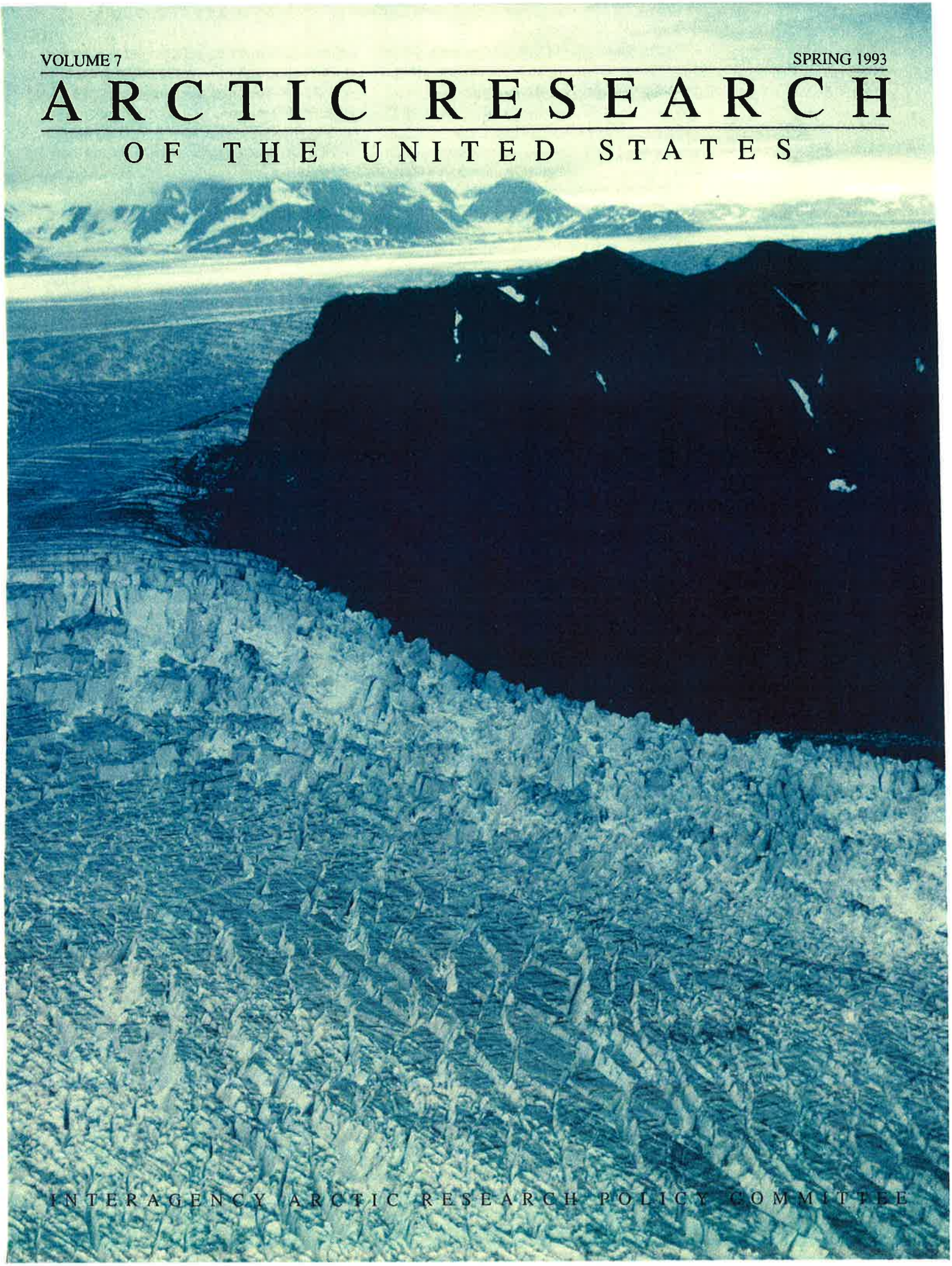
VOLUME 7 SPRING 1993

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*, Division of Polar Programs, Room 620, National Science Foundation, Washington, D.C. 20550.

Cover

Ice crevasses within Bering Glacier wrap around at the northwestern terminus of the Grindle Hills, Alaska, showing evidence of a new surge of the glacier. Bering Glacier, almost 200 kilometers long, is the largest glacier in North America. (Photograph by Bruce F. Molnia.)

VOLUME 7 SPRING 1993

ARCTIC RESEARCH

OF THE UNITED STATES

U.S. Arctic Research Plan
Biennial Revision: 1994–1995

United States Arctic Research Plan

Biennial Revision: 1994–1995

Executive Summary

1. Background

As required by the Arctic Research and Policy Act of 1984 (Public Law 98-373),* 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 revision was submitted on August 1, 1989, and the second revision was submitted in July 1991. This document, the third biennial revision to the Arctic Research Plan, updates the previous three documents and elaborates on requirements of Section 109(a).

United States research in the Arctic, described in this biennial revision, is governed by the goals and objectives agreed upon by the Interagency Committee on February 3, 1986, and by the guidance provided by the Arctic Research Commission. This includes supporting research to implement national policy for protecting national security interests, promoting rational development while minimizing adverse effects, contributing to the knowledge of environments best studied in the Arctic, and contributing to mutually beneficial international cooperation.

The Act did not provide separate additional funding for Arctic research. Agencies are expected to request and justify funds as part of their normal budgetary processes. It was anticipated in the 1987 Plan that agencies would provide levels of funding consistent with the Plan's recommendations and existing programs during the intervening period. FY 94 expenditures for Arctic research in the 12 Federal agencies are estimated at $145 million.

The Arctic Research and Policy Act requires cooperation among agencies of the U.S. Government that have missions and programs relevant to the Arctic. The Interagency Committee provides the mechanism for developing and coordinating overall U.S. Arctic research activities. This biennial revision to the U.S. Arctic Research Plan serves as guidance for planning by individual agencies and for coordinating and implementing mutually beneficial national and international research programs. The document includes two major sections: the Integrated Interagency Research Plans, and revisions to Agency Programs. The Integrated Interagency Research Plans provide another step in implementing the intent of the Arctic Research and Policy Act. They represent Federal agencies' efforts to plan and implement research involving a number of agencies and to cooperate in the international scientific arena on research related to the U.S. Arctic. The Agency Programs consist of six major topics important to Arctic research and conducted as part of individual missions of the twelve Federal agencies.

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

2. Integrated Interagency Research Plans

The Interagency Committee, at its meeting on June 28, 1990, agreed upon 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.

Benefits to the Nation from Arctic research include improved:

- Knowledge of fishery resources and controlling dynamics;
- Models and data for assessing global change and its effects;
- Understanding of past climates;
- 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 historic cultural resources.

Four programs now represent significant multiagency focused efforts:

- Western Arctic Ocean Circulation and Productivity

Goal: Understand the processes controlling physical and biogeochemical variability and productivity of the marine western Arctic.

- Geodynamics of the Arctic Basin and its Margins
  Goal: Determine the climatic, paleo-oceanographic and tectonic evolutions of the Arctic and their effects on global change.
- Arctic Monitoring and Contamination Studies
  Goal: Building on existing sites and databases, participate in a coordinated international network of long-term atmospheric, terrestrial and oceanographic monitoring stations and facilitate analysis, storage and dissemination of acquired data; and support a coordinated U.S. program to evaluate the ecological and health risk of Arctic contamination, to rescue data from world archives and to promote international scientific coordination.
- Bering Land Bridge
  Goal: Determine human responses and adaptations to changing climate and environment.

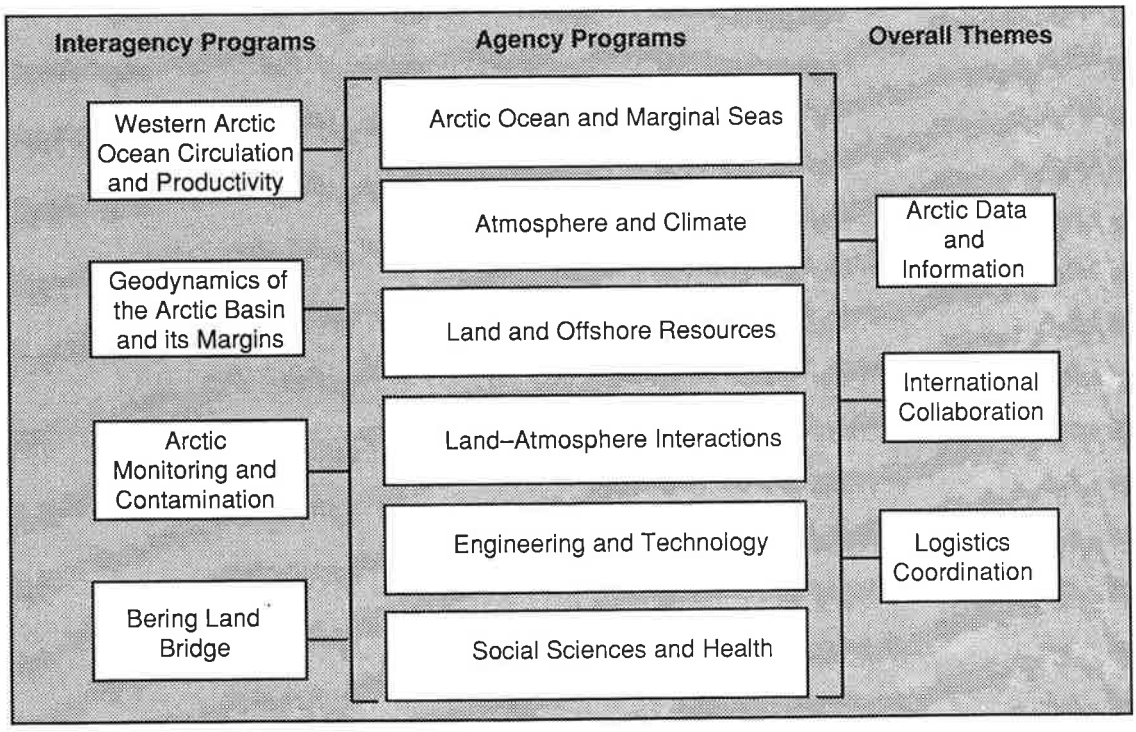
Another area of cooperation already underway involves data and information. Interagency activities have been initiated to develop an Arctic Environmental Data Directory and to automate, integrate and exchange Arctic bibliographic references. An interagency effort is underway to facilitate the exchange of Arctic data and published literature, not only within the U.S. but on an international basis. The initial products are the Arctic Environmental Data Directory and several CD-ROMs, including prototypes of the Arctic Data Interactive and bibliographic citations.

These coordinated, multiagency programs are being designed to:

- Focus research activities in concert with national needs and Global Change Research Program plans;
- 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, especially with Russia.

3. Agency Programs

This section of the revision to the Plan covers the six major components and their individual elements. Individual agency accomplishments were discussed in the Spring 1992 issue of *Arctic Research of the United States* and will be updated in the Spring 1994 issue. Objectives of Federal agencies are briefly described, focusing on the period covered by this revision (1994–1995).



Arctic Ocean and Marginal Seas

Research in ice dynamics and oceanography is important to advance our understanding of Arctic Ocean dynamics and air–sea heat and gas exchange. A systematic program of oceanographic measurements is urgently needed to support the objectives of interagency and individual agency programs.

Arctic marine ecosystems are dominated by sea ice, and coastal ecosystems are influenced by freshwater input and seasonal sediment loads. There is a need to quantify the influence of physical processes on the variability of marine living resources through long-term and well-designed interdisciplinary research.

The Arctic continental margin and deep ocean basin constitute one of the world's least understood geological regions. A better understanding of the tectonic history, geologic structure, sediment processes and distribution, and climatic and glacial history of the deeper basins will require extensive geophysieal and geological research and the integration of newly collected data on an international scale.

Atmosphere and Climate

The goal of upper atmosphere and near-Earth space physics research is to trace the flow of energy, momentum and mass from the sun to the Earth, and to understand their interaction. Arctic-based studies of this energy flow are necessary to help develop and verify theoretical models needed for future predictions.

The Arctic climate has global implications as well as local and regional importance. Research is needed to address Arctic weather problems occurring on a variety of spatial and temporal scales that range from microscale to global. There is a need to study the relationship of Arctic atmospheric circulation to midlatitude weather and to measure and understand phenomena that may be linked to potential global warming.

The chemistry of the Arctic atmosphere is dynamic, changing in response to natural and man-induced disturbances. Ozone depletion is a bipolar process. Expected warming trends could have a significant influence on biosphere–atmosphere interactions, trace gas emissions and retention, and atmospheric photochemical processes.

Land and Offshore Resources

The geologic framework of the Arctic is poorly known because of its complexity, its remoteness and a relative lack of exploration. Information is necessary for discovery, assessment and mapping of new and dependable sources of oil, gas, coal and strategic minerals.

Erosion rates are extremely high along the Alaskan Arctic coast, where sea ice and permafrost degradation are dominant geomorphic agents. Specific questions about where to locate causeways, man-made islands and other structures require studies of coastal erosion and sediment transport and an understanding of the long-term history of coastal areas.

The Arctic supports many unique species of birds, mammals, fish and plants that are important resources to the Nation, as well as to Alaskan Natives. 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 on environmental factors of importance to vital processes (for example, feeding, breeding).

Increased knowledge of the current and potential productivity of Arctic and Subarctic forests and soils will lead to improved management practices for increased productivity of renewable resources.

Land–Atmosphere Interactions

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 covers and glaciers, especially as they relate to and record climatic change. Reliable long-term information is needed on surface water quality and quantity.

Geologic processes that are responsible for the present morphology and land surface are to a large degree a function of the underlying permafrost. Additional knowledge is needed about the temperature, distribution, thickness and depth of permafrost throughout all geomorphic provinces of the Arctic, including the continental shelf.

Global Circulation Models (GCMs) indicate that the Arctic will be sensitive to the effects of possible climatic changes resulting from greenhouse warming. Research is needed to improve understanding of the influence of climate on land and freshwater processes, including heat balance relationships and landscape alteration. This should include the identification of biological indicators of change, long-term trends in biological diversity, and management strategies for living resources.

Engineering and Technology

Development of Alaskan resources requires assessing and resolving economic and environmen-

tal issues with sound scientific analyses. Research is required to determine high-value, cost-effective methods and systems necessary for protecting the environment. including oil spill prevention technology and innovative containment and cleanup operations for oil spills in ice-infested waters and permafrost terrain. Research is also needed to determine high-value, cost-effective methods for improving human habitability, including waste disposal and air pollution control, power generation and energy storage, and transportation systems.

Social Sciences and Health

Long records of cultural and environmental change, when combined with the proxy records of ethnography and history, make the study of Arctic cultures critical for modeling human responses to global climatic and environmental change. Additional research is needed on the prehistory and history of Arctic cultures, on their interactions with other Native and Western peoples, and on their relationships with past and present environments.

Rapid economic, social and political changes have resulted in the emergence of human problems that, while not unique to the Arctic, are nevertheless accentuated by economic development in this environment. Most prominent among them are human–environmental relationships, community viability and social reorientation. Unprecedented opportunities exist for basic and applied social and behavioral science research in Arctic regions.

The Arctic is a region where health research has broad implications and applications. Key concerns in health and health research include social and behavioral problems, disease trends and transmission, nutrition, bioaccumulation, and human adaptation to extreme environmental and occupational challenges. The health–culture–socioeconomic component is important in the attempt to address the complex issues being faced in the Arctic.

4. Operational Support

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. In 1988 the Interagency Committee established a working group on Arctic logistics to deal with Arctic operational needs and to compile information on Federal Arctic logistics capabilities. This interagency effort produced an electronic directory of Federal Arctic logistics capabilities. In September 1989 a workshop was convened to address new technologies available to facilitate Arctic operations and logistics. The Interagency Committee continues to endorse the need for an icebreaker fleet for logistics and research and a more centralized approach for Federal logistics information and scheduling.

The recent availability of a U.S. Navy nuclear submarine to support a research cruise in the central Arctic Ocean has provided a significant boost to access to this remote area of the Arctic Ocean. Continuation of such a project would prove extremely valuable to all elements of Arctic science.

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.

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 revision was submitted on August 1, 1989 (IARPC 1989). The second revision was submitted on June 18, 1991. This document, the third biennial revision to the Arctic Research Plan, updates the previous three 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 but are more restricted in scope, and they focus on what might be accomplished in the succeeding two-year periods (1990-91, 1992-93, 1994-95 etc.). In addition to the individual agency research activities (described in Section 3), this revision presents several integrated, interagency research programs (Section 2) as requested by the Interagency Committee. These cooperative efforts were initiated in the 1992-93 period and will continue into 1994 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 Goals and Objectives

United States research in the Arctic and this biennial revision are governed by national interests and Arctic research goals and objectives agreed upon by the Interagency Committee on February 3, 1986, and guidance provided by the Arctic Research Commission.

U.S. Interests

It is in the national interest of the United States to support scientific and engineering research to implement its national policy of protecting essential security interests, promoting rational development of the Arctic region while minimizing adverse environmental effects, and contributing to the knowledge of the Arctic environment or to aspects of science that are most advantageously studied in the Arctic. 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 the Arctic as a natural laboratory, national defense, natural hazards, global climate and weather, energy and minerals, transportation, communications, renewable resources, pollution, 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 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 exploitation technology;
- Develop an understanding of the role of the Arctic in predicting global environmental changes and perform research to reveal early signals and to determine the significance of global changes in the Arctic;
- Continue and promote the U.S.'s efforts and forecasting capability related to improved protection of life and property from the extremes of the Arctic environment;

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

- Contribute to the understanding of the relationship between Arctic residents and subsistence 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 the individuals and communities involved in the research;
- Continue to document and understand the role of permafrost in environmental activities;
- Advance knowledge of the Arctic geologic framework and paleoenvironments;
- Develop the scientific basis for responding to social changes and the health needs of Arctic people;
- Contribute to the understanding of upper atmospheric and outer space phenomena;
- Develop and maintain databases and data and information networks;
- Promote mutually beneficial international research programs and cooperation; 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 and recommendations for improvements in logistics for support of Arctic research (ARC 1988b) and for focused research on the Bering Sea as an Arctic marine ecosystem (ARC 1988a), on data and information (ARC 1989), on engineering (ARC 1990a) and on oil spills in ice-infested waters (ARC 1992). This revision of the Plan is consistent with many of these Commission recommendations.

