluxes and surface properties over the Arctic Ocean, and the application of these estimated fields to ice–ocean modeling. Coordination between EOS and SHEBA aims to ensure that the in-situ and satellite data sets needed to evaluate and improve satellite-based estimates of surface fluxes

and ice–atmosphere properties are available for the SHEBA experimental period.

The SHEBA SWG is coordinating their planning with the developing NASA participation in RADARSAT. It is anticipated that accurate information on meso- and large-scale ice deformation, including changes in open water area and the ice thickness distribution, will be estimated from a combination of RADARSAT ice displacement grids and SHEBA surface measurements acquired during the field experiment.

SHEBA has been recognized as an essential contribution by the Arctic Climate System Study of the World Climate Research Program. The SHEBA SWG is coordinated with ACSYS by SWG representatives on the ACSYS Scientific Steering Group.

2.3 Beringian Systems Program

Background

Beringia, the region surrounding Bering Strait including the Chukchi and Bering Seas and adjacent portions of Siberia and Alaska, is situated at a geographic crossroads and international border. Beringia is a center of human and biological interchange in the Arctic region. In modern times it has also been a center of economic growth and development based on its rich fisheries, timber, minerals and other resources. The post-Cold War era has seen Beringia re-emerge as an important zone of international scientific collaboration and cooperation.

The Beringian Systems Initiative provides a focus for interagency collaboration and research in Beringia and the greater North Pacific region. Significant advances can be made, especially in trans-Beringian anthropology, biology and natural science, and it is an important focus for studies of land–shelf interactions and of Pacific–Arctic Ocean hydrological and biological exchange. Yet there has been no concerted attempt to develop an integrated understanding of Beringian ecosystems and cultures. Development of a regional Beringian perspective will also facilitate understanding of larger Arctic environmental systems and their role in global processes.

Recent political developments provide opportunities for Beringian studies. For more than half a century Beringia was an aggressively defended frontier, and little scientific communication across the Bering Strait was possible. As a result, despite common elements of climate, environment, resources, cultures and history that unite the region, the area today is poorly understood and is known largely from national perspectives. Research encouraging international collaboration, especially with Russia, Canada and Japan, can broaden scientific understanding of a region that is rapidly becoming an important zone of economic enterprise.

The Beringian Systems Initiative draws on existing programs conducted by Federal, state and university sectors. Collectively these programs support a growing body of research. The program links components of existing research programs into a geographically focused and thematically integrated network. In accordance with recent reports and recommendations (previous IARPC Research Plans, PRB *Agenda for Action*, and the Fall 1992 issue of *Arctic Research of the U.S.* on social science research), the objective is to develop an integrated study of Beringian ecosystems, processes, cultures and history. A primary thrust will be to develop knowledge useful for studying human and biological dimensions of global change and to ensure maximal environmental productivity and protection. Relevance to modern issues will help guide the research, and Native and community participation will be encouraged.

Research Themes

The ecologically rich Beringian region has long been seen as a birthplace of New World Arctic cultures and the center from which its peoples spread into other regions of the New World and nearby Asia. Geographically the region is crucial to any understanding of North Pacific and Arctic prehistory. This region saw the first migrations of humans into the New World and has been a center of Eskimo development and a conduit for Asian–American cultural exchanges for the past 15,000 years. The long history of human occupation of Beringia provides an unparalleled record of human adaptation to changing climatic, environmental and sociocultural conditions. Today the ecologically diverse and resource-rich Beringian region is home to numerous Native groups, whose participation in political and economic development is essential. Archeological excavations in the Beringian region provide long-term data on faunal changes in both marine and terrestrial mammals, as well as changes in invertebrates, plants and soil chemistry. Coastal settlements correlate with changes in sea level and reflect the influences of these changes on local and regional animal and plant populations. Pollen and macrofossil samples from sediment cores and stratigraphy from human settlement sites can correlate human activities with environmental change.

These data, combined with information from geology, can provide the time depth necessary to

construct predictive and testable models relevant to global change research. Among the most important research topics that can be addressed here are the peopling of the New World, adaptations and dynamics of Arctic social and cultural change, regional paleoecology and glaciology and their impact on human history, Russian–American history, and contemporary cultural, social, demographic, linguistic, psychological and health issues of the region's indigenous peoples.

Research Program

The need for new information about the Beringian region has been highlighted by recent developments, including major exhibitions; by the proposed Beringian Heritage International Park, recently strengthened by the 1994 Gore–Chernomyrdin process; by plans and reports on research needs; by Russian–American conferences and scholarly exchanges; and by the Smithsonian's "Jesup 2" program, a ten-year program that reviews the history and progress of Beringian–North Pacific research as part of the centennial of the Jesup North Pacific Expedition (1897–1903).

The social and biological sciences provide the core of this integrated initiative, which involves collaboration with natural sciences including geology, paleoecology and marine sciences. The program provides both time depth and a multidisciplinary analysis of human and animal adaptations in the Arctic. Knowledge will be gained about circumpolar cultural and biotic development, past and present, and models will be formulated for human–ecosystem dynamics and demographic change. Knowledge gained by this program will be of interest not only to scientists but to planners and indigenous peoples.

Cultural resource management is a mission of numerous Federal agencies. In this regard the Department of Interior (particularly the National Park Service, the Bureau of Land Management and the Bureau of Indian Affairs) and the Smithsonian Institution share responsibilities for preserving archeological sites and the cultural heritage of indigenous cultures of today. Cooperative scientific investigations on Federal lands must be undertaken to accurately document and manage cultural resources for research, preservation and use. The same is true regarding modern indigenous socioeconomics and health concerns, which require collaboration with the Department of Health and Human Services and its Indian Health Service, NOAA's Sea Grant Program, local governments, and Native councils and organizations in Alaska. Recent concerns about pollution require monitoring the spread of pollutants through marine and terrestrial food chains and studying their potential impact on human populations in accordance with conventions of the Helsinki accords.

Goals and Objectives

- Increase baseline documentation on early Beringian cultures and archeological sites to establish regional culture history and refine cultural chronologies, profiles and evidence of trans-Beringian contacts and exchange;
- Reconstruct paleoenvironments, landscape history and distributions of marine and terrestrial flora and fauna;
- Document Native traditional ecological knowledge and contemporary human responses and adaptation to changing climatic, environmental and sociocultural conditions;
- Establish baseline documentation on pollutants and their presence and pathways in Beringian area food chains;
- Compare baseline data from archeological and historical records with modern data to determine processes, trends and effects of human–environmental interactions;
- Relate results of regional studies to larger global patterns of climatic and environmental interactions; and
- Develop coordination and infrastructure by enhancing regional research centers, by promoting the spread of scientific knowledge and by encouraging cooperative and international research and educational programs that include representation of northern residents and communities.

Planned Elements

During the past two years, substantial progress has been made in developing the infrastructure for the Beringian Systems Initiative by agencies with ongoing relevant projects. The Vladivostok and Magadan meetings of 1994; the establishment of a regional office in Anchorage for the Smithsonian Arctic Studies Center in 1994 and the planning for the international "Jesup 2" symposium in 1997; and the formation of the Arctic Native Science Commission are important components that will be coordinated and implemented by agencies through the Beringian Systems Initiative. Each agency is expected to develop plans concordant with existing missions, but with greater emphasis on joint planning, shared benefits and growth of international activities. Federal agencies propose to work with Native organizations to collect and classify indigenous knowledge. A sample of proposed activities includes:

- National Park Service: Continue heritage research and educational programs associated with the Beringian Heritage International Park,

including international contacts and exchanges, field programs, films and ongoing research programs in existing parks; ethnographic, ethnoarcheological, archeological, geomorphological, paleoecological and landscape history research;
- Smithsonian Institution: Develop capabilities of the Alaska regional office; coordinate "Jesup 2" research and museum programs on trans-Beringian biology, archeology, ethnography, history and art, operating through a consortium of museums, universities and international contacts; develop community research, education and exhibition programs and tour "Crossroads Alaska/Siberia" exhibition to the Russian Far East;
- National Science Foundation: Consider funding of research, workshops and conferences and provide interagency coordination and assistance in international exchange programs;
- Fish and Wildlife Service: Provide assistance in biological studies and logistics in accordance with existing operations and research plans;
- Department of State: Assist in the support of international research and facilitate international contacts and exchanges;
- NOAA: Support relevant research through the Sea Grant Program and provide assistance in marine food chain studies and logistics;
- EPA: Provide assistance in studies of Arctic pollutants and pathways;
- Health and Human Services: Provide assistance in studying the impacts of modern socioeconomic and environmental change on nutrition, health and related issues; and
- DOD: Provide funding for pollution research and logistics support for field activities consistent with current mission objectives.

Implementation

Many of the programs described above are already in the process of being implemented but require further planning and development. This focused social and natural sciences initiative is being undertaken within the framework of interagency cooperation. Using cooperative agreements, an interagency working group composed of representatives from Alaska- and Washington, D.C.-based agencies is developing and implementing existing and new research programs. Programs under the U.S.–Russia Agreement on Cooperation in the Field of Environmental Protection and other international instruments will be used to facilitate international aspects of bilateral research.

Missions and research specialties unique to individual agencies will be combined into a coordinated plan. Each agency will seek support for specific components of planned activities: NPS through contract and in-house studies on park lands; NSF through peer-review projects; and the Smithsonian Institution through in-house programs and academic collaborators operating through a "Jesup 2" research and exchange consortium. Coordination with other agencies will be developed to enhance mutual goals and the overall program. Coordination on Federal lands will be through the land managers. These activities will be coordinated with nongovernment organizations, universities, research centers and Native and community organizations.

2.4 Arctic Data and Information

Arctic Data

The Arctic Environmental Data Directory (AEDD) is a collection of information that describes the major Arctic data holdings of the IARPC Federal agencies. With more than 400 entries, AEDD also identifies selected Arctic data sets managed by state and local agencies in Alaska, various universities and some other Arctic nations. All data set descriptions in AEDD are reviewed prior to entry for completeness, consistency and accuracy. AEDD resides on a Unix computer in offices of the U.S. Geological Survey (USGS) in Anchorage, Alaska, and is accessible over the Internet using information superhighway tools such as Mosaic, the Wide Area Information Service (WAIS) and Gopher.

The IARPC challenged the AEDD Working Group to make the directory circumpolar in scope, including data set descriptions for data residing in all Arctic nations. To this end, the AEDD Working Group has formed an effective working relationship with the United Nations Environment Program (UNEP) Global Resources Information Database (GRID) office in Arendal, Norway. The two groups sponsored a series of workshops, first in Arendal, Norway, and subsequently in San Francisco, California, with the objective of identifying contacts in other nations with interest in creating an international Arctic Data Directory (ADD). Participants from seven of the eight Arctic nations have agreed to assemble compatible directories with the idea that, using the Internet, researchers can access all of them as if they were one directory.

As a first step, an international ADD node was established in early 1994 at the UNEP/GRID-Arendal office. Based on the model that AEDD initiated, the Arendal directory holds information about Arctic data for the Nordic countries and por-

tions of western Russia. Both AEDD (as the U.S. node for ADD) and the Arendal ADD node have agreed to identify and use certain standards that will make it easier for researchers to use the directory. For example, the structure and content of all ADD nodes are based on the Directory Interchange Format (DIF), which is used by the Global Change Master Directory, the Master Directory of the International Geosphere/Biosphere Programme, and the NASA Master Directory. Use of the DIF simplifies the task of researchers who must access many data sources. As another example, all ADD nodes will use the Internet as their primary means of access, with obvious benefits to the research community. All ADD nodes will use WAIS and Mosaic as primary search and retrieval mechanisms.

The AEDD Working Group and UNEP/GRID-Arendal are working closely with the Russian Ministry of Environment Protection and Natural Resources to establish a third ADD node in Moscow or St. Petersburg, Russia. The objective is to facilitate the process of making information about Russian Arctic data more readily known and available to researchers in all countries. More than 80 Russian institutes holding Arctic data and information have already been identified. The plans are to establish the Russian node during 1995 and to have representative descriptions of key Russian Arctic data holdings entered and reviewed by 1996. Clearly this endeavor requires close cooperation between scientists in western nations and those in the Russian Federation, as well as a commitment to apply equivalent review and quality standards to the data set descriptions from all sources. The International Arctic Science Committee (an international affiliate of the Polar Research Board of the U.S. National Academy of Sciences) will assist ADD by helping to identify and review data sets of priority interest.

Through the ADD workshops, the AEDD Working Group has also established contacts within Canada, Denmark, Finland, Germany, Italy, Japan, the Netherlands, New Zealand, Sweden and the United Kingdom. Each of these countries is being encouraged to consider sponsoring a node of the ADD. Eventually ADD will contain, and make available to the research community, descriptions of all major Arctic data holdings worldwide.

AEDD and the ADD are also actively participating in other IARPC activities. The Arctic Monitoring and Assessment Program (AMAP) was established in support of the Arctic Environmental Protection Strategy (AEPS). With headquarters in Oslo, Norway, AMAP is identifying and using data sets from all Arctic nations. AEDD and ADD are both being used as key resources to be accessed and used by AMAP researchers. The USGS, as the AMAP data manager for North American data, is supporting AMAP activities with AEDD. In this regard, AEDD is focusing on adding descriptions of data sets that relate to Arctic contamination. Data sets that measure contaminants in the marine and freshwater environments, on land surfaces, in the atmosphere and in the flora and fauna will be added to AEDD. Of particular interest will be data sets on medicine, human health, marine biology, socioeconomics, demographics and the physical measurements of radionuclides, persistent organics and heavy metals in the Arctic environment.

AEDD will also be working with nongovernmental organizations that have mutual interests in Arctic environmental data and information. For example, the International Permafrost Association (IPA) is working to identify and rescue frozen-ground data that may be at risk of being lost due to retirements, deaths or lack of funds or attention by agencies in various countries. As organizations such as the IPA succeed in building data sets of interest, whether in the U.S., Russia or other countries, they will use AEDD and the international ADD to document the results. Through associations with such organizations, descriptions in the international ADD of larger numbers of Arctic data sets will be realized with minimum cost and effort to the AEDD working group.

The National Snow and Ice Data Center (NSIDC), University of Colorado at Boulder, is funded by NSF as the Arctic System Science (ARCSS) Data Coordination Center. Current NSIDC efforts focus on integrating communication among the ARCSS component communities and on providing access to existing, unarchived data of interest for ARCSS research. In parallel, archiving planning for ARCSS-funded data sets continues in concert with the OAII (Ocean–Atmosphere–Ice Interactions), LAII (Land–Atmosphere–Ice Interactions), GISP2 (Greenland Ice Sheet Project Two) and PALE (Paleoclimates of Arctic Lakes and Estuaries) Science Management Offices. The concept of "System Science" depends heavily on the accessibility and sharing of data and results among all those involved. NSIDC is seeking to ensure that accessibility.