1.2 Budgetary Considerations

The Act did not provide separate additional funding for Arctic research. Agencies were expected to request and justify funds for these activities as part of their normal budgetary processes. 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 1992–1994 period. The total interagency Arctic budget estimate for FY 93 is $155 million; for FY 94 it is $145 million. In Table 2 Arctic funding is presented according to the three major policy objectives described above, and as reported for 1994 in the President's budget request. Categories on resource development and the Arctic as a laboratory include activities directly related to environmental protection and monitoring. See Sections 2 and 3 for details. Appendix C contains agency budgets broken down by major sub-elements and cross referenced to the policy objectives. The Plan provides detailed budgets for the next two years (1994 and 1995), but program descriptions may be assumed to reflect the general direction of agency activities over the next several years.

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

Agency	*FY 92 Actual*	*FY 93 Estimated*	*FY 94 Proposed*
DOD	23,229	34,070†	23,092
DOI	27,688	27,795	27,974
NSF	34,946	34,950	38,422
NASA	24,465	19,785	20,215
NOAA	15,281	15,511	16,061
DOE	1,936	2,726	1,830
DHHS	11,202	10,040	8,084
SI	675	675	705
DOT	2,794	2,724	2,780
EPA	918	1,387	1,262
DA4,416	4,498	4,290	
DOS	475	1,250	175
Total	148,025	155,411	144,890

* Capital facilities are not included in these estimates.

† In FY 93 Congress provided $10 million to DOD for Arctic contamination studies. As of the publication date of this report, no additional funds have been provided to DOD for this purpose for FY 94.

Table 2. Arctic research by major categories (in millions of dollars).

	1993 Enacted	*1994 Proposed*	*Dollar change*
Resource development*	55.9	54.4	–1.5
Arctic as laboratory†	65.4	67.4	+2.0
National security**	34.1	23.1	–11.0††
Total	155.4	144.9	–10.5

* Includes DOI, DOC, DA, DOE, DOT, DOS and EPA.

† Includes DHHS, NASA, NSF and SI.

** Includes DOD.

†† In FY 93 Congress provided $10 million to DOD for Arctic contamination studies. As of the publication date of this report, no additional funds have been provided to DOD for this purpose for FY 94.

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 6, Spring 1992), published by NSF on behalf of the IARPC.

The Act mandates specific requirements for implementing a coordinated U.S. Arctic research program. Mechanisms for appropriate levels of coordination are still evolving. Three levels of coordination and cooperation are needed for an effective national Arctic research program:

- Specific research conducted in the Alaskan Arctic;
- 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. Data, information and logistics groups are pursuing a number of interagency activities. These are reported in the subsequent sections. The Environmental Monitoring and Assessment Working Group is developing plans for Arctic contamination studies to be published by IARPC in the fall of 1993.

Many interagency agreements and planning and coordinating activities already exist in Alaska. 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 will be encouraged.

1.4 International Collaboration

The Arctic is an arena for scientific research that transcends national boundaries and interests. Over the past two years there has been an increasing amount of activity involving international cooperation in the Arctic. Prior to this time, Arctic cooperation was confined to bilateral or regional arrangements. The growing willingness of Russia to cooperate in international forums has facilitated these discussions on circumarctic cooperation.

In 1990 the International Arctic Science Committee (IASC) was formalized. This nongovernmental body includes representatives of all eight Arctic rim nations and other nations with a significant capability in Arctic research (France, Germany, the United Kingdom, Japan, Poland and the Netherlands). The functioning of the IASC will facilitate cooperative regional research. The National Academy of Sciences is the designated U.S. representative.

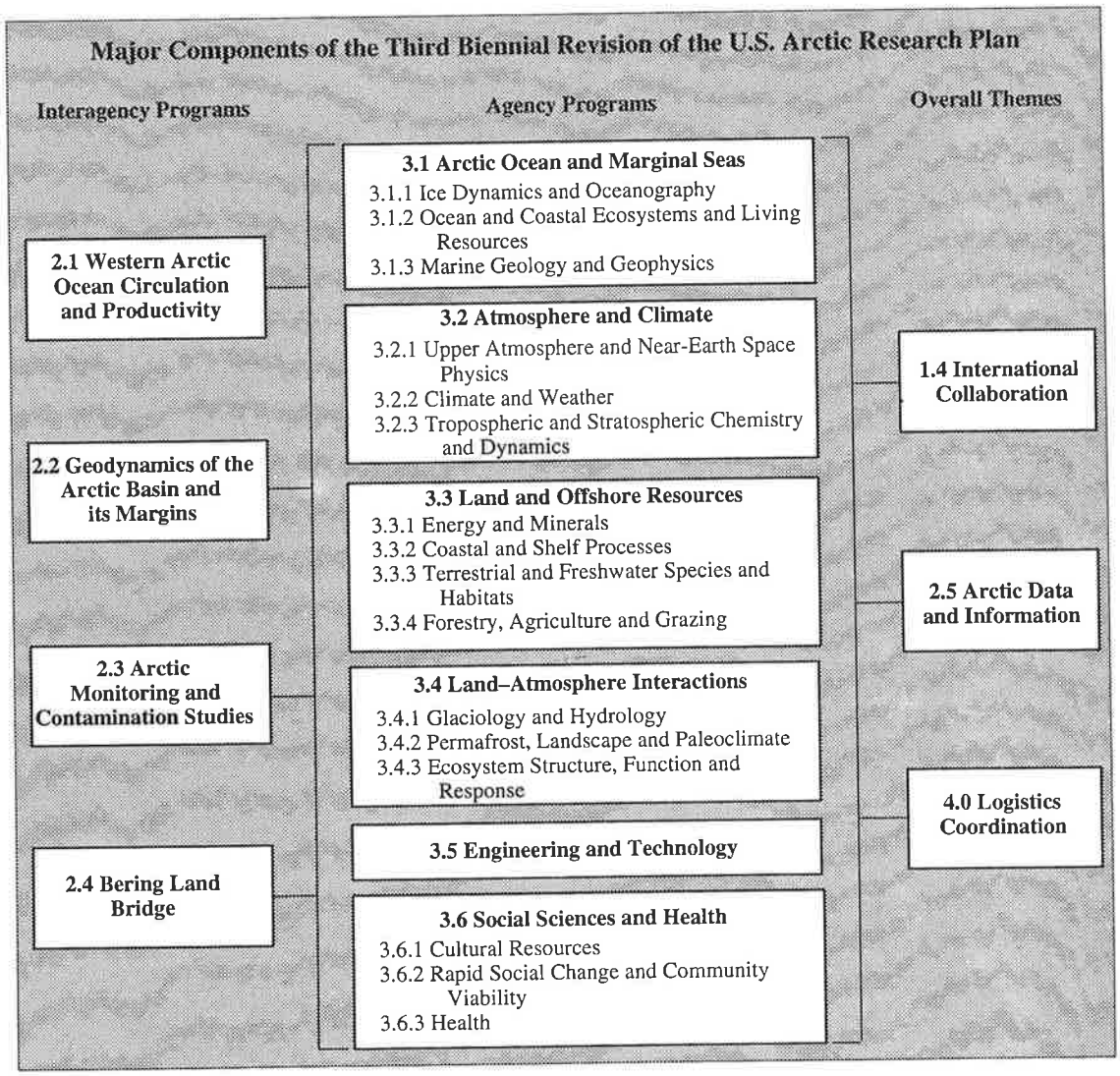
Environmental concerns in the Arctic are being addressed at the intergovernmental level as a result of the Arctic Environmental Protection Strategy. Over the past year and a half, significant progress has been made in pursuit of the strategy's goals. Monitoring experts met in Norway in December 1991 and in Canada in December 1992. They produced an Arctic monitoring plan, which will be implemented beginning in 1993. Planning for an assessment report to ministers, which will be completed in 1996, will start at the fourth meeting of the Arctic Monitoring and Assessment (AMAP) Task Force in October 1993. Canada hosted a working group on protection of Arctic flora and fauna in early 1992, which drafted a work plan for this area. A second meeting was held in the U.S. in May 1993 to refine the plan for presentation to the ministers. Meetings on emergency preparedness were held in Sweden in March and October 1992. The U.S. and Canada agreed to lead the drafting of a risk assessment framework for Arctic environmental emergencies, which is also to be ready in time for the September 1993 ministerial meeting.

The U.S. Man and the Biosphere (MAB) Program, through its High Latitudes Directorate, is participating in the UNESCO MAB Northern Sciences Network, located at the Arctic Center, Rovaniemi, Finland. The NSN focuses on protected areas, sustainable development and subarctic birch forests. US-MAB supported a senior fellowship to work with the Network secretariat in developing and implementing international plans. MAB also contributed to the development of an International Tundra Experiment (ITEX) to monitor the impact of global change on specific flora and fauna.

Among several bilateral efforts, the U.S.–Russia Ocean Studies Agreement has identified a number of Arctic scientific research proposals that may be developed into joint projects and thereby offer access to the Arctic Ocean region. The U.S.–Russia Agreement on Cooperation in the Field of Environmental Protection continues several major Arctic activities related to climate, flora, fauna, ecosystems and pollution. The increasing pace of Arctic research sponsored by the European community is evident in the proposed Nansen Arctic Drilling (NAD) Program, the Norwegian Nansen Drift Program and the Barents Region Initiative. Japan is also expanding its Arctic research efforts in a number of areas, including buoy technology.

The Arctic Ocean Sciences Board (AOSB), a nongovernmental body that coordinates selected Arctic ocean research, has been successful in defining and organizing international research efforts. AOSB attention is now directed at an International Arctic Polynya Program, proposing comparative investigations of polynyas in the Bering Sea, the Greenland Sea and Baffin Bay.

The North Pacific Marine Science Organizations (known as PICES) was established in 1990 to promote and coordinate marine scientific knowledge in the subarctic region of the north Pacific Ocean, including the Bering Sea. Studies of the ocean environment and its role in and response to global weather and climate change, uses and resources, and impacts from human activities are all envisioned as projects PICES will undertake.



The governor of Alaska convened the Northern Forum, an organization of regional local governments, in September 1990 to agree upon regional approaches to economic and environmental cooperation. A permanent secretariat is located in Anchorage.

1.5 Revision to the Plan

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

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

The Agency Programs represent the objectives of Federal agencies, focusing on the period covered by this revision (1994–1995). 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 Spring 1992 issue of *Arctic Research of the United States* and will be updated in the Spring 1994 issue. The complementarity of the interagency programs and the agency programs is shown in the following figure. 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

During its meeting of June 28, 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.

The U.S. has a substantial economic, strategic and environmental stake in the Arctic

Subsequently the IARPC agencies examined Arctic research from an interagency perspective and concluded that the following four programs were ready for immediate attention as multiagency focused efforts:

- Western Arctic Ocean Circulation and Productivity;
- Geodynamics of the Arctic Basin and its Margins;
- Arctic Monitoring; and
- Bering Land Bridge.

In 1992 the investigation of Arctic contamination from the former Soviet Union was assigned as an IARPC responsibility under the Arctic Monitoring focused effort.

These coordinated, multiagency programs are being designed to:

- Focus research activities in concert with national needs and Global Change Research Program plans;
- 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 safe 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 includes improved:

- Knowledge of fishery resources and controlling dynamics;
- Models and data for assessing global change and its effects;
- Understanding of past climates;
- 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 historic cultural resources.

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

Nonrenewable Resources

Currently 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 the former Soviet Union. 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 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 well 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.

High-latitude warming may disturb the equilibrium of Arctic ice masses and hence global sea levels. Such events are well 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 chlorine and bromine reach the highest levels ever experienced on the planet. 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 applies to virtually every science element in the U.S. Global Change Research Program Priority Framework.

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, depend on hunting, trapping and fishing. Evidence shows increased exposure in these communities to contaminants from lower latitudes. 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 pristine 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 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. Currently Advanced Very High Resolution Radiometer (AVHRR) data from the NOAA polar-orbiting satellites are analyzed for polar sea ice mapping by the Navy/NOAA Joint 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 provide 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.

Common to all programs is the need for a data management program within the Federal agencies

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 micro-satellites, 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 fisheries 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 (see Section 1.4) 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 a data management program within 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. The National Snow and Ice Data Cen-

ter (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 data archiving activities 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 the U.S. participation in an international Arctic Monitoring and Assessment Program. (See Section 2.5.)

The demise of the Soviet Union offers an unprecedented opportunity to develop bilateral research programs on Arctic scientific issues of common concern to the U.S. and Russia

U.S.–Russia Collaboration

The demise of the Soviet Union offers 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, as well as requests for financial aid. Proposals for specific projects with Federal agencies have resulted. Other 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, assess and clean up environmental contamination in the Arctic will create opportunities for scientific and technical research in support of these activities, such as development of improved monitoring and cleanup techniques and methods of sampling and analyzing for the presence of contaminants in Arctic ecosystems.

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, by agreement with the OSRI, 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 U.S. Coast Guard's oil pollution fund.

2.1 Western Arctic Ocean Circulation and Productivity

Goal: To understand the processes controlling the physical and biogeochemical variability and the productivity of the marine western Arctic and thus improve both short- and long-term environmental forecasting capabilities.

Background

Both the physical and biological characteristics of the Arctic marine environment are determined by balances between local processes and exchanges with the Atlantic and Pacific oceans. Within the western Arctic region, the Bering Sea, the Northern Bering/Chukchi Shelf and the Arctic Ocean (extending from the shelf approximately to the Lomonosov Ridge) are three coupled yet distinct physical and biogeochemical regimes that may respond sensitively to plausible scenarios of climatic change.

The Pacific source waters for the western Arctic are derived from flow through the Bering Sea, a large portion being nutrient-rich waters that upwell onto the shelf. Upwelling is particularly effective in the northwestern Bering Sea, where it fuels remarkably high biological productivity over the shelf, extending northward to Bering Strait. In contrast, the waters of lower salinity transiting the Bering Shelf farther eastward carry reduced nutrients with correspondingly lower productivity.

The physical and biological characteristics of the Arctic marine environment are determined by balances between local processes and exchanges with the Atlantic and Pacific oceans

From the northern Bering Sea, the Pacific waters continue through the Bering Strait into the Chukchi Sea, where, aided by nutrients recycled in winter, they support another extremely productive ecosystem. The carbon production in this region may supply 50% of the respiration demands within the Arctic Basin. Hence, the variability in production and the fate of the carbon are important inputs for calculating the oceanic carbon budget as it pertains to global change. Both the western inflow and the fresher waters entering through eastern Bering Strait are significantly altered in the Chukchi Sea by mixing and by interaction with the atmosphere, the ice cover and the sea floor as they circulate on the shelf. Modified but distinct Pacific waters eventually drain off the Chukchi Shelf into the deep Arctic Ocean. Within the Arctic Ocean the modified Pacific waters spread throughout the Canadian Basin, where they form a distinct layer between the surface ice cover and the warmer water below derived from the Atlantic inflow in the eastern Arctic. In this way the Pacific inflow insulates the enormous sea ice canopy of the western Arctic from melting and at the same time fertilizes the upper ocean with nutrients originally upwelled across the Bering slope. The stability of this system is critical in maintaining the Arctic climate. There are very few long-term current records for the Arctic Ocean and no hydrographic transects from which to understand the large-scale circulation or water column structure. Data on the radiation budget in this region are also inadequate.

Freezing and melting of sea ice in the Bering Sea and on the Arctic Ocean shelves are critical in the process of water mass formation and biological productivity. Ice mechanics also plays a direct role in the transport of energy between the atmosphere and the ocean. Seasonal and interannual variability is extremely large in this system, much of it associated with wind. This region could be critical for future U.S. activity in offshore oil exploration and production. Our ability to proceed with these commercial activities is seriously constrained by the lack of sufficiently accurate forecasts of weather and the strength and movement of the pack ice.

Improving both short- and long-term environmental forecasting capabilities for the western Arctic requires understanding of the role of atmospheric forcing, ice dynamics, water column productivity, sediment biogeochemistry and the Pacific inflow. What controls the ocean transport and pathways from the deep Bering Sea onto the shelves? What are the principal patterns and scales of the shelf circulation? How does this circulation control production? What are the principal interactions between the variable ice cover and the shelf waters? How are the chemical and biological properties of the northward-moving waters redistributed? How are these waters modified in crossing the vast Arctic shelves? What controls the transport of the shelf-modified waters into the Arctic Ocean and their subsequent spreading? Recommendations contained in *Arctic System Science: Ocean–Atmosphere–Ice Interactions* (Joint Oceanographic Institutions Inc. 1990) and *Priorities in Arctic Marine Science* (National Research Council 1988) will be considered in implementing the program.

Objectives

- Define the principal pathways, rates and variability of Pacific waters through the western Arctic and the dynamics governing the flow;
- Define the distribution of discrete stocks of important fish, shellfish and marine mammals, and the relationship of these distributions to physical, chemical and biological factors;
- Determine biological production rates and dynamics on the shelves of the western Arctic and assess their susceptibility to change;
- Relate sea ice dynamics to atmospheric forcing and determine the consequences for ocean circulation and biological production;
- Develop an accurate, high-resolution sea ice forecasting system with defined limits of predictability;
- Quantify the relative magnitude and sensitivity of fluxes contributing to the surface heat budget;
- Define the mechanisms and time scales of principal biogeochemical cycles in the western Arctic; and
- Determine the transfer of energy between trophic levels and the sequestration or loss of carbon from the shelf system.

Summary of existing and planned contributions to the Western Arctic Ocean Circulation and Productivity program.