Because communication is a fundamental building block for integration, NSIDC is providing an ARCSS information server on the Internet. A "listserver" provides electronic mail communication and transfer of small data and information files within and among the ARCSS component communities. A World Wide Web "Home Page" will follow in 1995.

Discussion of data issues and priorities across all ARCSS components will continue in the context of

the proposed ARCSS Modeling Working Group and ARCSS Data Management Working Group. The Modeling Working Group is intended to develop a coherent plan for an integrated approach to ARCSS modeling strategies. Priorities for data product development and delivery mechanisms will be set by the Data Management Working Group, with additional guidance from the NSF ARCSS Advisory Committee.

To ensure that data collected as part of the ARCSS program are cared for on a long-term basis, NSIDC plans to maintain a complete copy of each ARCSS data set and data product. Existing national data centers may be identified as appropriate additional dissemination sites for particular types of data, in which case the data will be deposited at that national center, with a copy at NSIDC either on a "CD-ROM of record" or on another appropriate archival medium. NSIDC's coordinating role is to provide a complete catalog of the ARCSS data, with pointers to locations where copies of the data may be obtained. The primary intent of the catalog is to provide a permanent, published record of the ARCSS program, viewed through its data output. Future ARCSS data activities at NSIDC will be directed in large measure by feedback received from the community, especially through the channels provided by the Data Management and Modeling Working Groups.

Planned Interagency and International Data Activities

- Increase the number of entries in AEDD, with a focus on Arctic contamination issues related to the impact on human inhabitants and to the physical environment;
- Work with IARPC programs that support the AEPS, such as AMAP and CAFF, to provide information about and access to Arctic data;
- Help identify, rescue and document Arctic data sets at risk of being lost, in conjunction with other organizations that share common interests;
- Seek expansion of the international ADD, with near-term potential for new nodes in Russia, Canada, Japan, the United Kingdom and perhaps Denmark;
- Help establish an international ADD node in Russia, with UNEP/GRID, to begin the process of documenting and providing access to Russian Arctic data and information;
- Improve access to AEDD by adopting broader suites of contemporary tools on the Internet (such as WAIS, Mosaic and Gopher), with an emphasis on standards;
- Investigate new technologies that will make it as easy as possible to identify and use Arctic data sets while maintaining the high quality and reliability of AEDD and its contents; and
- Develop and distribute tools that will help scientists and data managers document Arctic data sets properly, such as a "DIF template on a diskette" for use on desktop computers or "FTP on a floppy" for better access to Internet resources.

Arctic Information

The U.S. Polar Information Working Group (USPIWG) is an independent body of U.S. polar information specialists associated with the international Polar Libraries Colloquy. The objective of USPIWG is to offer a single service to the U.S. Arctic and Antarctic scientific communities for matching information resources with information needs in a user-based context.

Institutions and organizations currently represented are the University of Alaska Fairbanks, the University of Alaska Anchorage, the World Data Center A and the Institute of Arctic and Alpine Research at the University of Colorado at Boulder, the Byrd Polar Research Center at the Ohio State University, Dartmouth College, the Cold Regions Research and Engineering Laboratory, the Cold Regions Bibliography Project, and Arctic Connections.

At their NSF-sponsored meeting in Cambridge, UK, in July 1994, the group discussed activities in progress, networks, USPIWG services and the status of tasks proposed to NSF. These tasks include the activities listed below.

Ongoing and Planned Activities

- Revise *Arctic Information and Data: A Guide to Selected Resources*, published in September 1992 by the Arctic Research Consortium of the United States (ARCUS); the updated version will expand upon the earlier brief descriptions and contact information for libraries, data centers, directory services (such as the Global Change Master Directory and the Arctic Environmental Data Directory), journals and newsletters, CD-ROM and printed indices and other sources of information or data relating to the Arctic; a new subsection of international directories will be added, as well as a vastly expanded section on Internet services.
- Provide improved information regarding individual database descriptions and policies for users of PolarPac and Arctic and Antarctic Regions CD-ROMs;
- Improve the coverage of information published in document types not adequately represented in the CD-ROM databases, such as technical reports, nonpolar journals, book chapters, conference papers, dissertations, theses, maps and abstracts;

- Reduce the necessity for duplicate indexing among the databases published on PolarPac and Arctic and Antarctic Regions CD-ROMs by distributing responsibilities for indexing; the Cold Regions Bibliography Project is currently cooperating with the Scott Polar Research Institute in England to implement appropriate strategies to meet this challenge;
- Contribute to the new Internet listserv POLLIB-L and to the Polar Information Sources Gopher managed at the University of Calgary, Canada;
- Serve on the Polar Libraries Colloquy Steering Committee (three U.S. members of USPIWG are among the ten members);
- Distribute the revised version of *Polar and Cold Regions Library Resources: A Directory*, which was readied for the 1994 Polar Libraries Colloquy at the University of Cambridge, England;
- Seek opportunities at scientific conferences to demonstrate access services and document delivery opportunities to users of polar regions information; and
- Pursue topics of particular interest to the U.S. polar community between the biennial, international Polar Libraries Colloquy meetings.

Electronic Access to Polar Information Resources

PolarPac version 3, the CD-ROM database of international polar regions bibliographic information, was published in the summer of 1993. In addition to the eight Alaskan and three "lower-48" polar regions libraries included in the second edition, libraries from the U.K., Finland and Canada are added. Serials titles are already included from these libraries and several dozen worldwide. PolarPac version 4, with new files from Russian libraries, is due out in 1995.

Arctic and Antarctic Regions, NISC's CD-ROM suite of polar regions reference databases from around the world, in its Fall 1994 version, has over half a million records, mostly of journal articles. Reference databases from the U.S., U.K. and Canada are globally searchable.

The two CD-ROMs complement each other to a great extent to include coverage of all cold regions and document types such as monographs, serial analytics and technical reports. Both library catalogs and reference databases are included on the disks.

The Internet Gopher can now link the user to "Polar Information Sources" via the University of Calgary. There are ten sections at present, all of which are interesting and useful to the polar science and information science community. Both the guide—*Arctic Information and Data: A Guide to Selected Resources*—and the directory—*Polar and Cold Regions Library Resources: A Directory*—appear here in full text under Polar Libraries and Polar Information Directories. Bibliographic databases and polar data sets are also available.

3. Agency Programs

3.1 Arctic Ocean and Marginal Seas

This section of the revision to the Plan covers the six major components and their individual mission elements. Individual agency mission accomplishments were discussed in the Fall 1994 issue of Arctic Research of the United States *and will be updated in 1996. Objectives of Federal agencies are briefly described, focusing on the period covered by this revision (1996–2000).*

3.1.1 Ice Dynamics and Oceanography

A prominent feature of the Arctic Ocean is its permanent, dynamic ice cover. This marine cryosphere significantly impacts the environment on all scales, from climatic to molecular. Critical processes governing this impact occur in the atmosphere and oceanic boundary layers above and below the ice. A major priority is the development of the next generation of operational ice forecasting tools and models. A systematic program of oceanographic, cryospheric and atmospheric measurements by such conventional technologies, as well as new technologies such as autonomous underwater vehicles (AUVs), is needed to support the objectives of this research and the interagency program.

Objectives

- Determine the processes, history, dynamics and mechanisms of ice production, deformation, advection and decay;
- Determine the processes of renewal and mixing of Arctic and Subarctic water masses from large to small scales;
- Determine the large-scale circulation of the Arctic Ocean, and circulation variability and dynamics, including the role of shelf seas, boundary currents and exchanges with adjoining seas;
- Continue to develop advanced methods of unmanned environmental monitoring such as buoys and AUVs; and
- Determine the mean and natural range of variability of currents and hydrographic features in the nearshore region of the Bering, Chukchi and eastern U.S. Beaufort Seas.

3.1.2 Ocean and Coastal Ecosystems and Living Resources

The biota of marine and coastal ecosystems are influenced by physical processes, including seasonal extremes of light and temperature. Arctic marine ecosystems are dominated by sea ice, while coastal ecosystems are influenced by freshwater input and seasonal sediment loads, as well as by seasonal sea ice. There is a need to quantify the resulting variability in the rates of biological production of marine living resources through long-term and well-designed interdisciplinary research.

Objectives

- Determine the status and trends of fish, bird and marine mammal populations and identify their habitat requirements;
- Monitor coastal ecosystems to detect and quantify temporal changes in nutrient and energy exchange and their effect on biota;
- Determine the magnitude and variation of marine productivity in Arctic areas through studies of the structure, dynamics and natural variability of the ecosystems;
- Consider the influence of ice and human activities on both the biotic and abiotic components of the Arctic environment;
- Study the influence of Arctic marine productivity on the global cycling of biologically active materials, including carbon and nitrogen; and
- Understand the physical and biological processes that affect fisheries recruitment in the U.S. waters of the Bering, Chukchi and Beaufort seas.

3.1.3 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 asin will require extensive geophysical and geological research and the integration of newly collected data on an international scale.

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 ques-

tions 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 Atmosphere and Climate

3.2.1 Upper Atmosphere and Near-Earth Space Physics

The goals of this research are to trace the flow of energy, momentum and mass from the sun to the Earth and to understand the interaction within and between the intervening regions. The upper atmo-sphere, the ionosphere and the magneto-sphere comprise these intermediate regions. Most of the magnetosphere—the outer part of the Earth plasma environment—is connected to the polar regions through the converging magnetic field lines, and thus a large fraction of the energy that goes through the magnetosphere is deposited in the polar upper atmosphere, with dramatic consequences across the full optical, radio and particle spectra. Our understanding of these coupling processes is far from complete due to the sparsity of measurements in the Arctic regions.

Plans are being considered for a Polar Cap Observatory (PCO) near the Earth's geomagnetic pole at Resolute Bay on Cornwallis Island in the Northwest Territories of Canada. The scientific requirements for the PCO have been identified by a series of workshops that brought together leading upper-atmosphere researchers. Two chains of incoherent scatter radar facilities, one in North America and one emerging in Europe, currently provide measurements of ionospheric electron content, plasma drifts, electron and ion temperatures and a variety of other atmospheric parameters that are derived from these quantities. The Polar Cap Observatory would constitute an apex of both of these chains. The plans call for the main component of the PCO to be a state-of-the-art in-coherent scatter radar consisting of a high-power transmitter and a large steerable antenna that allows atmospheric properties to be measured over a large portion of the polar cap. Also included would be a suite of smaller optical and radio-wave devices for remotely sensing atmospheric parameters not measured by the incoherent scatter radar. This arrangement would constitute a comprehensive set of polar cap diagnostic instruments, capable of producing data for many scientists in the national and international research communities.

The state of the space environment near Earth and its response to solar inputs has come to be known as "space weather." At present there is a multiagency effort to coordinate research and model development in this area, with the goal of enabling improved space forecasting abilities. Arctic observations, such as will be made by the Polar Cap Observatory, are critical to the success of these efforts.

There is great interest in understanding and separating anthropogenic effects (for example, 20th century increased emissions of greenhouse gases) and natural variability (for example, decadal temperature swings) in the upper atmosphere. Recent evidence suggests that some of the latter is due to solar-induced effects, especially at polar latitudes. It is expected that the coupling of the sun to the upper atmosphere will become a major topic of study in the next five years. This research will be supported partially under the U.S. Global Change Research Program (USGCRP) and, because of the Arctic's high sensitivity to climate change, will focus on high latitudes.

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 Polar Cap 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 the 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 radio-wave propagation in and through the Earth's ionosphere.

3.2.2 Climate and Weather

The outstanding characteristic of the Arctic climate and weather is its dramatic variability in clouds, radiation and surface heat exchange. Most projections of future climate change suggest that high-latitude regions will incur the greatest temperature fluctuations. Research is needed to clarify the impact of potential change and to address Arctic weather problems occurring on a variety of spatial and temporal scales that range from microscale to global. A major need is for accurate regional and local weather forecasts, especially to predict such hazardous weather phenomena as Arctic lows, storm surges, icing conditions and fog, which canaffect human activities.

Objectives

- Develop an Integrated Arctic Climate Studies Program as part of the USGCRP, including studies of climate effects on Arctic indigenous peoples and biological resources, and a systematic program of intercomparison between observations and modeling results, focused on the Arctic radiative balance, cloud processes and their effects on local, regional and global climate;
- Understand the extent to which Arctic climate variations are amplified signals derived from elsewhere or are generated locally as a result of the sensitivities of the regional environment;
- Understand whether, how and with what result Arctic climate anomalies propagate to middle and lower latitudes;
- Quantify snow cover and ice feedback mechanisms that amplify climate change at high latitudes, quantify high-latitude terrestrial ice and snow changes, and consider their effects;
- Quantify land and sea surface–atmosphere momentum and both sensible and latent heat exchanges, and model the role of surface–atmosphere interactions in influencing mesoscale tropospheric and stratospheric dynamics; and
- Develop a "testbed site" on the North Slope of Alaska for making atmospheric radiation measurements to improve mathematical simulations of cloud and radiative transfer processes in General Circulation Models (GCMs) as part of the USGCRP.

3.2.3 Tropospheric and Stratospheric Chemistry and Dynamics

The chemistry of the Arctic atmosphere is dynamic, changing in response to natural and human-induced disturbances. Stratospheric ozone depletion is a global process accentuated at the poles. Ice core chemistry reveals current and historic trends in global natural and anthropogenic gas and aerosol concentrations. Expected warming trends could have a significant influence on biosphere–atmosphere interactions, trace gas emissions and retention, and atmospheric photochemical processes. In addition, an annual average of 1.7 million acres of wildfire in Alaska has an impact on airborne particulates and atmospheric chemistry.

Objectives

- Establish the correlation, if any, among the chemistry of polar stratospheric clouds in the Arctic, the ozone concentration at northern midlatitudes and the incident ultraviolet radiation reaching the Earth's surface;
- Develop a database for determining long-term regional trends in climate and air chemistry, including solar radiation levels and anthropogenic contaminant levels (organics, metals and radionuclides), across the circumpolar regions of the globe;
- Conduct periodic sampling of the Arctic stratosphere and troposphere to understand ozone depletion, atmospheric transport phenomena and the role of anthropogenic airborne pollutants in the Arctic; and
- Establish regional and seasonal variations in sources and sinks of carbon, nitrogen and sulfur, atmospheric gases and aerosol species and assess the importance of local emissions.