	Bering Sea	*Chukchi Sea*	*Arctic Ocean*
Atmospheric forcing	Interannual variability (NOAA, NSF)		Lead forcing (ONR, NOAA)
Sea ice processes	Interannual variability (NOAA, NSF, NASA)		Seasonal variability (NOAA,NSF, NASA) Large-scale surface fluxes (NASA, ONR) Lead fluxes and formation processes (ONR, NOAA, NASA)
Ocean circulation water mass structure	Seasonal surveys (NOAA, NSF, MMS, Russia, Canada, Japan)		Point monitoring (NOAA, ONR, NSF, Canada) Basin cross section (NOAA, ONR, Canada)
Nutrient distribution	Data synthesis (NSF) Seasonal surveys (NSF, MMS, NOAA)		
Pollutant transport	Seasonal surface trajectories (MMS, ONR)		
Carbon cycling	Data synthesis (NSF)		
	Neritic, benthic processes (NSF) Sequestration, export mechanisms (NOAA, NSF)		
Primary, secondary production	Seasonal surveys (NSF)		
	Polynya processes (NSF, NOAA, NASA)		
Fish, mammal dynamics	Historical stock analysis (NOAA/NMFS) Pollock recruitment and larvae transport (NOAA/NMFS)		
		Marine mammal dynamics (NOAA,FWS/MMS)	
		Polar bear ecology (FWS/MMS)	
Instrument development/application	RNA probe (NOAA)		
	Autonomous underwater vehicles and oceanographic sampling network (ONR) Buoy systems (ONR, NOAA, NSF, NASA) Visible and infrared, passive microwave, SAR (NASA) SEAWiFS color sensor (NASA)		
Ecosystem dynamics	NAS study (DOS) BERPAC - Long-term ecological research (DOT, ONR, NSF)		

Implementation

Implementation of individual program elements will proceed in phases designed to build databases and modeling capabilities sufficient to guide the formulation and testing of hypotheses:

- Phase I: Reconnaissance site surveys, synthesis of historical databases, initial model dedvelopment, interagency and international linkages for collaborative efforts.
- Phase II: Multidisciplinary field experiments and process studies with interagency and international collaboration, data assimilation into high-resolution predictive models and long-term observational systems.

Most agencies have implemented limited Phase I efforts with existing resources; several studies were initiated in FY 92 and 93. Phase II represents a significant enhancement with a higher level of coordination, and progress has been made in this area with the initiation of the Arctic System Science (ARCSS) program, part of NSF's global change initiative. Programs listed under "Future Cooperative Program Elements" below have been identified as critical needs that require additional funding for implementation.

The diagram on p. 16 is a summary of the overall program.

Future Cooperative Program Elements

Bering Sea

- Expansion of field surveys sufficient to define the spatial and temporal variability in circulation;
- Regional climatology to determine the principal atmospheric and oceanographic forcing of the variable circulation in the Bering Sea;
- Primary and secondary production and its relationship to sea ice dynamics;
- Processes controlling the transfer of energy between trophic levels and the sequestration or export of carbon from the Bering Shelf;
- Coupled modeling of physical dynamics and ecosystem interactions;
- Continuation of BERPAC (Program for Long-Term Ecological Research in Ecosystems of the Bering and Chukchi Seas and the Pacific Ocean).

Northern Bering/Chukchi Shelf

- Shelf-basin exchange, including plume dynamics, export of carbon and nutrients;
- Expansion of biological sampling and measurements of primary production to define spatial and temporal variability and off-shelf components;
- Monitoring of ice thickness and ice deformation;
- Process studies of ice thermodynamics;
- Integration of SAR data into regional ice models;
- Higher-trophic-level dynamics, including the effects of low-frequency sound.

Arctic Ocean

- Proposed coordinated transpolar expedition in the summer of 1994 with a U.S. Coast Guard icebreaker and the Canadian icebreaker *Louis St. Laurent* to obtain oceanographic and geophysical sections across the Arctic Ocean;
- Proposed acoustic tomography experiments that can provide integrated estimates of ice-thickness changes and changes in Arctic Ocean circulation and the heat budget of the Arctic Ocean;
- Planned submarine cruises in 1993 that would obtain samples from the water column above the continental slope and in the central Arctic Ocean;
- Process studies of circulation dynamics on the continental slope and in the central Arctic Ocean;
- Continuous ocean and ice monitoring for spatial and temporal variability in ice thickness, upper ocean structure, circulation and water column sediment flux;
- Determination of the implications of leads process studies for the western Arctic (on a regional scale), particularly the consequences for mixed-layer, atmospheric circulation;
- Coupled air–ice–ocean circulation modeling to look at coupling between higher and lower latitudes;
- Assessment of the transport and fate of radionuclides and other pollutants.

Under the integrated program, agencies will coordinate announcements of research opportunities and will align current research with the goals of the interagency effort. An interagency science steering committee will assure the continuity and integrity of the overall program.

2.2 Geodynamics of the Arctic Basin and Its Margins

Goal: To determine the climatic, paleo-oceanographic and tectonic evolutions of the Arctic region and their effects on global climate, the biosphere and the dynamics of world oceans and atmosphere.

Background

The origin of the Arctic Basin is linked to the evolution of adjacent ocean basins and continents. Understanding past and present plate movements in the Arctic is necessary before a complete model of plate motions and paleogeography in the Northern Hemisphere can be constructed. The Cenozoic tectonic history (the past 67 million years) of the Eurasian Basin is relatively well known, since the Eurasian Plate and the North American Plate have been studied extensively to the south. The basin also contains a well-documented and decipherable magnetic lineation history. Little is known about much of the rest of the Arctic Ocean margin system. The evolution of the Amerasian Basin is a major unresolved problem. Rotation of the Arctic-Alaska Plate away from the Canadian Northwest Territories during the Cretaceous (prior to 65 million years ago) is consistent with the geology of the Canadian Arctic Islands and Alaska. However, interrelationships with the Markarov Basin are unknown.

Understanding the history of the ridges and the basins is critical for reconstructing past climate

One of the major unsolved questions in earth sciences is the paleo-oceanographic and paleoclimatic evolution of the north polar deep-sea basins. Identification of greenhouse warming within historical records requires quantifying the magnitudes, frequencies and rates of natural climate change. Of hundreds of samples collected in the Arctic Ocean, only seven contain sediments that predate the onset of cold climatic conditions. The oldest black muds (about 80 million years old—Campanian age) and siliceous oozes (about 67 million years old—uppermost Cretaceous and earliest Paleocene) indicate that at least part of the Arctic Ocean was a relatively warm, productive, deep-sea basin prior to 40 million years ago. Three recent cores by the USGS may also record Cretaceous sediments. One sediment core from ice island T-3 and a recently recovered core during ARK-VU/3 of *Polarstern* comprise the only records of the Paleogene from the central Arctic Ocean. The T-3 core contained displaced sediments and consisted of obviously laminated siliceous oozes with Eocene phytoplankton. The Paleogene oceanographic scenario is similar to that during the late Mesozoic. All other sediment cores from the Arctic Basin contain younger sediment, deposited in a cold, at least partially ice-covered, deep-sea regime. The record documents periods when iceberg-transported, terrigenous sediment was deposited on the basin floor. There are no marine data from 5 to 40 million years ago when the Arctic climate cooled, and thus no information is available to decipher the forcing functions or time of onset of glacial conditions. Today, dense, cold, Arctic surface waters sink and flow southward, filling the deep basins of the Atlantic and Pacific oceans. This circulation in the past may have been substantially different, with consequent climatic implications. The Alpha and Lomonosov ridges in the past were a greater barrier to circulation than at present; their rates of subsidence are unknown. Understanding the history of the ridges and the basins is critical for reconstructing past climate. Sixty-five million years ago (late Cretaceous), Alpha Ridge may have been a volcanic oceanic plateau. Lomonosov Ridge is probably a sliver of the Barents Sea margin. The geodynamic forces responsible for the origin of the Alpha and Lomonosov ridges are unknown.

Twenty-five percent of the Nation's production of hydrocarbons comes from the Alaskan coastal plain, and 20% of reserves are estimated to be within the continental margin. Understanding the geologic history and structure of the Arctic margin is necessary for further development and management of these nonrenewable resources. In permafrost regions in the Northern Hemisphere, both onshore and offshore, considerable quantities of methane in the form of a hydrate are contained within and beneath the permafrost layer. Because global climate warming is postulated to be magnified in the Arctic, accelerated thawing of permafrost may occur, possibly releasing methane into the atmosphere. Continental shelves are potentially rich in gas from suspected frozen methane (clathrate) deposits.

Unlike temperate regions, where water is the only medium of energy exchange with the sea floor, the Arctic continental margin is a unique environmental domain involving not only the

water column but also the interaction of two solids: ice and the sea floor. The surfaces of these solids are variable in form, both temporally and spatially, and the dynamics of their interaction results in ever-changing conditions. Erosion rates are extremely high along the low-lying Arctic coastlines, where sea ice and permafrost are common. Two recent offshore oil discoveries along the Alaska coast of the Beaufort Sea point to the potential for future oil production by pipeline and more exploration in a sea ice environment. Specific questions about where to build causeways, man-made islands and other structures can only be answered after basic process information is collected and interpreted. Knowledge of erosion and sediment transport in the Arctic is essential for intelligently managing the coastal region.

The tectonic and paleoclimatic history of the Arctic Ocean margin system needs to be addressed at a minimum of six time ranges:

- The last few hundred years: How precisely do the sediments record the history of the influence of man on the global system?
- 12,000–18,000 years ago: What changes occurred at the end of the Pleistocene that triggered the decay of the major ice sheets?
- 125,000 years ago: What were the conditions during the last major interglacial period?
- The last 2 million years: What is the timing, magnitude and periodicity of high-amplitude, late-Cenozoic climate oscillations and resultant ice sheets, both continental and marine?
- About 25 million years ago: What conditions triggered the initial Arctic climatic cooling, the formation of sea-ice cover and the earliest glaciations?
- About 67–85 million years ago: What was the climate at the end of the Cretaceous? How can we characterize the preglacial Arctic deep-sea paleoenvironment?

A general question that can be asked for each time range is: What were the paleo-oceanographic and paleontologic (both faunal and floral) responses to climate change, warm–cold oscillations and changes in the depth and width of ocean corridors linking the Arctic with the global ocean?

Objectives

- Determine the tectonic and geologic history of major structural elements of the Arctic Ocean margin system;
- Determine the climatic and paleo-oceanographic evolutions and their effects on global climate;
- Understand coastal processes unique to high-latitude shelves;
- Estimate the volume of methane in permafrost regions and how rapidly it would be released by various degrees of warming; and
- Establish the tectonics and sea level oscillations of the Bering land bridge in order to understand the fauna and flora migrations.

Implementation

Implementation is designed to take advantage of planned and proposed international programs, including those of the Arctic Ocean Sciences Board. The initial activities are primarily exploratory. Multi-year programs involve major additional operational support. Sections 3.1.3 and 3.3.2 present specific agency and multiagency plans that contribute to this integrated program.

Future Cooperative Program Elements

Joint U.S./Canadian Traverse of the Arctic Basin

The geologic component will include a geophysical transect of the Chukchi borderland to obtain seismic refraction data to define Arctic continental margins. Sediment coring will be conducted to sample the geologic structure and obtain paleo-oceanographic data.

Arctic Gateway Drilling

The Ocean Drilling Program has established a program, entitled "North Atlantic Arctic Gateways," aimed at unraveling the paleo-oceanographic and paleoclimatic history of the high-latitude areas of the North Atlantic region. Included in the plans are targets on the Yermak Plateau, north of Spitzbergen, the Fram Strait, targets off East Greenland, in the Iceland Sea and on both sides of the Scotland–Greenland Ridge. This expedition will be the first scientific drilling in the Arctic Ocean and the first phase of NAD (Nansen Arctic Drilling), a phase involving drilling in the more accessible areas near the marginal ice zone before drilling in the central Arctic.

Nansen Centennial Arctic Program

Norwegian scientists plan to commemorate the Nansen *Fram* drift of 1883–1886 with a freeze-in of an ice-strengthened vessel for a two-year drift, starting at approximately 85°N and 120°E. Two small satellite camps will be deployed 100 km to either side of the ship to be used as an advance base for regional surveys within a 300-km-wide corridor along the drift path. The geological objectives are to elucidate the onset and history of glaciations in the Arctic; the onset and variability of sea-ice cover; the history of ocean circulation and

water mass exchange, and their influence on global climate change; the correlation of climatic records from land and ocean; the importance of the Arctic in global climate modeling; the development of deep circulation adaptations of marine biota to a cold hydrosphere; and sediment flux and carbon cycling in the Arctic Basin.

Detailed knowledge of the sea floor morphology and sub-bottom sediment distribution will be obtained to provide information on active and relict depositional and erosional processes along the northern continental margin and the adjacent Nansen Basin. This pertains in particular to the contrast between pre-glacial and glacial depositional environments. Improved bathymetric data are also required for a better understanding of the influence of sea floor topography on the deep oceanic circulation pattern.

Joint U.S.–Canadian Fjord Study

This study of the Kangerdlugssuaq Fjord, Shelf Trough and Upperslope off east Greenland using the Canadian research vessel CSS *Hudson* will be an international cruise with an emphasis on high-resolution seismic stratigraphy, coring, physical and chemical oceanography and biology. A major contribution to this effort will be to provide a high-resolution time series of changes in nearshore conditions during the last 2000 years and from the last glaciation to the present.

Arctic 95

Planning is now underway for a multi-ship, multi-disciplinary international Arctic Expedition with a target date of July 15 to September 30, 1995. The main goal of the expedition is a better understanding of the evolution and present state of the Arctic system, with an emphasis on how the Arctic will be influenced by global change and how a changing Arctic will impact the global climate system.

The expedition will investigate the deep basin of the central Arctic, including the Eurasian and Canadian basins and their link to the continental margins and shelf seas. There will be a strong geology and geophysics program as well as programs in other disciplines. Target regions extend from the Laptev and East Siberian seas to the North Pole and include the Gakkel, Lomonosov and Alpha–Mendeleyev ridges and intervening basins. The cruise tracks will be designed to provide opportunities for station work in the deep basins, on the ridge systems and on the continental shelves and slopes.

Potential platforms for the expedition are six icebreakers and icebreaking research vessels from Canada (*St. Laurent*), Germany (*Polarstern*), Russia (*Sibir* and *Akademik Lazarus*), Sweden (*Oden*) and the United States (*Polar Sea*). It is envisioned that these vessels will work in pairs to provide geographic coverage, synopticity, and efficient and economical logistics.

Existing and Planned Agency Contributions

DOD/ONR has ongoing research to understand the transport of sediment under the seasonal ice cover in the Barents Sea. The field program began in June 1991, when bottom lander tripods, which measure currents, water properties, suspended sediment concentrations and seabed configurations, were deployed in a major fjord (Storfjord) and glacial trough (Olgastret) south and east of Svalbard. The instruments were recovered and redeployed in 1991 at the end of the Arctic summer. Finally, after wintering over, all instruments were retrieved in September, and a new unit was installed in Olgastret.

DOI/USGS is investigating the structure and history of the Chukchi Borderland via an icebreaker program of geology and geophysics. Additional work is planned for 1993 onshore boreholes in the Yukon Flats and Old Crow basins to investigate late-Cenozoic paleoenvironments in cooperation with the Geological Survey of Canada.

2.3 Arctic Monitoring and Contamination Studies

Goal: Building on existing sites and databases, to participate in a coordinated international network of long-term atmospheric, terrestrial and oceanographic monitoring stations and to facilitate analysis, storage and dissemination of acquired data; and to support a coordinated U.S. program to evaluate the ecological and health risks of Arctic contamination, rescue data from world archives and promote international scientific coordination.

Arctic Monitoring

Public, scientific and intergovernmental concerns for the well-being and protection of the Arctic are increasing, and the governments of the circumpolar states have become increasingly aware of the need, and their responsibility, to combat these threats to the Arctic ecosystem. It is often difficult to distinguish between changes in the environment due to human-induced activities and those resulting from natural variability. Furthermore, the Arctic is being exposed to increasing inputs or effects of contaminants from lower latitudes due to atmospheric, marine and riverine transport. The spatial and temporal variability of contaminants, their fates and effects, and the overall status and trends in the quality of the Arctic environment and the condition of the biota are generally not well known.

The governments of the circumpolar states have become increasingly aware of the need, and their responsibility, to combat threats to the Arctic ecosystem

As indicated in Section 1.4, the Arctic Environmental Protection Strategy includes an international Arctic Monitoring and Assessment Program (AMAP), whose primary objective is to measure the levels of anthropogenic pollutants and assess their effects in relevant components of the environment, focusing on pertinent organic contaminants and selected heavy metals and radionuclides. The Arctic Environmental Monitoring and Assessment Working Group, cochaired by EPA and NOAA, was established by the Interagency Arctic Research Policy Committee (IARPC) in June 1991 to support AMAP. In its August 1992 meeting, IARPC added to the responsibilities of the Working Group by directing it to evaluate the risks posed by the contaminant releases of the former Soviet Union.

The AMAP Task Force met in December 1992 in Toronto, Canada. The meeting was attended by 55 people from all eight Arctic nations, as well as representatives from observing countries (Germany, the Netherlands and the U.K.), indigenous peoples (the Inuit Circumpolar Council and the Nordic Saami Council) and other groups. The Task Force approved a plan for monitoring in the Arctic for the upcoming year, providing for the collection of data on emissions and discharges, the atmosphere, terrestrial ecosystems, freshwater ecosystems, marine ecosystems and human health. The AMAP plan considers the potential for the use of remote sensing, reflecting a report developed by the United States.

In addition to a monitoring program, the Task Force is considering how to develop the assessments expected by the ministers. The final substantive issue discussed at the second Task Force meeting was the recognition that the implementation of AMAP is challenging all participants, particularly Russia. There is an emerging consensus of concern over the pollution situation in Arctic Russia, but there is a corresponding lack of substantiated information. It was agreed that steps must be taken to assist Russia in implementing specific AMAP projects.

The U.S. agencies, in accord with national and international programs and agreements, propose to develop their contribution to AMAP by monitoring chemical, biological and physical conditions and conducting environmental process research. Included are assessments of the nature and degree of contamination, the effects of contamination and other forms of human disturbance on the biota and ecosystems, and variations of physical parameters of the environment. Monitoring the physical parameters of the Arctic environment and the cryosphere (sea ice, permafrost, snow cover, glaciers etc.) is being addressed in more detail in the U.S. Global Change Research Program.

Monitoring and related research in the Arctic is important for:

- Establishing a quantitative baseline against which natural variability and future changes can be evaluated;
- Detecting food chain contamination in ecosystems and humans;
- Detecting early signals of biological and physical changes in the environment;
- Determining sources and persistence of natural and anthropogenic contaminants;
- Determining sources and effects of natural and anthropogenic disturbances;
- Serving as a basis for management, mitigation

Existing chemical, ecological and cryospheric research- and monitoring-related activities within agencies.