3.3 Land and Offshore Resources

3.3.1 Energy and Minerals

The geologic framework of the Arctic is very poorly known because of the complexities of its geologic setting, 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 indepen-

dence, as well as for local use and economics (see Section 3.1.3 for related activities).

Objectives

- Continue 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, heavy oil, tar sands, gas hydrates, solar and wind);
- 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.

3.3.2 Coastal and Shelf Processes

Erosion rates are extremely high along the Alaskan Arctic coast, where sea ice and permafrost are common. 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. 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, entrainment in frazil ice).

3.3.3 Terrestrial and Freshwater Species and Habitats

The Arctic supports many unique 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 and identify measures to mitigate the declines of Arctic biological resources and the destruction of habitats.

3.3.4 Forestry, Agriculture and Grazing

Increased knowledge of ecosystem processes and the current and potential productivity of Arctic and Subarctic forests and soils will lead to improved management practices for increasing sustainability and the productivity of renewable resources. The goals are to promote self-sufficiency among local inhabitants and to accrue economic benefits.

Objectives

- Continue and enhance a sustained program of research into ecosystem processes of northern boreal forest ecosystems, focusing on issues of forest landscape and stream ecosystem sustainability and productivity over long time periods; ecosystem stability in the face of episodic disturbance and global climate change; and interactions among atmosphere, landscape, forest and stream ecosystems and ecosystem management for societal goals;

- Enhance soil and crop science research to develop effective management practices under conditions of permafrost, low temperatures, wildfire and development impacts; and
- Provide technology for enhancing the economic well-being and quality of life at high latitudes.

3.4 Land–Atmosphere–Water Interactions

3.4.1 Glaciology and Hydrology

Documentation of seasonal, interannual and long-term trends in the physical environment of the Arctic requires attention to the special features of seasonal and perennial snow and ice cover and glaciers, especially as they relate to and record climatic change. Also, reliable information is needed on surface water quality and quantity. Collection of this information will help provide a climatic and hydrologic baseline for the Arctic. The Arctic is expected to be especially sensitive to the effects of possible global changes, including possible greenhouse warming, on terrestrial, atmosphere and marine environments.

Objectives

- Continue to develop paleoenvironmental records from ice caps, ice sheets and mountain glaciers; conduct research on the incorporation of global, hemispheric and regional climate signals in snow and ice records; conduct research on the processes by which gases, aerosols and particulates are incorporated into the snow and ice; and support interpretation of results from existing records and correlation of these records with adjacent records from other sources and proxy records;
- Document the relationships between glaciers, sea ice and global hydrology, including the relationship to world sea-level changes and climatic fluctuations, and continue to develop models for glacier mechanisms;
- Determine the consequences of specific renewable and nonrenewable resource development and harvest practices on ground and surface water, and develop predictive models for stream flow and water quality;
- Forecast future sea-level fluctuations attributable to greenhouse-gas-induced changes in polar glaciers and ice caps;
- Establish the role of land–water interactions in the control of nutrient cycling; and
- Investigate the hydrology and biogeochemistry of the Arctic drainage basin from a systems perspective, and study linkages between the land and water components of the Arctic system, with emphasis on the water resources in this system (water quality, bioaccumulation, sediment and dissolved material pathways and flux rates).

3.4.2 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;
- Understand how geologic processes affecting Arctic morphology and land surfaces have responded to changes in the past, and conversely, how these land surfaces and their constituent sediments document the history of past climate;
- Improve the ability to assess and predict the degree and rate of disturbance and recovery of permafrost terrain following natural or human-induced changes;
- Develop results leading to the ability to predict future climate-induced changes to the Arctic landscape;
- Assess the future carbon cycle within the permafrost zone under a climate warming scenario; and
- Reconstruct the late Glacial and Holocene climate history in the Arctic.

3.4.3 Ecosystem Structure, Function and Response

The Arctic is expected to be especially sensitive to the effects of possible global changes and contaminant transport and deposition on terrestrial, freshwater, marine and atmosphere environments. 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 environmental 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 CO_2 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 CO_2 flux from tundra and the responses of vegetation to elevated levels of CO_2; and
- Determine the environmental factors controlling methane fluxes.

3.5 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 advancement 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.

In this time of scarce resources, cooperation between government agencies, academia and the private sector provides an excellent opportunity to leverage resources and assure that the advanced technologies developed by government and academia can be practically and effectively applied. Development of goals that meet both commercial and technological interests will help assure that technologies developed will move rapidly into the marketplace.

The January 1993 biennial statement of the Arctic Research Commission, *Goals and Priorities to Guide United States Arctic Research,* provides clear priorities for Arctic engineering and technology. In this document the Commission found that to achieve the basic principles of the U.S. Arctic policy and to achieve the desired national competitiveness in the Arctic, the Nation's Arctic engineering capabilities must be improved through a balanced and coordinated continuing program of cold-regions engineering research at universities and national laboratories. The Commission recommended that the IARPC develop an Arctic engineering research plan with special emphasis on the following items:

- Improved methods for the continued performance of existing transportation and public facilities in cold regions;
- New and more cost-effective construction technologies and materials for Arctic purposes;
- Capabilities for testing the performance of outdoor material and equipment;
- Methods for waste disposal and local air pollution control under Arctic conditions; and
- Small-scale power generation and energy storage technologies.

The Commission also recommended that the Interagency Coordinating Committee on Oil Pollution Research support research for an adequate and thoroughly tested oil spill prevention technology and response capability for the Arctic. Three specific types of research were recommended: perfection of in-situ burning techniques, development of alternatives to combustion, and policy analysis and information transfer activities related to testing and accepting new pollution abatement processes.

The recommendations given above are consistent with those presented in the April 1990 *Findings and Recommendations of the Arctic Research Commission, Arctic Engineering Research: Initial Findings and Recommendations.* The 1990 report of the Commission also recognized the following critical areas of scientific research, the results of which are of major importance and will be crucial for successful technology development and transfer:

- Physical properties of snow and ice;
- Physical and chemical behavior of Arctic soils;
- More extensive communications and cooperation between government agencies and the professional societies, conferences with specialized Arctic engineering activities, and more effective mechanisms for technology transfer; and
- New engineering courses and programs specializing in Arctic engineering topics.

Objectives

- Develop engineering data and criteria for building, operating and maintaining strategic and operational facilities in the Arctic;
- Provide the capability to conduct logistics operations in the Arctic;
- Develop environmentally compatible engineering technologies for the Arctic;
- Provide design criteria for ship operations in ice-infested waters;
- Provide engineering data and criteria for water resources activities and environmental impact permitting;
- Ensure that future outer-continental-shelf oil and gas development operations are safe and pollution free;
- Ensure that the best available and safest technologies are used in the development of oil and gas in the Arctic;
- 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;
- Prevent the discharge of oil, chemicals and other hazardous materials into the marine environment;
- Ensure the quick, effective detection and cleanup of pollution discharges;
- Develop and maintain effective surface transportation facilities in the Arctic; and
- Develop mechanisms for technology transfer between government, academia and private industry.

3.6 Social Sciences and Health

The Arctic Research and Policy Act of 1984 makes explicit reference to the importance of the social, behavioral and health sciences (Section 102b). The purpose of the title is to establish national policy, priorities and goals for a Federal program for basic and applied scientific research. The National Science Foundation was designated as lead Federal agency for implementing this policy. The long-range goal for social science and health research was defined in the 1989 U.S. Arctic Research Plan as follows:

> To investigate the human dimensions of global, regional and local change through the study of past and present northern cultures and societies, and to gain an understanding of human–environment nteractions relating to health and well being.

In accordance with these stated goals and recommendations by the National Science Board, an Arctic Social Sciences Program was established within the Office of Polar Programs at the National Science Foundation.

In addition, an Interagency Arctic Social Sciences Task Force was established within IARPC and is chaired by the Program Director of the NSF Arctic Social Sciences Program. From the outset the Task Force implemented a Statement of Principles for the Conduct of Research in the Arctic, which addresses the need for improved communication and increased collaboration between Arctic researchers and northern peoples (see Appendix E).

The Arctic Social Sciences Task Force

The Interagency Social Science Task Force consists of various agency representatives including, but not limited to, the Department of Agriculture (USFS), the Department of Commerce (NOAA, NMFS, Sea Grant), the Department of Health and Human Services (IHS, NIH, CDC), the Environmental Protection Agency, the Department of Interior (MMS, BIA, BLM, NPS, FWS), the Department of Defense, the Department of State (OES), the Smithsonian Institution, the Council on Environmental Quality and the National Academy of Science (Polar Research Board).

Included within the mandate are the following:

- Prepare Arctic social science and health research and budget cross-cuts;
- Facilitate coordination between social sciences, health, medical and environmental research in the Arctic;
- Promote educational and training opportunities in the Arctic; and
- Advance public understanding of Arctic social science research.

U.S. Arctic Policy and Indigenous People

In September 1994 a revised U.S. Arctic Policy Statement was issued by the State Department. The new post-Cold War policy emphasizes national security, resources, science and the environment. In addition to emphasizing wise stewardship of

resources, coordination with the State of Alaska and the traditional cultural values and practices of indigenous people is recognized as essential.

International Arctic Social Science and Health Research

A number of international scientific organizations have incorporated the social and health sciences into their programs, including the International Arctic Social Sciences Association (IASSA), the International Arctic Science Committee (IASC), the Arctic Environmental Protection Strategy (AEPS) and the International Union for Circumpolar Health (IUCH).

The formation of the International Arctic Science Committee (IASC) in August 1990 brought to the forefront the need for international coordination of Arctic research. The International Arctic Social Sciences Association (IASSA) was also formed 1990 to represent the social sciences in IASC, as well as to emphasize the need for research partnerships with Native peoples. IASSA organized the First International Conference of Arctic Social Scientists in Quebec City, Canada, in October 1992, and a Second Conference (ICASS II) will take place in Rovaniemi, Finland, and Kautokeino, Norway, in June 1995. IASSA has been formally recognized as an advisory body to IASC, together with the IUCH. IASC will convene a conference in Hanover, NH, in December 1995. Two themes of importance in this context are Sustainable Use of Living Resources of High Value to Arctic Residents, and Environmental and Social Impacts of Industrialization on the Arctic.

In September 1994 the Arctic Environmental Protection Strategy convened a special seminar in Iceland on the Integration of Indigenous Peoples' Knowledge into the AEPS, with specific recommendations regarding involvement of indigenous people in environmental research and management. Arctic health was the subject of the 9th International Circumpolar Health Conference, which was held in May 1993, also in Iceland.

The U.S. has actively participated in and supported these organizations through the National Science Foundation, the National Oceanic and Atmospheric Administration, the Department of State, the Smithsonian Institution, the Department of Defense, the Department of Interior (BIA, USGS, FWS) and the Department of Health and Human Services (NIH, IHS).

The Northern Sciences Network (NSN)

The international coordination of ecological research in the Arctic has been facilitated by the Secretariat of the NSN, which is now based at the Danish Polar Centre in Copenhagen. U.S. support of the NSN is made possible through the Department of State. The High Latitude Directorate, together with NSF, has supported a study of joint management of the Alaskan/Canadian Porcupine Caribou Herd.

Arctic Contamination and the Social and Health Sciences

On December 16, 1994, Vice President Al Gore and Russian Prime Minister Viktor Chernomyrdin signed an agreement on Prevention of Pollution in the Arctic. The agreement makes specific reference to the Beringian Heritage International Park (Section 2.3), "which takes into account the interests of indigenous peoples in both countries... and underscores the importance of enhanced cooperation on Arctic pollution for the sake of the health and well-being of indigenous Northern peoples."

Since 1992 the NSF Arctic Social Sciences Program has provided funding for a four-year project dealing with comparative U.S. and Russian decision, risk and management frameworks relating to Arctic pollution and natural resource development.

The Arctic Environmental Protection Strategy (AEPS) also makes reference to human health risks and the participation of indigenous peoples in planning and implementing environmental protection. The Arctic Social Sciences Task Force has participated in DOS meetings relating to U.S. participation in the AEPS, attended IARPC meetings concerned with the Arctic Contamination Initiative, and participated in international environmental meetings of the AEPS/AMAP.

In May 1994 an IARPC Workshop on Arctic Contamination was held in Anchorage, Alaska, with several sessions dealing with Alaska Native perceptions of health risks and recommendations for the creation of an Alaska Native Science Commission (ANSC). Special funding was subsequently provided to the Alaska Federation of Natives by the Arctic Social Sciences Program to develop such a commission. The goal of the ANSC is to improve communication between the scientific community and Native people in Alaska, to facilitate the documentation and use of traditional and local Native knowledge and experience, and to better coordinate and regulate the access and logistics interests of researchers in Alaska.

A joint University of Alaska Southeast and Alaska State Office of Environmental Conservation proposal was supported by the NSF Office of Polar Programs (OPP) to examine the attitudes and perceptions of Alaska Natives about environmental risks. In parallel, an EPA-supported project is examining the special health risks of Native residents as compared with other Alaskans.

Human Dimensions of Global Change

The NSF supports three related funding opportunities for research on the Human Dimensions of Global Change (HDGC). HDGC research focuses on the interactions between human and natural systems, with an emphasis on the social and behavioral processes that shape and influence those interactions. For FY 95, proposals are being solicited for three related competitions: general research on HDGC, policy sciences research and a consortium of centers for HDGC research.

Since 1991 the NSF Arctic Social Sciences Program has funded numerous projects relating to the human dimensions of global change. This trend will continue in collaboration with the HDGC program in the NSF Social, Behavioral and Economic Sciences Directorate.

Among the general themes that especially relate to the Arctic are:

- Resource use and management, including land use, land cover and land use technologies; and
- Institutions and governance, including sociolegal dimensions of global phenomena.

The HDGC Policy Sciences Program, which is partly funded by OPP, has a strong focus on inter-disciplinary approaches and is particularly concerned with basic research on environmental policies, including:

- The impacts of environmental policies on environmental attitudes;
- Research on risk and uncertainty;
- Societal values and environmental justice; and
- International environmental monitoring and compliance regimes.

In addition to the NSF, other agencies such as NOAA and the Smithsonian Institution's Arctic Studies Program support research on the HDGC. The Smithsonian Institution's Arctic Studies Center opened a regional office in Anchorage, Alaska, in cooperation with the Anchorage Museum of History and Art in 1994. This office will develop research, education and exhibition programs with local constituencies and will participate in the Jesup 2 North Pacific Research Program, which will investigate global cultural, biological and environmental change in a Beringian context.

Training and Education

The numbers of researchers working in the North are small, and it has long been recognized that this situation requires special attention. Arctic research is costly for established scholars and can be prohibitive for younger academics and graduate students.

The lack of graduate education in the North has also made it difficult for Native students to pursue academic careers in science and education. For these reasons the NSF and Federal agencies in Alaska bear special responsibilities for supporting science, not only through research grants but through training and educational programs.

The Arctic Social Sciences Program has awarded 21 dissertation improvement grants for PhD degrees, three of which were for Alaska Native graduate students. Other forms of support are the NSF Research Experience for Undergraduate (REU) supplements, which provide training through participation on research projects.

The RAPS (Resource Apprenticeship Program) of the Department of Interior has provided summer jobs for Alaska Natives through the NPS, BLM and FWS. Other programs, such as the Co-op Ed 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, field trips) and other opportunities for education that foster stewardship and the conservation of heritage resources. Project SEEK involved Mt. Edgecumbe High School students in archaeological excavation and analysis in Tongass National Forest. The USDA Forest Service is continuing a comprehensive program of cultural resource presentations, subsistence awareness sessions, and site monitoring and protection, in cooperation with the University of Alaska Southeast, Ketchikan Campus. The USDA/FS will continue to sponsor multicultural educational opportunities involving Native and local communities, as well as the diverse range of National Forest visitors.

The SI has conducted educational programs in the North Pacific and Russian Far East and provided museum and exhibit training in Anchorage and Fairbanks (see Section 2.3).

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 cul-tural resources, historic and prehistoric sites, arti-facts and landscapes require documentation and protection, renewable resources, especially fish and game, are also culturally defined through subsistence needs. In 1989, Alaska State subsis-

tence laws were declared unconstitutional because they discriminated against nonrural 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.

It is increasingly necessary that Federal agencies coordinate their activities and increase collaboration with Native, university, private and state research interests. The Arctic Research Commission reports *Improvements to the Scientific Content of Environmental Impact Statement Process* (December 1989, 1992) and the Arctic Research Commission Biennial Statement *Goals and Priorities to Guide United States Arctic Research* (1993) emphasize the necessity of peer-reviewed research. Better research ultimately entails improved management and savings for all sectors of society, both public and private.

Alaska Tribal Commission and Tribal Sovereignty

The Indian Law Enforcement Act (Public Law 101-379) was signed into law on August 18, 1990. The Act established a Joint Federal–State Commission on Policies and Programs Affecting Alaska Natives. Congress, recognizing the growing economic crisis among Alaska Natives, found it timely to review all policies and programs designed to serve Alaska Natives and to determine specific actions that would help assure that public goals were being achieved.

On January 11, 1993, the Office of the Solicitor of the Department of Interior issued a 133-page memorandum (M-36975) titled *Governmental Jurisdiction of Alaska Native Villages Over Land and Nonmembers*. The Joint Federal–State Commission, as well as the Governor and Attorney General of Alaska, Native and Congressional leaders, were consulted. The conclusion expressed by the DOI is that Alaska Natives are eligible for benefits provided under a number of statutes for the benefit of Indian tribes and their members. This implies that Native villages in Alaska can qualify as Federally recognized tribes.

Although tribal status can be recognized for villages, it was also concluded that the Alaska Native Claims Settlement Act (ANCSA) precludes Native lands from being recognized as Indian country (tribal lands). This limits the extent to which Alaska Native villages can exercise sovereignty within the State of Alaska. It is expected that Alaska Natives will continue to argue for the right to have their lands recognized as tribal.

3.6.1 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, some of which are rapidly losing their traditional lifeways, languages and cultural heritage. This traditional and local knowledge base can provide long-term information about northern ecosystems and wildlife, of considerable value in resource management.

The fact that many agencies have similar administrative and management structures and mandates suggests that excellent opportunities exist for interagency cooperation. The opening of the Smithsonian's Arctic Center office in Anchorage offers possibilities for cooperation between land-managing agencies and the Smithsonian in a wide variety of research and programmatic activities. With tighter budget restraints, interagency collaboration is not only preferable but will increasingly become necessary.

A number of agencies support research on archaeology, history and Native culture (BIA, BLM, USFS, NPS, SI, NSF). In addition, the DOS U.S. Man and the Biosphere Program (MAB) has a High Latitude Ecosystem Directorate, which is charged with developing multiyear interdisciplinary (social/natural) core projects.

Because of the dependence of northern peoples on hunting and fishing, these studies are closely linked to zoological and ecological conditions throughout the Arctic. Finds of artifacts and bones give evidence of past economies, and historical and ethnographic descriptions tell of more recent conditions. Coastal resources—fish, seals, walruses, whales—supported the largest human populations in Alaska, and changing shorelines and maritime conditions are reflected by these sites.

To maximize the effectiveness of research sponsored by Federal agencies, there needs to be increased initial planning and coordination of projects, pooling of technical resources and use of existing databases. The results of such research should also be made public through popular publications, and special efforts made to make results accessible to residents potentially affected by the research.

Objectives

- Document and analyze the origins and trans-

formations 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 become a major priority for museums and research institutes since the passage of NAGPRA (Native American Graves Protection 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 of Alaskan collections at the Smithsonian has led to several major collection returns during the past several years, with more to follow in the future. Consultation in this process has opened new channels of communication between the Smithsonian and Alaska Native peoples that offer potential for future program development in research, education and exhibition development in collaboration with the Institution's Arctic Studies Center office.

3.6.2 Rapid Social Change and Community Viability

The Polar Research Board Report *Arctic Social Sciences: An Agenda for Action* (1989) defined major priorities for research under three themes: human–environment interactions, rapid social change and community viability. As stated in the 1990-91 Biennial Revision, the study of contemporary change in northern societies is the least developed in the Federal research system and yet in terms of human impact should have high priority. While many problems—unemployment, inadequate education, social breakdown and poor health—are found elsewhere, the unique physical environment of the Arctic exacerbates the problems. Communities are small and isolated and function under extreme environmental restraints; economic development is extremely costly and environmental impacts are long-lasting. Furthermore, there are major conflicts between the cultural values of indigenous peoples and Western culture.

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 has been a concurrent loss of traditional cultural values. Chronic unemployment, family violence, substance abuse and societal breakdown in general have reached epidemic proportions. One key to recovery is the facilitation of increased local control of land, resources, social institutions and education. All across the Arctic, including Alaska, there are demands for greater political autonomy. While this will add greatly to northern community empowerment, success will ultimately depend on economic viability and the balancing of development with ecologically sound policies. Within these contexts, subsistence hunting and fishing is a major factor in northern socioeconomics.

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.

3.6.3 Health

Health can be defined as a combination of physical, psychological, social and spiritual well-being. Unique cross-cultural interactions and social interdependencies due to harsh environmental conditions in the Arctic highlight this definition. Consequently Arctic health research must take into account complex human and environmental interactions.

Health research in the Arctic includes basic and applied biomedical research (such as molecular biology and genetics), the study of the effects of cultural change on Native populations, epidemiology of disease, adaptation of humans to extreme environmental conditions, environmental health risks, contamination and health care delivery in remote and isolated communities. Health concerns in the Arctic are often related to international health issues. Western culture (and potentially Asian culture) can impact Native people adversely by introducing lifestyle and dietary changes and new infectious agents. Research

esigned to study these effects and techniques for disease prevention is urgently needed. Health research in the Arctic is done, individually or collaboratively, by the Arctic Investigations Program of the Centers for Disease Control, the Indian Health Service, the National Institutes of Health, the Substance Abuse and Mental Health Services Administration, the Department of Defense and the Division of Public Health, State of Alaska. Nonclinical research on social and behavioral aspects of health is supported by the National Science Foundation's Arctic Social Sciences Program.

Among the ongoing and planned activities in Arctic health research is the continuation of studies of fetal alcohol syndrome among Alaska Natives, including projects for research and training designed to counteract this fully preventable problem. The National Institute for Occupational Safety and Health and the Center for Environmental Health, in collaboration with the State of Alaska, will continue studies on the epidemiology, risk factors and prevention strategies for occupational injuries in Alaska communities. Investigations will continue on the incidence of Alaska Natives with cancer; a five-year surveillance project and the establishment of a database are part of this project.

In 1994 the National Institute on Alcohol Abuse and Alcoholism (NIAAA), in conjunction with the Office of Research on Minority Health at NIH, funded a study titled "Phenotypes of Alcoholism among Native Alaskans." The five-year study is designed to examine the genetic, biological and behavioral characteristics of alcoholism subtypes among Alaska Natives in comparison to alcoholics at six sites in the lower 48 states. Identification of these characteristics may have implications for improving patient–treatment matching procedures and for developing more-effective prevention and treatment programs. The study involves a collaboration between scientists at the University of Connecticut, the Indiana University School of Medicine and the University of Alaska.

NIAAA also funded a research study in 1994 through the University of Alaska to assess the degree to which alcohol control by Alaska Native villages has reduced the risk of violent death by homicide, suicide and accidents. The 18-month study consists primarily of statistical analyses of death certificates from 1980 to 1990. Estimates are being made of the effects of the legal status of alcohol on the risk for death of individuals of a given age, sex and marital status.

Other areas of focus are research on suicide among Alaska Native youth, alcohol and substance abuse, and mental health with the goal of establishing an American Indian and Alaska Native Mental Research Center. The NIH/NIDA has just funded the first NIH Fellowship in the State of Alaska. The fellowship grant deals with substance abuse and AIDS risk. A State Epidemiology Working Group is also being developed and will deal with substance abuse and its correlates and consequences (such as AIDS, STDs, TB, violence and crime).

Research on the accumulation of pollutants at the base of the human food chain and potential health risks due to nuclear contamination are the subject of both U.S. and international efforts in connection with the AEPS. This effort coincides with the IARPC Arctic Contamination Initiative.

The DOD will continue to study the Polar T Syndrome for Arctic residents, circannual seasonal patterns in energy balance, cold injury and cold weather clothing and rations.

The National Science Foundation's Arctic Social Sciences Program is supporting research on childrearing practices and Native perceptions of environmental risk, as well as a comparative multidimensional Alaskan–Siberian study of Native health status and rapid social change.

Objectives

- Establish and support basic and applied scientific inquiry for the purpose of improving health through biomedical and behavioral research programs;
- Disseminate new information derived from basic and applied research into studies of the etiology, pathogenicity, prevention, diagnosis and treatment of human biomedical disorders and studies of the psychosocial factors associated with poor health status or associated with environmental contaminants;
- Establish and support epidemiologic monitoring systems in the Arctic that can guide research and assist in the development of timely interventions;
- Study individual populations for underlying connections between substance abuse, infectious diseases, accidents, and sociocultural and economic conditions; and
- Make Arctic health data and information more accessible to the public.

4. Logistics and Operational Support

Ships and Ice Platforms

Vessels supporting research in ice-covered areas fall into five categories, based on their ice-going capability. The categories are:

- Icebreakers operated by the Coast Guard;
- Ice-capable and ice-strengthened vessels for research and survey purposes;
- Nuclear submarines provided by the U.S. Navy;
- Manned drifting ice stations; and
- NOAA's National Undersea Research Program (NURP) capabilities and expertise with manned and unmanned deep-diving vehicles.

The Federal Oceanographic Fleet Coordinating Council (FOFCC) 1990 report supports the need for the Coast Guard to maintain and operate a fleet of icebreakers for polar ice escort, logistics support and research support. It reaffirms that an ice-capable research ship should be operated as a national facility for both the Federal and academic communities.

The Arctic Research and Policy Act (ARPA) confirms the Coast Guard's role as manager of the nation's icebreaker fleet to serve the Nation's interests in the heavy ice regions of the Arctic. This includes security, economic and environmental interests. Research in support of those interests is specified in ARPA. Coast Guard icebreakers support research in these regions in two general ways: on dedicated science deployments and, as opportunities arise, in conjunction with other missions. The Coast Guard has two icebreakers and is acquiring a third. A design and construction contract was awarded to Avondale Industries, Inc., of New Orleans in July 1993. The vessel is scheduled to be delivered in FY 98.

A research vessel providing all-season access to the Arctic region is essential for many research requirements. The University National Oceanographic Laboratory System (UNOLS) published updated Scientific Mission Requirements for the Arctic Research Vessel in 1993 and completed the Arctic Research Vessel Preliminary Design Report in 1994.

As part of the planning process, the National Academy of Sciences is conducting a review and evaluation of the scientific requirements for an Arctic research vessel in the context of current national research needs in the Arctic ocean regions. The study includes an assessment and update of past studies, a comprehensive analysis of all Arctic facilities and their roles in meeting research requirements, and recommendations for national planning and coordination.

Coast Guard icebreakers are available to users on a partial-reimbursable basis. Daily fuel costs and a portion of the helicopter and ship maintenance costs are charged to users, as mandated by OMB.

Drift stations and other ice platforms including Russian and Canadian opportunities will be utilized as research needs dictate. A manned drifting ice station, SHEBA (Surface Heat Budget of the Arctic), is planned for April 1997. It is anticipated that SHEBA will drift for 16 months, making it the first U.S. year-round ice station since AIDJEX in 1975-76.

In late 1994 the U.S. Arctic Research Commission assisted in drafting and implementing a Memorandum of Agreement (MOA) that lays the foundation for a series of annual nuclear submarine cruises dedicated to science in the Arctic Ocean, starting in the spring of 1995. This new series of science cruises is a follow-on to the very successful proof-of-concept deployment of the USS *Pargo* in the summer of 1993. The 1995 cruise is on the USS *Cavella*. During these cruises the principal mission of the submarines will be to conduct unclassified experiments selected from competitive proposals. The submarines will spend 40–60 days each year collecting data in the Arctic, with the costs being shared by the U.S. Navy (which will provide the Arctic-capable submarine at no cost to the science community) and the participating science agencies (who will fund the experiment and the unique data collection systems to be installed). Each cruise will be supported by the Naval Undersea Warfare Center's Arctic Submarine Laboratory, which has coordinated all the Navy's Submarine Arctic Exercises for the past 40 years. Scientists conducting key experiments may be able to accompany the ship on the cruises.

The unique opportunities for collecting comprehensive data in areas of the Arctic Ocean, many of which are routinely accessible only by submarine, are significant, particularly because the Navy intends to declassify all data and make it available to the world science community. Some of the types of data to be collected include:

- Water samples at various depths;
- Depth and roughness of the ice canopy;
- Meteorological observations;
- Topographic, bathymetric and gravity profiling; and
- Studies of Arctic Basin water masses, their sources and circulation.

Measurements will be taken while underway and submerged, when surfaced through the ice, or by

the deployment of automatic buoys, which can provide continuous data via satellite long after the submarine has departed.