Atmosphere	
Climate	DOC/NOAA
Chemical	DOC/NOAA, DOE, DOI/NPS, EPA, NASA, NSF
Oceans	
Physical	DOC/NOAA, DOD/ONR, DOI/MMS, NSF, NASA
Ice	DOC/NOAA, DOD/ONR, DOI/USGS, DOT/USCG, NASA, NSF
Chemical	DOC/NOAA, DOI/MMS, NSF
Biological	DOC/NOAA, DOI/MMS/FWS, NSF
Geological	DOI/USGS, NSF
Terrestrial Environments	
Freshwater	DOC/NOAA, DOI/FWS/USGS/NPS, EPA, NSF, USDA/FS/SCS, NASA
Land	DOI/BLM/NPS/FWS/USGS, NSF, EPA, DOE, USDA/FS, NASA
Snow/Glaciers/Permafrost	DOD/CRREL, DOI/USGS/NPS, NASA, NSF, USDA/FS/SCS
Social	
Socioeconomic	DOC/NOAA, DOI/MMS/BIA
Cultural	DOI/BIA/NPS/MMS, NOAA, NSF, SI

and preservation of biodiversity (flora, fauna and habitats); and

- Developing more accurate predictive models of Arctic variables and establishing the information to initiate these models.

Deficiencies in existing national and international Arctic programs include:

- The minimal amount of baseline data from which to establish trends;
- The lack of a comprehensive network of environmentally appropriate sites;
- The lack of standardized strategies and protocols for gathering data for all existing sites;
- The lack of a long-term commitment to coordinated, interagency observational programs;
- The lack of a synthesis and integration capability;
- The lack of systematic storage, access and analyses of Arctic environmental data; and
- The lack of adequate international coordination.

The goals and objectives for program design and data management are to:

- Design a national and cooperative international sampling network and protocols, and provide for intercalibration of instruments and methods;
- Extend baseline measurements at selected U.S. sites and along transects (CMDL, LTER, NADP, parks and refuges, ALERT sites);
- Provide international harmonization of standards for measuring key pollutants and ecosystem health;
- Conduct satellite-based atmospheric observations and marine expeditions and cruises to document transport processes and rates of change;
- Develop habitat indices and inventories of species, populations and communities for assessing impacts and monitoring change;
- Conduct research on the fate and effects of chemical contaminants;
- Further develop centers for the international storage, exchanges and analyses of environmental data; and
- Identify data sets for input to the Arctic Environmental Data Directory (AEDD) and the Arctic Data Interactive (ADI) CD-ROM.

Implementation

The U.S monitoring activities will be conducted, in part, on a network of long-term terrestrial and oceanographic stations generally situated along transects and environmental gradients. One component, the Arctic Long-term Environmental Research Transects (ALERT), will consist of monitoring, assessment and research activities on physical, chemical and biological properties and processes. ALERT sites will be coordinated with circumpolar sites and other major U.S. and international programs (LTER, NADP, IGBP, UNESCO-MAB, IHP etc.) and expeditionary programs such as AGASP and routine satellite and oceans monitoring programs. Workshops are planned to design the sampling and monitoring approaches. EPA is sponsoring a symposium on the effects of Arctic airborne contaminants in October 1993 as part of its efforts under the Arctic Monitoring and Assessment Program.

These activities will be coordinated with AMAP, IASC and other international programs that have provisions for long-term monitoring (IGBP, MAB etc.). Essentially all research components presented in Section 3 of this Plan contain monitoring activities as illustrated below.

Future Cooperative Program Elements

- Design a monitoring program as part of an international Arctic Monitoring and Assessment Program, expand the AEDD and participate in workshops and symposia;
- Further develop appropriate methodologies for assessing the extent and magnitude of pollution in Arctic ecosystems caused by airborne contaminants; lichens and mosses will be sampled using a regional, probability-based sampling frame that will result in quantitative contaminant estimates for the U.S. Arctic; sediments will be analyzed from lakes throughout the Arctic to determine the source and timing of contaminants; additional studies will provide information on the levels of bio-

accumulation of contaminants by various components of the terrestrial Arctic food webs; proper controls must also be established to discern anthropogenic effects from those due to natural processes, for example, natural diagenesis in Arctic lake sediments (DOE/EML, EPA);

- Under an expanded Arctic Studies Center, renew the Smithsonian Institution's basic systematic, evolutionary and ecological research on the Arctic biota in several key areas: inventory of the plant and animal species in both the terrestrial and marine environments, distribution and ecology of species, systematics and evolution of Arctic taxa, life history and environmental adaptation, and questions relating to the conservation of biodiversity (SI);
- Develop plans for upgrades to the ASF to accommodate SAR data from the Canadian Radarsat, which would offer the first opportunity to obtain weekly synoptic SAR coverage of the entire Arctic ice-covered oceans; together with other satellite and in-situ data, such observations would enable estimates of energy fluxes between the ocean and atmosphere at high latitudes (NASA);

During the past year, numerous international sources have independently reported and documented a history of dumping of nuclear and other toxic waste materials by the former Soviet Union into the Arctic Ocean, its marginal seas and the northwestern Pacific Ocean

- Develop a quantitative classification system for snow covers based on a broad range of physical properties (DOD/CRREL);
- Establish an Arctic data office to control data quality, promote data exchange, and link data and information; establish a real-time coastal ocean monitoring and analysis capability in the Arctic within NOAA's Coastal Ocean Program; develop and distribute data on coastal oceanography and fisheries in a CD-ROM, based on a compilation of Beaufort Sea studies (DOC/NOAA);
- Conduct cooperative long-term ecosystem monitoring along two transects: a circumpolar transect in the boreal and Arctic climatic zones, and a Pacific transect from Alaska to Tierra del Fuego; monitor total carbon loading, vegetation vigor and health, employing research tools such as GIS/remote sensing modeling and dendrochronological techniques (USDA/FS);
- As part of the Northwest Alaska Biogeographic Area global change program, centered on the MAB-designated Noatak National Preserve, establish a monitoring and research program that contributes plant, animal and environmental data to the circumpolar long-term monitoring program, including Russian Arctic preserves (DOI/NPS);
- Undertake a five-year program on contaminants in Arctic fish and wildlife to sample tissues and to establish baseline levels for determining seasonal, annual and individual variations, identifying species or groups of species as contaminant sinks, determining their potential vulnerability to contaminant effects, and identifying the relationship of contaminants to patterns of habitat use and movement known from ongoing satellite telemetry and molecular stock identification studies (DOI/FWS);
- Monitor the effects of subsistence usage on populations and the effects of subsistence on regional ecology (DOI/BLM/NPS);
- Conduct studies related to global climate change (DOE/ER, DOI/BLM/NPS, EPA);
- Enhance regional glacier monitoring through the establishment of north–south and east–west transects of "benchmark" maritime and continental glacier basins in North America and further develop sea ice, snow, hydrologic, permafrost and trace gas monitoring programs under the Global Climate Change Program (DOI/GS/NPS); and
- Enhance the Surface Air Monitoring Program, which is monitoring the concentration and deposition of radioactivity in the lower Arctic troposphere to include measurements of other contaminants (DOE/EML).

Arctic Contamination

During the past year, numerous international sources, including a Russian Federation Commission of Inquiry on "Questions Relating to the Dumping of Radioactive Waste at Sea," have independently reported and documented a history of dumping of nuclear and other toxic waste materials by the former Soviet Union into the Arctic Ocean, its marginal seas and the northwestern Pacific Ocean. Materials dumped or lost in the marine environment are purported to include thousands of sealed barrels of liquid and solid radioactive waste, sealed barrels of other hazardous and toxic waste, fueled nuclear submarines and up to 18 nuclear reactors. Other reports indicate that radioactive and toxic waste products have been dumped into Arctic Ocean tributaries, including the Ob, Lena and Ye-

nisey rivers, and that these chemicals are migrating towards the Arctic Basin. Previously known were nuclear reactor accidents, such as at Chernobyl, and a history of atmospheric, surface and subsurface nuclear weapons testing, especially in the Novaya Zemlya region, both of which produced radioactive atmospheric fallout over much of the Arctic. The results of the Commission's Inquiry, released on March 23, 1993, identified 2,359,000 curies of radionuclide waste that had been systematically dumped on the east side of Novaya Zemlya.

Many other nations are also responsible for discharging radionuclide materials and other contaminants into the Arctic environment. The magnitude of the damage and risk to aquatic ecosystems, terrestrial ecosystems and human inhabitants of the Arctic and beyond caused by these historical contamination and dumping activities is unknown. However, members of Congress, the Central Intelligence Agency, other Arctic nations, Arctic residents and many nongovernmental entities have voiced concern about both short- and long-term consequences.

It is in response to this international concern that the IARPC has begun to address the issue of Arctic contamination. Its first significant response was an international Federal Workshop on Arctic Contamination, held in Anchorage, Alaska, on May 2–7, 1993. The Workshop attempted to:

- Characterize the extent of Arctic contamination by evaluating existing data and information about sources and types of contaminant releases;
- Evaluate and define known and probable transport pathways, sinks and effects of Arctic contaminants on ecosystems and human health;
- Identify a methodology for compiling and managing a Federal database on Arctic contamination;
- Identify, through risk assessment methodologies, whether short- or long-term human health and ecosystem risks to Alaska exist, and answer the question: Is the geographic scope of this contamination strictly a Russian Federation problem, a European problem or a global Arctic problem?
- Prepare a plan with recommendations for an integrated assessment of Russian Arctic contamination, including synthesizing existing data sources and identifying new data needed to complete the assessment;
- Develop a program for continuing to assess and monitor Arctic contamination; and
- Prepare recommendations and a summary of existing information for Federal policy and decision makers on how to deal with the issue of Arctic contamination.

The decision to hold the Workshop on Arctic Contamination was the result of a number of factors. On April 28, 1992, Senator Frank Murkowski of Alaska, in a letter to then-NSF Director Walter Massey, chair of the IARPC, challenged the IARPC to "organize a coherent, coordinated approach to this international issue." The Arctic Research Commission adopted a resolution on August 11, 1992, urging IARPC to prepare and coordinate a multiagency scientific plan to assess Arctic contaminants. This challenge was followed on August 15, 1992, by a hearing of the Senate Select Committee on Intelligence in Fairbanks, Alaska, to address radiation contamination in the Arctic.

At its August 27, 1992 meeting, the IARPC agency principals adopted a Policy Statement on Arctic Contamination (Appendix F), which expressed 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 disposal of radioactive and other toxic wastes directly into the Arctic Ocean and into aquatic and terrestrial arctic and sub-arctic sites."

In November 1992 the IARPC approved an Agenda for Action to implement the Policy Statement (Appendix G). Actions endorsed include 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." The Agenda for Action was approved by IARPC Chairman Massey on November 25, 1992. The May workshop represents the first public action implementing the Agenda for Action.

2.4 Bering Land Bridge Program

Goal: To promote understanding and conservation of Beringian environments, ecosystems, cultures, cultural resources and heritage, and history.

Background

A Beringian Studies Initiative is proposed to provide a focus for interagency collaborative research in the Beringian and greater North Pacific region. The initiative draws on existing Beringian programs conducted by Federal, state and university sectors. Collectively these programs support a large body of scientific research, much of which is now conducted with little coordination. Especially significant advances can be made in trans-Beringian research, where international collaboration is required. Closer ties and a regional perspective would facilitate understanding of human responses to environmental change and ecosystem perturbation in this shared northern environment.

An important feature of the Beringian environment is its position as a unique, tightly confined geographic, historic and cultural region. This condition enhances its importance scientifically and is the major justification for a regionally integrated program of study. In taking a regional approach this program seeks to broaden the history of separate nationally based research to develop a new synthesis based on regional integration and multidisciplinary study.

The ecologically rich Beringian region has long been seen as the birthplace of New World Arctic cultures and the center from which these cultures spread into other regions of the New World and nearby Asia

The Beringian Studies Initiative proposes to link components of existing research programs into a geographically focused and thematically integrated network and to enhance these programs through collaborative and cooperative study. The accordance with recent reports and recommendations (IARPC Research Plan, PRB Agenda for Action, *Arctic Research of the U.S.*, Fall 1992 social science issue), the objective is to develop an integrated approach to studies of Beringian ecosystems, processes, cultures and history. A primary thrust will be to develop knowledge useful for studying human dimensions of global change and to ensure maximum environmental productivity and protection. The program is planned to be multidisciplinary and international. Relevance to modern issues will help guide the research, and Native and local community participation will be encouraged.

Research Themes

The ecologically rich Beringian region has long been seen as the birthplace of New World Arctic cultures and the center from which these cultures spread into other regions of the New World and nearby Asia. The long history of human occupation of the Beringian region 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 Bering 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, tectonic activity, volcanism and climatic change, and they reflect the influences of these changes on local and regional animal and plant populations. Pollen and macrofossil samples from cores and stratigraphy from human settlement sites can correlate human activities with environmental change.

These data can provide the time depth necessary to construct predictive and testable models relevant to many aspects of global change research. Among the most important social science research topics that can be addressed are the peopling of the New World, adaptations and dynamics of Arctic social and cultural change, regional paleoecology, landscape history, Russian–American history, and contemporary cultural, social, demographic, linguistic, psychological and health issues.

Research Program

The need for new information about the Beringian region has been highlighted by a number of recent developments, including production of several major exhibitions by the Smithsonian ("Crossroads of Continents," "Russian America" and "Etholin"); the proposed Beringian Heritage International Park (1989); the existing shared Beringian Heritage Program, which is providing the background research for the park concept; plans and reports on research needs (IARPC Plan; PRB report; Hopkins et al.

1990); increases in Russian–American conferences and scholarly exchanges (NAS; Young 1992); proposals for new interdisciplinary research dedicated to trans-Beringian science like "Arctic Crossroads" and "Jesup II"; and proposals generated at the First International Congress of Arctic Social Sciences, held in Quebec in October 1992.

The social sciences (archeology, anthropology, history etc.) provide the core of this integrated initiative, which involves collaboration with natural sciences including biology, geology, paleoecology and marine sciences. The program provides both time depth and a multidisciplinary analysis of human adaptation in the Arctic. Knowledge will be gained about circumpolar cultural development, past and present, and models will be formulated for human–ecosystem dynamics and demographic change.

Cultural resources management is a mission of numerous Federal agencies. The Department of Interior (particularly the National Park Service, the Bureau of Land Management and the Bureau of Indian Affairs) share responsibilities for preservation of 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 and preservation. The same is true regarding modern indigenous socioeconomic and health concerns, which require collaboration with the Department of Health and Human Services and its Indian Health Service, local governments, and Native councils and organizations in Alaska.

Goals and Objectives

- Increase baseline documentation on early Beringian cultures and archeological sites to establish regional cultural 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 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–environment interactions;
- Relate results of regional studies to larger global patterns of climatic and environmental interactions; and
- Promote the spread of traditional and scientific knowledge and encourage cooperative and international research and educational programs that include representation of northern residents and communities.

Existing and Planned Agency Contributions

The Beringian Research Initiative should be planned and conducted by a group of agencies whose current interests already include a wide array of projects relevant to this program. During the coming biennial period those elements most suitable for integration into the program should be identified and a working committee should be established for coordination and implementation. Each agency is expected to develop plans concordant with existing missions but with greater attention to joint planning, shared benefits and growth of international activities. A sample of proposed activities might include:

- 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, ethnoarchaeological, archaeological, geomorphological, paleoecological and landscape history research;
- Smithsonian Institution: Develop research and museum programs directed at studies of trans-Beringian archeology, ethnography, history and art as part of a centennial "Jesup II" program operating through a consortium of American museums, universities and international contacts;
- National Science Foundation: Fund 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 facilitating international contacts and exchanges;
- NOAA: Support relevant research through its Sea Grant Program and with assistance in marine food chain studies and field 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;
- DOD: Provide funding for pollution research and logistics support for field activities consistent with current mission objectives.

Implementation

This social and natural sciences initiative should be 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 would develop and implement existing and new research programs. Programs under the U.S.–Russia Agreement on Cooperation in the Field of Environmental Protection and other international instruments would be used to facilitate international aspects of bilateral research.

Missions and research specialties unique to individual agencies would be combined into a coordinated plan. Each agency would seek support for specific components of planned activities: NPS through contract and in-house studies on park lands; NSF through peer-review projects; Smithsonian Institution through in-house programs and academic collaborators operating through a "Jesup II" 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 and research centers.

2.5 Arctic Data and Information

Goal: To facilitate Arctic research by identifying and developing methods to improve the acquisition, storage and dissemination of Arctic data and information.

Arctic Data

The Arctic Environmental Data Directory Working Group has assembled the AEDD, which now contains over 400 references to the significant Arctic data holdings managed by IARPC agencies, several Alaska state and local agencies, various universities that conduct Arctic research, and a few ministries in Canada and other Arctic nations. The IARPC requested that funds be made available from each agency to support the AEDD and related work at the USGS. Seven agencies are currently contributing funds directly to this effort.

The initial thrust of AEDD was to describe the major data holdings of the earth-science community. A recent focus has been to identify and include major Arctic socioeconomic data sets, including data relating to health, medicine, demographics and the Native population. In 1992 the AEDD Working Group completed the first quality-control review of all AEDD entries for completeness, consistency and accuracy. The Group wrote an instruction manual to assist contributors and reviewers in generating high-quality data-set descriptions for the AEDD.

The AEDD is linked to other data directory activities. It shares structure and exchange capability with the Global Change Master Directory (GCMD) to improve the use of Arctic data for global change research and the use of global change data for Arctic research. All entries in AEDD are compatible with the Directory Interchange Format (DIF) used by GCMD so that entries in either may be exchanged with the other. AEDD is a logical subset of the Earth Science Data Directory of the USGS. AEDD and its documented data input and review procedures are being used as the basis for the Arctic data directory activities of the United Nations Environmental Program/Global Resources Database (UNEP/ GRID) node in Arendel, Norway. The UNEP/ GRID program supports the IARPC Arctic Monitoring and Assessment Program's data and information activity.