In addition to these purely scientific benefits, the knowledge gained during these cruises will assist policymakers in making decisions regarding environmental protection, fisheries management, natural resource distribution, and exploitation and management of the Arctic Ocean and adjoining coasts.

The Arctic Science Submarine Cruise MOA is the product of several years of effort and negotiation among numerous agencies through the Arctic Research Commission. The MOA was signed by the National Science Foundation, the National Oceanographic and Atmospheric Administration, the U.S. Geological Survey, the Chief of Naval Research, the Director of the Submarine Warfare Division in the Office of the Chief of Naval Operations, and the Commanders of both the Atlantic and Pacific Submarine Forces. It is a significant document that demonstrates a unique interagency partnership established to address national and global issues for the benefit of all, while using available resources. The resultant availability of submarines provides a new source and level of operational support for research and will both expand and improve the quality of data sets from the central Arctic Ocean.

The NOAA National Undersea Research Program has extensive expertise and experience in conducting deep-diving efforts in all types of aquatic environments. NURP is assessing the possible application of their expertise and capabilities to studies focusing on the contamination of the Arctic, particularly contamination associated with the practices of the former Soviet Union.

Land-Based Facilities

The Polar Ice Coring Office provides logistics support for research in Greenland. The logistics support for the NSF facilities in Sondrestrom have changed dramatically since Greenland was granted Home Rule and since September 1992 when the U.S. Air Force terminated operations at Sondrestrom. The logistics support, which was provided by the Air Force, is now done through arrangements negotiated with the Greenland Home Rule Government.

The Polar Ice Coring Office (PICO) provides logistics support as required for NSF in Kangerlussuaq (formerly Sondrestrom AB), Greenland. In 1995 the New York Air National Guard ski-equipped LC-130s will shift most of their Greenland operations to Thule AB and will also operate from Kangerlussuaq when appropriate.

The Space and Naval Warfare Systems Command (SPAWAR) provides logistics support for research in Greenland and at ice stations on the Arctic Ocean sea ice. U.S. investigators have access, on a cooperative or reimbursable basis or both, to logistics staging bases in Canada and Greenland (Thule, Alert and Station Nord). SPAWAR maintains a heated warehouse building (10,800 sq. ft.) at Thule, Greenland, for storing and maintaining field equipment for the support of research facilities on sea ice. An office and billeting facility, with HF communications, is also maintained. SPAWAR and NSF/ARCSS/PICO are cooperating on the use of the Thule AB SPAWAR Arctic logistics infrastructure.

U.S. investigators have access, on a cooperative or reimbursable basis or both, to land-based facilities in Canada and Nordic countries. Cooperative arrangements with the Polar Continental Shelf Project Office in Canada provide for logistics support in the Canadian High Arctic. Facilities in Svalbard are available through the Norwegian Polar Institute, Norwegian universities and other national programs.

Small seasonal camps are maintained in the Alaskan Arctic by individual agencies or groups of agencies to support field programs. The Toolik Lake camp, operated by the University of Alaska and now being upgraded with NSF/PICO support, and the privately operated facilities at Barrow and Prudhoe Bay provide fixed bases for land-based research (DOC/NOAA, DOE, DOI/FWS/NPS/GS, NSF).

DOC/NOAA maintains a warehouse building, located at Elmendorf Air Force Base, for storing and maintaining field equipment, scientific instruments and Arctic gear. The building provides nearly 7000 sq. ft. of heated space (DOC/NOAA/NOS).

Atmospheric Facilities and Platforms

Poker Flat Rocket Range, Alaska, is being upgraded with DOD funds ($10 million in FY 92) to state-of-the-art upper-atmosphere research capability so that it can support coordinated rocket and atmospheric monitoring programs.

Subject to the agreement of the Danish authorities, periodic rocket launches take place from Thule and Kangerlussuaq, Greenland. The U.S. incoherent-scatter radar facility at Sondrestrom is used by several agencies. The U.S. Air Force terminated operations at Kangerlussuaq Air Base on September 30, 1992. Science programs that formerly relied on the Air Force for logistics support are now supported by sponsoring agencies. NSF has also sponsored the construction of a building at Resolute Bay, Northwest Territories,

Canada, to house a variety of instruments for upper atmospheric and space research. Referred to as the Early Polar Cap Observatory, this facility could become a focal point for future space physics experiments within the polar cap.

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.

Central Coordination and Logistics Information Clearinghouse

Several agencies compiled a directory of Federal Arctic research logistics capabilities. The State of Alaska has published a complementary inventory of Arctic logistics capabilities. Federal agencies participated in a logistics planning workshop at the Arctic Science Conference, Fairbanks; a workshop report was published. The Department of the Interior supports an Alaska Office of Aircraft Services (OAS), which coordinates aircraft services on a reimbursable basis.

An electronic bulletin board, formerly on OMNET, is being redesigned and updated for use on the Internet. The IARPC Logistics and Operational Support Working Group and NSF are coordinating this effort.

Data Facilities

Archiving and distribution functions for data required in support of Arctic research are distributed among all the U.S. national data centers. Disciplinary data for the Arctic 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). Global satellite data archives for polar-orbiting satellites are held at NOAA/NESDIS/Satellite Data Services Division.

There is a particular Arctic focus at two facilities, the National Snow and Ice Data Center (NSIDC) at the University of Colorado at Boulder and the Alaska SAR Facility at the Geophysical Institute at the University of Alaska Fairbanks. The NSIDC provides access to cryospheric data for both northern and southern hemispheres, with the present emphasis on the Arctic. NSIDC is chartered and 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 the NASA Earth Observation System Data and Information System (EOSDIS) project as a Distributed Data Archive Center (DDAC), providing data services for snow and ice, including products from passive microwave remote sensing instruments, such as SSM/I and SMMR, and in-situ data.

The Alaska SAR Facility also operates a DDAC under contract to NASA/EOSDIS. The facility receives and processes polar imagery from synthetic aperture radars on the currently operational European and Japanese (ERS-1 and JERS-1) satellites. Data from the Canadian Radarsat will be included when it becomes operational. Higher-level data products from the SAR data include sea ice motion and classification, and ocean wave height and direction parameters. Other data sets maintained at ASF, with an Alaska regional emphasis, include Landsat and AVHRR imagery, and the 1978–1986 Alaska High-Altitude Photography (AHAP).

Without archives, Arctic data would in time be lost. Without a method to locate data in the archives, scientists would have no access to the data required for Arctic and other research. Both the Arctic Environmental Data Directory (AEDD), with its Arctic focus, and the Global Change Master Directory (GCMD), having a broader mandate, are vital windows into the U.S. national data archives, providing a means for scientists to locate the data they require.

5. Bibliography

Alaska Federation of Natives (1989) The AFN Report on the Status of Alaska Natives: A Call for Action. Anchorage, Alaska.

Arctic Research Commission (1988a) Entering the Age of the Arctic: Opportunities and Obligations of an Arctic Nation. Los Angeles, California.

Arctic Research Commission (1988b) Logistics Support of Arctic Research. Issue No. 1, Washington, D.C.

Arctic Research Commission (1989) Arctic Data and Information: Issues and Goals. Findings and Recommendations. No. 3, Washington, D.C.

Arctic Research Commission (1990a) Arctic Engineering Research: Initial Findings and Recommendations. Washington, D.C.

Arctic Research Commission (1990b) Logistic Support of United States Research in Greenland: Current Situation and Prospects. No. 6, Washington, D.C.

Arctic Research Commission (1991a) Goals, Objectives and Priorities to Guide United States Arctic Research. Issue No. 7, Washington, D.C.

Arctic Research Commission (1991b) Arctic Research in a Changing World. Washington, D.C.

Arctic Research Commission (1992) Research Needed to Respond to Oil Spills in Ice Infested Waters. Washington, D.C.

Arctic Research Commission (1993) Goals and Priorities to Guide United States Arctic Research. Washington, D.C.

Arctic Research Consortium of the United States (1991) Arctic System Science: Land/Atmosphere/Ice Interactions—A Plan for Action. Boulder, Colorado.

Arctic Research of the United States (1990) Interagency Arctic Research Policy Committee (NSF 90-151), Fall 1990, Washington, D.C.

Carlson, R., J. Zarling and L. Link (1989) Cold Regions Engineering Research —Strategic Plan. *Journal of Cold Regions Engineering,* Vol. 3, no. 4.

Committee on Earth and Environmental Sciences (1991) Our Changing Planet: The FY 1992 U.S. Global Change Research Program. Office of Science and Technology Policy, Washington, D.C.

Federal Oceanographic Fleet Coordination Council (1990) Federal Oceanographic Fleet Requirements. Washington, D.C.

Glosten Associates (1993) Concept Design Status Report for an Arctic Research Vessel. Seattle, Washington.

Hopkins, D.M., W.H. Arundale and C.W. Slaughter (1990) Science in Northwest Alaska: Research Needs and Opportunities on Federally Protected Lands. Occasional Paper No. 3, Alaska Quaternary Center, University of Alaska, Fairbanks, Alaska.

Interagency Arctic Research Policy Committee (1987) United States Arctic Research Plan. Washington, D.C.

Interagency Arctic Research Policy Committee (1990) Arctic Oceans Research: Strategy for an FY 1991 U.S. Program. Washington, D.C.

Interagency Arctic Research Policy Committee (1991) Biennial Revision of the United States Arctic Research Plan. *Arctic Research of the United States,* Spring 1991, Washington, D.C.

Interagency Arctic Research Policy Committee (1991) Strategy for Integrated U.S. Arctic Research Programs. Washington, D.C.

Jet Propulsion Laboratory (1989) Science Plan for Alaska SAR Facility Program. NASA-JPL Publication 89-14, Pasadena, California.

Joint Oceanographic Institutions Inc. (1990) Arctic System Science: Oceans–Atmosphere–Ice Interactions. Washington, D.C.

Kelley, J.J., H. Stockholm and D. Dahl (Ed.) (1990) New Technological Developments in Support of Arctic Research. University of Alaska Fairbanks.

Kivilahti, R., L. Kurppa and M. Pretes (Ed.) (1990) Man's Future in Arctic Areas. *Proceedings of the 13th Polar Libraries Colloquy,* University of Lapland, Rovaniemi, Finland.

Laughlin, T.L. (1988) Report of the Arctic Environmental Data Workshop, Boulder, Colorado, November 21–24, 1988. NOAA, Washington, D.C.

Minerals Management Service (1992) Federal Arctic Research Information. Report of March 1991 Workshop, Anchorage, Alaska.

National Research Council (1989) Arctic Social Science: An Agenda for Action. National Academy Press, Washington, D.C.

National Science Board (1987) The Role of the National Science Foundation in Polar Regions—A Report to the National Science Board. NSB 87-128, Washington, D.C.

Office of Management and Budget (1990) Presidential Report on Polar Icebreaker Requirements. Washington, D.C.

Schneider, J.L. (1990) 1990 Annual Report on Alaska's Mineral Resources. Circular 1056, U.S. Geological Survey, Washington, D.C.

State of Alaska (1990) Cooperation in a Changing

World. Summary Proceedings, Third Northern Regions Conference, Anchorage, Alaska.
Thomas, C.P. et al. (1991) Alaska Oil and Gas: Energy Wealth or Vanishing Opportunity? Report DOE/ID/01570-H1, Department of Energy, Washington, D.C.
Thomas, R.H. (n.d.) Polar Research from Satellites. Joint Oceanographic Institutions, Inc., Washington, D.C.
UCAR (1988a) Arctic Interactions: Recommendations for an Arctic Component in the International Geosphere–Biosphere Programme. Office of Interdisciplinary Earth Sciences, Report OIES-4, Boulder, Colorado.
UCAR (1988b) Ocean Systems Studies, NOAA/OAR Research Strategy. I, The Ocean System.
U.S. Forest Service (1988) Forest Health and Productivity in a Changing Atmospheric Environment, A Priority Research Program. Washington, D.C.

Appendix A: Glossary of Acronyms

ADAMHA	Alcohol, Drug Abuse and Mental Health Administration
ADEOS	Advanced Earth Observation System
ADI	Arctic Data Interactive
AEDD	Arctic Environmental Data Directory
AEPS	Arctic Environmental Protection Strategy
AFES	Agriculture and Forestry Experiment Station
AFN	Alaska Federation of Natives
AGASP	Arctic Gas and Aerosol Sampling Program
AHAP	Alaska High-Altitude Photography
AIP	Arctic Investigations Program
ALERT	Arctic Long-term Environmental Research Transects
AMAP	Arctic Monitoring and Assessment Program
ANILCA	Alaska National Interest Lands Conservation Act
AOSB	Arctic Ocean Science Board
ARC	Arctic Research Commission
ARCSS	Arctic Systems Science
ARCUS	Arctic Research Consortium of the United States
ARM	Atmospheric Radiation Measurements program
ARPA	Arctic Research and Policy Act
ASF	Alaska SAR Facility
AUV	Autonomous Underwater Vehicles
AVHRR	Advanced Very High Resolution Radiometer
BERPAC	Program for Long-Term Ecological Research in Ecosystems of the Bering and Chukchi Seas and the Pacific Ocean
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOM	Bureau of Mines
CART	Cloud and Radiation Testbed
CDC	Centers for Disease Control
CD-ROM	Compact Disk–Read-Only Memory
CIRES	Cooperative Institute for Research in Environmental Sciences
CMDL	Climate Monitoring and Diagnostic Laboratory (formerly GMCC)
CONRIM	Council on Northern Resources Information Management
CRREL	Cold Regions Research and Engineering Laboratory
CSRS	Cooperative State Research Service
DA	Department of Agriculture
DDAC	Distributed Data Archive Center
DHHS	Department of Health and Human Services
DIF	Directory Interchange Format
DIRWOG	Data and Information Resources Working Group
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOS	Department of State
DOT	Department of Transportation
EM	Environmental Management (DOE)
EML	Environmental Measurement Laboratory
EOSDIS	Earth Observation System Data and Information System
EPA	Environmental Protection Agency
ER	Energy Research
ERS-1	European Remote-sensing Satellite
ESDD	Earth Science Data Directory
FE	Fossil Energy
FHWA	Federal Highway Administration
FIRE	First ISCCP Regional Experiment
FOFCC	Federal Oceanographic Fleet Coordinating Council
FS	Forest Service
FSU	Former Soviet Union
FWS	Fish and Wildlife Service
FY	Fiscal Year
GCM	General Circulation Model
GCMD	Global Change Master Directory
GIS	Geographic Information System
GISP2	Greenland Ice Sheet Project II
GS	Geological Survey
HCFA	Health Care Financing Administration
HDGC	Human Dimensions of Global Change program
HF	High Frequency
HRSA	Health Resources Services Administration
IARPC	Interagency Arctic Research Policy Committee
IASC	International Arctic Science Committee
IASSA	International Arctic Social Sciences Association
IGBP	International Geosphere–Biosphere Program
IHP	International Hydrological Program

IHS	Indian Health Service
ISCCP	International Satellite Cloud Climatology Program
ITEX	International Tundra Experiment
JERS-1	Japanese Earth Resources Satellite
JPL	Jet Propulsion Laboratory
LTER	Long-Term Ecological Research
MAB	Man and the Biosphere
MARC	Machine Readable Record
MF	Medium Frequency
MMS	Minerals Management Service
NAD	Nansen Arctic Drilling program
NADP/NTN	National Atmospheric Deposition Program/National Trends Network
NAGPRA	Native American Graves Protection Act
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite Data and Information Service
NIGEC	National Institute of Global Environmental Change
NIH	National Institutes of Health
NISC	National Information Services Corporation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Oceanographic Service (NOAA)
NPS	National Park Service
NSB	National Science Board
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
NSN	Northern Sciences Network
NURP	National Undersea Research Program (NOAA)
OAII	Ocean–Atmosphere–Ice Interactions
OAR	Office of Oceanic and Atmospheric Research
OAS	Office of Aircraft Services
OES	Bureau of Oceans and International Environmental and Scientific Affairs (DOS)
OIES	Office of Interdisciplinary Earth Sciences
ONR	Office of Naval Research
OSRI	Oil Spill Recovery Institute
PICES	Pacific International Council for the Exploration of the Sea
PRB	Polar Research Board
RADARSAT	Canada's imaging satellite
REU	Research Experience for Undergraduates program
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SeaWiFS	Sea-Viewing Wide-Field Sensor
SHEBA	Surface Heat Budget of the Arctic Ocean program
SI	Smithsonian Institution
SMMR	Scanning Multichannel Microwave Radiometer
SPAWAR	Space and Naval Warfare Systems Command
SSM/I	Special Sensor Microwave/Imager
TCP/IP	Transmission Control Protocol/ Internet Protocol
TOPEX	Poseiden Ocean Topography Experiment
UCAR	University Corporation for Atmospheric Research
UNEP/GRID	United Nations Environmental Program/Global Resources Information Database
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOLS	University National Oceanographic Laboratory System
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey
USPIWG	United States Polar Information Working Group
WAIS	Wide Area Information Server

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

February 1, 1992, to January 31, 1994

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 "dealing with particularity the recommendations of the Arctic Research Commission with respect to Federal interagency activities in Arctic research and the disposition and responses to those recommendations." In response to this requirement, the IARPC has examined all recommendations of the Arctic Research Commission since February 1992. The required statement appears in Appendix A.

Activities and Accomplishments

During the period February 1, 1992, to January 31, 1994, the IARPC has:

- Prepared and published the third biennial revision to the United States Arctic Research Plan, as required by Section 108(a)(4) of the Act. The President transmitted the Plan to Congress on July 29, 1993.
- Published and distributed four issues of the journal *Arctic Research of the United States.* The journal reviewed all Federal agency Arctic research for FY 91 and 92 and included summaries of the IARPC and Arctic Research Commission meetings and activities. The Spring 1993 issue contained the full text of the third 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 all meetings of the Commission, and responded to Commission reports and recommendations on logistics, oil spills in ice-infested waters, natural resources, environment, engineering and technology (Appendix A).
- Continued the processes of interagency cooperation required under Sections 108(a)(6), (7), (8) and (9).
- Provided input to an integrated budget analysis for Arctic research for the President's budget, which identified $148 million in Federal support for FY 92 and $155 million in FY 93.
- Arranged for public participation in the development of the third biennial revision to the U.S. Arctic Research Plan as required in Section 108(a)(10). This public involvement culminated in a meeting in Anchorage in May 1993.
- Converted the Arctic Environmental Data Directory (AEDD), which now contains information on 370 Arctic data sets, to be available from Alaska as a resource on the Internet using the Wide Area Information Service (WAIS).
- Co-chaired, through a representative, an international workshop recommending the network approach to sharing information about circumpolar Arctic data sources.
- Continued the activities of an Interagency Social Sciences Task Force and prepared a coordinated social sciences and health research plan. Of special concern is research on the health of indigenous peoples and research on the Arctic as a unique environment for studying human environmental adaptation and sociocultural change. A special issue of the journal *Arctic Research of the United States* was devoted to the health and social sciences.
- Supported continued U.S. participation in the nongovernmental International Arctic Science Committee.
- Participated in the 1993 National Security Council review of U.S. policy in the Arctic. This review recommended expanding the focus of U.S. Arctic policy to include greater

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

emphasis on science and environmental protection.

- Participated in policy formulation and official endorsement of the September 1993 second international Ministerial meeting on the Arctic Environmental Protection Strategy. This strategy contains a set of principles and objectives for the protection of the Arctic environment. IARPC's Arctic Monitoring Working Group serves as a U.S. focal point for the Arctic Monitoring and Assessment Program (AMAP) and coordinates domestic monitoring efforts.
- Focused attention within the U.S. government on the dumping of nuclear waste and other toxic waste materials by the former Soviet Union on land and into the Arctic Ocean, seas and rivers.
- In response to international and U.S. awareness and concern about this dumping, approved a *Policy Statement on Arctic Contamination* on August 27, 1992, and an *Agenda for Action* to implement the Policy Statement in November 1992.
- Convened a workshop on Arctic contamination in Anchorage, Alaska, from May 2 to 7, 1993. Besides radionuclide contamination the workshop addressed heavy and trace metal, persistent organic and hydrocarbon contamination. The workshop's purposes were to characterize the extent of Arctic contamination by evaluating and identifying existing data and information about Arctic contamination, to identify major data gaps that prevent a comprehensive analysis of Arctic contamination, and to begin the process of determining whether specific Arctic contaminants present a risk to the environment, ecosystems or human health in Alaska, the Arctic or the global environment.
- Developed a coordinated Federal agency research initiative on Arctic contamination, in accordance with a resolution adopted at IARPC's meeting on July 1, 1993. The strategy maximizes individual agency mission-related programs and expertise to address the key unanswered questions about Arctic contamination. The strategy is intended to help guide internal agency planning and assist in budget deliberations of the Executive Branch and the Congress. The overall goal of the IARPC Arctic contamination research program is to assess sources, transport, fate, effects and risks of contaminants directly dumped in the Arctic, as well as contaminants accumulating in the Arctic from non-Arctic sources, on human health and ecosystems on Alaska, on the remainder of the Arctic and on the Earth as a whole. The results will be used to provide a sound scientific basis for informed policy decisions concerning the possible risks of, and responses to, this contamination. To achieve this goal the program will systematically determine the type, location, distribution, transportation pathways and mechanisms, and history of Arctic contaminants. This approach involves development of an integrated, comprehensive assessment, including data rescue and synthesis, observations, process-oriented research, model development, impacts analysis and determination of risk, and information management.
- Convened two formal meetings of the Committee, in August 1992, and July 1993, and twenty-four meetings of the IARPC staff to accomplish the above items.

Appendix C: Arctic Research Budgets of Federal Agencies

		Budget (dollars in thousands)		
Dept/Agency	*Program name*	*FY 94 actual*	*FY 95 budget*	*FY 96 proposed*
DOD	Arctic Engineering	2,976	3,547	3,632
DOD	Permafrost/Frozen Ground	1,245	1,124	1,194
DOD	Snow and Ice Hydrology	7,181	6,178	6,097
DOD	Oceanography	8,665	8,000	7,997
DOD	Lower Atmosphere	397	134	129
DOD	Upper Atmosphere	2,500	2,250	2,250
DOD	Medical and Human Engr	2,262	1,880	1,884
DOD	Arctic Contamination Studies	10,000	10,000	0
	DOD TOTAL	35,226	33,653	23,183
DOI/MMS	Technology Assessment/Research	2,820	3,320	3,320
DOI/MMS	Environmental Studies	1,900	1,810	1,810
DOI/USGS	Energy and Minerals	6,500	4,500	4,500
DOI/USGS	Natural Hazards	3,500	3,500	3,500
DOI/USGS	Global Change	2,000	1,500	2,500
DOI/USGS	Marine and Coastal Geology	1,000	1,000	1,000
DOI/USGS	Geomagnetism	250	250	250
DOI/USGS	Ice and Climate	480	480	480
DOI/USGS	Hydrology	130	130	130
DOI/USGS	Mapping	1,000	1,070	1,070
DOI/NBS	Marine Mammals	1,600	1,660	1,660
DOI/NBS	Migratory Birds	2,560	2,390	2,390
DOI/NBS	Fisheries Research	360	360	360
DOI/NBS	Cooperative Research	330	330	330
DOI/NBS	Terrestrial Ecology	1,130	1,130	1,130
DOI/NBS	Park Research	1,140	1,140	1,140
DOI/BLM	Minerals (ANWR)	10	0	0
DOI/BLM	Natural Ecology	1,175	1,180	1,500
DOI/BLM	Cultural Resources	168	200	250
DOI/BLM	Pipeline Monitoring	500	500	500
DOI/BLM	Fire Control	350	350	350
DOI/BLM	Mining Administration	250	250	250
DOI/NPS	Cultural Resources	850	790	790
DOI/NPS	Natural Ecology	1,400	1,650	1,650
DOI/BIA	Cultural	1,500	600	600
DOI/BIA	Subsistence	850	1,050	1,250
DOI/BOM	Mineral Resources Assessments	3,637	1,362	1,000
DOI/BOM	Mining/Reclamation Technology	383	0	0
DOI/BOM	Mining/Reclamation Technology	211	175	175
	DOI TOTAL	37,984	32,677	33,885
NSF	Atmospheric Sciences	9,130	9,130	9,130
NSF	Ocean Sciences/Ship Support	2,738	2,740	2,740
NSF	Biological Sciences	4,274	4,270	4,270
NSF	Glaciology	4,101	4,100	4,100
NSF	Earth Sciences	3,440	3,440	3,440
NSF	Arctic Systems Science	13,326	13,330	19,330

Dept/Agency	Program name	Budget (dollars in thousands) FY 94 actual	FY 95 budget	FY 96 proposed
NSF	Engineering	62	100	100
NSF	Social Science/Education	2,018	2,020	2,090
NSF	Coordination	835	800	800
NSF	Arctic Research Commission	560	570	500
	NSF TOTAL	40,484	40,500	46,500
NASA	Polar Ocean/Ice Sheets	6,500	6,500	6,000
NASA	Land Processes	2,700	1,900	1,800
NASA	Solid Earth Science	1,200	1,200	1,200
NASA	Atmospheric Sciences	1,000	1,500	1,500
NASA	Arctic Ozone	1,500	1,500	1,500
NASA	Sounding Rocket Program	6,750	3,750	4,500
NASA	Ops/Maint Poker Flat Range	1,500	1,500	1,500
NASA	Poker Flat Range Upgrades	5,000	0	0
NASA	Sub-orbital Science	1,400	1,250	1,250
NASA	Iono/Thermo/Mesospheric SR&T	1,290	1,300	1,300
NASA	FAST Auroral Snapshot	800	4,200	4,000
NASA	Magnetospheric SR&T	1,000	1,000	1,000
NASA	Solar Terrestrial Theory	420	420	420
	NASA TOTAL	47,460	40,520	38,970
DOC/NOAA	Arctic Haze	50	0	0
DOC/NOAA	Solar Terrestrial	201	201	204
DOC/NOAA	Atmos Trace Constituents	185	185	185
DOC/NOAA	Environmental Prediction	950	950	950
DOC/NOAA	Fisheries Assessment	2,478	2,476	2,476
DOC/NOAA	Marine Mammal Assessment	1,200	1,200	1,200
DOC/NOAA	Coastal Hazards	42	44	44
DOC/NOAA	Ocean Assessment	112	102	0
DOC/NOAA	Stratospheric Ozone	150	200	200
DOC/NOAA	Satellites/Data Management	800	800	800
DOC/NOAA	Human Resources	569	617	617
DOC/NOAA	Aircraft/Vessels	2,500	2,500	2,500
DOC/NOAA	Climate and Global Change	784	720	720
DOC/NOAA	Arctic Ice	315	475	500
	DOC TOTAL	10,336	10,470	10,396
DOE/EM	Environ Monitoring/Assessment	1,150	1,150	1,150
DOE/EML	Environmental Measurements	20	20	20
DOE/ER	Nat Inst Global Env Change	300	300	300
DOE/ER	Response to Carbon Dioxide	60	0	0
DOE/ER	Atmos Radiation/Planning	500	500	500
DOE/ER	Magnetosphere Research	140	0	0
	DOE TOTAL	2,170	1,970	1,970
DHHS	Indian Health Service	250	250	250
DHHS	National Institutes of Health	3,932	4,348	4,525
DHHS	Communicable Disease Con Ctr	2,057	2,051	2,063
DHHS	HCFA	200	100	0
	DHHS TOTAL	6,439	6,749	6,838
SMITHSONIAN	Anthropology	630	500	600
SMITHSONIAN	Arctic Biology	75	50	75
	SMITHSONIAN TOTAL	705	550	675
DOT/USCG	Test and Evaluation	800	500	0
DOT/USCG	Arctic Science Support Equipment	702	719	719
DOT/USCG	Extramural Support	35	25	25

Dept/Agency	Program name	Budget (dollars in thousands) FY 94 actual	FY 95 budget	FY 96 proposed
DOT/FHA	Stream Crossings/Hydrological	375	100	100
DOT/FHA	Pavement Problems	1,000	800	800
DOT/FHA	Soils/Subbases (Permafrost)	80	50	50
DOT/FHA	Weather Monitoring/Storm Forecast	90	140	140
DOT/FHA	Snow Control/Pavement Treatment	374	330	330
	DOT TOTAL*	3,456	2,664	2,164
EPA	Arctic Contaminants	925	0	0
EPA	Climate Change	200	157	0
EPA	Radionuclide Contamination (DOD)	0	0	0
EPA	Comparative Risk Assessment	75	0	0
EPA	Region 10 R-EMAP (Alaska)	0	250	250
	EPA TOTAL	1,200	407	250
AGRICULTURE	Forest Service–Environment	959	912	912
AGRICULTURE	Forest Service–Climate Change	441	488	488
AGRICULTURE	Agricultural Research Service	730	0	0
AGRICULTURE	Cooperative State Res–Environ	722	725	725
AGRICULTURE	Cooperative State Res–Food/Saf	790	793	793
AGRICULTURE	Natural ResCon S–Environ	1,102	1,040	1,040
AGRICULTURE	Natural ResCon S–Climate C	276	260	260
	AGRICULTURE TOTAL	5,020	4,218	4,218
STATE	Arctic Environmental Research	500	350	350
STATE	MAB: Arctic Directorate	200	200	200
	STATE TOTAL	700	550	550
	GRAND TOTALS	191,180	174,928	169,599

* DOT/USCG provides an additional $14.4 million to maintain two Polar-class icebreakers for Arctic science support.