AEDD is making the change from being a mainframe database to being a server in the client–server environment. Access to AEDD is available internationally to desktop users of the Internet either directly using the TCP/IP protocol or as a data source through the standardized Wide Area Information Servers (WAIS). By early 1993 AEDD will reside on a local-area network in the USGS offices in Anchorage, Alaska, as a WAIS server.

The AEDD Working Group developed a prototype digital data publication, the Arctic Data Interactive (ADI), on CD-ROM. The ADI, which is a prototype publication for the release and distribution of Arctic data and information, puts the data directory onto desktops of users with PCs or Macintoshes. With a second printing, nearly 1000 copies of the ADI CD-ROM have been requested and distributed to Arctic scientists, educators, libraries and the public. The innovative ADI received the 1992 Presidential Design Achievement Award from the National Endowment for the Arts, the first project based on electronic media ever to receive this quadrennial award.

A very active outreach program has been organized by the AEDD Working Group to contact organizations that gather, manage and use Arctic data and information. Workshops have been held in many Alaska locations, and presentations on Arctic data activities have been given to Federal, state and academic groups and conferences. Through CONRIM, the Council on Northern Resources Information Management, the AEDD Working Group actively involves a diverse group of Alaska-based Federal, state and academic organizations. The AEDD activities have been described in articles written for the scientific, educational and technology media. The AEDD Working Group maintains active contact with the Arctic Research Commission, the Polar Research Board and other IARPC programs.

Objective

- To be *the* source to answer the question "Who has what data for the Arctic?" To accomplish this, AEDD must make it as easy as possible to access information about Arctic data. To this end, AEDD shares database structures, quality-control procedures, and access mechanisms among Arctic directories world-wide. Scientists, educators and the interested public may query any or all of these directories concurrently. The user sees entries from all of the directories, including AEDD, as if they were one.

Planned Interagency Activities

- Cosponsor a workshop for organizations that actively maintain Arctic directories with the purpose of sharing standard data-base structures, quality-control procedures and access mechanisms;

- Coordinate the implementation of WAIS, the Wide Area Information Servers, as a standard means of accessing Arctic directories from desktops using the Internet, world-wide;
- Increase the number of entries in AEDD to represent more completely the major earth-science and socioeconomic Arctic data holdings of the U.S. Federal agencies, the agencies of the State of Alaska, and selected universities and other research organizations;
- Collaborate with U.S. and international organizations to identify, gather, document, preserve and disseminate Arctic contamination data from the former Soviet Union and represent these data as appropriate in AEDD, together with descriptions of Arctic contamination data sets of the U.S. Federal agencies, the agencies of the State of Alaska, and academic institutions;
- Improve existing entries in AEDD through a cycle of review and updates from organizations that sponsored or provided the data-set references;
- Support the data management activities of the other IARPC programs, including the Arctic Monitoring and Assessment Program, the Arctic marine and terrestrial mesoscale ecosystem programs (for example, the Bering Sea), Arctic contamination investigations and other integrated U.S. Arctic programs;
- Establish or strengthen links between AEDD and related directories in the U.S., including the Global Change Master Directory, the Global Land Information System, UNEP/GRID and directory systems developed in the Antarctic research community;
- Distribute AEDD more broadly to the Arctic science and education community with tools that facilitate access to and use of valuable information about Arctic data;
- Participate in the development of new directory exchange and search mechanisms, such as studying library-based MARC format for data-set descriptions; and
- Promote adoption of the AEDD by the AEPS as its Arctic data system.

Arctic Information

The U.S. Polar Information Working Group (USPIWG) has now formalized and combined its efforts with the Data and Information Resources Working Group (DIRWOG). USPIWG is an independent body of U.S. polar information specialists associated with the international Polar Libraries Colloquy. Institutions and organizations currently represented are the University of Alaska Fairbanks, University of Alaska Anchorage, World Data Center A and Institute of Arctic and Alpine Research at the University of Colorado, Byrd Polar Research Center at the Ohio State University, Dartmouth College, Cold Regions Research and Engineering Laboratory, and the Cold Regions Bibliography Project. At their NSF-sponsored meeting in Boulder in March 1993, the group discussed polar archival resources, bibliographies of permafrost and of Inuit health, modernization of the Cold Regions Bibliography Project, the PolarPac and Arctic and Antarctic Regions CD-ROMs, and a plan for distributing responsibilities for accessioning and indexing polar regions information. 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.

Ongoing and Planned Activities

- Provide improved information regarding individual database descriptions and policies for users of PolarPac and Arctic and Antarctic Regions CD-ROMs;
- Improve 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 implementing appropriate strategies to meet this challenge;
- Develop an electronic mail network on Internet, similar to POLAR.LIT on Omnet, to promote further international networking of bibliographic activities;
- Initiate a column in the twice-yearly *Polar Libraries Bulletin* to acquaint readers with locally held bibliographic files that may be of general interest;
- Produce a revised version of *Polar and Cold Regions Library Resources: A Directory* 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 Bibliographic Information

PolarPac version 3, the CD-ROM database of international polar regions bibliographic information, will be available 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 will be included. Serials titles are already included from the above libraries and several dozen worldwide. Arctic and Antarctic Regions, NISC's CD-ROM suite of polar regions reference databases from around the world, in its December 1992 version, has over half a million records, mostly of journal articles. 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.

Arctic Data and Information

An ad hoc Data and Information Resources Working Group (DIRWOG) produced a guide to Arctic information and data sources for distribution to libraries and university and high school science departments. *Arctic Information and Data: A Guide to Selected Resources* was completed in September 1992 and is being distributed by the Arctic Research Consortium of the United States (ARCUS). The 50-page compilation contains 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. Because of limited time and resources, the focus is on U.S. sources.

The DIRWOG comprised volunteers from the U.S. Army Cold Regions Research and Engineering Laboratory Library; the Rasmuson Library, University of Alaska; the U.S. Fish and Wildlife Service Office of Information Transfer; Hughes/STX representing NASA's Global Change Master Directory; Kilkelly Environmental Consultants representing the Environmental Protection Agency; the Dartmouth College Library; the Institute of Arctic and Alpine Research, University of Colorado; and the National Snow and Ice Data Center, University of Colorado. (See Section 4 for a discussion of data facilities.)

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 Spring 1992 issue of *Arctic Research of the United States* and will be updated in the Spring 1994 issue. Objectives of Federal agencies are briefly described, focusing on the period covered by this revision (1994–1995).

3.1.1 Ice Dynamics and Oceanography

A singular feature of the Arctic Ocean is the 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 models. A systematic program of oceanographic, cryosphere and atmospheric measurements by conventional technologies, as well as new technologies such as autonomous underwater vehicles (AUVs), is needed to support the objectives of this mission element and the interagency program (see Section 2.1).

Objectives

- Determine the processes, 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, its 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 (see Section 2.1).

Objectives

- Determine the status and trends of fish, birds and marine mammals 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 on the environment and of human activities on both the biotic and abiotic 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 basin will require extensive geophysical and geological research and the integration of newly collected data on an international scale (see Section 2.2).

Objectives

- Develop and perfect new techniques for deployment of instruments in the harsh Arctic environment (for example, seismic tomography, geophysical arrays, hydraulic piston coring, scientific deep drilling);
- Initiate Arctic marine geological and geophysical studies to provide information on past and present climate change, support rational development of natural resources, and address fundamental questions of global geo-

logic 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 atmosphere, the ionosphere and the magnetosphere 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.

Our understanding of these coupling processes is far from complete due to the sparsity of measurements in the Arctic regions

There is great interest in understanding and separating anthropogenic effects (such as greenhouse gases) and natural variability (such as 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 will be supported partially under the U.S. Global Change Research Program (USGCRP) and will naturally 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 setting up a coordinated rocket program, promoting the use of special facilities and making use of research aircraft;
- Maintain active theoretical programs and promote the evolution of models to describe the unique physics of the atmosphere and ionosphere in Arctic regions;
- Understand solar phenomena that affect Earth's environment;
- Understand electromagnetic waves, fields and particles in near-Earth space; and
- Develop an understanding and the ability to make long-term predictions of radio propagation in and through 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. It is necessary 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 hazardous weather, such as Arctic lows, storm surges, icing conditions and fog, which can affect human activities.

Objectives
- Develop an Integrated Arctic Climate Studies Program as part of the U.S. Global Change Research Program, 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 parameterizations of cloud and radiative transfer processes in General Circulation Models (GCMs) as part of the U.S. Global Climate Change Research Program.

3.2.3 Tropospheric and Stratospheric Chemistry and Dynamics

The chemistry of the Arctic atmosphere is dynamic, changing in response to natural and man-induced disturbances. Stratospheric ozone depletion is a global process accentuated at the poles. Ice core chemistry reveals current and historic trends in global 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 chemistry.

Objectives
- Establish the correlation between the chemistry of polar stratospheric clouds in the Arctic and the ozone concentration at northern midlatitudes;
- Develop a database for determining long-term regional trends in climate and air chemistry, including solar radiation levels, 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 a relative lack of exploration. The remote frozen environment requires long lead times for energy and mineral development. Additional information is necessary to allow the discovery, assessment and mapping of new and dependable sources of oil, gas, coal and strategic minerals. These resources are important for national security and independence, as well as for local use and economics (see Sections 3.1.3 and 2.2 for related activities).

Objectives
- Continue systematic mineral appraisal activities and expand programs to provide for periodic assessment 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, complete geologic database, increase geologic mapping, expand modeling efforts and design derivative maps to address broader earth-science questions; and
- Evaluate the economic, environmental 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 only be answered 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 (see Sections 2.2 and 2.4 for related activities).

Objectives
- Map beach, littoral and nearshore sediment and subsea permafrost and determine its asso-

ciated 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 and sediment distribution patterns 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 parameters of importance to vital processes (for example, feeding and breeding).

To assure that biological resources are protected, management agencies must have adequate data and information on the biology and ecology of these species, as well as information on environmental parameters of importance to vital processes

Objectives
- Determine the 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 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. Reliable information is also needed on surface water quality and quantity. Collection of this information will help provide a climatic and hydrologic baseline for the Arctic.

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;

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

- 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 change caused by "greenhouse"-induced changes in polar glaciers and ice caps; and
- Establish the role of land–water interactions in the control of nutrient cycling.

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, including possible greenhouse warming, on terrestrial, atmosphere and marine environments, as well as contaminant transport and deposition. Research is needed to improve our understanding of the influence of climate on land and freshwater processes and vice versa. Topics of particular importance include heat balance relationships, landscape alteration, impacts of wildfire, identification of biological indicators of change, current 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;
- Expand the number of Long-Term Ecological Research sites and biological observatories into representative Arctic sites under LTER, MAB and ANILCA activities;
- 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

Perhaps no other area can provide as immediate a return on investment for the Arctic than the development of new and enhanced engineering capabilities and technologies. These areas are critical for improving and expanding infrastructure, addressing environmental quality mitigation and restoration problems, environmentally sustainable development of natural resources and improving the quality of life available in remote communities. The harsh and unique environment of the Arctic makes advancement in these areas particularly difficult and limits the ability to simply borrow or share in engineering and technology advances from non-polar regimes. Only focused and specific efforts will develop the capabilities needed for the Arctic. Programs that address the priority Arctic engineering research needs are necessary to support these efforts.

The January 1993 biennial statement of the Arctic Research Commission, *Goals and Priorities to Guide United States Arctic Research,* is the most recent statement of priority areas for Arctic engineering and technology. In this document the Commission found that in order to achieve the basic principles of the United States Arctic policy and to achieve the desired national competitiveness in the Arctic, the nation's Arctic engineering capabilities must be improved through a balanced, sustained and coordinated 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;
- Outdoor material and equipment performance testing capabilities;
- Methods for waste disposal and local air pollution control under Arctic conditions; and
- Small-scale power generation and energy storage technologies.

Perhaps no other area can provide as immediate a return on investment for the Arctic than the development of new and enhanced engineering capabilities and 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, alternatives to combustion, and policy analysis and information transfer activities related to testing and acceptance of 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 identified the following priority areas of scientific research whose results are of critical importance and are areas of important technology 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 construction, operation and maintenance of 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 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 (Sec. 102b). The purpose of the Act 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 the 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 interactions relating to health and well being.

In the post-Cold-War world, new opportunities have opened for Arctic research, but at the same time there are greater demands to respond to the needs of society within and outside of northern regions

In accordance with these stated goals and with 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.

Arctic Social Sciences Task Force

The Interagency Arctic Social Science Task Force meets periodically and consists of various agency representatives, including the National Science Foundation, 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 the 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.

Special Social Sciences and Health Issue of Arctic Research of the United States

The Arctic Social Sciences Task Force prepared and edited the Fall 1992 issue of the IARPC journal, bringing together a collection of seventeen scientific articles. The special issue was created to showcase Federally funded social science, health and education projects and to demonstrate the value of these efforts. The articles are loosely grouped under three themes: human–environment interactions, community viability and rapid social change.

In the post-Cold-War world, new opportunities have opened for Arctic research, but at the same time there are greater demands to respond to the needs of society within and outside of northern regions. This issue of *Arctic Research of the United States* was a timely response to the new challenges and demonstrated the important role of Arctic social science and health research for the United States and internationally.

International Arctic Social Sciences Association

The formation of the International Arctic Science Committee (IASC) in August 1990 brought to the forefront the need for international coordination of research. With the input of the Arctic Social Sciences Program, an International Arctic Social Sciences Association (IASSA) was formed at the NSF-sponsored Inuit Studies Conference in July 1990. The goal of IASSA is to objectively represent the social sciences in the 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. The next conference will be held in Rovaniemi in 1995.

Northern Sciences Network

The international coordination of ecological research in the Arctic has been facilitated by the Secretariat of the NSN at Rovaniemi, Finland. U.S. support of the NSN was made possible through the Department of State-sponsored U.S. MAB High Latitude Directorate. During FY 92 funding was provided for a U.S. post-doctoral fellowship in Rovaniemi, and this position was held by an Arctic social scientist. The NSN office will move to the Danish Polar Center in 1994.

Arctic Pollution and the Social Sciences

The Arctic Environmental Protection Strategy (AEPS) specifically refers 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 leading to the endorsement and ongoing development of the Protection Strategy, and it has participated in IARPC meetings concerned with pollution problems. The DOS continues to coordinate U.S. participation in AEPS, signed by the eight Arctic nations in 1991.

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

Human Dimensions of Global Change

Global change is one of the major research themes of the decade. It is widely recognized that human activities contribute to these changes and will be severely affected by the consequences.

The NSF Arctic Social Sciences Program funded seven projects relating to the Human Dimensions of Global Change (HDGC) in 1992. This trend will continue in 1993 in collaboration with the HDGC Program in the NSF Social, Behavioral and Economic Sciences Directorate.

The NOAA Office of Global Programs, with Sea Grant leadership, sponsored a national workshop on the Human Dimensions of Global Change and is developing an HDGC research agenda and budget initiative that will complement the efforts of other Federal agencies.

The Department of Agriculture Social Dynamics Working Group is developing an integrated research strategy involving social scientists from the U.S. Forest Service, the National Science Foundation, NOAA, the U.S. Fish and Wildlife Service, the National Park Service and the Smithsonian.

The Department of State, through the Polar Research Board and IASC, follows the activities of IASC, which includes working groups on the human and social sciences under the theme of Arctic global change.

The Smithsonian Institution's Arctic Studies Program is developing the Jesup II North Pacific Research Program, which will investigate global cultural and environmental change in a Beringian context.

Resources Management

Over 66% of Alaska is managed by Federal agencies. Cultural and natural resources are protected by law. Although cultural resources, historic and prehistoric sites, artifacts and landscapes require documentation and protection, renewable resources, especially fish and game, are also culturally defined through subsistence needs. In 1990, Alaska's subsistence laws were declared unconstitutional because they discriminated against non-rural residents. As a result, Federal land management agencies assumed responsibility for subsistence management. The U.S. 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 (fish and most species of marine mammals) is led by the 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.

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 NSF Arctic Social Sciences Program has awarded 12 dissertation improvement grants for Ph.D. 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 Resource Apprenticeship Program of the Department of the Interior has provided summer jobs for Alaska Natives through the National Park Service, Bureau of Land Management and Fish and Wildlife Service. 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 to 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 Forest Service will continue to sponsor multicultural educational opportunities involving Native and local communities as well as the diverse range of forest visitors.

The Smithsonian has conducted educational programs in the North Pacific and Russian Far East and provided museum and exhibit training in Anchorage and Fairbanks (see Section 2.4).

Repatriation

Repatriation has become a major priority for museums and research institutes since the passage of NAGPRA (Native American Graves Protection Act) of 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.

The process has already started at the Smithsonian with the return of a large collection of human remains and grave goods to the town of Larson Bay, Kodiak Island. Repatriation is expected to provide a basis for closer and more productive working relationships between Native peoples and the academic community.

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 should be made accessible to residents potentially affected by the research.

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, which are rapidly losing their traditional ways of life, oral histories, languages and cultural heritage. It is recognized that 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. With tighter budget restraints, interagency collaboration is not only preferable but will become increasingly 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's (MAB) High Latitude Ecosystem Directorate is charged with developing multiyear interdisciplinary core projects in the social and natural sciences.

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, walrus

and whales supported the largest human populations in Alaska, and changing shorelines and maritime conditions are reflected by these sites.

Objectives

- Document and analyze the origins and transformations of Arctic cultural systems, ethnic groups and languages;
- Record and analyze traditional knowledge systems, languages, oral histories, 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.

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 it 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 they function under extreme environmental constraints. Economic development is extremely costly, and environmental impacts are long-lasting. Furthermore, there are major conflicts between the 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. One key to recovery is 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.

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 is physical, mental, social and spiritual well-being. Unique cross-cultural interactions and social interdependencies due to harsh environmental conditions in the Arctic highlight this definition of health. Therefore, all Arctic health research must take into account complex human and environmental interactions.

Health research in the Arctic includes 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 Arctic communities. Health concerns in the Arctic are often related to international health issues. Western culture (and potentially Asian culture) impacts Native people adversely by introducing lifestyle and dietary changes and new infectious agents. Research designed 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 Alcohol, Drug Abuse and Mental Health Administration, the Department of Defense and the Division of Public Health, State of Alaska.

Objectives

- Establish and support basic and applied scientific inquiry for the purpose of improving human health through biomedical and behavioral research programs; and
- 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.

4. Operational Support

Ships and Ice Platforms

Vessels supporting research in ice-covered areas fall into four 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; 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. Central management of the icebreaker fleet, given adequate resources, permits the interchangeability of ships to ensure mission accomplishment. The Coast Guard has two icebreakers and is acquiring a third, with construction scheduled to begin in 1993.

The requirement for research in the Arctic has increased recently. No suitable dedicated U.S. research vessel exists to support this need. The University National Oceanographic Laboratory System (UNOLS) published the report *Science Mission for an Intermediate Ice Capable Research Vessel* in 1993. The science mission requirements for an Arctic research vessel are being updated by the UNOLS Fleet Improvement Committee. There is a need for specific identification of research vessels to collect seismic reflection profiles, geopotential data, sediment samples and seismic-refraction profiles in the Bering Sea, Arctic Ocean and Chukchi Sea, and to conduct winter research in the Bering and Greenland sea polynyas. NSF plans include support for the construction of an Arctic research vessel. The conceptual design has been completed and has undergone community review (Glosten Associates 1993). Model tests are in progress.

Coast Guard icebreakers are available to users on a reimbursable basis. Daily fuel costs and maintenance surcharges are charged to users.

Drift stations and other ice platforms including Russian and Canadian opportunities will be utilized as research needs dictate.

The U.S. Navy is planning to support a scientific cruise under the Arctic Sea ice in a nuclear submarine in the summer of 1993. Although the Navy has previously carried out classified scientific work from nuclear submarines in the Arctic Ocean, this will be the first cruise for which the Navy has issued an open invitation to the U.S. science community to participate and from which the data that are collected will be released to the public. The scientific program is a joint effort of the Commander Submarine Force U.S. Atlantic Fleet, the Navy's Arctic Submarine Laboratory, the U.S. Arctic Research Commission and UNOLS.

The cruise results will provide vital new data relevant to studies of climate change, threats to the Arctic environment, movement and changes of the permanent ice pack and the geological history of the Arctic Ocean basins. In fulfilling the objectives of the science plan, the cruise will consist of 19 days of surveying and station work under the ice in the central Arctic Ocean basins. Transects will be conducted across the central basin from near the North Pole and the Alaskan continental shelf and back, as well as several additional crossings of the Lomonosov Ridge, the Markarov Basin and the Alpha–Mendeleyev Ridge. Two bathymetric–ice cover grid survey areas will be considered: one of the Lomonosov Ridge and the other near the Alpha–Mendeleyev Ridge.

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

Land-Based Facilities

The Polar Ice Coring Office provides logistics support for research in Greenland, with emphasis on the Greenland Ice Sheet Project 2 (GISP2). 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 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 land-based facilities 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.

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 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 square feet 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 Sondrestrom, Greenland. The U.S. incoherent-scatter radar facility at Sondrestrom is used by several agencies. The U.S. Air Force terminated operations at Sondrestrom Air Base on September 30, 1992. Science programs that formerly relied on the Air Force for logistics support are now supported by sponsoring agencies.

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 on OMNET is available for posting currently available logistics information (ARCTIC.LOGISTICS).

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) and at the National Geophysical Data Center (seismology, geomagnetism, marine geology and geophysics, solar and ionospheric studies, ecosystems, topography and paleoclimatology). 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 (DAAC), 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 DAAC 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 search the archives, scientists would have no access to the data

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, 1 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
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
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
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
DA	Department of Agriculture
DAAC	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
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
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
GEOSAT	Geostationary Satellite
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
ITEX	International Tundra Experiment
JERS-1	Japanese ERS-1
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
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)
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	Radar Remote Sensing Satellite
REU	Research Experience for Undergraduates program
SAR	Synthetic Aperture Radar
SCS	Soil Conservation Service
SeaWiFS	Sea-Viewing Wide-Field Sensor
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 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: Fourth Biennial Report of the Interagency Arctic Research Policy Committee to the Congress

February 1, 1990, to January 31, 1992

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 it was established in 1985. The required statements were published in *Arctic Research of the United States*, Spring 1992.

During the period February 1, 1990, to January 31, 1992, the IARPC has:

- Prepared and published the second 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 23, 1991.
- Published and distributed four issues of the journal *Arctic Research of the United States.* The journal reviewed all Federal agency Arctic research for FY 1989 and 1990 and included summaries of the IARPC and Arctic Research Commission meetings and activities. The Spring 1991 issue contained the full text of the second biennial revision to the U. S. Arctic Research Plan.
- Consulted with the Commission on policy and program matters described in the Section 108(a)(3), was represented at all meetings of the Commission, and responded to Commission reports on goals and objectives, logistics and data.
- Continued the processes of interagency cooperation and coordination required under Section 108(a)(6), (7), (8) and (9).
- Provided input to an integrated budget analysis for Arctic research for the President's budget, which identified $116 million in Federal support for FY 1990 and $128 million in FY 1991.
- Provided for public participation as required in Section 108(a)(10), which culminated in public involvement in the development of the recommendations and the second biennial revision to the Plan at a meeting in Anchorage in March 1991.
- Prepared a strategy report, published in January 1991, for an FY 1992 interagency Arctic program that identified four key science elements for future research and coordination (Western Arctic Ocean Circulation and Productivity; Arctic Basin Geodynamics; Arctic Environmental Monitoring; and the Bering Land Bridge Program).
- Participated in the development of testimony on Federal Arctic research for hearings on April 24, 1991, by the National Ocean Policy Study of the Senate Committee on Commerce, Science, and Transportation, and hearings on May 13, 1991, by the Science, Technology, and Space Subcommittee of the Senate Committee on Commerce, Science, and Transportation.
- Prepared and updated the Arctic Environmental Data Directory, which now contains information on 350 Arctic data sets, and published Arctic Data Interactive (ADI), a prototype CD-ROM (compact disc–read only memory) product containing Arctic environmental data and information.
- Established 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.
- Approved an Interagency Statement of Principles for the Conduct of Research in the Arctic to encourage communication and

scientific partnerships with northern indigenous peoples (published in the second biennial revision to the United States Arctic Research Plan).

- Participated in the establishment of the nongovernmental International Arctic Science Committee.
- Participated in policy formulation and official endorsement of the June 1991 international agreement for an Arctic Environmental Protection Strategy. This strategy contains a set of principles and objectives for the protection of the Arctic environment. It also established the Arctic Monitoring and Assessment Program (AMAP) to provide a forum for international harmonization of Arctic monitoring programs. IARPC's Environmental Monitoring Working Group serves as a U.S. focal point for AMAP and coordinates domestic monitoring efforts.
- Convened two formal meetings of the Committee, in June 1990 and June 1991.

Appendix C: Arctic Research Budgets of Federal Agencies

Dept/ Agency	*Program name*	*Category**	*Budget (dollars in thousands) FY 92 actual*	*FY 93 budget*	*FY 94 proposed*
DOD	Arctic Engineering	S	2,615	2,795	3,654
DOD	Permafrost/Frozen Ground	S	1,139	1,195	1,163
DOD	Snow and Ice Hydrology	S	4,589	5,264	4,894
DOD	Oceanography	S	8,920	9,538	8,520
DOD	Lower Atmosphere	S	1,715	1,222	621
DOD	Upper Atmosphere	S	3,650	3,400	3,300
DOD	Medical and Human Engr	S	601	656	940
DOD	Arctic Contamination Studies	S	0	10,000	0
	DOD TOTAL		23,229	34,070	23,092
DOI/MMS	Technology Assessment/Research	R	3,250	2,960	2,850
DOI/MMS	Environmental Studies	R	2,027	2,802	1,795
DOI/USGS	Energy and Minerals	R	2,850	2,850	2,850
DOI/USGS	Natural Hazards	R	3,700	3,700	4,200
DOI/USGS	Ice and Climate	R	750	675	675
DOI/USGS	Hydrology	R	150	130	130
DOI/USGS	Glaciology and Quaternary	R	175	165	165
DOI/USGS	Marine Geology	R	500	500	500
DOI/USGS	Magnetosphere	R	25	25	250
DOI/USGS	Mapping	R	1,000	1,000	1,000
DOI/FWS	Marine Mammals	R	1,450	1,459	1,460
DOI/FWS	Migratory Birds	R	1,970	1,970	2,070
DOI/FWS	Fisheries Research	R	388	389	389
DOI/FWS	Cooperative Research	R	350	350	350
DOI/FWS	Terrestrial Ecology	R	1,100	1,100	1,100
DOI/BLM	National Wildlife Refuge	R	60	60	60
DOI/BLM	Habitat-Arctic	R	300	300	300
DOI/BLM	Habitat-Kobuk	R	550	550	550
DOI/BLM	Pipeline Studies	R	325	350	275
DOI/BLM	Fire Control	R	350	350	350
DOI/BLM	Nat Petro Reserve/Alaska	R	60	60	60
DOI/BLM	Minerals/Mining	R	350	330	300
DOI/BLM	Global Change	R	40	40	420
DOI/NPS	Cultural Resources	R	628	625	850
DOI/NPS	Natural Ecology	R	1,400	1,400	1,400
DOI/BIA	Cultural	R	1,700	1,700	1,500
DOI/BIA	Subsistence	R	750	750	850
DOI/BOM	Minerals	R	1,490	1,205	1,275
	DOI TOTAL		27,688	27,795	27,974
NSF	Atmospheric Sciences	L	6,606	6,600	7,260
NSF	Ocean Sciences/Ship Support	L	3,270	3,270	3,597
NSF	Biological Sciences	L	5,410	5,410	5,951
NSF	Glaciology	L	2,364	2,360	2,596

* Category: S = National Security, R = Resource Development, L = Arctic as Laboratory.

Dept/ Agency	Program name	Category*	Budget (dollars in thousands) FY 92 actual	FY 93 budget	FY 94 proposed
NSF	Earth Sciences	L	3,105	3,100	3,410
NSF	Arctic Systems Science	L	11,346	11,350	12,485
NSF	Engineering	L	204	200	220
NSF	Social Science/Education	L	1,895	1,900	2,090
NSF	Coordination	L	210	230	253
NSF	Arctic Research Commission	L	536	530	560
	NSF TOTAL		34,946	34,950	38,422
NASA	Polar Ocean/Ice Sheets	R	10,500	11,000	12,000
NASA	Land Processes	R	1,600	3,000	2,000
NASA	Solid Earth Science	R	1,100	1,000	1,200
NASA	Atmospheric Sciences	R	750	620	1,000
NASA	Arctic Ozone	R	7,500	1,500	1,500
NASA	Sounding Rocket Program	R	1,100	1,150	1,200
NASA	Dynamics Explorer	R	600	200	0
NASA	Space Plasma Research	R	895	895	895
NASA	Solar Terrestrial Theory	R	420	420	420
	NASA TOTAL		24,465	19,785	20,215
DOC/NOAA	Arctic Haze	R	100	100	100
DOC/NOAA	Solar Terrestrial	R	250	250	250
DOC/NOAA	Atmos Trace Constituents	R	180	180	180
DOC/NOAA	Climate Modeling	R	300	300	300
DOC/NOAA	Environmental Prediction	R	1,065	1,065	1,065
DOC/NOAA	Fisheries Assessment	R	2,400	2,400	2,400
DOC/NOAA	Marine Mammal Assessment	R	1,200	1,200	1,200
DOC/NOAA	Sea Grant	R	195	195	195
DOC/NOAA	Ocean Assessment	R	20	500	800
DOC/NOAA	Stratospheric Ozone	R	1,000	750	1,000
DOC/NOAA	Arctic Ecosystems	R	1,890	1,890	1,890
DOC/NOAA	Data Management	R	1,415	1,415	1,415
DOC/NOAA	Human Resources	R	679	679	679
DOC/NOAA	Aircraft/Vessels	R	2,805	2,805	2,805
DOC/NOAA	Global Change	R	1,782	1,782	1,782
	DOC TOTAL	R	15,281	15,511	16,061
DOE/FE	Gas Hydrates	R	100	0	0
DOE/EML	Environmental Measurements	R	212	415	415
DOE/ER	Ecosystem Response	R	717	1,295	0
DOE/ER	Ecological Research (PER)	R	0	0	400
DOE/ER	Response to Carbon Dioxide	R	469	470	375
DOE/ER	Atmos Radiation/Planning	R	290	394	500
DOE/ER	Magnetosphere Research	R	148	152	140
	DOE TOTAL		1,936	2,726	1,830
DHHS	Indian Health Service	L	750	750	250
DHHS	National Institutes of Health	L	2,766	2,766	1,850
DHHS	Communicable Disease Con Ctr	L	4,130	3,194	2,284
DHHS	HRSA/HCFA	L	225	0	0
DHHS	ADAMHA	L	3,331	3,330	3,700
	DHHS TOTAL		11,202	10,040	8,084

* Category: S = National Security, R = Resource Development, L = Arctic as Laboratory.

† Includes major operational support $5.5 million/yr.

Dept/ Agency	Program name	Category*	Budget (dollars in thousands) FY 92 actual	FY 93 budget	FY 94 proposed
SMITHSONIAN	Anthropology	L	600	600	630
SMITHSONIAN	Arctic Biology	L	75	75	75
	SMITHSONIAN TOTAL		675	675	705
DOT/USCG	Test and Evaluation	R	814	814	1,200
DOT/USCG	Extramural Support	R	50	50	50
DOT/FHWA	Stream Crossings/Hydrological	R	250	250	250
DOT/FHWA	Pavement Problems	R	1,500	1,000	1,000
DOT/FHWA	Weather Monitoring	R	40	80	80
DOT/FHWA	Snow Control	R	140	530	200
	DOT TOTAL		2,794	2,724	2,780
EPA	Arctic Contaminants	R	837	837	837
EPA	Climate Change	R	81	425	425
EPA	Wetlands Restoration	R	0	125	0
	EPA TOTAL		918	1,387	1,262
AGRICULTURE	Forest Service	R	1,243	1,350	1,089
AGRICULTURE	Agricultural Research Service	R	778	778	778
AGRICULTURE	Cooperative State Res Service	R	1,291	1,222	1,275
AGRICULTURE	Soil Conservation Service	R	1,104	1,148	1,148
	AGRICULTURE TOTAL		4,416	4,498	4,290
STATE	Arctic Environmental Research	R	300	1,075	†
STATE	MAB: Arctic Directorate	R	175	175	175
	STATE TOTAL		475	1,250	175
GRAND TOTALS			148,025	155,411	144,890

* Category: S = National Security; R = Resource Development; L = Arctic as Laboratory.

† The Department of State has requested additional funds for environmental activities in FY 94. If approved, some portion of these funds will be available for Arctic research.

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

Introduction

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

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.

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

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 in-

formed 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: IARPC Policy Statement on Arctic Contamination

The U.S. and other countries are becoming aware of a potential problem that requires international cooperation: the extent of contamination of the Arctic area and the bordering seas by radioactive materials and a variety of other hazardous substances.

For example, there are many reported instances of Former Soviet Union disposal of radioactive and other toxic wastes directly into the Arctic Ocean and into aquatic and terrestrial Arctic and Subarctic sites. The contamination reported in the Former Soviet Union is of concern to eight Arctic nations and other countries because of the potential for redistribution and:

1. The level and distribution of radioactive and toxic contamination in terrestrial, aquatic, and marine Arctic environments,
2. The ecological risk of surface contamination to terrestrial, aquatic, and marine Arctic ecosystems,
3. The health risk to human populations, and
4. The economic impacts associated with contaminant transport throughout the Arctic and adjacent seas, and affecting fisheries, foodstuffs and other resources.

At present there is limited information regarding such contamination. Scientifically based quantitative data are essential for sound risk assessment activities.

IARPC agencies support a coordinated U. S. program to evaluate the ecological and health risks of Arctic contamination and a coordinated international effort under the umbrella of appropriate international organizations to:

1. Evaluate the scope of this problem,
2. Rescue data from world archives, and
3. Promote international scientific cooperation.

The international organizations include, for example, the Arctic Environmental Protection Strategy, with its focused efforts under the Arctic Monitoring and Assessment Program (AMAP), the International Atomic Energy Agency (IAEA), the International Maritime Organization (IMO), and the International Arctic Science Committee (IASC).

— adopted August 27, 1992

Appendix G: IARPC Agenda for Action to Implement Policy Statement on Arctic Contamination

IARPC intends to pursue an incremental plan to implement the Policy Statement on Arctic Contamination (adopted on August 27, 1992). IARPC will implement appropriate steps as warranted by successive analyses and available funds. These steps are:

1. Identify, compile and evaluate existing data on Arctic contamination resulting from the practices of the Former Soviet Union, in cooperation with scientists in other countries. Include results of 1992 *Polar Star* and Office of Naval Research cruises.
2. Assess the rates of movement of toxic materials and contaminated organisms into and out of Russian territorial waters. Assess the probable long-term effect on food webs and peoples of the North, and through export of fishery products, on peoples of lower latitudes. Where warranted, define the additional data necessary to assess the scope of the problem.
3 Depending on the outcome of the assessment activities, define policy issues, additional risk assessment activities, and risk management options for mitigative actions or other steps commensurate with the scientific risk or exposure assessments.
4. Define the potential for advancing Arctic science by measurements of labeled isotopes.

International collaboration will be conducted through the International Arctic Environmental Protection Strategy and its focused efforts under the Arctic Monitoring and Assessment Program (AMAP), and through bilateral cooperation and agreements with Russia. Data and information will be broadly shared.

The actions endorsed at this time are:

I. IARPC will sponsor 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.

II. IARPC, working through the U.S. Coast Guard and the U.S. Geological Survey, will design a series of monitoring activities to be conducted on the 1993 cruise of the *Polar Star*. These experiments will expand the compilation of biological, hydrological, and geological baselines in the western Arctic Basin and Margin, begun on the 1992 cruise of *Polar Star*.

III. Depending on the results of I and the availability of funds, IARPC agencies will issue an interagency announcement to solicit proposals from the scientific community to implement the recommendations from I.

IV. IARPC directs its Arctic Environmental Monitoring and Assessment Task Force to plan and implement these activities and to coordinate IARPC's actions with the International Arctic Environmental Protection Strategy and its focused efforts under the Arctic Monitoring and Assessment Program (AMAP).