Appendix D: 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 E: Principles for the Conduct of Research in the Arctic

Prepared by the Social Science Task Force of the U.S. Interagency Arctic Research Policy Committee, and approved by IARPC, June 28, 1990

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 Division 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 F: White House Statement on Agreement on Prevention of Pollution in the Arctic

THE WHITE HOUSE
Office of the Vice President

For Immediate Release December 16, 1994

U.S.-Russian Joint Commission
on Economic and Technological Cooperation

Fact Sheet

U.S.-RUSSIAN PARTNERSHIP ON RESPONSIBLE STEWARDSHIP OF THE ARCTIC

A landmark in post-Cold War U.S.-Russian cooperation was reached today when Vice President Al Gore and Prime Minister Viktor Chernomyrdin signed an Agreement on Prevention of Pollution in the Arctic.

The Agreement recognizes that traditional national security interests in the Arctic should be supplemented by joint efforts to understand and control pollution of the Arctic from all sources. The Agreement also underscores the importance of enhanced cooperation on Arctic pollution for the sake of the health and well-being of indigenous Northern peoples.

The Agreement calls on the two countries to cooperate in assessing the levels of hazardous contamination and their potential environmental impacts. It also authorizes consultation on technical measures to eliminate radioactive and other types of contaminants.

In the spirit of the new Agreement, the two countries will cooperate with Norway to assess the feasibility of expanding Russia's capability to treat low-level liquid radioactive waste in Murmansk, the world's largest city above the Arctic Circle.

U.S. and Russian experts are expected to meet in Alaska early in 1995 to discuss environmentally safe oil and gas development, production, and transportation in the Arctic. American expertise may also play a role in responding to the recent oil spill in the Komi region of the Russian Arctic.

Another initiative relating to the Arctic environment is the creation of a binational Beringian Heritage Park straddling the Bering Strait. This initiative would facilitate cooperation for the protection of the natural resources of the Beringia region, while taking into account the interests of indigenous peoples in both countries.

Russia and the U.S. will also continue to work actively under the Arctic Environmental Protection Strategy, an international forum which includes all Arctic nations.

###

AGREEMENT BETWEEN THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE GOVERNMENT OF THE RUSSIAN FEDERATION ON COOPERATION IN THE PREVENTION OF POLLUTION OF THE ENVIRONMENT IN THE ARCTIC

The Government of the United States of America and the Government of the Russian Federation (hereinafter referred to as the Parties),

Recognizing the sensitivity of the Arctic environment and our mutual commitment to protect the Arctic environment and to promote the social and economic interests of local, especially indigenous populations, including their traditional way of life;

Concerned over the potential threats posed by contaminants in the Arctic region to the health of the indigenous and local populations of the region as well as to its flora and fauna;

Convinced that cooperation and sharing of experience between the Parties will contribute to understanding and effective response to any such threat both on a national basis and within broader international efforts to protect the Arctic environment;

Desiring to build upon the results of the American-Russian Summit held in Vancouver, April 3-4, 1993;

Noting the particular importance of relevant provisions of Part XII of the United Nations Convention on the Law of the Sea of 1982; the provisions of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972; and the provisions of the Arctic Environmental Protection Strategy of 1991;

Have agreed as follows:

Article 1

The Parties shall cooperate in the prevention, reduction and control of pollution in the Arctic marine and terrestrial environment resulting from the accidental or intentional introduction of contaminants into that environment.

To this end the Parties shall cooperate in research, monitoring, assessment and other activities, bilaterally and in the appropriate multilateral fora.

Article 2

1. The Parties shall cooperate in the conduct of scientific research, monitoring, and assessment activities to determine the potential impacts of contaminants in the Arctic environment, including, inter alia:

1) the pathways by which such contaminants reach and are dispersed within the Arctic environment;

2) the effects of such contaminants, including rates of bio-accumulation, upon Arctic flora and fauna, including fish populations; and

3) the effects of such contaminants upon human health in the Arctic environment, especially upon local and indigenous populations.

2. The Parties further shall cooperate in the monitoring and assessment of levels of hazardous contamination in the Arctic environment, including, inter alia:

1) exchange of data and information on the effects of disposal and release of such contaminants introduced directly or indirectly into the Arctic environment;

2) determination of the level, chemical composition, and patterns of such contamination caused by releases from sites at which materials have been stored, processed or disposed; and

3) determination of the amount, concentrations and dynamics of transport of such contaminants introduced into the marine zone, including through rivers and other watercourses, natural or artificial, and via ice transport and ice rafted sediment.

3. The Parties shall consult with regard to technical solutions for the elimination of radioactive and other types of contamination impacts.

4. The Parties shall cooperate in the conduct of joint scientific research to predict ecological impacts of the existing disposals of radioactive waste and consult with regard to technical solutions for the elimination of disposals in places where ecological safety is not insured.

5. Cooperation between the Parties in scientific research and monitoring referred to in this Article shall take place bilaterally, and within the appropriate international, including regional, mechanisms, in particular the Arctic Monitoring and Assessment Program of the Arctic Environmental Protection Strategy of 1991 and the International Arctic Seas Assessment Program of 1993 the International Atomic Energy Agency.

Article 3

1. Each Party shall facilitate joint activities under Article 2 in areas that are under its jurisdiction in accordance with international law and that are or are believed to be contaminated, under such reasonable conditions as it may establish.

2. The Parties shall ensure that the data and information resulting from such research and monitoring are exchanged and made freely available on a reciprocal basis.

Article 4

The Parties shall promote the development of specific measures to give effect to this Agreement, including:

1) programs for the exchange of scientists, students and experts;

2) organization of seminars and meetings of experts;

3) organization of joint research activities, including marine scientific research cruises;

4) development of Geographic Information Systems, data bases and inventories on Arctic environmental data;

5) cooperation in emergency preparedness exercises and prompt exchange of information concerning major accidental releases of contaminants into the Arctic environment; and

6) exchange of information on technologies and assessment methodologies applicable within the framework of this Agreement and on relevant environmental protection legislation and regulations.

Article 5

Activities under this Agreement, including specific projects and programs, shall be carried out by responsible agencies of each Party in accordance with the Agreement Between the Government of the Union of Soviet Socialist Republics and the Government of the United States on Cooperation in Ocean Studies of 1990 and the Agreement between the Government of the United Sates and the Government of the Russian Federation on Cooperation in the Field of Protection of the Environment and National Resources of 1994 and under the overall coordination of the United States-Russian Commission on Economic and Technological Cooperation or under any other coordinating body as may be agreed by the Parties.

Article 6

1. All activities undertaken pursuant to this Agreement shall be conducted in accordance with the applicable laws, regulations, and procedures in both countries and shall be subject to the availability of funds and personnel.

2. Scientific and technological information resulting from cooperation under this Agreement, other than information which is not disclosed for national security, commercial or industrial reasons, shall be made freely available, unless otherwise agreed.

3. Issues of intellectual property created or furnished in the course of joint activities under this Agreement shall be governed by Annex II of the Agreement between the Government of the United States of America and the Government of the Russian Federation on Science and Technology Cooperation, signed at Moscow December 16, 1993.

Article 7

The Parties shall resolve by consultation any differences as to the interpretation or application of this Agreement.

Article 8

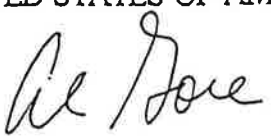
1 This Agreement shall enter into force upon signature and remain in force for a period of five years, and may be extended for additional five year periods upon written agreement of the Parties.

2. Either Party may terminate this Agreement by so notifying the other Party in writing. Such termination shall be effective six months from such written notification.

IN WITNESS WHEREOF, the undersigned, being duly authorized by their respective Governments, have signed this Agreement.

DONE at Moscow, in duplicate, this sixteenth day of December 1994, in the English and Russian languages, each text being equally authentic.

FOR THE GOVERNMENT OF
THE UNITED STATES OF AMERICA:



FOR THE GOVERNMENT OF
THE RUSSIAN FEDERATION:

Appendix G: U.S. National Arctic Policy Statement

On September 29, 1994, the United States announced a new policy to deal with emerging issues in the Arctic region. The policy highlights six principal objectives:

- 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 local, regional, and global environmental issues.
- Meeting post-Cold War national security and defense needs.

Background

The United States has been an Arctic nation, with important interests in the region, since the purchase of Alaska over a century ago. National security, economic development, 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 added interdependence and new challenges and opportunities for policy makers in Arctic nations.

The new U.S. Arctic policy reflects these elements of continuity and change. It emphasizes environmental protection, environmentally sustainable development, and the role of indigenous people, while recognizing U.S. national security requirements in a post-cold war world. It also is concerned with the need for scientific research and the importance of international cooperation to achieving Arctic objectives.

Arctic Environmental Protection Strategy

The United States is expanding cooperation under the Arctic Environmental Protection Strategy (AEPS).

Beginning in 1989, the eight Arctic countries—United States, Canada, Denmark, Finland, Iceland, Norway, Russia, and Sweden—began discussions on improving Arctic cooperation. In 1991, in Rovaniemi, Finland, they reached agreement on the Arctic Environmental Protection Strategy (AEPS). This contains objectives as well as an action plan, which includes four implementing working groups.

Sustainable Development and Environmental Assessment

The United States aims to work with international organizations to improve protection of the environment while providing for environmentally sustainable development. The task force established at the September 1993 Ministerial Meeting, in Nuuk, Greenland, broadens the AEPS by investigating sustainable development issues. These activities are essential to determine priorities and set a course for the future.

The Nuuk Ministerial Meeting produced a Declaration on Environment and Development in the Arctic and established the Task Force on Arctic Sustainable Development. The declaration stressed the importance of the UN Conference on Environment and Development to the Arctic and reaffirmed the Ministers' commitment to conserve, protect, and, as appropriate, restore the ecosystems of the Arctic. Federal agencies are reviewing environmental assessment procedures to assure that development planning takes into account cyclical economic impacts, social impacts on indigenous people, and long term environmental impacts. The U.S. will urge other

AEPS Implementing Working Groups

Arctic Monitoring and Assessment Program (AMAP): Assesses the health and ecological risks associated with contamination from radioactive waste, heavy metals, persistent organics, and other contaminants, some of which originate many miles away from the Arctic region.

Conservation of Arctic Flora and Fauna (CAFF): Studies the adequacy of habitat protection and ways to strengthen wildlife protection, possibly through an international network of protected areas, more effective laws, and conservation practices.

Protection of the Arctic Marine Environment (PAME): Studies national and international legislation to determine how these laws can be strengthened to further protect the Arctic marine environment. PAME examines a range of sources and contaminants including offshore oil and gas development, ocean dumping of radioactive wastes, and other matter and land-based sources of pollution.

Emergency Prevention, Preparedness and Response (EPPR): Addresses the problems of disasters not created by nature. The group has focused recently on risk assessments, dealing with nuclear disasters and rapid response to oil spills. ❑

Arctic nations to adopt and implement transparent domestic procedures for environmental assessment which assure that development planning addresses the full range of economic, social, and environmental impacts from national government projects that affect the Arctic.

Scientific Research

The United States plans to further scientific research through development of an integrated national Arctic research program. This would include support for international cooperation in monitoring, assessment, and environmental research.

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.

Conservation

The United States works to improve efforts to conserve Arctic wildlife and protect habitat, with particular attention to polar bears, walruses, seals, caribou, migratory birds and boreal forests. It cooperates with other Arctic nations to conserve the region's rich and unique biological resources and is engaged in a cooperative review of existing Arctic wildlife reserves, including relevant U.S. reserves in Alaska. For example, the review is examining with Canada whether existing reserves and reserve management policies in the two countries adequately protect the habitat of the Porcupine River caribou herd.

With other Arctic nations, the U.S. strengthens conservation of polar bears, seals, and walruses. Consistent with the Agreement on the Conservation of Polar Bears, the U.S. is discussing ways to improve conservation of polar bear populations whose range extends to Russia and the United States. The U.S. also is exploring options to better implement measures, such as the 1916 Migratory Bird Treaty, to conserve populations of migratory species of birds that breed in the Arctic.

Environmental Safeguards

The United States is working with other Arctic nations to protect the marine environment from pollution from land-based and offshore development activities and from potentially increased use of the Arctic Ocean as a shipping corridor. The U.S also is reviewing the adequacy of current U.S. emergency response measures and urges other Arctic nations to adopt comparable marine environmental safeguards.

Indigenous People and The State of Alaska

The U.S. is increasing involvement with the state of Alaska and Alaskan indigenous people in Arctic policy-making. Representatives of the State, local governments, and indigenous people will be included where appropriate on U.S. delegations to international meetings. Federal agencies will give careful consideration to the unique health, cultural and environmental concerns of indigenous people when developing Arctic policies.

Cooperation With Russia And Other Nations

The U.S. plans to improve overall international cooperation, especially U.S.-Russian Arctic environmental cooperation.