V. IARPC will integrate specific research and assessment plans of U.S. Federal agencies into the Third Biennial Revision to the U.S. Arctic Research Plan that will be submitted to the President by July 31, 1993.

United States Arctic Research Commission

Twenty-Ninth Meeting
December 2–3, 1992

Commission Members Present: *Donald D. O'Dowd, Chairperson; Luis M. Proenza, Vice Chairperson; James O. Campbell; Clifford D. Groh; Charles H. Johnson; George B. Newton; and Peter Wilkniss representing the Ex-Officio Member Walter E. Massey.*

Staff: *Philip L. Johnson, Executive Director; and Lyle D. Perrigo, Head, Alaska Office.*

Advisors: *Knut Aagaard, Jerry Brown, Bill Fitzhugh and Norbert Untersteiner.*

Visitors: *Syun Akasofu, Scott Jackson, Jim Kelly and Tom Royer, University of Alaska Fairbanks; Charles Broches, Seattle, Washington; Walter Bugno, Alaska Oil and Gas Association; Roger Colomy, Applied Physics Laboratory; Dave Garman, U.S. Senate; Bonni Hycyk, Canadian Polar Shelf Project; Fred Karig, Applied Physics Laboratory; Richard Moritz, University of Washington; Charles Myers, National Science Foundation; R. Parson, U.S. Coast Guard; Fred Richard, National Bank of Alaska; John Roos, Pacific Seafood Processors; Neal Thayer and Tom Walker, U.S. Coast Guard; and Linc Washburn, Seattle, Washington.*

The Arctic Research Commission held its meeting at the Applied Physics Laboratory (APL), University of Washington, Seattle, on December 2–3, 1993. Chairperson Donald O'Dowd summarized activities since the previous meeting, which included participation in an important conference, "The Changing Role of the U.S. in the Circumpolar North," and presentation of testimony to the Senate Select Committee on Intelligence, both in Fairbanks in August. The Commissioners sought and initiated discussions with the Alaska Oil and Gas Association and with representatives of the fishing industry in Seattle on Arctic issues.

Following the Commission's resolution in August 1992 urging IARPC to prepare and coordinate a multiagency scientific plan to assess nuclear pollution in the Arctic, IARPC has adopted a policy statement (August) and an action plan (November).

The Commission provided a letter to NASA endorsing the planned upgrade of the Poker Flat Research Range and endorsed a proposal by Alaska State Senator Arliss Sturgulewski to establish a marine science foundation with funds from the *Exxon Valdez* settlement.

The Commission discussed and subsequently adopted a list of priority items to focus its activities for the coming year.

Alaska Congressional Delegation

Dave Garman of Senator Murkowski's staff reported that the Congress had designated $10 million to conduct a scientific assessment of nuclear waste disposal by the former Soviet Union in the Arctic. He intends that a coordinated multiyear program will be implemented, and he will continue via hearings to push for an Arctic Monitoring and Assessment Program (AMAP). He is also sensitive that the U.S. continue to seek Russian scientific cooperation.

The Commission has moved. Their new address is:

Arctic Research Commission
4350 N. Fairfax Drive, Suite 630
Arlington, Virginia 22203
Phone: (703) 525-0111
Fax: (703) 525-0114

Alaska Governor's Office

Luis Proenza reported that Governor Hickel had convened an Alaska economic futures conference, which projected a downward trend in revenue for that state. He also indicated that both the Alaska Department of Environmental Conservation and the Northern Forum were interested in the Russian nuclear dumping issue.

Interagency Arctic Research Policy Committee

Charles Myers, NSF staff for IARPC, reported that agency representatives had devoted considerable time since May 1992 to the issue of Russian nuclear pollution. On August 27 Chairman Walter Massey convened the Committee solely to discuss this subject, and a policy statement was adopted. By November 25th an Action Agenda to address this policy was agreed to by IARPC agencies. The specific actions so far endorsed are:

I. IARPC will sponsor 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. The first workshop may be in Anchorage in March 1993.

II. IARPC, working through the U.S. Coast Guard and the U.S. Geological Survey, will design a series of monitoring activities to be conducted on the 1993 cruise of the *Polar Star*. These experiments will expand the compilation of biological, hydrological and geological baselines in the western Arctic Basin and margin, begun on the 1992 cruise of *Polar Star*.

III. Depending on the results of I and the availability of funds, IARPC agencies will issue

an interagency announcement to solicit proposals from the scientific community to implement the recommendations from I.

IV. IARPC directs its Arctic Environmental Monitoring and Assessment Task Force to plan and implement these activities and to coordinate IARPC's actions with the International Arctic Environmental Protection Strategy and its focused efforts under the Arctic Monitoring and Assessment Program (AMAP).

V. IARPC will integrate specific research and assessment plans of U.S. Federal agencies into the Third Biennial Revision to the U.S. Arctic Research Plan that will be submitted to the President by July 31, 1993.

Charles Myers also reported that the joint Russian–Norwegian cruise to collect radiation data near Novaya Zemlya in August largely failed because the Russian Navy denied entry into Russian territorial waters, even though permission had been obtained to do so before leaving port. Peter Wilkness reported that organizational plans for an Arctic Section within NSF were completed but not yet announced.

Alaska Oil and Gas Association

Walter Bugno, representing the Alaska Oil and Gas Association (AOGA), discussed the difficulties the industry is having in further exploration and development of oil and gas in Arctic Alaska. The combination of international price of oil, increasing environmental regulation and public perceptions of acceptable risk translates into the prospect of no future activity. The most important assistance that the Arctic Research Commission could provide is a risk assessment to establish scientifically acceptable criteria to allow oil and gas exploration and development in the Arctic. Upon discussion the Commission decided to cooperate with the industry in better defining needed research and to appoint a committee of Members to consider and select a response to the AOGA.

Fisheries Industry Research Activity

John Roos, Vice President of the Pacific Seafood Processors Association, reported that after 26 years with the Pacific Salmon Commission he is now a science advisor to the Association. The North Pacific fishing industry is very concerned about declining populations of certain marine mammals, particularly the Steller sea lion in the Gulf of Alaska and eastern Bering Sea. The reasons for this decline are unknown; overfishing is a speculated cause that has led to regulatory actions. Consequently the industry has raised $300,000 for research beginning in 1993. The North Pacific Universities Marine Mammal Research Consortium has been formed as an independent science organization to carry out the research supported by industry funding. Dr. Peter Larkin, University of British Columbia, has been selected as research manager. Some of the work will take place in Canadian waters due to easier permitting of animal collections. The intent is to obtain independent data and analysis for credible scientific information on the factors affecting sea lion survival and the relationship between commercial fishing and marine mammals. Later efforts may analyze harbor seal and selected seabird populations. This project will be coordinated with Federal and state activities to avoid duplication.

Arctic Logistics Coordination

Lyle Perrigo introduced the purpose of the presentations on logistics coordination as (a) discharge of the Commission's mandated duties, (b) discussion of current issues and ideas, and (c) identification of needs and alternatives to improve logistics support of Arctic research. He indicated a full spectrum of logistics considerations, including marine, terrestrial and space as well as regional, national and international. Concerns also include costs of Arctic logistics, efficiency of services, safety of operations and ability to recruit new researchers, especially students, to Arctic science.

Fred Karig, Applied Research Laboratory (APL), University of Washington, identified the role of APL in providing logistics support for basic studies (6.1) and applied acoustics research (6.2 and 6.3) to the Office of Naval Research in the eastern and western Arctic seas. APL contracts directly with private-sector air carriers and provides equipment, instruments and personnel such as under-ice divers. Experience in operating research camps on sea ice over the years has built a valuable cache of Arctic logistic experience at APL. He estimates that 30–40% of research costs performed from ice camps is for logistics.

Syan-Ichi Akasofu, Director, Geophysical Institute, University of Alaska Fairbanks, thanked the Commission for its recommendation in 1988 to upgrade the facilities for Arctic space science at Poker Flats Research Range and for a crucial letter of endorsement to NASA in 1992 that helped release the $10 million for such improvements. He illustrated a new real-time data display now oper-

ating at Poker Flat that replaces conventional data analysis of aurora cameras and magnetic records previously requiring up to three years. He reported that over 95% of scientists using Poker Flat Research Range are non-Alaskans, so it is a national facility.

Dr. Akasofu illustrated a broad array of facilities supporting Arctic science in Alaska. These included the Volcanic Observatory, which examines continental drift and volcanic ash events; the Alaska SAR Facility, which is especially useful for sea ice studies using satellite-based radar data downlinked to Fairbanks; the Alaska Earthquake Information Center; the Arctic Super Computing Center to be established in Fairbanks; the Atmospheric Radiation Measurement site planned by the Department of Energy for the North Slope; and various capabilities for atmospheric monitoring, ozone research and space physics experiments.

Dr. Akasofu reported a need pending in the University of Alaska to double the space of the Geophysical Institute in Fairbanks. A design is being prepared that could also accommodate personnel from the National Weather Service, the Alaska Branch of the U.S. Geological Survey and NASA. This arrangement would assist research coordination.

Bonni Hycyk, Director, Canadian Polar Continental Shelf Program, reported that the program was originally established in 1958 by the Canadian federal government to determine the continental shelf boundaries. Since 1980 it is a logistics support
organization to some 40 Canadian agencies and universities; 250 groups were serviced without charges. Foreign parties can use these logistics services but pay a fee; for example, room and board charges are $80 per day. Primarily work in the natural sciences is supported, and the operation avoids competing with commercial services by providing logistics services in remote areas. The operating budget is currently $5 million, and it is part of the federal Energy Department. It is generally cost-effective to use its services in Canada in areas where the Polar Continental Shelf Program operates.

Tom Royer, University of Alaska Fairbanks and chairperson of the UNOLS planning committee for replacement of the research vessel *Alpha Helix*, reviewed the recent history of efforts to obtain a new ice-capable Arctic research ship. Funds were included in the NSF appropriation for completion of plans and a bid package for an Arctic research vessel. A concept design was completed and critiqued in the summer of 1991. The science requirements and a preliminary design were finished in the summer of 1992. A new design is expected by January 1993 and final specification by January 1994. This would allow construction to be completed in 1997. The present design considerations to meet the science requirements suggest an A-3 ice classification, up to 295 feet long at a cost of about $120 million, twice the original forecast. Various approaches to funding are being considered.

Dr. Royer stated that availability of a submarine would not change the science requirements for this ship, nor could a Russian ship satisfy the requirements. Renovation and maintenance of a Russian ship would be very expensive. The new research ship would also need to meet new stringent requirements for Canadian waters.

John Kelley, University of Alaska Fairbanks, pointed out the need for flexibility and diversity in Arctic science facilities by citing the Naval Arctic Research Laboratory as an example of a Federal facility locked in a cycle of rising costs and changing science interests better met in other locations. He cited the Canadian Polar Continental Shelf Program as a model with flexibility to meet changing needs that was coordinated through a single office for logistics information and arrangements.

Dr. Kelley offered a model being developed to assist the Polar Ice Coring Office as a means for the U.S. to improve Arctic logistics. He described and provided reports in support of a logistics information system (LIS) capable of being frequently updated. Its value could be enhanced by the addition of an expert systems approach to yield a Value Added Logistics Information System (VALIS). The injection of expert systems, as developed in engineering, into an interlinked logistics network could cut costs, improve response time and allow agencies, institutions and individuals to share and benefit from a common information base.

Capt. Alan Walker, Ice Operations, USCG, referred to the list of improvements announced by RADM Ecker at the 25th Meeting of the Commission in Monterey, California, and summarized substantial progress, including:

1. A Science Liaison Officer has been designated for both icebreakers to work with science parties and ships' crew before and during science deployments.
2. Experience for future bridge officers has been enhanced by rotating duty on Canadian and other ice-capable ships.
3. Commanding officers for icebreakers are now designated 18 months in advance to allow time for appropriate ice training.
4. A bilateral agreement between the U.S. and Canada allowed Canada to resupply Thule AFB, Greenland, freeing 60 days of icebreakers' time for a science mission.

5. Flight operations have become more responsive and manpower reduced.
6. Better communications via satellite are being sought.

Capt. Walker reported that the science deployment east of Greenland with an NSF-sponsored party aboard was successful in summer 1992 and entirely satisfactory to participants. Regarding procurement of a third icebreaker, specifications to meet future needs of science are being revised, and the ship will be re-bid in 1993 and will be available in 1997.

Thirtieth Meeting March 24–25, 1993

The Arctic Research Commission held its meeting at the Institute of Arctic and Alpine Research, University of Colorado, Boulder, on March 24 and 25, 1993. Chairperson Donald O'Dowd reported that since the December meeting the Annual Report and the Goals and Priorities Report had been published and distributed. The Chair has designated a committee of Members to consider the need for an oil and gas risk assessment requested by industry. All of the 26 advisors invited accepted two-year appointments. In February the Chairperson visited Juneau, Fairbanks and Anchorage, Alaska, and met with key state officials as well as selected scientists. Also in February the Chairperson visited Washington, D.C., and met with the Director of NSF and Alaska Congressional representatives.

Commission Members Present: *Donald D. O'Dowd, Chairperson; James O. Campbell; Clifford D. Groh; Ben C. Gerwick; Charles H. Johnson; George B. Newton; and Charles Myers representing the Ex-Officio Member Walter E. Massey.*

Staff: *Philip L. Johnson, Executive Director; and Lyle D. Perrigo, Head, Alaska Office.*

Advisor: *Jerry Brown.*

Visitors: *Roger Barry and Ron Weaver, National Snow and Ice Center, Boulder, Colorado; Joseph Fletcher and Susan Solomon, NOM, Boulder, Colorado; Mark Meier and Fran Simpson, INSTMR, Boulder, Colorado; David Garman, U.S. Senate; Al Johnson, San Diego, CA; Cornelius W. Sullivan, Director-designate, Office of Polar Programs, NSF, Washington, D.C.; Alan Walker, U.S. Coast Guard, Washington, D.C.; and Patrick Webber, East Lansing, Michigan.*

Interagency Arctic Research Policy Committee

Charles Myers, Office of Polar Programs, NSF, representing the Ex-Officio Member, reported that Walter Massey would leave the NSF in early April; Fred Bernthal will be the Acting Director, NSF. A number of senior members of IARPC await appointment by the President. Dr. Cornelius Sullivan, University of Southern California, was introduced as the Director-designate of the Office of Polar Program, NSF. He will report full time on May 17, 1993, and is in a periodic consulting status until then. IAPRC activities since the last meeting include:

- An issue of *Arctic Research of the United States* devoted to Arctic social science research was published.
- The Federal agency budget for Arctic research was compiled, which totaled $147,969,000 in FY 92 and $157,486 in FY 93, and was requested to be $147,624 in the President's Budget for FY 94.
- Assistance was provided to ONR in reviewing proposals for evaluating Arctic radiological wastes, for which $120 million of proposals have been submitted for an appropriation of $10 million.
- The *Third Biennial Revision: 1994–1995 of the Arctic Research Plan* was prepared. A public hearing on the plan will be held in Anchorage on May 5, 1993. Draft copies will be provided for the Commission's review in April.
- IARPC agencies are participating in an Arctic environmental policy review requested by the National Security Council and chaired by the State Department.

Arctic Data Management

Roger Barry, Director of the National Snow and Ice Data Center, summarized his organization and provided a tour of its facilities. This center is one of three international data archive centers for glaciological information. The purpose is to store, analyze and facilitate international exchange of snow and ice data. The collection includes bibliographic, photographic and satellite data as well as modern computer imaging analysis. Products of research are published, and data are provided to users in a variety of formats, including CD-ROM.

Martha Andrews, University of Colorado, and Lynn Lay, Ohio State University, provided an update on the U.S. Polar Bibliographic Information Working Group. Referring to previous recommendations of the Commission and to a keynote address by past Chairman Juan Roederer, they discussed continuing progress via a series of meetings of the Polar Libraries Colloquy. A CD-ROM, Polar Pac, was first issued in 1991, and the third, Polar Pac3, will be issued in June 1993. While significant progress has occurred to increase access to polar information, more national and international support is necessary.

Bering Sea Research

A draft plan for ARC activities regarding Bering Sea research, with background material including a two-year study by the National Academy of Sciences and on the NOM Bering Sea FOCI (Fisheries–Oceanography Coordinated Investigations), was provided in the meeting book. James Campbell stated that an important need was the

creation and maintenance of an inventory of past and current research activity. He distributed a proposal by Charles Broches and Marc Miller, Paragon, Inc., Seattle, Washington, which proposes (1) an inventory of researchers and research agendas, (2) analysis of research activity and (3) a research workshop and proceedings. A budget of $103,180 over a 12-month period was attached. He indicated that such an inventory, once compiled, could be maintained by the University of Alaska.

Donald O'Dowd asked how the Broches proposal related to a funded study ($500,000/two years) at the National Academy of Sciences? That study proposes to (1) synthesize available scientific and technical information and describe the present understanding of the Bering Sea ecosystem, (2) identify gaps in understanding of the Bering Sea ecosystem and (3) access the resource management alternatives. It was observed that the National Academy study would likely emphasize basic science and would not be likely to include technologies and applied science considerations. Upon discussion the Commission decided to seek terms of reference for the National Academy of Sciences study and to monitor their efforts.

Submarine Science Deployment

George Newton reported that a formal Memorandum of Agreement between the Navy, the University National Oceans Laboratory System (UNOLS) and the Commission has been signed. The Memorandum calls on the Commission to facilitate an interface with the Arctic marine science community. A process is well underway to complete a science plan using standard instruments on a nuclear submarine to be deployed in the central Arctic Basin (3300 miles, 420 hours under sea ice) this summer. A science planning committee is actively arranging for projects in two clusters: water and ice studies, and sea bottom studies. A public announcement of opportunity has been circulated, but the planning time is so short as to likely limit participation to researchers who already have funding. Four scientists will be aboard the submarine, and Navy personnel will help collect data for other scientists.

Arctic Policy Review

In August 1992, in Fairbanks, Alaska, E.U. Curtis Bohlen, Assistant Secretary of State, announced at the "Changing Role of the U.S. in the Circumpolar North" that a review and update of U.S. Arctic policy as stated in National Security Decision Directive (NSDD-90) in 1983 would occur. In February 1993, Presidential Review Directive/NSC-12 disestablished a number of interagency policy committees, including the Interagency Arctic Policy Group established under NSDD-90. The new administration requested in NSC-12 a comprehensive review of global environmental policies and programs in 12 areas, including those with regard to the Arctic. These interagency reviews, due April 16, 1993, are chaired by Mr. Bohlen. Instructions by the National Security Council apparently restrict participation in these reviews to selected Federal officials.

The Executive Director was asked by the State Department to draft material about coordination of Arctic science as input to an extensive outline prepared by DOS. Upon discussion of the background and circumstances of the review of Arctic policy, the Commission decided to prepare a letter to Assistant Secretary Bohlen stating the role of the Commission as prescribed by the Arctic Research and Policy Act (ARPA) and emphasizing positive contributions of the Commission. The intent is to urge the effective and full implementation by all agencies cited in ARPA.

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, *National Science Foundation, Room 620, 1800 G St., NW, Washington, D.C. 20550.*

1993

25th Annual Symposium on Remote Sensing and Global Environment Change
4–8 April 1993, Graz, Austria
Contact: ERIM/International Symposium, P.O. Box 134001, Ann Arbor, Michigan 48113-4001
Phone: (313) 994-5123, ext. 3234
Fax: (313) 994-5123

Scientific Conference on the IGBP Core Project International Global Atmospheric Chemistry (IGAC)
15–22 April 1993, Eilat, Israel
Contact: Dr. Ronald Prinn, IGAC Core Project Office, MIT Building 54-1312, Cambridge, Massachusetts 02139
Phone: (617) 253-4902
Fax: (617) 253-0354
Omnet R.Prinn

Symposium on Applied Ice and Snow Research
18–23 April 1993, Rovaniemi, Finland
Contact: Secretary General, IGS, Lensfield Road, Cambridge CB2 1ER, United Kingdom

A Regional Response to Global Climate Change: New England and Eastern Canada
19–21 May 1993, Portland Maine
Contact: Nick Houtman, Water Resources Program, University of Maine, 11 Coburn Hall, Orono, Maine 04469
Phone: (207) 581-1491
Fax: (207) 581-1426

International Symposium on Environmental Information Management and Analysis: "Ecosystem to Global Scales"
20–22 May 1993, Albuquerque, New Mexico
Contact: William Michener, Baruch Institute, University of South Carolina, Columbia, South Carolina 29208
Phone: (803) 777-3926
Fax: (803) 777-3935

The Calotte Academy 1993
20–22 May 1993, Inari Finland and Svanvik, Norway
Contact: Lassi Heininen or Raija Kivilahti, Arctic Centre, University of Lapland, P.O. Box 122, SF-96101 Rovaniemi, Finland
Phone: +358-60-324 778
Fax: +358-60-324 760

Symposium on Arctic Resources: The Challenge of Development
24–26 May 1993, Anchorage, Alaska
Contact: Donald P. Blasko, U.S. Bureau of Mines, 3301 "C" Street, Suite 525, Anchorage, Alaska 99503-3935
Phone: (907) 271-2455
Fax: (907) 271-3933

International Symposium on Climate Change, Natural Disasters and Agricultural Strategies
26–29 May 1993, Beijing, China
Contact: Prof. Lu Guangming or Dr. Wu Lianhai, Beijing Agricultural University, 100094 Beijing, People's Republic of China
Fax: 86-01-2582332

ISOPE-93; The Third International Offshore and Polar Engineering Conference
6–11 June 1993, Singapore
Contact: ISOPE, P.O. Box 1107, Golden, Colorado 80402-1107
Fax: 1-303-420-3760

Fourth Canadian Marine Geotechnical Conference
7–30 June 1993, St. John's, Newfoundland, Canada
Contact: Farrokh Poorooshasb, Technical Chairman, Fourth Canadian Marine Technical Conference, C-CORE, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada
Phone: (709) 737-8371/8354
Fax: (709) 737-4706

Scientific Assembly of the International Association of Meteorology and Atmospheric Physics and the International Association of Hydrological Sciences
11–23 June 1993, Yokohama, Japan
Contact: IAMAP-IAHS '93, c/o Sankei Convention, Sankei Building, 10F, 1-7-2 Otemachi, Chiyodaku, Tokyo, Japan
Phone: 81-3-3273-2084
Fax: 81-3-3279-6287

International Conference on Offshore Mechanics and Arctic Engineering
20–24 June 1993, Glasgow, Scotland
Contact: S.K. Chakrabarti, c/o CBI Research, 1501 North Division St., Plainfield, Illinois 60544-9829
Phone: (815) 436-2912
Fax: (815) 436-8345

IX International Congress on Circumpolar Health
20–25 June 1993, Reykjavik, Iceland
Contact: Dr. Gudrun Petursdottir, Secretary General, IX International Congress on Circumpolar Health, University of Iceland, Vatnsmyrarvegi 16, IS-101 Reykjavik, Iceland
Phone: (354)-(1)-694825 and 694830
Fax: (354)-(1)-694884

Nansen Centennial Symposium on the Role of the Polar Oceans in Shaping the Global Environment
21–25 June 1993, Oslo, Norway
Contact: Bente E. Johannessen, Local Organizing Committee, Nansen Centennial Symposium, NERSC, Edvard Griegsvei 3a, N03957 Solheisviken, Norway
Phone: 47-5-29-72-88
Fax: 47-5-20-00-50

4th Canadian Marine Geotechnical Conference
27–30 June 1993, St. John's, Newfoundland, Canada
Contact: Farrokh Poorooshasb, Technical Chairman, 4th Canadian Marine Geotechnical Conference, C-CORE, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada
Phone: (709) 737-8371/8354
Fax: (709) 737-4706

Frost '93: International Symposium on Frost in Geotechnical Engineering
28 June–1 July 1993
Contact: Arvind Phukan, School of Engineering, University of Alaska, 3211 Providence Drive, Anchorage, Alaska 99508-8096

The Genesis and Classification of Permafrost-Affected Soils—A Tour and Meeting
July 1993
Sponsored by the USDA-SCS, Agriculture Canada, University of Alaska–Fairbanks and Alaska/Yukon Society of Professional Soil Scientists
Contact: Dr. John Kimble, USDA-SCS-NCSS, Federal Building, Room 152, 100 Centennial Mall North, Lincoln, Nebraska 68508-3866

VI International Conference on Permafrost
5–9 July 1993, Beijing, China
Contact: G.D. Cheng, Lanzhou Institute of Glaciology and Geocryology, Academia Sinica, Lanzhou, China
Phone: 26726-385
Fax: 86 931 485 241
Telex: 72008 IGGAS CN

Joint CSCE/ASCE Conference on Environmental Engineering
12–14 July 1993, Montreal, Quebec, Canada
Contact: Raymond N. Young, Conference Chair, Geotechnical Research Centre, McGill University, 817 Sherbrooke St. West, Montreal, Quebec H3A 2K6, Canada
Phone: (514) 398-0672
Fax: (514) 398-7361

Climate Change and World Food Security (NATO Advanced Research Workshop)
15–16 July, Oxford, United Kingdom
Contact: Prof. M. Parry, Environmental Change Unit, University of Oxford, Oxford OX1 ETB, United Kingdom
Phone: 44-865-281180
Fax: 44-865-281181

Symposium on the Impacts of Climatic Change/ Global Warming on Hydrology and Water Resources in Mountainous Regions and Cold Regions
Mid-July 1993, Lhasa, Tibet, China
Contact: Chairman, Organizing Committee, Ming-Ko Woo, Department of Geography, McMaster University, McMaster University, Hamilton, Ontario L8S 4K1, Canada, or Liu Changmin/Guobin Fu, Secretariat of Symposium, Department of Hydrology, Institute of Geography, CAS, Building 917, Datun Road, Beijing 100101, China
Phone: (861) 4321539
Fax: (861) 4231551
Telex: 222483 CAAMS

International Cryosols Tour: Classification, Correlation, and Management of Permafrost Soils
18–30 July 1993, Northwest Canada and Alaska
Contact: John Kimble, USDA-SCS, Federal Building, Room 152, 100 Centennial Mall North, Lincoln, Nebraska 68508-3866
Phone: (402) 437-5363
Fax: (402) 437-5336

The Cultural and Biological Dimensions of Global Change: XII International Congress of Anthropological and Ethnological Sciences
28 July–5 August 1993
Contact: Dr. L. Manzanilla, UNAM, Ciudad Universitaria, 04510 Mexico DF, Mexico

Pre-Conference Field Trip, Geomorphology and Permafrost,
11–22 August 1993, Yukon and Western Canadian Arctic
Contact: C.R. Burn, Department of Geography, University of British Columbia, Vancouver, B.C. V6T 1W5, Canada

Third International Conference on Geomorphology
23–29 August 1993, Hamilton, Canada including the Binghamton Symposium on Geomorphology, 25 August 1993)
Contact: McMaster University, Hamilton, Ontario L85 4K1, Canada
Phone: (416) 546-9140 ext. 4535
Fax: (416) 546-0463
Telex: 061-8347

1993 Symposium on Greenhouse Gas Emissions and Mitigation Research
18–20 August 1993, Washington, D.C.
Contact: T. Kelly Janes, MD-63, U.S. Environmental Protection Agency, Air and Engineering Research Laboratory, Global Warming Control Branch, Research Triangle Park, North Carolina 27711

Global Change and Arctic Terrestrial Ecosystems: An International Conference
21–26 August 1993, Oppdal, Norway
Contact: NINA (Norwegian Institute for Nature Research), Dr. Jarle I. Holten, Tungasletta 2, N-7005 Trondheim, Norway
Phone: +47-7-58-05-00
Fax: +47-7-91-54-33

3rd International Conference on Geomorphology
23–29 August 1993, Hamilton, Ontario, Canada
Contact: McMaster University, Hamilton, Ontario L8S 4K1, Canada
Phone: (416) 546-9140, ext. 4535
Fax: (416) 546-0463
Telex: 061-8347

POAC '93: Port and Ocean Engineering under Arctic Conditions
17–20 August 1993, Hamburg, Germany
Contact: Hamburgische Schiffbau-Versuchsanstalt, P.O. Box 600929, 2000 Hamburg 160, Germany

Arctic Opportunities
13–16 September 1993, Rovaniemi, Finland
Contact: Raija Kivilahti, Arctic Centre, University of Lapland, P.O. Box 122, SF-96101 Rovaniemi, Finland
Phone: +358-60-324 778
Fax: +358-60-324 760

Fourth International CO_2 Conference
13–17 September 1993, Carqueiranne, France
Contact: Institute National des Sciences, de l'univers/ CNRS (Maritine Revillon, INSU), 77 Avenue Denfert Rochereau, 75014 Paris, France
Phone: 33-1-40-51-20-08
Fax: 33-1-40-51-21-49

44th Arctic Science Conference: Circumpolar Information Exchange
15–18 September 1993, Whitehorse, Yukon, Canada
Contact: Arctic Science Conference, P.O. Box 31137, Whitehorse, Yukon Y1A 5P7, Canada
Phone: (403) 667-4288
Fax: (403) 633-6965

5th World Wilderness Conference: Wild Nature and Sustainable Living in Circumpolar Regions
24 September–1 October 1993, Tromsø, Norway
Contact: The Northern Forum, Offices of the Secretariat, 4101 University Drive, Alaska Pacific University, Carr-Gottstein Academic Center, Suite 211, Anchorage, Alaska 99508
Phone: (907) 561-6645
Fax: (907) 561-6645

5th World Wilderness Congress: Wild Nature and Sustainable Living in Circumpolar Regions
25 September–1 October 1993, Tromsø, Norway
Contact: Charlotte Winsnes, Congress Director, Joint Secretariat, Post Box 190, 9001 Tromsø, Norway
Phone: +47 83 80 811
Fax: +47 83 80 618

MARSIN '93—International Conference on Marine Simulation and Ship Manoeuvrability
26 September–2 October 1993, St. John's, Newfoundland, Canada
Contact: Mrs. J. Harris, MARSIN '93 Conference Coordinator, Marine Institute, P.O. Box 4920, St. John's, Newfoundland A1C 5R3 Canada
Phone: (709) 778-0660
Fax: (709) 778-0346

4th Northern Regions Conference—People in the Arctic: Regional Rights and Regional Management
27 September–3 October 1993, Tromsø, Norway
Contact: 4th Northern Regions Conference, Joint Secretariat, Post Box 190, 9001 Tromsø, Norway
Phone: +47 83 80 811
Fax: +47 83 80 618

Fourth International Symposium on Thermal Engineering and Science for Cold Regions
28 September–1 October 1993, Hanover, N.H.
Contact: Virgil Lunardini, USA Cold Regions Research and Engineering Laboratory, 72 Lyme Road, Hanover, New Hampshire 03755-1290
Phone: (603)646-4326
Fax: (603) 646-4640
Telex: 710 366 1826

International Symposium on the Ecological Effects of Arctic Airborne Contaminants
4–8 October 1993, Reykjavik, Iceland
Contact: Debra Steward, Technical Resources, Inc., 3202 Tower Oaks Boulevard, Rockville, Maryland 20852
Phone: (301) 770-3513
Fax: (301) 468-2245

Beijing 93'S International Symposium on Sea Ice
19–22 October 1993, Beijing, China
Contact: Ms. Shi Ping, Office of Beijing 93'S International Symposium on Sea Ice, Da Hui Si No. 8, Haidian District, National Research Center for Marine Environmental Forecasts, Beijing 100081, China
Phone: (861)-8313593

Redressing the Imbalance: Health Human Resources in Rural and Northern Communities
21–24 October 1993, Thunder Bay, Ontario, Canada
Contact: Connie Hartviksen, Redressing the Imbalance, c/o Northern Health Human Resources Research Unit, Health Sciences North, Lakehead University, 955 Oliver Road, Thunder Bay, Ontario P7B 5E4, Canada
Phone: (807) 343-2135
Fax: (807) 343-2104

Growth and Environment: Challenging Extreme Frontiers—2nd International Design for Extreme Environments Assembly
23–28 October 1993, Montreal, Canada
Contact: IDEEA Two, Centre for Northern Studies and Research, Burnside Hall, Suite 720, McGill University, 805 Sherbrooke Street West, Montreal, Quebec H3A 2K6, Canada
Phone: (514) 398-6052
Fax: (514) 398-8364

Sea Level Changes: Measurements and Analysis
9–10 December 1993, London, United Kingdom
Contact: PSMSL, Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, Merseyside L43 7RA, United Kingdom
Fax: 44-51-653-6269

1994

Circumpolar Ecosystems in Winter 3
16–21 February 1994, Churchill, Manitoba, Canada
Contact: CEW-3, Churchill Northern Studies Centre, P.O. Box 610, Churchill, Manitoba R0B 0E0, Canada
Phone: (204) 675-2307
Fax: (204) 675-2139

Seventh International Cold Regions Engineering Specialty Conference
7–9 March 1994, Edmonton, Alberta, Canada
Contact: Dr. Daniel W. Smith, Department of Civil Engineering, University of Alberta, Edmonton, Alberta T6G 2G7, Canada

Polar Tech '94
22–25 March 1994, Luleå, Sweden
Contact: CENTEX, Lena Allheim Karbin, Luleå University of Technology, S-95187, Luleå, Sweden

ISOPE-94; The Fourth International Offshore and Polar Engineering Conference
10–15 April 1994, Osaka, Japan
Contact: ISOPE, P.O. Box 1107, Golden, Colorado 80402-1107
Fax: 1-303-420-3760

ISCORD 1994—International Symposium on Cold Regions Development
13–16 June 1994, Espoo, Finland
Contact: ISCORD '94 Symposium Secretariat, c/o Association of Finnish Civil Engineers RIL, Meritullinkatu 16 A 5, SF-00170 Helsinki, Finland
Phone: +358 0 1356300
Fax: +358 0 1357669

Bipolar Information Initiatives: The Needs of Polar Research—15th Polar Libraries Colloquy
3–8 July 1994, Cambridge, United Kingdom
Contact: William Mills, Scott Polar Research Institute, Cambridge CB2 1ER, U.K.
Phone: 0223-336557
Fax: 0223-336549
E-Mail: wjm13@uk.ac.cam.phx

International Conference on the Arctic and North Pacific: Bridges of Science Between North America and the Russian Far East
25 August–2 September 1994, Anchorage Alaska, and Vladivostok, Russia
Contact: Dr. Gunter Weller, Geophysical Institute, University of Alaska, Fairbanks, Alaska 99775-0800
Fax: (907) 474-7290
E-Mail: gunter@dino.gi.alaska.edu

Second International Conference on Arctic Margins (ICAM)
September 1994, Magadan, Russia
Contact: Dennis Thurston, Anchorage, Alaska
Phone: (907) 271-6545, 6010

1994 International Conference on Arctic Margins
5–9 September 1994, Magadan, Russia
Contact: Kirill V. Simakov, North East Scientific Centre, 16 Portovaya Street, Magadan, 685000 Russia, or Dennis K. Thurston, U.S. Minerals Management Service, 949 E. 36th Avenue, Rm 605, Anchorage, Alaska 99508-4320
Phone: (907) 474-7219 (Kirill Simakov, U.S.)
(7-41) 3 223-0953 (Kirill Simakov, Russia)
(907) 271-6545 (Dennis Thurston)
Fax: (907) 271-6565

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, D.C. 20090

Edward Myers
National Oceanic and Atmospheric Administration
Department of Commerce
Silver Spring, Maryland 20910

Bradley Smith
Department of Defense
Washington, D.C. 20301

Curtis Olsen
Department of Energy
Washington, D.C. 20545

Paul Ringold
U.S. Environmental Protection Agency
Washington, D.C. 20460

W. Craig Vanderwagen
Indian Health Service
Department of Health and Human Services
Rockville, Maryland 20857

James Devine
U.S. Geological Survey
Department of Interior
Reston, Virginia 22092

Jack Fellows
Office of Management and Budget
Washington, D.C. 20503

Robert Thomas
National Aeronautics and Space Administration
Washington, D.C. 20546

Charles E. Myers
National Science Foundation
Washington, DC 20550

William Fitzhugh
Smithsonian Institution
Washington, D.C. 20560

Ray Arnaudo
Department of State
Washington, D.C. 20520

Captain Alan Walker
U.S. Coast Guard
Department of Transportation
Washington, D.C. 20593

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550