The end of the Cold War has created opportunities for enhanced cooperation on Arctic issues. Russia has substantial scientific expertise but limited economic resources; it faces major challenges in dealing with problems of pollution and species conservation that affect the Arctic region. The U.S. Government will consider Arctic issues in initiatives for Russian assistance. Meeting the expanded need for environmental cooperation in the Arctic will require strengthened international institutions. The United States will seek to create a more formal policy forum through which Arctic nations can oversee implementation of Arctic strategy. ■

Selected Meetings of Interest

Listed here is a compilation of recent and forthcoming meetings, workshops and conferences on Arctic or northern topics and activities. Readers are invited to submit information on upcoming meetings, as well as reports on national or international meetings attended, to Editor, Arctic Research, *Arctic Research and Policy Staff, Office of Polar Programs, National Science Foundation, 4201 Wilson Boulevard, Arlington, Virginia 22203.*

1995

Symposium on Biochemistry of Seasonally Snow-Covered Catchments (ICSI/ICWQ/ICT)
3–14 July 1995
Contact: K. Tonnessen, U.S. National Park Service, Air Quality Division, P.O. Box 25287, Denver, Colorado 80225-0287

XIV International Union for Quaternary Research (INQUA) and IPA Council Meeting
3–10 August 1995, Berlin, Germany
Contact: Congress Partner GMBH, Emmastr. 220, 28213 Bremen, Germany
Tel: 49 421 21 9073
Fax: 49 421 21 6419

Arctic Ungulate Conference
13–17 August 1995, Fairbanks, Alaska
Contact: David Klein, Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7020, USA
Fax: 1 907 474 6967

Global Change and Geography
14–18 August 1995, Moscow, Russia
Contact: Secretariat, IGU '95, Staromonetry 29, Moscow 109017, Russia
Fax: 7 095 230 2090
E-mail: geography@glas.apc.org

POAC–The 13th International Conference on Port and Ocean Engineering Under Arctic Conditions
15–18 August 1995, Murmansk, Russia
Contact: Alexandre Timofeev, Murmansk Shipping Co., 15 Kominterna St., 183636 Murmansk, Russia
Fax: 47 789 10442

IGS International Symposium on Glacial Erosion and Sedimentation
20–25 August 1995, Reykjavik, Iceland
Contact: Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, U.K.
Phone: 0223 355974
Fax: 0223 336543

International Conference on Environmental Radioactivity in the Arctic
21–26 August 1995, Oslo, Norway
Contact: Hans A. Velle, Norwegian Radiation Protection Authority, P O Box 55, N-1345 Osteraas, Norway
Fax: 47 6714 7407
E-mail: Hans.Velle@nrpa.no

The International Arctic Science Committee has established a new service to the Arctic research community: an Arctic meetings listing available via the Internet. Called SAM (Survey of Arctic Meetings), it contains information on international arctic meetings, as well as major national meetings with international participation. The World Wide Web address for SAM is http://www.npolar.no/iasc/sam.htm.

International Conference on Past, Present, and Future Climate
22–25 August 1995, Helsinki, Finland
Contact: SILMU, Academy of Finland, P.O. Box 57, FIN-00551, Helsinki, Finland
Phone: 358 0 7748 8338
Fax: 358 0 7748 8299
E-mail: silmu@aka.fi

Managing Common Resources in the North: Divergent Interest in a Changing World
4–8 September 1995, Kangerlussuaq, Greenland
Contact: Geir Arnulf, Center for Environment and Development, University of Oslo, P.O. Box 1050 Blindern, 0316 Oslo, Norway
Fax: 47 22 85 46 05

Periodic Changes in the Arctic Tundra
9–10 September 1995, Kangerlussuaq, Greenland
Contact: Nils Chr. Stenseth, Institute of Zoology, University of Oslo, P.O. Box 1050 Blindern, 0316 Oslo, Norway
Fax: 47 22 85 46 05

EISMINT International Symposium on Ice-Sheet Modeling
18–22 September 1995, Strasbourg, France
Contact: C.S.M. Doake, EISMINT, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.
or
P. Pirra, EISMINT, European Science Foundation, 1 quai Lezay Marnésia, F-67080 Strasbourg Cedex, France

The 46th AAA Arctic Division Science Conference–Landscapes: Human Ecology/Landscape Ecology/Earth System Science
19–22 September 1995, Fairbanks, Alaska, USA
Contact: Robert White, Chair, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7000 USA
Phone: 1 907 474 7648
E-mail: ffrgw@aurora.alaska.edu
or
Patricia Anderson, Executive Secretary, Center for Global Change, University of Alaska Fairbanks, Fairbanks, Alaska 99777-7740
Phone: 1 907 474 5698
E-mail: atricia@gi.alaska.edu

Shaping Tomorrow's North–The Role of Tourism and Recreation
12–15 October, 1995, Thunder Bay, Ontario
Contact: Center for Northern Studies, Lakehead University, Thunder Bay, Ontario, P7B 5E1, Canada
Phone: 1 807 343 8360
Fax: 1 807 343 8100
E-mail: robbie.ferguson@lakeheadu.ca

PICES Annual Meeting
16–22 October 1995, Qingdao, People's Republic of China
Contact: PICES Secretariat, P.O. Box 6000, Sidney, British Columbia, Canada V8L 4B2
Fax: 1 604 363 6827
E-mail: pices@ios.bc.ca

Third International Polar Ecotourism Symposium
23–26 October 1995, St. Petersburg, Russia
Contact: (France and International) Laurence Girard, General Secretary, A pas de Loup, 48 av. Félix Faure, 75015 Paris, France
Phone/fax: 33 1 45 57 48 99
or
(Russia) Svetlana Gusarova Petercon, Bogatyrsky 12, St. Petersburg 197348, Russia
Fax: 19 7 812 3522688

1955 Wadati Conference on Global Change and the Polar Climate
7–10 November 1995, Tsukuba Science City, Japan
Contact: Wadati Conference, c/o Dr Hiroshi Tanaka, Institute of Geoscience, University of Tsukuba, Tsukuba, Ibaraki, 305, Japan
Fax: 81 298 51 9764
E-mail: tanaka@atm.geo.tsukuba.ac.jp

Second International Conference on Development of the Russian Arctic Offshore (RAO-95)
18–22 September 1995, St Petersburg, Russia
Contact: Alexander Bolshev, St. Petersburg State Technical University, Polytechnicneskaya 29, St. Petersburg, Russia 195251
Fax: 7 812 534 1227
E-mail: SPGP1@sovam.com

International Conference for Arctic Research Planning
5–9 December 1995, Hanover, New Hampshire
Contact: Oran R. Young, Director, Institute of Arctic Studies, 6193 Murdough Center, Dartmouth College, Hanover, New Hampshire 03755, USA
Fax: 1 603 646 1279
E-mail: oran.r.young@dartmouth.edu

Monitoring of Permafrost and Frozen Soils: Implications for Studies of Periglacial Processes Under a Changing Climate (proposed)
American Geophysical Union Fall Meeting
11–15 December 1995, San Francisco, California
Contact: Bernard Hallet, Quaternary Research Center, AK-60, University of Washington, Seattle, Washington 98195, USA
Phone: 1 206 685 2409
Fax: 1 206 543 3836
E-mail: hallet@u.washington.edu

1996

International Union of Circumpolar Health Meeting
Third week of May 1996, Anchorage, Alaska, USA
Contact: Tom Bender, International Union for Circumpolar Health, P.O. Box 212001, Anchorage, Alaska 99521-2001 USA
Fax: 1 907 786 4353

ISOPE '96–Offshore and Polar Engineering Conference
26–31 May 1996, Los Angeles, California, USA
Contact: Jin S. Chung, Chairman, ISOPE-96, Box 1107, Golden, Colorado 80402-1107, USA
Tel: 1 303 273 367
Fax: 1 303 420 3760

Second International Conference on Cryopedology
June 1996, Syktyvkar, Russia
Contact: David Gilichinsky, Institute of Soil Science and Photosynthesis, Pushchino, Moscow Region, Russia
Tel: 7 095 923 1887
E-mail: gilichin@issp.serpukhov.su

Interpraevent 1996: Protection of Habitat Against Floods, Debris Flows and Avalanches
24–28 June 1995, Garmisch-Partenkirchen, Germany
Contact: Interpraevent 1996, c/o Bayerisches Landesamt für Wasserwirtschaft, Lazarettstr. 67, D-806365 Munich, Germany

30th International Geological Congress
4–14 August 1996, Beijing, China
Contact: Professor Zhao Xun, 30th International Geological Congress, P.O. Box 823, Beijing 100037, China
Phone: 86 1 8327772
Fax: 86 1 8328928

International Symposium on Representation of the Cryosphere in Climate and Hydrological Models
12–15 August 1996, Victoria, British Columbia, Canada
Contact: Secretary General, International Glaciological Society, Lensfield Road, Cambridge, CB2 1ER, United Kingdom
Phone: 44 1223 355974
Fax: 44 1223 336543

8th International Cold Regions Engineering Conference
12–17 August 1996, Fairbanks, Alaska, USA
Contact: Larry Bennett, School of Engineering, University of Alaska, Fairbanks, Alaska 99775, USA
Tel: 1 907 474 6121
Fax: 1 907 474 6087

IX International Symposium on the Physics and Chemistry of Ice
27–31 August 1996, Hanover, New Hampshire, USA
Contact: Victor Petrenko, 8000 Cummings Hall, Dartmouth College, Hanover, New Hampshire 03755-8000, USA

International Conference on Oil, Gas and Ecology of the Earth Cryosphere
September 1996, Nizhnevartovsk, Tumen
Contact: Vladimir Melnikov
Tel: 34 52 24 3649; Fax: 34 52 22 3380
E-mail: root@ikz.tyumen.su

1997

8th International Symposium on Ground Freezing and 3rd International Symposium on Frost in Geotechnical Engineering
14–17 April 1997, Luleå, Sweden

ISCORD 1997 International Symposium on Cold Regions Development
16–19 June 1997, Anchorage, Alaska, USA
Contact: Ted Vinson, Department of Civil Engineering, Oregon State University, Corvallis, Oregon 97331-2302, USA
Tel: 1 503 753 0725
Fax: 1 503 753 3052
E-mail: vinsont@ccmail.orst.edu

IV International Geomorphology Conference and IPA Executive Committee Meeting
28 August–3 September 1997, Bologna, Italy
Contact: M Panizza, University Degli Studi di Moden, 59-41100 Modena, Italy
Phone: 059 23 0394
Fax: 059 21 8326

1998

Seventh International Conference on Permafrost
27–31 July 1998, Yellowknife, Canada
Contact: J.A. Heginbottom, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8, Canada
Phone: 1 613 992 7813
Fax: 1 613 992 2468
E-mail: heginbottom@gsc.emr.ca

Interagency Arctic Research Policy Committee Staff

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.

Richard Cline
U.S. Forest Service
Department of Agriculture
Washington, DC 20090
(202-205-1524)

Renee Tatusco
National Oceanic and Atmospheric Administration
Department of Commerce
Silver Spring, Maryland 20910
(301-713-2469)

Bradley Smith
Department of Defense
Washington, DC 20301
(703-695-9604)

Merrill Heit
Department of Energy
Washington, DC 20545
(301-903-0238)

Sidney Draggan
U.S. Environmental Protection Agency
Washington, DC 20460
(202-260-4724)

Philip S. Chen, Jr.
National Institutes of Health
Department of Health and Human Services
Bethesda, Maryland 20892
(301-402-2220)

James Devine
U.S. Geological Survey
Department of Interior
Reston, Virginia 22092
(703-648-4423)

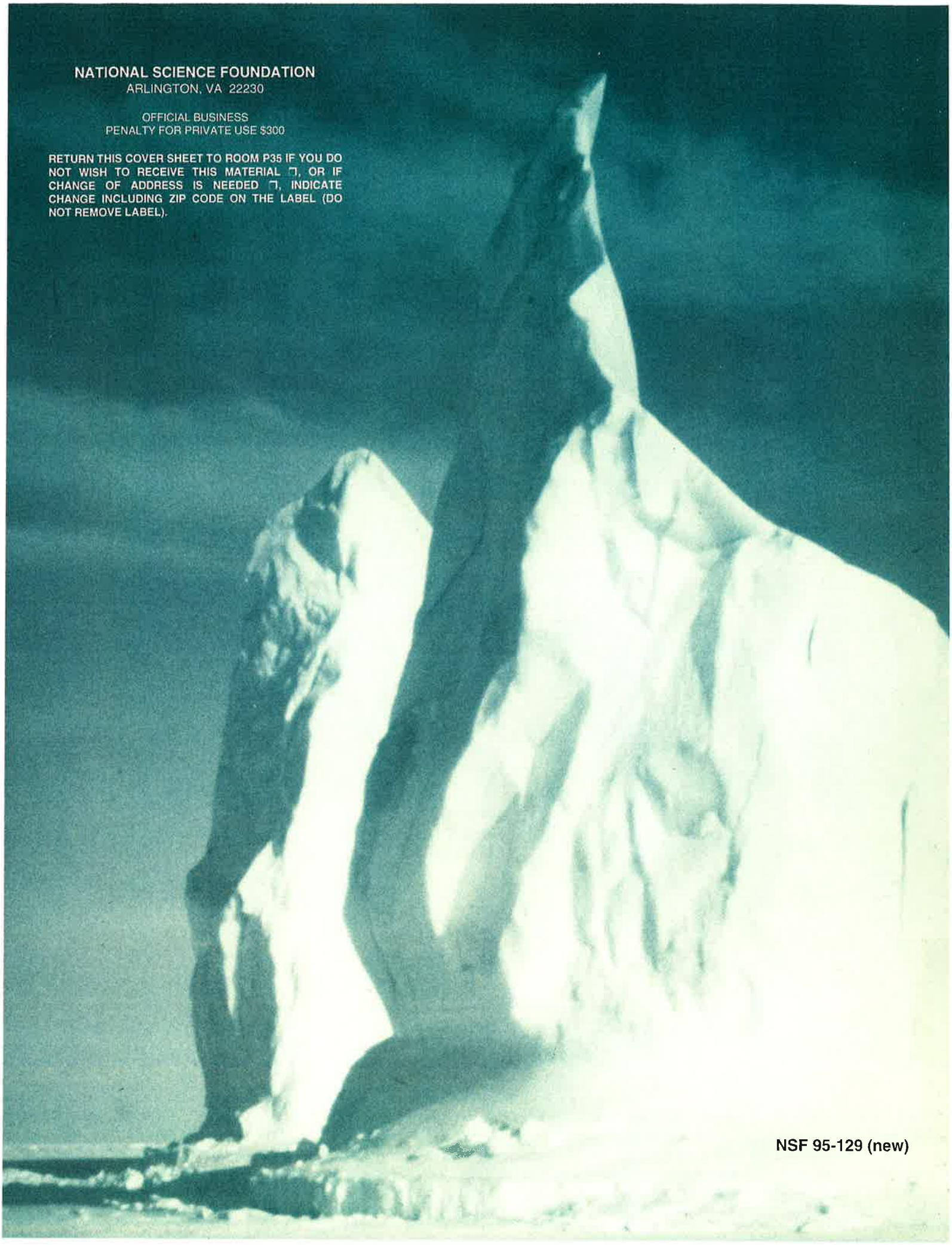
Robert Thomas
National Aeronautics and Space Administration
Washington, DC 20546
(202-358-1154)

Charles E. Myers
National Science Foundation
Arlington, Virginia 22230
(703-306-1031)

William Fitzhugh
Smithsonian Institution
Washington, DC 20560
(202-357-2682)

Robert S. Senseney
Department of State
Washington, DC 20520
(202-647-3262)

Captain Alan Summy
U.S. Coast Guard
Department of Transportation
Washington, DC 20593
(202-267-1450)



NSF 95-129 (new)